COMMUNICATIONS, INC

CTA COMMUNICATIONS CONSULTANTS

FINAL

EBRCS Design Evaluation Report

County of Contra Costa, California

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EXECUTIVE SUMMARY

Introduction

Public safety officials representing law enforcement and fire / rescue agencies in Alameda County and Contra Costa County have been working cooperatively over the past two or three years to develop a plan for a regional communications system. One goal of this plan is to provide a common radio infrastructure where all public safety users in both counties can operate on a common frequency band using a common protocol. This will facilitate joint operations, sharing of data and resources, as well as improving the efficiency and safety of the public safety personnel who are performing their duties in protecting the life and property of local citizens. The joint activities between the counties may also afford opportunities to save public funds through the realization of economies of scale and the sharing of certain critical components in the infrastructure. By adopting the open, standards-based P25 architecture as the technology base for this plan, the local public safety officials have embraced the standards endorsed by the federal government and by many national public safety organizations. This plan for a regional, interoperable P25 network serving all of the public safety agencies in the two counties should meet the criteria set by the U. S. Department of Homeland Security, and place an application for funding via a federal grant in a favorable position to gain approval. (It should be clearly understood that funding is contingent on a competitive evaluation process, and that even if the County is successful in securing additional monies for the project, it is unlikely that the federal government will bear more than a fraction of the total cost of the system.)

The public safety officials who have been developing these plans for a regional system deserve recognition and commendation for their wisdom and foresight. The plan clearly parallels the long-term goals that Contra Costa County adopted in 2002 as part of its "master plan" to address the need for a technology upgrade. This plan finally moves the discussion concerning the need for improvements in public safety communications in Contra Costa County from the study mode to an action plan. The public safety officials involved in this process should also be commended for working together on this plan – a partnership among the local agencies will ultimately result in a superior design, which in turn will provide safer working conditions for first responders.

Alameda County Contract with Motorola

Alameda County contracted with Motorola in October 2005 to supply certain critical infrastructure as part of the roll-out of this P25 network for that County. One of the tasks in that contract was for Motorola to develop a conceptual design for a two-county P25 trunked radio system, which has been named the East Bay Radio Communications System (EBRCS). On May

12, 2006, Motorola delivered its design for the EBRCS to Alameda County in a document that included sample test plans, a scope of work, warranty and post-warranty maintenance plans, and a price proposal for the system. This document has been shared with officials in Contra Costa County, and has been the subject of some discussion over the past few months.

Independent Third Party Review

CTA Communications, a consulting firm based in Virginia with its practice focused on land mobile radio technology, was engaged by Contra Costa County to review the EBRCS documentation. As an independent consultant with no connection to any manufacturer or supplier of radio equipment or systems, CTA was asked to render its opinion on the viability of the proposed EBRCS design, the reasonableness and completeness of the pricing proposal, and to make recommendations for actions designed to move the project forward.

P25 Standard

The technical design described in the EBRCS document is a feasible architecture that appears to have been carefully planned to meet the needs of public safety users in Alameda and Contra Costa counties. We agree with the selection of open-standards based P25 as the underlying technology. From our perspective, the land mobile radio industry in North America has fully embraced P25, with nearly all manufacturers now shipping at least some products that are compliant with the standard. Motorola and M/A-Com, the two major manufacturers of trunked systems in the United States, are both shifting emphasis from proprietary technology to P25 compliant products. There is no other standard for digital or trunked mobile radio in North America; in fact, P25 is the only conventional and trunked two-way radio standard currently deployed throughout the world.

The federal government has decided to likewise embrace P25 – this is now the standard for all U.S. government agencies that use land mobile radio. For example, the Integrated Wireless Network (IWN), currently under construction, will be a nationwide network integrating all federal law enforcement agencies on a common P25 infrastructure, although in a different frequency band from the EBRCS. Many states across the country are also building P25 networks to integrate agencies in a common architecture. The U.S. Department of Homeland Security and the U.S. Department of Justice have strongly encouraged the use of P25 in federal grant applications involving radio communications funding at the state and local level. By choosing the P25 technology for the EBRCS design, Contra Costa County will conform to one of the qualifying criteria for this funding. Approval of a funding application may result in the savings

of millions of dollars for the local citizens. Again, we commend the public safety officials participating in the EBRCS development for their efforts on this front.

Design for Transmitter Placement

CTA has examined some of the fundamental design elements and compared them to criteria regularly used in our practice and in the industry at large. One factor we looked at was the placement and separation of sites for the radio coverage offered by the EBRCS design. Since the design in Contra Costa County involves the use of simulcast technology, which is based on extremely precise timing of transmissions from the towers, it is critical that the sites not be placed too far apart. The design document has shown that the spacing of sites is appropriate, and that reasonable countywide coverage should be obtainable with the selected sites.

Capacity for Radio Traffic

We have also studied the capacity requirements of the EBRCS, and generally agree with the traffic analysis shown in the design document. The EBRCS document showed that 27 channels would be required in Contra Costa County. CTA's independent analysis, using a different traffic modeling tool, showed the need for 28 channels. We felt that the eastern simulcast cell in Contra Costa County would need 8 channels, not 7. The number of available channels, either already licensed to the County or that could be licensed by the FCC, was not considered a factor in the CTA analysis. This may have been a realistic limitation that Motorola took into account in its analysis, resulting in our arriving at slightly different results.

Fault Tolerance and Redundancy

In addition to the fundamental design elements, we also note that the EBRCS design includes redundancy in the critical network management elements, the incorporation of packet data using IP standards for the inter-site transport of digital voice and control signals. This in turn allows the use of routers, hubs and Ethernet in place of "back-room" equipment racks. Even the use of trunking, which has become commonplace across America, will be a substantial leap forward for many in Contra Costa County. The quality of the products offered in the EBRCS document is among the best in the world for commercially available equipment. If the network is constructed to the R56 standards recommended by Motorola, the system will be highly reliable and robust, providing service to the users even in situations involving extreme weather, power outages and other natural or manmade disasters. The EBRCS is scalable, meaning that changes in configuration and expansion for future use are factored into the design concept.

Therefore, in our professional opinion, there are no fatal flaws in the EBRCS design or in the equipment proposed in the May 2006 document.

Findings and Recommendations – Coverage Maps

That being said, we do have some questions that were not fully answered in the Motorola document, and offer some revisions in the details of the design that might prove beneficial to the County. The coverage maps supplied with the document show composite coverage for the two-county regional system. Our experience with Motorola has shown that their coverage maps are conservative estimates, so we do not doubt that the composite coverage shown is in fact achievable. However, there are no maps in the EBRCS document that show individual simulcast cell performance. This is critical in assessing how Contra County users will actually perceive the performance of the system. Equally important, the coverage of the individual cells will impact the accuracy of the traffic loading analysis. If the coverage of the individual simulcast cells does not correspond with the operational boundaries for the various agencies using the system, the quantity of wide area calls (involving more than one cell) and wide area roaming will exceed the percentages assumed in the analysis. This means that the capacity of the designed system may be inadequate. Without the individual maps this is impossible to evaluate.

Coverage Claims

We did find that the analyses assumed that the user had a portable attached at hip level, which is a conservative approach. We concur with the coverage analysis being done in this manner. However, we did not find the attenuation values used for "light, medium and heavy" building types. Without these parameters, it is impossible for CTA to either agree or disagree with the coverage claims made in the EBRCS document for indoor portable use.

CTA recommends that the coverage test plan contained in Appendix B of the EBRCS document be modified to better protect the County, and to better characterize the performance of the completed system. We suggest that the entire service area, as defined by the geopolitical boundaries of the County, be subject to test – not limited to the "covered" areas indicated on the maps. The vendor's guarantee for coverage should be modified accordingly. The test as proposed only considers the one-way performance (talk-out from base to mobile). Provisions should be included in the plan for testing the talk-in (mobile to base) link. Likewise, we recommend that other items be added to the acceptance test plans – verification of simulcast alignment, channel to channel balance, interference, system access, etc. We recommend that provisions for re-testing failed grid cells be carefully considered during negotiations before including in the final acceptance test plan.

Returning to the capacity analysis, we note that the EBRCS design included a 20% growth factor uniformly distributed throughout Contra Costa County. It is not stated how this figure was derived. Normally, CTA designs a system for a 15 to 20 year life. So we use the growth in users over that period of time. Often, population growth estimates are used as the basis for these predictions. If 20% is a reasonable growth projection for the County over the next 15 to 20 years, then the EBRCS analysis is valid. If there are certain areas of the County that will grow at different rates, then this should be a factor in the planning of the three simulcast cells.

Single Simulcast Cell

While we recognize the constraints that the EBRCS design team was under, we suggest that there may be other configurations that should be considered before committing to the specific configuration described in the EBRCS document. One such alternative might be a single simulcast cell that encompasses all of Contra Costa County. This configuration would be more efficient and would be operationally simpler for the agencies to use. Fewer overall frequencies (channels) would be needed in this design approach. It would eliminate our concerns with the composite coverage maps because that is, in fact, how that system would operate. And operationally, each agency can determine its district boundaries and procedures without regard to the constraints of the radio system.

It appears that the EBRCS design was based on exclusive use of channels in the 800 MHz band; this is a limiting factor since there is considerable congestion in the northern California area near Contra Costa County. We believe that the use of 700 MHz frequencies would eliminate this constraint. The problem with 700 MHz spectrum is that it will not be available in your area until 2009, which may or may not be a limiting factor. (P25 equipment is now available from the major manufacturers that will cover both the 700 and 800 MHz bands, so operations would appear seamless to the users. We recommend that participating agencies in the County and cities purchasing new equipment for use on the EBRCS carefully consider this factor before committing their funds.)

P25 Phase 2 Considerations

As proposed in the EBRCS design, the radio system will carry voice communications on channels in the 800 MHz band using a P25 Phase 1 protocol. The major drawback in the 800 MHz band is the limited availability of channels for the EBRCS, which limits your ability to implement a single simulcast cell covering the entire County. Use of the 700 MHz band alleviates the congestion of frequencies, and hence enables the consideration of a single simulcast configuration. However, there is a catch – the FCC has mandated the further

narrowbanding of the 700 MHz band (to one voice channel per 6.25 kHz) by January 1, 2017. There is no corresponding mandate for the 800 MHz band.

Industry's answer to this mandate is a revision to the standard protocol for P25 that would result in the improved channel efficiency – this extension to the standard is called "P25 Phase 2". Under this approach, time division multiple access (TDMA) would be used to carry two simultaneous calls on each 12.5 kHz channel – essentially doubling the voice capacity of the network. The TIA/EIA-102 standards committee is now close to agreement on the general framework for Phase 2. We expect that the initial documents codifying the basic tenants of P25 Phase 2 modulation will be published later this year. However, committee members have indicated that it may take another one to two years for all of the details in the protocol definition to be worked out and agreed upon. Adding another 12 to 18 months for the initial development cycle by the manufacturers, we estimate that the first P25 products using TDMA Phase 2 standards will probably be not be available until very late in 2009 or 2010 at the very earliest, and more likely not until 2011.

