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900 MHz TRUNKED COMMUNICATIONS SYSTEM FUNCTIONAL REQUIREMENTS DEVELOPMENT

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900 MHz TRUNKED COMMUNICATIONS SYSTEM FUNCTIONAL REQUIREMENTS DEVELOPMENT

**THE IDENTIFICATION OF THE SPECIFIC OPERATIONAL
CAPABILITIES THAT SHOULD BE INCORPORATED IN A
DEMONSTRATION TRUNKED COMMUNICATION SYSTEM FOR
LAW ENFORCEMENT AGENCIES**

BY

THE ASSOCIATED PUBLIC-SAFETY COMMUNICATIONS OFFICERS, INC.



PROJECT 16-A

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PREPARED UNDER GRANT NO. 78 SS AX 0021

from the

LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

UNITED STATES DEPARTMENT OF JUSTICE

**THIS REPORT WAS PREPARED UNDER A LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
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EXECUTIVE SUMMARY

APCO's Project 16 pointed out that the opening of the 900 MHz band by the FCC under Docket No. 18262 offered the public safety communications community the opportunity to develop communication systems having significantly enhanced capabilities. The advent of trunked communications systems, as mandated in this Docket, coupled with the development of technically feasible and economic digital address techniques, makes possible an entirely new approach to public safety communications systems design.

Communications systems using these concepts can be organized by the use of digital addresses for each system user, rather than relying on pre-assigned frequencies to provide individual communications links. The inherent flexibility of these digital addressing techniques permits the incorporation of highly flexible command/control concepts, the use of group and discrete unit addressing, flexible, centrally controllable, system configuration and reconfiguration, and other management tools heretofore unutilized by public safety communications systems designers.

The application of these techniques makes possible the growth of a single agency system into one capable of supporting all of the mobile radio communications requirements of a community while at the same time maintaining the necessary operational prerogatives and privacies of individual using agencies.

This document constitutes the second phase of an APCO/LEAA sponsored program to make these capabilities available to the public safety communities throughout the United States. Its purpose is to define those specific characteristics and functional capabilities that such a system should have. It addresses such characteristics as:

- channel access times
- automated priority recognition
- data systems interface
- individuality of system users
- command/control flexibility
- system growth capability
- frequency utilization
- reliability

It also lists desirable features that may be selected should they be required by individual procuring agencies. The intention is to bring about a system concept that will satisfy the minimum needs of all potential users and that will also permit the inclusion of more complex requirements that may be needed by some communities or may become desirable at some point in the future.

The document describes a multi-channel mobile communications system that employs digital addressing techniques and frequency switching systems to optimize user flexibility and channel access. The system concept envisions a central switching unit that, upon request for service, identifies an unused channel. A signaling system, coupled with the assignment of digital addresses to all units of the system, directs the units between which communication is desired to automatically switch to the selected RF channels.

By having the address include both group and discrete elements, groups of units can be switched to the selected frequency if desired. In this way the multiple unit communications requirements of public safety users can be satisfied. By assigning different group addresses to different functions (or agencies), separate users can maintain a requisite level of communication integrity or privacy.

This addressing technique greatly enhances system flexibility. The number of individual, functional assignments can be determined by the number of group addresses used, rather than by the number of frequencies assigned to the system. The system defined by this document specifies that no less than 100 group addresses be available. These group addresses may (at the user's discretion) be operator selectable, thereby permitting considerable operational flexibility.

The operation of this system is basically controlled by the configuration of the system controller. This switch can be configured such that its protocols may be altered to fit differing operational needs. Group addresses that normally operate independently of each other can be combined for emergency actions. Automatic priorities can be assigned (or reassigned) to specific group addresses. Features such as automatic status reporting and mobile digital access can be included at the choice of the procuring agency.

This document is not intended to provide a specific system design. It defines mandatory and desirable system performance capabilities. The particular operational needs of the using communities must be spelled out in their individual procurement actions. The detailed techniques by which these capabilities are best provided are to be determined by the vendor community. The purpose of this document is to spell out what the system must do to meet the needs of the public safety community, now and in the future.

ACKNOWLEDGMENTS

This functional requirements document presents a description of a new approach to providing communications services to law enforcement and other public safety agencies within a community. It applies the functional capabilities made possible by modern technology to the long-standing needs of public safety communications. As such, it represents a combination of two major areas of knowledge and experience, i.e., the operational capabilities that such systems must provide, and the functional possibilities now permitted by engineering developments.

The preparation of such a document depends heavily upon the professional expertise of its contributors. Not only must they have the in-depth knowledge of their field, but they must also possess the imagination and foresight needed to perceive how new and heretofore unknown concepts can be applied to the solution of present and future problems. The public safety community is indeed fortunate to have access to such individuals serving at many levels of government and with the vendor community. Their professional skills, initiative and dedication have made this document possible.

The Federal Communications Commission and the members of its staff that early perceived a role for trunked systems in the improvement of spectrum efficiency deserve great credit for their foresight. The land mobile communications community also owes a debt of gratitude to the Law Enforcement Assistance Administration and its staff for the leadership and financial support that has made possible the application of these new techniques to law enforcement communications problems.

The APCO Board of Officers, constituted as Project 16A Task Group I, and those members of APCO who donated their time and professional skills, on a voluntary basis, to provide that operational experience and professional knowledge upon which this document is based, deserve the gratitude of all.

Particular appreciation should be expressed for the leadership of the communities of Lexington, KY; Phoenix, AZ; Bucks County, PA and Salt Lake County, UT. Their foresight and cooperation, as demonstrated by their participation in this project and the designation of their highly skilled and professionally competent representatives, have constituted a major source of the technical, operational and management expertise so vital to this document.

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INTRODUCTION

The opening of the 900 MHz^{1/} spectrum for land mobile communications in 1976, coupled with the FCC mandated requirement for the application of trunking techniques to those systems requiring more than five channels, confronted the public safety communications systems designers with a new set of problems and opportunities. APCO's Project 16, conducted under a grant from the Law Enforcement Assistance Administration (LEAA), analyzed these concepts and concluded that the implementation of trunked 900 MHz systems, exploiting the opportunities inherent in the digitally addressed, trunked concept, presented the opportunity to make a major step forward in the development of new capabilities in public safety communications systems.

Digital addressing techniques, particularly applicable to the operation of trunked systems, have long been employed by the Department of Defense and commercial services. Advances in technology now offer economically feasible and technically practical possibilities for the use of such techniques in public safety systems. By permitting systems organization to be based on group and discrete addressing systems, rather than on the assignment of discrete frequencies, an entirely new approach to system configuration is possible.

Digital addressing permits communication with designated (or "addressed") units. By assigning "groups" of units common or "group" address indicators, in addition to their individual unit (or discrete) address, communications are possible among all members of that group. Units not in the "group" are not parties to the communications. Group addresses can be assigned organizationally or functionally, or both, thereby permitting organizational or functional privacy, i.e., police department members only, fire department members only, etc. Similarly,

^{1/} This newly available spectrum has been referred to by several appellations during the development of Docket No. 18262. Technically, it is a portion of the UHF band and currently it is frequently referred to as the "800 MHz" band or the "860 MHz" band. During much of the period in which Docket No. 18262 was active, the entire portion of the spectrum under consideration in that Docket was widely referred to as the "900 MHz" band. In deference to this historical precedent, this Report will continue to use that term to designate that portion of the spectrum available for land mobile radio service use between 806 MHz and 870 MHz.

addresses can be assigned to patrol divisions, detective divisions, mutual aid needs, or other agency requirements.

The use of addressing by groups as well as by individual units permits agencies within the community to utilize a common communications system while still maintaining requisite operational independence and integrity. By careful design of the system's signaling concept, many specialized operational features such as automatic status reporting and priority of access, flexible command and control organization, system privacy, and other needed features often impractical in conventional networks, are now possible.

The development of such a system, wherein the potential capabilities are so many, poses a special need to initially define those minimum functions that the system must satisfy. Desirable features should also be identified so that vendors can develop cost estimates, thereby making possible cost benefit tradeoffs.

This document presents a description of those functional requirements that a digitally addressed, trunked, 900 MHz system should have to satisfy the needs of the public safety community. It specifies those features that will permit such a system to meet the mobile communications needs of a community government. It describes how the individual elements of a digitally addressed, trunked system contribute to the operation of the entire system.

