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Westinghouse Justice Institute

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San Jose, California
Police Communications System

LEAA POLICE TA

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FOREWORD

The San Jose (California) Police Department requested technical assistance concerning the plan for the future of their Police Communications System. In response to this request, the Westinghouse Justice Institute, under the terms and conditions of LEAA Contract J-LEAA-016-72, U.S. Department of Justice, provided M. Wayne Kincheloe as Consultant. This report documents the findings and recommendations developed from his brief but intensive on-site survey between April 15, 1973, and April 25, 1973.

CONTENTS

1. INTRODUCTION

This report summarizes findings concerning the communications system of the San Jose Police Department. The present system is described and alternatives and recommendations for a new system are presented.

The report is based upon review of documentation and an on-site visit and discussion with officials of the City of San Jose, including its Chief of Police and other officials and operating personnel of the San Jose Police Department.

2. SUMMARY AND CONCLUSIONS

2.1 Consulting Engineering Firm

Before the revamping of its police communications system is begun, the City of San Jose should first retain a single consulting engineering firm to provide preliminary design, detailed design, and construction engineering. In the preliminary design phase, the consulting firm will provide an evaluation of the different alternatives which meet system requirements, and will make a recommendation for the final system configuration.

A qualified consultant will assure that the proposed system meets the technical requirements of the Police Department and that it will be developed in an orderly, expeditious, and economical manner.

The selection of a single consulting firm will clearly fix responsibility for the overall project design and management of implementation.

Should the city select a computer-assisted dispatch system, the consultant would be responsible for the following:

(1) Hardware, software, and overall planning, design, and implementation. The firm will act as advisor to and coordinator for the city.

(2) Preparing plans, specifications, and contract documents for facility renovation, equipment, and related services.

(3) Assisting the city in the advertising, receiving, and evaluation of bids for facility renovation, equipment, and services.

(4) Coordinating procurement contracts and providing construction engineering services for renovation of facilities, installation of equipment, programming services, and testing and startup of the completed system.

See Section 3.1 for details of consultant qualifications and selection information.

2.2 Supervision of the Communication Center

There is much evidence to indicate that this center should be under direct supervision of the Police Department. It is recommended that this be achieved by modifying the authority hierarchy as delineated in Section 3.2.1.

2.3 Existing Communication Center

2.3.1 Telephone Operators

It is recommended that the work shifts be modified to more nearly fit the traffic load. A backup operator should be available to handle overload conditions.

2.3.2 Complaint Operators

These operators must have the proper combination of background and training for handling all calls in a professional manner. This is true regardless of the demographic stratum of the caller, or whether he needs help, assistance, or merely advice. The expertise these operators demonstrate will help shape the caller's long-term opinion of the Police Department.

It is recommended that only well qualified, motivated, and trained people be used in these positions (see Section 3.4.3.1). A backup operator should be available to handle overloads.

2.3.3 Report Takers

It is recommended that the police officers on this task be replaced with clerks, who should be located in the Communications Center. It is further recommended that the clerks be trained and used as backup operators for the complaint and telephone desks.

2.3.4 MIR Card Belt System

It is recommended that two new belts be installed (see Section 3.4.1. item 5) to replace the existing antiquated single-belt system which routes all cards through the chief dispatcher. The four area radio dispatchers should be divided into two groups of two. One belt would serve each dispatcher group. From the incident address, the complaint operator would determine the appropriate group of dispatchers, and the card would be placed on the proper belt. Each pair of dispatchers, while basically responsible for a given area, would in reality share the work-load, thus decreasing response time.

The proposed system would also free the chief dispatcher for administration and supervision.

2.3.5 Chief Dispatcher

It is recommended that the chief dispatcher, in addition to his supervisory role, be responsible for the initial handling of all "hot" calls. He would broadcast on all channels before turning the incident over to the appropriate area dispatcher. The area dispatcher would then assign the prime car, backup cars, and sector cars. It should also be the area dispatcher's responsibility to "back-off" or release excess cars for return to other duties.

2.3.6 Dispatcher's Clerk

It is recommended that a clerk be positioned near the dispatchers to run all computer checks.

2.3.7 Overall Working Conditions

It is believed that current working conditions are unsatisfactory, and that alternatives for improvement such as outlined in Section 3.4 should be investigated.