This issue is important to the County because if you opt to build a new system using 700 MHz frequencies, which should be abundant after February 2009, you will need to plan for a mandated upgrade in technology by 2017. Use of 800 MHz frequencies in the design will avoid this forced upgrade, but the scalability of that band is limited in northern California due to channel congestion. Although the use of P25 Phase 2 TDMA technology (or similar technology with equivalent efficiency) will not be mandatory in 800 MHz, its use there does offer the possibility of modifying the EBRCS design to incorporate P25 Phase 2 protocol in the future. (The FCC rules are open to the use of P25 Phase protocol on 800 MHz frequencies.) This is an intriguing alternative that should be considered in the region's long-term plans. Even if the EBRCS doesn't elect to use either 700 MHz channels or the Phase 2 TDMA technology in its implementation, it is highly likely that other jurisdictions in northern California will eventually choose these options. A plan for interoperability with these agencies will be essential.

CTA has recently learned of a county that negotiated a contract with a radio vendor that included an upgrade to P25 Phase 2 at whatever point it becomes available in the market. This provision was placed in the basic contract and agreed upon by both parties. This might be another approach Contra Costa County might want to consider as it studies options that could protect its investment.

Pricing

CTA has also reviewed the price proposal included in the EBRCS design document of May 2006. We used the technical data from the design of the EBRCS as input to our own cost model, which uses a database derived from similar projects around the country, and produced an independent opinion of probable cost. We then compared our cost model results with the prices quoted in the May 2006 document. Our findings can be generally broken into two categories: first, the agreement of the prices for the equipment and services quoted with pricing norms that we have observed on other projects; and secondly, the completeness of the "total system cost" shown for the EBRCS.

1. On the first point, CTA's analysis shows that the price quoted for the equipment and services in the EBRCS is about $11,500,000 higher than what we would estimate for a competitive procurement. When taken as a percentage of the competitive estimate, this is about 26.5%. If instead we consider the case of a negotiated (sole source) procurement, the price quoted for the EBRCS is about $6,000,000 higher than the CTA model estimate, which works out to about 12.5%. Remember that our price model is based on the final *negotiated* price, and not the original *starting* price. We have found that in negotiations where we have participated, price reductions of 10 to 18% can be obtained. Of course, this often involves some refinement, clarification or reduction of scope in the vendor's proposal, as well as other factors.

2. Upon examination of the pricing details in the EBRCS document, the equipment prices are about what we normally see in other procurements, and in our opinion are fairly reasonable considering the non-competitive environment in which they were derived.

3. The cost for installation ($8,237,760) appears high. This is approximately 23% of the cost for the equipment. Normally, we would expect the cost for installation to be about 15% of the equipment cost.

4. The cost for all other vendor services (Project Management, Project Administration, etc.) is $14,735,624, which is 37% of the cost for equipment. These costs appear high. Normally, we would expect the cost for these services to be about 18% of the equipment cost.

5. We then performed a "gap" analysis, comparing our cost model and the elements of cost to the EBRCS price for the "total system" ($60,151,063). Two major elements of the total cost for the project are missing from the quoted "total system price" for EBRCS. In

the Statement of Work (section 5 of the EBRCS document), the vendor has placed responsibility for the physical facilities on the owners (Contra Costa County and Alameda County); the cost for "physical facilities" is not included in the price proposal. Likewise, the vendor has quoted prices for individual radios, which will be very helpful for agencies to use in their planning of purchases, but a total cost for the replacement of all subscriber equipment is not included in the total price for the EBRCS.

6. Physical facilities include elements like towers, tower upgrades, structural analyses, access roads (to radio sites), fencing and enclosures, equipment shelters (vaults), expansion or renovation of existing buildings or vaults, HVAC (heating, ventilation, air-conditioning) units, smoke detection and fire suppression systems, emergency generators, grounding, surge protection, site acquisition or site leasing costs, etc. Between the two counties, there are 31 radio sites, plus numerous locations where dispatch consoles will be installed and PSAP E-911 centers may need expansion or renovation (or even replacement). None of the costs for any of this activity is included in the price for the EBRCS. In our opinion, a minimum of $5 million will be needed – and this will be for very limited upgrades and renovation. The actual cost could, of course, run much higher – up to $20 million if there are towers or buildings (vaults) that need replacement, or if there are substantial upgrades. (The cost for new dispatch centers is not considered here.)

7. Using the existing inventory of portable and mobile radios among the potential participating agencies in EBRCS (18,048 units in 2006), and using the prices quoted in the design document, we have estimated that the probable cost for replacing the current radios will run about $36,400,000.

Opinion of Total Cost

Adding a rough estimate for the physical facilities and the subscriber equipment to the "total system price", CTA believes the total cost of the system (before negotiations with the vendor) will likely range between $100 and $115 million, with our best estimate probably at about $110 million.

Contingency

Note that the total above does not include provisions for mobile data, automatic vehicle location, fire alert systems, paging, etc. CTA recommends that the County establish a "contingency fund" (typically about 10% of the infrastructure cost) for factors that may arise during the course of implementation. This contingency fund can also be used to provide in-building systems should

the coverage testing reveal that some facilities are not adequately covered. (This is more cost effective than *requiring* the vendor to guarantee coverage inside specific buildings.)

Cost Control Opportunities

1. There are opportunities to reduce and control costs on the project. One is the approach that the EBRCS task team has taken by separating the microwave connectivity network and the physical facilities from the radio infrastructure. By eliminating overhead costs of a system integrator, the County (or the JPA team) can realize substantial savings and also obtain the best products by competing these subsystems or project elements. The EBRCS team can also competitively procure the subscriber equipment from a variety of P25 manufacturers. By separating the project into elements, though, the owners must realize that they are taking on the responsibility for integrating the activity, establishing interfaces, and managing the project. This will require that the counties provide strong project management and oversight, which will demand personnel with skills, experience and knowledge specific to the mobile radio industry.

2. Enlisting the services of an independent consultant – an individual or firm with extensive experience and technical knowledge – would be a wise investment in a project of this magnitude. The expert advice and guidance they could provide may prove to be worth many times their fee. Assistance with the development of functional specifications, advice during negotiations with the contractor (or contractors), as well as oversight and project management during the implementation and acceptance test phases are all activities where this independent expert can act as an advocate for the County (or JPA).

3. Taking it one step further, there is also the opportunity to competitively procure the radio infrastructure for the Contra Costa County simulcast cells. While Alameda County had a requirement for compatibility with existing equipment in their legacy SmartNet system, Contra Costa County may have a different requirement. The cities participating with Richmond have an EDACS system that is not compatible with the Motorola subscriber equipment proposed in the EBRCS document. A cost effective solution may be for EDACS users to purchase M/A-Com subscriber equipment that is P25 compliant, and therefore compatible with the EBRCS. With the recent introduction of the ISSI (inter-subsystem interface) by the P25 standards committee, another cost-effective measure might include the upgrade of the existing EDACS system in Richmond to operate as a P25 network – essentially becoming the West County simulcast cell envisioned in the EBRCS design. In this way, the infrastructure that those cities have built and paid for

will not be lost. Total savings on the EBRCS design may make this alternative worth investigating.

Conclusion

Finally, we would again like to commend the EBRCS team in both Alameda County and Contra Costa County for making substantial progress in developing a concept for a regional, interoperable radio system. CTA concurs with their findings and with the direction the project is taking. The success of this project will benefit the first responders and ultimately the citizens in the community for many years to come. We recommend that Contra Costa County provide its approval of the plans and move forward with the Joint Powers Agreement (JPA) to keep the implementation of the EBRCS on track. We also hope that our critical comments, alternatives and suggested modifications of the plan offered here be given consideration. They have been suggested in order to improve the chances of success for the project, and to assist the governments in realizing potential economic benefits through cost efficiencies.

1.0 INTRODUCTION

This report provides Contra Costa County with an independent review of the Motorola Design Document for the East Bay Radio Communications System (EBRCS). The EBRCS document, dated May 12, 2006, describes a two-county design developed as a paid task under Alameda County contract. In this design concept, both Contra Costa County and Alameda County will share an open, standards-based P25 network operating in the 800 MHz band. This design will move all public safety and local government users into the same frequency band and onto a common architecture, which will in turn provide superior interoperability throughout the region. This architecture will also satisfy the criteria for the Homeland Security grant funding that is being sought by both counties. This is a significant step forward for public safety in the East Bay community, and we commend the team responsible for moving this long-needed communications system from paper studies to action.

2.0 PROJECT BACKGROUND

Contra Costa County conducted a needs assessment of their communications systems in 2002. Over the past four years the County has meticulously followed the Master Plan developed in that study, especially as it applied to short- and medium-term strategies.

In 2005, Alameda County released a Request for Proposal (RFP) for a P25 trunked system as a replacement for their aging Motorola SmartNet system. In addition to some P25 equipment, including a network manager and audio switch, the RFP included a task for the contractor to develop a design that would provide coverage to encompass both Alameda and Contra Costa Counties. Motorola was the only responding vendor to this RFP, and subsequently was awarded the contract with the approval of the Alameda County Board of Supervisors. It is our understanding that Contra Costa County has also used this contract vehicle to purchase certain P25 equipment with federal funds obtained through a grant from the U. S. Department of Homeland Security.

In May 2006 Motorola submitted to Alameda County its report entitled "East Bay Regional Communications System – Two County Design Document" in compliance with its scope of work. This document, which has been commonly referred to as a "proposal", contains a description of a preliminary design concept for a multi-zone, trunked radio system operating in the 700/800 MHz frequency band. The document contains an Executive Summary, a fairly detailed System Description, including drawings, tables, and maps showing predicted radio coverage, and then some materials customarily found in proposals. This proposal material included a Statement of Work (to implement the system), which was used as the basis for the Pricing Summary, as well as a project schedule, warranty and post-warranty service plans, product literature, Motorola standard contract terms & conditions, etc.

Contra Costa County was not a party to the original 2005 contract with Motorola, and did not participate in the procurement process through which Motorola was selected. Nevertheless, inasmuch as the County has been included in the East Bay Regional Communications System (EBRCS) design, the Board of Supervisors have requested an independent review of the EBRCS design document, with an emphasis on the technical design – its strengths and flaws, and appropriateness for Contra Costa County; and an analysis of the proposed system cost. The Board also asked for recommendations concerning the proposed upgrade or replacement of the communications systems in Contra Costa County.

Alameda County upgraded their communications from a system using conventional architecture to a trunked, simulcast network operating in the 800 MHz band in the early 1990s. The equipment in Alameda County uses Motorola's proprietary SmartNet technology. Although this system has served Alameda well over the last 15 years, the equipment and technology is being phased out by Motorola. It is natural, therefore, for Alameda County to be planning for an upgrade or replacement for their SmartNet system.

Contra Costa County, meanwhile, still uses conventional systems in the VHF high band (151-162 MHz) for public safety communications. The consortium of cities led by Richmond have purchased an EDACS (Enhanced Digitally Accessed Communications System), which is proprietary technology belonging to M/A-Com (a division of Tyco Electronics). Even though the EDACS system operated by the Richmond consortium is in the same 800 MHz band with the SmartNet system operated by Alameda County, radios from the two systems have mutually incompatible protocols (they cannot communicate directly on one another's infrastructure). (It is interesting to note that the City of Oakland and the Bay Area Rapid Transit [BART] have likewise installed 800 MHz, trunked networks employing EDACS technology.)

The inability to communicate between dissimilar trunking protocols has been a problem within the public safety community for much of the past 20 years. The break-down of communications in New York City on September 11, 2001, while not a result of incompatible trunking protocols, nevertheless was to a great extent the result of incompatible radio systems. The recent emphasis within the public safety community on interoperability has focused much of its attention on these proprietary algorithms. Beginning in the mid-1990s, the Association of Public Safety Communications Officials (APCO) appointed a committee to explore the possibility of establishing an open, standards-based protocol for advanced communications systems. This was the genesis of Project 25, commonly referred to now as P25. The technical details of the standard were delegated from APCO to the Telecommunications Industry Association (TIA) / Electronic Industries Alliance (EIA) Committee 102, usually abbreviated as TIA/EIA-102. The committee is composed of representatives from a wide variety of land mobile radio manufacturers, as well as public safety users and experts that do not work for equipment manufacturers.

