NTIA-SP-79-3

Emergency Medical Services Communications System Technical Planning Guide

NTIA

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U.S. DEPARTMENT OF COMMERCE • National Telecommunications and Information Administration

NTIA-SP-79-3

Emergency Medical Services Communications System Technical Planning Guide

J.A. Hull
J.M. Harman
M.N. Olson
H.D. Hunt

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

Henry Geller, Assistant Secretary
for Communications and Information

March 1979

PREFACE

This document was prepared at the request of the Communications Working Group of the Interagency Emergency Medical Services Committee. The resultant document is intended to be a simple, practical technical planning guide for Emergency Medical Service (EMS) communications.

The authors prepared a proposed outline of this document which was distributed to attendees at the 1977 Department of Health, Education and Welfare (DHEW) Tri-regional Workshops on EMS Communications. Requests were made at these workshops for resource material from attendees working in the field and for critiques of the outline. A list of the resource material received, largely through these meetings, is contained in the bibliography of this report. Subsequent meetings with the DHEW Regional Telecommunications Consultant Team were extremely helpful in selecting relevant material which has been used in the preparation of this document.

The authors invite comment, critique, and suggestions concerning this document and any revision or update which might be useful to the user community.

TABLE OF CONTENTS

Table of Contents (Continued)

LIST OF FIGURES

List of Figures (Continued)

List of Figures (Continued)

LIST OF TABLES

EMERGENCY MEDICAL SERVICES (EMS) COMMUNICATIONS SYSTEM TECHNICAL PLANNING GUIDE

Joseph A. Hull
John M. Harman
Marylyn N. Olson
H. David Hunt*

This document is intended to provide guidance in planning Emergency Medical System (EMS) communications. Processes and procedures are presented for such planning. Recommendations for obtaining technical, consultative and other assistance in designing and implementing EMS systems are given.

Services

In addition, this report is designed to familiarize the non-technical person with common communication terms, concepts and helpful references. Fundamental elements of land-mobile radio are introduced, and details of citizen access and emergency medical responses are addressed. Planning a 911 emergency system is discussed. The development of an EMS command and control center is highlighted. Frequency-assignment regulations and selected configurations for an EMS system are introduced.

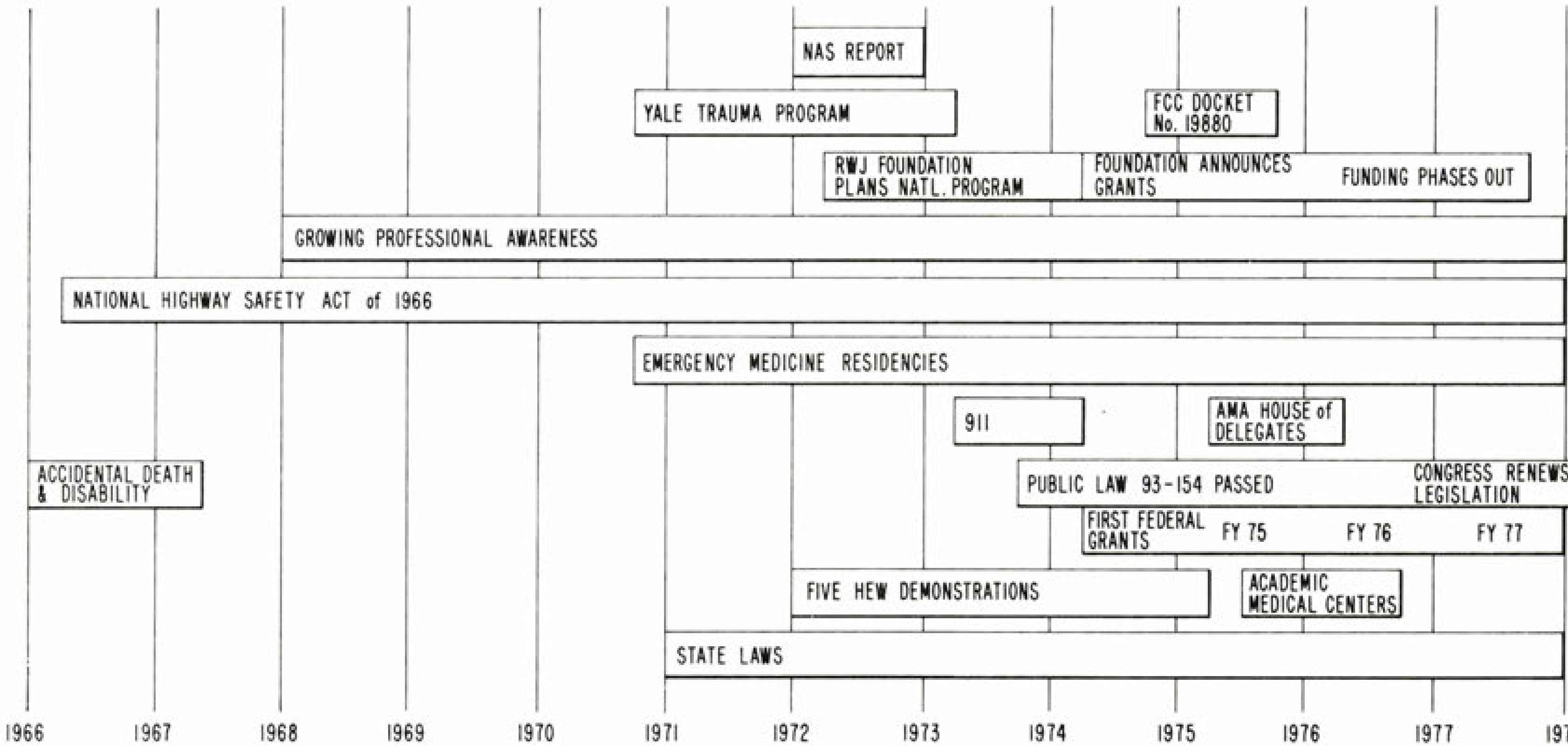
Key words: Ambulance communications; emergency medical communications; emergency preparedness; health services; hospital communications; frequency allocation; land-mobile radio.

1. INTRODUCTION

1.1. Background

Recognition of Emergency Medical Services (EMS) as a public safety obligation in the United States was stimulated by a study published by the National Academy of Sciences in 1966. A summary of the events which followed is shown in Figure 1. Considerable progress toward the development and implementation of EMS is

*The authors are with the Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Dept. of Commerce, Boulder, CO 80303.



"Accidental Death and Disability: The Neglected Disease of Modern Society": landmark study is published by National Academy of Sciences

National Highway Safety Act of 1966: authorizes Department of Transportation to provide funds for ambulances, communications, training programs and statewide planning

Growing Professional Awareness: established organizations (e.g., American Medical Association, American Hospital Association, American College of Surgeons) as well as new groups (e.g., American Trauma Society, Emergency Department Nurses Association, American College of Emergency Physicians) become increasingly active in emergency medicine

Yale Trauma Program: lengthy study, when issued in 1972, advocates development of regionalized emergency medical communications systems

Emergency Medicine Residencies: first established at University of Cincinnati; by 1976 there were 32 throughout the country

State Laws: California is first to pass paramedic legislation, beginning large growth in state involvement. Today more than 40 have EMS legislation; half have laws regarding training of ambulance personnel

NAS Report Urges Federal Initiative: Roles and Resources of Federal Agencies, published by National Academy of Sciences calling for coordinated national effort has widespread impact

Five HEW Demonstrations: HEW allocates $16 million to EMS demonstration programs in States of Arkansas and Illinois, and in areas around Jacksonville, San Diego, and Athens, Ohio

Robert Wood Johnson Foundation Plans National Program: $15 million to be made available for projects throughout nation; largest sum of private funds ever allocated to emergency medical services.

911: White House Office of Telecommunications Policy issues statement urging adoption of 911.

Public Law 93-154 Passed: Emergency Medical Services Systems Act of 1973, after surviving one veto, signed into law in November, 1973 with a $185 million authorization over three years.

Robert Wood Johnson Foundation Announces Grants: selected from among 251 applicants, 44 regions receive grants in 32 states and Puerto Rico.

Federal Communications Commission Docket #19880: new rules and regulations for EMS communications sets aside new radio frequencies.

First Federal Grants: 88 made totaling $17 million in FY 1974

FY 75: 114 regions receive $32 million.

FY 76: $29 million granted to 52 regions.

FY 77: $32 million for 82 regions.

AMA House of Delegates: recommends that emergency medicine be considered new speciality.

Academic Medical Centers: University of California (San Francisco) and Johns Hopkins establish special emergency medicine programs to develop faculty for medical schools.

Congress Renews Legislation: bill extending legislation through 1979 authorizes $200 million for system development, $15 million for research, $40 million for training, and $14 million for burn injuries.

Robert Wood Johnson Foundation Funding Phases Out: 4' projects continue with other support.

Figure 1. Chronology of events in the development of EMS. (Prepared by Robert Wood Johnson Foundation)

evidenced by the initiatives and funding levels indicated in the figure. The largest of these programs is that authorized under the Emergency Medical Services Systems (EMSS) Act of 1973 (42 U.S.C. 300d). This Act was revised and extended by Public Law 94-573 (known as the Emergency Medical Services Amendments Act of 1976). The congressional intent is to provide assistance and encouragement for the development of comprehensive emergency medical services systems throughout the country and thereby improve the quality of patient care and reduce morbidity and mortality.

Emergency Medical Services communications planning and system implementation requires interface and cooperation with other medical services and public safety activities such as law enforcement, fire, search and rescue, emergency preparedness, transportation, public utilities, etc. within the area to be served to solve the many jurisdictional problems inherent in most regional systems. Since EMS systems generally require long-term operational public funding, there is much competition for local acceptance and support.

Two Department of Transportation/National Highway Traffic Safety Administration (DoT/NHTSA) documents, "Appendix P--Communications Planning to Highway Safety Program Manual No. 11 - Emergency Medical Service", April 1, 1974, and "Communications Manual - Addendum 1 to Highway Safety Program Manual, Volume II" provide guidelines that are used primarily for the planning of EMS communications systems on a statewide basis pursuant to the Highway Safety Act of 1966 (Amended). Using the format of NHTSA's Appendix P, the Department of Health Education and Welfare (DHEW) prepared "Guidelines for Developing an EMS Communications Plan, HSA 77-2036," March 1977, which addresses development of comprehensive communications plans for grant application under Public Law 93-154 (Amended). HSA 77-2036 differs from Appendix P by addressing regional EMS planning rather than statewide planning and primarily in its added emphasis on tailoring the regional EMS communications system design to a particular style of "medical control."

1.2. Purpose

This document is intended to provide guidance in the preparation of required background (data bases). It is also intended to aid the planner in identifying the procedures for obtaining appropriate technical assistance in the conception, design, and evaluation of regional EMS communication systems. It is not intended to replace the need for hiring a consultant or to provide a comprehensive technical reference for specific system design.

If the document significantly improves the understanding and written/verbal communications between the local planner, local/regional communication specialist, and the consultant/supplier community, the objectives of this document will have been satisfied.

1.3. Section Highlights

Section 2 presents an overview of the EMS System as defined by the EMSS Act and related documentation. The requirements for an EMSS communications system and the sequence of planning, procurement, and implementation under the DHEW grant series are also summarized.

Section 3 is an overview and description of the subsystems of an EMS Telecommunication System. This Section is intended as an orientation for the reader who is not familiar with EMS telecommunications purposes and concepts.

Section 4 describes the communications system planning process. This section will aid the reader in gaining an understanding of the planning process delineated in the DoT and DHEW planning guides.

Section 5 addresses the basic EMS communication elements. The purpose of this section is to acquaint the planner with the fundamental concepts of land-mobile radio.

Section 6 expands on citizen access and emergency medical response. The first major subsection involves the 911 planning process. The second major subsection addresses the concepts and development of the EMS command and control center.

Section 7 discusses the concepts, regulation and selected radio configurations employed in EMS medical control communications. This section is intended to introduce the planner to specific operational medical control communication systems.

2. OVERVIEW OF EMS SYSTEM

The EMS problem was identified in 1966 by the National Academy of Sciences in "Accidental Death and Disability; the Neglected Disease of Modern Society." This study was the catalyst for a series of Federal, state, and local community initiatives to improve the care of emergency patients by a coordinated application of technology and medical resources. Most notably, under the Highway Safety Act of 1966 (Amended), programs were developed in each state to enhance all aspects of pre-hospital emergency medical services as a countermeasure to death and injury from highway accidents. This act resulted in the establishment of national standards for EMS personnel, equipment, vehicles, communications, and other components needed for a system approach to EMS. However, it was not until the passage of the Emergency Medical Service Systems (EMSS) Act of 1973 that a national, comprehensive systems approach to emergency medical services became authorized under Federal law.

2.1. EMSS Act

As defined in the EMSS Act of 1973 (Amended), an emergency medical services system is one ". . . which provides for the arrangement of personnel, facilities, and equipment for the effective and coordinated delivery, in an appropriate geographical area, of health care services under emergency conditions (occurring either as a result of the patient's condition or of natural disasters or similar conditions), and which is administered by a public or non-profit private entity which has the authority and the resources to provide effective administration of the system."

2.1.1. Fifteen mandated components

The Act of 1973 (Amended 1976), which is administered by the EMS Division of the DHEW, identifies fifteen components which are considered mandatory for an efficient operational system and must be addressed to qualify for funding under this act:

- PROVISION OF MANPOWER
- TRAINING OF PERSONNEL
- COMMUNICATIONS
- TRANSPORTATION
- FACILITIES
- CRITICAL CARE UNITS
- USE OF PUBLIC SAFETY AGENCIES
- CONSUMER PARTICIPATION
- ACCESSIBILITY TO CARE
- TRANSFER OF PATIENTS
- COORDINATED MEDICAL RECORD-KEEPING
- CONSUMER INFORMATION AND EDUCATION
- REVIEW AND EVALUATION
- DISASTER LINKAGE
- MUTUAL AID AGREEMENTS.

2.1.2. EMSS overview

It is the intent of Congress and the DHEW to develop EMS systems, administered under a regional health authority, to deliver emergency patient care from an accident scene to a general hospital and/or specialty care center. Special attention is given to the six clinical target patient categories: trauma, burn, spinal-cord injury, cardiac, poison, and high-risk infant patients. This effort includes the development of functional emergency and critical-care treatment plans for general and specific emergency medical care for patients and addressing of the 15 mandatory components.

Two specific levels of services are to be developed under this program, namely:

Basic Life Support Services (BLS) - The minimum acceptable level of care services available in an areawide EMS system. Services include universal access and central dispatch of approved national standard ambulances, with appropriate medical and communication equipment, operated by a complete complement of Emergency Medical Technicians (EMT) and Emergency Medical Technicians-Ambulance (EMT-A), availability of a Category* II hospital facility staffed by physicians and nurses with emergency medical knowledge and skills and full implementation of the 15 system components,

and

Advanced Life Support Services (ALS) - The advanced care services which may be planned for areawide EMS systems. In addition to all of the basic life support services, ALS includes sophisticated transportation vehicles with full equipment and telemetry staffed by advanced EMT's (paramedics) providing onsite, pre-hospital, and inter-hospital mobile intensive care, specialized physician and nursing staffs operating critical care units and emergency departments, and full regional implementation of the 15 system components. The specific adaptations of ALS services will of necessity be different in varying geographic areas.

These two levels of service are progressive stages in the development of the system concept. This does not however, imply that communities which do not complete all of the stages outlined (such as telemetry) are receiving a lower level of health care.

*Categorization: A system used to identify the readiness and capabilities of the hospital and its entire staff to receive and treat emergency patients adequately and expeditiously. The four basic American Medical Association categories are: I Comprehensive, II Major, III General, IV Basic. Many states have developed their own categorization schemes which identify levels of urgent and critical care capability.

There may be circumstances which obviate the need for such telemetry capability.

2.1.3. EMSS grant series

Federal assistance is available through grants under Sections 1202, 1203, and 1204 of Title XII of this Act. These grants may be awarded to states, units of local government, public entities administering a compact or other regional consortium, or any other public entity and non-profit private entity for:

Feasibility Studies and Planning - SECTION 1202
Establishment and Initial Operation - SECTION 1203
Expansion and Improvement - SECTION 1204.

Table 1 delineates the activities for which these grant sections are to be used. Guides to other funding sources for establishment of communication systems are listed in the bibliography.

2.1.4. EMS communication system

This planning guide deals primarily with communications which is but one of the 15 EMS system components mentioned earlier. These components are interdependent and communications requirements may be influenced by decisions implementing the other 14 requirements. This interaction will become apparent as planning of the overall system proceeds.

Most people have intuitive ideas about systems planning or "systems engineering" as it is called in more technically oriented contexts. Systems engineering emphasizes defining goals and relating system performance to these goals. It places emphasis on decision criteria, developing alternatives, modeling systems for analysis, and controlling implementation and operation. The following quote of Ralph F. Miles, Jr. (1973) may be helpful in applying systems engineering concept to EMS system development:

> "Systems engineering draws on all the concepts of the basic sciences and disciplines. The present state of the art for system engineering is that there now

Table 1. Summary of Milestones

Public Law 93-154

Title XII

SECTION 1202 FEASIBILITY STUDIES AND PLANNING	SECTION 1203 ESTABLISHMENT & INITIAL OPERATION		SECTION 1204 EXPANSION & IMPROVEMENT	
	Phase I	Phase II		
o EMS Council - Subcommittee on Communications o Inventory Assessment of Subsystems - Communications, Facilities, Disaster Plans,. . . o Table of Organization and Liaison Relationships - Public Safety Organizations o Plans for Intercommunications with Adjoining Regions	o Develop Basic Communication Plan -Communications Requirements - Ambulance/Hospital/ Medical -Hospital and Interhospital Networks (Required for ALS) o Communication System Design (Reflecting Vertical Categorization) o Implementation of Improved Telephone Access o Central Ambulance Dispatch o Communications Engineering Design, Bid Specifications and Contracts o Mutual Aid Agreements for day-to-day Operations and Disaster Linkages with Public Safety Agencies o Recordkeeping System for Access, Dispatch, Ambulance, Emergency Departments. . . for Project Reporting	o Implement, Test and Operate Communications Access and Dispatch System o Implement, Test and Operate Basic Two-way Voice Medical Communications o Plan for Medical Control/Communications from Resource Hospital & Associate Hospitals -Establish Hospital Regional Network -Designate Hospital for Medical Control of ALS o Develop Workshops at State and Regional Level on Communications, Disaster Linkage Drills, Public Education and Support Issues o Design technical Interfacing of Radio and Telephone to Provide Medical Control to Paramedics and Facilities from Resource Hospital -Dedicated phone lines to Associate Hospitals	o Implement Medical Control Communications - Two-way Voice and/or Telemetry o Implement Linkages to Rehabilitation Facilities and Services o Monitor Pre/Inter Mobile Intensive Care o Plan Regionwide Disaster Drill	o Test and Evaluate Communications System o Prepare Final Report -General Description and Operational Protocols to be Included in Regional EMS Plan

exists a well-demonstrated methodology for integrating technical disciplines into technical systems.

"The systems approach will not solve problems for you. Only you can do that. What the system approach will do is permit you to undertake the resolution--your resolution--of a problem in a logical, rational manner. You are the one who must ascertain that a problem or a need exists. You are the one who must develop the criteria for selecting a suitable alternative. The systems approach will not do any of these things for you.

"The systems approach will allow you to express your individualism rationally when you identify your problem, your alternatives, and your decision criteria."

Section 4 describes the systems engineering approach to the development of EMS communications.

2.2. Individual and Organizational Relationships

The political, economic, and social environment in which an EMS system evolves is all too frequently either ignored or poorly understood by the technical planner. This may result from an attitude that technology and politics are mutually exclusive or from a tendency for technically oriented individuals to shun such problems. Regardless of the reasons, EMS communications planning must be conducted in the real world with as clear a perspective of the political, economic, and social realities as of the technical aspects. To ignore these realities, will not only insure program problems, but will reduce the chances of achieving maximum EMS system efficiency.

2.2.1. Local organizational relationships

It is particularly important for the EMS planner to earn credibility and legitimacy within the local communication community. If a communications committee does not exist, the planner should endeavor to establish one. Figure 2 depicts those agencies

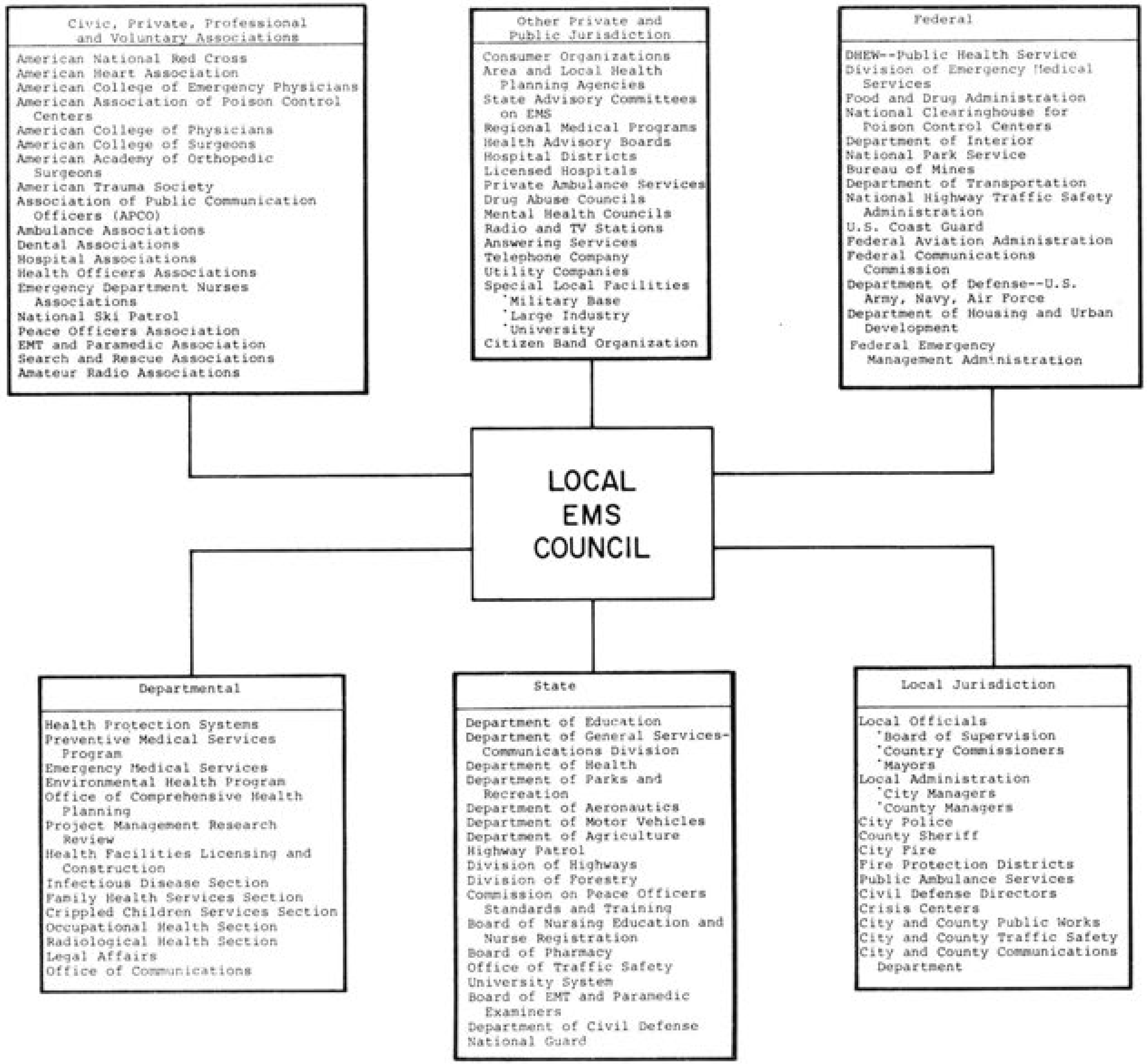


Figure 2. EMS contributing agencies.

which should, depending upon the size of the communications system, be advised that a system or system update is being planned. Input from many of these agencies and associations may well provide the basic building blocks for the planner. The local committee should serve as a forum for formulation and direction of EMS communication planning. An agency or department manager (police, fire, hospital, ambulance, etc.) who is represented, consulted, and involved in the early stages of policy formulation will usually take a positive attitude toward the EMS planner and EMS planning. This should not imply that early coordination will automatically insure agency approval or endorsement, but will improve the chances of later cooperation when moving from concept to implementation.