2.4 Proposed Communications Center

It is recommended that the City of San Jose plan replacement of the existing communication center with a new facility (see Section 3.4.1) based on the "Automatic Call Director" described in Section 3.4.2.

As proposed, this facility is capable of handling the "911" emergency system, and can be expanded into a minicomputer-assisted dispatch center. Incorporation of the minicomputer would make possible the addition of CRT (cathode ray tube)/keyboard terminals for the complaint operators and radio dispatchers. Addition of the mobile digital system is also possible. CRT/keyboard terminals would render obsolete and unnecessary the time stamps and card and belt systems. However, those systems would be retained for backup.

The proposed facility could be expanded and changed to fit emerging technology at any point in time, and in phases. Response time would be reduced, and the citizens of San Jose would have a much-improved service.

2.5 Microwave versus Telephone

It is recommended that the city utilize its existing microwave equipment for the sites that would incur maximun telephone line charges,

and utilize telephone facilities for the rest. It is also recommended that an outside consultant or consulting firm do a detailed cost comparison so the city may determine the proper direction for the future.

It is doubtful that the city can justify the loop microwave system which is being considered, especially since some of the essential links are old and badly deteriorated (see Section 3.5).

2.6 Radio System

Since a mobile police officer needs radio access both in his vehicle and out of it, it is recommended that the City of San Jose adopt the "jerk and pull" type of unit. The officer merely takes the vehicle unit with him when he leaves the car. The cost advantages of this system are clear, since a separate portable unit for each officer is unnecessary.

It is suggested that providing an eight- or twelve-channel radio for the vehicle is excessive. Instead, it is recommended that the city utilize 6-channel-capability jerk-and-pull radios equipped with the minimum of channels. For example, patrol units should be equipped with the following frequencies:

(1) Area frequency

(2) Tactical channel

(3) CLEMAR (inter-agency) channel

(4) Simplex channel for the area frequency

The tactical channel can be used when it is necessary for one area to communicate with a radio-equipped unit from another area.

It is also recommended that the receiver voting scheme be fully implemented, utilizing telephone facilities. The current radio coverage in some areas of the city is poor, so that this change should be made as soon as possible. At least one other major city (Seattle) uses voting schemes and four-channel "jerk-and-pull" radios. This configuration gives the officer a constant communication link that is efficient, trouble-free, convenient, and low-cost. Further details on the recommended radio systems are in Section 3.6.

2.7 Digital Mobile Terminals

At this time it is recommended that digital mobile units not be purchased. While such a system would be a great asset if properly

implemented, and while it may be possible to prepare a specification for a system that will work well, the systems now in the field have serious unresolved problems.

Should San Jose install a digital mobile system, it is recommended that a radio system be dedicated for digital service only, and that another system (for voice only) be made available for emergency use. This would require two radios in the vehicle, one for the normal voice (emergency) system and one for the digital system. Further details are in Section 3.7.

2.8 Communication Department Specifications

In preparation of specifications, it is recommended that the Communication Department use the following procedure:

(1) Prepare a preliminary design document.

(2) Distribute the document to all major vendors of the desired equipment.

(3) Ask vendors if they can bid competitively to a specification based on the information provided.

(4) Ask vendors to indicate any problem areas that might make their bid noncompetitive.

(5) Request suggestions for alternative means of accomplishing the needed task.

When the information is returned, the Communication Department can create a specification that will meet the needs of the city, while allowing a maximum number of bids.

It is not in the best interest of the city to have Motorola or any other vendor be the only bidder, as was the case in the last bid. In the recent case, other vendors were capable of providing the equipment for less money.

2.9 Car Locator System

It is recommended that a car locator system not be considered at this time. These systems are at the very edge of present technology and are not yet reliable enough for use by the Police Department.

2.10 County-Wide Plan

The recommendation for such a plan becomes situation-specific. Consolidation of separate, localized efforts in a given activity can be strongly justified on the bases of efficiency and economy, given active cooperation and sharing of responsibility.

When the organizations involved can field sufficiently enlightened leadership, such a joint venture can realize optimal results in terms of a cost/benefit ratio. However, differences must be faced and resolved, and cooperation as equal partners must take place. Anything less will result in inefficiency at best and chaos at worst.

The organizations must of course evaluate their own leadership resources and philosophy in this regard.

