Prepared for:

Los Angeles Police Department
Emergency Command Control Communications System
Program Management Office
Los Angeles, California

LOS ANGELES POLICE DEPARTMENT EMERGENCY COMMAND CONTROL COMMUNICATION SYSTEM

MASTER RADIO PLAN
VOLUME I OF II

1200-226 July 14, 1975

G. A. Berry
JPL Task Leader

W. W. Coplin III
Telcom, Inc. Project Engineer

Approved by: W. G. Leflang
W. G. Leflang
Project Manager

The preparation of these materials was financially aided through a Federal grant from the Law Enforcement Assistance Administration (LEAA) under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. The opinions, findings and conclusions in this publication are those of the author and are not necessarily those of the LEAA. The LEAA reserves a royalty-free, non-exclusive and irrevocable license to reproduce, publish and use these materials o authorize others to do so.

document presents the results of one phase of research carried out at et Propulsion Laboratory, California Institute of Technology, under act NAS7-100, sponsored by the National Aeronautics and Space Administration.

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1

GENERAL

1.1 PURPOSE

Under Jet Propulsion Laboratory (JPL) Contract No. 953953, Telcom has developed a Master Radio Plan (MRP) for the City of Los Angeles Police Department (LAPD). This report documents the MRP and the implementation plan. It fulfills the requirements of Tasks 2.6.4 and 2.7.1 of the JPL contract.

1.2 SCOPE

This document describes and sets forth requirements for a Radio Communications System (RCS) which will support the LAPD Emergency Command and Control Communications System (ECCCS) through the year 1990. The report is divided into four subsequent sections which set forth technical requirements and organization, describe operating procedures, present a plan for funding and implementation and suggest potential areas of future development, respectively.

The interface between the RCS and ECCCS is at the main distribution frame of the Central Dispatch Center (CDC). The MRP is thus limited to describing requirements which are external to the CDC. It therefore does not specify the radio consoles.

1.3 APPLICABLE DOCUMENTS

The latest issue of the following documents form a part of this report, where applicable.

1.3.1 JPL Documents

a. ECCCS "System Operations and Performance Requirements," JPL #1200-212, Revision A, dated June 6, 1975.

b. ECCCS "Digital Implementation Design Report," JPL #1200-213, dated February 28, 1975.

c. ECCCS "System Design Report," JPL #1200-234, dated July 9, 1975.

d. ECCCS "Facilities Description for AE Design," JPL #1200-243, dated June 23, 1975.

1.3.2 Telcom, Inc., Documents and Drawings

a. "Statistical Analysis of Radio Communications Requirements for the City of Los Angeles Emergency Command and Control Communications System," Telcom Report JPLR-75-002, dated January 24, 1975.

b. Los Angeles Police Department Project ECCCS Drawings:

(1) Satellite Receiver System Siting Plan; Drawing No. 75-8001-0020

(2) UHF Satellite Receiver System Service Area Diagram; Drawing No. 75-8001-0021

(3) Transmitter System Siting Plan; Drawing No. 75-8001-0023

(4) UHF Digital Transceiver System Service Area Diagram; Drawing No. 75-8001-0024

(5) UHF Voice Transmitter System Service Area Diagram; Drawing No. 75-8001-0025

(6) Voice Radio System Block & Level Diagram; Drawing No. 75-8001-0026

(7) Digital Radio System Block & Level Diagram; Drawing No. 75-8001-0027A

(8) Voice Radio Receiver Site Interconnection Diagram; Drawing No 75-8001-0028

(9) Voice Radio Transmitter Site Interconnection Diagram; Drawing No. 75-8001-0029

(10) Digital Radio Transceiver Site Interconnection Diagram; Drawing No. 75-8001-0030

(11) Voice Radio Receiver Site Cable Rack & Equipment Layout; Drawing No. 75-8001-0031

(12) Voice Radio Transmitter Site Cable Rack & Equipment Layout; Drawing No. 75-8001-0032

(13) Digital Radio Transceiver Site Cable Rack & Equipment Layout; Drawing No. 75-8001-0033

(14) Receiver/Transmitter Site MDF Layout & Details; Drawing No. 75-8001-0034

(15) Central Dispatch Center Equipment Room Layout; Drawing No. 75-8001-0035

(16) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0036

(17) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0037

(18) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0038

(19) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0039

(20) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0040

(21) Transmitter & Receiver Site Patch Panel Rack; Drawing No. 75-8001-0041

(22) Bureau Control Center Cable Rack & Equipment Layout; Drawing No. 75-8001-0042

(23) Voice Radio System Block & Level Diagram; Drawing No. 75-8001-0043

(24) Digital Radio Transceiver Site Channel Assignment Schedule; Drawing No. 75-8001-0044A

(25) Voice Radio Transmitter Site Channel Assignment Schedule; Drawing No. 75-8001-0045A

(26) Voice Radio Transmitter Site Channel Assignment Schedule; Drawing No. 75-8001-0046A

(27) Voice Radio Transmitter Site Channel Assignment Schedule; Drawing No. 75-8001-0047A

(28) Voice Radio Transmitter Site Channel Assignment Schedule; Drawing No. 75-8001-0048A

(29) Voice Radio Receiver Site Channel Assignment Schedule; Drawing No. 75-8001-0049A

(30) Voice Radio Receiver Site Channel Assignment Schedule; Drawing No. 75-8001-0050A

(31) Voice Radio Receiver Site Channel Assignment Schedule; Drawing No. 75-8001-0051A

(32) Voice Radio Receiver Site Channel Assignment Schedule; Drawing No. 75-8001-0052A

c. "Detail Specification for a Radio Channel Monitoring System," Telcom, Inc., Specification JPLS-75-001, dated June 20, 1975.

1.3.3 EIA Specifications

a. Minimum Standards for Land Mobile Communications System using FM or PM in the 25-470 MHz Spectrum, EIA Standard RS237.

b. Minimum Standards for Land Mobile Communications FM or PM Receivers, 25-470 MHz, EIA Standard RS204A.

c. Minimum Standards for FM or PM Transmitters, 25-470 MHz, EIA Standard RS152B.

d. Minimum Standards for Personal/Portable Communications FM or PM Equipment, 25-470 MHz, EIA Standard RS316.

e. Standard Microwave Transmission Systems, EIA Standard RS252A.

f. Continuous Tone Control Squelch Systems (CTCSS) RS220 April 1959.

g. Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange, EIA Standard RS232C.

h. Minimum Standards for Land Mobile Communications Antennas, Parts I & II, EIA Standards RS329 and RS329-1.

1.3.4 Other Specifications

a. "Transmission Specifications for Voice Grade Private Line Data Channels," Bell System Data Communications Technical Reference, March 1969, issued by the Engineering Director, Transmission Services.

b. "Specification for Personal/Portable UHF/FM Transmitter/Receiver," City of Los Angeles Department of Public Utilities & Transportation Specification DPU&T 75-358, dated June 24, 1975.

c. "Closed Circuit Television System," as specified by City of Los Angeles Contract No. 43297, dated November 13, 1974.

1.4 SUMMARY

The system proposed herein consists of 21 radio channels in the ultra high frequency (UHF) band. Each channel consists of 2 frequencies separated by several megahertz. Organization of the channels is given in Table 1-1.

There are several major operational concepts involved in the design of this system which will enhance operations for the field officer. These are:

a. All portable operation featuring a satellite receiver network and distributed transmitters which will allow officers to leave their vehicle and still have excellent communications.

b. Capability to reallocate channels from the dispatch center to areas requiring added radio service on a short term basis.

c. Capability of field officers to talk either directly to cooperating officers when they are located within close range of each other or to repeat through a

TABLE 1-1

LAPD RADIO CHANNELING PLAN

Channel	Function
1 2 3	Central Bureau Voice Dispatch
4 5 6	West Bureau Voice Dispatch
7 8 9	South Bureau Voice Dispatch
10 11 12	Valley Bureau Voice Dispatch
13 14	Citywide Tactical
15	Citywide Tactical, Command, Metro
16	Citywide Emergency Trigger
17	Central/South - Digital
18	Valley/West - Digital
19 20 21	Administrative Vice and Narcotics and Other Special Functions

mountaintop base station for wider area coverage requirements.

d. Availability of digital transmission to facilitate data base inquiry on suspects, computer aided dispatching and status monitoring.

e. Ability to activate an emergency alarm (trigger) on the portable radio to denote officer needs help.

f. Transparency of field units for dispatch channels bureauwide and tactical channels citywide.

Due to the distributed nature of the system, the Federal Communications Commission (FCC) frequency assignment strategy and the increased channel capacity of the system, many benefits will be achieved technically. Distributed operation will improve both coverage and reliability. Moreover, if frequency reuse (use of the same frequencies in several areas of the city) becomes desirable, then the distributed structure will adapt to this very easily.

FCC will allocate these UHF channels on an exclusive basis provided that at least 50 units (FCC rules count portables as 1/2 unit) are assigned for each net. In addition, all channels are paired frequencies. This allows separation of transmit and receive frequencies, thus minimizing adjacent channel and co-channel interference. Coupled with 8 channel capacity in the portable, which will allow ease of channel reassignment in dispatch or tactical situations, the UHF approach should provide very good communications to LAPD through 1990.

1.4.1 Voice Networks

In order to facilitate these operational enhancements, a distributed transceiving system is required. Approximately 35 sites throughout the city will be equipped with satellite receivers. A citywide receiving net will utilize all 35 sites (see Telcom Drawing 75-8001-0020). A bureau net will have a lesser number to restrict coverage to the desired geographic area. Received audio from the receiver sites will be routed to a common point via leased telephone lines where each signal will be compared for audio quality and the best one subsequently selected (voted). This choice is periodically reviewed and reselected if required.

The chosen audio signal will then be relayed to appropriate transmitter sites and consoles via city-owned microwave and leased telephone lines for relay to field units and to dispatch operating positions as appropriate. Each channel will be provided with at least 2 transmitter sites to improve coverage and enhance reliability (see Telcom Drawing 75-8001-0023).

1.4.2 Emergency Networks

An emergency "trigger" network will be provided citywide. This net will initially be dedicated solely to monitoring emergency messages from field officers. Operation of the network will be as follows. Each portable radio will be equipped with an emergency switch or "trigger" which will automatically force transmission of identification and emergency signal on the emergency channel when activated. The signal will be repeated by the radio at intervals. The officer can follow up with voice information. A duplex channel is provided so that communications with a unit following the distress signal will have a clear channel.

1.4.3 Field Unit Equipment

Field units will consist of small, 8 channel, portable radios which are capable of operating in either a repeat or direct mode on each channel. Each unit will be equipped with a digital identification code which will be transmitted at the beginning of each transmission and displayed at the dispatch console. Each car will be equipped with a vehicular adapter kit consisting of a microphone, battery charger, speaker and rooftop antenna. These will reduce battery requirements, provide more audio power and provide reliable communications inside the vehicle under all conditions of police work.

Operation using the direct or simplex option is limited to the field unit receive frequency. In this manner, when an officer chooses simplex operation for local use, his transmissions do not enter the satellite receiver system and thus are not rebroadcast. Judicious use of this feature will greatly enhance reuse of tactical frequencies and provide survivability of the network in emergency conditions.

All field units will be equipped with a busy signal indicator to alert the officer that the channel is in use. Finally, all field units will be equipped with a group decoder to allow combined operation of different groups on one net without each hearing the other's traffic.

1.4.4 Digital Networks

Digital channels will be distributed in a manner similar to voice networks. Since the permissible link power for mobiles and base stations may be reciprocal, an equal number of transmit sites and receiver sites are required (see Telcom Drawing 75-8001-0024). Operation of this net also involves voting and multiple transmitters but the protocol is quite different. Signals transmitted from mobile digital radios will be received at one or more received sites and routed to a Terminal Communications Controller (TCC) where they will be compared (voted). Identical messages will be eliminated. The TCC will queue messages for transmission to the controller which supervises the digital network. The TCC will also identify the receiver site which was chosen.

The controller will then process the digital message and format a reply which will be routed to the transmitters in the network on a sequential basis. The most likely transmitter to cover the unit in question will be automatically selected by the controller for the first transmission. If the unit does not acknowledge the message, then a subsequent transmitter is selected automatically by the transmitter controller. After several unsuccessful attempts to deliver the message, the message is "killed" and the system attendant alerted.

1.4.5 Console Operation

Although not a part of the MRP, the role of the dispatch operator in the system must be considered. In the proposed LAPD UHF system, the Radio Telephone Operator (RTO) can function in a manner very similar to the present system with the exception that, at most, 2 RTO's will share a channel. The uplink messages will be routed to each position by automatically interpreting the appropriate identification from the field unit. Although all uplink messages will be repeated, each dispatch position will be provided with repeat override so that the downlink can be seized when required.

A basis will be provided in the new system for greatly enhanced operation. RTO's currently are overloaded due to the heavy workload involved in monitoring, logging status, assigning calls and checking on suspects. At times each channel requires more than one RTO. Ultimately, this will require RTO queuing (load sharing) of some type. All digital individual identification (ID) will allow appropriate CDC design to equalize workloads on RTO's by utilizing the ID to route calls. Availability of nets to be reassigned from the CDC will allow more channels to be added in areas during periods of heavy channel loading.

1.4.6 Implementation

It is currently planned that the MRP be implemented by 1980. Operation in Central Bureau and on citywide nets would be completed in 1976-1977. One bureau per year would then be installed until the job is complete. Funding requirements are given in Table 1-2. Implementation would be directed by the city but performed by a turn-key contractor. The funding table is based on the acquisition of 2,500 portable radios by 1980 but does not include any funds for mobile digital radios. Fixed site digital radio equipment is included.

1.4.7 Future Development

Land mobile radio systems are currently in a great state of flux. The advent of digital signaling transmission and voting as well as the impending development of dynamic channel assignment and frequency reuse techniques will greatly increase the flexibility of the system proposed herein. Thus, there will always exist external pressures to modify and change the network as designed to respond to enhancements from industry. These should be accepted and responded to in the sense that LA is creating a dynamic resource which will be relatively easy to modify.

The factors which appear to most dramatically affect the operation of land mobile radio nets are digital encoding of traffic and digital control of networks. If digital traffic in the form of Data Base Inquiry (DBI), Status Monitoring (SM) and Computer Aided Dispatching (CAD) is

TABLE 1-2

MASTER RADIO PLAN COST SUMMARY

Cost Item	FY '76	FY '77	FY '78	FY '79	FY '80	FY '81	FY '82	Total
Backbone System Equip.	120.6	516.2	-	49.9	-	-	-	$ 686.7
Fixed-Site Voice Radio Equip.	175.6	210.7	159.2	117.9	87.2	-	-	750.6
Fixed-Site Digital Radio Equip.	-	-	87.8	-	-	-	-	87.8
FIXED EQUIPMENT SUBTOTAL	296.2	726.9	247.0	167.8	87.2	-	-	$1,525.1
Radio System Engineering	80.0	39.0	-	-	-	-	-	119.0
Installation and Testing								
a. Contractor	225.4	440.0	66.7	-	-	-	-	732.1
b. LA City	123.0	64.0	64.0	64.0	64.0	-	-	379.0
INSTALL AND TEST SUBTOTAL	348.4	504.0	130.7	64.0	64.0	-	-	$1,111.1
Field Units	542.9	415.0	2,412.0	2,407.0	2,060.0	-	-	7,836.9
TOTALS	1,267.5	1,684.9	2,789.7	2,638.8	2,211.2	-	-	$10,592.1

implemented heavily, voice traffic will decrease. This may affect the number of nets in the 18 channel complement which are assigned for digital transmission. The city must be prepared to actively monitor this process and anticipate requirements for change.