The purpose of this document is to provide a basic, descriptive framework of system operation and capabilities that can be used by designers of individual community systems. It is intended to identify a framework of mandatory and desirable functional capabilities from which system designers can select those features needed to satisfy the requirements of their communities.

This document provides an overall statement of the systems' operation. It defines mandatory minimum system performance requirements. It also lists desirable features that may be chosen by individual procuring agencies to satisfy their needs. Subjects more properly defined in individual systems procurements, except as they affect or are affected by the functioning of the digitally addressed, trunked system characteristics, are left to the discretion of the individual procuring agencies. This is done not to negate the importance of such factors, but rather to confine the scope of the document to those topics related to the operation of digitally addressed, trunked radio systems.

This document provides a generalized description of system operation, applicable to all digitally addressed, trunked systems. Those specialized requirements peculiar to an individual using agency should be spelled out in subsequent individual system procurements. The goal

of this functional description is to assure that necessary requirements are defined for use by potential system developers, that system signaling and configuration concepts permit the incorporation of specialized features that some users may find desirable, and that needed capabilities of any user are not inadvertently precluded by some factor inherent in the system design.

The functional requirements document is a description of system operation. It may be used as the basis of, but not a substitute for, individual procurement specifications to be developed by procuring communities. Such specifications should describe the specific system-related requirements of the user.

Because of the scope and complexity of this functional requirements document, the individual Sections have been prepared such that they can stand alone to provide a ready reference to the reader. Each Section, therefore, has been made as complete as possible. This may result in a certain amount of redundancy, hopefully justified by increased usefulness to the user.

DEFINITIONS

The definitions below are intended to explain those terms used in this document in the particular connotation of digitally addressed, trunked, radio communications systems.

System control center:	A physical location at which technical control of the system can be exercised. This location should include system status displays, reprogramming capability for the system controller, channel monitoring equipment, and other system management and control features as may be required.
System controller:	An automatic switching device that interfaces between dispatch locations, the signaling system and the voice channel RF equipment. Its function is to identify an available RF channel, direct the signaling system to move the addressed unit or units to the selected channel, and to control those automatic functions necessary for system operation.
Address:	The information which uniquely diverts a communication from one terminal point to another.
Digital address:	An address resulting from the assignment of a unique code set consisting of only two code elements.
Discrete address:	A digital address assigned to a single unit or user of the system.
Group address:	A digital address assigned to two or more units of the system. All units having a common group address will have access to all messages within that group. Typically, units in the system will be assigned both group and discrete addresses.
Universal address:	A digital address that is assigned to all units in the system. A special group address.
Dispatch location:	The physical location of agency dispatching/operational personnel. There may be several dispatch locations in one system. One or

more may serve one agency while others may serve other agencies. A dispatch location will have one or more dispatch positions.

Dispatch position:

Those equipments, displays and control capability at which one operator interfaces with the system. There may be more than one dispatch position at each dispatch location.

Signaling system:

The means by which units in the system are addressed and directed to perform switching and reporting functions necessary to satisfy the specified functional requirements. The signaling system includes the signaling language, switching equipment, and signaling transmission techniques needed for system operation.

Synergistic:

A condition whereby the results of a cooperative endeavor yields benefits greater than the sum of the individual contributions.

SECTION I

THE DEVELOPMENT PROGRAM

1.1 General

The introduction to the public safety community of new operational capabilities made possible by the digitally addressed, trunked system (DATS) techniques requires an extensive program that includes feasibility study, the definition of functional requirements, implementation planning, demonstration and testing, and the system evaluation. As originally conceived by APCO, this program is described in detail in Chapter 5 of the Final Report of APCO's Project 16. 1/ This Functional Requirements Document constitutes the second step of this program. It defines the system functional capabilities that must be satisfied to meet the needs of the public safety communications community. The follow-on phases of the program, including implementation planning, test and demonstration, will be discussed below under three headings: the implementation planning program, the development and demonstration phase, and the evaluation and technology transfer phase.

1.2 The System Implementation Planning Program

1.2.1 Community planning needs

The efficient implementation of these advanced systems represents significant economic investment. Adequate implementation planning must be accomplished by each implementing community to insure that such systems are mutually supportive, and that schedules accommodate the operational needs and functional responsibilities of agencies whose operations are affected. Above all, implementation planning must assure the continuation of uninterrupted public safety services.

This implementation planning requires the resolution and documentation of diverse technical, economic and managerial problems. The interface with related systems, either in being or planned for the future, must be defined both technically and procedurally. The communications language and support organizations must be configured to accommodate existing or planned information

1/ Copies of this document may be obtained through the National Office of APCO, P.O. Box 669, New Smyrna Beach, Florida 32069.

systems needs.

Planning and scheduling concepts must reflect economic and contractual demands and the availability of funds. Such planning must also identify the specific spectrum requirements and regulatory factors affecting the availability of needed frequencies and with sufficient detail to comply with Federal Communications Commission (FCC) requirements. The development of such plans must make possible the preparation of detailed, accurate and comprehensive Requests for Proposals (RFPs).

No standardized approach to major systems implementation planning is available on a national basis to the public safety community. This poses problems to many communities as they attempt to improve the cost effectiveness and efficiency of their communications capabilities through the introduction of modern systems.

To assist communities participating in the development program it is planned to develop a format of a Systems Implementation Plan (SIP) that will provide a basis for the development of individual SIPs by each community. It is intended that each of the individual communities participating in the demonstration program will be provided assistance during the SIP phase. This SIP phase will include the following:

- 1.2.2 Determination of the phasing for system implementation. It is expected that communities may choose to implement the system in several steps, i.e., perhaps a mobile system for police only, then the addition of other public safety systems, followed by the expansion of the system to incorporate those additional government agencies deemed appropriate. A portion of this phasing identification will be the development of concepts relating to the integration of portable radio systems, either through conventional systems interface or the eventual incorporation of trunked portables when available.
- 1.2.3 A second requirement would be the aggregation of system requirements. This includes the determination of those specific community-related needs that will form the quantitative basis for the system procurement that will form the basis of the demonstration program.
- 1.2.4 The preparation of Notices to the FCC regarding spectrum requirements.
- 1.2.5 The development of plans for system procurement, installation and cutover.

Details of this phase of the program will be as spelled out in the SIP documents by the individual communities.

1.3 The Demonstration and Test Phase

1.3.1 Purpose

The application of the DATS capabilities to community public mobile communication needs involves the application of concepts and technologies in ways heretofore not applied to the public safety sector. The focus of this program will, therefore, be to assure that such new techniques do in fact satisfy the needs of the using agency. This requirement presents two considerations: first, that the techniques are realizable by available, reliable hardware; and secondly, that this hardware, configured as a system, provides the capabilities specified by the using agency.

The implementation of a conventional communications system seldom requires the demonstration of both of these two points. The operation of radio systems is well understood, and the services that they provide to the using agencies are well known. In the usual implementation program, specifications for radio system performance are prepared and acceptance tests of delivered equipments conducted to show that such equipments in fact meet the specifications established.

1.3.2 Signaling System Demonstration

The introduction of the new concepts contained in the digitally addressed, trunked system technology may require development efforts before such systems can be procured on a more or less routine basis. For example, the signaling language and sufficient switching hardware must be assembled to show that they can satisfy the functional requirements established for the system. The extent to which this will be accomplished by the vendor community as part of their in-house engineering programs or, on the other hand, that may require public financing, will be dependent upon a number of factors such as perceived market potential, timing of demonstration project procurements, the rate of technological developments, and complexity of the functional requirements.

As part of a demonstration and test phase, an evaluation of system signaling concepts should be conducted. This evaluation can be conducted as a separate prototype

SECTION II

SYSTEM DESCRIPTION

2.1 General

A digitally addressed, trunked land mobile communications system for law enforcement, other public safety, and related governmental agencies must be capable of providing the complete mobile communications requirements of the implementing governmental agency. Through automatic switching techniques inherent in the trunked concept, it makes optimum use of the assigned radio frequencies. The digital addressing concepts also make possible the exercise of private, flexible command/control of the resources of the agencies using the system while permitting necessary and adaptable intra- and inter-agency communication, as may be configured or reconfigured to meet the changing needs of the community.