Another important by-product of initial agency participation is that the concerns, fears, suspicions, and objections of the various agencies can be understood and more fully considered in the system design. A common failure in many programs is the tendency to ignore early concerns, thinking they will disappear as the program proceeds. Conversely, some early agency concerns will indeed fade away when the implementation phase commences. The planner must exercise care in differentiating between these two cases.

The structure of the EMS communications committee will become evident during regular meetings, but it is important for the planner to meet with the various agency members individually to insure that both the private and public EMS positions are understood. This understanding gained from informal discussions usually leads to greater cooperation. Of particular concern, is the need to work with the various agencies' operational personnel with the knowledge and approval of the agency heads. These are the people who must ultimately endorse and actively support change within their agency. In addition, the operational personnel are most familiar with the strengths and weaknesses of an existing communication system and will be most affected by any changes. The advantages to be gained from their experiences and recommendations will improve the chances for implementing any needed system modification because agency personnel can identify with the proposed changes.

The local EMS organization usually takes the form of an EMS council. This council is generally designated by the local governing authority (City Council, Board of County Commissioners, etc.) as the focus for EMS-related planning and coordination. The committee structure of the EMS council will vary to some degree depending on the priorities, leadership patterns, and area of the particular community. The council typically has a number of standing committees, one of which will be communications. Figure 3 sets forth one configuration depicting local EMS council interrelationships. By-laws and membership requirements vary from council to council and reflect local differences and needs.

2.2.2. State organizational relationships

The local EMS communication planner will usually coordinate with a number of communication planners representing the various state departments set forth in Figure 4.

Most states have one or more EMS-related agencies that assist and/or coordinate Federal programs with bodies having local jurisdiction. In most states, the lead EMS agencies are affiliated with the State Health Department and the State Highway Safety Department. It may well be that these agencies have funding allocations for essentially the same EMS tasks (EMS communications, transportation, dispatch center development. . .), generating some degree of duplicated effort and intragovernmental rivalry. This rivalry may be generated at the state level or be a result of Federal legislation and resulting Federal bureaucratic differences. Regardless of the reasons for the rivalry, the local EMS planner must attempt to utilize these various state and Federal programs, as applicable, to solve local EMS problems. It is important that the planners develop a working knowledge of program requirements of each funding agency to ensure that all possible sources of potential EMS funding are submitted for local EMS council consideration.

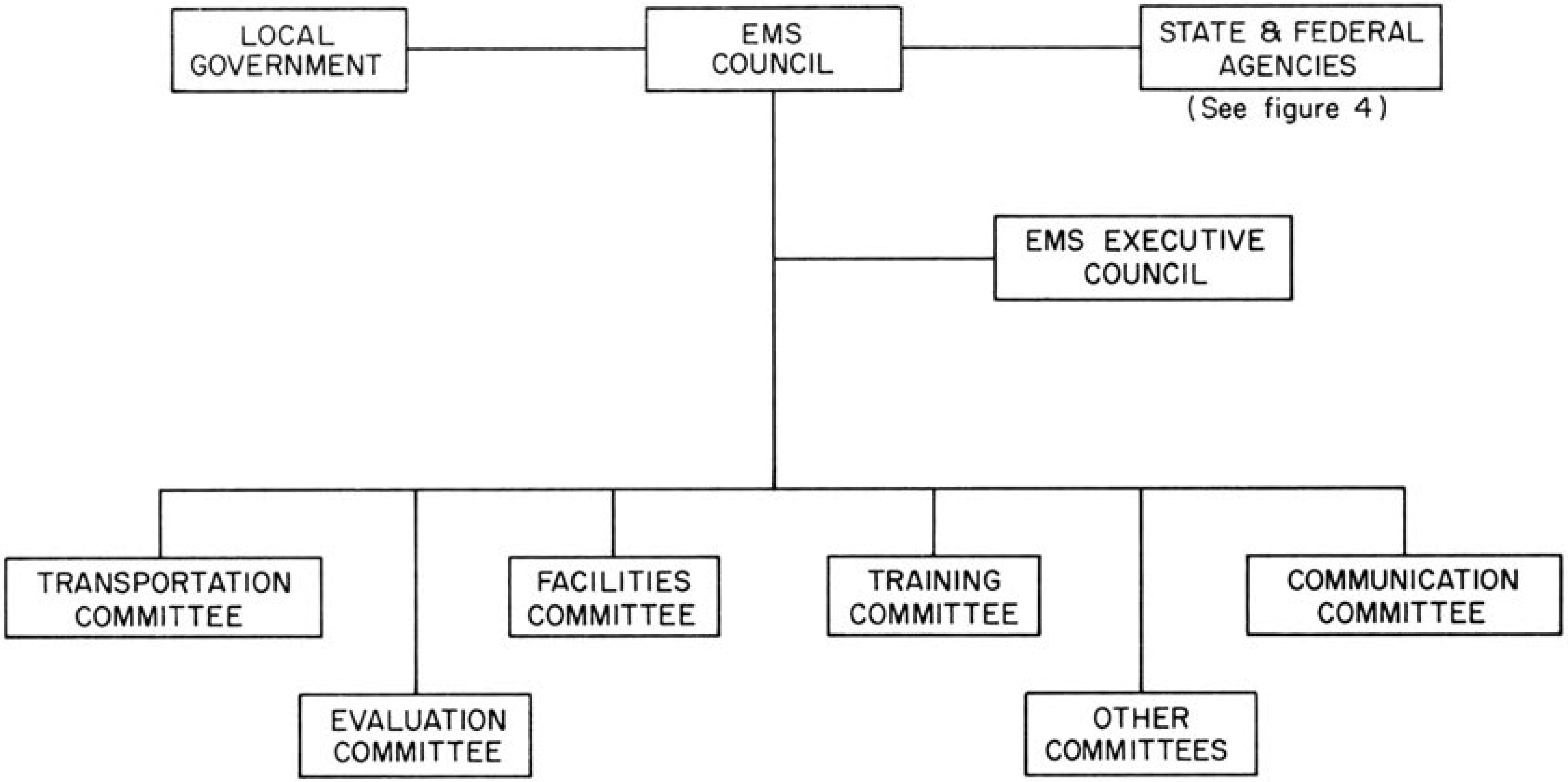


Figure 3. EMS council interrelationships.

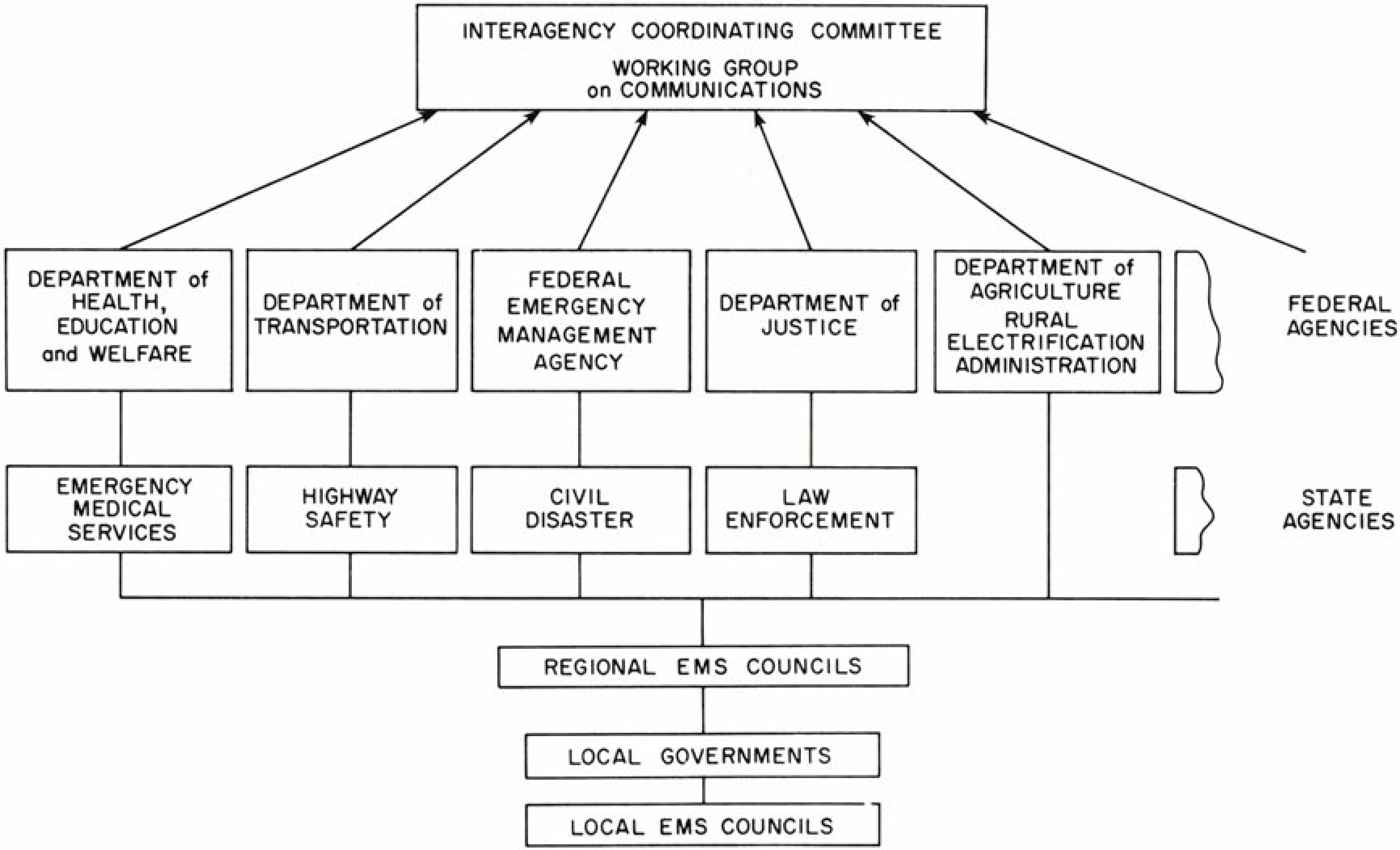


Figure 4. Relationships of local, state and federal EMS.

2.2.3. Federal organizational relationships

Most Federal agencies involved in EMS have regional offices through which programs are administered. It is therefore unlikely that the local EMS communication planner will have the need or occasion to interface directly with the various Federal agencies responsible for EMS program administration. This, however, does not mean that the local planner should not be aware of, or participate in, the various EMS conferences and workshops held under Federal sponsorship. Attendance at these events gives the local planner the opportunity to discuss the problems encountered with other planners who may or may not have experienced the same trials and tribulations.

2.2.4. EMSS project region organizational relationships

EMSS project regions are various groupings of local EMS systems which together serve a larger geographical area. These regions, determined by Federal, state and local jurisdictions, were designed to preclude geographical overlap and to conform as closely as possible to established medical service catchment areas. Figure 5 depicts the project regions within the state of Colorado. There are more than 300 such project regions within the United States.

The administrative structure of these project regions is difficult to categorize because the region is frequently not a political entity (city, county, state, etc.), but a combination or subset of counties or states. This frequently leads to confusion regarding political jurisdiction, cost sharing, urban domination, etc.

Relationships with other regional or area members are usually an outgrowth of common problems, personal friendships, grant requirements and the like. The makeup of the EMSS Project Region requires the local communication planner to understand the political, economic, and social ramifications of the region in much the same way as he must understand the local EMS system itself. There is a need for the planner to be sensitive to urban/rural differences, to historical and human differences and misunderstandings, and to the unique needs of the area involved.

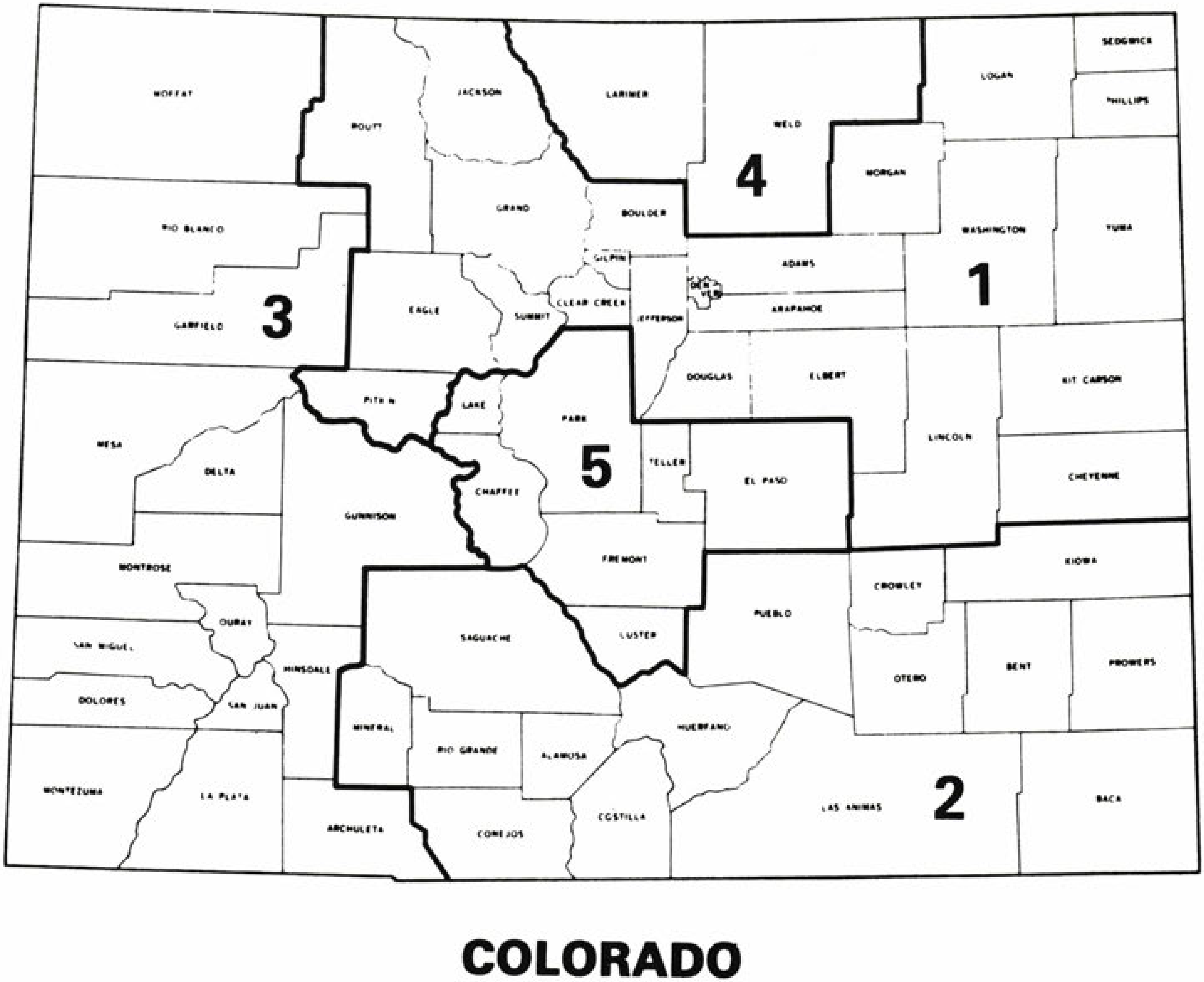


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Figure 5. Project regions within the state of Colorado.

Since the EMSS Project Region is frequently a grouping of autonomous cities and counties, regional decision making is usually reliant on a consensus of these bodies. This does not imply that agreement and decisions are never reached, but the process is often ill-defined and subject to electoral politics. Each participant must see some short- and/or long-range advantage in the process. These conditions are not unique to the EMSS Project Region, but are shared by most regional organizations which attempt to persuade their members to give up a degree of local autonomy. The planner will also find that historical misunderstandings on non-EMS issues will influence decisions on EMS, requiring patience and understanding in order to gain acceptance and support for EMS cooperation.

2.2.5. DHEW regional jurisdictions

The EMSS Act is administered by two agencies of the Public Health Service: the Health Services Administration (HSA) and the Health Resources Administration. The HSA, through its Division of Emergency Medical Services, administers the 1202, 1203 and 1204 grants. The 300 EMSS project regions mentioned in Section 2.2.4 are combined, under the DHEW grant series, into ten super regions, as shown in Figure 6, with one regional office serving each. Each of these offices has an EMS program consultant in the office of the Regional Health Administrator. Also, in each of the ten regions, a medical doctor consultant has been designated to assist in the management and administration of the grant program. The doctor, in turn, is aided by a telecommunications engineering consultant. These ten telecommunications engineering consultants and a chairman constitute a nation-wide EMS Telecommunications Consultant Team to assist Regional Administrators and EMS project regions in utilizing appropriate technology under the 1973-1976 EMS Act.

The role and responsibilities of the EMS Telecommunications Consultants are:

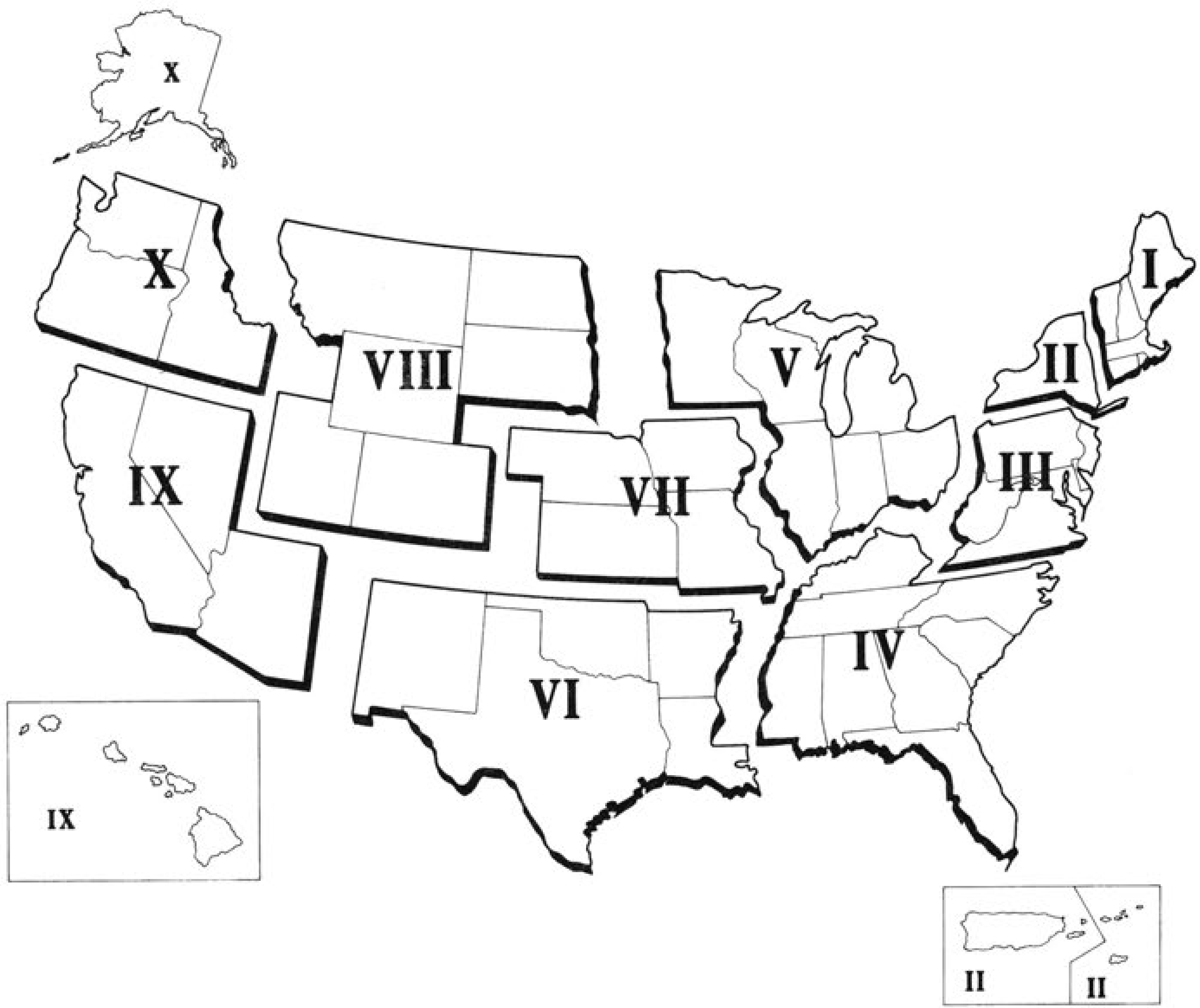

Figure 6. Ten super regions under DHEW.

(1) To provide technical assistance to all prospective grantees

a. identifying the need for including more advanced EMS operational features in future equipment,

b. recommending critical design limits that go into production of EMS-related communications equipment, e.g., size, weight, complexity of operation, etc.,

c. identifying the impact of new equipment on existing EMS system implementation and the problems that develop on a regional or state-wide basis with the incompatibility of "new" versus "old" systems.

(2) To review and approve regional communication system implementation plans for 1203 and 1204 projects (any differences of opinion will be reviewed by the team leader and other team members.)