3. DISCUSSION

3.1 Consultant

To obtain a technically sound installation of a police communications system, promptly and cost-effectively, requires expertise in several engineering disciplines. For a municipality, the complexity of the task ordinarily means that the retaining of a Consulting Engineering Firm is requisite.

3.1.1 Consultant Qualifications

The consulting engineering firm selected for this project should have staff size and depth to assign sufficient personnel in all of the required disciplines for efficient and timely completion of the project. On a project of this magnitude, it may be necessary, during various stages of the work, to have 10, 15, or 20 people working at one time. This firm should have a staff of licensed professional engineers, and have expertise in the following general design areas:

(1) Real-time computer-directed control systems, facilities, and system design, including the application of computer equipment, operator's consoles, loggers, CRTs/keyboard, and digital transmission and all related interface equipment.

(2) Telecommunication systems, including mobile radio, microwave, digital telemetry, and supervisory and telephone.

(3) Real-time computer programming, including system, application, and mathematical models. Have in-house computer facilities for testing and debugging of application and model programs, or have access to a shared-time computer for this purpose.

(4) System engineering, including reliability and redundancy design commensurate with overall economics.

(5) Experience in design, construction, and renovation of control center facilities.

(6) Experience in developing and implementing public bidding procedures.

(7) Project administration, management, and scheduling, utilizing PERT and CPM techniques.

In order to provide professional engineering services based on objective and impartial evaluation, the consulting engineering firm should have no commercial connection with manufacturers, suppliers, or contractors; or if he is a manufacturer, supplier, or contractor, he shall excuse himself from bidding on any of the construction contracts and from providing any hardware for this project.

3.1.2 Consultant Selection

In selecting a consulting engineering firm, it is desirable to consider several firms. Names of consulting engineering firms can be obtained from the various professional engineering organizations.

Written project requirements, along with budget and time limitations, should be prepared and sent to the several candidate engineering firms. After this information has been distributed, an explanatory meeting regarding the proposed project should be held between the engineers and the City. This explanatory meeting has a two-fold purpose:

(1) It allows City officials to present the same information and answers to everyone at the same time.

(2) It provides City officials an opportunity to observe the interested engineers.

This meeting should be devoted only to the discussion of the project and not allowed to deteriorate into a competitive session concerning the qualifications of the firms represented.

After this meeting, the interested firms should submit proposals. These proposals should list professional background, previous experience, number and qualifications of personnel, and a list of references who might be contacted regarding past projects. In addition, they should describe the firm's ability to handle this specific project. A committee (composed of officials -- at least one should be an engineer -- of the departments involved in obtaining the communications system) should evaluate the proposals and conduct interviews with the firms whose qualifications and availability meet the requirements of the project. Upon completion of the screening process, recommendations should be made to the governing body. The names of several firms, listed in order of preference, along with the reasons they are recommended, should be submitted to the governing body.

Certain selection considerations should be used in order to arrive at a logical choice:

(1) Competence

  (a) Technical

  (b) General experience in this kind of project.

  (c) Availability of adequate personnel, equipment, and facilities to do the work in the time allotted.

  (d) The name(s) of the individual(s) to be assigned to the project, with particular attention to their qualifications.

  (e) Approach to the solution to the problems at hand.

(2) Current work load

(3) Financial responsibility

(4) Ability to insure contractual compliance

(5) Past record of professional accomplishments.

Note that at this stage of the process, cost is not yet a consideration.

When the City has selected its first preference based on the technical and management factors indicated above, the process of cost negotiation between the City and the Consultant Firm begins. The negotiation, which is usually informal in nature, should include such items as:

(1) How much time the engineer estimates.

(2) What engineering personnel, by name, will be assigned to the project.

(3) Upon what basis the fee shall be established.

(4) Time periods when the fee shall be due and payable.

(5) Will the consultant back up any errors by assuming personal financial responsibility?

(6) Scope of engineering work to be performed.

(7) Whether or not programming, inspection, and acceptance testing will be considered as an extra fee.

If the negotiations prove unsuccessful with the first preference, then the firm should be notified that negotiations are terminated. Negotiations should then be commenced with the second preference and the negotiating process should be continued until a mutually satisfactory arrangement has been worked out between the City and the Consulting Engineering firm.