TIA/EIA-102 has developed an open, standards-based architecture for both conventional and trunked radio systems. The technology is designed entirely around digital modulation schemes that emphasize spectral efficiency. Phase 1 P25 standards call for

channels with 12.5 kHz bandwidth (vs. 25 kHz channels currently in use both in Alameda and Contra Costa Counties).

Phase 2 of the standards, now in active development by TIA/EIA-102, calls for an "effective" channel bandwidth of 6.25 kHz, which will likely be achieved through the use of two-slot TDMA (time division multiple access) where two simultaneous calls can be carried on a single 12.5 kHz channel.

The evolutionary concept in P25 technology is that with a standards-based protocol, equipment from any manufacturer that complies with the standard will be compatible with P25 infrastructure. Proprietary protocols will be eliminated. This revolution in the industry will foster competition, and should ultimately benefit the public safety / first responder community with better products priced via market conditions. Conventional P25 products were being marketed in the late 1990s, and first production units were being shipped by about 2000. Trunked equipment, which is more advanced and complex, was a few years later. To the best of our knowledge, Motorola produced the first P25 trunked system, installing it in Mesa, Arizona in 2000-01. That system became fully operational by 2002. Since that time, M/A-Com has completed its development cycle and has installed P25 trunked networks – the first becoming operational in 2003 or 2004. E. F. Johnson has also produced P25 infrastructure – primarily conventional, though they do have a P25 repeater for trunked applications. Tait Electronics has recently entered the market of P25 conventional systems.

Unlike the existing equipment used in Alameda County, Richmond, Oakland and BART, the P25 systems fielded by Motorola will host M/A-Com subscriber equipment, and M/A-Com infrastructure will host Motorola subscriber equipment. As mentioned above, E. F. Johnson also manufactures trunked P25 subscriber equipment. Other manufacturers of P25 equipment include Thales, Kenwood and Tait Electronics (and possibly others). EADS, a major manufacturer of telecommunications equipment in Europe, is a member of the TIA/EIA-102 standards committee, and has indicated that it too is interested in entering the U.S. market with a P25 product line. Any of the above P25 subscriber equipment will work on any P25 land mobile radio infrastructure in the same frequency band and operating mode that is produced by E. F. Johnson, Motorola, M/A-Com, Tait Electronics, or any other P25 infrastructure vendor.

Current activity in the TIA/EIA-102 standards committee focuses on not only the TDMA modulation scheme for Phase 2, but also the standard for the inter-subsystem interface (ISSI), which will be used to interconnect networks. In fact, the TIA/EIA-102 committee

issued the initial document on ISSI in mid-2006, and there is hope that this standard will be completed by the end of this year (2007).

Having this interface defined in the industry will allow networks manufactured by various vendors to be connected and to pass communications between network managers. Thus, a Motorola system could communicate directly with a M/A-Com system. We note, however, that components of one system will not directly operate within the other – a Motorola system requires Motorola base stations, for example. Today we have direct over-the-air compatibility between radios and infrastructure manufactured by a variety of vendors. When the ISSI is completed (later this year), there is the potential of linking networks of various manufacturers into regional, statewide or even national scope.

No longer are agencies or jurisdictions forced to decide which manufacturer to choose in the procurement of a public safety radio system based on interoperability needs. The P25 technology already in place and available from several manufacturers allows an informed buyer to choose equipment on a function, quality and cost basis.

It is against this background of not only the local community but also the recent significant advancements in the land mobile radio industry that we have evaluated the "proposal" from Motorola. We acknowledge and value the considerable efforts expended on the development of an EBRCS design for the counties of Alameda and Contra Costa.

We agree with the current efforts to develop and procure a system, or perhaps a combination of interconnected systems based on the P25 standard architecture. Such a system (or network of systems) would, by its very nature, address your growing needs for effective radio communications and for interoperability between County agencies, city agencies and neighboring jurisdictions in the East Bay area.

3.0 EVALUATION PROCESS

In order to gain a clear picture of the current project status, we began by reviewing Contra Costa County historical documentation, including the 2002 Needs Assessment and Master Plan (developed with the assistance of Federal Engineering). APPENDIX A has a complete list of the documentation provided by Contra Costa County and reviewed by CTA Communications during this evaluation. Next, we reviewed the historical documentation regarding the Alameda County purchasing process. Most of our effort in the review focused on the EBRCS Design Document, submitted to Alameda County on May 12, 2006.

We have examined the technical details of the EBRCS design proposed by Motorola and compared them to CTA standards, to practices generally accepted within the industry, and to regulatory standards. We have also looked at the technical content of the report with an eye towards possible alternatives to be considered, and to gaps in the design. The EBRCS design document contains material beyond the design concept that will impact its viability as the basis of a contract – the Statement of Work (where responsibilities are assigned) and Acceptance Test Procedures are two such areas that will be discussed here. To a large extent, we will confine our comments to those aspects of the technical design that affect Contra Costa County.

The cost of the system is considered as a separate topic in this report. Our analysis will focus on two primary aspects of the cost proposal contained in the EBRCS document. As in the technical review, we will look for gaps in the cost – areas that are either incomplete, or areas that haven't been considered at all. We will also look at the prices quoted and render our opinion on whether these prices are in line with pricing that CTA has observed for similar technology on projects with similar scope.

4.0 TECHNICAL REVIEW & COMMENTS

4.1 System Overview

The preliminary design described in Motorola's document dated May 12, 2006 was developed in response to a task requiring "a two-county design option" in their contract with Alameda County, which was executed in October 2005. The request for proposal (RFP) that Alameda County issued prior to awarding the contract to Motorola lacked specific guidelines or requirements for the design, and there did not appear to be a formal needs assessment made prior to issuing the RFP. We are thus unable to evaluate the two-county design in the context of its adequacy in meeting user-developed requirements or attributes.

In the design document, Motorola has recommended a SmartZone 800 MHz P25 architecture to provide radio coverage to both Contra Costa County and Alameda County. This is a fully digital, P25 compliant trunked two-way radio system that would serve most (if not all) public safety agencies in both counties and in all the incorporated cities. The design concept for the EBRCS (East Bay Regional Communications System) is comprised of the following major system elements:

- Five (5) Simulcast Cells
- One (1) Stand-alone Trunked Repeater Site
- Thirty-one (31) Dispatch Locations (centers)
- Twenty-nine (29) Fixed RF sites

Three of the simulcast cells are to be within Contra Costa County (abbreviated CCC) – CCC West, CCC Central and CCC East. The other two simulcast cells and the stand-alone trunked repeater site are in Alameda County. The three cells in Contra Costa County have the following characteristics:

- CCC West simulcast cell consists of 4 radio sites (with transmitters & receivers) located at Nichol Knob (the "prime" site), 10900 San Pablo, Pearl Reservoir and Turquoise. Ten (10) channels, or frequency pairs, in the 800 MHz band will be located at each site. The set of frequencies at each site is identical – hence the term "simulcast". The "prime" site (Motorola terminology) is the location where simulcast timing (for extremely precise control of the transmit signals) is performed. The "prime" site also houses the comparators, Motorola term for the

equipment used to select the optimum received signal from the sites in a simulcast cell.

- CCC Central simulcast cell contains five (5) radio sites located at 40 Glacier Drive (the "prime" site), Bald Peak, Rocky Ridge, Sidney Drive and Cummings Peak. Ten (10) channels will be located at each site. This set of frequencies is identical at all 5 sites in the CCC Central cell. The CCC Central set of frequencies are different from the CCC West cell and from the CCC East cell.

- CCC East simulcast cell is also comprised of five (5) radio sites located at Kregor (the "prime" site), Highland Peak, Shadybrook, Marsh Creek Detention Facility and Old Fire Station 53. Seven (7) channels will be used at each of these sites. These 7 channels are unique frequencies, used only in this simulcast cell.

In this design concept, there are a total of 14 radio sites to be located in Contra Costa County. These sites will utilize a total of 27 unique channels (frequency pairs) in the 800 MHz band. Additional tower sites, simulcast cells and channels are required for Alameda County.

4.2 Technology Base

We fully endorse the selection of P25 as the basis of the design. Progress in the development of this standards-based, open architecture by TIA/EIA-102 has been substantial in the past five years. Furthermore, the entire land mobile radio industry in North America has apparently embraced P25, with nearly all manufacturers now shipping products that are compliant with the standard. There is no other standard for digital or trunked two-way radio in North America. Motorola has announced that it is discontinuing its proprietary line of products (like the SmartNet equipment owned by Alameda County), and will only be manufacturing P25 products for future digital and trunked applications. M/A-Com, the other major manufacturer of trunked systems in North America, is also shifting its emphasis from proprietary systems to P25 compliant products.

The federal government has decided to likewise embrace P25 – this is now the standard for all U.S. government agencies that use land mobile radio. The Integrated Wireless Network (IWN), currently in the procure & implement phase, will be a nationwide network integrating all federal law enforcement agencies on a common P25 infrastructure, although in a different frequency band from the EBRCS. Many states

across the country are also constructing P25 networks to integrate all agencies in a common architecture.

The U.S. Department of Homeland Security and the U.S. Department of Justice have strongly encouraged the use of P25 in grant applications involving radio communications funding at the state and local level.

Thus, the choice of P25 as the base technology is correct. In the following sections we will examine some of the finer details in the EBRCS design.

4.3 Proposed Topology

The three-cell approach in Contra Costa County appears to be based on the County Sheriff's current geographical operations, with patrol-related dispatching in their designated west, central, and east zones. These existing operational zones were likely based on the radio coverage provided by single-site conventional repeaters in the VHF frequency band. However, the Sheriff's Department will not be the only agency in Contra Costa County to use the EBRCS, and it's not clear that dividing the County into three segments will present the optimum operating scenario for all of these other agencies.

In our experience, we have found that a single simulcast cell covering the entire geographical area of a county is preferable to a segmented approach. A single simulcast cell for Contra Costa County would simplify operations for most County agencies, and would be far more efficient in the use of channels. Using the standard CTA traffic model with Contra Costa figures, we estimate that instead of 27 channels, a single simulcast cell covering the County could achieve the same grade of service (GOS) with only 17 channels. More importantly, the single cell approach would be much easier for all of the participating agencies to create efficient operating procedures. (There are some negatives to this approach – a single point where simulcast control is made could make this design more vulnerable to failure or attack. There will also be more repeaters installed at each site. We also understand that until 700 MHz frequencies are released in northern California, it would be very difficult to employ a single simulcast cell design for EBRCS in Contra Costa County with only the currently available 800 MHz channels.)

The following is a list of potential problems or issues that the proposed EBRCS configuration will present to the participating user agencies:

- County agencies have different operational boundaries, and a system designed around any one agency will create inefficiencies for the other agencies.

- Calls straddling two or more simulcast cells will be the norm for all agencies with operational boundaries that differ from the simulcast cell boundaries.

- The segmented configuration in the EBRCS design will demand that the talk-group structure and operational procedures implemented by each agency be strictly controlled and tailored to restrict calls between cells. Countywide communications will have to be discouraged because such calls will consume 3 of the 27 channels (vs. 1 channel in a single cell design).