2.2 System Users

The system will ultimately be capable of supporting the total mobile communications needs of the community. By so doing, it can optimize frequency usage and permit improved interagency cooperation and emergency response through enhanced interagency communications in times of need.

Public safety agencies will usually be the initial users of the system. The large numbers of units of such agencies and their needs for command/control flexibility make digital addressed systems of special value to these agencies. Other governmental agencies will also benefit from the emergency access capability of the systems and the variety of operational uses permitted by the selectable group address designations.

The combining of these agencies into one system, each still maintaining their individual system privacy, will permit more effective response to total public safety needs when interagency communications are required.

The combination of access to all frequencies, with an automatic priority system established to accommodate operational precedence needs in those rare instances where loading might possibly result in contention for channels, will permit synergistic benefits to all system users. While each user will effectively have access to as many frequencies as assigned in a conventional system, the automatic potential for access to all the frequencies in the system offers a potential for a level of service considerably in excess of that possible using conventional, a priori frequency assignment.

activity or as part of the engineering phase of implementation contracts. Procuring activities should be provided data describing the functioning of the signaling system in connection with actual hardware to demonstrate that the system performs those functional requirements called out in the individual procurement documents. This data should be provided before equipment installation proceeds.

1.3.3 Implementation, Cutover and Acceptance Testing

Implementation of demonstration systems will involve the procurement, installation, cutover and testing of new equipments by each of the participating communities. These activities must be conducted in accordance with the particular operational, managerial, environmental and fiscal requirements of each community. Installation and cutover must be accomplished with a minimum disruption of activities and without impediment to necessary public safety services.

Normal hardware unit acceptance testing should be accomplished in accordance with the usual community procurement procedures and the dictates of the individual community SIP. Provisions should be included in the SIP for system performance testing. Where practical, such system testing should be conducted on an incremental basis, to evaluate the system's compliance with specifications, both from a qualitative and a quantitative standpoint.

Adequate documentation of all levels of testing should be maintained and made available to other potential users of the system.

1.4 The Evaluation and Technology Transfer Phase

Upon completion of systems implementation and acceptance testing by the procuring agency, a program should be implemented to evaluate the performance of the system in the operational mode and to accumulate that data necessary to make possible repetitive procurements by other potential users. This evaluation phase must be directed particularly toward identifying the contributions that the introduction of the trunked, digitally addressed technology has made to the using agency and the functioning of the community as a whole. This includes not only factors relating to agency capabilities but also an evaluation of the contributions such systems might make to improve agency efficiency.

Since the system permits independent dispatch locations and private group addresses with appropriately assigned priority access, increased management flexibility and reduced maintenance and operational costs can result by incorporating all governmental mobile communications needs into a single system. Such users as senior executive personnel can have access as deemed appropriate. School bus systems, highway maintenance, and similar governmental users can share the system. Significant overall spectrum savings can result by exploiting the difference in the times of peak loads of general government users and public safety agencies.

2.3 Concept of Operation

- 2.3.1 Trunked system concepts derive from telephone experience. Telephone systems, by using switches in the vicinity of major concentrations of subscribers, select from available "trunk" lines between switches to permit communications between subscribers in different areas (see Figure 2.1). In this manner a large number of subscribers at each switch location have access to any available or unused trunk between switches.

Radio experience has long been confined by the a priori assignment of common frequencies as a means for conducting communications between designated users. In the event that a frequency assigned to two pre-assigned users is not in use, other users, who may be in the same system but have been assigned a different frequency, must wait the availability of their frequency to communicate, despite the non-use of another frequency in the same system. This means that a user desiring access to a loaded dispatch frequency must await availability of that frequency despite the fact that another frequency in the system, such as an interagency communications frequency, might not be in use.

The development of modern solid state technology and advances in radio system equipment design have made possible the practical application of the trunked philosophy to radio systems. The fundamental concepts involved are shown in Figure 2.2. Assigned frequencies are established at a base station. A "system controller", or system switch, automatically identifies which of these frequencies is not in use at any time a request for service is made. Using a command link (or as it will be called in this document, a "signaling system"), individual mobiles to whom the communications are addressed or from which the request for service is initiated are automatically advised of the available frequency. The mobile is then automatically switched via instructions through the signaling system to the selected frequency.