The basis of the engineer's fee should be established during the negotiating phase. In general, the fee for this type of project should be based upon a salary-cost times a multiplier, plus direct nonsalary expenses. (An average multiplier is about 2.5.) A limit (percentage of estimated construction cost) could be imposed on this fee structure.

A written contract should then be executed by the City and the Engineer. This contract agreement ensures a mutual understanding of the project requirements, the responsibilities of the consultant regarding the engineering to be performed, and the matter of fee payments.

3.2 General Criteria for Supervision and Functional Organization of Proposed Communication Center

3.2.1 Supervision

The following hierarchy is recommended to establish the chain of command within the Communication Division:

(a) Director of Communications. This position would be appointed by the Chief of Police from members of the department holding the civil service rank of Lieutenant. The title of Director shall be considered equivalent to the rank of Captain. The rank of Director shall be subordinate to the rank of Deputy Chief and superior to the rank of Sergeant. The Director shall command the Communications Division.

(b) Sergeant of Communications. This position would be appointed by the Director from a certified eligible list as provided by the Civil Service Commission of the City of San Jose. The rank of Sergeant shall be

subordinate to the rank of Director and superior to the ranks of Chief Dispatcher, Senior Dispatcher, Dispatcher, Complaint Operator, Report Operator, and Telephone Operator. A Sergeant shall command a watch, section, or unit.

(c) Chief Dispatcher. This position would be appointed by the Director from members of the department holding the civil service rank of Police Officer. The rank of Chief Dispatcher shall be considered subordinate to the rank of Sergeant but superior to the ranks of Senior Dispatcher, Dispatcher, Complaint Operator, Report Operator, and Telephone Operator. A Chief Dispatcher shall command a radio section, and in the absence of the Shift Sergeant, shall perform those duties as an acting Sergeant.

(d) Senior Police Communications Dispatcher. This position would be appointed by the Director from members of the department holding the civil service rank of Police Communication Dispatcher. The rank of Senior Police Communications Dispatcher shall be subordinate to the rank of Chief Dispatcher.

(e) Police Communications Dispatcher. This position would be appointed by the Director from a certified eligible list as provided by the Civil Service Commission of the City of San Jose. The rank of Police Communications Dispatcher shall be considered subordinate to the rank of Senior Dispatcher.

(f) Telephone, Complaint, and Report Operators. These positions would be appointed by the Director from a certified eligible list as provided by the Civil Service Commission of the City of San Jose. These ranks shall be considered subordinate to the rank of Chief Dispatcher.

3.2.2 Functional Organization

It is recommended that San Jose Police Communications Division be divided into the following sections:

(1) Administration

(2) Radio

(3) Telephone Operations and Procedures

(a) Administration Section. This section consists of one Director and several Sergeants, an administrative aide, a clerk-typist, and others as assigned by the Director. This section is responsible for administration and supervision of the Communications Division.

(b) Radio Section. The radio section has the responsibility of receiving and relaying information via radio, telephone, and computer to all units rendering a police service, which include San Jose mobile units and outside police agencies, as well as other emergency services. This section, under the command of a Chief Dispatcher, shall also be responsible for maintenance of a sufficient number of units in service to meet emergency needs.

(c) Telephone Operations and Procedures. These consist of telephone, complaint, and report operators who receive and relay all information coming to the center via telephone. Duties include the transfer of calls to other agencies and the writing of reports for distribution throughout the Police Department.

3.3 Existing Communication Center

3.3.1 Operations

Staffing of the Center normally seems to be as follows:

(1) Six telephone operators from 8:00 a.m. to 5:00 p.m., with two operators at other times.

(2) Four people at the complaint desk.

(3) One Chief Dispatcher.

(4) Four area dispatchers.

(5) One civilian supervisor.

(6) One police lieutenant and one sergeant during the day; one sergeant all other hours. The police personnel are staff only, with no supervisory authority.

There are ten telephone lines for police emergency calls. The operators who handle the calls also answer all city administration calls.

When handling police calls, the operator assigned the calls to the appropriate one of four basic priority categories:

(1) Hot calls, including

(a) crime in progress
(b) ambulance needed
(c) alarms

There is one line for each of the three types of "hot" calls. These lines ring both the complaint desk and the dispatcher's desk. Both individuals answer. The complaint operator fills out the MIR card and the dispatcher activates the necessary units.