- Risk of dropping calls, delays in placing calls, or not being joined in a call when a user is roaming from one area to an adjacent cell.

An example of this last point would be when a call is placed in the West cell to a user in the East (or a talk-group with users in both cells). If all of the channels in the East cell are busy, you will have to decide whether to a) wait for a free channel in the East before initiating the call, or b) proceed with the call even though the users operating in the East will either miss the call or enter the call late. Neither option is desirable.

The single cell approach would avoid these problems. The number of sites proposed for Contra Costa County (14) is not outside the bounds of a reasonable configuration for a single simulcast cell. This design approach would also afford a greater degree of coverage overlap between sites – improving the overall reliability of the network. It should be noted that we do not consider a single cell for the two-county design, i.e. one cell covering both Alameda County and Contra Costa County, to be feasible. However, in our experience, the inter-county radio traffic will be much lighter than intra-county traffic. In the documentation we reviewed, it was noted that the County's workload was not evenly balanced as currently configured, suggesting the traffic study and coverage analysis needs to address this imbalance as part of the final design configuration.

4.4 System Capacity

The capacity of a radio system to handle the volume of traffic is determined by the number of talk-paths, the number of talk-groups, the number of active users, the characteristics of the calls (how frequently are calls made, what is the average length of the call, etc.).
Also affecting the traffic are the nature of special calls made on the system – individual-to-individual (private) calls, status updates, data calls, telephone calls, etc. In a multi-zone system, such as the one described by the EBRCS design document, the amount of roaming between zones and the percentage of calls that involve more than one zone will also impact the capacity of the network. The relevant discussion in the design document is section 2.8.

When we first reviewed this section, our instinct was that the projected system usage statistics were too low, resulting in a design that would be inadequate to handle the expected traffic load. Then we read that Motorola used actual traffic statistics from the Alameda County system manager in their analysis. The CTA traffic model is different from the Motorola model (we use Erlang C, whereas we believe that Motorola uses a Monte Carlo model), and we admittedly use some conservative parameters (with justification for public safety clients). However, to provide some perspective, we contacted a long-standing client of ours who has been using a similar Motorola SmartZone system with approximately 7,000 subscriber units in the inventory. The vast majority of the calls on this system are in the analog mode, much like the traffic on the Alameda County SmartNet system. When we examined the traffic data recorded in the period June 2006 through January 2007, it was surprising to find that the average length of a call during the "busy" hour was 5.3 seconds, and that the frequency of calls was 0.7 calls per hour per unit. These statistics are very close to the statistics Motorola used of 5 seconds and 0.8 calls/hour per unit.

In the CTA model, we recommend that the capacity of a public safety system be governed by a maximum acceptable delay of 1 second with a Grade of Service (GOS) for delayed calls of 1% or less during the "busy" hour. (The busy hour is the single hour during a month that experiences the maximum radio traffic. Crises or emergencies, like 9/11 or Hurricane Katrina, are excluded. Thus the busy hour is the normally expected peak traffic. Emergencies are handled by adjusting priority, limiting or eliminating certain categories of calls, etc.) Assuming the Motorola statistics for roaming and inter-system calls (shown in Figure 18, EBRCS User Load Distribution), and a 20% growth factor (per the design document), we calculated the number of channels required for each

of the three simulcast cells in Contra Costa County using the CTA traffic model. Our results matched those given in the EBRCS document for the West and Central zones in Contra Costa County (10 channels each), but we estimated 8 channels for the East zone (vs. 7 per the design document).

Despite this close agreement, we do have a critique of some assumptions used in the EBRCS design document:

- 2.5 seconds was used as a figure of merit for the time a call would spend in the busy queue. In our experience, the maximum acceptable delay from push-to-talk (PTT) to system access for public safety use is usually set to 1 second.

- In applying the statistics for call characteristics observed in the Alameda County SmartNet system to the EBRCS design, we need to recall the fact that we are moving from an analog message to digital operation. In our experience, we have seen that the analog-to-digital conversion (at the originating radio) to the digital-to-analog inversion (at the listening radio) consumes about 0.5 seconds. Unless this additional call latency was included, we believe the average length of a typical call on the EBRCS network will be 5.5 seconds and not 5 seconds. Although this might be viewed as insignificant, it will actually add about 10% to the loading experienced on the network.

- For future growth, 20% was applied to the quantity of radios. CTA generally uses a 15 year lifespan for a new system. Assuming that the number of radios in the County inventory will be proportional to the population, 20% only represents about a 10-year life for a system in a moderately growing community (1.5 to 2% per year). If Contra Costa County is a slow-growth area, then 20% may be appropriate.

- The assumptions for roaming and inter-zone (wide area) calls given in Figure 18 seem off to us. From that figure, CCC West cell will receive a higher quantity of calls from Alameda County than from the other two cells in Contra Costa County (319 Alameda calls/hour vs. 107 Contra Costa calls/hour). No calls from Contra Costa East will be carried in CCC West. We would expect a significantly higher ratio of calls within each county. The number of calls between counties would be comparatively small.

- From this same figure, it appears that the number of calls within a cell was reduced by the percentage of calls that are going outside of the cell. The reality is that calls placed within a cell will be carried by that cell as well as by other cells (zones) that have users logged into the participating sites. Instead of 90% of the traffic on CCC West remaining on CCC West (as shown in the diagram), we believe that the model should consider 100% of the traffic remaining on the home cell.

The net result is that we believe that the EBRCS design is undersized for the intended traffic. This tight environment will force the participating agencies to restrict the use of special features, and maybe even deny use of the system to agencies that would otherwise have been invited to join. This design may also limit the useful life of the system in that you will reach the ceiling for capacity at an early date. The solution at that point will be a significant upgrade or system replacement.

One solution to this issue would be to refine the traffic loading model with better assumptions and target the design to 15 years (or more) in the future. This would probably result in additional channels in one or more of the simulcast cells. Another solution would be to change the configuration from 3 simulcast cells to 2 cells or even one cell, as discussed above. Because a single cell approach is more efficient in its traffic handling capability, we estimate that the total number of licensed channels would actually be reduced significantly over the quantity required in the current EBRCS design. Even using more conservative estimates for 15 years growth (33% increase in inventory) and including a 5% inter-system traffic requirement with Alameda County, our model shows that capacity can be met with only 19 channels (vs. the 27 in the EBRCS design) in a single simulcast cell architecture for Contra Costa County.

4.5 Frequency Plan

The traffic loading analysis yields the number of voice talk-paths required to meet the system goals (e.g., 1% Delayed Call GOS with a maximum acceptable call delay of 1 second during the “busy” hour). For a radio system designed on the basis of P25 Phase 1, which uses frequency division multiple access (FDMA) with 12.5 kHz channel bandwidth, the number of talk-paths equals the number of channels required (plus one control channel).

We have examined the channel plan shown in section 2.8, and have the following comments:

- Seven of the 27 channels required by the EBRCS design for Contra Costa County are currently licensed to the City of Richmond. Obviously, the plan assumes that Richmond will switch all operations from their current system to the EBRCS. (Their existing equipment will be scrapped under this plan.)

- The cutover from the existing Richmond system to the new EBRCS will be a delicate operation – turning the existing system "off" while the new system is installed is certainly not feasible. The design document does address any of these issues, and a cutover or transition plan was not included in the materials we have seen.

- We have also examined the Repacking Information contained in Appendix D of the Design Document. This information basically reflects the data contained in the National Plan Region 6 (Northern California) frequency allocation. In the current plan, Contra Costa County is allocated 24 channels in the public safety band (NPSPAC – National Public Safety Planning & Advisory Committee), which currently spans the 821-824 / 866-869 MHz range. Four (4) of these channels are reserved for special functions – prison (3) and data (1), leaving 20 channels for use in a trunked radio system. The information in the Appendix D of the design document matches the data shown in Attachment G (Table of Channels) of the Region 6 Plan, as revised November 2005. The City of Richmond is also listed with 8 channels. In the previous Region 6 Plan, dated April 2001, we note that Contra Costa County was allotted 32 channels, 8 more than in the latest "repacked" plan. (Richmond was shown in the 2001 plan with its 8 licensed channels.)

- Nowhere in the EBRCS Design Document did we find discussion concerning the licensing and use of the International mutual aid channels (one I-Call + 4 I-Tac channels), CLEMARS (California Law Enforcement Mutual Aid Radio System) or FIREMARS (California Fire-EMS Mutual Aid). Unless another agency (State of California) owns infrastructure that provides radio coverage to all of Contra Costa County, we feel that this is an oversight that should be corrected in the implementation of the EBRCS. Having these channels available for mutual aid situations will be beneficial to the County, and well worth the incremental investment.

4.6 Radio Coverage

The coverage maps for the EBRCS are shown in section 4 of the Design Document. Unfortunately, these maps are not particularly useful in determining the predicted performance of the system design. This is partly due to the configuration of the proposed network in Alameda and Contra Costa counties. Remember that the EBRCS consists of 5 simulcast cells and one trunked site (Crane Ridge in Alameda County).

These cells and the single, isolated site will operate as independent zones. We presume that many talk-groups, and perhaps some users, will be restricted in their operation to their "home" site. For example, Richmond Police "Main Dispatch" (a fictional talk-group used here to illustrate the issue) may be restricted to CCC West. So if a RPD officer is monitoring this talk-group, he/she will have to remain within the coverage area provided by the sites in CCC West simulcast cell. The maps in Section 4 do not show the coverage provided by CCC West. To be more correct, the maps in Section 4 do not show the *limits* of coverage for the CCC West cell. Instead, the maps show a *composite* coverage, which is not what most users will experience – especially as they reach the fringe of their coverage area.

If Contra Costa County had a single simulcast cell overlaying the entire County, instead of three separate cells, the composite map would be appropriate and representative of the coverage that users should expect. With a three-cell approach, a user can be in area where he might expect coverage by looking at the map, but the stronger signal is actually from Alameda County or a different simulcast cell in Contra Costa County. In this case, since the user is logged onto the cell with weaker signal, he may in fact not receive calls.

We note that the mobile coverage maps are displayed with separate talk-out and talk-back predictions. This is appropriate since there is likely to be a difference due to the higher system gain in the mobile-to-base direction. We assume that the system will be balanced for portable use. This is achieved through the use of tower-top pre-amplifiers on all receive antennas at the radio sites. By properly adjusting the pre-amplifiers and the gain on the multi-coupler, the system gain on both the talk-in (mobile-to-base) and the talk-out (base-to-mobile) paths should be approximately equal. This would mean there would be no difference between talk-out and talk-in. Showing both maps for portable-on-the-street and portable in-building in section 4 of the EBRCS design document is redundant. Instead, we would have preferred to see separate maps for each simulcast cell, and separate maps for portable usage in light, medium and heavy buildings.

While the system was designed for in-building coverage, the maps provided do not show sufficient detail to establish whether building construction types were taken into consideration for the various levels of construction in the County. What was the building loss factor (i.e., signal attenuation) used in each situation? The maps appear to show a composite (i.e., best server) prediction for light buildings.

Some geometrical polygons are shown on those maps where presumably medium and heavy building coverage is needed. How were these polygons developed? Was this derived from Contra Costa County user input; if so, from which agencies? We note that only 10 agencies in Contra Costa County were contacted in the needs assessment. In any case, we would normally expect to see predictions of the coverage within each of these building categories as a separate map (for each simulcast cell). Thus, there would be a minimum of 18 coverage maps needed to characterize the coverage of EBRCS inside Contra Costa County – 6 for mobile coverage and 3 each for portable-on-the-street, light building, medium building and heavy building.