Digital control of networks may take many forms. Dynamic Channel Assignment (DCA) or trunking wherein an idle channel is assigned to units requesting service is one such approach. This would require both hardware and software enhancements of the system proposed in order to be effective. However, the frequency plan and site selection provided forms a basis from which to implement this system. Another digital control approach is for all units attempting to place a call to the dispatch center to simply initiate a request to transmit digitally and await RTO acknowledgement of the request. This will reduce air time and improve net discipline.

The overall flexibility of the proposed UHF plan will demand that the cognizant city agency continually evaluate and modify the basic operating system to increase benefits to the users. A program of experimentation should be evolved to assess new ideas. Evolution will thus be continuous rather than sporadic. The plan calls for the city to create a systems analysis group within their department which can direct this effort. This same flexibility can be ruinous unless operating procedures are written and alternate modes thoroughly tested to avoid operator or equipment unwanted responses.

SECTION 2

TECHNICAL DESCRIPTION OF SYSTEM

2.1 COMMUNICATIONS NETWORK DEFINITIONS

Telcom has taken the approach that the LAPD communication networks should be defined on the basis of the functions to be performed. This permits them to be described in terms of the type of service to be provided (e.g., dispatching) with as many subdivisions or channels as required. This approach has resulted in definitions of four major networks to provide for in LAPD system design. These networks are discussed below.

2.1.1 The Dispatch Network

The dispatching network provides the means for relaying calls for service from the public to units in the field. These units may be patrol cars, foot patrols, motor units, etc. This network also provides the means for field units to request service or information, report status and vehicle location as is necessary to an officer performing his duty. The network function is the same for either digital or analog (voice) modes of transmission.

2.1.2 The Tactical Network

The tactical network provides the means for field units to communicate with each other without disrupting the dispatch net. It is also used by area command centers (ACC) and mobile command centers (MCC) for directing field units during unusual occurrences. Transmissions may be either digital or voice; however, digital messages must go through a central processor for logging and routing.

2.1.3 The Emergency Trigger Network

The emergency trigger network provides the means for an officer to send an emergency message prior to (or in lieu of) supplying vocal information. The field unit radio transmitter sends a digital code to the central dispatch center which identifies the officer needing assistance. The central dispatch center then determines the officer's most likely location and dispatches the appropriate assistance.

2.1.4 The Special Function Network

The special function network provides communications for unique groups of officers who need different communication capability from standard patrol units. These unique units are groups such as field supervisors, metropolitan division, vice, narcotics, intelligence and administrative personnel. The special network is intended to provide only intra-group communications. Inter-group communications would take place on the tactical network.

2.2 FREQUENCY PLAN, CHANNEL ALLOCATION & PROTOCOL

2.2.1 Frequency Plan

The assignment plan outlined in Table 2-1 assigns frequencies to all radio sites in such a way that interference is minimized and transmitter/receiver performance is optimized. Given the frequency plan in Table 2-1, it is impossible to eliminate potential intermodulation (IM) products. The frequency design is thus organized to make maximum use of diplexors to eliminate IM. The effects of receiver desensitization and transmitter sideband noise are minimized by separation of the transmit and receive frequencies and by use of cavity filters.

2.2.2 Channel Complement

LAPD has 12 types of field units which require radio service. Table 2-2 summarizes these units and identifies the channel complement required for their support. The table is applicable to Central Bureau. Extension to other bureaus is straightforward.

From this table radio unit channel requirements can be identified. For example, all black and white units must be equipped with a 7 voice channel portable radio as well as a minimum 2 channel digital radio. (Digital radios should, as a minimum, have 4 channel capability to provide for digital system growth). Metro units and astro units (helicopters) require 16 voice channels plus 2 digital channels. MCC's require all channels.

TABLE 2-1

FREQUENCY ASSIGNMENTS

Channel Number	User	Base Station Transmitter Frequency (MHz)	Mobile Station Transmitter Frequency (MHz)
1	Central Bureau Dispatch	507.1625	510.1625
2	Central Bureau Dispatch	507.1875	510.1875
3	Central Bureau Dispatch	507.2625	510.2625
4	West Bureau Dispatch	507.6625	510.6625
5	West Bureau Dispatch	507.7375	510.7375
6	West Bureau Dispatch	507.7125	510.7125
7	South Bureau Dispatch	506.9875	509.9875
8	South Bureau Dispatch	507.2125	510.2125
9	South Bureau Dispatch	507.2875	510.2875
10	Valley Bureau Dispatch	507.2375	510.2375
11	Valley Bureau Dispatch	507.6875	510.6875
12	Valley Bureau Dispatch	507.7625	510.7625
13	Citywide Tactical	506.5875	509.5875
14	Citywide Tactical	506.7375	509.7375
15	Citywide Tactical and Metro/Command	506.8125	509.8125
16	Emergency Trigger	507.0875	510.0875
17	Digital, South and Central Bureau	507.9625	510.9625
18	Digital, West and Valley Bureau	506.7875	509.7875
19	Citywide, Special	453.3500	458.3500
20	Citywide, Special	453.1000	458.1000
21	Citywide, Special	453.8750	458.8750

TABLE 2-2

TYPICAL CHANNELING PLAN FOR UNITS OPERATING IN CENTRAL BUREAU

	B&W	Supvr.	Metro	Inves.	Footbeats	Astro	Motors	Narco	Vice	Int.	ACC	MCC
Voice	1	1	1	1	1	1	1				1	1
Dispatch	2	2	2	2	2	2	2				2	2
Channels	3	3	3	3	3	3	3				3	3
			4			4						4
			5			5						5
			6			6						6
			7			7						7
			8			8						8
			9			9						9
			10			10						10
			11			11						11
			12			12						12
Voice	13	13	13	13	13	13	13				13	13
Tactical	14	14	14	14	14	14	14				14	14
Channels	15	15	15	15	15	15	15				15	15
Emergency Channel	16	16	16	16	16	16	16				16	16
Digital	17	17	17			17					17	17
Dispatch Channels	18	18	18			18					18	18
Special								19	19	19		19
Function								20	20	20		20
Channels								21	21	21		21

120-026

2.2.3 Traffic Loading

2.2.3.1 Voice Dispatch Channels

A detailed traffic analysis[1] of LAPD was completed by Telcom early in 1975. That analysis showed four key features pertaining to traffic loading.

a. Uplinks (mobile to CDC) were lightly loaded.

b. Downlinks (CDC to mobile) were very heavily loaded and operators encountered excessive delay.

c. Digital transmission was likely to reduce the loading on radio channels.

d. A need for more tactical channel capacity existed.

Based on these results, it was determined that 12 radio channels would support dispatch operations through 1990. This holds true even if digital transmission is not heavily implemented. Table 2-3 summarizes present traffic loads. Figure 2-1 depicts the number of channels required. Detailed analysis of traffic by category of message, length and by organizational unit are contained in reference 1.3.2a.

Channel utilization or loading is defined as ρ, where ρ is the fraction of time a channel is in use in a given time period. A desirable long-term channel utilization figure is $\rho = .35$. This will limit hourly peaks to less than $\rho = .60$ 95 percent of the time. This level results in an average message delay of 2 seconds, which users of most real time communications systems find tolerable.

A 12 channel dispatch complement will be under this level of utilization through the mid 1980's. At the end of this period, assuming a growth factor of 2 and no unloading of voice channels due to digital use, a channel utilization of .5 will be reached. At this level, redesign will be required to provide a reduced utilization.

---

[1] W. W. Coplin, "Statistical Analysis of Radio Communications Requirements for the City of Los Angeles Emergency Command and Control Communications System", Telcom Report JPLR-75-002, dated January 24, 1975.

TABLE 2-3

CURRENT LAPD RADIO CHANNEL UTILIZATION

Channel Description	Average Utilization ρ	Average Expected Waiting Time $\bar{t}$ (Seconds)	Standard Deviation σ	95th Percentile Utilization ($\rho_{.95}$)	95th Percentile Average Delay $\bar{t}_{.95}$ (Seconds)	99th Percentile Utilization ($\rho_{.99}$)	99th Percentile Average Delay $\bar{t}_{.99}$ (Seconds)
Downlinks							
A	.48	6.8	.13	.69	11.3	.78	15.9
B	.45	6.4	.17	.73	13.0	.85	21.0
C	.56	8.0	.21	.90	35.1	1.00*	Undefined
D	.44	6.3	.15	.68	11.0	.79	16.7
E	.54	7.6	.17	.82	19.5	.94	59.0
Division Uplinks							
Central	.13	4.7	.04	.20	5.1	.22	5.2
Rampart	.13	4.7	.06	.23	5.3	.27	5.6
Southwest	.14	4.8	.05	.22	5.2	.26	5.5
Hollenbeck/NE	.11	4.6	.03	.16	4.9	.18	5.0
Harbor/Pool	.11	4.6	.04	.18	5.0	.20	5.1
Hollywood	.14	4.8	.07	.26	5.5	.30	5.8
Wilshire	.13	4.7	.07	.25	5.5	.29	5.8
West LA	.15	4.8	.05	.23	5.3	.26	5.5
Van Nuys	.11	4.6	.04	.18	5.0	.20	5.1
Devonshire	.10	4.5	.06	.20	5.1	.24	5.4

*Demand exceeds channel capacity

TABLE 2-3

CURRENT LAPD RADIO CHANNEL UTILIZATION
(Continued)

Channel Description	Average Utilization ρ	Average Expected Waiting Time $\bar{t}$ (Seconds)	Standard Deviation σ	95th Percentile Utilization ($\rho_{.95}$)	95th Percentile Average Delay $\bar{t}_{.95}$ (Seconds)	99th Percentile Utilization ($\rho_{.99}$)	99th Percentile Average Delay $\bar{t}_{.99}$ (Seconds)
77th Street	.11	4.6	.05	.19	5.0	.23	5.3
Newton	.12	4.6	.05	.20	5.1	.24	5.4
Venice	.11	4.6	.04	.18	5.0	.20	5.1
North Hollywood**	.17	4.9	.07	.29	5.8	.33	6.1
Foothill	.10	4.5	.05	.18	5.0	.22	5.2
West Valley	.10	4.5	.04	.17	4.9	.19	5.0
TAC 1	.19	5.0	.16	.45	7.4	.56	9.3
TAC 2	.33	6.1	.18	.63	11.1	.75	16.4
TAC 3			NOT INSTALLED				
Metro/Central Traffic	.09	4.5	.06	.19	5.0	.23	5.3
South Traffic	.12	4.6	.04	.19	5.0	.21	5.2
Ad/Narcotics, Ad/Vice, Staff, etc.	.08	4.4	.09	.23	5.3	.29	5.9

**Simplex

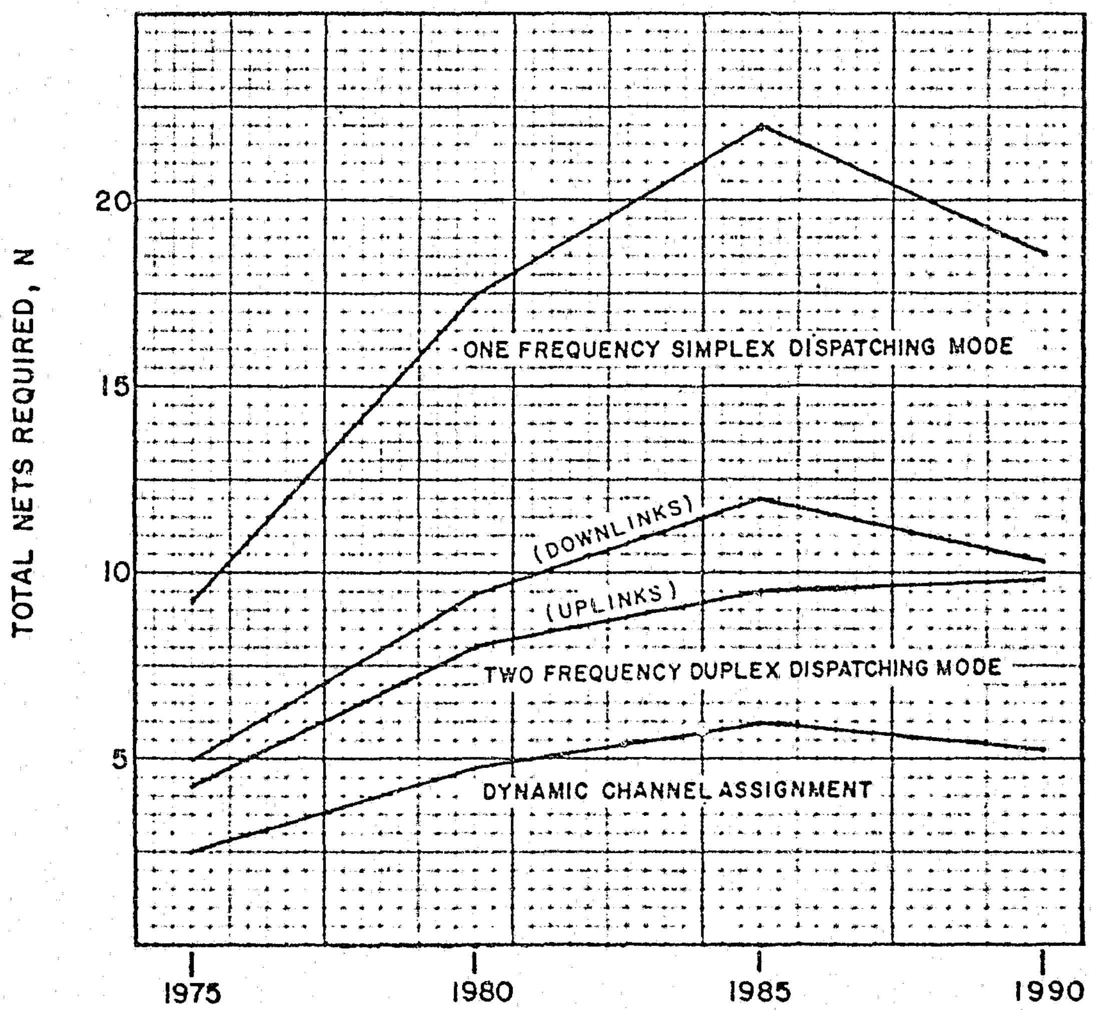


FIGURE 2-1 DISPATCH CHANNELS REQUIRED

2.2.3.2 Digital Channels

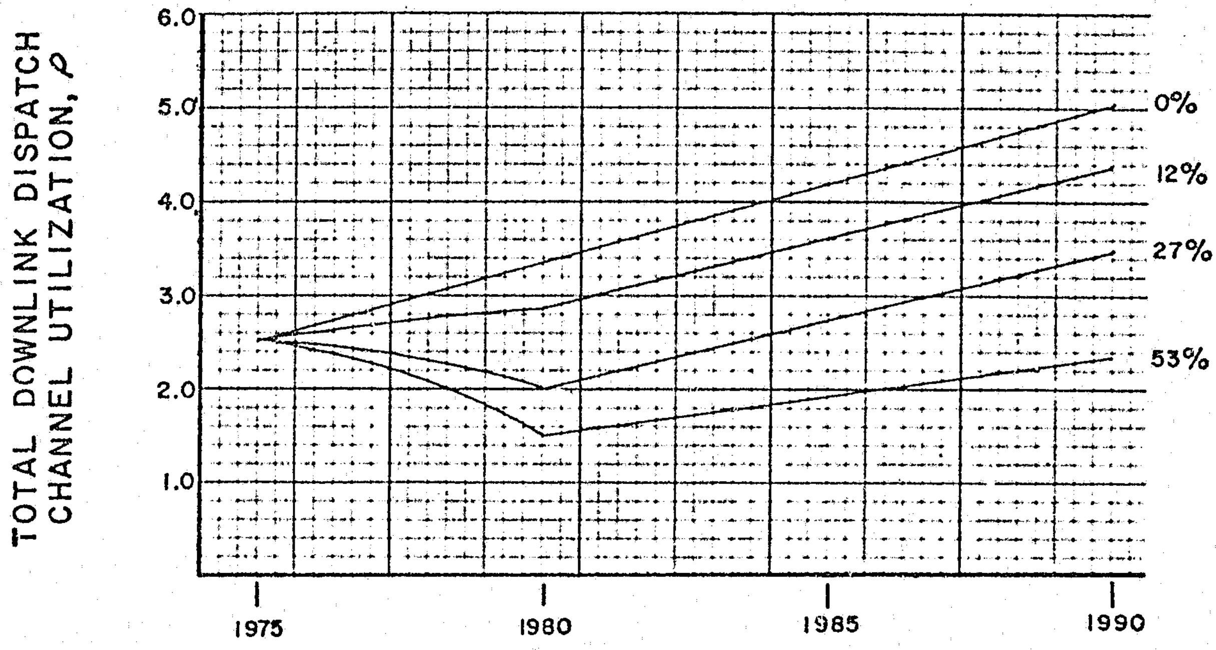
Digital transmission can greatly affect voice loading. At present, it is not clear when digital transmission will be implemented in LA. However, Figure 2-2 relates the potential effect of various levels of digitization on LAPD. Assuming that digital data base inquiry, responses, dispatches and status keeping are all implemented, a reduction in channel loading by a factor of 3/4 for downlink and 1/2 for uplink traffic would result. This level of unloading probably will not be obtained since all units would not have mobile digital terminals and all potential messages could not be transmitted digitally in any case (e.g., code 2 and code 3 dispatches).