(3) To assist Federal Regional Directors in administering the blanket communication conditions placed on each local region project.

(4) To assist Federal regions and the Office of the Director of DHEW, EMS, to pursue opportunities and more actively to utilize joint Federal agency funding in the implementation of regional communication systems with common public access to meet public safety and security needs.

(5) To represent the Office of the Director of the DHEW, EMS, within and before public safety communications professional organizations, public utility interface study groups (911) and the communication industry.

(6) To assure close working relationships with committee or planners of other related telecommunication system developments within the Federal region, keeping the region director and EMS project managers advised of such plans (i.e., motorist aid--DoT; wired city--HUD;

highway systems and agricultural sensors--DoT/Agriculture; parks and recreation centers remote services--Dept. Interior; etc.)

3. EMS COMMUNICATION SUBSYSTEMS

3.1 Functions

Communications is that vital link required for rapidly obtaining professional medical services or professional medical advice. This link and the wise management of all resources can well mean life or death for the critically ill or injured person. Many lives could be saved and much disability prevented simply by the prompt, systematic application of established principles of emergency medical care. The problem is usually one of time and distance.

The rudiments of EMS communications are illustrated in Figure 7. The functions represented here are Citizen Access, Emergency Response, and Medical Control. Other interface coordination functions may also be required, depending upon the emergency and the region or community (i.e., metropolitan area with many public safety agencies and associate hospitals).

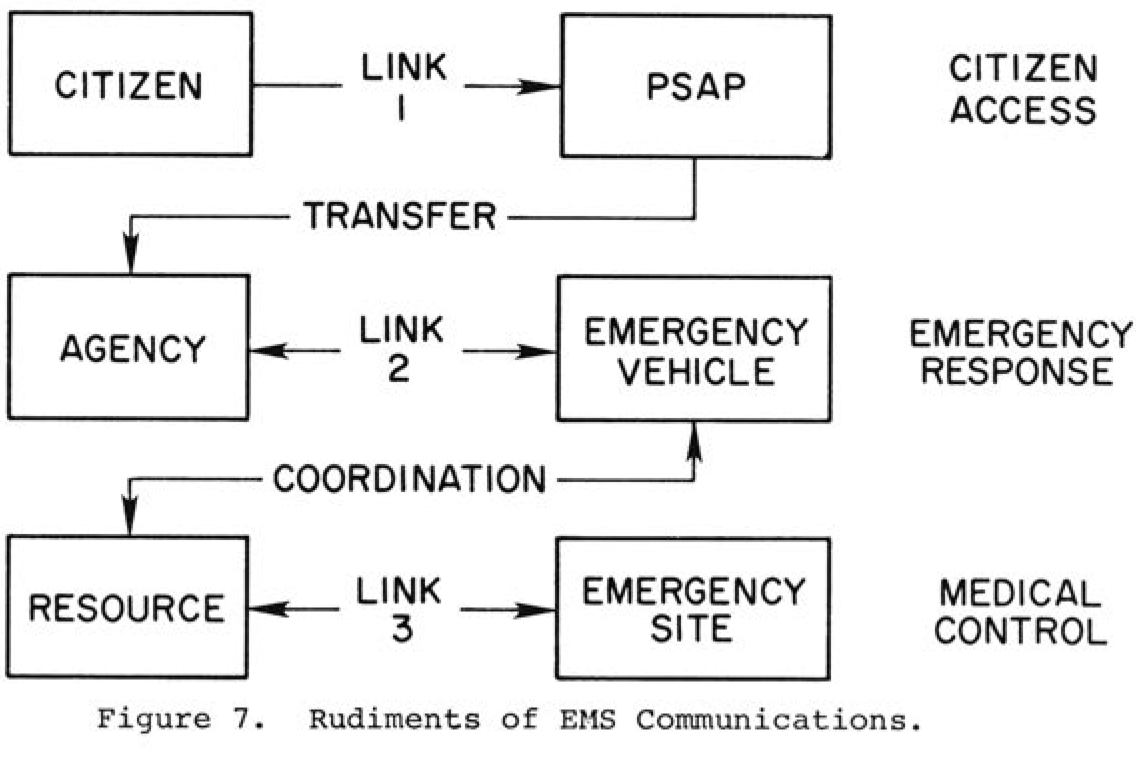

Figure 7. Rudiments of EMS Communications.

3.1.1. Citizen access

The telephone system serves as the most readily available means for most citizens to notify the EMS system of an emergency. Technically, it is quite feasible to develop a universal emergency number, 911, to access all public safety agencies in a region or community via a Public Safety Answering Point (PSAP). This is the most expeditious way in which contact with the proper EMS agency may be achieved. If the incorporation of 911 during the planning and implementation of the system is not feasible, a common 7-digit number for emergency access to police, fire and EMS is encouraged for the community. This simplifies the task for the citizen since it reduces the number of decisions he must make regarding the type of EMS response(s) required and the amount of equipment needed. This increases the responsibility of the public safety communications office, but will generally improve the efficiency of the dispatch command and control function.

In addition to the public telephone system, some communities have additional citizen access through citizen band radio (Channel 9), radio call boxes (street and highway), commercial radio systems (i.e., utility companies, private bus systems, taxicabs. . .), private alarm systems, aircraft radio systems and amateur radio monitoring. The use and resulting influence of these various other access methods is determined by need and cooperation at the local level. Section 6 will treat the technical planning aspects of this subsystem in more detail.

3.1.2. Emergency response

The response of the EMS system elements to an emergency request involves the coordination of public safety resources. Public safety is really teamwork requiring resource allocation decisions. Some emergency systems require the citizen to make the resource allocation decision by dialing the appropriate agency (law enforcement, fire, ambulance, hospital. . .). This is usually one of a long list of 7-digit numbers. In other words, the citizen must decide, usually during a time of extreme anxiety, the type of aid required. Ideally, the citizen requesting emergency assistance dials a single number (i.e., 911), reports the problem to a trained operator, and the appropriate level and type(s) of response are provided in the shortest possible time.

In many cases a single incident may require response from more than one public safety agency. As in the case of a traffic accident, the police department is needed for traffic and crowd control, the fire department is needed for a gasoline fire hazard, and perhaps extracation of victims, and medical assistance is needed in the case of injury. Whenever such an emergency demands supporting agency assistance, such assistance requires a communication system, tied to a control center which can coordinate the separate resources and their activities.

Operational experience with PSAP systems has shown that approximately 85% of incoming calls involve police services, 10% fire services, and 5% EMS. However, further analysis of these statistics indicates that some 35% of the police calls have associated medical requirements. Figure 8 shows the flow from incident to response and Section 6 will further explain the PSAP concept.

The organizational and technical configuration of the emergency response system will vary depending on the need and cooperation of the various agencies in the system (public safety, private ambulance, hospitals, search and rescue. . .). The specific configuration of the communication dispatch system will reflect this level of agency cooperation in its operational structure and technical interface design. Sections 5 and 6 will deal more fully with the technical aspects of designing an EMS response communication system.

It is the responsibility of the EMS Communications Planner to work closely with the EMS Communications Committee in developing an emergency system which facilitates both citizen access and appropriate agency response. The first act on the part of EMS is the mobilization and dispatch of personnel and equipment to the scene of the emergency. As part of this mobilization, the hospital(s) will also be alerted to prepare to receive the emergency patient(s).

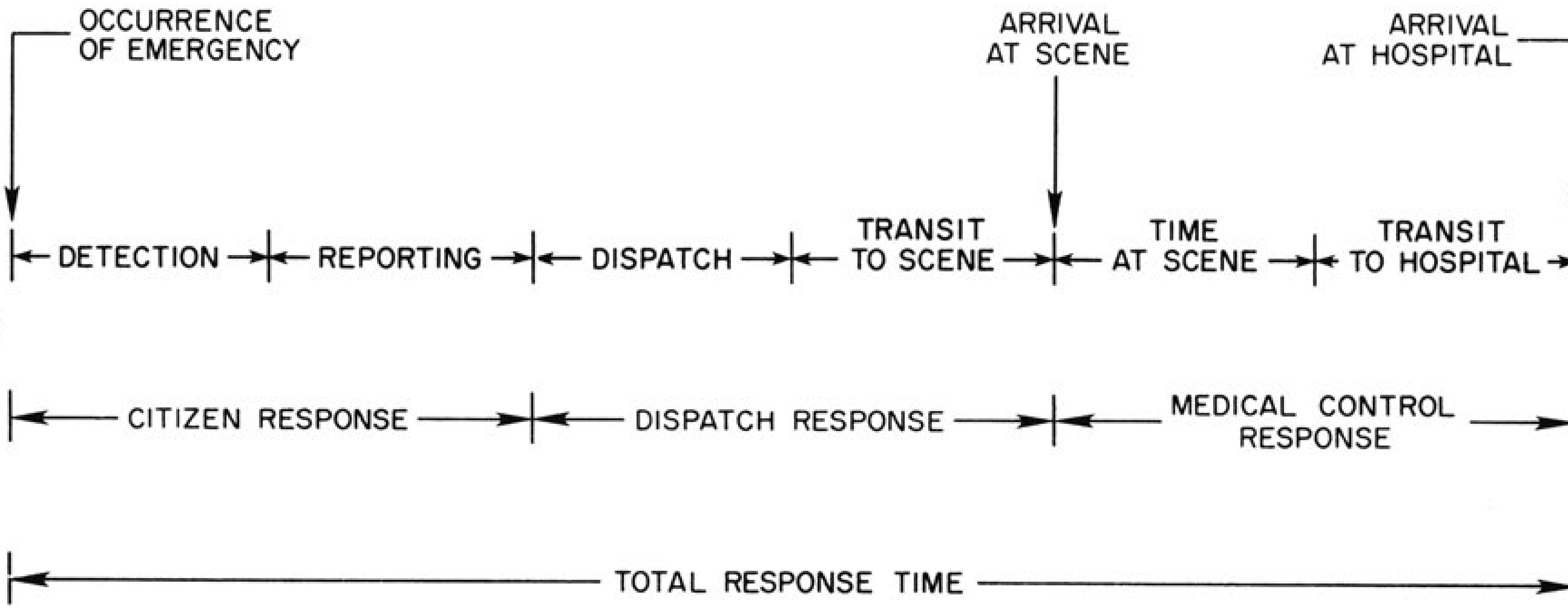

Figure 8. Emergency system response.

The dispatch function coordinates the vehicle movement generally through radio dispatch channels. This vehicle command and control usually requires only brief use of a radio channel to give instructions and directions.

3.1.3. Medical control/supervision

The term medical control/supervision means the direction and advice provided from a centrally designated medical facility staffed by appropriate EMS personnel, operating under medical supervision, supplying professional support through radio or telephone communication to on-site and in-transit basic and advanced life-support personnel. The communication linkages necessary for this function should have pre-established protocols.

Medical control requires a channel to be available at all times when a patient is being served in the field. The channel is assigned to the vehicle by a central communications control to permit dialog to be set up between the EMS field personnel and the physician control. The radio system is used to transmit the general condition of the patient and such vital signs as blood pressure, pulse rate, approximate age, weight, etc., by two-way voice communications to a physician or physician surrogate (nurse/paramedic) at a hospital. Hand-held portable radio units permit communications outside the emergency vehicle - especially from the event site. Also, personal portable units are important to rural physicians who may not be resident at a hospital when assistance is needed. In some cases, vital signs such as electrocardiograms are also transmitted via the radio channel to assist the physician in providing medical instructions and supervision to the personnel in the field. The EMS communications systems may allow crosstalk between units to assist in coordination, but a primary link for medical control is always required.

3.1.4. Other

A set of operational procedures is an essential element in the operation of the communication system. No matter how well planned the communication system may be or how many sophisticated devices may be used, trained operators are essential if the system is to be fully utilized. Simple, concise procedures must be developed, distributed, and thoroughly understood by all persons who use the system. Included in these procedures is the definition of responsibility for the communication functions.

In summary, the communication system should have the capability to provide at least the following functions:

- o Rapid citizen access
- o Mobilization of EMS and public safety resources (alerting, paging)
- o Vehicle coordination (dispatch and delivery)
- o Medical control/supervision
- o Interface coordination (radio and/or wire line)
- o Hospital security*
- o Supporting operational procedures.

4. THE EMS TELECOMMUNICATIONS PLANNING PROCESS

This section summarizes and adapts the content of a report entitled, "Planning Guidelines for Law Enforcement Telecommunications Systems"** prepared by The Associated Public-Safety Communications Officers, Inc. (APCO) for the Law Enforcement Assistance Administration (LEAA) under Project 13. This law-enforcement planning process, adapted to EMS and supplemented by the DHEW and NHTSA communication guidelines, is designed to serve a similar objective in assisting local, regional, and state EMS

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*Hospital security is an inherent part of the EMS system. Hospital security personnel are often trained to coordinate arrival of patients and are particularly useful in sensitive cases involving alcohol, drug abuse or other law violators who may need emergency medical help. Some cases may even involve emotionally disturbed patients.

**These guidelines were specifically developed to assist municipal, county, and state personnel engaged in developing telecommunications plans under the concept of the State Planning Agency in conformance with the "Omnibus Crime Control Act of 1968." The primary objective of these guidelines was to ensure a rational, orderly process of plan development from identification of goals and objectives through implementation and evaluation.

planners. It is also anticipated that the use of a common planning process will encourage greater planning cooperation among public safety agencies and reduce the duplication of effort in data base collection.

4.1. EMS Telecommunications Systems Planning

The systems approach or "systems engineering", as mentioned in Section 2, is popular term today, but in common parlance does not have a very precise meaning.

Emergency Medical Service telecommunication systems planning is the analytical process by which the communications needs of a specific local or regional EMS system are identified, a set of desired goals and objectives are defined, and alternative courses of action are developed. This includes the selection and implementation of a course of action from among those alternatives.

The planning process requires that both short-range and long-range goals be considered carefully. Short-range goals should be designed so that they not only address conspicuous system deficiencies, but also incorporate objectives which are readily achievable and provide early, positive feedback to the user groups. Long-range goals, by their very nature, are more far-reaching and must consider the impact of totally new systems and technology.

4.2. General Description

The organization of the planning process can be described by the following interrelated steps or phases:

- Identify and understand the problem
- Establish goals and objectives
- Establish planning assumptions
- Determine alternative courses of action
- Evaluate the alternative courses of action
- Select a course of action from the alternatives
- Establish priorities for using available resources
- Implement the selection
- Evaluate the results in terms of the problem.

These steps are mutually dependent and several iterations or feedback paths are defined in the graphic representation shown in Figure 9. Some basic considerations for developing the planning elements in the figure are shown in Table 2. The planning process should be flexible enough to accommodate any size project. For large projects, the plan may be written in detail and published formally as a comprehensive plan with numerous short-range plans supporting it. Small projects may require only a schedule and check list for the planner's use. Planning logic will lead to points within the plan outline where decisions are made regarding how the plan should proceed. A flow diagram for a large project is shown in Figure 10.

In order for the planner(s) to proceed logically with the EMS planning process, an understanding of user requirements and local resources (data base) must be developed. Working within the policy framework of the local EMS Council, the planner(s) must document the user requirements and existing resources so that the EMS Council can develop and recommend short- and long-range goals. These goals would then be submitted to the appropriate local officials for approval and funding authorization. Since EMS must compete with other local groups for funding, well-developed plans and presentations to local officials will enhance the probability of obtaining EMS system funding.

4.3. EMS Telecommunications User Requirements

Prior to collecting detailed resources (data bases), it is necessary to understand the basic user needs for the local EMS system. This requires explicit understanding of the general framework in which the problem is to be defined (definition, description of the EMS geographical area, detailed listing of each agency involved.

The total EMS telecommunications system must be verbally defined and diagrammed. Diagramming their telecommunications system can, if done during early interviews with the EMS user groups, prevent misunderstandings and can enhance agency confidence in the planner. In addition, it provides the planner with

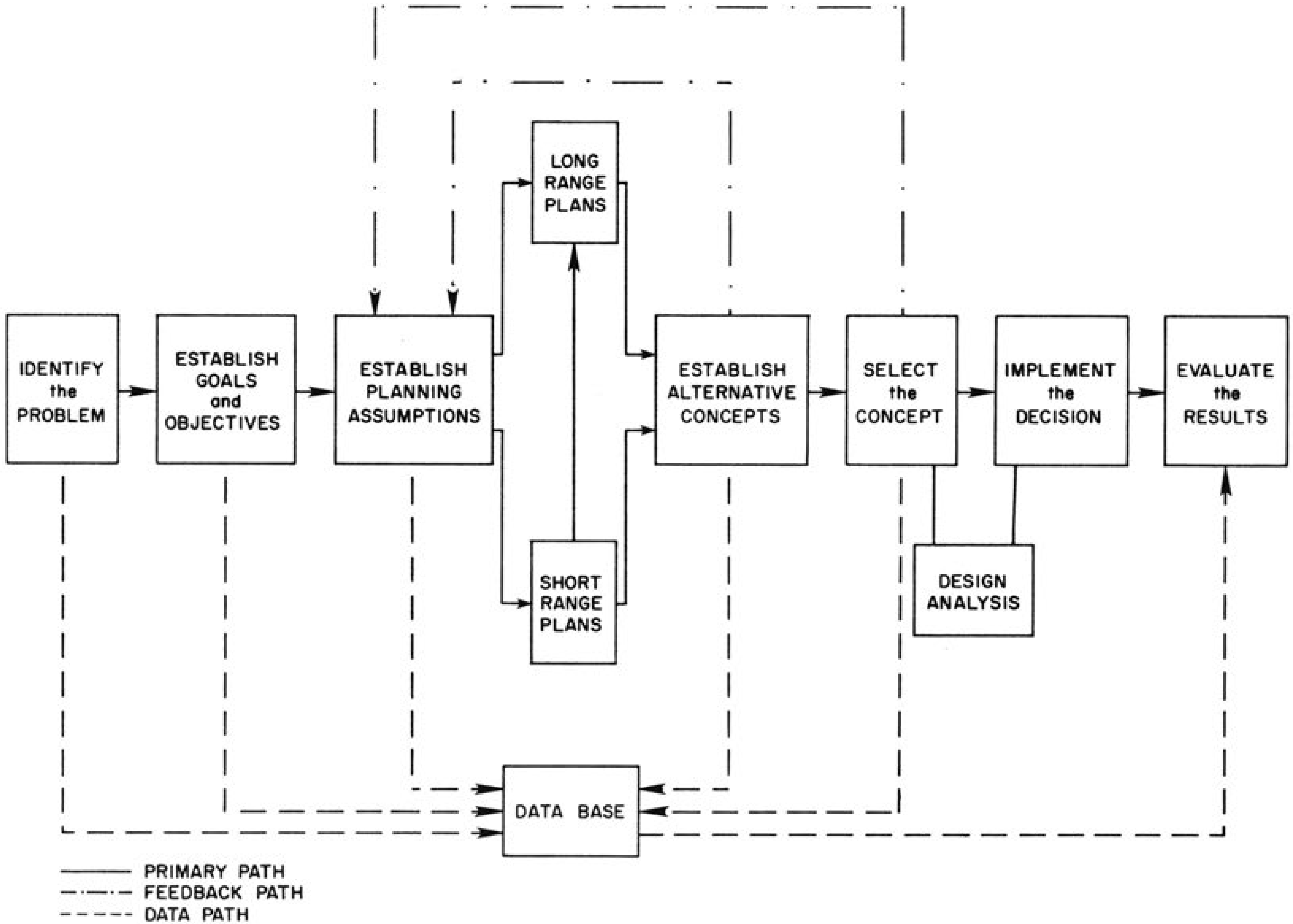

Figure 9. Basic planning process.

Table 2.

Planning Considerations

Significant Considerations \ Elements of the Plan	Identify the Problem	Objectives and Requirements	Planning Assumptions	Establish Alternative Concepts	Evaluate Alternative Concepts	Select the Concept	Implement the Plan	Evaluate the Results
The projection of future needs is confirmed	x	x	x					
The need to change is supported by fact	x	x	x					
The need to change is acceptable to the user		x	x	x				
The planning for change is not premature			x	x				
The present system can be defined factually	x		x	x				
The planned change can satisfy the need		x	x	x	x	x		
Resources are available to generate a plan			x	x	x	x		
The planning process will have dynamic feedback			x	x	x	x	x	x
Authority to make planning decisions is clear			x		x	x	x	x
Resources are available to implement the plan			x			x	x	
Results will be measurable quantities							x	x
Measurable results are comparable to established needs		x						x

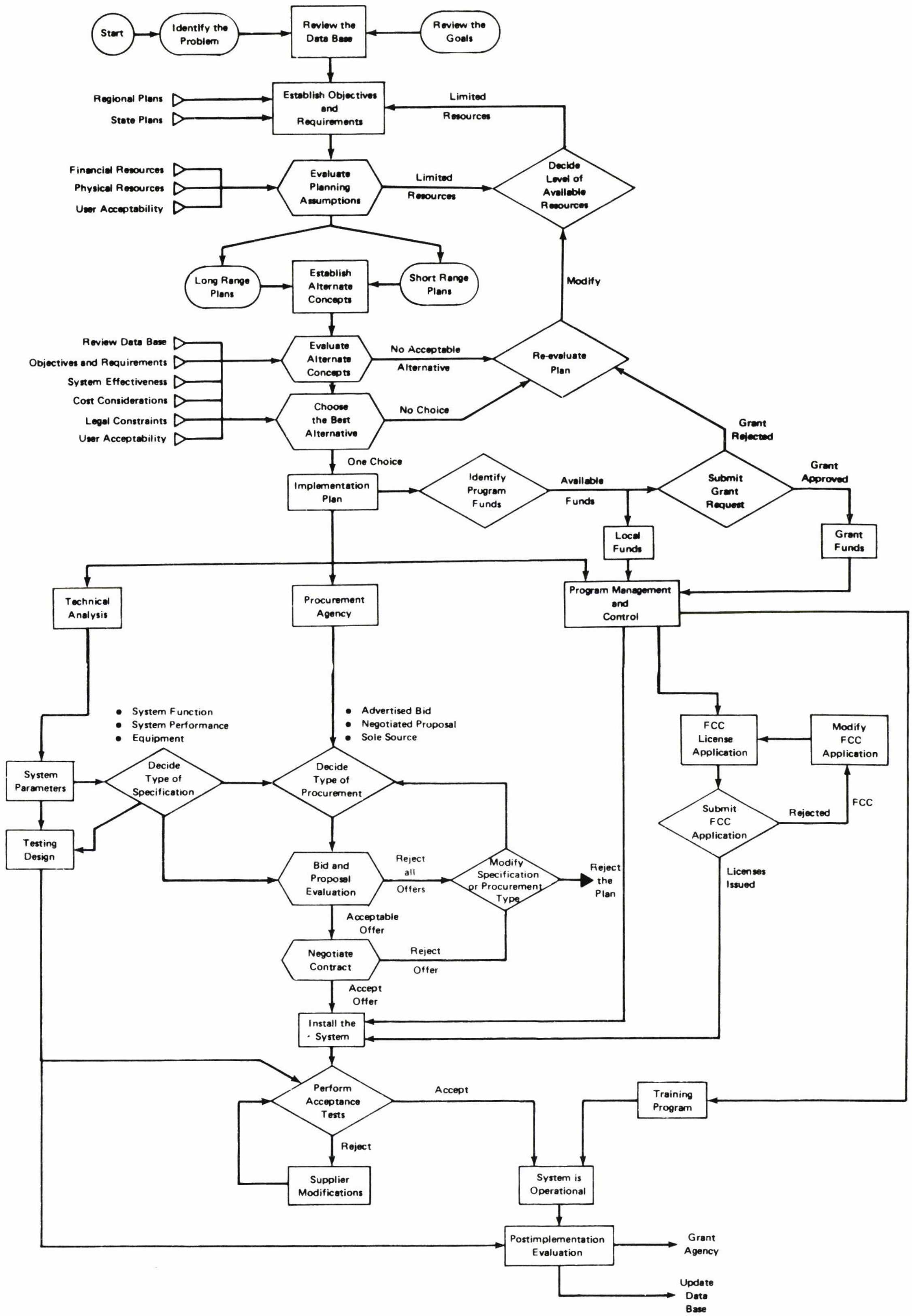

Figure 10. Sample planning decision chart.

a better understanding of the existing system so that a more logical, efficient data-base-collection plan can be developed.