In our opinion, the coverage acceptance test plan contained in the EBRCS document is designed to be easily passed, but will not provide a comprehensive analysis of the installed system performance. We note that coverage testing will be performed *only* within the colored areas shown on the maps. See page 11 of Appendix B, "Acceptance Test Procedures", where the first sentence in the third paragraph states: ***"No acceptance testing will be performed in locations on Motorola's coverage map(s) predicted to be below the required reliability."*** What this means is that acceptance testing will *only* be performed in areas where the contractor has determined that there is at least a 95% probability of passing the test. The fact that there are white areas on the coverage maps does not remove them from the County's jurisdiction. We recommend that coverage acceptance testing be performed throughout the County's "service area", where the service area is defined by the jurisdictional boundaries of the County and not some arbitrary polygon from a vendor. No tiles within the County should be excluded from acceptance testing, as is the intention of the proposed EBRCS test plan.

Secondly, the test plan described in Appendix B of the EBRCS design document states that the testing will be performed on the composite signal for a portable-on-the-street (see page 8, second sentence under the heading "Equipment Configurations"). As was noted earlier, by allowing the test equipment to pick the strongest signal from any of the surrounding cells, the results of the test will not necessarily reflect a user's experience when operating with a simulcast cell. Instead of this procedure, we recommend that an independent test be performed on each simulcast cell within Contra Costa County.

By restricting the test to the simulcast cell, the results will give a better indication of expected performance.

As noted in the preceding paragraph, the proposed test will only test performance for a portable on the street. This test will not provide needed information on other configurations, particularly inside buildings. We recommend that independent tests also be performed in areas requiring in-building coverage: separate tests in light building, medium building and heavy building areas. If there are portions of the County that only require mobile coverage, a test configured to test that area should also be conducted. We typically find that a single coordinated test throughout the area can accommodate all design configurations. We are therefore *not* suggesting that tiles be tested multiple times for the various configurations. For example, if a particular tile is in a medium building area, it only needs to be tested for operation in a medium building. Testing for light building or portable-on-the-street configurations is not necessary. In-building tests are conducted in a moving vehicle (as described in the test plan) with appropriate attenuation added to the test receiver antenna line to simulate the loss factor for the various building categories. We recommend 8 dB attenuation for light buildings, 12 dB for medium buildings and 20 dB for heavy buildings. We do *not* recommend testing in actual buildings as part of the vendor's guarantee, since the vendor cannot control the actual loss of a specific building and the predictive capabilities of propagation models are targeted at statistical results. Such a test will unnecessarily add risk to the vendor's guarantee, which in turn will add cost to the County. This is an area where it makes financial sense for the County to assume some risk.

Returning to the coverage test plan contained in Appendix B of the design document, the eighth bullet on page 12 states ***"Any tile that fails the objective Voyager℠ BER test described above will be re-tested using a subjective Delivered Audio Quality (DAQ) test. Any tile that fails the objective test, but passes the subjective re-test will be declared passed."*** The next bullet goes on to state ***"Motorola reserves the right to review any test tiles that fail both the objective BER and subjective DAQ tests, versus the signal strength samples taken for the same test tiles."*** In our opinion, there are several problems with this approach: (1) The subjective DAQ test referenced is sometimes termed the "shout and holler" test, which typically involves the vendor's personnel as the test team. The test plan included in the EBRCS is mute on whether representatives from the County would be invited to participate. (2) Re-testing failed tiles provides a much better chance of passing the test, although it does not provide a commensurately better indication of whether the system will provide appropriate

operation. Even if the test fails the BER and DAQ test, Motorola stills holds out the possibility that the tile could pass if the signal strength is sufficient.

Note that these tests are only checking the "talk-out" path, and there are no tests conducted on the "talk-in" capability. (3) Testing only in the "shaded area" on the map does not provide proof that the system will provide coverage in 95% of the County's operational area, only that it will provide coverage in 95% of the places that the vendor already is confident that it will cover. Keeping in mind the fact that *only* those tiles that the vendor has predicted will have a *minimum* probability of 95% will be tested as part of the System Acceptance process, that each tile has at least two kinds of tests that can produce a "passing" score, and that the vendor will be administering the test with its own personnel, it is likely that the test will be passed even if there are coverage problems within the service area.

Ideally, the County should have an independent coverage test conducted. In addition to measuring BER as a test criteria, we have used on various occasions received signal strength and recorded voice calls. In the latter example, one can measure DAQ by comparing the recorded message to the original message using an objective mathematical algorithm. The recommended test (by whatever method or methods) should include data collected for both the talk-out and talk-in directions.

At the least, the County should have its own personnel or representative to participate and oversee the coverage test conducted by the vendor. The vendor should guarantee coverage in both the talk-out and talk-in directions, and the test plan should be designed to verify the two-way operation of the radio system. An analysis of the system gain in both talk-in and talk-out directions for both mobiles and portables will aid in determining the reciprocity of the measurements.

Another routine that we often use is an "access" test, where the PTT is pressed once and only once in each tile visited during the coverage test. If the radio gains access with a single PTT (including automatic retries), then the grid passes the test in that tile. The vendor is required to supply a guarantee for this access test over the owner's service area with their proposal. This test requires two-way communications because the control channel executes a hand-shake with the individual radio initiating a call.

We also recommend that the County conduct tests and obtain data that can confirm the proper performance of the simulcast function. The timing of signals arriving in "overlap" areas (where the signal strength from two or more towers in the same simulcast

cell) must be carefully managed, else an effect called "time delay interference" will result.

Even though there is a strong signal in these overlap areas, if the simulcast controller is not properly adjusted calls will not be completed. Nowhere in the Acceptance Test Procedures did we find any test designed to check for this important factor. It is an area that the vendor should demonstrate proper operation before the County approves final system acceptance.

4.7 Reliability And Failure Modes

The balance of the material in Appendix B (Acceptance Test Procedures) is an outline of the tests that would be included in the factory staging and in the field tests at acceptance time. This list of tests is typical of our experience with Motorola. Note that this is simply a list of test scripts that would be used. The details of the test procedures are usually developed after the detailed design review (well after contract signing). Additional tests might be indicated following a review by County technical staff.

One area that should draw attention is the group of tests shown on pages 5 and 6 that deal with reliability, redundancy, alarms, system monitoring and diagnostics. In our professional opinion, any radio system of the size and scope of EBRCS can be, and should be designed such that there are no single points of failure. The design of the system should make this a central theme. We would expect that it will be reviewed during and following the detailed design review by competent technical personnel. Testing of the system should fully exercise all of the failure modes included in the vendor's design to assure proper function. There are options in any vendor's design that can improve the overall reliability of the system.

We recommend that a thorough vulnerability analysis be performed on the design prior to granting approval for construction. This would include normally occurring factors like climate and expected extremes in weather, as well as natural disasters (earthquakes), man-made disasters, and intentional attacks or incursions by criminals or terrorists. It is not clear from the EBRCS design document that such a review has yet been performed.

The reader should understand that there is a difference between a design that is "fault tolerant" and a design that is "redundant". Different vendors have different approaches in their design, and this is an important factor in evaluating alternatives.

Even after making a choice on the vendor and their technology, there are choices to be made in the details of the design.

This topic is closely related to the vulnerability analysis mentioned in the previous paragraph, and in fact fault tolerance and redundancy are two methods of mitigating the identified risks. We recommend that the project team carefully consider these choices in making decisions on the ultimate design.

5.0 COST ANALYSIS

5.1 Opinion Of Pricing Summary

In section 9 of the EBRCS Design Document, Motorola presented a "Pricing Summary" for the voice infrastructure and microwave subsystem. The total price shown for the "system" on page 3 (before sales tax was added and work already contracted to Alameda County subtracted) was $60,151,063. Also included in section 9 was a "Radio Equipment Price Book" listing details on a wide variety of Motorola radio products, optional features and accessories. Some "standard" package prices were given, as well as the individual prices a la carte style.

CTA Communications has worked with clients on land mobile radio system projects similar to the EBRCS all over the United States over the past 22 years. We have accumulated a substantial database of prices for systems, equipment and services procured and contracted in a variety of situations – from highly competitive to sole source selection, and from "turn key" to individual modules. This database includes prices from most of the vendors who manufacture communications related equipment in North America. We use this database to assist our clients in developing budgets for projects similar to EBRCS, and in anticipating the probable cost of the system prior to embarking on the development of a Request for Proposal (RFP). We have used our model to independently develop our opinion of probable cost for the EBRCS as described in the design document, using P25 technology and recent data (in the past 1-2 years).

In order to make the prices from the EBRCS document comparable to the costs developed with the CTA cost model, we have made the following adjustments to the pricing material from Motorola. Since sales tax, and the items subject to that tax, varies from state to state, we have not included the sales tax shown in the EBRCS document, nor is sales tax part of the cost estimated by the CTA model. It is our understanding that the microwave equipment listed on page 1 of section 9 has been (or will be) the subject of a separate procurement. Therefore, we have subtracted $5,352,833 for the three lines titled "ICTAP Microwave System", "Alameda County Microwave Spurs" and "Contra Costa County Microwave Spurs" from the system price. It could be argued that some of the cost for Program Management, Field Engineering and System Installation should be reduced, but we do not have sufficient information to base any deductions in those areas. Likewise, we have not attempted to estimate the cost for Contra Costa County's equipment since there are many areas of this design that are integrated – e.g., the P25 Master Site, Fault Management System, Spare & Test Equipment and all of the services.

In Table 5-1 below, we show at the summary level a comparison of the CTA cost model estimate and the pricing given in section 9.1 in the EBRCS document. The totals shown for the EBRCS System are the "sub-total" shown on page 3 less $5,352,833 for the microwave equipment (as described above). In our opinion, these figures are now directly comparable to those produced by the CTA model.

TABLE 5-1 COST COMPARISON

	CTA COST BUDGETING ANALYST℠			EBRCS System Price
	List Cost	Negotiated Estimate	Competitive Estimate	
Radio Infrastructure (Install and Staging)	$48,446,400	$41,381,400	$36,844,700	$40,062,606
Vendor Services	$8,634,000	$7,338,900	$6,475,500	$14,735,624
Total	**$57,080,400**	**$48,720,300**	**$43,320,200**	**$54,798,230**

The CTA model includes the cost of installation and factory staging with the equipment cost, so we have combined those figures from the EBRCS price pages with the equipment price. Vendor Services include all of the items under "Integration Services" in section 9.1 of the EBRCS document, except for installation and staging – i.e., Program Management, Field Engineering, System Integration, Project Administration, Documentation and Training. "List Cost" is the CTA estimate of the vendor's undiscounted catalog price. (Remember that the CTA estimate is based on *industry* prices and not confined to Motorola prices.) The "Negotiated Estimate" is based on our experience with clients who dealt with a single vendor – either via a "sole source" determination prior to issuance of an RFP, or where a competitive RFP was issued but only a single vendor responded with a proposal. The "Competitive Estimate" is based on our experience with clients who conducted a competitive procurement, were proactive in assuring impartiality in the source selection criteria, and received two or more proposals. In our opinion, the EBRCS pricing as it stands is similar to a "negotiated" procurement prior to the start of negotiations.

With respect to the equipment prices shown on page 1 section 9.1 (except for microwave equipment), CTA finds these to be reasonable and within the normal range for the industry.

With respect to the price for Installation Services ($8,237,760), we find these to be high. Normally, installation costs average about 15% of the equipment cost. In this case, the vendor has quoted a price that is 23% of the equipment cost.