THE TRUNKING CONCEPT
TELEPHONE VERSION

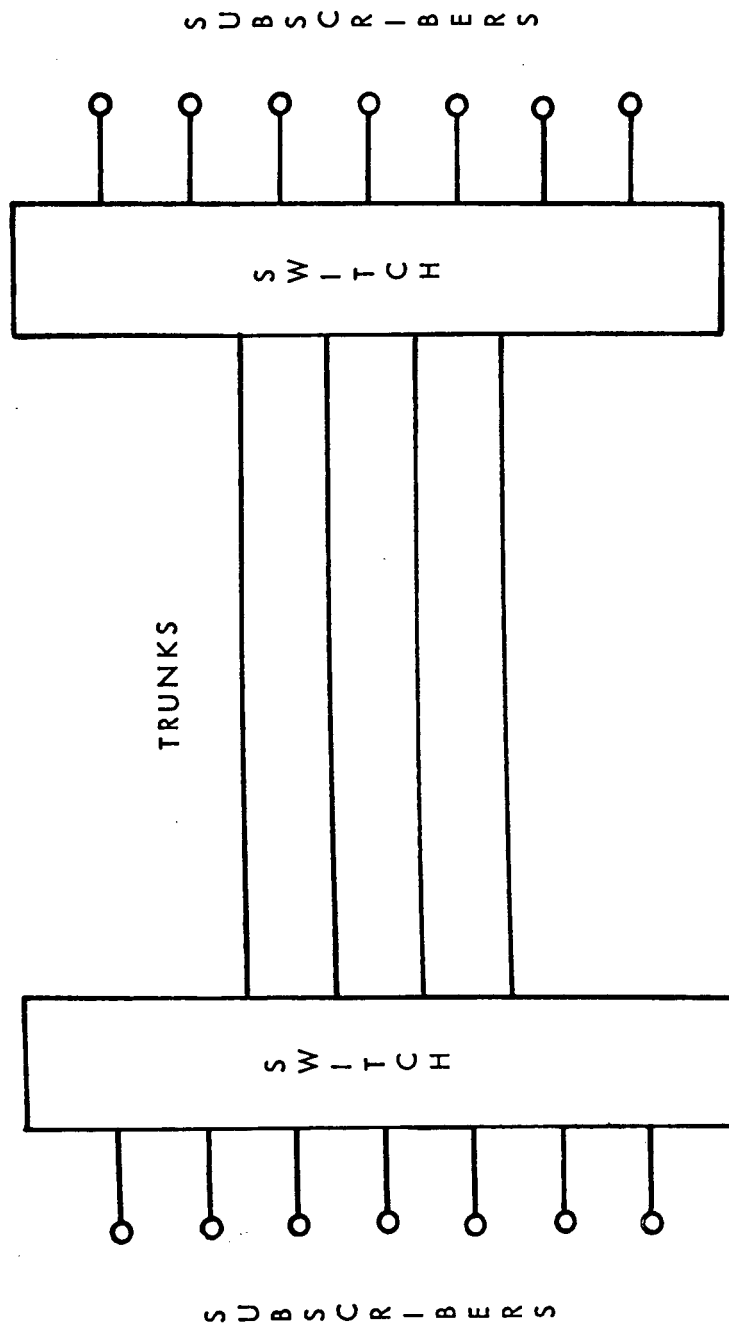


Figure 2.1

THE DIGITAL ADDRESS CONCEPT

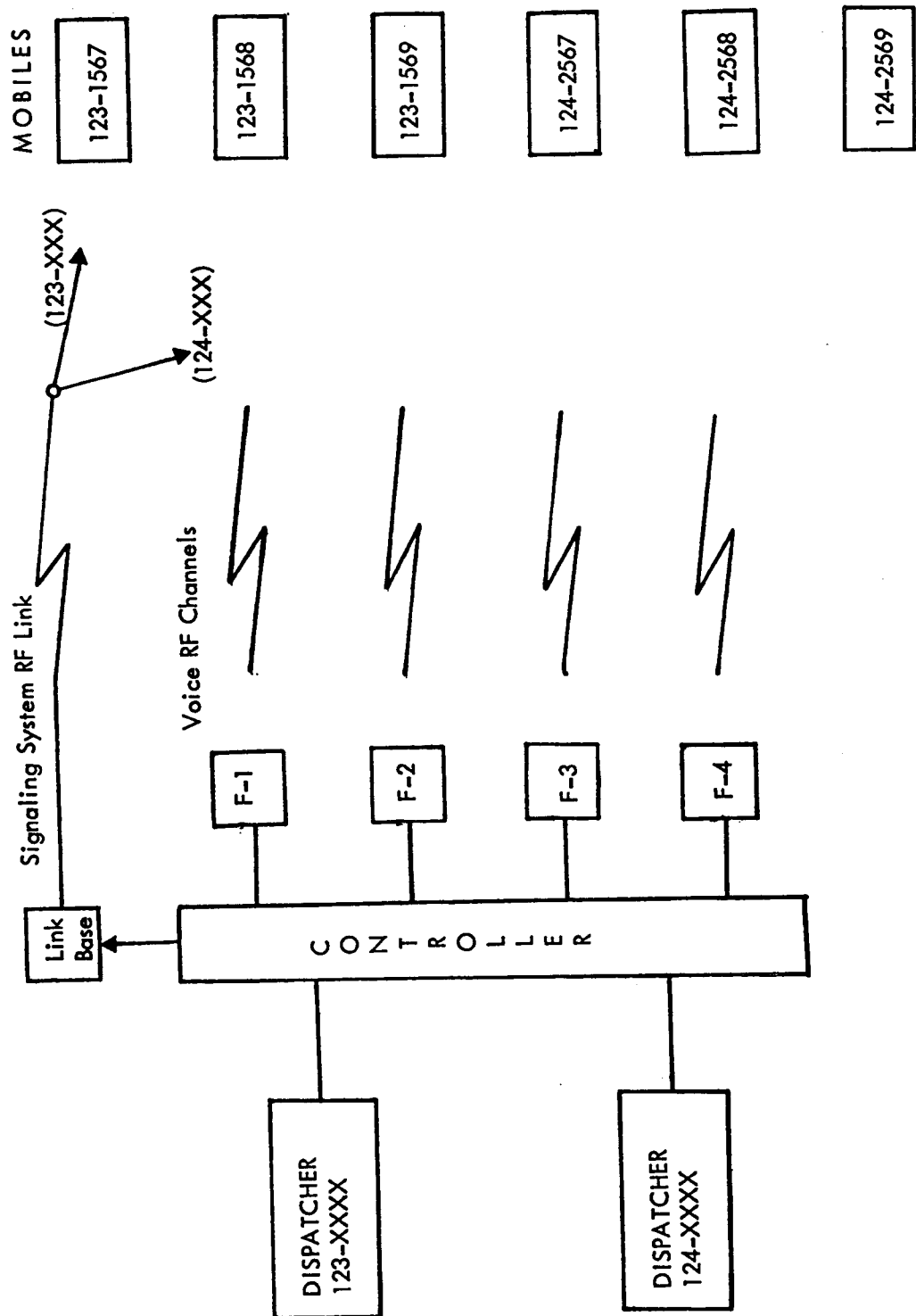


Figure 2.2

After communications are complete on this assigned frequency, the mobile reverts to monitoring the signaling system.

The functioning of this system derives from the ability of the signaling system to not only select an available frequency but also to address the particular mobile unit to whom the communication is directed. This addressing ability is made possible through the assignment of a digital address to each unit in the system.

The digital addressing concept used is at the discretion of the system designer. In systems such as public safety networks wherein communication between groups of units is required and where the communications network must support a command/control philosophy that complies with agency organizational concepts, the use of a two-part addressing technique is especially attractive.

This two-part address includes a discrete address assigned to each unit in the system and a group address which may be assigned either permanently to groups of units requiring common communications or which may be selectable at the unit operator's or system manager's will.

- 2.3.2 The basic concept of operation of this system hinges on the ability of a system controller that automatically identifies an (assigned) RF channel that is not in use, contacts a designated recipient by use of a signaling system, and directs the call recipient's equipment to the selected RF channel, enabling direct communication to pass between the initiator and the recipient.

This signaling system employs digital addressing techniques that identify the unit to which the call is directed. These techniques permit adaptable system organization and system reconfiguration to meet varieties of operational needs. Through identifying units by means of both discrete and group addresses, communication can be accomplished individually or among designated groups of units. By switching the group address of a unit, that unit can leave one group and communicate with one or more other groups or units. Groups can be established and rearranged almost immediately by the system controller.

2.4 System Elements

A trunked, digitally addressed public safety land mobile communications system will include the following elements (see Figure 2.3):

- dispatch locations;
- system controller;
- base station RF and control equipment;
- mobile units;
- signaling system;
- interface equipment.

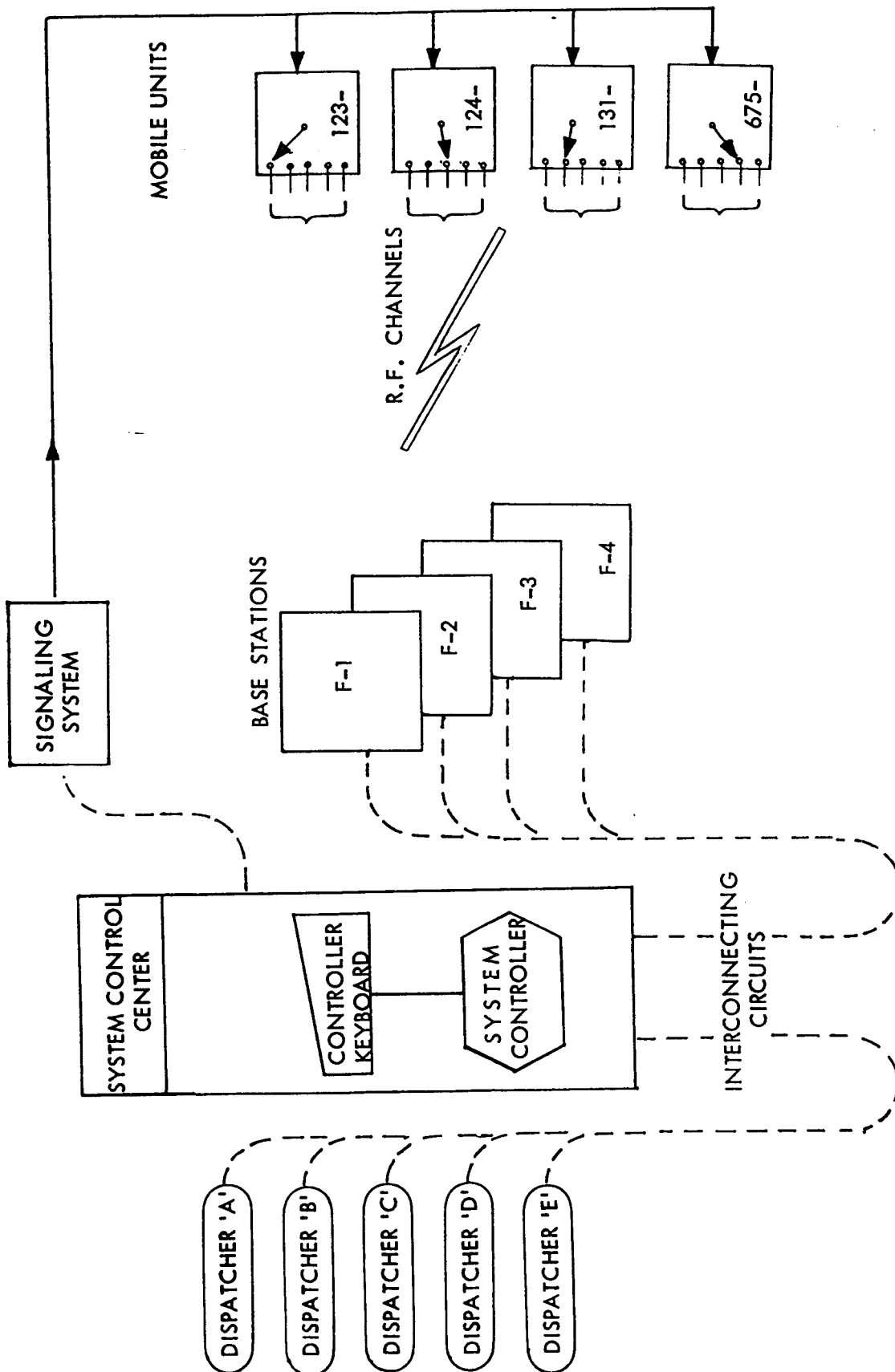
These elements are combined to provide a land mobile radio system that permits two-way communications between dispatch locations through the base station and one or more mobile units, and/or between two or more mobile units, individually or in groups. ^{1/} The system configuration in many ways follows that of conventional multi-channel land mobile radio communications systems. Individual base station transmitters, receivers and antenna systems operate from an optimally selected site to provide coverage of the required area. Mobile units incorporating multi-channel transmitters and receivers must incorporate the capability of having the operating channel selected by means of a signaling system. A system controller, or automatic switching device, selects the base station transmitters and receivers channel and directs the signaling system to move selected ("addressed") mobile units to the appropriate frequency.