4.3.1. External constraints on the system

The existence of numerous external constraints covering the range of possible solutions constitutes a large part of the challenge in planning EMS telecommunication systems. Awareness of the primary applicable external constraints (political, technical, legal, or fiscal) is necessary prior to commencing system design or modification.

For example, one of the principal external constraints in urban areas is the limited portion of the radio spectrum that is available. This is expressed in the form of legal requirements that apply to the use of two-way radio systems. The Federal Communications Commission (FCC) assigns the use of the frequency spectrum to the various nongovernment radio services. The Interdepartment Radio Advisory Committee (IRAC) has similar authority for Federal Government users. The EMS dedicated frequencies are shared and are thus jointly allocated under the same rules and regulations. In addition, Part 17 of the FCC Rules and Regulations covers the construction, marking and lighting of antenna structures. These Rules and Regulations were developed in conjunction with the Federal Aviation Administration (FAA). In some instances, municipal, county, or other local laws may also affect certain aspects of communications planning. For example, zoning ordinances and building codes may apply to the construction of buildings which house communications equipment.

4.3.2. System performance standards

Each agency or service involved in the delivery of EMS patient care is concerned with various performance standards. A performance standard may either be an exact value which must be attained, or, more frequently, such a standard may be a set of bounds, i.e., a minimum value that should be equaled or exceeded and a maximum value that should not be exceeded. If both a minimum and a maximum value are specified for a performance measure, then a range of acceptable values is defined.

In EMS telecommunication systems, there is a degree of uncertainty concerning the exact conditions that will be encountered. For example, the number of telephone calls requesting emergency service in any future time interval cannot be known in advance. A central concept in coping with uncertainty is that of probability. This is a numerical measure of the relative frequency of occurrence of alternative conditions or events. The proper use of probabilities in conjunction with EMS telecommunication system evaluation and planning introduces a degree of realism that is useful. For example, the use of a sufficient number of dedicated or direct lines to eliminate all busy signals or delays in the system is desirable but prohibitively expensive. The provision of sufficient lines to assure a probability of 0.99 that a call can be completed may be much more realistic and adequate for most needs. Much work has been done on such standards of performance, particularly for police communications, and experience obtained there should be adapted to EMS communications planning.

4.4. Establishing a Data Base

A local resource data base is a collection of basic and factual information organized for easy retrieval. It provides a measure of the status for both resources and management of the existing telecommunications system. The size of the data base and the sophistication of associated data retrieval methods will depend on the scope of the telcommunications management system responsibilities and the equipment available for data system management. The data base files are used to:

- Identify existing system objectives
- Identify existing system inadequacies
- Establish implementation priorities through the quantification of needs
- Document the current system parameters for use in post-project evaluation
- Identify existing resources to be used for system improvement.

Rural regions and regions with minimal existing communications facilities will not require an elaborate data base or data management system.

Regional EMS system development generally requires coordinating and bringing together existing health-care facilities such as hospitals, ambulance services, information centers, dispatch capabilities, public access communications, etc. The resultant telecommunication system is highly dependent upon existing and planned resources which make up this health care system for the planning region. Designing an appropriate telecommunications system to meet the EMS delivery requirements for the region will be frought not only with the technical difficulties of making the existing hardware serve the total system requirements but also with jurisdictional problems associated with changing from the existing operations to an integrated system. Acquiring, maintaining, updating, and evaluating the regional data base will be a continuing responsibility.

Data bases contain three general classifications of material, namely: inventory files, management data files, and technical data files.

4.4.1. Inventory files

The inventory files are lists of current physical assets (antennas, transmitters, etc.) and resources of EMS telecommunication systems in the city, county, region, or state. Initially, much of this inventory may be privately owned and this presents a special challenge for EMS system planners who must determine proper incorporation or disposal of existing equipment. Similar inventory files from police and fire departments should also be available if sharing of equipment is planned. Some suggested subdivisions of these files are shown in Table 3. For example, the table shows that the make, model, serial number, and age of all hardware units in computer systems, control consoles, base stations, mobile stations, microwave control links, data terminals, recording systems and emergency power units should be filed in the data base.

Table 3.

Inventory File

Data Required *	Data Source								
	Computer System	Control Consoles	Base Stations	Mobile Stations	Portable Stations	Microwave Control Links	Data Terminals	Recording Systems	Emergency Power Units
Make, Model, and Age–All Hardware Units	X	X	X	X	X	X	X	X	X
Location of All Base and Remote Units	X	X	X			X	X	X	X
Number of Units	X	X	X	X	X	X	X	X	X
Number of Channels per Unit		X	X	X	X	X	X	X	
Frequency of Each Channel		X	X	X	X	X			
Assignment of Each Channel		X	X	X	X	X	X	X	
Mode of Operation of Each Channel	X	X	X	X	X	X	X	X	
Transmitter Power Output			X	X	X	X			
Receiver Sensitivity, Noise Blanking, Output			X	X	X	X			
Selective Signaling Tone/Digital Devices		X	X	X	X	X			
Antenna Towers, Transmission Lines, and Filters			X			X			
Antenna Location, Height, Gain, Pattern, etc.			X			X			
Number Remote Control Links–Wireline/Radio	X		X			X			X
Number and Type of Mobile or Fixed Data Terminals	X			X					
Number of Repeaters–Fixed and Mobile			X	X	X	X			
Number of Portables and Mobiles				X	X				
Number of Auxiliary Booster Amplifiers			X	X	X				
Number and Type of Battery Chargers			X	X	X				
Number and Type of Logging Recorders		X	X			X	X	X	
Number and Type of Instant Playback Recorders		X						X	
Number and Type of Closed Circuit TV Units		X	X					X	
Number and Type of Pagers and Public Address Systems		X	X	X	X				
Number and Type of Facsimile Systems		X	X	X	X		X	X	
Number and Type of Telemetry Systems			X	X	X	X	X		
Number and Type of Electronic Sirens and Warning Devices			X	X	X				
Continuous and Intermittent Power Rating			X	X	X	X			X
Maximum Allowable Time at Full Power			X	X	X	X			X
Type and Characteristics of Activation Systems						X		X	X
Voltage, Current, Frequency and Phase Ratings	X	X	X						X
Fuel Type and Storage Requirements									X
Identity of Data System Accessed by Each Unit	X	X					X		
Number and Type of Data Display Units	X	X							
Number and Type of Situation Display Units		X							
Security System Type and Characteristics	X	X	X	X		X	X	X	X
Number and Type of Leased Units	X	X	X	X	X	X	X	X	X

*Equipment serial numbers should be included on the inventory sheet if available, because the configuration is often associated with the serial number.

4.4.2. Management data files

Management files contain data on organizations, operations, and subelements (hospitals, dispatch centers, transportation resources, etc.) that will assist in the regional management of EMS telecommunications resources. These files are established and updated by periodic surveys of hospitals, resource centers, fire departments, and other cooperating agencies in the EMS region and by state and local government agencies which may contribute or cooperate with the EMS system within a given region or state. Management files are important for obtaining a clear understanding of the functional and operational requirements of each subelement and for identifying and evaluating alternative organization systems. Suggested data which can be included in a management file are displayed in Table 4.

4.4.3. Technical data files

Technical and engineering data files are established and updated as resource material to support telecommunications system design and improvements. Some of the suggested files which provide the basic resource data are outlined in Table 5. Required radio propagation data are often available from the user and/or firms that have provided engineering services in support of previous installations. Contracts for the design or implementation of public safety telecommunications systems within the planning area should contain a standard clause requiring all engineering data generated under the contract to be added to the data base in the technical files.

A formal methodology is needed if a truly comprehensive telecommunications system data base is to be obtained and kept current. At least the following eight steps are required:

- o Identify the user communities
- o Identify the system manager
- o Compile the data survey information
- o Conduct orientation meetings
- o Collect the data

Table 4.

Management Files

Data Required	Data Source					
	Computer Center	Resource Coordination Unit	Telephone System	Planning Unit	Administrative Unit	Hospital Communications Unit
Labor and Overhead Cost per Shift	x	x		x	x	x
Training Costs	x	x		x	x	x
Maintenance Costs per System and Unit	x	x				x
Lease and Rental Costs	x	x	x		x	x
Hardware Purchased Prices	x	x	x	x	x	x
Number of Agencies Dispatched per Shift		x				
Number of Dispatch Positions per Shift		x				
Number of Complaint Positions per Shift		x	x			
Number of Personnel by Classification per Shift	x	x	x	x	x	x
Annual On-Air Time and Down Time per System	x	x				x
Communication Traffic Rates — All Circuits		x	x			x
Information System Traffic Rates	x	x				
Intrusion and Fire Alarm Rates		x				
Crossband System Activation Rates		x				
Phone Patch System Activation Rates		x	x			x
FCC License Renewal File				x	x	
Mutual Aid Communication Plan and Agreements		x			x	x
Disaster Communication Plan and Agreements		x			x	x
Catalog of Computer System Output Reports	x				x	
Charts of Mutual Aid and Statewide Frequency Channels		x		x	x	
Copies of Lease, Rent and Use Agreements					x	
Number of Emergency Telephone Lines		x	x			x
Number of Administrative Telephone Lines		x	x		x	x
Number and Type of Special Wirelines (WATS, etc.)	x	x	x			x
Computer Aided Dispatching Facility	x	x				
Vehicle Locater and Display Facility	x	x				
Phone Patch Capability	x	x	x			x

Table 5. Technical Files

Data Required	Suggested Data Source
Vendor's Catalogs of Available Hardware	Vendors' Representatives
Specifications for Present System Hardware Items	Procurement Documents from Purchase Contract
Specifications for Present System Perforamance Parameters	Procurement Documents and Test Results
Installation Data for Present Hardware Items	Hardware Installation Manuals and Instructions
Computer System Programs and Users' Manuals	Computer Center and Computer Vendor
Information System User's Manuals	Information System Vendor or Owner
File of Standard Procurement Specifications and Procedures	Regional or State EMS Planning Agency
Spectrum Management Data	Federal Commmunications Commission (FCC)
Records of Radio Channel Interference and Noise	Logs of the Dispatch Center and Communication Center
Propagation Test Results—Radio Coverage Maps	System Contractor Engineering Unit and System Test Reports
Propagation Analysis Data for In-Service Channels	System Contractor Engineering Data and System Test Reports
Logs of Traffic Loads by Type for Wirelines and Radio	Logs of the Dispatch Center and Communications Center
Queueing Analysis for Wireline and Radio Channels	System Engineering and Telephone Company Engineering
Topographic Maps of Radio Service Area	United States Geological Survey—U.S. Department of the Interior
Statistical Projections of Area Population Growth	U.S. Census Data—U.S. Census Bureau
Statistical Projections of Area Demographic Trends	Local Chamber of Commerce Statistical Service
Estimates of Number and Duration of EMS Events	Receiving Hospital Emergency Room Records
Statistical Projections of Wireline and Radio Traffic Growth	In-House Projection from Historical Growth Data

- o Compile the data base
- o Analyze the data base
- o Update the data base.

Traditional methods of conducting a data survey are individual interviews, mail surveys, and telephone surveys.

4.5. Defining Specific EMS Communication Problems

The preceding two steps (user requirements and data base development) should provide the planner with a clear understanding of the existing telecommunications systems and the operational procedures associated with their use. An analysis of these data will assist the planner in documenting existing EMS system strengths and weaknesses and formulating recommendations.

At this point in the planning process, it is often advantageous for the planner to visit other EMS systems which have similar characteristics (i.e., population, geography. . .). It is also appropriate to include representatives from public safety and medical services in the visit so that they can directly interface with their respective counterparts (i.e., personnel in law enforcement, fire protection, ambulance, and emergency room service, public education, communication maintenance. . .). Drawing the various service personnel together for site visits also has the advantage of focusing their attention on telecommunications, a task which may prove difficult or impossible in their busy, day-to-day work environment. The site visits, if carefully planned, can provide a forum for new ideas, can allay real or imagined fears, can develop confidence in proposed system changes, and can serve as a point of contact for future discussions of problems.

From study of user requirements, existing local resources (data bases), and from experiences gained from other EMS systems, the planner can submit a report to the EMS communications Committee for their review and coordination with the EMS Council. This report, integrated with the other EMS Committee reports (i.e. transportation, training, facilities. . .), will provide the EMS Council with the necessary information to formulate long- and short-range goals.

It is again stressed that telecommunications is only one component of the system. The EMS Council is responsible for assuring that the mandatory EMS components are integrated and organized in a manner consistent with local needs. Telecommunications, like the other components, is but one way of improving patient care, and should not be considered an end in itself.

Thus far, the various planning steps described above are those performed by local personnel. However, it is advisable for the EMS Council to submit the planning data to a qualified consultant for review and comments. This added step requires additional time and funding, but it can prevent inbreeding of ideas, can propose options not considered and standards not incorporated, and it can confirm that the planning is basically sound.

4.6. Setting Goals, Objectives, and Requirements

Experience indicates that goals are always present, whether by neglect or positive action. It is assumed that the analysis of user requirements and existing local resources (data base) will enable the planner to develop recommendations which will cause existing goals to be confirmed, modified, discarded and/or new goals to be formulated. A well-formulated and documented progression of system goals will enable the EMS Council to define the system objectives and program requirements, thereby increasing the likelihood of approval and funding.

The following definitions may be helpful:

Goal: A statement of broad direction, general purpose, or intent. A goal is general and timeless and is not concerned with a particular achievement within a specified time period.

Objective: A desired accomplishment that can be measured within a given time frame and under specifiable conditions. The attainment of the objective advances the system toward a corresponding goal.

Requirement: A desired accomplishment which is subordinate to an objective. A requirement is attainable within a specified and immediate time limit, is consistent with the time frame of the objective and is clearly measurable, often in numerical values. The fulfillment of a requirement is usually based on the performance of one or more tasks.

Task: The smallest increment of achievable work that is identifiable, assignable, and measurable within an immediate time frame. A task may be time dependent on other tasks (one task would start only after the start or completion of another task).

The example in Table 6 illustrates the relationships between goals, objectives, and requirements. Achievement of each stated requirement is necessary to accomplish the objective. Accomplishment of the objective contributes to and supports achievement of the goal.

Table 6. Illustration of Goal, Objective, Requirement, and Task

Goal: Provide the best possible public access to a regional EMS system
Objective: Eliminate the need for multiple 7-digit telephone access numbers for the EMS region.
Requirement: Establish a 911 public access system or equivalent.
Task: Enlist the support of local telephone company(ies) to plan a 911 system for the region

Factors to be considered in establishing goals, objectives, and requirements are discussed in the subsections that follow. Task identities are self-evident once requirements are defined and, since they take on an endless variety of definitions, tasks will not be discussed further.

Use of goals to identify objectives

The goal defines the ultimate capability that is desired. A logical first step in identifying objectives is to review and analyze the goals from the viewpoint of the course of action required to reach such goals. A listing of the conditions to be met in order to reach a goal will identify a number of potential objectives. A rearrangement in the order of dependency will separate objectives from subordinate requirements.

Use of a data base to identify objectives

Examination and analysis of the data bases will often reveal areas of deficiencies in the existing telecommunications systems. These deficiencies, if properly correlated, may indicate program objectives with program goals. Another method for identifying possible objectives from the data base is comparing the data bases from similar cities, regions, or states. Significant differences may identify candidate objectives.

Use of resource agencies to develop objectives

The development of effective telecommunications system objectives requires inputs from all elements of the EMS Council. Resource agencies must be used to provide inputs.

Use of recognized standards to identify objectives

Federal, state, and local entities have established EMS performance standards in certain areas (ambulance licensing, training requirements, radio regulations. . .) which the planner must research for the particular area.

Review of objectives

It is important that any proposed objectives be well understood and accepted by the people responsible for project implementation and evaluation.

The review process should address, in particular, factors relating to:

- o The attainability and feasibility of the objective
- o The impact of the objective in reaching the goal
- o Priority of the objectives.

The proposed objectives should be distributed to all resource and user agencies. Documentation describing the objectives, the background data needed for analysis, and the rationale for the objectives should be incorporated in the review package along with requests for specific comments on each objective.

The extent of the review process will depend on the magnitude, scope, and sophistication of the proposed objective. Programs of limited scope could be reviewed adequately by informal discussions with responsible personnel of the user agencies.

Requirements

The planner must establish a set of attainable and measurable requirements for each project objective. These requirements define the course of action which must be followed in order to meet the project objectives. These are also the action items that establish the dimensions of the work to be accomplished by the project staff.

The scope of the requirements will include all aspects of system implementation. Each project objective should be fully supported by subordinate requirements covering a full range of definitive technical, financial, legal, and administrative considerations. Each requirement must satisfy the test of definition (attainment must be clearly measurable and must be reached within a specified time limit).

Use of objectives to identify requirements

The procedure for separating objectives from project goals should have resulted in the listing of conditions and parameters to be met and the order of their dependency. The more specific of these technical, financial, legal and administrative conditions can usually be defined as a requirement, i.e., these conditions are desired accomplishments attainable within a specified time limit and are clearly measurable often in numerical values.

Use of the data base to identify requirements

The files of the data base will provide many of the numerical values for project requirements. The technical files are rich in system performance parameters. The inventory files show the number and type of additional system components needed. The management files provide operational parameters as well as financial data.

Use of resource agencies to develop requirements

The success of the project depends upon its meeting the needs of the user agencies and the agencies with whom it interfaces. Those agencies should be used to provide policy inputs and the data base update.

Review of requirements

The requirements of the project should be well understood and accepted by the people responsible for project implementation. A review of the requirements by these people before general publication is mandatory.

Performance validation of EMS telecommunication systems

Since telecommunications is only one of many components which constitute an EMS system, evaluation of the telecommunications component does not necessarily provide overall EMS system performance. This would suggest that EMS systems require various evaluation strategies, those which provide management feedback for the component, as well as those which examine the total EMS system. Evaluation, within the scope of this planning guide, will focus on the operational or performance validation of the EMS telecommunications component. For patient outcome evaluation, a measure of EMS system performance, the planner should consult texts which address the more complex issues and variables involved in system evaluation.

Performance validation consists of measuring the implemented telecommunication system to determine if it meets the criteria set forth in the goals and objectives (Dept. of Health, Educ., and Welfare, 1976). It is obvious that the more explicit (quantifiable) the telecommunications objectives are, the simpler the task of validating the performance. Care must be taken, however, that the development of objectives is not overly compromised by quantification. This tradeoff between quantification and more broad-based objectives is not unique to this type of planning. Skill and system understanding are required by the planner to reach appropriate compromises.

5. ELEMENTS OF EMS TELECOMMMUNICATION SYSTEMS

This section is intended to introduce technical concepts and terminology to the nontechnical planner so that he or she can be more effective in the telecommunications environment. It is not a substitute for a telecommunication training course or technical text, but is designed as an introduction to telecommunications, with bibliographic references for those planners who wish a more detailed explanation of the material.

5.1. Base-Mobile System

The heart of an EMS telecommunication system is the base-mobile radio system by which the dispatch center and hospital personnel maintain communications with field personnel.

Base-mobile communication has two primary operating modes. The first mode consists of a communications requirement between a geographically fixed unit, or base station, and a geographically mobile unit as shown in Figure 11a. The second mode involves two or more mobile units as illustrated in Figure 11b. The mobile units in each instance may be personel or portable units as well as vehicles.

The telephone subsystem, which is an integral part of the EMS system, is equally necessary for system operation; however, integration of the total EMS telecommunication system generally requires fewer technical decisions to be made regarding the telephone subsystem than the two-way radio subsystem. Therefore,

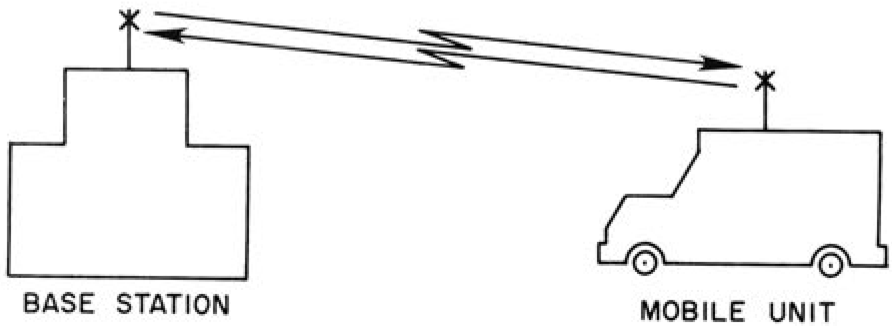

Figure 11a. Base station/mobile mode.

Figure 11b. Mobile-to-mobile mode.