With respect to the price of all other Vendor Services ($14,735,624), we find these to be high. Normally, vendor services average about 18% of the infrastructure cost. In this case, the vendor has quoted a total price that is 37% of the equipment cost.

Including the "soft" prices from services, we find the total price of $54,798,230 in the EBRCS document to be high. We note that this price is about 12.5% higher than would be normally expected in a sole source environment, and about 26.5% higher than might be obtained in a truly competitive procurement.

In our experience, we have often seen the vendor offer a "system discount" rather than change individual prices within their system proposal. No such discount was offered in the EBRCS price proposal (section 9).

We recommend that Motorola justify their prices for installation and vendor services, demonstrating that they are consistent with other competitively procured systems. Furthermore, we recommend that a question on system discount be posed.

5.2 Gap Analysis

Before embarking on a program of this magnitude, it would seem prudent to understand the total cost of the project, including all of the likely acquisition costs, as well as the cost of operating and maintaining the system, including periodic upgrades and replacement of equipment as it wears out. To this point, it should be clear that the "total system" cost provided on page 3 of section 9.1 in the EBRCS document does not provide Alameda County and Contra Costa County a complete cost of acquisition.

Returning to the sub-total for the total system cost on page 3, we note that this value ($60,151,063) includes the cost of the microwave connectivity system at $5,352,833.

On the surface, this figure appears reasonable for budget planning purposes. We note, however, that in procurements of this type where we have been involved, total costs usually include the following:

	Included in EBRCS?
Fixed Radio equipment infrastructure	Yes
Subscriber Equipment	No
Installation Services	Yes
Vendor Services	Yes
Maintenance Contract	Yes
Connectivity Network	Yes
Physical Facilities	No
Mobile Data	No
Contingency	No

The EBRCS pricing summary does not include costs for improvements or construction of required physical facilities. These involve the towers, buildings, generators, grounding systems, access roads, parking areas, fencing, and a myriad of other items that will be needed to house and operate the EBRCS fixed equipment. Even if existing sites are used, our experience has shown that facilities are rarely adequate in every way to accommodate the new equipment. Upgrades can sometimes approach the cost of new facilities, depending on the age and condition of the existing facilities. And if building permits are required, the facility automatically becomes subject to the newest code. This could mean that an existing tower may not meet code when new antennas and lines are added to the structure.

A careful read of the Statement of Work (Section 5 of the EBRCS document) will reveal that the vendor has placed responsibility on the owners for nearly everything but the fixed radio equipment, and this includes all of the physical facilities. The cost could be as small as $5 or $6 million, but could easily reach $10, $20 million or more. If either of the counties or any of the cities are planning major renovation of emergency communications centers, where radio dispatch consoles will be installed, the cost could climb dramatically. In any case, physical facilities will be a very significant cost item, and a serious risk item.

The “total system” cost quoted in section 9.1 does not include a single radio for either county. Using the package prices for subscriber equipment (mobiles and portables) and assuming a distribution of 5% high tier, 10% mid tier, 70% basic tier and 15% agency

tier, we have estimated a total cost of $36,443,000 to replace the current (2006) inventory of equipment. This amount does not include encryption for any law enforcement officers. It does not include intrinsically safe options for fire fighters. It does not include spare batteries, spare antennas, spare radios, gang chargers, or other accessories. The inventory number included in the EBRCS document (top of page 64 in section 2) did not identify desktop control (base) stations. This cost figure does not include programming or installation.

Pricing for mobile data equipment for vehicles is included in the price book in section 9. However, the cost of infrastructure is not included with the $60 million for the voice system. We do not recommend the use of integrated voice & data (IV&D) in a public safety radio network. The cost of a private mobile data system would be significantly less than the cost of the voice system, and can be accommodated as an overlay. However, the cost would still likely be several million dollars. Likewise, an automatic vehicle location (AVL) system could be added to the network. There is some discussion of a mesh network at 4.9 GHz in pricing book (section 9), but it should be clear that the mesh network is not included in the cost of the system. Other typical items found in new systems, such as paging and the mutual aid channels (discussed earlier), are not included in the system cost.

Assuming that there was no intention to purchase any of these extras, we believe a more realistic cost for the voice system (including the subscriber equipment) is probably between $100 and $115 million.

CTA recommends that a contingency be included in the budget. Generally, this amount would be 10% of the infrastructure cost (radio fixed equipment, microwave subsystem, physical facilities, etc.). The cost of an independent consulting firm to assist the EBRCS team through system acceptance would also be an appropriate addition to the budget. In-building bi-directional amplifier systems may be needed in some government facilities. However, we recommend that the owners not require these of the radio vendor, and instead plan on using a portion of the contingency fund for these (if needed). Do not procure these items until the project is complete and the specific buildings tested with the new system.

Finally, the ongoing costs of the system must be considered. The post-warranty maintenance costs are cited in section 8 of the EBRCS document. Note that these costs cover the radio equipment – both fixed and non-fixed, and the software services subscription, which will be essential in the new system. However, there will also be

ongoing costs for non-radio equipment, such as generators, air conditioning units, buildings, towers, access roads, microwave equipment, etc. The cost for leasing tower space or building space is not included. The cost of power to the sites needs to be considered, as does the cost of support staff in the various jurisdictions, or in the employ of the JPA.

6.0 CONCLUSIONS AND RECOMMENDATIONS

While we concur with the decision to implement a P25 trunked radio system using the 700/800 MHz band, there are many questions still concerning the details of the design that should be answered. Likewise, while Motorola is a major manufacturer of high quality land mobile radio products, indeed the company with the largest market share in America, there is nothing in the requirements for the EBRCS that would exclude participation by other vendors. Exploration of alternatives to the approach given in the EBRCS design document may yield better solutions with significant savings in project cost.

We have indicated that one alternative that should be considered (whether in a sole source arrangement with Motorola, or in a competitive solicitation) is a configuration with a single simulcast zone covering Contra Costa County. On examination of the proposed sites, their distances one from another, and the potential coverage, it seems that such an approach is technically feasible. In our opinion, it would offer a significant improvement in operational performance.

If the County decides to move forward with the EBRCS design and vendor, we recommend that contract negotiations with Motorola be focused on areas that would benefit the owners. Items to consider include improvements to the technical design, appropriate revisions to test plans, contract terms & conditions, statement of work, and reductions in pricing of installation and other services.

With respect to opportunities for competition, we concur with the decision to separate the microwave elements from the radio infrastructure. Likewise, it will be cost-effective for the owners to perform the upgrades and construction of physical facilities as a separate activity. Mobile data and AVL (when and if they become a requirement) should be purchased through a competitive process. P25 subscriber equipment (portables and mobiles) can be purchased separately by the various participating entities, and multiple vendors do provide compatible equipment. Splitting the system into modules will have an impact on the owners. There will be more responsibility in defining interfaces, in making sure that schedules match, and in looking for gaps in the requirements. It will take additional staff to manage the project. Alternatively, the owners can contract for services to assist in the management and oversight of the project. This is generally a cost-effect investment in that the total project cost should be reduced.

The radio infrastructure can be split between the counties – each with its own competitive procurement. This process can be pushed down to the cities, where each county has multiple systems. With P25 technology, this will not be a barrier to interoperability and wide area calling, but it may become cumbersome, and in the end may not be as cost-effective. We suggest that only major entities be separated – each county, for instance, and perhaps the City of Oakland due to its size and complexity. And if a common platform can be agreed upon by all participating agencies, such as that envisioned for the EBRCS, this would be optimum for future operations.

Recalling our introductory remarks concerning the progress being made with the P25 standards, and the way the radio industry has moved towards fully embracing this new standard, a competitive procurement could be beneficial to the owners. It should be understood that this is not necessarily a "winner take all" contest in the manner we grew used to in the 1980s and 1990s. In fact, Contra Costa County could procure a P25 network from a different vendor than what Alameda County operates with. Interoperability would not be affected. The two networks could, in fact, communicate with each other and exchange data and connect wide area or regional calls. Contra Costa County could have two networks manufactured by different vendors within its own borders and not compromise interoperability, though this would not operate as smoothly as a single simulcast zone, which would have to be manufactured by the same vendor.

It is standard practice for radio vendors to state that they can "upgrade" rather than replace earlier versions of proprietary equipment and achieve the P25 standard. These upgrades would presumably involve software and the replacement of modules in the equipment racks. The cost of this upgrade could be significantly lower than a wholesale replacement and overlay, although care should be taken to understanding exactly what is being provided and what operational guarantees will be included. It is worth considering in the context of a life cycle that will extend for the next 15 years or more.

And certainly the subscriber equipment can be purchased from a wide variety of P25 manufacturers. For example, M/A-Com offers portables and mobiles that will operate on both the Richmond EDACS system and on the EBRCS P25 net. The counties may want to consider having open, "indefinite quantity" contracts with multiple vendors so that each agency can choose the equipment it wants to purchase according to functions, features and price.

We suggest that the County consider using the services of an independent consultant with expertise in land mobile radio. This consultant can provide guidance throughout the project – from determining the County's requirements and assisting in the development of a budget, to oversight of the final system acceptance testing. A good consultant will save the County several times his own fee in project costs.

The steps that need to be undertaken (in this order) are:

1. Determine the system requirements. Much of this can be gleaned from earlier work, and indeed by the EBRCS document. In particular, a definitive list of participating agencies needs to be compiled. Growth rates should be calculated and used to determine the required system capacity, and hence the channel needs. Coverage requirements should likewise be solicited from the user community. Feasibility and affordability should be part of this process.

2. Develop a list of alternatives – one simulcast zone per county, or 3? One vendor or possibly two or more vendors with the ISSI connectivity to link the networks? Competitive bids or sole source procurement. (The justification for sole source on technical grounds will be extremely difficult considering the introduction of the open P25 standards.)

3. Develop a business plan, including a budget for the project (acquisition cost) and life cycle costs. Include all facets of the project plus contingencies.

4. Develop functional specifications for the system. The specifications should be open so that the vendor can respond with creative designs, but have enough teeth so that all of the risk does not end up on the owner's side of the table. If it is to be a competitive procurement, the RFP should be fair and open with objective selection criteria clearly stated from the beginning.

5. Consider the use of a consultant during contract negotiations with the selected vendor. In our experience, when clients have sought CTA's counsel during negotiations, they have been successful in not only tightening the technical requirements but also in avoiding pitfalls in the terms & conditions, as well as saving millions in the contract price.

6. Use technically qualified people to oversee the design details after contract award. There will be ongoing drawings, plans, design revisions, change requests, and a myriad of technical submittals.

7. Use technically qualified people to inspect the work, assist in the development of test plans, participate in and witness the acceptance testing, review final record drawings and documentation.

8. Even if an outside firm is used in the project, the County will also need to assign its own personnel to oversee the project, and later to manage, operate and maintain the new radio system.

9. Oversight committees will need to be formed. We sometimes see an Executive Committee, composed of representatives from the County and the cities, that is primarily responsible for managing the system, setting the budget, allocating costs to the participating agencies, etc. Technical Committees or User Committees, also composed of user representatives from the participating agencies, will often set operating procedures and policies, decide on system parameters, and make recommendations to the Executive Committee on the expenditure of funds.

This is an important project for Contra Costa County, one that will affect most of its agencies and departments, as well as the citizens for many years to come. We cannot over-emphasize the importance of carefully planning the next steps. Only you can determine the best path to take – whether to continue with the EBRCS design as it currently exists, or to explore other alternatives.