Assuming the levels of digitalization in Table 2-4, a total traffic load of $\rho = .32$ for uplink messages and .88 for downlink messages would be required in 1990. This is marginally acceptable for a single digital net and is quite acceptable for the 2 nets provided in the design. This would achieve a dispatch net unloading of approximately 50%.

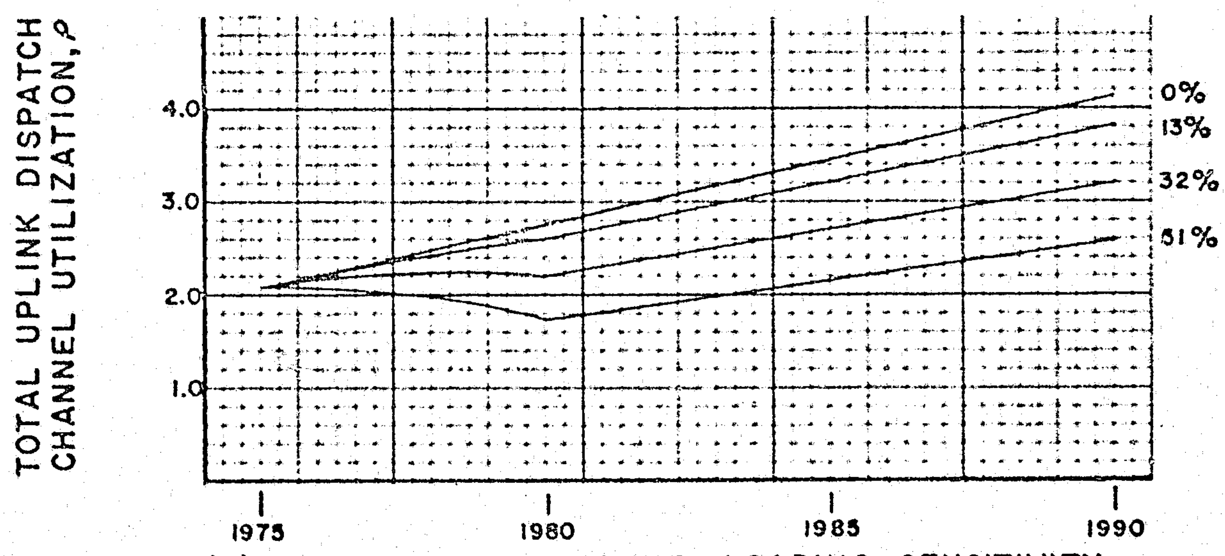
2.2.3.3 Tactical Channels

Tactical channels should be designed to average no more than $\rho = .30$. These channels are generally in heavy demand for short periods of time and thus ρ has larger variances than for dispatch channels. In order to limit peak utilization to .60, as in the voice dispatch case, it is necessary to reduce the average ρ.

In order to add tactical channel capacity, a unique operational feature has been designed into the tactical network. This feature is the option to communicate in a simplex or repeated mode on each channel of field unit radios. Since the simplex mode will effectively cover a radius of about 3/4 mile around a unit, the range is severely limited. For 2 units separated by 3/4 mile, the 95% coverage area will be approximately 2.3 square miles. Since seven zones are required for an adequate reuse pattern and Los Angeles encompasses 464 square miles, there are 30 such areas in which a single frequency can be used simultaneously with a low probability of mutual interference.



(a) DOWNLINK VOICE CHANNEL LOADING SENSITIVITY TO % OF DIGITAL TRANSMISSIONS



(b) UPLINK VOICE CHANNEL LOADING SENSITIVITY TO % OF DIGITAL TRANSMISSIONS

FIGURE 2-2 EFFECT OF DIGITAL TRANSMISSION ON CHANNEL LOADING

This feature means that 30 conversations on the average can operate simultaneously in the city on one tactical channel without interfering with one another. There will be contention between the repeater transmitter and the simplex portable transmitter which operates on the field unit receive frequency. Figure 2-3 shows the probability of contention (P_c) versus the channel loading in the repeated (ρ_r) and simplex (ρ_s) use cases. It is apparent from the figure that, for $\rho_r = \rho_s = .3$, $P_c = \rho_r \rho_s = .09$. A total channel capacity (ρ_t) in the sense of a multi-server queue of

$$\rho_t = \rho_r + 30 (\rho_s) = .3 + 9 = 9.3$$

results considering channel reuse. This feature is enhanced by assigning tactical channels in such a manner that repeated operation is restricted to 1 channel per bureau with simplex operation permitted on that channel in other bureaus. Simplex operation would be permitted in all areas on the emergency trigger channel. Table 2-5 reflects these assignment rules.

TABLE 2-5

TACTICAL CHANNEL ALLOCATIONS

Bureau Mode	Central	West	South	Valley
Repeated	15	14	13	13
Simplex	14	15	15	15
Simplex	13	13	14	14
Simplex	16	16	16	16

Exact operational procedures for implementing this feature will require field testing and refinement. The capacity multiplication through reuse, however, is quite impressive. It is possible that this feature will operate acceptably on dispatch channels as well if the tactical traffic is minimal.

2.2.3.4 Emergency Channels

This channel will be used for detecting emergency alarms throughout the city. For this reason it is desirable to minimize the probability that the net is busy. Thus, use of the net will be initially restricted to

TABLE 2-4

LAPD HOURLY MESSAGE ARRIVAL RATES - 1990

	Digital			1990	Voice				1990
	DBR	CAD	BFT	Digital Total	DBR	Dispatches	BAN	BFT	Voice Total
Central Bureau	700	140	800	1640	34	34	200	158	426
South Bureau	690	138	744	1572	34	34	198	146	412
West Bureau	750	150	858	1758	38	38	216	170	462
Valley Bureau	690	138	744	1572	34	34	198	146	412

This feature means that 30 conversations on the average can operate simultaneously in the city on one tactical channel without interfering with one another. There will be contention between the repeater transmitter and the simplex portable transmitter which operates on the field unit receive frequency. Figure 2-3 shows the probability of contention (P_c) versus the channel loading in the repeated (ρ_r) and simplex (ρ_s) use cases. It is apparent from the figure that, for $\rho_r = \rho_s = .3$, $P_c = \rho_r \rho_s = .09$. A total channel capacity (ρ_t) in the sense of a multi-server queue of

$$\rho_t = \rho_r + 30\ (\rho_s) = .3 + 9 = 9.3$$

results considering channel reuse. This feature is enhanced by assigning tactical channels in such a manner that repeated operation is restricted to 1 channel per bureau with simplex operation permitted on that channel in other bureaus. Simplex operation would be permitted in all areas on the emergency trigger channel. Table 2-5 reflects these assignment rules.

TABLE 2-5

TACTICAL CHANNEL ALLOCATIONS

Bureau Mode	Central	West	South	Valley
Repeated	15	14	13	13
Simplex	14	15	15	15
Simplex	13	13	14	14
Simplex	16	16	16	16

Exact operational procedures for implementing this feature will require field testing and refinement. The capacity multiplication through reuse, however, is quite impressive. It is possible that this feature will operate acceptably on dispatch channels as well if the tactical traffic is minimal.

2.2.3.4 Emergency Channels

This channel will be used for detecting emergency alarms throughout the city. For this reason it is desirable to minimize the probability that the net is busy. Thus, use of the net will be initially restricted to

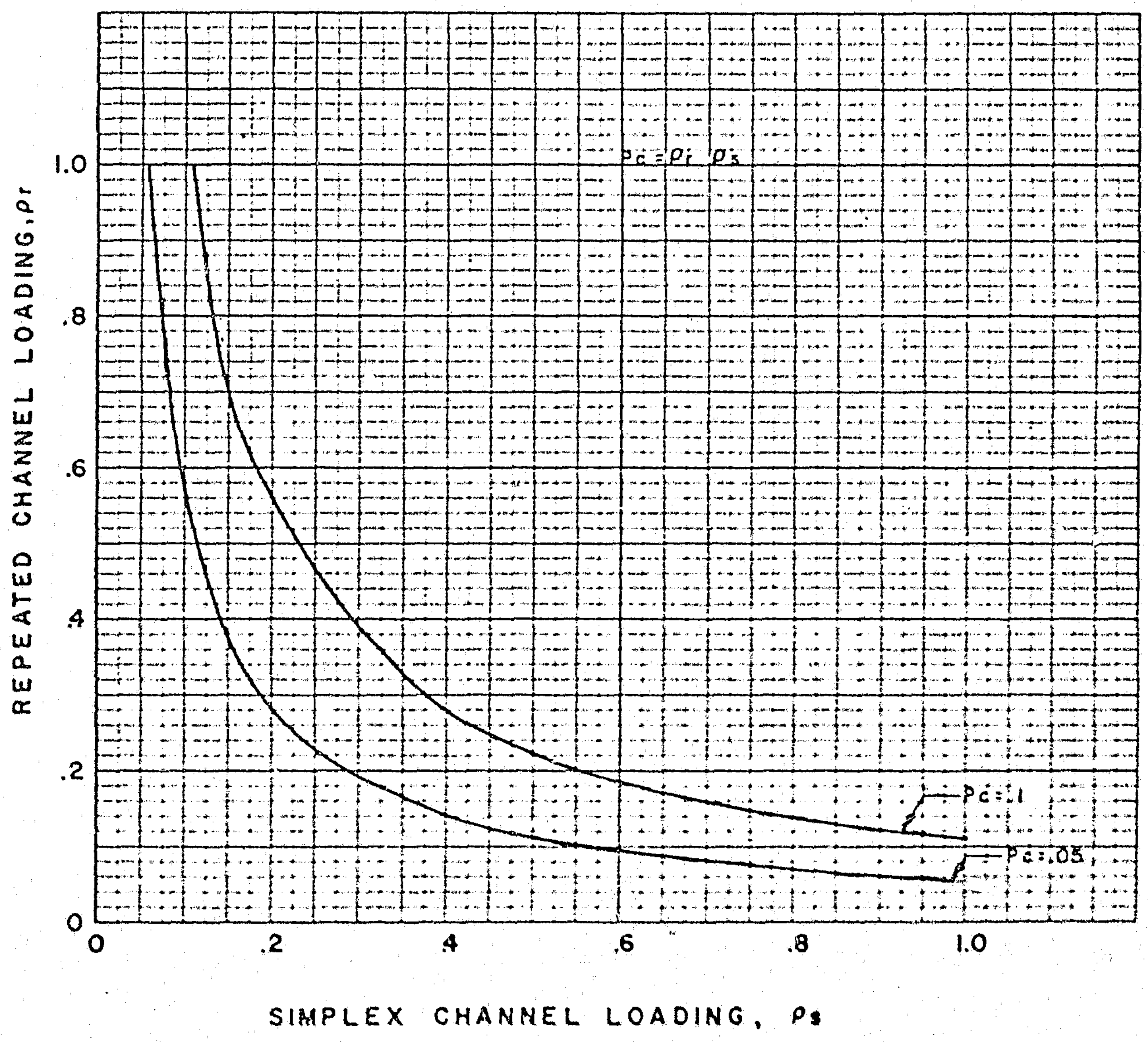


FIGURE 2-3 PROBABILITY OF SIMPLEX/REPEAT CONTENTION (Pc) ON TACTICAL CHANNELS

emergency messages for the uplink channel. The downlink will be available for simplex tactical use. By assuring an officer a high probability of quick access, the loading on the uplink channels can be increased.

In the future it may be decided to implement other functions on the emergency channel. Little experience currently exists with such an emergency function. If experience proves its use minimal, and if the trigger message can be detected reliably through voice messages via a direct contention method, this net could be converted to voice operation in a repeated mode.

One obvious use of the emergency channel would be digital signaling such as "request to transmit" functions. This use would not load the net greatly and would therefore not significantly reduce the probability of successfully receiving an emergency trigger message.

2.2.4 Channel Control & Signaling

To control channel switching and routing, mask interference and allow channel sharing a plan for signaling is required. The ideal system for the RCS will provide the following functions.

a. Each channel in the network shall have a unique continuous tone coded squelch control circuit on both transmit and receive functions.

b. Each group in the LAPD shall have a unique continuous tone coded squelch control on both transmit and receive functions.

c. These two above control functions shall be series connected so that both signals are required to operate a receiver.

d. The group call function shall be capable of being disabled by a switch on the field unit to allow intergroup communications in tactical situations.

In addition, each field unit shall be equipped with a digital identification code which is unique to that unit. It shall be transmitted at the beginning of each field unit message. The probability of correct detection at the dispatch center will be .999. The total on time for the signaling scheme shall be less than 350 ms. If the signaling spectrum lies outside the frequency band of 300 to 3000 Hz, a method of sending the signal on commercial telephone or microwave circuitry is required.

The purpose of the channel squelch control is to mask potential interference. The purpose of the group control is to detect and route group traffic to the appropriate RTO. The digital ID is intended to identify each field unit.

An alternative approach to signaling would be to omit the group coded squelch control function. In this case no disable switch would be required. Group decoding would be performed by processing the digital ID to determine which group it belonged to. The ID may contain the group identifier. This approach simplifies the field unit and provides a more flexible assignment strategy in the CDC since groupings can be rearranged by reprogramming the channel controller.