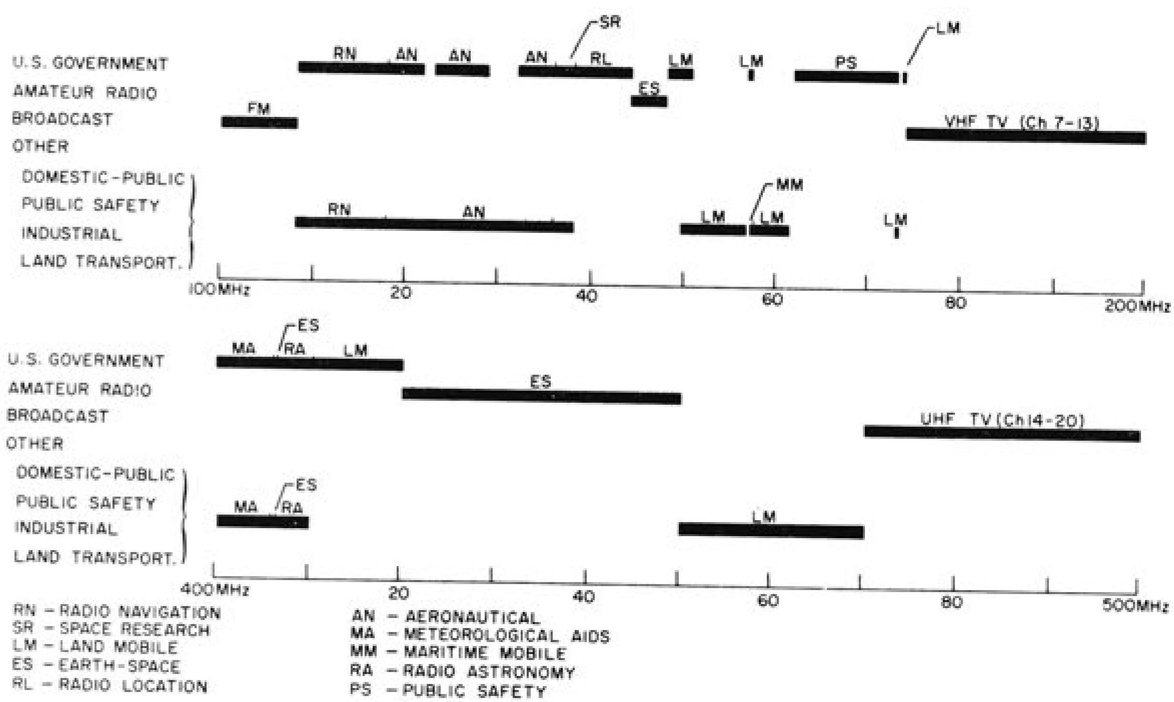

Figure 12. Portions of the radio spectrum.

the discussion of the radio subsystem will be presented in greater detail in this section, and the telephone subsystem will be presented in Section 6.

5.2. The Radio Frequency Spectrum

Radio waves (or more precisely, electromagnetic waves) are the means by which radio communications are conducted. An EMS radio system operates on a certain radio or channel frequency and actually includes a small range--called a band of frequencies or sidebands--around that frequency. When all possible radio frequencies are taken as a group, the term "radio spectrum" is used. A simplified version of a portion of the radio spectrum (encompassing VHF-high band and UHF-band emergency radio) is seen in Figure 12.

This spectrum is in essence a finite natural resource which, unlike most other resources, cannot be detected by any of our human senses. This resource is an invisible means by which energy can be transmitted at one point and received at another to convey information. Since electromagnetic energy can be transmitted without wires, it is an extremely valuable means of conveying information whenever either the sender or receiver or both is in motion, as in EMS operations. Every radio transmission has three basic attributes:

- It occupies a certain geographic area
- It occupies a certain period of time
- It occupies a certain portion of the radio spectrum.

These attributes are very important aspects of a radio communication system. A basic rule is that no two radio users can use the same portion of the spectrum at the same time and in the same area without interfering with each other. In order to prevent interference, the users must be separated sufficiently in geographical area of operation, in time or in frequency.

In order to transmit information, a certain amount of frequency spectrum is needed. The amount of spectrum required increases as more information needs to be transmitted simultaneously. For example, a television picture transmission uses several hundred times more spectrum than voice transmission. The amount of spectrum occupied by a transmission is termed the bandwidth of the transmission.

Each user of spectrum is assigned a certain amount of spectrum bandwidth for his use. The assignments include a small amount of buffer spectrum bandwidth, called the guard band, which serves to prevent interference from adjacent users.

5.2.1. Frequencies, channels and radio communication

Radio signals transfer information from one point to another by means of electromagnetic waves. These waves have a number of characteristic properties that enable them to be employed as radio signals. Of primary concern to us here are the properties of frequency and power (sometimes called energy content).

Electromagnetic waves are familiar to us as broadcast radio and television signals, radiant heat, light, and X-rays. All are manifestations of electromagnetic waves that transfer energy and information over a distance. One of the basic differences between these various forms of electromagnetic waves is frequency. The totality of frequencies of such waves is called the electromagnetic spectrum (or just spectrum). The EMS radio systems with which we are concerned occupy a very small part of the lower portion of the radio spectrum, viz., some of the frequencies in the ranges listed in Table 7. The VHF high-band and UHF band are used more extensively by municipal and county systems than the other bands, because radio waves at those frequencies have desirable propagation characteristics. In brief, a limited area can be covered more completely by radio signals at these frequencies (without causing as much interference outside the desired area) than by frequencies in other bands.

TABLE 7.

Spectrum Ranges Containing EMS Radio Frequencies*

FREQUENCY RANGE IN MHz	DESIGNATION	BAND	USE
2.00 to 3.00	-	MF	Fixed
2.726	-	MF	Base & mobile
3.201	-	HF	Base & mobile
33.02 to 47.66	VHF low-band	VHF	Base & mobile
72.0 to 76.0	-	VHF	Operational fixed
150.775-163.250	VHF high-band or 150 MHz-band	VHF	Base & mobile
458.025-468.175	UHF or 450 MHz band	UHF	Base & mobile
952-40,000	Microwave	UHF,SHF & EHF	Base, mobile, operational fixed & radio location

In order for a radio signal to contain information it must consist of a band of frequencies; that is, a certain amount of frequency spectrum. The nominal bandwidth for radio signals in the land-mobile service is 20 kHz. For frequency modululated (FM) voice signals, the maximum authorized frequency deviation is 5 kHz on either side of the center frequency. (Frequency deviation of an FM signal is the change in the carrier frequency produced by the modulating signal.) The frequency assignments are called "channels." They consist of a band of frequencies (wide enough for the transmission of the information being conveyed) and the guard band. In the very high frequency (VHF) high-band the spacing is 15 kHz, while at ultra high frequency (UHF) it is 25 kHz. Thus, two adjacent channels in the high-band cannot carry 20-kHz wide signals without some overlap. If the signal strengths in the adjacent channels are comparable at the intended receivers, the receivers will most likely experience interference. Adjacent channel assignments must therefore be made with sufficient geographic separation (or other precautions) to prevent this kind of interference.

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*See Federal Communications Commission (FCC) Rules and Regulations, Volume 5, Part 89, Subpart P, Section 89.501, for a detailed description of the rules and regulations.

Frequency assignment in the land-mobile services is a difficult task because in many areas of the U.S., and in most services, there are more users than can be readily accommodated in the spectrum space available. This is particularly true in and near metropolitan areas. The FCC, which issues the licenses and which has the ultimate authority over frequency allocation and assignment, has enlisted the aid of user groups in various land-mobile services to coordinate the assignments in a given service and geographical area. In the Local Government and Police Radio Services, the Associated Public Safety Communications Officers, Inc. (APCO) performs this function through designated frequency coordinators and frequency advisory committees. Its function is to coordinate applications both for new licenses and for license modifications (involving power and antenna height) with existing frequency assignments, and to advise the FCC and the applicant by making a recommendation in each case. The names of the frequency coordinator and chairman of the Frequency Advisory Committee can be obtained from the local APCO chapter or the national chairman.

5.3. Radio Propagation, Transmitted Power, Antennas, and Receivers

Fundamental to any EMS telecommunication system are the basic concepts which help to explain the actual transmission, propagation and reception of the radio frequency signals by which messages are sent. The treatment of these subjects here is introductory. For detailed treatment of the concepts discussed, refer to the Bibliography.

In any radio communication system it is necessary that at least a certain minimum signal level be present at the receivers. This is required independent of location within the operating area of the users. Since it is neither economically viable nor legally permissible to use excessive transmitter power, estimates must be made of the minimum power necessary to reach the most remote points of the area. These estimates can be made by calculating the approximate propagation loss suffered by the signal between the transmitter and the receiver at those remote points of the system's service area. The propagation loss and the minimum amount of power acceptable at the receiver can then be related to the required transmitter power. There are several methods available to determine approximate propagation losses. These losses are mainly dependent on:

- The radio frequency used
- The type of terrain and buildings in the area
- The heights of the transmitting and receiving antennas.

Calculating propagation loss can only give approximate results. An engineering survey is usually required before system parameters are finally chosen. Propagation losses are only one part of the "losses" and "gains" of power which exists in a radio system. These are shown in Figure 13. In particular, power gains usually occur in the following places:

- The radio transmitter
- The transmitter antenna
- The receiver antenna

and power losses usually occur in:

- The transmitter transmission line to the antenna
- The mismatch between the transmission line and the transmitter antenna
- The propagation to the receiver
- The mismatch between the receiver antenna and the receiver transmission line
- The receiver transmission line from the antenna
- Radio frequency (rf) cavities and filters, duplexers and isolation elements.

All of these losses and gains must be considered in determining the "total" or net loss in power between the transmitter and the receiver.

Transmitting and receiving antenna gain is usually specified relative to a standard antenna, a half-wave dipole. With restrictions on transmitting and receiving in certain directions, certain

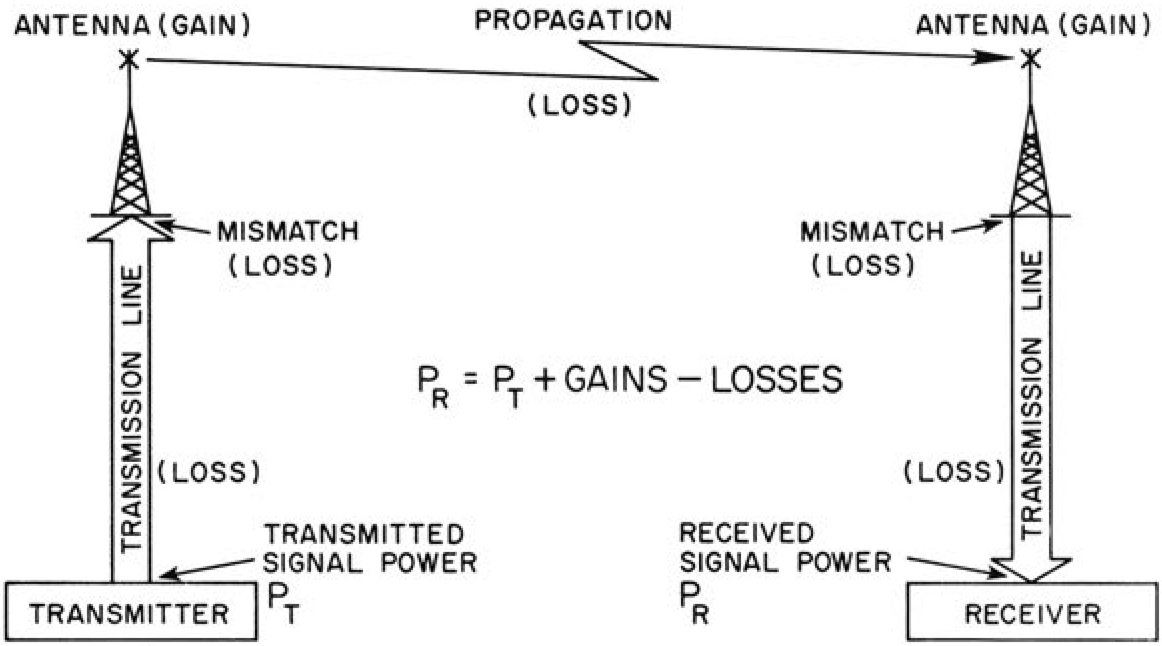


Figure 13. Gains and losses in a radio system.

antennas display an effective gain over the half-wave dipole because they concentrate their transmitted or received energy in certain limited directions. The direction of this concentration is usually along a horizontal plane for base-mobile systems, since most mobile units are located on the ground. (Aircraft units are the obvious but rare exception.) There is a practical limit to maximum achievable antenna gain because of restrictions on antenna size. The allowable size of an antenna must take into account factors such as FCC regulations and structural ruggedness.

It is common to speak of the "effective radiated power" (ERP) of a radio station. This is the power that actually leaves the antenna. It is <u>not</u> the same as the radio frequency power of the transmitter itself, since losses occur in the transmission line to the antenna and are caused by inexact matching to the antenna. Further, a gain usually occurs in the antenna itself. Thus, the net power emitted by the antenna (the effective radiated power) may be either higher or lower than the radio frequency power generated by the transmitter itself.

The propagation losses in the signal between the transmitter and the receiver cause the signal power at the receiver to have a very small magnitude, unless the distance between transmitter and receiver is small. All receivers have a power level threshold below which their output is not intelligible. This threshold is referred to as the "receiver sensitivity." Radio noise from such sources as auto ignitions, electric motors and natural sources (called "ambient noise"), or interfering signals from other radio stations -- all these noise sources often exist at power levels above receiver sensitivities. The received signal power usually must be greater than these interfering signals in order for the receiver output to be intelligible. In general, a receiver rejects signals which have frequencies different from the desired signal. When the interfering signals have the same or nearly the same frequency, in-band interference results. In FM receivers, when the desired signal is stronger than the interfering signals by a given ratio, called the "capture ratio," the desired signal may often be received in spite of the in-band interference.

Improving the coverage over the area to be served by the existing system can be accomplished in five possible ways:

- o Changing the transmitter power or the receiver sensitivity
- o Changing the height of the base station antenna
- o Changing the gain of the base station antenna
- o Reducing any system transmission line losses
- o Move the transmitter antenna site.

The first three improvements are usually restricted by legal (FCC, FAA, etc.) and economic factors. Limits in transmitter power are often imposed by the FCC. The costs of improving receiver sensitivities or raising an antenna can be excessive. Increasing the gain of the antenna (making it more directive) and reducing system losses, especially losses in the transmission line between the transmitter and antenna, provide the most economical way of increasing coverage.

5.4. Network Organization and Channel Configurations

There are a number of different channel and network configurations which can be used in EMS telecommunication systems. This subsection will acquaint the planner with the basic channel and network configurations. Section 7 will discuss operational channel and network configurations.

The word "channel" as used in base-mobile telecommunications has two definitions which should be understood at the outset. In the first, a channel is one certain portion of the radio spectrum assigned to a user for his messages. The second meaning arises from the fact that many base-mobile systems use one channel (as just defined) for the base station transmissions and a separate channel (or more than one) for the mobile unit transmissions. In such systems, this combination is also called a "channel." Thus, in general, all of the slices of spectrum needed to carry on two-way communication, taken together, are called a channel. Ordinarily, no confusion results since the meaning intended is usually clear from the context. It is also common to use the words "frequency" and "channel" interchangeably, where here the first definition of channel is intended, and the frequency referred to is the center frequency of that channel. A diagram of a generalized base mobile communications channel is presented in Figure 14. The channel consists of a base frequency and a mobile frequency, each with its own transmitting and receiving equipment. In a two-frequency channel, the base and mobile frequencies, f_1 and f_2 are different. A single-frequency channel uses a common frequency for the base and mobiles, and consequently f_1 and f_2 are the same in that case.

The more common channel configurations in radio telecommunications are shown in Figures 15 through 19.

5.4.1. Network configurations

In general, a network is defined as a collection of several radio channels operated by one or more departments in a coordinated fashion to provide radio service in a certain area. The

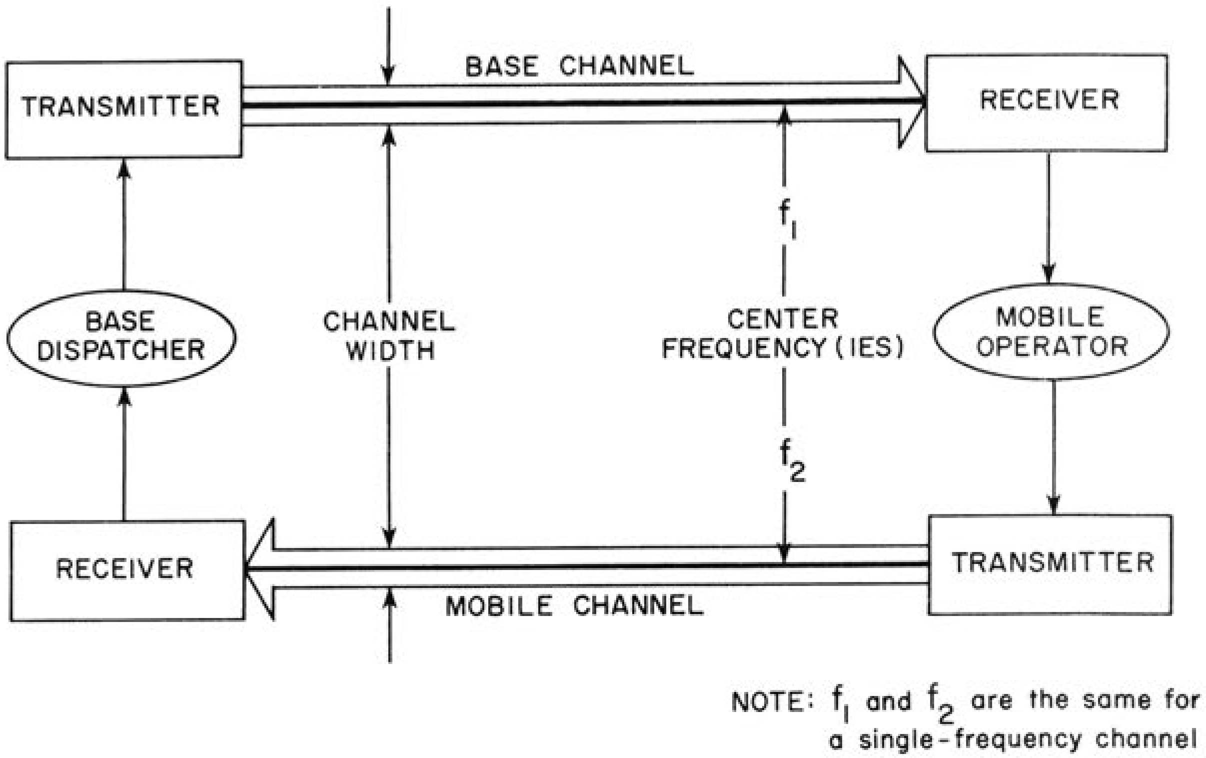


Figure 14. A base-mobile communications channel.

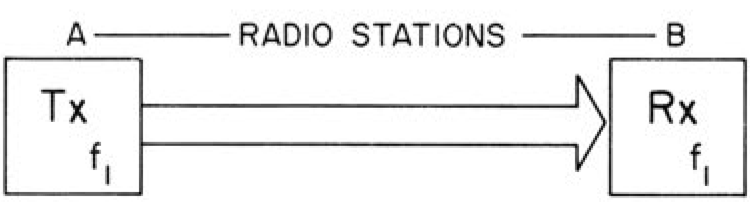


Figure 15. Single-frequency, one-way operation--permitting transmission of information from User A to B, but not vice versa.

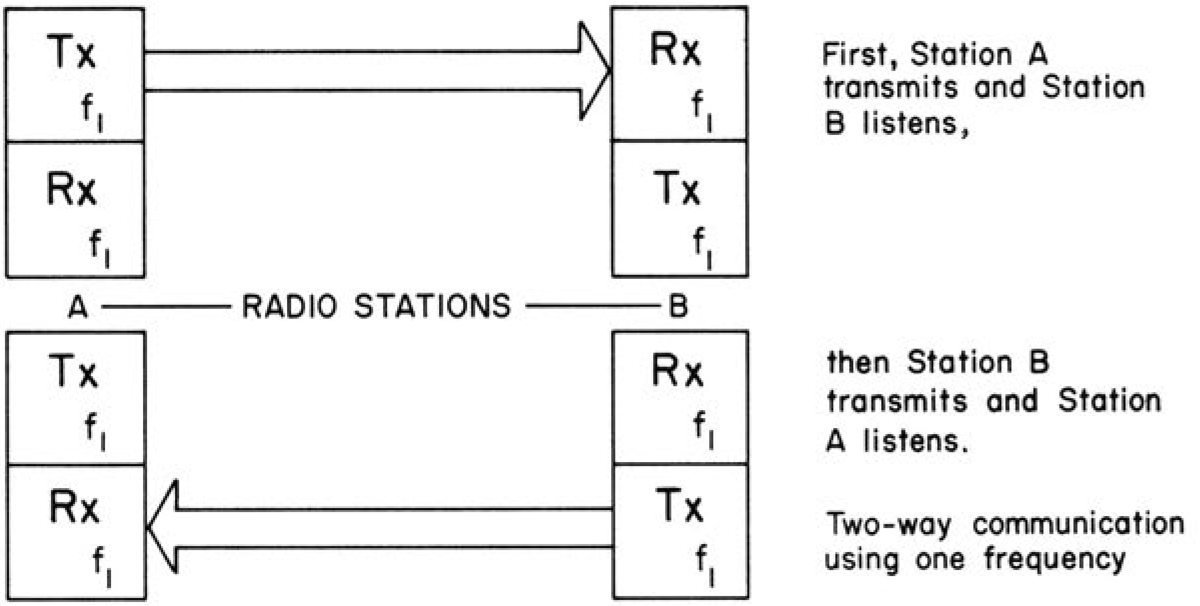


Figure 16. Single-frequency simplex operation--permitting transmission from A to B or from B to A, but not in both directions simultaneously, and using the same frequency in both directions.

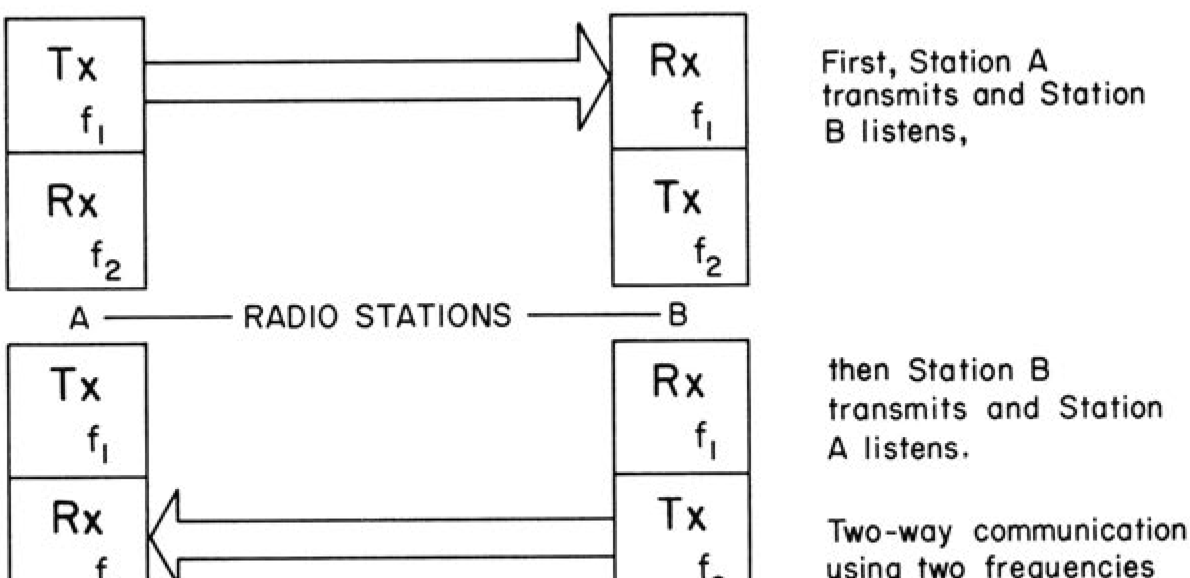


Figure 17. Two-frequency, simplex operation--permitting transmission from A to B or from B to A on two distinct frequencies, but not in both directions simultaneously.