2.5 System Operation

When a dispatch position initiates the call, the system controller determines which of the RF channels is available. This decision will incorporate necessary considerations of priority and/or addressing. The system controller then causes a signaling message to be transmitted to the unit(s) with which the communication is to be established. The signaling message directs each unit to automatically switch to the frequency selected by the system controller. After both the base station and the mobile unit have reached the designated channel, communications can begin.

Each unit in the system has an address composed of three parts,

^{1/} There is nothing in the digitally addressed, trunked system concept that precludes multiple base stations rebroadcasting or "simulcasting" techniques. For the purpose of this functional requirements statement, however, a single base station site will be assumed. Those systems requiring multiple site installations should incorporate necessary requirements in their procurement specifications. This functional requirements statement does incorporate those requirements related to satellite receiver systems.



THE TRUNKING CONCEPT
MOBILE RADIO

a universal address, a group address, and a discrete address. The universal address is assigned to all units. The discrete address is particular to the individual unit. The group address may (but not necessarily must) be assigned to a number of units whose operational requirements make it necessary for each to hear all communications within the group. These group addresses may be changeable by the operators of the units (both fixed and designated mobile) so that communication with various groups can be established at will. The designation of the functions of these group addresses is under direction of the systems management and may be changed by access to the protocols of the system controller.

The message sent by the signaling system to the mobile unit incorporates both the discrete address of that mobile unit and a group address. Depending on operational needs, one or more designated mobile units may use the same group address. By use of the group address, dispatchers and other mobile units can broadcast to a predetermined group of mobile units simultaneously.

In normal operation all mobile units monitor the signaling system when not in active communication with other units in the system. They move to a designated frequency when so directed by instructions received via the signaling system. When a mobile unit desires to initiate a call, it initiates a request for channel access via the signaling system to the system controller. The system controller then treats this request similar to a dispatcher request. The system controller determines which RF channel is available, directs the mobile unit to move to that channel, and activates the appropriate base station transmitter and receiver pair. All other units having the same group address are similarly instructed to move, via the signaling system, to the selected RF channel. In this manner all units having the same group address monitor all communications within their group. Normal communication between mobile units will be through the base station, using it as a mobile relay.

Continuous channel assignment updates must be transmitted repetitively via the signaling system, indicating all currently active channel assignments. This will insure that any unit coming into service or entering the RF coverage area while a message to his group is in progress will be promptly directed to the appropriate channel.

The characteristics of the signaling system and the functions made possible by the organization of the group and discrete addressing protocols permit considerable operational flexibility. The ability to manually alter the operational program of the system controller permits re-configuration of the system to meet changing operational needs.

2.6 Generalized System Requirements

The following is a listing of generalized system functional requirements. This listing is provided to insure that the basic system design and signaling system be configured to permit these functional capabilities. Individual procuring agencies may select various levels of capability or combinations of capabilities, i.e., a system might include many mobiles with only a minimum of address flexibility, with only a few having greater capabilities. Basic system design must permit selection of those mandatory features (identified by (M)) and should permit choice of desirable features (identified by (D)).

- (M) 2.6.1 Those RF channels assigned to the system will be automatically selected in accordance with their availability such that all system users will have access to all assigned voice channels in accordance with the established system priority protocol.
- (M) 2.6.2 The basic system will have a minimum of six channels. It will be expandable in steps of one or more channels to a maximum of 20 channels.
- (D) 2.6.3 For those systems that may be required to support user requirements in excess of 20 channels, systems designs will incorporate the capability of interfacing each 20 channel system with one or more additional systems, each having a maximum capacity of 20 channels.
- (M) 2.6.4 The signaling language will be capable of supporting 20 channels having a maximum of 1,600 in-service mobile units and 20 dispatch locations for each system. Sufficient addresses will be available to support at least 4,000 discrete addresses.
- (M) 2.6.5 The basic six channel system hardware will be capable of supporting a minimum of six dispatch locations, each of which will permit use of no less than five dispatch positions. For each channel in addition to the basic six channels, provisions for at least one additional dispatch location will be added.
- (M) 2.6.6 The signaling language will permit each system to assign no less than 4,000 discrete mobile addresses and 100 discrete dispatch position addresses, regardless of system size.
- (M) 2.6.7 All dispatch positions and mobile units will be capable of being assigned group address designators that will permit communications between individual dispatch positions, groups of dispatch positions, individual mobile

mobile units, groups of mobile units, or combinations thereof. All units operating within the same group will receive both sides of all communications (except digital information) addressed to or from the group.

- (D) 2.6.8 Dispatch locations may or may not be co-located. All signaling between dispatch locations, the system controller and base station RF equipment should be compatible with voice grade (300 to 2,700 Hz) common carrier landline and/or microwave transmission standards.
- (M) 2.6.9 When one or more voice channels in the system is not in use, any system user will automatically have access to a voice channel within 1 /2 second after momentarily activating a microphone switch (or other request for channel device). The system design must automatically compensate for any signaling attempts lost due to simultaneous attempts to access. Should a voice channel not be available, the caller will be placed in a queue and be given an indication that his request has been received and queued. He will be notified automatically when he has been assigned a valid channel. The system will continue to request an available channel automatically until channel assignment has been established.
- (M) 2.6.10 Anytime that a unit is out of contact with the signaling system, an indication will be presented at the unit.
- (M) 2.6.11 Once the system controller has selected an RF channel for communication between units, those units will remain on that channel for the duration of each transmission and reception plus approximately two seconds. Should there be no transmission addressed to the group address using the channel within the two-second "hang" time, all units of that group will revert to the signaling system monitoring condition.
- (D) 2.6.12 The two-second "hang" time will be capable of being terminated by activation of a manual switch.
- (M) 2.6.13 The system will incorporate five levels of priority. Assignment of these levels of priority will be made at the system control center. The structure of the signaling language will be such to assure access to the signaling system in accordance with the level of priority involved. Access to the system will be only at the expense of the lowest level of priority necessary, i.e., a priority level 2 call on a fully loaded system will preempt the system from a priority level 5 user if there are any on the system; if not, priority level 4

or 3, in order. Such preemption will be indicated to the affected user.