2.2.5 Channel Busy Signal

In order to maximize system throughput it will be necessary to provide a signal to the field unit which denotes that the uplink is busy on his channel. This will minimize contention when the repeat function is disabled by an RTO override and will alert a user of a shared uplink that it is in use. Uplink/downlink frequencies can thus be utilized independently.

Appropriate signals shall be applied to the downlink frequency each time a signal is present on the uplink frequency for each channel in the system. A suitable alarm at the field unit will be a green light emitting diode, appropriately filtered for viewing indirect sunlight at angles of $\pm 45^{\circ}$ and distances of 4 feet at the extreme angles. It shall be permissible to use a continuous tone signal to activate the light.

It is possible to eliminate this feature if a "request to transmit" function were incorporated whereby a user always transmitted digital ID only and awaited an RTO acknowledgement prior to sending his message. Contention would be minimized due to the short digital burst. If transmitted on the emergency trigger channel, this would minimize loading and tone signals on the dispatch channels.

2.3 VOICE DISPATCH NETWORK

Voice dispatch nets are allocated to bureaus (3 per bureau). Within the bureau each net can be dynamically allocated depending on current channel load as measured by the traffic monitoring system. A block diagram of voice dispatch system is outlined in Telcom drawing 75-8001-0026. Each satellite receiver is linked by leased voice grade telephone lines to a bureau control center where a comparator selects the best audio quality signal.

The selected audio will be routed through an operator override switch to a mixer panel and line driver network to both microwave and landline circuits which interconnect the transmitter sites and CDC. The landline circuits are backup to the microwave paths and are intended for operation in the event of a failure at Mt. Lee or the CDC. Landlines must be transferred via a command encoder/decoder operated at the BCC. The selected audio is looped through the CDC consoles where an RTO can manually override the repeat function to seize the net. Selected audio shall also be routed directly to each bureau via type 2002 leased lines.

2.3.1 Site Selection Matrix

Tables 2-6 and 2-7 list all proposed sites for receivers and transmitters for voice networks. (Site locations are defined in Telcom drawings 75-8001-0020, 0023). The matrix is organized so that required sites for three levels of administrative groups can be extracted. These allocation rules will provide estimated coverage according to Telcom drawing 75-8001-0021. An example of use for Table 2-1 can be made for Central Area. To provide predicted coverage over 95% of the area, receive sites 19, 23, and 24 must be implemented with receivers. Equivalent coverage over Central Bureau would require equipping 11 sites as can be read from the table. Table 2-2 can be used in a similar manner for transmitters.

2.3.2 Performance

2.3.2.1 Receiver System

The satellite receiving system yields a theoretical service probability of better than 99% for all locations within the LAPD jurisdiction for

Table 2-6. Voice receiver site requir ments for channels in a given area or bureau

AREAS	VOICE RECEIVER SITES																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CENTRAL																			X				X	X											
RAMPART											X							X	X				X												
SOUTHWEST																					X	X	X				X								
HOLLENBECK																			X				X	X	X										
HARBOR																													X	X	X	X			
HOLLYWOOD									X	X	X						X	X																	
WILSHIRE										X							X	X			X	X	X												
WEST L A								X	X				X	X	X	X	X				X														
VAN NUYS	X	X		X	X	X		X	X																										
WEST VALLEY	X			X	X	X		X																									X		
NORTHEAST											X	X							X				X	X	X										X
77TH STREET																											X	X	X		X				
NEWTON																						X	X		X		X	X							
VENICE														X						X	X					X	X								
NORTH HOLLYWOOD		X				X	X		X																										
FOOTHILL		X	X		X				X																									X	
DEVONSHIRE	X			X	X			X																									X	X	
RAMWOODSHIRE										X							X	X					X												
SOUTH LA																						X	X				X	X							
BUREAUS																																			
CENTRAL											X	X						X	X			X	X	X	X		X	X							X
SOUTH																					X	X	X				X	X	X	X	X	X			
WEST								X	X	X			X	X	X	X	X	X		X	X	X	X			X	X								
VALLEY	X	X	X	X	X	X	X	X	X																								X	X	

TABLE 2-7
VOICE TRANSMITTER SITE REQUIREMENTS FOR CHANNELS IN A GIVEN AREA OR BUREAU

AREAS	VOICE TRANSMITTER SITES							
	1	2	3	4	5	6	7	8
CENTRAL							X	
RAMPART							X	
SOUTHWEST						X		
HOLLENBECK							X	
HARBOR								X
HOLLYWOOD			X			X		
WILSHIRE						X	X	
WEST L.A.					X	X		
VAN NUYS	X	X						
WEST VALLEY	X	X						
NORTHEAST			X				X	
77TH. STREET						X		X
NEWTON							X	
VENICE						X		
NORTH HOLLYWOOD	X	X						
FOOTHILL	X	X						
DEVONSHIRE	X	X						
RAMWOODSHIRE			X					
SOUTH LA						X	X	
BUREAUS								
CENTRAL			X				X	
SOUTH						X		X
WEST			X		X	X		
VALLEY	X	X						

portable coverage both in and out of car. This estimate is based on a usable receiver threshold of -107 dBm, a portable power output of 2 watts, and actual heights of locations selected including terrain, towers and antennas.

2.3.2.2 Transmitting System

The transmitter allocation outlined in Table 2-7 provides an estimated service probability of better than 95% throughout the LA coverage area. This is based on an effective radiated power (ERP) of 155 watts. The distributed nature of the system (minimum of 2 transmitters per net) insures equipment redundancy as well as excellent service probability.

In order to prevent heterodyning and audio phase distortion, use of high stability oscillators (HSO) is required because of the proposed simultaneous operation of transmitters. This feature is adjustable and thus can be field optimized during system checkout. HSO long term (1 year) stability shall be .000005%.

2.3.2.3 Voting System

The voting system shall be based on selection of the best audio quality signal available. Subsequent selection of the best audio signal shall be effected periodically. The rate of voting shall be chosen on the basis of length of digital preamble plus digital ID and continuous tone coded squelch (CTCS) signaling in addition to human detection intervals for audio degradation. The probability of a lost ID message from all sources shall be limited to .0001.

Voice scramblers intended to operate with the voting system must either conform to the comparator protocol or pre-empt its operation. Each scrambler must be considered a special case requiring engineering assessment and testing.

2.3.2.4 Routing and Linking

All voice dispatch channels shall be routed per Telcom drawing 75-6001-0026. Each satellite receiver site shall be connected to the BCC via voice grade (type 2002) telephone circuits. The BCC location shall be chosen so as to minimize the total leased line recurring charges and to utilize a terminal of the LAPD video microwave system. The backup transmitter control circuit shall be routed via voice grade (type 2002) telephone lines.

2.3.2.5 Transmitter Keying and Control

All transmitter keying shall be effected using tone signaling. The total time required from initiation of the transmit command (from RTO console or comparator) signal until the transmitter has achieved 90% of full output power and is within .00025% of the channel frequency and fully modulated shall be less than 10 milliseconds. This approach has been chosen over direct current or E & M signaling since it is compatible with all conventional message channel communications media. Care must be exercised to select the tone signaling to be compatible with other signaling used within the system and by the telephone company.

2.4 VOICE TACTICAL NETWORK

All voice tactical nets will be provided on a citywide basis. Telcom drawing 75-8001-0043 describes this operation. Basic concepts such as diversity receivers, voting, transmitters with HSO's, signaling, performance specifications, and dispatcher override of the repeat function are inherently the same as the dispatch nets. Obviously all sites identified as location for voice transmitters and receivers in Tables 2-6 and 2-7 are required for citywide coverage.

The primary difference with citywide (tactical) channels is that two stage voting is proposed. This will allow subdivisions of the net on a bureau basis during periods when a tactical channel is allocated to the bureau (e.g., operation in accordance with Table 2-5). Moreover, in the event of Mt. Lee or CDC failure, the nets will remain functional in a backup mode similar to dispatch nets. A final effect of two stage voting is that the necessity for extending leased lines from each receiver location to the CDC is reduced by the concentrator action of voting at the BCC. This minimizes leased line recurring costs and microwave multiplex costs.

2.5 EMERGENCY TRIGGER NETWORK

This network is identical to a citywide channel with the exception of function and CDC equipment. Telcom drawing 75-8001-0043 thus describes the system. Functionally the emergency network, which consists of one set of radio frequencies, must monitor distress signals from field units which are of a high priority. The distress signal shall consist of a prescribed digital code in addition to the ID of the field unit. Selected audio shall be transmitted to both the CDC and each ACC from the appropriate BCC.

At the CDC the emergency signal must be decoded, routed to the appropriate RTO and to the area to which the unit belongs. The emergency trigger signal will be displayed appropriately at each of these locations. The ACC will be equipped with a separate decoder and display unit.

Due to the high priority of the network, no plans are made for using the emergency trigger receive channel for any other type of traffic at this time.

2.6 VOICE EQUIPMENT SPECIFICATION

2.6.1 Field Units

2.6.1.1 Channeling Plans

Channeling plans shall be provided in accordance with Tables 1-1 and 2-2.

2.6.1.2 Transmitter and Receiver Specifications

a. In accordance with LAPU&T specification DPU&T-75-358.

b. A busy signal shall be provided to the field unit to alert the officer that an uplink message is in progress in order to prevent contention.

2.6.2 Fixed Site Equipment

2.6.2.1 Channeling Plans

Each site shall be equipped with individual transmitters and receivers according to Telcom drawing 75-8001-0045 through 75-8001-0052.

2.6.2.2 Transmitter Specifications

The transmitters supplied shall meet or exceed the specifications of Quintion Corporation Model #QB-6703. Critical specifications include direct FM modulation, high stability oscillators, sideband noise and spurious harmonic radiation.

2.6.2.3 Receiver Specifications

The receivers supplied shall meet or exceed the specifications of Motorola Corporation Model C04-RTB-3108.

2.6.2.4 Voting System Specifications

Voting shall be on the basis of audio signal to noise quality. Initial decisions shall be on the basis of first signal arriving at the comparator. Appropriate allowance must be made for detection of digital signaling to prevent errors due to voting selection during a digital burst.

2.6.3 Receiver Site Details

2.6.3.1 Cable Tray and Equipment Racks

Each receiver site will be installed according to Telcom drawing 8001-75-0031. Each site shall be physically sized to ultimately accommodate all channels in the network.

2.6.3.2 Jackfields and Main Distribution Frame

Each receiver site shall be equipped with line, monitor and equipment jackfields, and a main distribution frame in accordance with Telcom drawing 8001-75-0034. The jackfield shall be wired according to Telcom drawings 8001-75-0034 through 8001-75-0041. They shall be ordered factory prewired.

2.6.3.3 Cross Connects

Cross connects between receivers and leased telephone lines shall be between the receiver site MDF and the telephone company terminal blocks in accordance with Telcom drawing 8001-75-0028.

2.6.3.4 Receiver Schedule

The receiver complement outlined in Telcom drawings 8001-75-0049 through 8001-75-0052 shall be installed in the appropriate shared sequences.

2.6.3.5 Power Distribution

A common power distribution system shall be provided for each receiver site. It shall consist of 24 VDC power supply and a standby battery capable of supporting the receiver site for 8 hours. Recharge time shall be 24 hours maximum.

2.6.3.6 Receiver Multicoupler

The receiver multicoupler shall, as a minimum, be a 10 input device meeting the specifications of Sinclair Radio Laboratories Model CR12-302CF.

The primary purpose of the multicoupler is to minimize tower and antenna requirements. Critical features are bandwidth, noise figure and dynamic range.

2.6.3.7 Tower

Towers shall be installed at all required sites as outlined in Telcom drawing 8001-75-0020. Where 150 foot towers are required, self-supporting poles may be used. These shall meet or exceed the specifications of Union Metal Manufacturing Company Model RA-500-Y7 and be equipped with obstruction lights. Detail design shall be supplied by the installation contractor and be certified by the Los Angeles Public Works Department.

2.6.3.8 Antenna and Feedline

Each multicoupler shall be interfaced to a "downtilt" antenna which equals or exceeds the specifications of Decibel Products Model DB-408T-4.

All antennas shall be interfaced with Andrew Corporation type FJH4-50A cable and type "N" connectors. Jumper cable shall consist of RG213/u cable.

2.6.4 <u>Transmitter Site Details</u>

2.6.4.1 Cable Tray and Equipment Details

Each transmitter site shall be installed according to Telcom drawing 8001-75-0032. Each site shall be physically sized to ultimately accommodate all channels in the network.

2.6.4.2 Jackfields and Main Distribution Frame

Each transmitter site shall be equipped with line, monitor, and equipment jackfields and a main distribution frame. The MDF shall be installed in accordance with Telcom drawing 8001-75-0034. The jackfield shall be wired according to Telcom drawing 8001-75-0036 through 8001-75-0041. They shall be ordered factory prewired.

2.6.4.3 Cross Connects

Cross connects between transmitters and microwave/telephone circuits shall be between the transmitter site MDF and a terminal block suitable for that purpose. The interconnection shall be in accordance with Telcom drawing 8001-75-0029.

2.6.4.4 Transmitter Schedule

The transmitter complement outlined in Telcom drawings 8001-75-0045 through 8001-75-0048 shall be installed in the appropriate sequence.

2.6.4.5 Power Distribution

A common power distribution system shall be provided for each transmitter site. It shall consist of a 48 VDC power supply and a standby battery capable of supporting the transmitter site for 8 hours based on a 75% transmit duty cycle. Recharge time shall be 24 hours maximum.

2.6.4.6 Transmitter Diplexor

A transmitter diplexor capable of interfacing 4 transmitters shall be provided. It shall meet or exceed the specifications of Decibel Product Model DB4380-4. The purpose of the diplexor is to minimize tower and antenna requirements and to minimize transmitter intermodulation (IM) products such that all potentially harmful IM products do not exceed an ERP of -50 dBm.

2.6.4.7 Tower

Towers shall be installed at all required sites as outlined in Telcom drawing 8001-75-0023.

2.6.4.8 Antenna and Feedline

A "downtilt" antenna which meets or exceeds the specifications of Decibel Products Model DB-40ST-4 shall be installed for each diplexor. The feedline shall consist of Andrew Corporation FJH4-50 heliax with type "N" connectors. Jumper cables shall consist of RG213/u cable and shall be minimized in length. Antennas shall be offset one quarter wavelength from towers where appropriate to provide added directional gain.

2.6.4.9 Transmitters

All transmitters shall be housed in shielded enclosures. Multitransmitters per enclosure will be allowed.

2.7 DIGITAL SYSTEMS

The digital radio system shall operate in accordance with Telcom block and level diagram 75-8001-0027. Each transceiver site shall be capable of full duplex operation. Each digital channel shall operate as follows. The digital signal shall enter the circuit via a transceiver duplexer, be demodulated to an audio signal and connected via an EIA RS232C interface to a digital modem through a multihop microwave system to Mt. Lee where it will be demodulated by a digital modem and distributed to the Terminal Communications Controller (TCC) of the digital system control equipment and relayed to the CDC. All modems shall be operated synchronously. Digital communications between mobiles will be possible when the CDC is inoperative.

The digital transmitter equipment shall be operated under control of the TCC equipment. Transmitters will be selected sequentially according to an algorithm which selects the appropriate transmitter. The digital control equipment will interface to the transmitter equipment via an EIA RS232C modem for transmitting data. Tone signaling will be provided to key the transmitters. The digital control equipment shall provide a "dry contact" closure to initiate the signaling equipment. At the transmitter input, the data stream will be demodulated by an appropriate modem and applied to the transmitter input. The transmitter shall be capable of interfacing to a standard EIA RS232C modem. The baseband data stream will be suitably encoded for transmission over the land mobile radio channel.