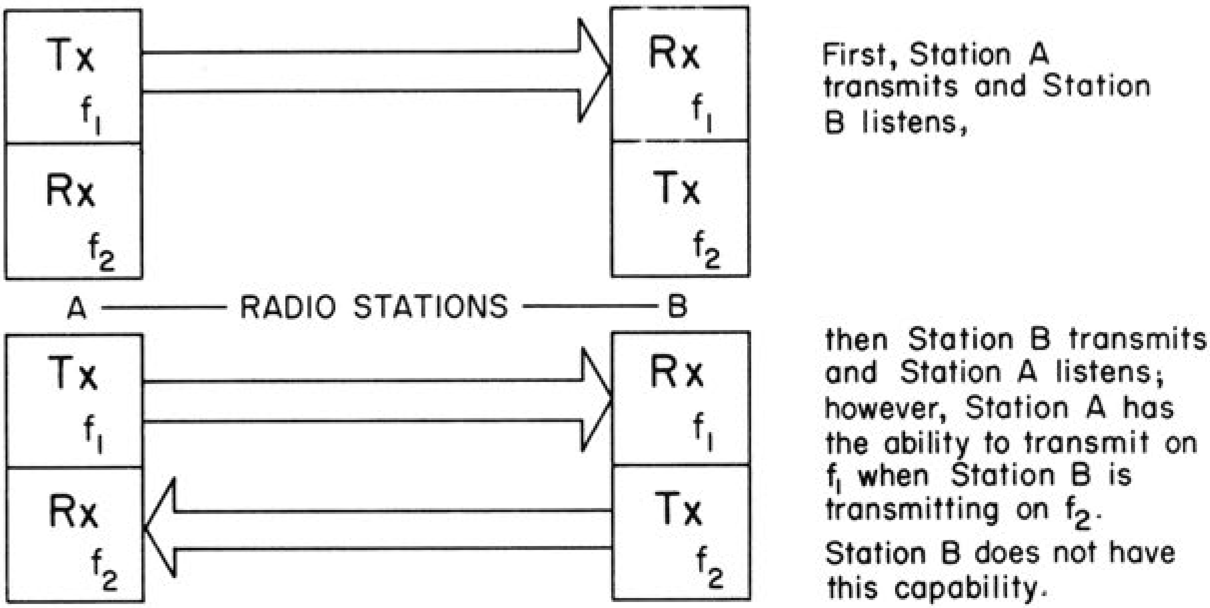


Figure 18. Two-frequency, half-duplex operation--permitting transmission from A to B or from B to A on two distinct frequencies, and simultaneously at the base end of the link, but not simultaneously at the mobile end.

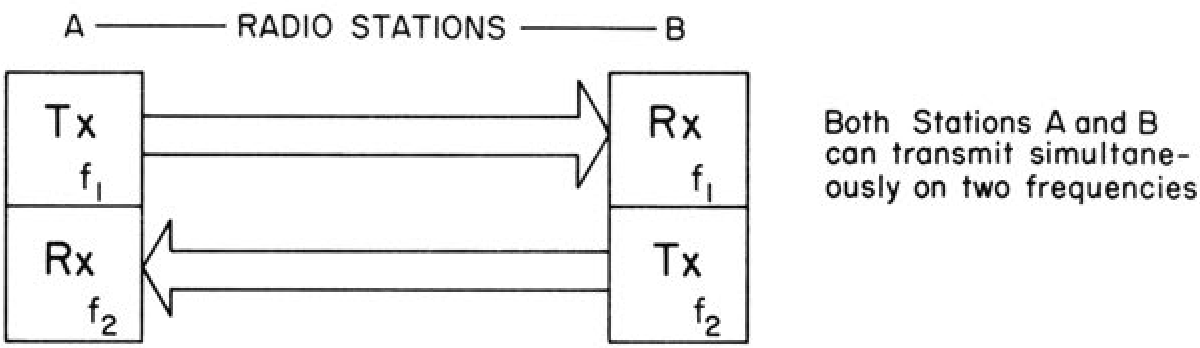


Figure 19. Two-frequency, duplex operation--permitting transmission from A to B or from B to A on two distinct frequencies, and simultaneously in both directions.

size and degree of formal organization of public safety radio networks varies widely. Unfortunately, many networks have been formed as a result of unstructured evolutionary growth and exhibit little cooperation between users.

A network is a complex system composed of many pieces of equipment and many persons working together to fulfill the communication needs of the users within the network. Examination of network structures, however, yields the following basic factors which roughly characterize them:

1. Location of the dispatching points
2. Location of the base station radio equipments
3. The number of frequencies in each channel
4. The number of channels in the network
5. The operation of the channels which make up the network.

In general, one can consider each of the factors to be more or less independent of the others. For each, there exists a pair of tradeoffs which one considers when building a network. These tradeoffs are the following pairs:

1. Dispersed or central location of dispatching points
2. Dispersed or central location of base station equipment
3. Single or multi-frequency channels
4. Simplex or duplex operation of the channels.

These tradeoffs can be combined to give 12 basic network configurations. Experience has shown that certain of these configurations are superior to others in serving the needs of particular EMS systems. Networks can best be compared to each other by examining the following:

- The types of interference to which the network is susceptible
- The available methods of channel "isolation" to prevent interference within the network
- The performance under heavy message loads
- The radio coverage characteristics

- The existence or nonexistence of mobile-to-mobile and base-to-base communications in the network
- The possibility of using special devices (such as radio telemetry) within the network.

The best network for any particular area is the one which provides the most effective service in view of the particular advantages and disadvantages of each configuration. Detailed discussion of typical successful system configurations can be found in Sections 6 and 7.

5.5. Fixed Equipment

A variety of equipment designed for use at a fixed location may be employed in a telecommunication system. Fixed location, or base station two-way radio equipment should include, as a minimum, transmitter(s), receiver(s), antenna(s), tower(s), control units and, finally, because every base station requires electric power for operation, an emergency power supply.

5.5.1. Base station two-way radio

A base station includes a radio transmitter and one or more radio receivers which are permanently installed at a fixed location such as a hospital or communication center. The primary purpose of the base station is to provide the dispatcher with a means of sending and receiving information from the mobile units. The base station is also used for point-to-point communication with other public safety agencies.

Two types of messages may be handled by the base station--voice and data. Either one may consist of analog or digital signals. Digital messages occur in systems which employ equipment such as teletypewriters, teleprinters, and computer terminals.

Base-station radio equipment varies widely in physical appearance. The transmitter and receiver may be mounted in the same housing or may be completely separate. Receivers tend to be smaller and more uniform in size than transmitters (usually about the size of a typewriter or smaller). The size of a transmitter depends mainly on its power rating. Some of the low-power units may be no larger than a common table radio while a high power unit may occupy a rack about 2 ft wide and 7 ft high. Equipment sizes also depend upon the type of circuitry used--vacuum tube or solid state. Solid-state circuitry, which employs transistors and other semiconductor devices, allows significant reduction in size over vacuum tube circuitry. Low-powered base-station solid-state transmitters and most receivers are often small enough for desk-top operation. High-powered transmitters, however, generally stand on the floor or are mounted on a wall or a pole.

Almost all EMS systems employ FM equipment. Commercially manufactured FM base-station equipment is available for operation in the VHF high-band, and UHF band. The FCC requires that communications in these bands be confined to assigned channels in order to minimize interference among users. Transmitters and receivers designed for use in these bands operate only on the assigned channels. They cannot be tuned in the manner that one tunes an AM or FM broadcast receiver, and because crystals are used in frequency generating circuits, the equipment is often referred to as crystal-controlled. Base-station radio equipment is produced with both single- and multiple-channel capabilities.

Figure 20 shows a base station two-way radio designed for desk-top operation. The radio cabinet houses both the transmitter and the receiver. A desk stand microphone is shown next to the radio. The receiver loudspeaker is built into the radio cabinet. The antenna functions for both transmission and reception.

Figure 21 shows a base station designed for remote operation. The use of the remote-control configuration allows the base station to be located near the antenna, reducing the length and loss of the transmission line.

The emission bandwidth of FM transmitters used in the VHF high-band, or UHF band is, as stated earlier, limited by the FCC to a maximum of 20 kHz. In other words, the frequencies which are generated by the transmitter and have appreciable amplitude

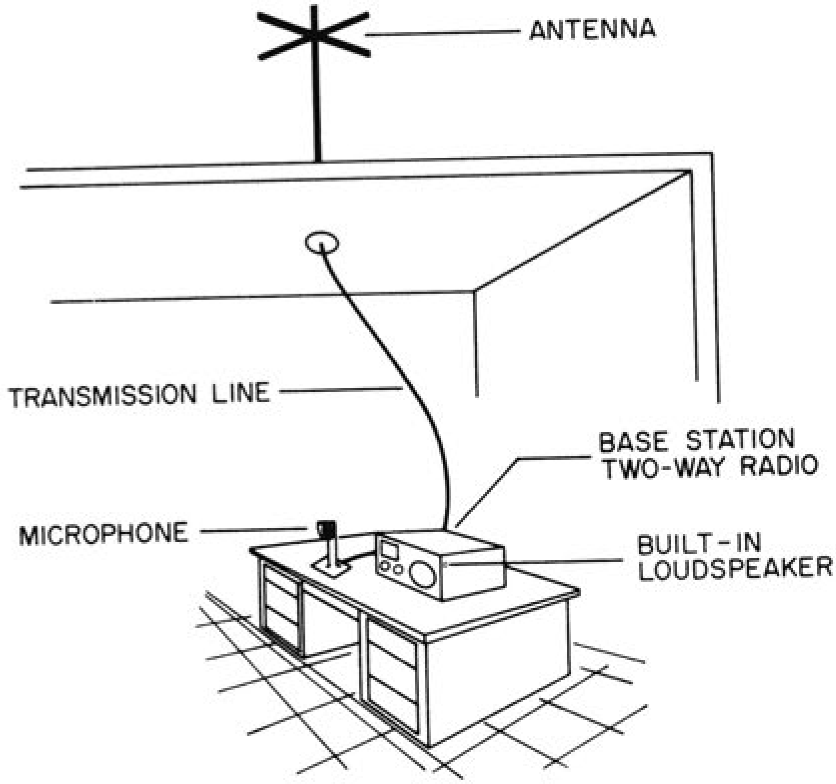


Figure 20. Typical small base station.

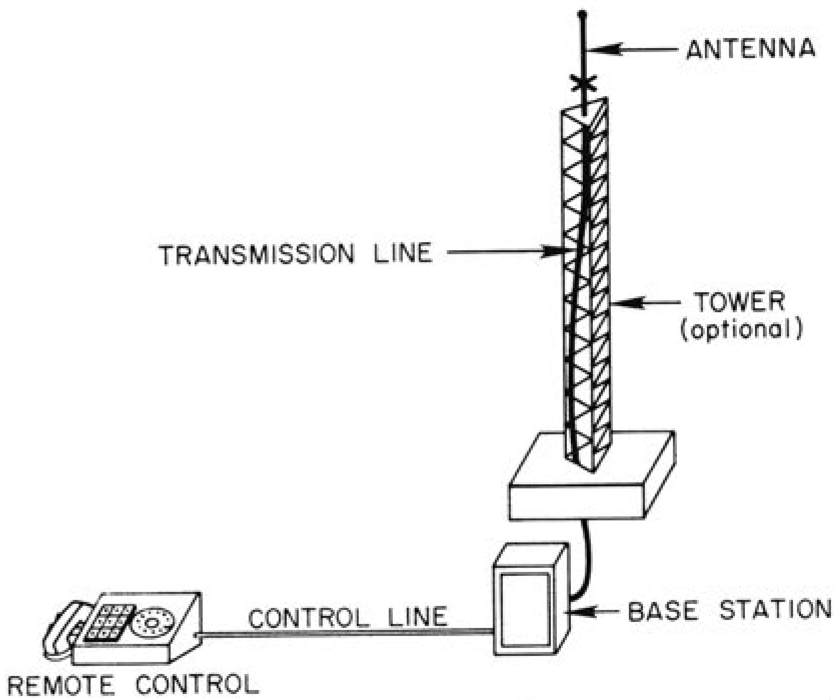


Figure 21. Base station-remote operation.

must fall within this 20 kHz channel. Frequencies which are generated outside of this channel, on either side, must be reduced in amplitude. Receivers, on the other hand, must be most sensitive to frequencies within the 20 kHz channel. Frequencies on either side must be rejected. This means, in effect, that an adjacent channel signal will not be heard at the receiver output. This receiver characteristic is referred to as adjacent channel selectivity.

Base-station transmitters are manufactured with a large selection of radio frequency (rf) power ratings. Limitations on transmitter power are imposed by the FCC in order to minimize interference among users within the same frequency bands. The limitations are stated in terms of the power input to the final rf stage of the transmitter. This final rf stage is commonly the vacuum tube or transistor amplifier circuit whose output goes directly to the antenna. Specifically, the limitation is 600 W for VHF high- and UHF-band units at operating frequencies less than 470 MHz; the maximum power input is specified in the station's FCC authorization. However, special authorization may be obtained from the FCC to operate at higher power levels. For example, some state police low-band ($\sim$2 MHz) transmitters operate with 10,000 W of power input to the final rf stage. These power figures are upper limits and not necessarily common values. Base-station transmitters are available with final rf stage power inputs of only 1 or 2 W.

The FCC assigns frequencies to various base stations within a geographical area depending upon the limitation of rf power outputs to certain levels. When these levels are exceeded, the transmitted signal may be strong enough to interfere with signals in other geographical areas. FCC regulations state that:

> "The RF power output of a station shall be no more than required for satisfactory technical operation considering the area to be covered and the local conditions."

In the interest of preventing interference, adherence to the above regulation is imperative. Excessive rf power output level can cause interference, as can antennas with unnecessarily high power gain or height.

One feature which is standard on all base-station receivers is carrier squelch. The purpose of carrier squelch is to eliminate disturbing background noise when no transmitted signal is present, thus reducing operator fatigue.

Another type of squelch, usually offered as an option, is tone-coded squelch. A receiver equipped with tone-coded squelch is activated only by signals containing a specific tone or tone combination and not by other signals. By equipping the mobile transmitters with the proper tone generating circuits, only the mobile units of the desired system will be heard by the dispatcher. Base-station transmitters and mobile receivers may also be equipped for tone-coded squelch. Detailed consideration is given to tone-coded squelch and selective signaling methods in Section 7.

5.5.2. Base-station antennas

The base-station antenna is a device used to excite or radiate into space the rf energy carrying the messages. It is also used to receive rf signals transmitted from mobile units. The antenna is a metal structure whose dimensions depend upon the wavelength (frequency) of the transmitted and received signals. Often, the height of the antenna relative to the surrounding terrain can affect the entire system performance. Normally, a higher antenna increases the area covered. Many times, the antenna is placed on a high point, such as the top of a building, or at a remote site such as a hilltop. The rf transmitter is located near the antenna and in the case of a remote site, the transmitter is controlled by a wire line (i.e., private leased telephone line),or a separate radio or microwave link. An unmanned transmitter and receiver station may act as a repeater station, retransmitting the radio signals sent to it by both base stations and mobile units. Remote control and repeater usage will be covered in depth in Section 6. The base-station antenna is usually centrally located in the service area. The radiation patterns of two types of antennas are shown in Figures 22 and 23. The pattern of a centrally located base-station antenna should be uniform (in the horizontal plane) in all directions, to achieve maximum coverage. The radiation pattern in the vertical plane is normally kept narrow, that is, squeezed into a doughnut shape, to achieve some gain in the horizontal direction. If the antenna is not centrally located, a suitable antenna type is used to make the radiation pattern more directional--that is, at a given distance from the antenna, the signal is stronger in the preferred direction than in others. By confining the rf energy to the intended service area the system can be operated more efficiently.

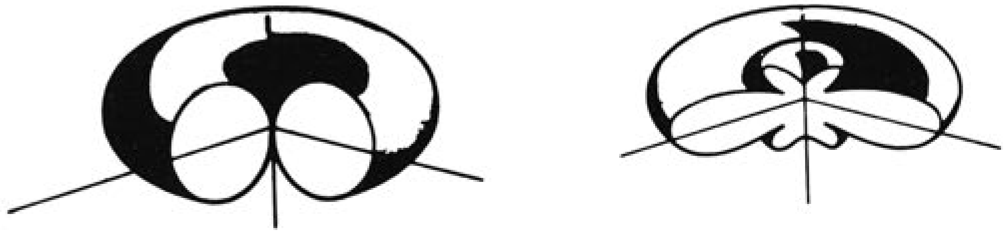
A proper impedance match between antenna and transmitter through the connecting transmission line is necessary for maximum operating efficiency. Normally, the characteristic impedance of the antenna, transmitter, and line is 50 ohms.

Antenna dimensions, as mentioned, are a function of the operating frequency. One antenna may, however, be required to handle several channels. Antenna dimensions must then be carefully chosen so that the antenna will perform well on all channels used.

Lastly, base-station antennas must perform their functions with little or no attention in every environment, in all types of weather. This requirement affects primarily the antenna's physical characteristics, and the tower and support structure.

5.6. Mobile Equipment

Mobile equipment is used by field personnel to communicate with the dispatcher, control hospital, or other public safety agencies. Two-way radios, either installed in vehicles or carried by individual field personnel (emergency medical technicians, paramedics. . .), are the two most important types of mobile equipment. Such two-way radios, often referred to as



(a) (b)

Figure 22. Three dimensional sketch of the radiation patterns of (a) a dipole antenna, (b) an antenna with directivity gain.

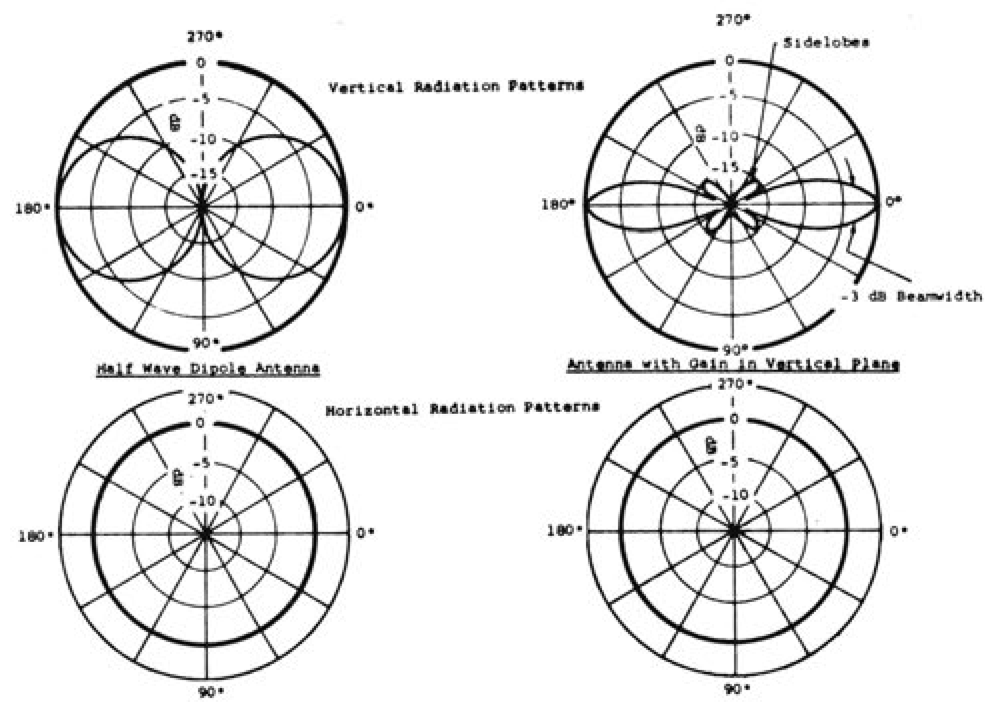


Figure 23. Typical principal plane radiation patterns for a half-wave dipole antenna and for an antenna exhibiting directivity gain in the vertical plane.

"mobile-units," are indispensable links in the communication chain which aid medical supervisory personnel in command and control of EMS patient field care.

5.6.1. Vehicular mounted two-way radios

A vehicular two-way radio usually consists of a transmitter and receiver packaged as a single unit. Some units are designed for installation under the dashboard of a car or truck. This type has built-in controls and speaker and an external hand-held microphone. Other units are designed for installation in an automobile trunk or elsewhere. In the latter case, the radio is operated through a control head which mounts under the dashboard and is connected to the unit with a multi-wire cable. The control head may contain a built-in speaker or the speaker may be a separate assembly. A mobile configuration is shown in Figure 24.

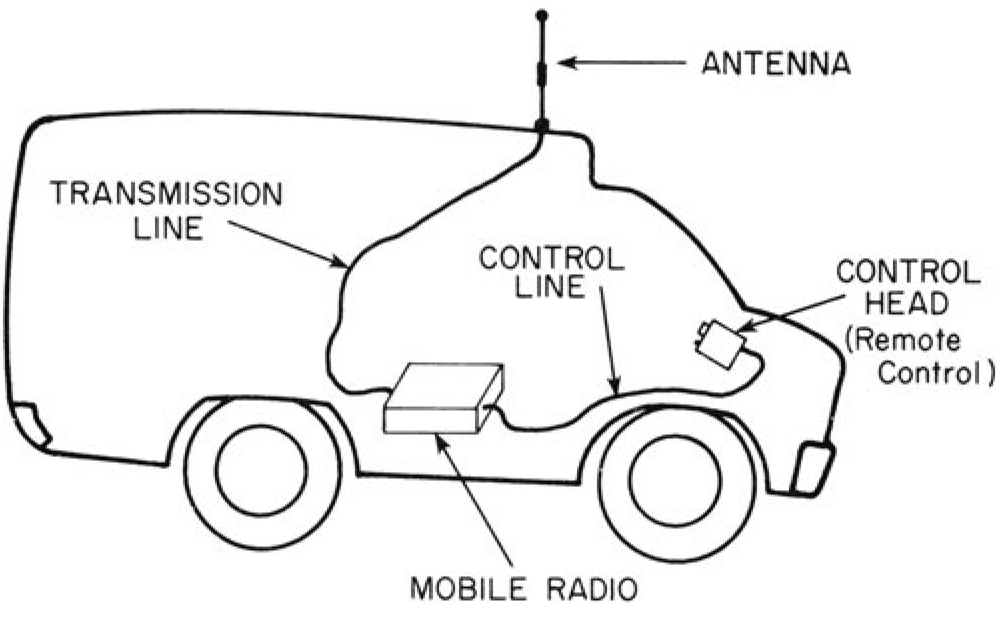


Figure 24. Mobile radio communications unit.