- (M) 2.6.14 All units in the system will have the capability of seizing access to this system via an instantaneous emergency switch. Activation of this switch will permit access to a dispatch position within 1/2 second. This level of precedence is intended for use only in those instances wherein immediacy of communications is necessary to preserve safety or life.
- (M) 2.6.15 Activation of the second precedence level or below should establish communication with some or all dispatch locations as determined by the procuring or using agency involved. Activation of precedence levels will remain in effect until a dispatch position takes those actions necessary to re-establish regular operation of the system. This precedence level is intended for use by those units in the system requiring immediate access to the communications channel in the performance of the mission of their agency, i.e., law enforcement in hot pursuit, a fire system en route, or other operational need designated by the system users. This precedence level will be established by activating an appropriate control at the dispatch and/or mobile unit. It will assure access to a channel in all instances except when a priority 1 signal takes precedence.
- (M) 2.6.16 Command priority (executive and supervisory: this level of precedence will be available for designated command or supervisory personnel. Use of this precedence may incorporate systems privacy (see Sec. 3.3) if so established in the system controller. Those group addressees or mobile units assigned this level of precedence may require such priority access as a normal procedure at the discretion of the procuring agency.
- (M) 2.6.17 Operational priority: The system will be capable of providing a level of precedence to public safety functions which will preempt routine (non-public safety/administrative) activities in the event of a fully loaded system. The distinction of these classes of service shall be established in the system controller via the system central control. The system shall maintain sufficient channels for each user to provide for pre-established operational requirements.
- (M) 2.6.18 Routine: the lowest level of precedence.
- (M) 2.6.19 The system controller will have the capability to receive requests for access to the system from mobile units via the signaling system and from dispatch locations. It

will identify an unused channel and direct the signaling system to move the addressed unit or units to the selected RF channel.

- (M) 2.6.20 The system controller will incorporate those features needed to permit the switching of discrete units and/or groups of units. It will assign channels in accordance with priorities and group assignment procedures established by the system user.
- (M) 2.6.21 It will be possible to reassign the priority levels of address groups and to change address group designators by direct access (via keyboard or similar means) to the logic of the system controller.
- (M) 2.6.22 In the event of failure of a portion of the base station voice channel (either the transmitter or receiver or any portion of their related equipment), the system controller will detect such failure and give indication of the defective channel at the system control center. The controller will not select a defective channel nor designate it for use, but will continue to assign traffic to the remaining operating channels.
- (M) 2.6.23 Should any portion of the RF link of the signaling system become defective, signaling will automatically be shifted to another channel(s) while concurrently shifting other system components in accordance with a predetermined protocol. Indication will be provided at the system control center of such failures.
- (M) 2.6.24 Provisions will be made for bypassing the system controller in the event of its failure. This will permit designated dispatch locations to have direct access to predetermined RF channels for operation in the conventional mode. Failure of the signaling system will cause an indication in all mobile units and at all dispatch positions. It must be possible to then switch all elements of the system to a conventional mode of operation within one minute.
- (D) 2.6.25 The system will be capable of displaying the discrete address or group address of any unit with which a dispatch position is in communication at that dispatch position.
- (M) 2.6.26 Each dispatch position and mobile unit in the system will be capable of changing its group address to no less than six other pre-established group addresses. Each user of the system will be able to select a mode of operation that permits broadcast to all of a selected number of groups as may be assigned to satisfy operational needs. Certain designated units will be capable of broadcasting

to all units in the system. This last capability will be incorporated within the system design but may be implemented in only selected units at the discretion of the procuring entity.

- (D) 2.6.27 A sub-system controller will be available at each dispatch location capable of permitting reprogramming of addressing protocol of those group and discrete addresses that may be assigned to that agency or dispatch location. For example, a dispatch location assigned to a fire agency should have the capability of altering the addressing protocol of the group and discrete addresses of the units assigned to that agency.
- (D) 2.6.28 Provisions will be made in the system design concept to incorporate a minimum of six automatic status reports. These status reports will be sent automatically in digital burst format by a mobile unit through activating an appropriate switch on the mobile unit control head.
- (D) 2.6.29 Provisions will be made to incorporate automatic interrogation of the status of individual units from dispatch positions. Such queries will be indicated in the mobile unit. Status replies to status requests will be displayed at the interrogating dispatch positions together with the discrete address of the unit involved. The implementation of this capability will be determined by the specification of the individual systems being procured.
- (D) 2.6.30 The system will be capable of interfacing with a computer aided dispatch system. Depending upon the requirements of the CAD system involved, the interface may be either direct or through buffering equipment. Such interface requirement and the appropriate data output needs will be specified in the individual system procurement documentation.
- (D) 2.6.31 The system will be capable of incorporating or interfacing with mobile digital terminal systems. The specific operation of this interface will be a function of the type and number of the terminals involved as specified by the individual system procurement.
- (M) 2.6.32 Only those mobile units having mobile digital terminals installed will have access to the digital information system.
- (M) 2.6.33 The system must be capable of operating a conventional mode in the event of failure of the system controller.

In the event of such a failure, an indication will be provided to all users of the system to alert them to revert to a predetermined system of conventional operation. In this event, dispatch locations will be assigned previously designated channels (see Sec. 2.6.24).

- (D) 2.6.34 The ability for the operator to change frequency to any authorized frequency in the 806-866 MHz band at will is a desirable feature that may be incorporated in selected units.
- (M) 2.6.35 Future incorporation of trunked portable units capable of meeting the regulatory, environmental and specific standards of the procuring agency is a mandatory requirement of the major municipal systems. Such portable units will have no less than six switchable group address capabilities and have the ability to be switched to a pre-designated conventional channel. They must have a priority level 1 emergency capability. While compatible, automatic status reporting similar to mobile units is desirable, it is not mandatory. It is desirable that selected portable units be capable of transmitting a broadcast to all groups assigned to a designated dispatch location and also to all groups in the system.
- (M) 2.6.36 While the system concept must be such that trunked portable units can be incorporated when they become available, the system must make provisions for interfacing with either an existing or new conventional portable system at the time of initial implementation. Definition of this system interface will be in accordance with the specifications of the procuring agency.

SECTION III

SYSTEM ELEMENTS

3.1 Base Station Transmitters and Receivers

- (M) 3.1.1 There will be at least one base station transmitter and receiver for each RF channel assigned. Each transmitter and receiver will be capable of operating independently of and simultaneously with any or all of the others assigned to the system. The transmitters and receivers will be controllable from the system controller or, in a conventional mode, from designated dispatch locations bypassing the system controller.
- (M) 3.1.2 Base station transmitters and receivers will comply with Part 90 of the FCC Rules and appropriate EIA, NBS and similar agency standards. Transmitter and receiver power levels, sensitivities, selectivity, propagation-related and operating characteristics, will be as defined in the system procurement specifications. Physical configuration, environmental requirements, primary and emergency power supply needs, and other equipment characteristics not directly related to digitally addressed, trunked systems functioning will be defined in the procurement specifications of the procuring agency.
- (M) 3.1.3 Base station transmitters and receivers will be controlled from fixed frequency sources (crystal or frequency synthesized). The transmitter and receiver frequencies will be technician-changeable to any frequency within the 806-866 MHz band.
- (M) 3.1.4 Receiver systems will be mated with associated base station transmitters. Receivers will be controlled by the system controller or by direct connection to a designated dispatch location, bypassing the system control, if required. Receiver output will have those characteristics appropriate to transmission over conventional voice grade landline or microwave circuits.
- (M) 3.1.5 Base station receiver implementation should include an analysis of the electromagnetic environment at the receiver antenna location that includes the assumption of all system transmitters operating simultaneously.
- (M) 3.1.6 Base station audio systems will permit simultaneous monitoring of various group audio outputs at designated dispatch positions. Designation of the groups to be monitored and the number and locations of the dispatch

position will be contained in the individual system procurement documents.

- (M) 3.1.7 System design will be such to prevent system users from hearing receiver noise or other audible outputs during periods when the position is monitoring the command channel or when no RF carrier is being received.

3.2 Remote Receivers (Satellite)

- (M) The system will be capable of incorporating satellite receivers with appropriate voting selectors, when necessary.

3.3 Base Station Antenna Systems

- (M) The base station antenna system includes those elements required to carry the radio frequency signal from the base receiver/transmitter to and including the radiating antenna (transducer(s)). The antenna system configuration must provide for simultaneous duplex operation of all channels without degradation on any one channel. Antenna system configuration will be such that the failure of any one active component will result in the loss of no more than one RF channel.

3.4 System Control Center

- (M) 3.4.1 A system control center will be established to permit monitoring of system operation. It will be possible to program the system controller from a position at the system control center. The system control center may or may not include the system controller hardware.
- (D) 3.4.2 The system control center will contain facilities and equipment to monitor and record all message traffic passing over the system as well as the signaling channel.
- (M) 3.4.3 Each base station transmitter and receiver, voting selector, and any system elements specifically designated for control or signaling purposes, will provide means to indicate at the system control center when it is transmitting or receiving a message. The characteristics of these indications will be defined in the system specification.
- (M) 3.4.4 Information to be available at the system control center for recording will include, but may not be limited to:
 - number of transactions, by user;
 - system element failures, including time of failure and time of restoration to service. For the purpose of this requirement, system elements will

include base stations, system controller, dispatch positions, control lines, microwave (if appropriate) support, and interconnect equipment.