(2) Warm calls (e.g., fight in progress or family dispute). Three lines are reserved for the "warm" calls, which go directly to complaint operators.

(3) Cold calls (all other calls requiring police units). There are five lines between the switchboard and complaint desk for these calls.

(4) Calls that can be handled by a report taken over the telephone. These calls are transferred to the Police Department building, where police officers are stationed to take the reports.

3.3.2 Deficiencies

During the on-site visit, the following real and potential deficiencies were observed.

(1) On the switchboard, telephone operator answers all calls, not just those intended for the police department. The operators set call priorities, which results in a rather curious situation: the operators become the central figures in the entire police communication system. There are times when the operators are short-handed, and during these periods there is a real possibility that emergency calls may go unanswered for a fairly long period, or that patch cords may be accidentally pulled down, cutting off an emergency call. There is no automatic queuing of incoming calls, and no backup capability for the operator. There is also no facility for use of a recorded message in the case of a major incident.

(2) At the complaint desk, there is no audible alarm to indicate an overload condition, the antiquated belt system loses cards, and time stamps are not in sync. Working conditions are poor, and the complaint personnel apparently are not motivated.

(3) In the dispatcher area, all MIR cards are routed through the Chief Dispatcher, thus creating a bottleneck. Operating problems are caused by antiquated equipment. License and driver information can only be accessed by telephone, which creates some rather lengthy delays for patrol units. One area dispatcher currently runs the license checks, which interrupts his normal routine. Dispatcher working conditions are also poor, and there is little "force" administration data available.

3.4 Proposed Communication Center and Procedures

3.4.1 Physical Environment

The control center should be located in one room characterized by a library-type atmosphere. For example, acoustical tile and other acoustical aids, including carpeting, should be installed to curtail extraneous noise. The background light level should be subdued, with individual work areas spotlighted.

The center should be equipped with:

(1) One Chief Dispatcher position

(2) Four Area Dispatcher positions

(3) Four Primary Operator positions and two Primary/Secondary positions

(4) Six Secondary Operator positions

(5) Two belts for MIR cards will connect the primary positions and the dispatchers. Primary/secondary positions will also have access to the belts.

The telephone-type switchboard will be discontinued and replaced with the "Automatic Call Distributing System" described in the next subsection.

3.4.2 Automatic Call Distributing System (ACD)

This system automatically distributes incoming calls to the primary operators. If all operators are busy, the system stores the calls and releases them in the order of arrival.

The ACD provides eighteen operator positions with Call-Director-type consoles for the Chief Dispatcher, four Area Dispatchers, a Sergeant, four primary operators, two primary/secondary, and six secondary operators.

The glow of a "calls waiting" light indicates all positions are busy and that unanswered calls await. The light appears at the four primary, two primary/secondary, and the sergeant's position. A supervisory lamp cabinet contains lamps for each incoming trunk, and lamps indicate which operator positions are busy or available. This gives the sergeant a visual indication of the traffic pattern, and aids him in the supervision of the operators' work.

3.4.3 Procedures

3.4.3.1 Primary Operator

The primary operator answers all emergency calls. When a call is dialed in, the operator hears a tone indicating a party is on the line. After finishing the call (sequence explained below), the operator

touches his release button and is then ready to receive another call. The ACD automatically distributes the work load evenly to the primary operators.

The primary operator is often the person the public first contacts in the Police Department. This initial contact is extremely important, not only in terms of professional image for the department, but also in terms of calming the caller if necessary so that vital information can be gathered quickly. Since speed, accuracy, and sensitivity are important attributes in a primary operator, candidates for those positions must be carefully screened.

To give the reader a "feel" for the ACD, some typical operating sequences are presented below.

(a) Incoming call to primary operator. Headset must be plugged in and "In" key depressed to make the position available for an incoming call.

(1) "In" key lamp lights.

(2) "ZIP" tone is heard.

(3) Answer with identifying phrase, "police emergency operator number XX."

(4) Complete necessary contact.

(5) Depress "RLS" key.

(6) Depress "In" key to make position ready for another call.

(b) Transferring call to secondary operator.

(1) Depress "EMER TRN" key. Call is automatically held, and operator can still talk with the caller.

(2) Listen for dial tone.

(3) Key appropriate transfer code, e.g., "4" for the Fire Department. Ringing signal heard. Operator maintains voice contact with caller during transfer.