As discussed previously, most telecommunication systems employ FM radio equipment. Frequency modulated vehicular two-way radios are commercially produced for operation in VHF low- and high-bands, or UHF-band. In these radio systems, multiple channel operation is used to achieve communication between mobiles as well as communication between mobile and base. Vehicular two-way radios are available with various transmitter power ratings. Maximum rf output power ranges from about 1 W to 110 W for low-band and high-band units, and from about 1 W to 90 W for UHF band units. The physical dimensions and input power requirements generally increase with transmitter power ratings. Input power for vehicle radios is obtained from the vehicle's electrical system, which may range in voltage from 6 to 70 V dc, with 12 V being a common value.

5.6.2. Portable and personal two-way radios

The portable two-way radio has become a fairly common item in communication systems in recent years. Portables are designed with self-contained power supplies and antennas, making them suitable for completely independent operation. Size and weight are kept low enough so that these units may be easily carried by field personnel.

The use of transistors rather than vacuum tube circuitry in portable units has resulted in substantial size and primary power reductions, so that some of the smaller portables are often referred to as "personal" radios. Personal radios are carried in various ways. Some units are held in the hand, while others are carried with a shoulder strap or clipped on a belt. The larger portables may be carried by hand or as a back pack. Weights of portable radios range from about 6 kg (15 lb) for the larger units to about 450 g (15 oz) for the personal types.

Various microphone and speaker options are also available for portable radios. In some types the microphone and speaker are contained within the unit's case. Hand-held microphones are employed in some cases and many also function as a speaker. In acoustically noisy environments, a telephone style handset containing both microphone and earphone is sometimes preferred. Shoulder microphones which attach to clothing leave hands free for other tasks. Helmets with built-in microphones and earspeakers are a fairly recent development, which also offer no-hands operation.

Portable two-way radios of the FM type are commercially produced in VHF low-band, high-band, and UHF-band versions. Fixed, crystal-controlled tuning is employed and units with multiple channel capabilities (not simultaneously), as high as eight channels or more within a single frequency band, may be purchased.

Maximum rf power outputs of portable two-way radios range from about 0.05 W to 15 W. Portables in the personal category have rf power outputs less than about 5 W.

Because of the relatively low rf output power of portables, it is frequently necessary to provide a relay system of some sort at an intermediate point between the portable and the base station. Two commonly used methods are 1) relay of the portable messages through a nearby ambulance and 2) relay of the messages by means of fixed satellite (not to be confused with earth-orbiting satellites) receivers at suitable locations throughout the operating area. If the messages are relayed through a vehicle, two separate channels must be used for the portable and vehicular transmissions. If there are many portables, this can lead to considerable loading of the mobile-base channel due to personal radio message traffic. With the satellite receiver system, the personal radio transmissions can be relayed either by a separate radio channel or wire lines. Satellite receiver systems are discussed in greater detail in Section 6.

Portable radios are designed to obtain input power from a variety of battery power sources. Some portables can be easily connected to draw power from a vehicle electrical system, and contain other features which make them suitable for vehicle usage. An example is the portable unit which can be removed from a vehicle charger when the ambulance attendant leaves the vehicle.

In addition, some portables are available with ac to dc power supplies and have features which suit them for base-station usage.

5.6.3. Mobile equipment antennas

Mobile antennas serve the same purpose as base-station antennas, i.e., reception and transmission of rf energy. However, mobile antennas are subject to more stringent restrictions on size and ruggedness. These antennas, usually mounted on car roofs, are vertically polarized and radiate in an omnidirectional pattern in the horizontal plane. Some gain can be achieved by narrowing the beamwidth in the vertical plane. To achieve gain, antenna length should be long with respect to operating wavelength. This means that higher frequency (i.e., shorter wavelength) systems are more suitable for mobile use because of the shorter antennas used.

5.7. Communication Control Equipment

In some EMS systems the dispatcher and the base station equipment may be situated in two different rooms or even in different buildings. It is often desirable to place the transmitter in a separate room because of the heat which is generated during operation. Also, the base station should be located fairly close to the antenna in order to minimize rf-power losses in transmission lines. Some systems employ several base stations and a number of dispatchers. This may necessitate separate locations for radio equipment and operating personnel because of space limitations.

All of the situations above require the use of special control equipment which enables the dispatcher to operate the base station from a separate location. There are three basic types of control units. The simplest type is the desk set, which is similar in appearance to an ordinary telephone and is designed for desk-top operation. Small control consoles are generally more elaborate and offer more control capabilities than the desk set and are larger in size. They are usually box-shaped and are small enough for desk-top operation.

Desk sets and small control consoles may be interconnected with each other in various ways to allow several dispatchers to operate a base station without interfering with one another. There are basically two types of control, local control and remote control. A system may be locally controlled when less than 30 m (100 ft) of cable is used to connect the base station with the most distant control point. The system should be remotely controlled when the base station and control point are separated by more than 30 m (100 ft). A telephone line is often used rather than a cable for remote control. Radio remote control methods will be discussed later in this section.

Every system must have at least one "control point" from which the system can be turned on and off. In a system with several control units, the FCC requires that the control point be capable of taking over complete control of the base station. This is generally accomplished by means of a supervisory switch at the control point which can remove control from the other units. In a system with more than one remote control unit, FCC rules state that each control point must also have a transmit indicator which shows when the transmitter is being used. The FCC also requires that an identification card or photocopy thereof displaying station license information be kept at each control point.

The most elaborate type of control unit is the control console, which offers more extensive capabilities than either the desk set or the small, desk-top control console. A control console usually consists of a control panel and includes a desk as a part of the overall unit. A typical standard production model is shown in Figure 25. The model shown has the "radio control" panel located in the center section of the console. In addition to standard production models, most console manufacturers will build special control consoles to meet particular system requirements. A custom designed console is illustrated in Figure 26.

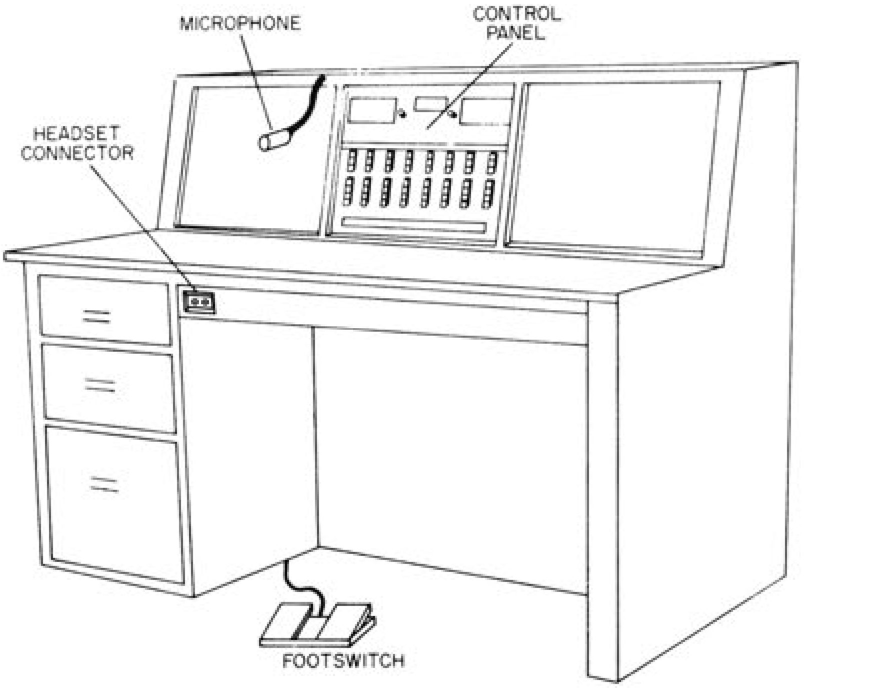


Figure 25. Standard production console unit.

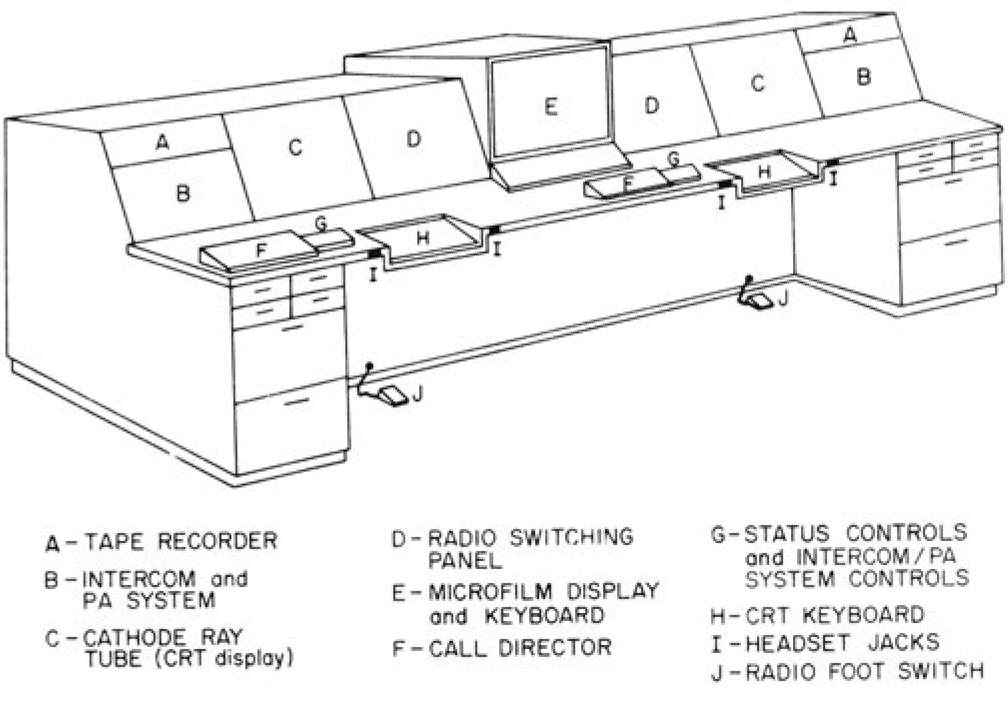


Figure 26. Special control console unit.

The more complex control consoles are usually the most poorly understood and documented element in communication planning. The fact that these organizational relationships are frequently misunderstood or seen from different perspectives, accounts for some of the confusion in control console planning. Some of the more common control console features and options, as they relate to EMS communication needs, will be discussed in Section 6.

5.7.1. Communication remote control methods

This subsection will discuss common ways of operating and controlling base stations, whether they are physically adjacent or remote from the operator. There are basically two methods for providing control: wireline, and radio.

In very simple installations, the base station may be located near enough to the operator that no extended control feature is required. However, the base station is usually placed near the antenna location, for reasons previously discussed, requiring some type of extended or remote control.

If the base station is located in the same building as the operator, it is common for the control wireline to be provided by the user as a permanent installation as in Figure 27. If the base station is located in an adjacent or distant structure, the control wire line is usually leased from the local telephone company, as illustrated in Figure 28.

The lease cost of the control wireline is generally based on the Air-mile distance between the base station and control point. The control line is provided by the telephone company as a "private-line" service and is not a part of the telephone switching network. Most base stations are equipped with standard or optional features which allow more than one remote control to be connected, allowing joint use of the base station. One of the control points, however, must be capable of exercising supervisory control as noted previously.

Radio control of remote base stations is generally considered when one or more of the following conditions are present:

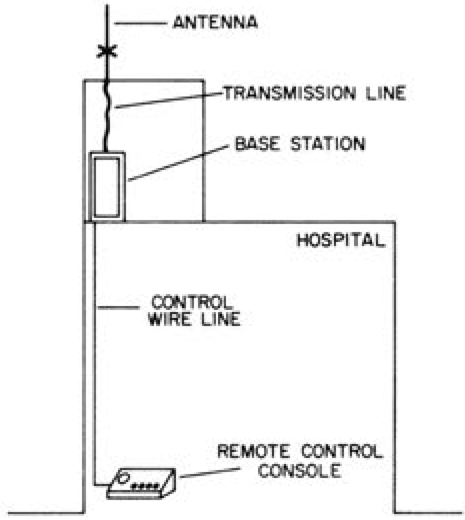


Figure 27. Remote control utilizing user supplied control line.

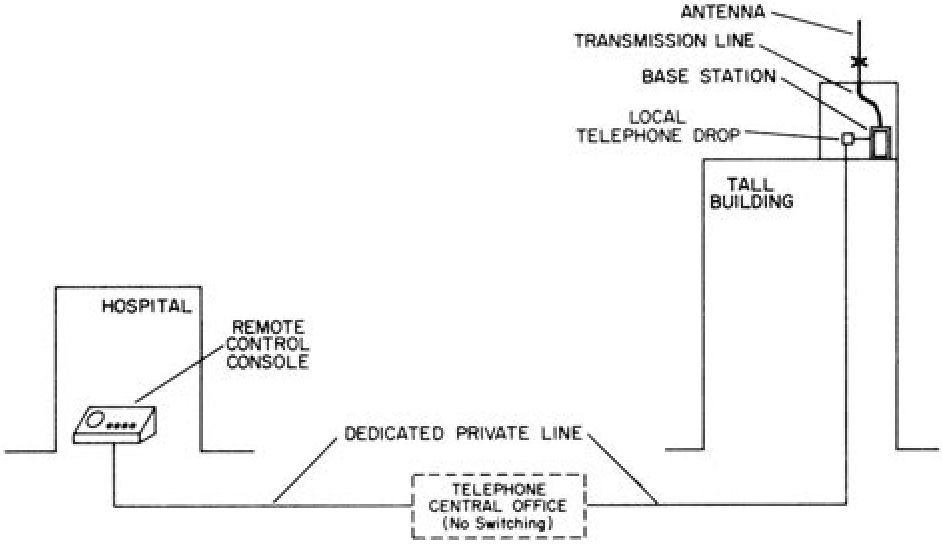


Figure 28. Remote control utilizing leased dedicated telephone line.

- Leased service is not offered or not available between the remote base station location and the control point. This may occur when a base station must be located on a nearby mountain or in remote terrain.
- The distance between the remote base station and control point is sufficiently long so that engineering economics justify procurement over lease.
- The poor quality and reliability of leased service justifies owner procurement of a radio control system.

Radio control, as governed by the rules and regulations of the FCC, is normally licensed in the UHF and microwave bands of the frequency spectrum (see Table 7). The selection of specific radio control frequencies is determined by the particular application and availability. UHF radio control is generally used when the number of remote base stations is small and the need for future expansion of a particular site is not anticipated. Figure 29 illustrates a typical common UHF base station control configuration.

Microwave line-of-sight radio systems represent a very practical means for providing radio control circuits where there are no existing wire lines. The use of microwave systems is widely recognized as a flexible, reliable and economical means for providing point-to-point communications. The communications capacity of a microwave system can vary from a few voice circuits to several hundreds of voice, telegraph, and data circuits. Various system arrangements can make provision for high-speed data, facsimile, or high-quality audio channels. Distances beyond line of sight can be covered by using relay or repeater stations arranged in tandem between the desired end terminals. Such systems are cost effective, particularly in mountainous areas where the cost of installing and maintaining wireline systems is not economically feasible.

A simplified drawing of a microwave line-of-sight system is shown in Figure 30. The system shown consists of two terminal stations and one repeater station. Many public safety and

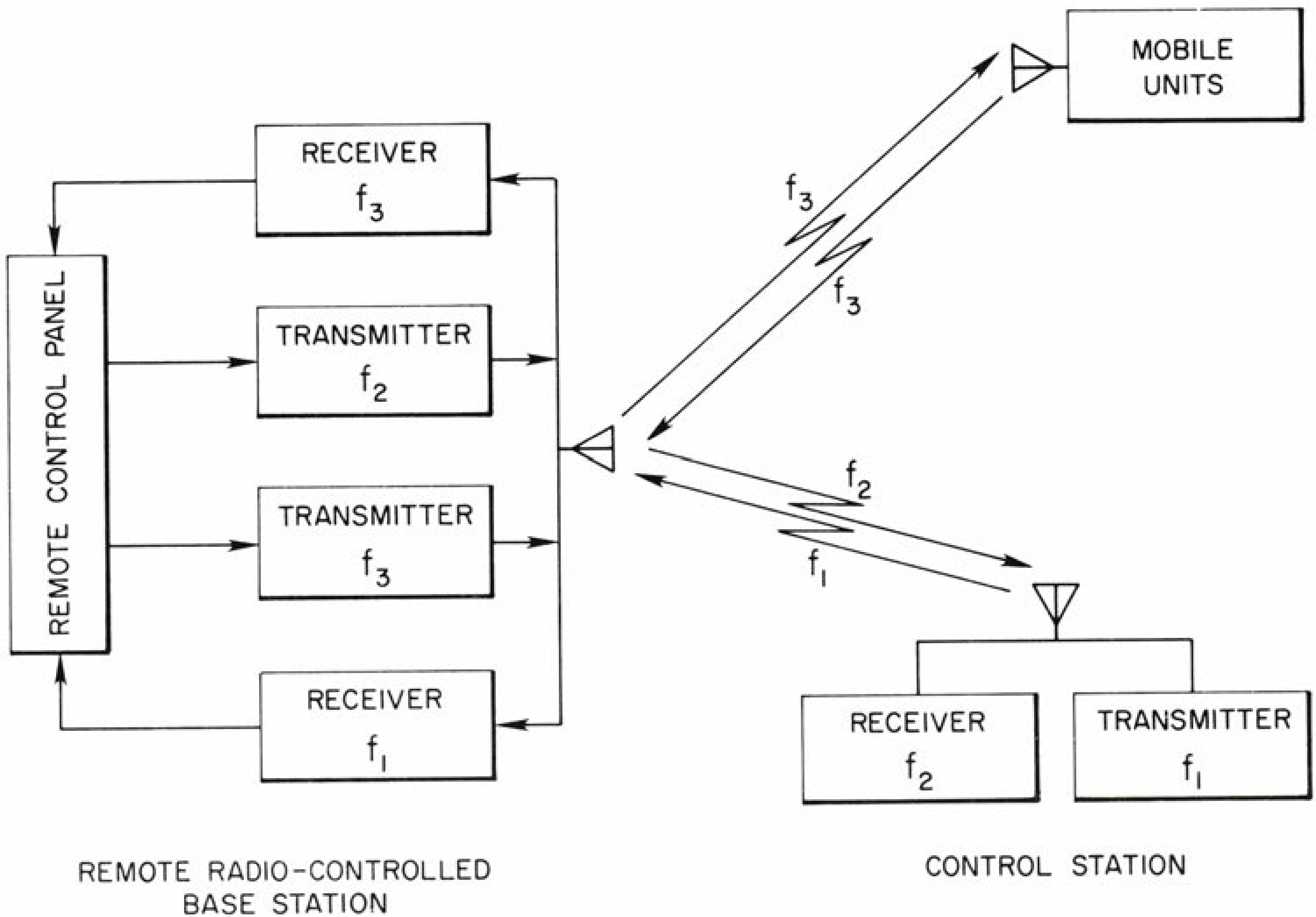


Figure 29. Typical UHF base station control configuration.

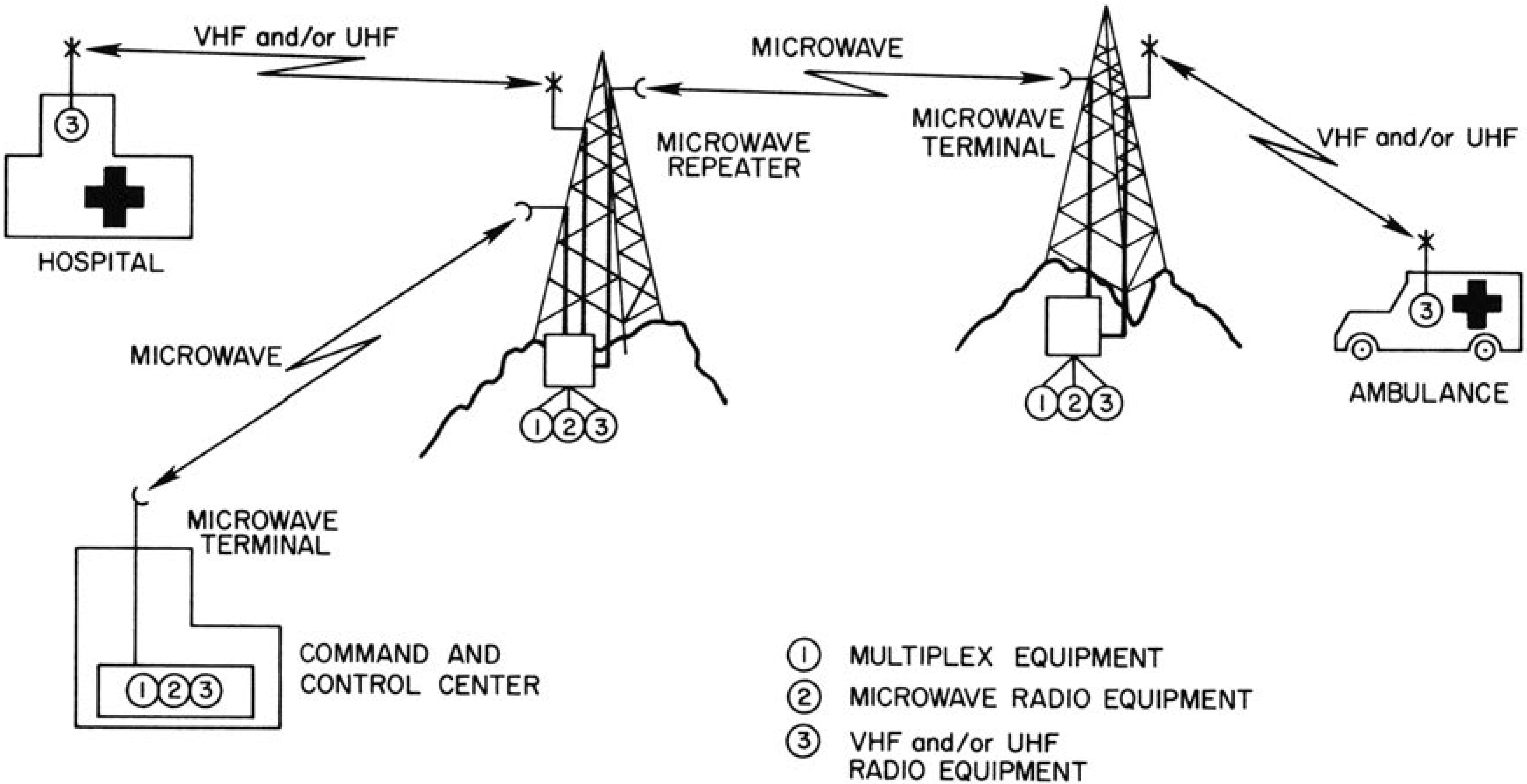


Figure 30. Microwave line-of-sight system.

municipal microwave systems are direct, however, and do not use any repeater stations. The stations each have a transmitter and receiver connected to the same antenna for two-way transmission. The repeater station (if there is one) has an antenna for two-way communication with each terminal station. The frequencies of the transmitted and received signals differ by a fixed amount, so that they can be readily separated.