APPENDIX A COUNTY PROVIDED HISTORICAL DOCUMENTATION

Binder 1 - Contra Costa County Historical Documents preceding the EBRCS

- CSI, "White Paper" – May 2. 2000
- Alan Burton, "2001 Study of Communications" – June 1, 2001
- Federal Engineering, "Needs Assessment" – March 27, 2002
- Federal Engineering, "Master Plan Presentation" – June 6, 2002 (separate binder)
- Federal Engineering, "Master Plan, Final Report" – June 18, 2002 (separate binder)
- BOS Item D1 Document – July 25, 2006
- BOS Item D1 Transcript Document – July 25, 2006
- Board Order SD.8 – October 3, 2006
- Board Order SD.8 Addendum – October 3, 2006

Binder 2 - Alameda County Historical Documents preceding the EBRCS

- Alameda County, RFI – June 30, 2005
- Alameda County, RFP – July 18, 2005
- Alameda Advertising List – July 20, 2005
- Alameda Lawrence Livermore Lab Sign In – August 1, 2005
- Alameda Bidder List – August 2, 2005
- Alameda County, RFP Addendum 1 – August 17, 2005
- Alameda Motorola Contract 1 of 2 – June 6, 2006
- Alameda Motorola Contract 2 of 2 – June 6, 2006
- Stop Work Order – July 28, 2006
- Alameda Response to Stop Work Order – August 17, 2006
- Doris Bryant e-mail – August 22, 2006

Binder 3 - Motorola East Bay Regional Communications System, Two County Design Document – May 12, 2006

APPENDIX B COMPARISON OF USER SURVEYS

Master Plan, Agency Interviews Final Report dated June 18, 2002	**Motorola Design Document User Surveys (report dated May 12, 2006)**
Contra Costa County	
Contra Costa County Sheriff's Dept	Contra Costa County Sheriff's Dept
Building Inspection Dept	
Animal Services Dept	
General Services Dept	
Public Works Dept	
Pinole, Rodeo, Hercules Fire	
Pinole Police	
Hercules Police	Hercules Police
Richmond Fire	Richmond Fire
El Cerrito Police	
West County School	
El Cerrito Fire	
Moraga/Orinda Fire	Moraga/Orinda Fire
Walnut Creek Police	Walnut Creek Police
Moraga Police	Moraga Police
Danville Police	
Orinda Police	
San Ramon Police	
San Ramon Valley Fire	San Ramon Valley Fire
Lafayette Police	
Health Services County	
Antioch Police	
Tri Delta Transport Transit	
Brentwood School	
Oakley Police	
Oakley Fire	
Brentwood Police	
Oakley School	
Martinez Police	Martinez Police
Concord Police	
Concord Fire	

Clayton Police	
Mt. Diablo School	
Martinez School	
Pleasant Hill Police	Pleasant Hill Police
Pleasant Hill Fire	
Contra Costa County Fire	
Richmond Police	Richmond Police
Bethyl Island Fire	
County District Attorney	
Pittsburg Police	
Alameda County	
	Alameda County Fire
	ALCO Fire
	ALCO Sheriff
	City of Alameda Police
	City of Alameda Public Work
	Alameda County Public Works
	Newark Police, Fire, and Public Works
	Emeryville Police
	Fremont Police, Fire, and Public Works
	Hayward Police, Fire, and Public Works
	City of Newark Police, Fire, and Public Works
	San Leandro
	Berkeley Police
	Dublin Police
	Livermore Police
	Piedmont Police and Fire
	Pleasanton Police
	UC Berkeley Police
	Union City Fire
Alameda & Contra Costa Counties	
BART Transit	
	East Bay Parks Police and Fire

APPENDIX C CTA RESPONSE TO REVIEWER COMMENTS

Following distribution of the draft version of this report, comments and suggested improvements were received from the Contra Costa County Sheriff's Office, Contra Costa County Department of Information Technology, Contra Costa County Fire, and the General Services Agency in Alameda County. We would like to express our thanks and appreciation to those individuals who took the time to carefully read our draft report and make the thoughtful comments and suggestions. CTA has reviewed these comments and incorporated modifications in the original text where we felt that improvements, clarifications or corrections were appropriate.

Other comments made in the reviews did not ask for modifications to our report, but did raise questions that we felt should be addressed and answered. We will do that in the following pages where we will quote the reviewers comment or question, and then append CTA's response in italics. (It should be noted that we have not made an exhaustive response to all questions or comments, confining our attention primarily to technical issues and questions concerning our evaluation of the EBRCS design report.)

1. "While we do not necessarily endorse the validity of the alternative recommended by CTA, we do think that any further investments in the infrastructure should be based on an independent design."

   CTA: *We would like to clarify our discussion concerning the single simulcast cell design for Contra Costa County. CTA's scope of work did not include the development and recommendation of an independent design configuration. We intended to include the discussion on a single simulcast cell as an example of an alternative that could be more desirable than the one proposed in the EBRCS document. Actually, we did include a second alternative when we discussed the P25 Phase 2 TDMA technology, which may or may not include simulcast capabilities. There may be other legitimate alternatives that should also be carefully considered before a final decision is reached. Planning flexibility into the design will likewise be useful so that the County is not locked into a technology that has no way to upgrade or expand the system.*

2. "Page 3 (P25 Standard) – P25 is a standard for digital radio systems regardless of them being conventional or trunked. CTA states "There is no other standard for digital or trunked mobile radio in North America". In fact there are other standards, Frequency Modulation (FM) is a standard used in analog communications systems. APCO Project 16, which pre-dated P25 by about 15 years, set the standard for analog trunked systems. A correct sentence would be "There is no other standard for digital trunked mobile radio systems in North America.""

CTA: *We agree that P25 is a standard for digital radio and that it covers both conventional and trunked protocols. We likewise agree that FM is a de facto "standard" for analog conventional radio in that there are no compatibility issues between manufacturers of this technology. APCO Project 16 did set a standard for trunked systems – but these "standards" only applied to functionality, and not to the details of protocol that would make the systems compatible. Manufacturers were left to their own devices in developing the technology to implement the Project 16 functions. The result was a Motorola SmartNet system and a GE (later Ericsson, ComNet and M/A-Com) EDACS system that both complied with Project 16 functions, but could not interoperate with one another. (E.F. Johnson had its LTR system, which likewise could not communicate with either the Motorola or M/A-Com technology.) These were all proprietary technologies and not standards-based. P25 is the first, and to date the only open-architecture, standards-based technology for trunked radio in North America. There are no standards-based analog trunked systems. P25 trunked systems can host radios manufactured by any P25 vendor. P25 trunked systems will also be able to interconnect subsystems built by different vendors via the ISSI (discussed in the report). (I am ignoring TETRA technology, which is also a standards-based protocol for land mobile radio, but is primarily deployed in Europe and Asia, and has no products for, or market in North America.)*

3. "Although P25 has become the accepted standard for digital systems, it has not been mandated yet by DHS or the FCC (exception in the interoperability channels of the new 700 MHz. Band). In fact, the Santa Clara county consortium is exploring a different technology and it remains to be seen how they intend to make it compatible with P25 with EBRCS or the proposed West Bay Regional Communications System (San Francisco and San Mateo counties)."

CTA: *We agree that P25 is not "mandated" by DHS or the FCC. Accordingly, we softened our statements in the final report. However, one should understand that all departments in the federal government have adopted P25 as the standard for radio communications. Per our response above, P25 is the only open standards-based technology for trunked radio in North America (and digital conventional radio). Given the need for interoperability between public safety agencies, it seems to us that only P25 technology makes sense. Arguing to spend funds on a new system that employs proprietary technology is counterintuitive – the resulting system will be an island, isolated from surrounding systems, or at best with convoluted and compromising interfaces for "patching" calls.*

4. "The latest research information, according to Dr. David Boyd, Director of DHS's SAFECOM Program, shows that P25 is great in a fixed environment (point-to-point) as it shows an overall

increase in coverage above analog FM. However, in a mobile environment, just the opposite occurs as coverage is decreased due to an increase in the bit error rate caused by the signal fluctuation.

I believe that P25 is an acceptable technology for a mobile radio system however; we must take into account the mobile nature of our system. When comparing coverage we are not only expecting a decrease in coverage due to the use of the higher frequency bands, but using P25 may also decrease that coverage even more."

CTA: *The difference in coverage between FM analog signals and digital protocols has been in dispute for some time. While our early experiences seemed to agree with Dr. Boyd's assessment, later results have shown an improvement in digital performance. It is possible that recent improvements in forward-error correcting algorithms employed in P25 have been responsible for the better coverage. CTA now considers P25 coverage to be nearly equivalent to that obtained with FM analog technology. The narrowbanding currently planned for the VHF and UHF bands will have the opposite effect. FM analog coverage with channels confined to 12.5 kHz bandwidth will shrink, whereas P25 coverage will be unaffected (due to the modulation scheme). Thus, P25 will outperform FM analog as we move to a band structure with narrower channels. The issue on high frequency bands vs. lower frequencies is not a simple answer. VHF will generally outperform 800 MHz if you're interested in mobile coverage over hilly or wooded terrain. However, this can be reversed if the VHF sites are in "noisy" areas. 800 MHz systems can employ tower-top pre-amplifiers to fix the noise figure at the antenna port, making them virtually transparent to noise (which isn't much of a factor at high frequencies, anyway). These devices are virtually useless at 150 MHz, where high noise can make a receiver nearly deaf. Furthermore, 800 MHz radio signals are much better at penetrating buildings than 150 MHz. This is due to the relationship between wavelength and the dimensions of windows.*

5. "Page 3 (Design for Transmitter Placement) – CTA states that "the spacing of sites is appropriate, and that reasonable countywide coverage should be obtainable with the selected sites." As I stated above, my issue is that we have a VHF system that is using most of the hilltop sites contained in the Motorola proposal. We have areas in which our coverage has been deemed to be unsatisfactory. We have added additional transmitter sites as well as voting receivers in order to enhance the coverage. We continue to this day to determine additional locations in which we could place transmitters or receivers to increase our coverage, especially in rural valley areas (Alhambra Valley near Martinez, Castle Rock Park area near Walnut Creek to name a few). This is all based on a VHF 150 MHz. system and its lack of optimum coverage. If we go to a 700/800 MHz. System, the number of sites must be increased due to the inherent propagation characteristics of the higher frequencies. My concern is that if we are having these problems at VHF, our coverage fill-in needs will only increase."

CTA: *If the County were reasonably level, the spacing of 8 miles between sites would be optimum for simulcast coverage at 800 MHz. The hilltop sites could be a problem for Motorola if they become "dominant" sites – overshooting other sites and interfering on the far side in the overlap area (where signal strength is nearly equal from the two sites). The bigger concern is extreme topography – steep mountains, deep ravines and the like. Effects on 800 MHz and VHF will be nearly equivalent if this is the case. (Our scope in this report did not involve an assessment of the topography in Contra Costa, or independent propagation studies, so we cannot comment in detail on the specifics.) Receiver sites are a common practice in VHF to fill in coverage "holes". These are unnecessary at 800 MHz – they are obsolete since tower-top amplifiers can provide a more economical solution. So it is not clear that more sites would result with an 800 MHz design. The number of sites Motorola proposed in their EBRCS design did not seem low to us, given our experience elsewhere in the country.*

6. "In regards to simulcast technology, CTA states that "it is critical that the sites not be placed too far apart." I believe that they meant just the opposite, more problems occur with simulcast if the sites are overlapping than if they are too far apart."