During periods when the digital system is inoperative for any reason, these channels shall be capable of operating in a voice mode. To facilitate this, a decoder is provided to bypass each modem in such cases. In addition, a voting circuit shall be provided at Mt. Lee to select the best quality audio in the same manner as required for voice. In this backup mode, all transmitters may be keyed simultaneously and, therefore, must possess high stability oscillators.

In addition to the microwave prime circuit, a landline backup circuit shall be provided to support voice communications in the event that the microwave equipment is out of service. Transfer to this circuit shall be accomplished via the same decoder. This circuit shall be operated only in the event that the CDC is disabled and is thus located at the BCC only.

2.7.1 Allocation and Frequency Plan

Table 2-8 contains the sites which must be equipped in order to support the LAPD digital requirement. The initial channel complement assigned consists of 2 channels shared by West and Valley Bureaus and South and Central Bureaus, respectively.

2.7.2 Digital Equipment

All digital transmitters and receivers shall be e..al to those specified for voice in Section 2.6 and its subparts.

2.7.3 Digital Transceiver Site Details

2.7.3.1 Collocation

Where digital transceivers are collocated with voice transmitters, they shall utilize the same installation materials and common equipment as specified for the voice network.

2.7.3.2 Cable Tray and Equipment Details

Each transceiver site shall be installed according to Telcom drawing 75-8001-0033 unless collocated with voice systems.

2.7.3.3 Jackfields and Main Distribution Frame

Each transceiver site shall be equipped with line, monitor, and equipment jackfields and main distribution frame in accordance with Telcom drawing 75-8001-0034. The jackfield shall be wired according to Telcom drawings 75-8001-0034 through 75-8001-0041. They shall be ordered factory prewired.

2.7.3.4 Cross Connects

Cross connects between transmitters and microwave/telephone circuits shall be between the transmitter site MDF and a terminal block suitable for that purpose. The interconnection shall be in accordance with Telcom drawing 75-8001-0030.

TABLE 2-8
DIGITAL TRANSCEIVER SITE REQUIREMENTS FOR CHANNELS IN A GIVEN AREA OR BUREAU

AREAS	DIGITAL TRANSCEIVER SITES							
	1	2	3	4	5	6	7	8
CENTRAL							X	
RAMPART			X				X	
SOUTHWEST						X	X	
HOLLENBECK				X			X	
HARBOR								X
HOLLYWOOD			X			X	X	
WILSHIRE			X			X	X	
WEST LA					X	X		
VAN NUYS	X	X	X					
WEST VALLEY	X	X						
NORTHEAST			X	X			X	
77TH STREET						X	X	X
NEWTON						X	X	
VENICE					X	X		
NORTH HOLLYWOOD		X	X					
FOOTHILL	X	X						
DEVONSHIRE	X							
RAMWOODSHIRE			X			X	X	
SOUTH LA						X	X	
BUREAUS								
CENTRAL			X	X			X	
SOUTH						X	X	X
WEST			X		X	X		
VALLEY	X	X	X					

2.7.3.5 Transceiver Duplexor

At each transceiver site a duplexor which, as a minimum, meets or exceeds the specifications of Decibel Products Model DB-4076 shall be provided to allow full duplex operation on a single antenna. When collocated with voice systems, diplexors and multicouplers may combine to minimize tower and antenna requirements.

2.7.3.6 Modem

A modem suitable for interfacing the transceiver to commercial private lines (Type 3002), SSB/microwave, wireline or carrier channels shall be provided. It shall be compatible with an EIA RS232C interface.

2.7.3.7 Other Transceiver Site Details

Tower installations, antennas, feedlines, and power distribution shall be equal to those specified for the voice system in Section 2.6 and its subparts.

2.8 LINKING SYSTEMS

Linking systems shall consist of both leased and city-owned telephone circuits and city-owned microwave circuits. All RCS equipment shall be capable of operating over standard telephone lines.

2.8.1 Existing Video Microwave

All satellite receiver circuits routed through BCC's to the CDC shall be interfaced via the CCTV system which has been designed to transmit message traffic simultaneously with video. Program channel subcarriers 1 and 2 shall be provided for this purpose. Where required, program channel subcarrier shall be added along with simplex, low density multiplex which meets or exceeds the requirements of Farinon LD2 type low density multiplex.

2.8.2 Existing Message Microwave

Supergroup IV shall be added between Mt. Lee and City Hall East to the existing Farinon SS6000W microwave system. To minimize cable requirements, the microwave high frequency signal may be distributed from the microwave radio equipment to a separate multiplex location. The multiplex shall meet or exceed the specifications of Farinon FC600 high density multiplex.

2.8.3 New Microwave Equipment

The proposed new transmitter sites at the UCB Building and at the General Telephone Building in Santa Monica require linking. Narrow band microwave is proposed to support this requirement equipped with full duplex low density multiplex for digital channels and simplex channels for voice transmitters only.

2.8.4 Other Circuits

The transmitter site at Flint Peak (#4) consists of circuits specifically for digital signaling. This circuit should initially be implemented using leased telephone lines. A leased telephone network between each BCC and the appropriate ACC shall be implemented for emergency trigger announcements.

2.9 BUREAU COMMAND CENTERS (BCC)/MT. LEE

Each BCC and Mt. Lee shall be provided with cable tray, racks and installation material in accordance with Telcom drawing 75-8001-0041.

2.10 CENTRAL DISPATCH CENTER (CDC) EQUIPMENT ROOM

The CDC equipment room shall be provided with cable tray, rack and installation material in accordance with Telcom drawing 75-8001-0035.

2.11 CONSOLE INTERFACES

Console design is explicitly not a requirement of the MRP. It is appropriate, however, to specify herein all functions which are required in order to facilitate optimum system operation. These functions are specified below and must be included in any console design envisioned or prepared by others.

2.11.1 Console Operations

Each operator position must be able to perform the following functions:

a. Access any channel in the network.

b. Interconnect any 2 channels in the network.

c. Connect any channel to the commercial dial telephone network.

d. Selectively monitor up to 2 channels.

e. Selectively monitor each group of field units assigned to a channel.

f. Display, at each position, the digital identification of up to 3 units simultaneously.

Operator positions shall be identical. Each operator shall set the console up as required for the shift and responsibilities assigned.

2.11.2 Computer Operations

The following functions will be performed by the ECCCS computer:

a. Monitor the emergency trigger channel and route alarms to the appropriate RTO.

b. Maintain a file of unit versus net he is assigned to.

c. Correlate unit ID to digital codes.

The output of these functions must be available to console operators.

2.12 TRAFFIC MONITORING SYSTEM (TMS)

The purpose of the traffic monitoring system is to aid network management by understanding dynamic channel loading within LAPD. Management can thereby effect changes which will minimize delay.

The TMS will interface to the RCS at the CDC mainframe. Channel loading shall be measured by interfacing tone control signals appearing on all circuits. Channel loading due to officer generated, dispatcher generated and repeated traffic will be measured along with message quantity and length. From this data computations of delay will be generated.

A variable interval measurement feature of the TMS is intended to determine forecasting capability. Since the LA system is flexible in that channels can be deployed dynamically, it is necessary to determine when channel loading indicates a need for channel re-allocation. A statistical analysis of loading trends is required over variable periods of measurement to determine when such re-allocations should be made.

SECTION 3

SYSTEM OPERATIONS

A primary feature of the ECCCS RCS is its flexibility and adaptability. This feature also increases the operational complexity of the system. The following paragraphs discuss system operation from the standpoint of type of operator as well as type of situation. In this way, a mode of operation can be stated in accordance with the intent of the network design. Enhancements and modifications to this concept are facilitated by the distributed nature of the system, the provision of numerous patch panels and digital signalling and control with analysis by the TMS.

3.1 NORMAL OPERATIONS

3.1.1 Field Unit

3.1.1.1 Channeling Plan

Note that the channeling plan for each field unit is identical on a bureau basis for dispatch purposes and citywide on a tactical basis. Thus, within a specific bureau, each of the three dispatch channels are available to all units. These nets may be reorganized as required to accommodate the communications load. In addition, tactical channels may be deployed as dispatch channels (or vice versa) if required by extremely heavy loads.

3.1.1.2 Dispatch Operations

Each field unit shall be assigned to a dispatch channel for normal operation. In this mode all messages generated by the field unit or by the Dispatch Center shall be disseminated throughout the administrative area to which the channel is assigned. The field unit shall not alter this assignment without notifying the Dispatch Center. Each time the field unit depresses the microphone button a digital identification shall appear at the console display to alert the RTO. Up to three unit ID codes can be displayed at the RTO position. In this way, the RTO will be aware of all units on the air. It will be unnecessary for field units to announce their identification when addressing the RTO.

3.1.1.3 Tactical Operations

Direct communications between field units is possible in a variety of ways. Since all channels are repeated, inter-unit communications can occur on the normally configured dispatch channel The RTO can override this channel as required. Direct communications over short ranges (1 mile nominally) is possible by activating the simplex switch on the field unit. In this way the repeat function of the network is bypassed but range is reduced. Since this circuit is implemented on the downlink frequency, the receiver network is undisturbed.

Normal operation of this system shall require that all messages be repeated on dispatch channels.

There will be four tactical nets. Three will be wide area multiple use or short range and one will be short range only, per Table 2-5.

The three repeated nets will be capable of operating citywide but will be partitioned in order to not tie up a net on a citywide basis. Simplex operation shall be possible on all tactical nets throughout the city but will be most efficient in areas other than the primary repeated channel.

3.1.2 Dispatch Center

Each RTO shall receive calls from field units as assigned. Where a single communications channel is assigned to multiple divisions and more than one RTO is required per channel, each division shall have a signal which can be used to route messages to appropriate RTO's. In turn, each RTO shall use CTCSS to disseminate messages to the appropriate group of users.

3.1.3 Area Command Center

Each ACC will be equipped with a multichannel radio (TACPAC) which shall, as a minimum, be equipped with the channels appropriate to its bureau. It shall normally function via the repeater network via the satellite receiver system.

3.2 UNUSUAL OCCURRENCES

During unusual occurrences (UO), channels can be dynamically allocated to cover the event. Citywide tactical channels can always be utilized to cover these exigencies. In addition, if circumstances require, bureau oriented channels may be used to cover these situations if the UO is geographically restricted to one bureau.

3.3 DEGRADED MODE OPERATIONS

During periods when the CDC, Mt. Lee or the telephone company systems are inoperable, there are two backup modes of operation.

3.3.1 CDC/Mt. Lee Degradation

If an equipment failure occurs at the CDC or Mt. Lee, all channels revert to bureau operation. A leased telephone line interconnects voted audio to the transmitter sites. Manual activation of a control system is required to enable the telephone line network. Dispatching will be accomplished from the ACC.

3.3.2 Total System Failure-Survival

In the event that all public communications systems fail, the police communications system will still be operative if all transmitter sites and satellite receivers have failed. Each field unit and ACC will operate in the simplex mode. Dispatching will be accomplished from the individual ACC.

SECTION 4

IMPLEMENTATION PLAN AND COST ESTIMATE

4.1 SCHEDULE

Implementation of the MRP will occur over a period of five years with completion scheduled for fiscal year (FY) 1980. The general approach is to initially implement the MRP citywide for tactical and emergency channels and in Central Bureau for dispatch channels. This effort will require most of FY '76 and FY '77. Each succeeding year would provide for dispatch capability in another bureau. Implementation of digital channels would occur as the capability for digital transmission grew. Table 4-1 defines these phases.

Designing the implementation plan in these phases minimizes disruption to existing operations and closely coordinates MRP scheduling with the total ECCCS program. The pertinent schedules from the ECCCS program are that:

a. CDC in City Hall East (CHE) will be ready for occupancy in February 1977.

b. The ROVER program requires demonstration by July 1976.

c. CAD will be operational by August 1977, thus allowing digital transmission to be implemented.

The MRP as presently structured attempts to meet these schedules by projecting Central Bureau operations to be activated by September 1976 and citywide facilities to be complete by March 1977. An added benefit to this approach is that, by March 1977, all major RCS facilities construction will be complete. Future implementation will then be a matter of electronics equipment implementation rather than major construction programs. This program could thus be accelerated providing funding became available.

4.2 DETAILED PHASE-IN REQUIREMENTS

4.2.1 Channel Crossovers

During the implementation of ECCCS, interbureau communications will require "crossovers" between new UHF units and existing VHF units.

TABLE 4-1

PHASE SCHEDULE FOR ECCCS

Phase	Time Period	Description
1. II	FY '76	a. Award contract for implementation.
		b. Complete system design.
		c. Begin installing backbone network.
2. III	FY '77	a. Activate 3 channels for voice dispatch in Central Bureau.
		b. Activate 2 channels for tactical operation citywide.
		c. Activate 1 channel for emergency trigger citywide.
3. IV	FY '78	a. Activate 3 voice dispatch channels in South Bureau.
		b. Activate 1 channel for tactical operation citywide.
		c. Activate 2 digital channels.
4. V	FY '79	a. Activate 3 voice dispatch channels in West Bureau.
5. VI	FY '80	a. Activate 3 voice dispatch channels in Valley Bureau.

The crossovers are summarized, along with the proposed method of handling them in Table 4-2.

There are two types of channel crossovers. The first is between field units equipped in different bands while the second occurs when field units on UHF and VHF require the same information from the base station. Figure 4-1, which describes a crossband repeater, will allow UHF and VHF field units to converse though they were on the same channel. This function shall be implemented when requested by the CDC watch commander at the Mt. Lee patch panel or at the CDC patch panel.

When both UHF and VHF units require the same dispatch center information, then a "simulcast" arrangement shall be implemented. In this manner the controlling RTO shall broadcast on both UHF and VHF. This function shall likewise be implemented at the Mt. Lee patch panel or at the CDC patch panel at the request of the CDC watch commander.

4.2.2 Interim Parker Center Operation

During the period from September 1976 (UHF Central Bureau operational) until the CDC is operational, the Parker Center dispatch facility must support Central Bureau dispatching. There are two approaches to the solution of this problem.

a. Utilize the existing RTO positions.

b. Provide new consoles.

The plan most easily implemented depends on the space available at the dispatch center, the method of placing the UHF system into operation and the recovery procedure in case a problem develops. To utilize the existing RTO positions would require that a special interface panel be designed to interface between the RTO consoles and the UHF circuits. This panel could be installed in the equipment room at Parker Center. In addition, 6 new microwave circuits between Mt. Lee and CHE must be provided. At the time of cutover the designated RTO positions would be interconnected to the UHF channels. If the cutover failed, then the system could be transferred back to VHF. The interface panel would mimic the present operation.