(4) Agency answers.

(5) Depress "RLS" key, leaving caller and called party connected.

(6) Depress "In" key to receive another call.

(d) Transferring dispatch calls.

(1) Depress "DISP" key. Call is automatically held, and allows voice contact with caller.

(2) Ringing heard.

(3) Dispatch answers. Operator stays on line throughout the call.

(4) Depress "RLS" key.

(5) Depress "In" key to receive another call.

In the case of a crime-in-progress, the operator transfers the caller to the Chief Dispatcher, alerting him as to the nature of the transferred call. The Chief Dispatcher elicits information necessary for immediate broadcast to all police units. As this occurs, the primary operator, still on the line, writes down pertinent information, such as descriptions. After the Chief Dispatcher has finished with the call, the primary operator completes necessary information for routing to the area dispatcher for regular dispatch. The completed MIR card is sent to the area dispatcher via the belt system.

3.4.3.2 Secondary Operator

The secondary operator's major responsibility is to be available for the disposition of transferred non-emergency calls from a primary operator. The transfer allows the primary operator to quickly free himself for the next call.

The secondary operator's time is spent largely in writing of reports and giving information to citizens.

Should all secondary operators be busy, the primary operator will fill out a "call-back" card and deliver it to a primary/secondary operator.

3.4.3.3 Primary/Secondary Operator

These operators perform a dual function in the control center, with their duties duplicating some of those performed by the primary and secondary operators.

The P/S operator's major duty is to handle overload emergency calls which surge into the Communication Center.

Though not directly on the Automatic Call Director System, the P/S operators do have "call waiting" lights on their consoles. Should the light remain on for more than approximately five seconds, the P/S operator can enter the system and handle the primary call. At other times he performs the duties of a secondary operator.

3.4.3.4 Force Administration Data System

The ACD system is equipped with a Force Administration Data System (FADS) which automatically tracks office performance in terms of number and distribution of handled communications. This feature allows for a performance check, and is also valuable for use in calculating average loads over time, and scheduling personnel for optimum efficiency.

3.5 Analysis of Microwave versus Telephone Systems

3.5.1 Microwave

(a) Existing Situation

The city presently has three Motorola MR 50 microwave links in service, and a fourth link which was never installed, but used for spare parts for the operating links. The fourth link apparently was not installed because funds were lacking for necessary related equipment. The models were purchased in 1962 by the city, and that model was discontinued three years later by the manufacturer. The system is now badly outdated, and spare parts are becoming very difficult to obtain.

The city also owns a Motorola model MR 50A which is about six years old. It has never been installed, again apparently due to lack of funds for related equipment.

Very recently the city purchased two Motorola model MR 600 links, which are currently stored in a warehouse. It should be noted that all microwave equipment owned by the city is of the non-standby type.

The city is now considering the expansion of the existing microwave system. The plan calls for ten microwave links connected in a loop configuration.

Some general observations appear to be in order concerning the city's microwave equipment and the procedure used for acquiring it:

(1) Obviously, microwave equipment gathering dust in a shop or warehouse represents misuse of resources. Such equipment should not be purchased unless enough funds are available for purchase of related equipment needed for a complete repeater site.

(2) Reliability of the present system leaves much to be desired. Unfortunately, the system now under consideration by the city does not offer a great deal more to the city, in view of the cost.

(3) The specification--bidding procedures appear to be very lax. The most recent specification released for bid resulted in only one quote--from Motorola.

The specification states:

> Each bidder shall submit a complete proposal with his bid and a complete description of the operation of the equipment proposed. This proposal shall include system block diagrams, loop switching circuits, detailed specifications and photographs of the equipment proposed, model numbers of equipment, exact proposed rack line up, and in general show all phases of the equipment. These specifications must be complete and cover in all details all requirements as set forth herein. Any deviations from these specifications shall be fully explained. No bids shall be considered which do not fulfill these requirements.

Apparently Motorola, the only bidder, did not provide the required material with the bid. They were awarded the contract.

There are other manufacturers with plants in the San Jose area, (both Farinon and Lenkurt) who could provide equipment to meet the city's needs.

(b) Service Characteristics and Design Requirements for Microwave Equipment

Microwave equipment may be installed when one or more of the following needs exist:

(1) Large quantities of data are to be transmitted over some distance.