CTA: *No, we had it right. If you place the sites too far apart, you cannot control the timing and phase of the signals with the precision required. Simulcast will absolutely result in overlap of coverage, which is actually good. What is bad about overlap is a situation where the overlap area is too large and you cannot control the timing of the signals, and hence their relative phase, everywhere within the overlap zone. This is a function of the signal rate – 9.6 kbps for P25 and its relationship to the speed of light. It turns out that when you get the sites too far apart, the resolution in launch time for the transmit signals can approach one-half a wavelength, and at one-half wavelength you'll get cancellation of the overlapping signals – two signals of nearly equal strength (definition of overlap), but opposite phase will cancel one another. If the sites are placed close enough to one another where you can control the phase in the overlap areas, you can get the opposite effect – i.e., two overlapping signals that are in phase with one another, so their signals add. The ideal simulcast scenario is where everywhere you go is an overlap zone, but all the signals are exactly in phase with one another. You've just saturated the area with signal, and your coverage results should be superb!*

7. "Municipal police officers typically have a need for in-building coverage more often than county sheriff's deputies. Likewise, fire's ability to talk-in and talk-out of large structures including commercial and multi-unit residential dwellings is essential. As an aside, I believe that fire will

certainly need to develop multiple direct simplex channels for fireground communications as was discussed in the Phoenix Fire Department study."

CTA: *We absolutely agree that several simplex channels that can be used for fireground communications by the Fire agencies must be included in the plans, regardless of the probable coverage of the trunked system from its fixed sites. In fact, these simplex channels (or additional frequencies) can also be effectively used by law enforcement officers in a variety of situations. We agree that the Phoenix Fire Department study clearly supports the use of simplex frequencies in conjunction with a trunked radio system. This is due to the fact that a trunked system with fixed sites can never achieve 100% coverage inside buildings. But in a fireground situation, this is what is needed – and low power, simplex channels used at the scene can meet this requirement.*

8. "CTA used technical data from their "proprietary cost model" to make statements regarding system costs. Without knowing the details of this cost model, CTA's claims are impossible to evaluate. The competitively bid systems used in their model are publicly bid systems and should be made available."

CTA: *Most of the cost data used in our model is from publicly bid systems, and can be obtained directly from the source. Over the past 22 years we have accumulated data from over 100 clients and have observed trends and nuances in the methods that the vendors use when bidding projects. We have also collected data from private sources, or sources that do not have the same public disclosure requirements that your County has. These data have also been factored into the model. The result is that we have many clients that rely on our ability to assist them in the development of an accurate budget so that they can plan for the procurement of these complex systems. We would be pleased to provide a list of references to the County for this purpose.*

9. "CTA also makes reference to negotiations in which they claim price reductions of 10 to 18% with refinement, clarification or reduction of scope. I would caution against any reduction in scope without clear understanding of the consequences to coverage and reliability."

CTA: *We agree that scope should not be reduced in areas that might affect coverage and reliability. Our experience in negotiations has been that an open and balanced exchange of goals and requirements on both sides can result in a fair settlement where all parties are satisfied with the outcome. Price is typically part of these discussions, and a reduction is often obtained via cuts in unnecessary services or products, or clarifications of intangible items like risk.*

10. "Site separation would prevent Contra Costa County from implementing one large simulcast cell. The system would interfere with itself due to the large distance between each of the sites. This contradicts CTA's earlier statement "*it is critical that the sites not be too far apart".*"

CTA: *See our response to item # 6 above. Contra Costa County is not too large for a single simulcast cell. There are many counties as large as or larger than Contra Costa around the country with this configuration. In fact, we have a client with an installed Motorola simulcast system in a County with over 2,500 square miles, with a population in excess of 1,000,000 people. The sites will not interfere with one another unless the timing has not been properly set in the overlap zones. But overlap only occurs when the arriving signals are nearly equal in strength, generally within about 6 dB. When the difference is more than this, the radio is considered to be "captured" by the stronger site. So despite the presence of other signals from distant sites, it is only a problem when the signals are nearly equal in magnitude, but opposite in phase.*

11. "CTA states a single cell system "*would be operationally simpler to use"*. Given that a subscriber unit can stay on the same talk group assignment with seamless roaming throughout the County, describe "operationally simpler"."

CTA: *An example from section 4.3 of the report shows that for the EBRCS as designed, a call may be placed in the West cell to a user in the East (or a talk-group with users in both cells). If all of the channels in the East cell are busy, you will have to decide whether to a) wait for a free channel in the East before initiating the call, or b) proceed with the call even though the users operating in the East will either miss the call or enter the call late. Neither option is desirable. In a single simulcast cell, this scenario would not occur. The call would be placed immediately between the two users regardless of their location.*

12. "CTA states, "*single cell design would require fewer channels*". Need elaboration as to why CTA thinks this is so and how many channels CTA thinks the system would need."

CTA: *Traffic loading analyses using the Erlang C model have shown this to be the case. This is the reason that the FCC has encouraged the use of simulcast in a myriad of situations – because it is an efficient use of spectrum. In section 4.4 of the report (System Capacity) we state that we estimate that 19 channels would be required in this configuration (single simulcast cell). This compares to the 27 channels in the EBRCS design.*

13. "Implementing all channels at each site would require a much larger footprint at each site. Space is already a premium at each of the sites with the proposed number of channels. Implementing all channels at each site would require additional shelters."

CTA: *We agree that more equipment would be located at each site, resulting in larger footprints in the shelters. This may result in new shelters at some locations. It is part of the trade-off that would have to be done in a detailed analysis.*

14. "Implementing all the channels at all sites would impact the traffic analysis. In most cases it would be significantly more than is required."

CTA: *Actually, a single simulcast cell will reduce the overall traffic – that is why it is more spectrally efficient. An example is a single call from the West cell to the East cell. In the EBRCS design (with 3 simulcast cells), there are 3 control channels (one in each cell) that are transmitting continuously. Plus a voice channel in the West cell is assigned and another voice channel in the East cell is assigned. So for the EBRCS system, a single call between two cells will result in a total of 5 channels on the air. In a single simulcast cell design, there would only be one control channel, and only one voice channel would be assigned – it's the same channel everywhere. So in this second scenario, only two channels would be transmitting during the call.*

15. "P25 Standard, page 3: In the first paragraph CTA refers to "…some products that are compliant with the (P25) standard." I would like to see the report define the distinction between a "compliant" and "compatible" device. In the radio world, as in the computer world you will find equipment that states it is compliant or compatible with some standard. Under these conditions, not all advertised equipment features will work. There have been several documents released by the P25 Steering Committee specifically addressing ongoing concerns with the compliant/comparable issue. At the Western Regional Association of Public Communications Officers (APCO) conference in March 2007, there was a restatement of this very concern and mention of certain vendors being less than cooperative in resolving the outstanding P25 standards issues."

CTA: *In response to comment # 2 above, we talked about Project 16 functional requirements. There is an instance in which two products could be compliant with the standard, but totally incompatible with one another. At present there is no governing body that tests for "compliance" to the P25 standard. There has been some discussion lately concerning the possible use of U. S. Government labs to do the independent testing and certification. But it's just talk now. All vendors do their own testing, and state whether there products "comply" with the standard. (Surprisingly, they all comply.) In*

our opinion, if the products in a system are compatible and perform all of the required functions, then "compliance" may be an unnecessary concern.

16. "CTA states, "The design document has shown that the spacing of sites is appropriate, and that reasonable countywide coverage should be obtainable with the selected sites." While the spacing of radio sites may be deemed appropriate this is not correct. The Motorola document on page 44-45 lists radio sites in the "CCC East Simulcast System" with incorrect latitude and longitude. These errors have been pointed out to Motorola. Their response has been that it would be resolved at a later date which is not an acceptable response since we are basing decisions of accepting the Motorola design on bad data. The incorrect placement of these sites will lead to inaccurate coverage maps. CTA covers this later in their document. Further, Motorola has suggested microwave radio paths to radio sites (Old Station 53) that are not possible. This has never been satisfactorily addressed by Motorola and must be addressed before the County accepts the Motorola document."

CTA: *We were not aware of errors in the EBRCS document. Statements and conclusions made in our report were based on the data presented to us. It was not in our scope of effort to independently determine the accuracy of the data contained in Motorola's design report.*

17. "I would like CTA comments regarding Contra Costa County radio traffic study per the Motorola report. Based on my reading of the Motorola report, this is barely touched upon. How can Contra Costa County be guaranteed user channel capacity without a valid radio traffic study?"

CTA: *As we stated in section 4.4 of the report, we felt that results from Motorola's traffic analysis were similar to those from the CTA model. The question is how good were the assumptions concerning growth rates in Contra Costa County, and where are those growths likely to occur? Assumptions concerning roaming and inter-cell traffic are also questionable – not that we think they're wrong, we just don't know. Actually, our experience is that the traffic analysis is something that we (as the consultant) usually do before a contractor (like Motorola) gets involved. The vendor then does a check by running the same set of initial conditions and assumptions on future patterns and growth through their model. If our results compare well, then we move on.*

18. "I would like to see the CTA study provide an overview of what fault tolerance and redundancy is, and how it affects this project."

CTA: *Generally speaking, fault tolerance is a design where failures can occur, but the system suffers no "down-time". From the user's perspective, there was no failure, because there was no interruption to service. Redundancy is where there is a second*

component or system element that can replace a failed component or element. It is a "back up". Failures can cause "down time" in a redundant system, and users may experience interruptions to their service (or even no service). Time to bring the redundant element on-line can range from less than a second to hours or even days. Most designs we review have both elements of fault tolerance and redundancy involved.

19. "The CTA reports, "…there are no fatal flaws in the EBRCS design or in the equipment proposed in the May 2006 document." In the strongest language possible, I disagree with CTA's position. I would like CTA to review what I have written and specifically respond to my concerns on Motorola and the P25 standard, transmitter placement, channel capacity for radio traffic and coverage claims. I believe their "no fatal flaws" is a premature pronouncement and needs to be withdrawn from the report until a more thorough analysis is conducted."

CTA: *To us, "no fatal flaws" means that the design is not beyond fixing, or that the equipment cannot be used for its intended purpose. Our experience over many years of working with Motorola on numerous projects is that they are capable of resolving problems with their customers, and that they build high quality products. The design for the EBRCS involves the latest technology at Motorola, configured in an appropriate manner (especially given the constraints they had to work with). While it may not be the ideal system design, it was probably the optimum design considering the external limitations placed on the design team. And given the scalability of their products, upgrades in the future could probably reconstitute the configuration into one that we might all consider "ideal". A system that can be upgraded into an "ideal" design should not be labeled as fatally flawed.*

20. "Single Simulcast Cell, page 6 – This is an interesting idea but not applicable to the 800 MHz band. Contra Costa County is in the middle of the San Francisco Bay Area and the Sacramento – San Joaquin Valley where radio channels are reused. 800 MHz radio channels that can be used in West County cannot be used in East County since they are already in use by Sacramento. This is a problem Motorola has struggled with in their design and I am impressed with their 3 cell approach for Contra Costa County. When 700 MHz becomes available in 2009, we should be able to implement the suggestion of a single simulcast cell for all of Contra Costa County for all of the reasons mentioned by CTA."

CTA: *We agree. Motorola did a superb job in developing the 3 cell approach using the limited 800 MHz channels available to Contra Costa and Alameda counties. The restrictions on the use of these frequencies in Contra Costa County made their task particularly difficult.*