TABLE [illegible]-2

UHF IMPLEMENTATION - PHASE II ECCCS (CENTRAL BUREAU)

	From \ To	RTO	Patrol, Motors, and Investigative: Mobile	Patrol, Motors, and Investigative: Portable	Metro	Helicopter	ACC	MCC
	RTO	NR	UHF-CB VHF-CW	UHF-CB VHF-CW	VHF-CW' 1, 2, 3	UHF-CB VHF-CW	UHF-CB VHF-CW	UHF-CB VHF-CW
Patrol, Motors, and Investigative	Mobile		UHF-CB VHF-CW 2	UHF-CB VHF-CW 2	UHF-CB VHF-CW 2, 3	UHF-CB VHF-CW	UHF-CB VHF-CW	UHF-CB VHF-CW
Patrol, Motors, and Investigative	Portable			UHF-CB VHF-CW 2	UHF-CB VHF-CW 2, 3	UHF-CB VHF-CW	UHF-CB VHF-CW	UHF-CB VHF-CW
	Metro				VHF-CW' or UHF-3	VHF-CW' or UHF-2 or UHF-3	VHF-CW' or UHF-2	VHF-CW' or UHF-2 or UHF-3
	Helicopter					VHF-CW' or UHF-CW'	VHF-CW' or UHF-2 or UHF-CB	VHF-CW' or UHF-CW' or UHF-2
	ACC						VHF-CW' or UHF-CB	VHF-CW' or UHF-2 or UHF-3
	MCC							VHF-CW' or UHF-CW' or UHF-2

Legend

NR - Not Required
CW' - Citywide
CB - Central Bureau
CW - Citywide other than CB

Notes

1. For Metro deployed to Central Bureau, simulcast Metro VHF and CB UHF or dispatch to either but not both.
2. Central Bureau cars assigned to other areas use CW TAC or area dispatch net cross linked to UHF TAC for repeat operation.
3. A preferred method of Metro operations in Central Bureau is to equip Metro with UHF in Phase II ECCCS.

1300-839

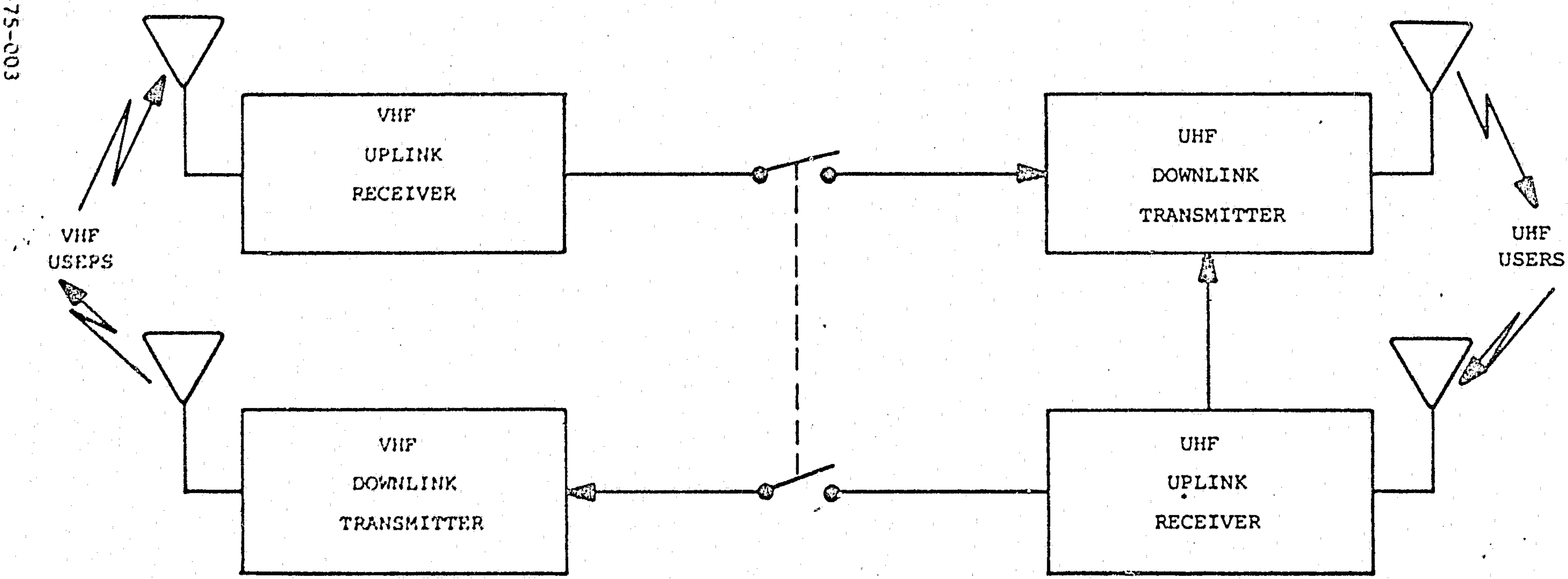


FIGURE 4-1 CROSS-LINKED REPEATER INTERCONNECTION

If new consoles were provided, a duplicate operational set-up would be implemented. The 6 microwave channels would still be required but separate Parker Center facilities would be provided. In this case, the RTO's would, at cutover time, physically move to the new consoles. To recover in the event of failure would require moving back to the old consoles.

Note that both plans require the existence of UHF and VHF in the field unit vehicles if the ability to recover to the existing operation is to exist. This creates the dual service shop problem in that separate antennas would be required and the VHF equipment could not be removed immediately upon installation of UHF equipment.

A better approach would be to check out the UHF system thoroughly and then to simply cutover field units to UHF without leaving VHF equipment installed. This could be effected by allowing simulcasting on VHF and UHF at the RTO console during the cutover period. To provide tactical channel operation as well as to minimize contention for RTO service each UHF channel could be interfaced to VHF with a crossband repeater. In this way operation of the UHF channel could be checked out with a few units for proper RTO and field unit operation. During this period all test field units (perhaps 5) would have both UHF and VHF. All bureau channels could then be certified with this complement. From this point on, all field units could be cut to total UHF.

Console operation will be more suitable by utilizing the existing consoles with a new interface panel. In this way RTO's and dispatchers will be largely unaffected. Use of separate consoles would require more space at Parker Center plus some sort of new method of complaint board operator (CBO) ticket distribution. This type of rearrangement should be deferred until August 1977 when operation in the new center with CAD will be implemented. In this way the number of changes in operation will be minimized.

4.2.3 Permanent CDC at CHE

On August 1, 1977, it is currently planned that the CAD system will be operational, that the Central Bureau incoming telephone trunks will be rerouted to CHE and that the CBO operation for Central Bureau will be transferred to CHE. At that time RTO positions for Central Bureau should be transferred to CHE also, using new consoles. About six months of training will be available prior to the time to establish procedures and work out details of protocol between Parker Center and CHE interactions.

4.2.4 Problem/Failure Reporting System

The RCS will consist of many new and sophisticated equipments. It is essential to detect and correct recurrent malfunctions and/or operational problems. A reporting and review system for all such occurrences must be established prior to receiving any equipment.

4.3 TASK LIST AND PERT CHART

Figure 4-2 defines in detail the sequence of activities required to implement the RCS through 1977. Controlling activities are the selection of a Master Contractor, completion of system detail design, procurement, installation and acceptance testing. In order to prepare this plan, a detailed analysis of implementing the RCS was considered. All tasks identified are listed in Figure 4-2. Their interrelationship is presented in PERT format. It was based on the following assumptions.

a. City Hall East (CHE) would be ready for use by February 1977.

b. It is desirable to demonstrate ROVER by July 1976.

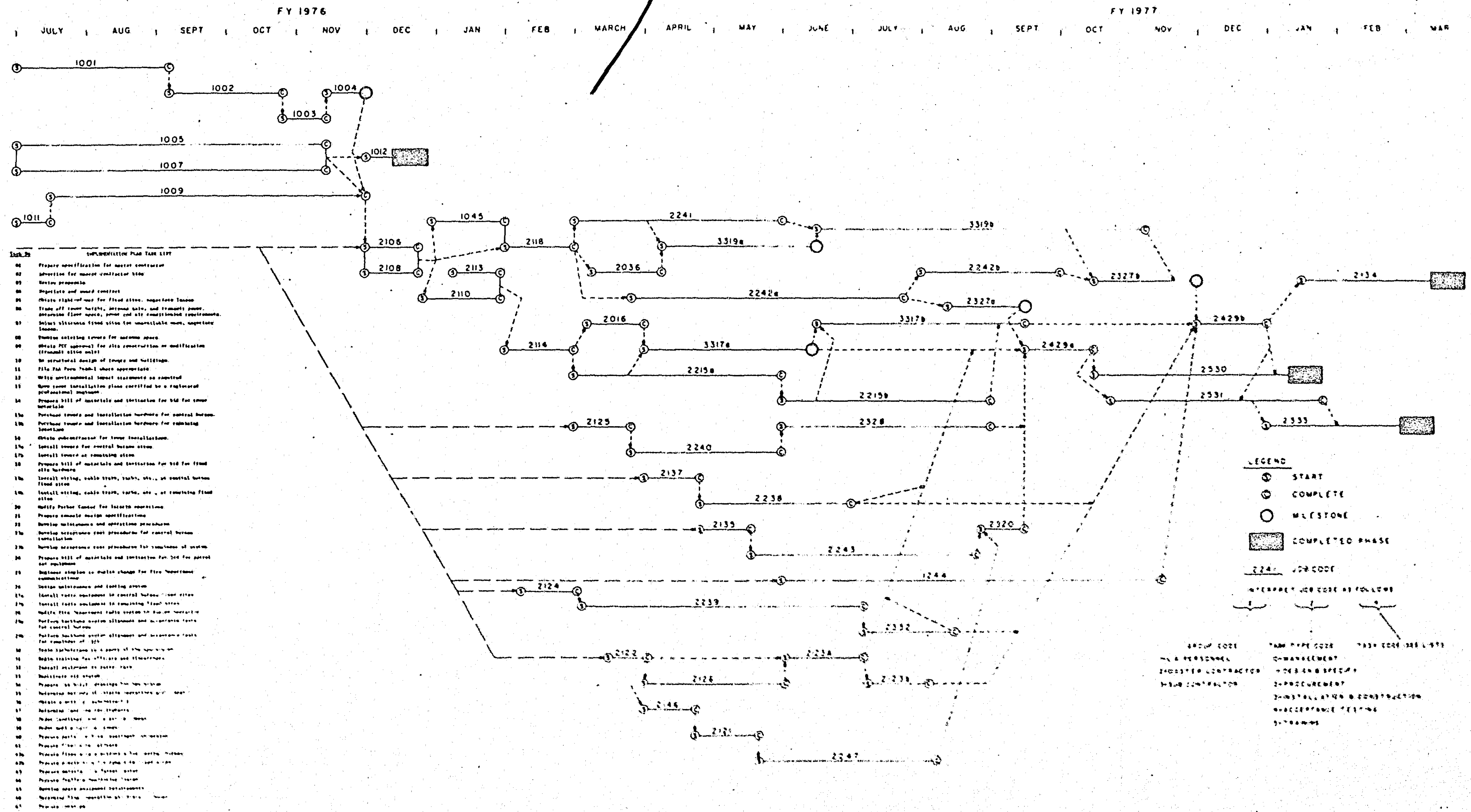
c. Selection of a Master Contractor would occur by October 1975.

d. The basic design presented herein would be followed.

e. The availability of manpower is unrestricted.

The PERT schedule depicts minimum times to complete the tasks along the critical path. Table 4-3 depicts manpower required versus time.

Based on this plan the Master Contractor would, immediately upon contract award, prepare detail specifications for all hardware required for site preparation. The city will have previously arranged leases and obtained FCC approval. Facilities installation would then be implemented in Central Bureau as soon as hardware began to arrive on site.



FY 1976
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MARCH
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
FY 1977
1001
1002
1003
1004
1005
1007
1009
1011
1012
1045
2106
2108
2118
2113
2110
2114
2241
3319b
3319a
2036
2242b
2242a
2327b
2327a
2016
3317b
3317a
2429b
2429a
2215a
2215b
2530
2531
2533
2334
2125
2328
2240
2137
2238
2135
2320
2243
2244
2124
2239
2332
2122
2234
2126
2233
2145
2247
LEGEND
START
COMPLETE
MILESTONE
COMPLETED PHASE
JOB CODE

Figure 4-2.

TABLE 4-3

MANPOWER REQUIREMENTS FOR IMPLEMENTATION PLAN

Month	Engineers	Technicians	Electricians	Tower Erectors	Other
FY '76					
July	2	-	-	-	3.0
August	2	-	-	-	3.0
September	.5	-	-	-	3.0
October	1	-	-	-	2.5
November	2	-	-	-	3.0
December	4	-	-	-	1.0
January	4	-	-	-	.5
February	4	-	-	-	.5
March	4	-	-	-	2.5
April	6	-	10	10	3.0
May	6	-	10	10	3.0
June	6	5	10	10	
FY '77					
July	5	7	10	10	3.0
August	4	10	10	10	1.5
September	3	12	10	5	1.5
October	2	12	10	-	3.0
November	2	10	5	-	2.0
December	1	8	-	-	2.0
January	1	5	-	-	3.0
February	1	4	-	-	3.0
March	.5	2	-	-	1.0

By September 1976, Central Bureau communications would be operating on UHF. Implementation of the additional sites and voice equipment would continue and be complete by March 1977. At this time all basic hardware required to support the ultimate system would be in place. Only installation of electronic equipment operating in the same manner as the Central Bureau would be required. Although scheduled through 1980, implementation could proceed as soon as funds become available.

4.4 FUNDING REQUIREMENTS

Based on the assumptions and schedule above, a funding plan has been made. The funding plan outlines both the type and level of effort required. Table 1-2 summarizes the costs. Appendix A presents, in detail, the costs of materials and labor. Electronic equipment schedules follow the schedules outlined in Telcom Drawings 75-8001-0044 through 75-8001-0052.

4.5 PHASE-OUT OF EXISTING SYSTEM-EQUIPMENT AND FREQUENCIES

Existing equipment can be phased out of operation as the new system is declared operational. Disposition of the equipment can affect other users beneficially. First, much of the VHF equipment is of recent vintage and can be potentially reused within the city. In this mode maximum "resale" value of the equipment can be realized. If sold on the open market, little salvage value will be realized.

The second beneficial return to other users is that a considerable amount of VHF spectrum can be released for other use. At this time it appears that 18 VHF frequencies can positively be released. These are listed in Table 4-4 along with comments which indicate users currently assigned and year to be returned. These would be returned according to the stated schedule provided system implementation proceeded as planned.