(2) Transmission is over difficult terrain or over very long distances.

(3) A degree of reliability is required which is not available over other communication channels.

To achieve high reliability with microwave, one of three configurations must be used: space diversity, frequency diversity or the loop system. The city is considering the latter system. Ten links will be required to complete the loop configuration.

(c) Summary and Cost Estimates--Microwave

To reiterate the present resources: there are three links in service, two in the shop and two links in a warehouse, a total of seven links.

Four of the seven links are eleven years old, one six years old, and two are new. Thus five links are of questionable value. For most comparison purposes, the entire system must be included.

Complete data are not available for the comparison at this writing, but "ball park" figures based on present equipment can be calculated, for purposes of demonstrating the method.

Costs are based on Motorola microwave and multiplex.

Cost for Multiplex Equipment (microwave)

Control Center	
MC 301 I basic assembly @ $490 (2)	$ 980
CM 301 I 4w channel modems @ $890 (6)	5,340
Remote No. 1	
MC 301 I @ $490 (1)	490
CM 301 I @ $890 (3)	2,670
Remote No. 2	
MC 301 I @ $490 (1)	490
CM 301 I @ $890 (3)	2,670
Equipment cost	$12,640
Less 13% discount	1,643
	10,997
Tax	549
	$11,546

The cost for one channel (both ends) = $11,546 ÷ 6, or $1,946 per channel

Typical remote repeater site will require 14 channels plus one alarm channel.

Material cost (15 x 1946)	$29,190	
Labor (approximately 10% of material)	2,919	
Total for Multiplex, installed (14 channels)		$32,109

Cost does not include assessories such as system pilots, alarm relays, terminal boards, card extenders, manuals, training, etc.

Cost for RF Equipment (microwave)

Motorola MR 600, one channel (2 terminals) no standby	$13,050	
Six-foot disc antenna & wave guide @ $1,500 (2)	3,000	
Additional cost for microwave towers above cost of VHF and UHF radio towers	15,000	
Total Material		$31,050
Labor		3,105
Total (installed)		$34,155
Grand total for microwave		$66,264

The cost of the equipment may be funded by monies obtained through bond issuance at approximately 5.7%. Assuming a fifteen year retirement, the annual equipment cost can be calculated:

$$\$66,264 \times 0.1012875 = \$6,712$$

A conservative maintenance figure is 5% of the total material cost per year

$$0.05 \times \$63,345 = \$3,167$$

Total annual cost for microwave and related multiplex

$$\$9,879$$

3.5.2 Telephone

It telephone facilities are used instead of microwave and multiplex, the system will require 23 channels. The circuit length for the

typical site is 7.5 miles (straight line between control center and remote site). A one-time installation charge of $10 per circuit can be expected.

$10 x 23	$230	
Monthly charge for 23 circuits of 7.5 miles	$690	
Yearly telephone lease charge		$8,280
Yearly estimated maintenance cost		1,000
Total		$9,280

Based on the estimated figures, use of telephone facilities represents an annual saving over microwave of approximately $600.

3.5.3 Transmission Equipment Comparison

The question of possible earthquake damage to telephone facilities has been raised as an argument favoring microwave. There is no evidence to indicate that a microwave system would incur less damage in an earthquake; indeed, the reverse may be true. The typical four-legged microwave tower is susceptible to twisting motion. The great precision required in focusing the microwave antennas makes the system vulnerable to the slightest misalignment. Should an antenna be moved even a few inches, communication may be totally disrupted.

Conversely, telephone facilities have survived earthquakes virtually unscathed. In the last major Los Angeles quake, the public dialing facilities were disrupted due to overload, but dedicated lines (such as those used in police communication systems) remained in full service. Apparently no buried or aerial cables were broken.

It must also be noted that the "fish pole" type of radio antenna can stand a great deal of virbation and swaying without collapsing, which cannot be claimed for microwave towers and antennae.

3.6 Radio System Design

In most cities today, when a police officer leaves his vehicle, he leaves his contact with the dispatch center and other officers behind. A radio system can be designed to eliminate this hazardous condition. In fact there are four alternative systems which can maintain the desired communication web uninterrupted.