- percentage of system up time;
- equipment status change;
- print-out of time of use by each user.

(D) 3.4.5 The system control center will incorporate provisions to display the status of all base station transmitters, receivers, and control unit. Failure status will be indicated both visually and aurally.

(M) 3.4.6 The system control center will provide a keyboard or equivalent type of operator position at which the following control protocols may be altered or implemented by entering the appropriate instructions to:

- change priority level assignments by group and discrete address;
- add to, change, or remove designated groups and discrete addresses from the list of automatic priority assignments;
- interchange address groups within the machine logic so that users of one address group can be automatically included with or excluded from other address groups;
- allocate discrete addresses to dispatch locations to increase or reduce the number of authorized dispatch positions;
- prohibit designated discrete address units from having access to the system;
- assign higher or lower level automatic priority assignments to discrete address units (i.e., executive or supervisory personnel);
- alter the configuration of selected address groups. This is to establish designated address groups with appropriately assigned discrete address numbers for special purpose or temporary functions.

3.5 System Controller

(M) 3.5.1 This device constitutes the central switcher of the system. It will incorporate that logic necessary to permit the system functioning as described in this document.

- (M) 3.5.2 The system controller will be capable of having its internal logic controlled from an external device such that those functions described in Section 2.4.5 and other functions as defined in this document can be performed. The system control unit should be capable of interfacing with other systems via standard voice grade, landline, or microwave circuits. (See Sec. 4.4.6)
- (M) 3.5.3 The system will have the ability to interface with computer aided dispatch installations as defined in the procurement specifications. This interface may be through direct interconnect or via buffering as determined by the needs of the individual system installation.
- (M) 3.5.4 The base station system controller will interface with the output of the receiver voting systems, when used.

3.6 Mobile Transmitter/Receiver (Mobile Unit)

- (M) 3.6.1 Mobile units will be designed in accordance with the requirements of Part 90 of the FCC Rules and the appropriate EIA, NBS and related agency specifications. Radio frequency, environmental impact, physical size and reliability characteristics will be defined in the individual system procurement specifications.
- (M) 3.6.2 It is mandatory that mobile units be capable of operating on a minimum of six frequencies with the capability of including as many as 20 frequencies in the trunked portion of the 900 MHz band.
- (D) 3.6.3 It is desirable that the mobile units be capable of operating on any of the 600 frequencies in the 900 MHz land mobile spectrum.
- (D) 3.6.4 It is desirable that certain mobile units be available that permit selection of the frequency for conventional operation by field technicians without the need for crystal replacement.
- (D) 3.6.5 The system should permit the design of mobile units that incorporate a scanning function by group address. This function should permit the selection of at least six group addresses for continuous scanning with the establishment of one of these addresses as a priority address. This is a desirable feature that may be selected as specified in the procurement specifications of the individual procurement agency.
- (M) 3.6.6 The mobile units will, when not engaged in a sequence of messages, continuously monitor a source of signaling information in accordance with the system control concept. The

mobile unit will have an assigned discrete address and incorporate provisions to select no less than six operator-selectable address groups.

- (M) 3.6.7 When in a monitoring condition, the mobile unit will recognize signaling instructions addressed to the address group to which the mobile unit has been switched. These instructions will direct the mobile unit to an RF channel selected by the system controller. Upon receipt of these instructions, the mobile unit will switch to the designated channel.
- (M) 3.6.8 The mobile unit will remain on the selected channel for the duration of all traffic transmitted or received during a sequence of exchanges. After two seconds (or a period determined by the system operator (see Sec. 2.6.12) of no traffic on a channel, the mobile unit will automatically revert to the monitor mode and the "on channel" indication will cease. It may be possible to terminate the two-second "hang time" by activation of a manual switch ("on hook" switch is acceptable). (See Sec. 2.6.12)
- (M) 3.6.9 Provisions will be made to prevent audio output when the unit is monitoring the command channel or when it is not being quieted by reception of an RF voice channel such as after completion of traffic and before the unit reverts to command channel monitoring.
- (M) 3.6.10 To initiate a call when in the monitor mode, activation of the transmit control will initiate a request for a channel via the signaling system. This request will include the group address to which the unit is assigned and the unit's discrete address. Appropriate priority information will also be included in the signaling message. In the event the signaling system is occupied, the unit will automatically attempt re-access until access is accomplished; or if no RF channel is available, an indication of "awaiting channel" queue will be presented.
- (M) 3.6.11 When the channel is selected by the system controller, the system controller will direct the units having the designated address to move to the selected channel and to monitor transmission on that channel. After two seconds (or manual interrupt) (see Sec. 2.6.12 and 3.6.8) of no communications on the channel, all units will revert to the signaling system monitor role.
- (D) 3.6.12 Each mobile unit will have the capability of selecting pre-assigned address groups. The functions of these address groups will be as defined in the individual procurement specifications.

- (D) 3.6.13 The system signaling concept will permit the incorporation of a minimum of six automatic status indicators. The incorporation of this capability in the mobile unit design will be a desired function defined in the individual system procurement specification. It will permit the mobile unit operator to transmit status indication by momentarily activating an appropriate switch and thereby having the status reported to the addressed dispatch position as designated by the using agency's system organization. This information will also be capable of being sent to a CAD if so specified in the procurement specification.
- (D) 3.6.14 A desirable capability includes the automatic interrogation of status, by discrete address, from a dispatch position. This interrogation could be via the signaling system providing a visual and aural indication at the mobile operator's position of a request for status information. The reply would be transmitted by the operator as described in Section 2.6.28.

3.7 Portable Units

- (M) 3.7.1 There is a mandatory requirement for the eventual incorporation of trunked, digitally addressed portable units into the system. See Sec. 2.6.35 and Sec. 2.6.36 for specific functional requirements of such units.
- (M) 3.7.2 The trunked, digitally addressed system must be capable of interfacing with portable systems in a manner optimally suited to the requirements of the individual procuring agency.

SECTION IV

SYSTEM RELATED CONSIDERATIONS

4.1 Priority Protocols

- (M) 4.1.1 The system will make provision for five levels of priority. Assignment of these levels of priority will be controllable at the system control center. The structure of the signaling language will be such that a priority user will access the system only at the expense of the lowest level of priority using the system, i.e., a priority level 2 call on a fully loaded system will preempt a priority level 5 user if there are any using the system; if not, priority level 4 or 3, in order.
- (M) 4.1.2 See Section 2.6.13 through 2.6.18 for detailed description.

4.2 Digital Traffic Requirements

- (D) 4.2.1 The system concept will permit transmission of digital traffic between mobile units and dispatcher positions, and between mobile units and digital information system interface units. The inclusion of this capability in a specific system will be as defined in the procurement specifications. For the purpose of this document, the digital information to be handled must be compatible with the transmission standards for transmission of digital information over standard voice channels as specified by the FCC Rules.
- (M) 4.2.2 The system concept will permit interface with digital terminal equipments installed in the mobile units. The digitally addressed, trunked system supplier will specify the input-output characteristics of this interconnect point, and where such characteristics differ from those that may be specified in the procurement specification, the supplier will provide needed buffering equipment.
- (M) 4.2.3 A separate address group will be designated for the handling of digital information requests. The digital reply will be presented only to the mobile digital units authorized reception.
- (M) 4.2.4 Mobile units will return to the monitor condition within 1/2 second of completion of transmission or reception of a digital message.
- (D) 4.2.5 A desirable feature of the system would be to permit dispatch positions to receive and to transmit digital messages

manually. Such messages should include a displayed discrete unit address and the message format as specified in the procurement specification.