A second group of VHF frequencies may also be returned. These are listed in Table 4-5. It is desirable to retain these at this time to potentially provide for greatly expanded digital operation, simplex special purpose operation and possible funding limitations to convert

TABLE 4-4

CANDIDATE FREQUENCIES TO BE SURRENDERED BY LAPD

Channel No.	Frequency	Area User	Other Users	Year of Return
3	154.650	3	Shared with Riverside Co. Statewide system on adjacent channel.	1979
10	154.710	7	West Covina, San Diego and San Bernardino Co. on adjacent channel. Intermodulation problem.	1978
20	154.785	9	Los Angeles Co., Orange Co. and Redlands on adjacent channel. Frequency 6 (TAC-2) separated by 15 kHz.	1980
5	154.890	Metro	Shared with Delano. Statewide system, Fontana, San Diego and Tehachapi on adjacent channel. Intermodulation problem.	1977
22	154.965	2	Shared with San Diego Co. Statewide system on adjacent channel.	1976
23	154.995	10	Statewide system on adjacent channel. Frequency 7 separated by 15 kHz.	1980
8	155.070	5	Shared with San Joaquin Valley at Blue Ridge. Oceanside, Tehachapi, San Diego Co. and Riverside Co. on adjacent channel.	1979
1	155.130	6	Goleta, San Bernardino Co., San Diego Co., City of Santa Monica and numerous search and rescue teams on adjacent channel.	1978
15	155.145	S.T.	Shared with Chino and San Diego Co. El Monte and Antelope Valley on adjacent channel.	1979
2	155.250	13	Santa Barbara, Oceanside and Orange on adjacent channel.	1976
16	155.310	Det.	Shared with Bakersfield, Chowchilla, Oxnard, Port Hueneme, Ventura and Palm Springs.	1980

TABLE 4-4

CANDIDATE FREQUENCIES TO BE SURRENDERED BY LAPD
(Continued)

Channel No.	Frequency	Area User	Other Users	Year of Return
4	155.370	1	Thousand Oaks, Simi, Camarillo, National City and Oceanside on adjacent channel.	1976
13	155.415	4/11	Intercity repeater input and hospitals in Oxnard, Fontana, Palmdale and La Puente on adjacent channel.	1976
11	155.535	16	Long Beach, Montclair and Pomona on adjacent channel. Frequency 17 separated by 15 kHz.	1980
18	155.550	16	Shared with Montclair, Pomona, San Bernardino Co., San Diego, Kern Co., and Long Beach. Frequency 17 and 19 separated by 15 kHz.	1980
12	155.565	C.T.	Long Beach, Montclair and Pomona on adjacent channel. Frequency 19 separated by 15 kHz.	1976
TAC-3	156.150	TAC-3	3.0 MHz from Frequency A, causing potential intermodulation problems with all UHF Channel 20 frequencies in use.	1980
-	158.895	-	Shared with Kern Co., and San Jacinto. Buena Park, Newport Beach, Oxnard, Port Hueneme and San Bernardino on adjacent channel. Frequency B separated by 15 kHz	1976

TABLE 4-5

CANDIDATE FREQUENCIES TO BE RETAINED BY LAPD

	Channel No.	Frequency	Comments
UPLINKS	6 (TAC-2)	154.770	Shared with Barstow. Duarte and Santa Barbara on adjacent channel.
	9 (TAC-1)	154.830	San Gabriel on adjacent channel.
	14	154.950	Shared with San Diego. San Diego Co. on adjacent channel.
	7	155.010	San Diego Co. on adjacent channel.
	15	155.190	San Diego, Orange, and Ventura Co. hospitals on adjacent channel.
	17	155.520	Irvine and Riverside on adjacent channel.
	19	155.580	Montclair, Ontario, Pomona and Upland on adjacent channel.
DOWNLINKS	E	158.865	Shared with San Diego Co. intersystem (emergency only). Buena Park, Newport Beach, Oxnard and Port Hueneme on adjacent channel.
	B	158.910	Thousand Oaks on adjacent channel.
	D	159.030	
	A	159.150	Shared with San Bernardino, San Diego Co., Kern Co. and Riverside Co. Frequency C separated by 30 kHz
	C	159.180	Glendale on adjacent channel. Frequency A separated by 30 kHz.

detective units to UHF. These frequencies have been selected for retention on the basis of current operation problems and a computer analysis to minimize interference of all types.

SECTION 5

FUTURE DEVELOPMENT OF THE RCS

There are a number of areas in which the RCS can potentially be expanded. It is the responsibility of active and interested network management to pursue developmental ideas. In order to accomplish this, functional analysis of the network is required as well as technical analysis of the usual channel loading and delay variables. During development of the MRP a great many ideas were developed and either not pursued or discarded. In many cases development was simply not warranted at this time. Most often the ideas are of a highly experimental nature and have no place in an operational system until well developed. This section of the MRP is devoted to preserving these ideas and to acquainting interested network designers with at least the basic concepts involved.

5.1 ELIMINATING NETWORK CONTENTION

To achieve short queuing times it is desirable to minimize the number and length of messages. In addition, it is desirable for control of each channel to be under the server (RTO) rather than the user (field unit) to prevent an insistent user from disrupting the net.

A technical innovation which achieves both these ends is to impose a "request to transmit" protocol on each field unit. This would be implemented as follows: Any unit requesting service would depress its microphone switch thereby sending a digital identification. The ID would be displayed at the console of the appropriate RTO, who would accept the call as soon as practicable.

This procedure would shorten calling times as well as give control of the channel to the server, replacing the troublesome contention procedure currently in use. Implementation could be done in several ways.

One ideal way would be to actually signal on the emergency trigger channel. The RTO could initiate the "OK" to transmit by sending an individual digital signal to the unit requesting service. The digital signal could have the unit's ID code simply retransmitted by depressing a switch to accept the unit ID appearing in the display before the RTO. This approach would actually remove messages from the dispatch channels.

This approach could be quite acceptable to a field officer since he would no longer be forced to monitor his radio awaiting a break so that he can transmit. This idea has been found acceptable in several operations in the U.S. and Canada.

5.2 EFFECTS OF DIGITAL TRANSMISSION ON RTO QUEUING

It is very likely that the assignment rule of one RTO per division will not suffice far into the future. Presently, RTO's are overloaded during some peak periods. Better control of the channel with digital signaling and contention minimization will help but not eliminate these problems. Thus, it is likely that some situations will require more than one RTO per channel.

On the other hand, digital transmission coupled with Computer Aided Dispatch (CAD) could relieve the RTO workload. Single stage dispatching will likewise have this effect. In these cases, an RTO might be expected to serve more than one radio channel. It might then be economical to reduce RTO staff during period of low activity.

All of these pressures point to automatic call distributing to RTO's. This can be done in many ways but in any case will require notification of status to the RTO taking the call. Thus, the CAD computer must recognize the unit calling and locate its status for the RTO. Call distribution algorithms would then equalize RTO load and minimize field unit waiting time.

Note that the requirement to allow queuing of RTO assignments is cooperative with those outlined for digital protocol on voice channels (Section 5.1). The point is that the basic design of the RCS is inherently capable of these optional developments.

5.3 VOTING ALTERNATIVES

A significantly important point about satellite receiver systems is that each receiver is independent of others. This means that there are potentially many more small receiving zones than with conventional systems. Standard voting reduces this independence back to one effective receiver per zone since all receivers are routed through one comparator for a given zone and repeated.

If the repeat function is disabled, uplink channel loading can be increased dramatically by multiple voting. In this concept all receivers in a given area would be routed through a voting point. A voter would be installed for each group (divisions, for instance) operating in the recei ing area. A gating filter would be in series with the voter to select the appropriate audio, as shown in Figure 5-1.

In this approach, interference would occur between users at the boundaries of the divisions but the distributed nature of the network would provide an alternate route for either or both competing audio circuits.

This technique is merely a method of increasing channel loading on uplink channels. The repeat function must be eliminated to prevent multiple audio competing for the transmitter network. Thus, operation would be similar to today's duplex dispatch network. Contention minimization in this case would require digital signaling to be available.

Note that this technique would be particularly effective on the emergency trigger network where repeated messages are not required. This procedure could be used to route audio to appropriate divisions.

5.4 FREQUENCY REUSE PLANS

Frequency reuse plans make an attempt to increase channel loading by restricting a radio frequency set to a small zone and then using the same set in another zone. Figures 5-2 and 5-3 depict some potential reuse zones for LA which preserve organizational lines. In general, these zones need to be separated by at least twice the zone diameter. The nature of the distributed system designed to support LAPD makes