3.6.1 Alternative Number One

The first alternative is a conventional multichannel mobile radio for the vehicle and a multichannel portable for the officer. All vehicle mobiles should have both simplex and repeater transmission capability. Portables should have at least one simplex channel. A group of receivers would be connected to form a voting subsystem, which is necessary to achieve required coverage from the relatively low-powered portables.

3.6.2 Alternative Number Two

The vehicle would be equipped with a conventional type of unit interfaced with another radio (similar to a portable) to create a mobile repeater. The unit carried by the officer will repeat through the vehicle unit. The base station transmitter also repeats through the mobile.

Another variation of this system allows only the portable to repeat through the vehicle unit. Transmission from the base station goes directly to the portable.

3.6.3 Alternative Number Three

In this system the vehicle is equipped with a "jerk and pull" unit. One unit serves as both the vehicle mobile and the personal portable.

In vehicle use, the unit is slipped into a vehicle-mounted bracket which provides connection to the external vehicle-mounted antenna, an audio amplifier and speaker, and to a conventional mobile radio microphone. The unit is also equipped with a built-in microphone, speaker, and antenna which become operative when removed from the dash mount. Power for portable use is provided by a built-in rechargeable battery.

If there are two officers in the vehicle, the use of the charging unit can be shared.

The unit can be locked into the vehicular unit in much the same way that shotguns are now locked.

3.6.4 Evaluation of Alternatives

The use of a conventional mobile radio instead of the "jerk and pull" type presents certain advantages, including superior operating characteristics (e.g., intermodulation rejection, higher transmitter power), and more available options.

The second alternative (conventional type plus repeater unit) tends to minimize the receiver voting system, but the complication of the mobile repeater and the required additional frequencies do not make this a good choice.

The third alternative, "jerk and pull," is recommended because necessary communication is provided for less cost.

3.6.5 System Capacity

The San Jose police radio system should provide for four area dispatch channels, each assigned to a specific geographic area of the city. Due to the nature of the system, there will be some overlap into other areas.

The system should also have three city-wide channels. The Administrative/Command channel may be commandeered at any time and administrative use precluded when an incident of great magnitude requires total coverage.

Another city-wide channel is necessary for use by detectives, vice and narcotics squads, etc. A third channel (CLEMAR) should be set aside for inter-agency use.

At a later date, a fourth city-wide channel may be required for a mobile digital system.

3.7 Digital Mobile Terminals

Unfortunately, any radio system can be overloaded at times. As traffic on a channel increases, the problem grows. It may be possible to enlarge the system, but a more suitable alternative may be to increase the efficiency of transmission. Digital transmission may provide that option.

Approximately 70% of traffic on police radio channels is related to records. If each vehicle is equipped with two channels, one for voice and one for digital transmission, the problem of overload may be prevented. A digital system transmits data with tremendous speed, accuracy, and complete security. At the same time, traffic on the voice channel is greatly reduced.

Though solving some major problems, the digital system is faced by a major weakness inherent in all two-way mobile radio systems--the problem created when two or more terminals attempt transmission at the same time. Though the problem exists in all two-way systems, it must be

noted that there may be twice as many mobile units on the digital system as on the voice system (caused by the increase in channel utilization).

Some methods of operation for the digital system are:

(1) Officer in the car detects that the channel is free; he keys the transmitter and begins transmitting data.

(2) Officer depresses a key which tells the mobile unit there is a message to be transmitted. If the mobile receiver does not detect the presence of a carrier, the transmitter is automatically keyed and the data transmitted.

(3) If the mobile receiver detects no carrier, the transmitter will be modulated with a digital address code for about 1/2 second. Transmitter then leaves the air for about 1 second. The master terminal will detect a valid address code and key its transmitter modulated with the same address code. The appropriate mobile terminal would then "lock on" the air. Other mobile terminals will be locked off. The time required to transmit one address code is about 10 ms, so the window where interference is possible is minized. The master terminal completes communication with the mobile terminal before it will accept information from other mobile units.

With many terminals on the channel, the first two alternatives are not viable. The last alternative will provide for a minimum amount of confusion. Because of the 10 ms address time, the probability of two address fields reaching the master terminal at the same time is almost zero.

One possible drawback for this system is that it may sometimes turn out that the mobile terminals are not serviced by the master in a first-in, first-out sequence. However, since the time for any one transmission is only about 2 seconds, the problem is not a major one.

Alternative three, digital address superimposed on the R.F., will give the best results.

END

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