4.3 System Broadcast and Individual Agency System Integrity Capability

- (M) 4.3.1 It is mandatory that certain public safety users have the ability to hear both sides of all conversations taking place within their area of responsibility. This requirement usually exists throughout an assigned patrol area, among certain operational squads or assigned task groups. Therefore, the system will permit re-broadcast of all mobile unit transmissions. This capability will be generally available for all address groups. However, the system controller will have the capability of being programmed via the system control center terminal to prevent the re-broadcast of mobile transmissions for designated or selected group addresses.
- (D) 4.3.2 A desirable feature will be the capability to program certain group addresses as being accessible by only designated discrete addresses. These group addresses will not be accessible to other units having discrete address except as permitted by the system control center. The purpose of this capability is to permit the provision of certain operational groupings for command, investigative, or other purposes.

4.4 Intra-system Interfaces

The functional concept of a digitally addressed, trunked system includes those organizational and technological characteristics that permit simultaneous use of the system by several different agencies, each maintaining an appropriate level of operational integrity. Interfaces within the system are of two types: between agencies using the system, and between segments of the system. These will be described individually.

- (M) 4.1.1 Intra-system interfaces between agencies will be made at the system controller. Each agency using the system will be assigned one or more of the available dispatch locations. These dispatch locations will incorporate the operationally required number of dispatch positions. Group and discrete addresses will be assigned to dispatch positions in accordance with the organizational requirements of the using agencies. Such addresses may be changed from time to time as required, at the system control center.
- (M) 4.2.2 Individual agency integrity will be maintained through the mechanism of the group address. Necessary interagency

communications will be possible through the selection of appropriately designated common group addresses to which individual units may be switched.

- (M) 4.4.3 Intra-system equipment interfaces between base stations and mobile units will be via RF links using authorized frequencies in the 806 to 866 MHz band. These links will comply with all appropriate FCC Rules and Regulations. Appropriate equipment characteristics necessary to meet the RF coverage requirements of the individual systems will be provided in accordance with the system procurement specifications.
- (M) 4.4.4 Communications between mobile units will normally be via the base station equipment. Mobile units assigned the same group address will receive all communications directed to or from that group. Mobile units requiring communications separate from their usual group assignment will switch to predesignated group addresses established for this purpose.
- (M) 4.4.5 Interfaces between elements of the mobile unit (transmitter to control head, antenna cabling, primary power requirements) will be the responsibility of the system supplier and be prepared in accordance with the requirements of the procuring specification.
- (M) 4.4.6 Design of the interfaces between base station equipment to include transmitter receivers, system controller, dispatch locations and dispatch position, will be the responsibility of the system supplier. It is desirable that all intra-system signaling be compatible with the transmission capabilities of the public switched telephone network. Should special circuit conditioning or characteristics be required for the transmission of information or signaling information, the system supplier will be responsible for the identification of such requirements or providing the necessary circuits, as defined in the procuring specification.

4.5 Intersystem Interface

- (M) 4.5.1 The basic system will be designed to provide radio communications for community public safety agencies. It will be expandable to ultimately incorporate all the governmental two-way radio requirements of the community.
- (D) 4.5.2 The system will be capable of interconnection with the public switched telephone network at each dispatch location in a manner compliant with the Rules of the FCC.

- (D) 4.5.3 The system will be capable of interfacing with computer aided dispatch systems at either the system controller or at designated dispatch locations. The CAD interface may be direct or through buffering equipment. The CAD interface means and location will be specified in the particular procurement specification.
- (D) 4.5.4 Mobile units and the system controller will be capable of interfacing with mobile digital terminals and digital information systems. The specific nature of these interfaces, and the kind and extent of buffering to be employed, will be specified, or made the responsibility of the vendor, in the system procurement specifications.
- (D) 4.5.5 Interface with the National Crime Information Center (NCIC) or other information systems will be either through a CAD system or via a manual dispatcher position as specified in the procurement specifications.
- (D) 4.5.6 Interface with other radio systems will be possible by mobile-to-mobile communications, via dispatch position relay, or patching interconnect. It must be assumed that in the near term, adjacent area systems used by other agencies will not be directly compatible, i.e., they may not be trunked, or if they are, they will use either different frequencies or different addressing techniques; therefore, direct mobile-to-mobile communication via a common system is unlikely.

4.6 Conventional Systems Interface

- (M) 4.6.1 There will be a conventional operational position on all mobile units. This position will permit transmission/reception by the mobile unit on an assigned conventional channel. It is a desirable feature of the system that the frequency of this conventional channel be capable of being changed without the addition of new components or crystals.
- (D) 4.6.2 An optional form of the mobile unit should include the capability to permit the operator to change the frequency of the conventional channel.
- (D) 4.6.3 Interface with those conventional systems not operating on the 806-866 MHz portion of the spectrum will be through the designated base dispatch locations as specified in the individual system procurement specifications.

4.7 Reliability Requirements

- (M) 4.7.1 System equipments will be configured in accordance with EIA, NBS, and other regulatory agency standards as appropriate. Reliability and environmental considerations will be in accordance with the specifications of the procuring agencies. System-related reliability enhancement techniques will be incorporated as follows:
- (M) 4.7.2 each base station RF channel will utilize a separate transmitter and receiver;
- (M) 4.7.3 the system will degrade gracefully, i.e., loss of one RF channel (degradation) will not affect operation of other channels. The system will automatically transfer the traffic to the remaining operating channels. Failure of a channel will be indicated at the system control center.
- (M) 4.7.4 Should a signaling channel become defective, the signaling load will be transferred to one or more remaining operating channels.
- (M) 4.7.5 In the event of failure of the system control unit, an audible alarm will be presented to all units and the system will be capable of being switched to a conventional mode, bypassing the system control element.
- (M) 4.7.6 The system controller will have the ability to program or reprogram the system control manually to "lock out" selected mobile units that may cause interference to the system.

4.8 Management Information

- (M) 4.8.1 An access port will be provided at the system controller that will permit print-out and/or recording of system activities. The information available will include, as a minimum:
 - channel in use time by channel;
 - channel in use time by group address;
 - out of service for repair time of each major system element.
- (M) 4.8.2 Provisions will be made at the system controller to record all voice traffic on each channel.

- (D) 4.8.3 Provisions will be made at the system controller to record voice traffic by address group. This will make possible continuous recording of user group traffic, regardless of the RF channel in use. This capability will be in addition to recording capabilities that may be provided at individual dispatch positions.

4.9 Maintainability

This program requires that vendors be prepared to support equipments in the field for a period of not less than 10 years after contract completion. Particular care should be paid to ease of maintenance of all equipments. To this extent the system should incorporate the following provisions.

- (M) 4.9.1 All equipments will be maintainable to the extent practical by commonly available test equipment. In the event specialized test equipment is required, the vendor will so specify.
- (D) 4.9.2 Maintenance techniques will include card level exchange. The cards will be house-technician repairable whenever practical. Any cards not repairable in the field by qualified technical personnel will be identified by the vendor. Included will be specifics of repair turnaround time and shipping methods to be used.
- (M) 4.9.3 The vendor will maintain an inventory of all cards in the system for no less than 10 years after contract completion. The vendor will warranty the availability of all field-repairable spare parts in the system for a period of not less than 10 years after contract completion.
- (D) 4.9.4 The successful vendor will offer a maintenance technician training program for support of the system as part of any implementation proposal. Cost and schedule thereof will be separately identified.
- (D) 4.9.5 The vendor will make available a vendor-provided maintenance service on an annual cost basis as part of the program implementation proposal.
- (D) 4.9.6 Detailed maintenance manuals will be prepared for all equipments in the system as well as describing overall system performance. These manuals will be made available in the numbers specified in the individual system procurements.

4.10 Training

- (D) 4.10.1 A major element in the successful implementation of this

program will be the training received by those operational personnel responsible for its use. The vendor will be prepared to provide both in-plant and on-site training as detailed in the individual procurement specifications to the minimum extent described below.

- (D) 4.10.2 The vendors will provide in-plant training in accordance with the requirements of the procuring agencies, for maintenance personnel, designated dispatch level personnel, and senior supervisory and management personnel.
- (D) 4.10.3 The vendor will provide training for those operational personnel using the system at the using agency's facilities to the extent designated in the procurement specifications.
- (M) 4.10.4 Training manuals describing overall systems operation, systems capabilities, operational techniques for dispatchers and mobile users, will be provided in numbers specified in the procurement specifications.
- (M) 4.10.5 A detailed manual describing the functioning of and techniques for use of the system controller will be provided.