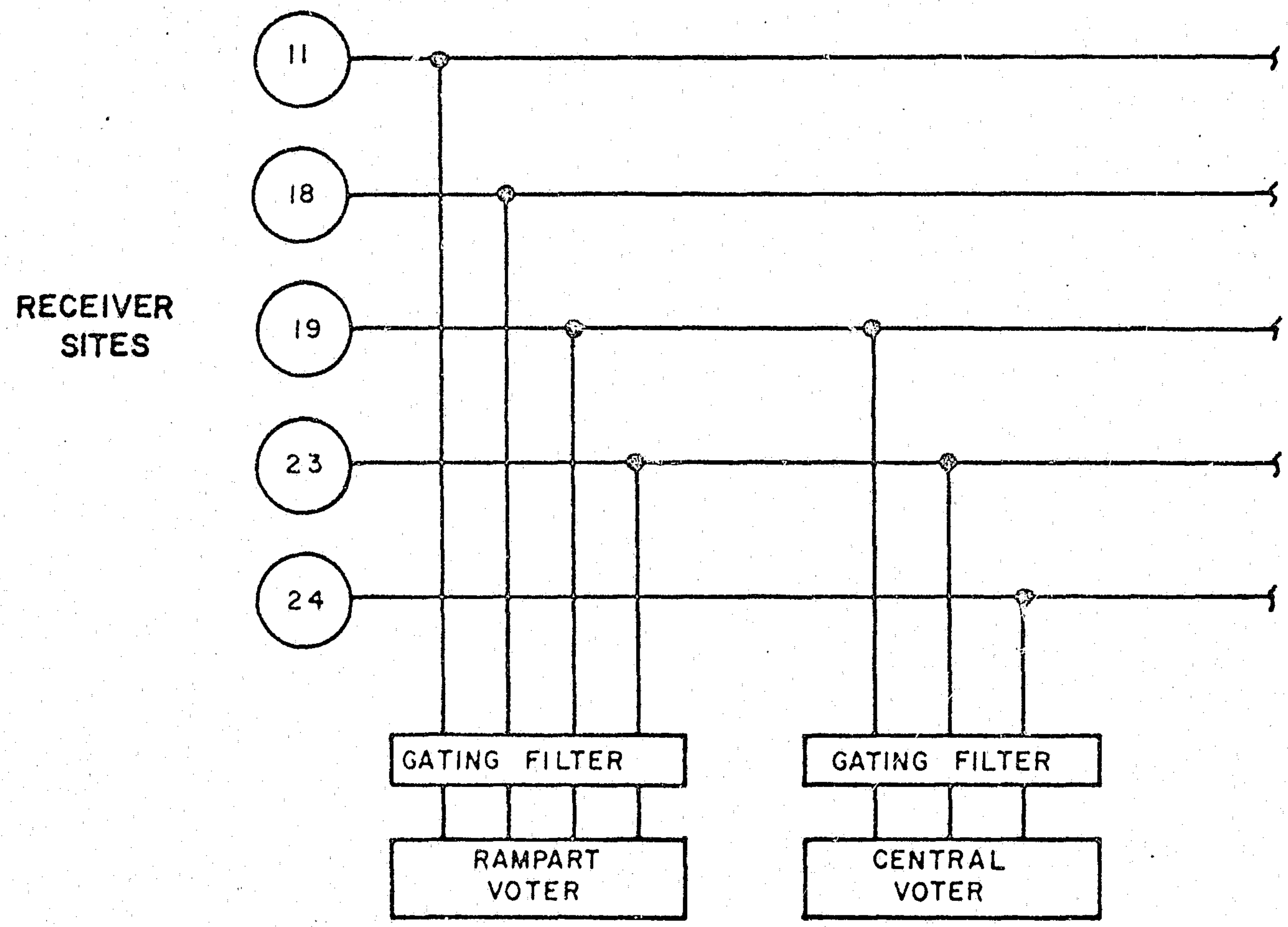


FIGURE 5-1 EXAMPLE OF MULTIPLE VOTING OF A SINGLE RF CHANNEL FOR RAMPART / CENTRAL AREAS

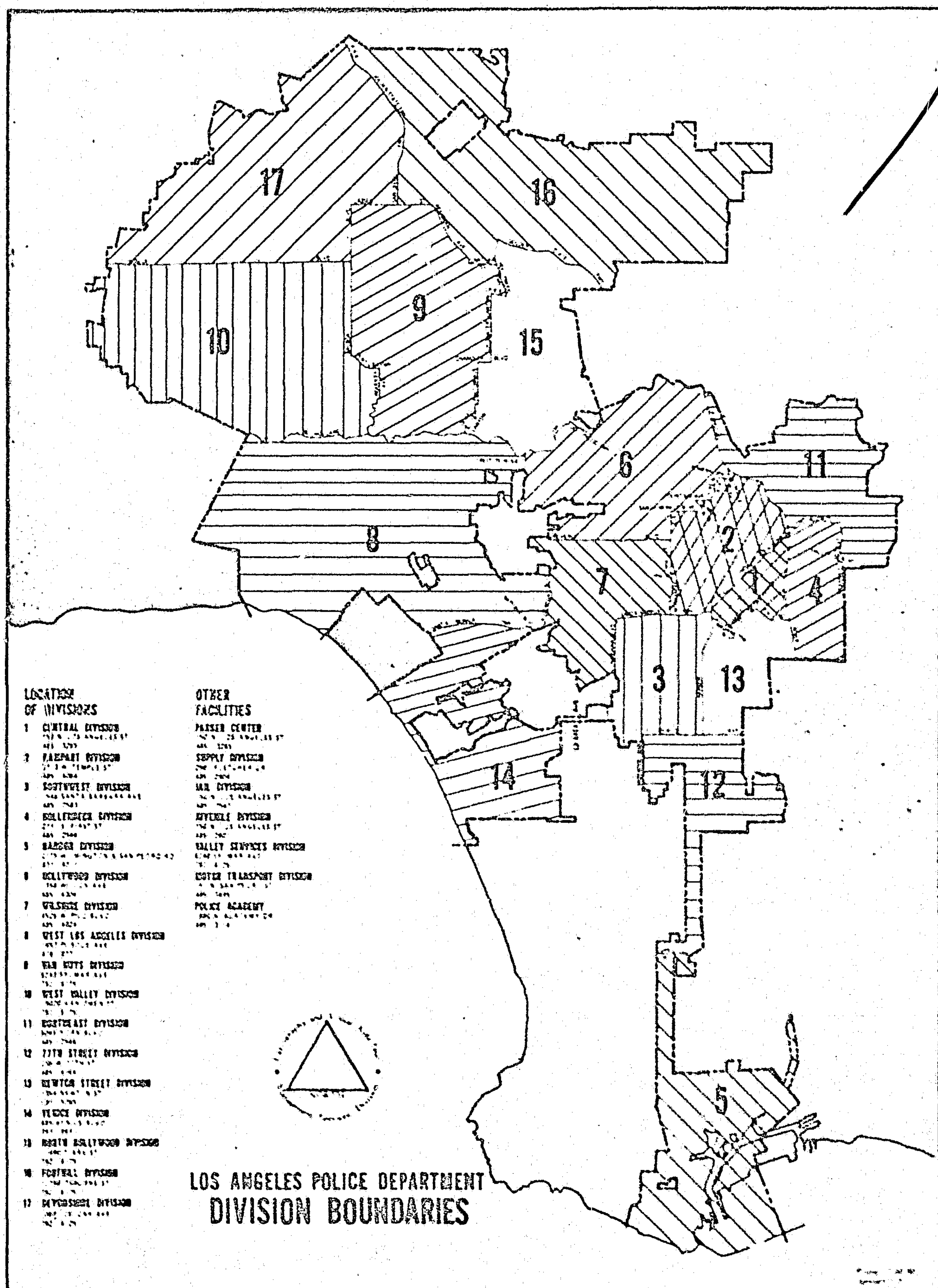


FIGURE 5-2 8 FREQUENCY PLAN

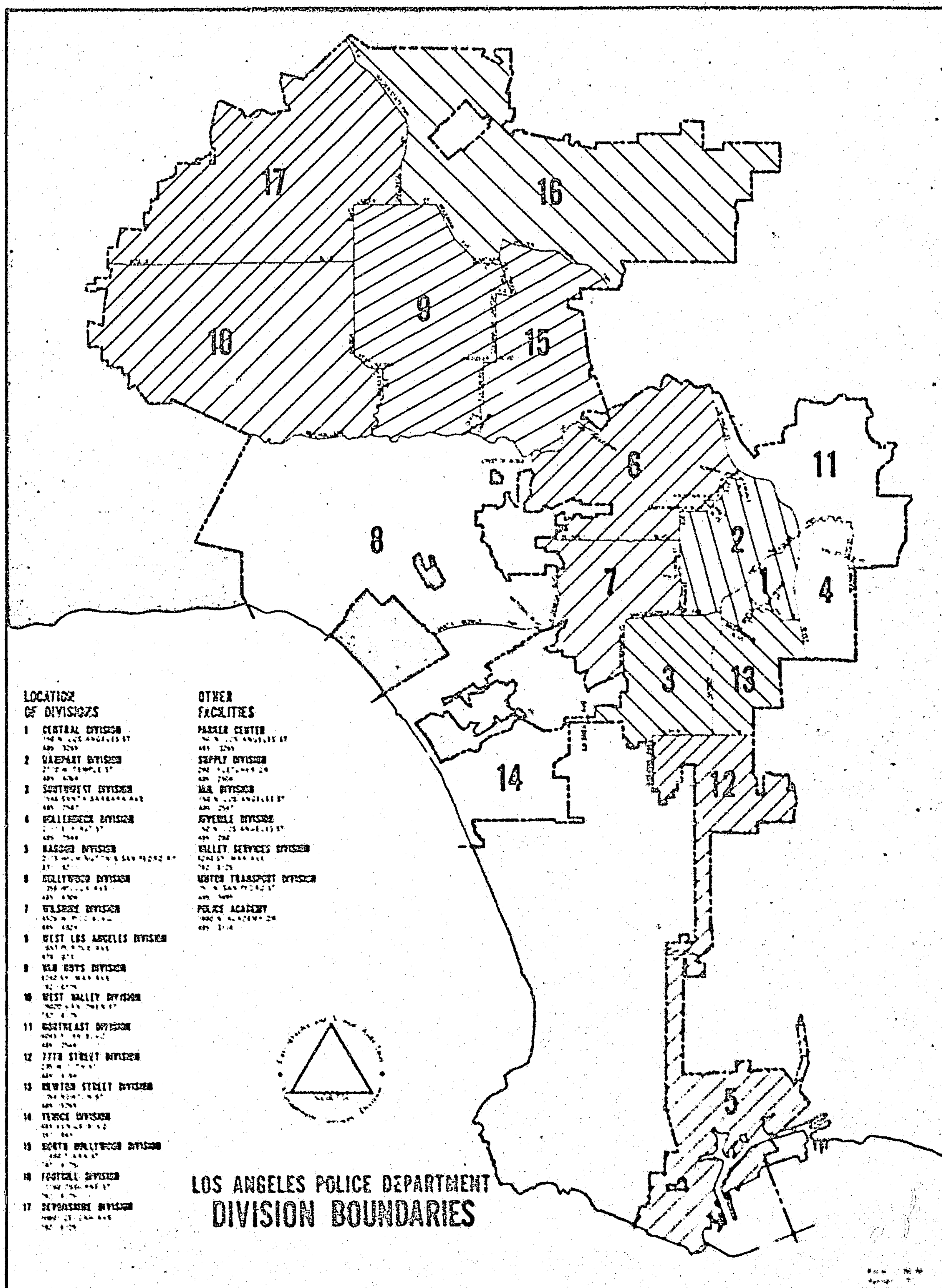


FIGURE 5-3 5 FREQUENCY PLAN

frequency reuse easy to implement. Sites developed for satellite receivers can support transmitters as well.

To convert to frequency reuse, it is necessary to compute a probable coverage area for a transmitter and select the zones in which it will be applied. This function is easier to implement when the distance between reuse zones is greater. For that reason, reuse between South and Valley Bureaus can be implemented with relative ease. Note that the primary operation of the tactical network proposes this in any case.

Interference to the helicopter in such plans will be relatively minimal provided individual "group call" signals are used for every functional group the helicopter wishes to converse with. It is possible that a steerable antenna or at least a directional antenna will be required for best operation.

5.5 PORTABLE ASSIGNMENT STRATEGIES, HANDLING PROCEDURES AND SPARES

5.5.1 Assignment Strategies

The total number of units required to support LAPD depends on the strategy used to allocate units to officers. If sharing is possible, whereby the radio unit is passed from shift to shift, less total units will be required. Even on peak deployment days, much less than 70% of the total available units are in service.

The current cost plan outlined in Appendix A ultimately provides for one portable radio per vehicle. One possible benefit of sharing would be to provide two radios to field units during most deployment periods. Spares can also be accommodated by this approach.

5.5.2 Handling Procedures

To effect sharing, a pool of radios would have to be allocated to each dispatch point or repair point. Units normally scheduled would be equipped with a radio. Units not scheduled or out of service would not be equipped. All radios for extra units would be drawn from the pool as would a second radio for a normally assigned unit. These pools would also serve as replacement sources for failed radios.

5.5.3 Spare Capacity Requirements

A portable radio can be expected to fail an average of between one and two times per year in police service. The mean time to repair such a failed unit is about eight hours. Assuming that a failed unit should be exchanged immediately upon request 90% of the time, the number of spares required can be calculated by the following procedure.

N = the number of identical units.

n = the maximum number of simultaneous failures tolerable (e.g., the number of spares required).

let P = probability of replacing a failed unit immediately.

p = probability that a unit has failed $\left(1- \frac{MTTR}{MTBF-MTTR}\right)$

Assuming that all units are identical, the failure distribution will follow a binomial probability which can be stated as

$$P = \sum_{i=0}^{n} \binom{N}{i} \left(p\right)^{i} \left(1-p\right)^{N-i}$$

Assuming that the probability of replacing a failed unit immediately is desired to be P = .99, N is 64 (division level) and p is .0018, the equation can be solved iteratively for n, the number of spares. In this case 1 unit is the indicated number of spares. This is less than 1% of the total number of units in service and could easily be provided by pooling out-of-service units.

The above procedure can be repeated to arrive at the desired spare capacity. It appears that less than 2% spares will be adequate provided the MTTR is actually held to less than 8 hours per failure. This will require spare parts to be available and all repairs to be effected in the service shop.

5.6 SPARE MULTICHANNEL RECEIVERS AND TRANSMITTERS

Backup support in this system is provided by redundant on line transmitters and receivers which are geographically separated. In the event that further backup is required, it would be most effective to provide multichannel units at each location. In this event, a failed unit can be replaced by switching the multichannel spare to the correct frequency. This replacement can be effected either manually or automatically.

5.7 TRANSMITTER SITE STANDBY RECEIVERS

The current worst case failure mode assumes that the transmitter/receiver system is completely inoperative. Survival is provided by reverting to simplex operation which provides limited coverage. Another level of survival could be provided by equipping each transmitter site with a standby receiver which could be activated by a remote control signal on its frequency. The transmitter sites could be placed into repeater operation by this technique in the event that leased lines or receiver networks are disabled.

APPENDIX A

COMPLETE COST DETAILS FOR THE MRP

The following tables contain the detailed cost estimates for the ECCCS MRP equipment, installation labor and engineering required to implement the plan. Detailed design engineering is estimated at 80.0K for FY '76 and 39.0K for FY '77 based on a rate of $40,000 per engineering man-year.

Table A-1. Cost estimate for ECCCS MRP backbone equipment

Item	Description	Unit Price	Unit	FY '76 Qty.	FY '76 Cost	FY '77 Qty.	FY '77 Cost	FY '78 Qty.	FY '78 Cost	FY '79 Qty.	FY '79 Cost	FY '80 Qty.	FY '80 Cost	Total
1.0	Backbone System Equipment													
1.1	Installation Material (Cable tray, racks, jackfields, encoders, decoders)													
a.	Receiver Sites	$ 2,046	lots	11	$ 22,506	24	$ 49,104							$ 71,610
b.	Transmitter Sites	1,998		2	3,996	5	9,990							13,986
c.	Transceiver Sites	1,780		-		1	1,780							1,780
d.	Bureau Control Centers	2,985		1	2,985	3	8,955							11,940
e.	Mt. Lee	2,985		-		1	2,985							2,985
f.	Central Dispatch Center	4,115		-		1	4,115							4,115
	Subtotal				29,487		76,929							$686,685
1.2	Antenna and Feedlines													
a.	200 ft. Installation	[illegible]		11	9,196	20	16,720							25,916
b.	75 ft. Installation	529		12	6,348	27	14,283							20,632
	Subtotal				15,544		31,003							46,547
1.3	Towers													
a.	150 ft.	7,452		5	37,260	10	74,520							111,780
b.	Stub	385		6	2,310	14	5,390							7,700
	Subtotal				39,570		79,910							119,480
1.4	RF Systems													
a.	Multicouplers	850		14	11,900	24	20,400							32,300
b.	Diplexers	5,700		4	22,800	12	68,400							91,200
c.	Duplexers	320		4	1,280	12	3,840							5,120
	Subtotal				35,980		92,640							128,620
1.5	Microwave													
a.	RF Terminals (Hot Standby)	21,345	lots			4	85,380							85,380
b.	CCITT Multiplex	83,742	lots			1	83,742							83,742
c.	Low Density Multiplex	2,300	each			22	50,600							50,600
d.	Subcarrier Modems	2,000	each			8	16,000							16,000
	Subtotal						235,722							235,722
1.6	Traffic Monitoring System	49,900	each							1	49,900			49,900
	TOTAL				$120,581		$516,204				$ 49,900			$686,685

CONTINUED

1 OF 2

Table A-2. Cost estimate for ECCCS MRP fixed site radio equipment

Item	Description	Unit Price	Unit	FY '76		FY '77		FY '78		FY '79		FY '80		Total
				Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	
1.1	Voice Equipment													
a.	Receiver/Encoders	$ 1,375	each	66	$ 90,750	82	$112,750	52	$ 71,500	45	$ 61,875	33	$ 45,375	$382,250
b.	Comparators	1,667	each	6	10,002	12	20,004	8	13,336	3	5,001	3	5,001	53,344
c.	Input Modules	180	each	70	12,600	80	14,400	66	11,880	45	8,100	33	5,940	52,920
d.	Keying Modules	180	each	7	1,260	11	1,980	8	1,440	3	540	3	540	5,760
e.	Test Modules	90	each	8	720	12	1,080	8	720	3	270	3	270	3,060
f.	Standby Power	57	each	7	399	11	627	8	456	3	171	3	171	1,824
g.	Transmitters	3,440	each	12	41,280	15	51,600	13	44,720	9	30,960	6	20,640	189,200
h.	RFI Cabinets	550	each	12	6,600	15	8,250	13	7,150	9	4,950	6	3,300	30,250
i.	Miscellaneous	2,000	lots	6	12,000	-		4	8,000	3	6,000	3	6,000	32,000
	Subtotal				$175,611		$210,691		$159,202		$117,867		$ 87,237	$750,608
1.2	Digital Equipment													
a.	Transceivers/Modems	4,940	each					16	79,040					79,040
b.	RFI Equipment	550	each					16	8,800					8,800
	Subtotal								$ 87,840					$ 87,840
	TOTAL				$175,611		$210,691		$247,042		$117,867		$ 87,237	$838,448

Table A-3. Cost estimate for ECCCS MRP mobile radio equipment

Item	Description	Unit Price	Unit	FY '76		FY '77		FY '78		FY '79		FY '80		Total
				Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	Qty.	Cost	
1.1	Helicopter Units	$ 1,800	each	18	$ 32,400			1	$ 1,800			1	$ 1,800	$ 36,000
1.2	Portable Units	2,500	each	150	375,000	150	375,000	800	2,000,000	800	2,000,000	600	1,500,000	6,250,000
1.3	Vehicular Adapters	330	each	100	33,000	100	33,000	600	198,000	600	198,000	600	198,000	660,000
1.4	Base Station Units (TACPACS)	3,500	each	7	24,500	2	7,000	4	14,000	4	14,000	5	17,500	77,000
1.5	Motorcycle Unit	1,300	each	60	78,000			150	195,000	150	195,000	140	182,000	650,000
	TOTAL				$542,900		$415,000		$2,408,800		$2,407,000		$1,899,300	$7,673,000

1200-75-26

Table A-4. Cost estimate for EGCCS MRP backbone equipment installation labor

Item	Description	Unit Price	Unit	FY '76 Qty.	FY '76 Cost	FY '77 Qty.	FY '77 Cost	FY '78 Qty.	FY '78 Cost	FY '79 Qty.	FY '79 Cost	FY '80 Qty.	FY '80 Cost	Total
1.0	Backbone System Equipment	$ 25	hour											
1.1	Installation Material													
a.	Cable Trays			1240	$ 31,000	2560	$ 64,000	120	$ 3,000					$ 98,000
b.	Racks			620	15,500	1280	32,000	60	1,500					49,000
c.	MDF Assembly			640	16,000	1380	34,500	64	1,600					52,100
d.	Interconnection			1840	46,000	3920	98,000	180	4,500					148,500
	Subtotal				108,500		228,500		10,600					347,600
1.2	Antenna and Feedlines			75	1,875	190	4,750	100	2,500					9,125
1.3	Towers													
a.	150'			2625	65,625	5370	134,250							199,875
b.	Stub			200	5,000	440	11,000	40	1,000					17,000
	Subtotal				70,625		145,250		1,000					216,875
1.4	RF Systems													
a.	Multicouplers			110	2,750	240	6,000							8,750
b.	Duplexers/Diplexers			15	375	25	625	15	375					1,375
	Subtotal				3,125		6,625		375					10,125
1.5	Microwave													
a.	RF Terminals			40	1,000	80	2,000							3,000
b.	Multiplex/Modems			120	1,000	420	10,500	200	5,000					18,500
	Subtotal				4,000		12,500		5,000					21,500
1.6	Traffic Monitoring System					64	1,600							1,600
	TOTAL				$188,125		$399,225		$19,475					$606,825

Table A-5. Cost estimate for ECCCS MRP radio equipment installation

Item	Description	Unit Price	Unit	FY '76 Qty.	FY '76 Cost	FY '77 Qty.	FY '77 Cost	FY '78 Qty.	FY '78 Cost	FY '79 Qty.	FY '79 Cost	FY '80 Qty.	FY '80 Cost	Total
1.1	Receivers	$ 25	hour	154	$ 3,850	176	$ 4,400	200	$ 5,000					$ 13,250
1.2	Comparators			74	1,850	84	2,100	84	2,100					6,050
1.3	Transmitters			56	1,400	78	1,950	100	2,500					5,850
1.4	System Alignment			306	7,650	248	6,200	360	9,000					22,850
1.5	Field Engineering			270	6,750	310	7,750	360	9,000					23,500
1.6	Project Engineering			270	6,750	310	7,750	360	9,000					23,500
1.7	Material Handling			361	9,025	414	10,350	414	10,350					29,725
	subtotal				$ 37,275		$ 40,500		$ 46,950					$124,725
	LA [illegible][1]													
2.1	Vehicular Adapters	$ 600	Inst.	100	$ 60,000	100	$ 60,000							$120,000
2.2	Helicopter Units	1,388	Inst.	18	24,984									24,984
2.3	Base Station Units	2,000	Inst.	7	14,000	2	4,000							18,000
2.4	Motorcycle Units	400	Inst.	60	24,000									24,000
	subtotal				$122,984		$ 64,000							$186,984
									$ 64,000		$ 64,000		$ 64,000	$192,000

Note:

1. After FY '77 it is assumed that the LA [illegible] budget is augmented by 64K per year for installing and removing fixed and mobile equipment.

END