The desirable characteristics of microwave systems for public safety, municipal and state use include the ability to:

- o Transmit many channels of information simultaneously
- o Replace wirelines where these may be impractical or uneconomical
- o Link together specific points by beaming signals only in the direction of the intended receiver
- o May increase reliability of point-to-point communications in some service areas.

The design of a microwave relay system requires considerations somewhat different from considerations for those systems designed for VHF or UHF land-mobile radio. In most cases system design begins with site selection and path design. The criteria for these choices, as well as the choice of directional antennas, transmitter power requirements and other related topics are to be found in the Bibliography.

Many states have installed microwave communication systems for the support of public safety and other local government communications requirements. Such systems can usually be expanded to provide communication links for EMS communications. This is particularly true in some states with large distances between population centers and, therefore, hospitals.

All EMS communications planners should consider using such local government systems or privately owned microwave systems. The EMS connection to such networks can be established using conventional wireline systems. The engineering of such entrance links will not be discussed here but need not present special problems.

6. EMS COMMUNICATIONS SYSTEM TECHNICAL PLANNING

6.1. Planning Guidelines

This Section has been assembled to assist EMS communications planners in responding to the requirements of the following guidelines: 1) DHEW (1977) HSA 77-2036, Guidelines for Developing an EMS Communications Plan; 2) NHTSA (1978) HS 802 976 Communications Manual, Addendum 1 to Highway Safety Program Manual, Volume 11; and 3) LEAA (1977) Planning Guidelines for Law Enforcement Telecommunications Systems. Specifically, these three interagency planning documents represent to the prospective DHEW grantee, three descending orders of detail which should clearly be integrated in order to provide for effective planning of local, regional and state-wide telecommunication systems. This planning activity will become less burdensome and much more comprehensive when the process is fully coordinated and when joint funding of the proposed communication systems is effected.

The DHEW and NHTSA planning documents are identical in all respects except for the specific applications. A communications plan, in accordance with the DHEW planning guide, is required as component number 3 for Title XII (1203, 1204) funding. This plan applies specifically to regional planning as defined in Section 2 of this guide. The NHTSA plan required for funding under Section 402 of the Highway Safety Act must be submitted as Appendix F, "Communications Plan to the State Comprehensive EMS Plan". These formulate the legislative framework for planning that encompasses local and regional efforts. Overall state planning for area-wide (inter-regional) emergency medical systems provides practical authority to enhance coordination in the utilization of available frequencies on a common systems basis and to enforce multi-disciplinary cooperation so that public needs can best be served. Regional Health Care planning agencies can then carry out specific communication implementation plans under the general state guidelines and within the general framework of the enabling legislation provided by the state. Ideally, then, the NHTSA EMS communications plan should address those features of the communication system that are to be standardized statewide. The DHEW EMS regional plan should be comprehensive, in accord with the standards of the statewide plan, and should address the complete communications picture including the interface with other adjoining EMS regions. These should particularly address physician control communications with the resource hospital and other participating hospitals and communications with specialized centers (e.g., burn, poison, . . .).

Since the majority of EMS situations requires citizen access and coordination with other public safety agencies (i.e., with police, fire, . . .), it is mandatory that these public safety agency communications plans be reviewed by EMS planners and the EMS Communication Committees. Specifically, the LEAA Communications Planning Guide cited above has evolved from a relatively long-term study effort. Section 4 of this Guide was adapted from a planning guide developed under such a project. The LEAA Planning Guide cited above was prepared using the specific format of the same guide adapted in Section 4. Also, communication planners should give careful attention to ongoing work sponsored by NHTSA, DHEW and LEAA. In addition, most DHEW regions have active Emergency Operating Centers sponsored by the Federal Emergency Management Agency. These dedicated communications facilities are potential resources for continuing fiscal support for shared communications facilities if suitable cooperative planning and operating procedures can be established.

As viewed by the sponsoring Federal agencies, the communications planning process at the local, state, and regional levels for EMS communications is intended to be an interagency cooperative process. In order to assure this cooperation and to assist in the uniformity of guidance to the local planners via the Federal funding agencies, a statutory Inter-agency Committee was formed under the EMS Act of 1973 (see Figure 4). A working group of this committee meets regularly to assist in the EMS communications development. Contact with this group can be obtained through the DHEW regional telecommunications consultants.

6.2. Overview

The primary objective of the EMS telecommunication subsystem is to provide the necessary communications links to minimize the lapse of time between the occurrence of a life-threatening or crippling incident and the rendering of medical service. Response times will vary in accordance with regional geographic and population factors but it is important to develop a goal for response time in each region being served by a planned EMS system. Two goals may be appropriate, namely: acceptable limits for (1) receiving on-scene advice, and (2) arrival on-scene of trained personnel. Most communities and local governments have a multiplicity of telecommunications services, facilities, and systems already available that relate in varying degrees to the mission of the EMS telecommunications subsystem. Planners need to consider how existing telecommunications, in a defined operational region, can be interfaced, interconnected, integrated, and/or expanded, rearranged, or modified to meet the requirements of an EMS system.

It is essential to understand the goals and objectives of the emergency medical services system to be served by the telecommunications subsystem in a given region in order to carry out adequately the communications planning function. A following subsection on 911 planning will provide the EMS planner with a detailed planning process. In the event that a particular community has initiated planning or implementation, the subsection can serve as a check-list to determine if important planning points have been overlooked or misunderstood.

6.3. Citizen Access

In January of 1968, the American Telephone and Telegraph Company (AT&T) announced that the digits 911 (nine-one-one, not nine-eleven) could be made available for installation on a national scale as the universal emergency telephone number. Numerous public safety officials and individuals at various government levels had long expressed keen interest in the establishment of such a number. The AT&T announcement followed the 1967 recommendation of the President's Commission on Law Enforcement and Administration of Justice. The Commission wrote: "wherever practical, a single (police emergency) number should be established, at least within a metropolitan area and preferably over the entire United States". Further stimulus was provided by the Commission on Civil Disorders and the Federal Communications Commission (FCC) which urged the telephone industry to provide a three-digit emergency telephone reporting number. These various recommendations had in turn received impetus from growing public concern over the increase in crimes, accidents, and medical emergencies and from Federal Government awareness that current emergency reporting methods were inadequate and that, in a population as large and as mobile as ours, a common emergency number made intrinsic sense.

6.3.1. The public telephone environment

The choice of the specific number, 911, was based primarily on cost and the comparative ease with which telephone company equipment could be modified to accept the number and other considerations which indicated that the combination of the digits 911 would be easily remembered and dialed by most persons. It was designed to provide the American public with direct access to an emergency answering center. It is emphasized that this number is used to gain access to an emergency answering center, not to a telephone company operator or any part of the telephone company structure or hierarchy. It is the number that has been designated for reporting an emergency and requesting assistance in any community in the United States that modifies its existing system to accommodate the number. The number 911 and associated emergency services are thus intended as a public service with the primary objective of preserving life and property. Ideally, this means that eventually nearly every person in America who has access to a telephone could summon aid by dialing this simple three-digit number, regardless of his or her location, familiarity with an area, the time of day, or type of emergency.

Presently, however, most citizens confronted with an emergency are presented with only three alternatives: (1) memorize all emergency service seven-digit telephone numbers; (2) find a directory and look up the proper seven-digit number; or, (3) dial "0" and ask the operator for assistance.

In a recent study of a large metropolitan area, only 34% of those interviewed knew the local police emergency number; only 5% knew the fire emergency number; and none knew the ambulance service number. In another study of two suburban shopping centers, only 55% of those interviewed were able to identify the municipality they were in; only 2% knew the police emergency number; and none knew the fire or ambulance number. Even in cases where there is one commonly used seven-digital number, it is less likely to be used than the "0" operator. For example, in New York City, where each of the five boroughs used the same simple seven-digit number, over 60% of the calls were placed through the "0" operator.

When a citizen dials "0", the operator must determine the type of emergency and the area of the emergency. In a continuing environment of reducing operating costs, telephone companies are eliminating local operators and often locating "0" attendants at some major switch point that may be as much as 300 km (200 mi) away from a local community. These attendants must take the time to access a computer list for telephone number information and have limited knowledge or information concerning local emergency resources. Subsequently, the operator must relay the call information or the caller to a public safety agency dispatch center operator, who must take down the appropriate information and either dispatch a unit or request that a dispatcher dispatch a unit. With 911, the "0" operator is bypassed and the calls go directly to highly trained emergency operators who take down the call information directly from the caller and then either dispatch a unit or have a unit dispatched.

The NHTSA and DHEW EMS programs require that consideration be given to the development of a universal (911) citizen access system. This is based on the logical assumption that time is a critical element in the delivery of emergency service and more specifically, emergency medical services. These and other Federal assistance programs have emphasized the importance of quick citizen access, yet 911 implementation nationally has been marked by only partial success. A recent report (Bauer, 1977) suggested several reasons why communications planners often failed to develop 911 systems:

- Public safety planners tied 911 development to other programmatic objectives such as central radio dispatch centers and universal radio dispatching personnel.
- Telephone company executives (probably taking their cue from the public safety planners), conditioned the participation of the telephone company on the community's commitment to central dispatching of all public safety responders.
- The 911 system was perceived by the emergency response agencies in the community as a threat to the equitable distribution of emergency assignments.
- Technical considerations and costs involved in the conversion of the existing telephone switching system were not understood or adequately justified.
- Confrontations occurred between the telephone company and the community over "who" was responsible for developing and monitoring the telephone components of the system.
- A public safety answering point could not be identified by the community.
- 911 was preconceived to be a "central dispatching" system which would lead to a regionalization or consolidation of government services which the residents of the community did not want.

These problematic factors have been included not to cause a pessimistic note on 911 development, but to alert the planner to potential problem areas and to underscore the importance of community involvement in the 911 planning process. The planner will more fully appreciate, as the planning process evolves, that the 911 center and central dispatch configurations are indeed interrelated.

Although this section places major emphasis on the planning and implementation of 911, it is clearly recognized that a community may select an alternative which employs some combination of one or more seven-digit telephone numbers. This may be the only feasible alternative due to existing political and/or technical constraints. Even if a less-than-desired alternative must be implemented, the 911 planning process should identify the basic problems and set the stage for future 911 implementation.

6.3.2. The mobile radio environment

Citizens' band (CB)

Many people injured in highway accidents die or are permanently injured simply for lack of prompt and proper emergency care. In 1975, the U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA) initiated the National Emergency Aid Radio (NEAR) program. Criteria for funding under Section 402 of the Highway Safety Act of 1977 were developed and each state was offered the opportunity to participate in the program to the extent determined by the state. The program is intended to provide the motoring public with an emergency assistance communications system for obtaining emergency services easily and rapidly without leaving the car.

Because there is no other such system now in effect, extensive use is being made of the Citizens' Band Radio Service, as a two-way, in-vehicle method convenient to the public. Some DoT-sponsored projects have demonstrated the value of CB in highway safety. Volunteer groups and public safety agencies have shown that they are willing to participate and cooperate in a CB network. Although there are technical and administrative problems to be solved, public safety can be served now by taking advantage of any type of communication available to the motorist.

The purpose of the NEAR program is to exploit the use of CB as an existing resource for highway safety to provide information to the motorist relating to personal safety and, at the same time, enhance citizen participation in highway safety. Improvement of this service will result from an effective monitoring of the Citizens' Radio Service emergency channel (CB Channel 9, 27.065 MHz) or other channels which may be designated in the future for emergency service use. This monitoring, for the most part, will be performed by public safety agencies, organized volunteer groups, motor carriers, professional driver groups and individual citizens.

At present, there are three types of volunteer groups who monitor, on an irregular basis, independent local clubs such as Radio Emergency Associated Citizens Teams (REACT), the Affiliated League of Emergency Radio Teams (ALERT) and the Citizens' Radio Watch. These organized groups are affiliated nationally for the purpose of emergency and public service communications and although independent citizen monitoring is encouraged, NHTSA recommends that government action concentrate on those volunteer groups:

- o Whose primary purpose is to provide emergency communications monitoring.
- o Who can demonstrate an organized monitoring capability and willingness to guard the National Emergency Channel 9, on a regular basis.
- o Whose organizational structure is based on the team or group concept, rather than individual performance.
- o Who actively subscribe to, and operate, under Federal Communications Commission (FCC) rules and regulations.

- o Who maintain an active affiliation with a recognized state or national organization capable of coordinating local, state, or regional activities with NEAR Advisory Groups.

Amateur radio public service communication

Amateur radio exists because it qualifies as a service. Its continued existence depends to a great degree, not on past services performed or on potential service, but on current services and planned future services. Recognizing this principle, the Amateur Radio Relay League (ARRL) established the Amateur Radio Emergency Corps (AREC) in 1935, the National Traffic System (NTS) in 1949, and consolidated these two into the Amateur Radio Public Service Corps (ARPSC) in 1963. In 1966, a third division, Radio Amateur Civil Emergency Service (RACES), was added. Thus, the ARPSC combines the emergency-preparedness program of the AREC and RACES with the daily (communications) traffic-handling program of the NTS into a single, strong facility for rendering continuous service to the public while at the same time the emergency-preparedness program is kept up to date by frequent drills and tests. In an emergency, the NTS serves as the vehicle for relay of traffic over medium and long distances while local AREC and RACES needs take care of local communications and deliveries.

Capabilities of these services should not be overlooked in EMS planning especially in areas where potential major disasters are significant possibilities.

6.4. 911 Planning

The 911 planning process should begin with the analysis, by the local EMS Communications Committee, of the local public safety telephone and local telephone company configurations and, ideally, end with the installation of a 911 system. A flow diagram is shown in Figure 31.

For the purposes of this section, which has been adapted from the Illinois Local Government 911 Planning Manual, the "911 committee" will be considered to be a subcommittee of the local EMS Communications Committee.

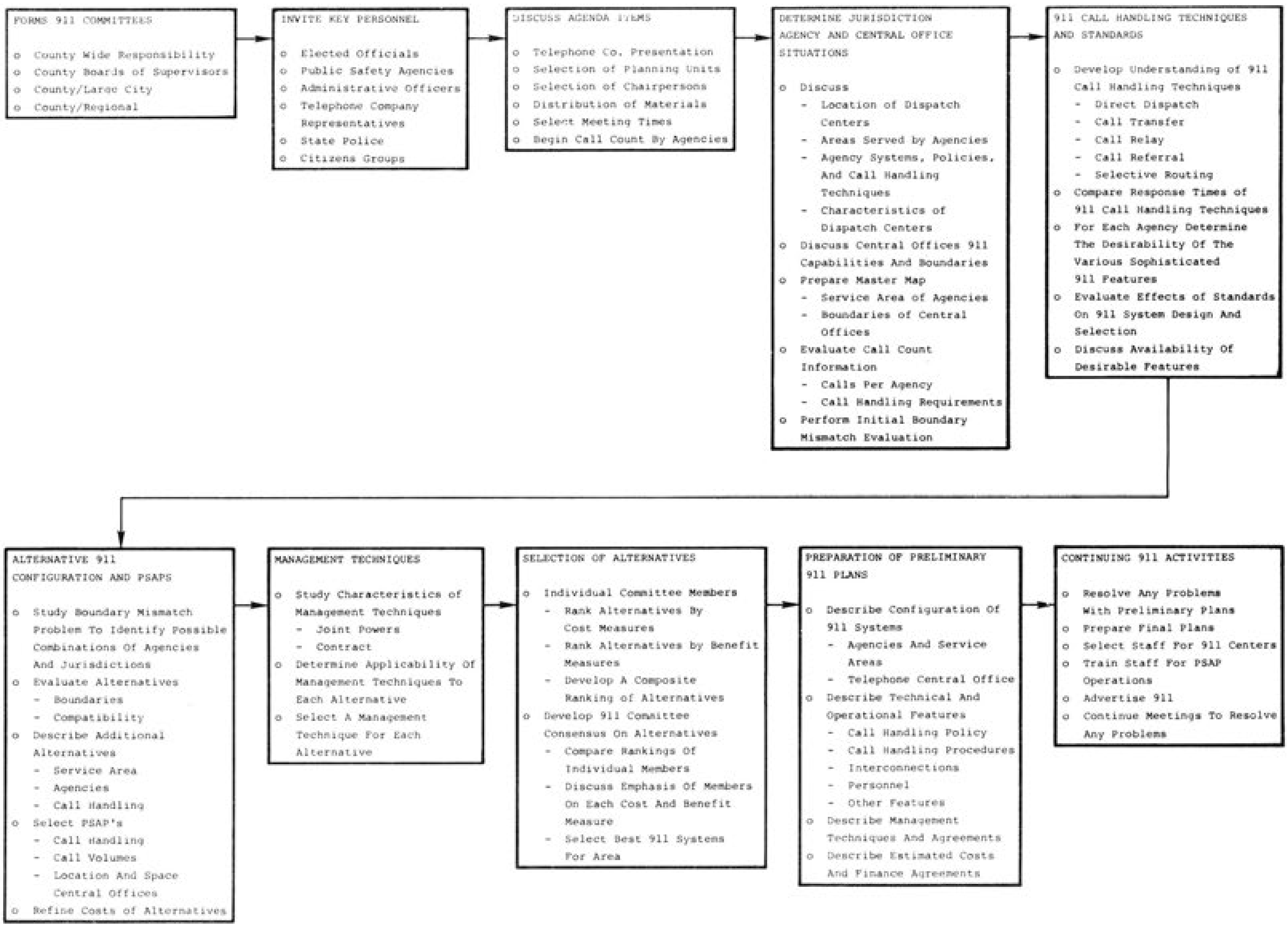


Figure 31. Flow chart of the 911 planning process.

During the development process, the following planning steps should be accomplished after the formation of a local 911 committee (see Section 2):

- o Analysis of local public safety jurisdictions and telephone configurations.
- o Evaluation of 911 call-handling techniques and standards.
- o Analysis of alternative 911 configurations and PSAP's.
- o Analysis of management forms.
- o Selection of alternatives.
- o Preparation of preliminary 911 plans.
- o Continued 911 activities, including preparation of final 911 plans, until 911 system is implemented.

It is recommended that each planning step be the subject of one or more meetings of the 911 committee with sufficient time allowed between meetings for the collection of information and interactions between system participants.

6.4.1. Analysis of local public safety agency jurisdictions and telephone central office configurations

This step is perhaps the most important of all the planning steps. Whether covered in one or several meetings, it will provide the basic groundwork upon which all subsequent planning steps are based. The objective of this step is to obtain sufficient information concerning the existing jurisdictions, agencies, and telephone company central offices in order to provide the basis for evaluating alternative 911 configurations.

Service areas and dispatch centers

In each 911 planning area, there will be a number of emergency service agencies (police, fire, medical facilities, etc.) which must be included in the area's 911 system. It is recommended that each of these agencies, before the first meeting, prepare a map of its service area including background information regarding its individual telephone system. Form B-1 (Appendix B) provides an example which would be used for this purpose.

The principal effort at the first session will be to transfer information on service areas and answering points to a master map. Most city police, sheriff, city fire, fire protection districts, and municipal ambulance/rescue services will have well-defined service areas. Private ambulance companies and the hospitals will probably not; however, these should not be excluded, but should provide as much information as possible concerning their coverage areas and existing systems.

Finally, if possible, the service areas of all other public safety facilities which can be included on the 911 plans (tow services, highway maintenance, poison control, suicide prevention, state forestry, Federal parks and forests, major industrial or commercial enterprises, etc.) should be obtained and added to the master map. In some instances, the utilization of aerial photography can provide a better understanding of residential/commercial building densities, traffic patterns and other emergency related planning parameters.

Depending on its complexity, the preparation of this map can occur at the first meeting or be delegated to one or more of the 911 committee members for preparation between meetings. The master map will then provide a common picture of the area service configurations as they affect 911 implementation.

Besides the requested telephone system data, the dispatch capabilities of the individual agency centers should be discussed. In any particular 911 planning area, the separate dispatch centers will have different levels of sophistication for interfacing with the public and with other agencies. For example, some centers will have common frequencies with other agencies, some will have CB equipment while others may be connected to highway emergency call boxes or fire alarm systems. The level of sophistication might reach computer-aided dispatch. Any information which can be assembled concerning special or unique systems should be discussed at these meetings to insure that complete information is available for the eventual selection of PSAP's and for the configuration of the total 911 system.

In addition to gathering the above information from the service agencies, a valuable step in the planning and sizing of alternative 911 systems will be a determination of the number and types of calls handled within the planning area. Incoming telephone calls and radio traffic for a representative period should be used to determine the call volumes for each agency. Forms B-2 and B-3 (Appendix B) provide an example which could be used for this purpose. Another valuable input to the 911 committee would be a description of recent periods that contained unusually high numbers of incoming calls. Call handling experience in these periods can help in sizing the 911 systems.

Telephone company interaction and boundary mismatch

The telephone central offices in the 911 planning regions can provide information on the types of 911 operating techniques that can be used, a briefing on their current central office equipment and their possible restraints on 911 techniques. Additionally, plans for changing central office equipment--particularly, in areas where current equipment restricts 911 alternatives--should be conveyed to the 911 Committee.

With the addition of the local telephone company's exchange area boundaries to the master map, the 911 Committee will be provided with a clear visualization of the extent to which the agency service areas match the telephone central office areas. In general, it will be found that there is little matching of these boundaries.

Figure 32 is an example of a boundary mismatch. In this example, city and county service areas do not match the telephone central office boundaries. Not all boundary mismatches are significant since in some cases there is a small population in the overlap area.

At this point in the planning process, it is advisable for each jurisdiction and agency to study the master map for the purposes of:

- o Determining the extent to which its service areas coincide with telephone central office boundaries,

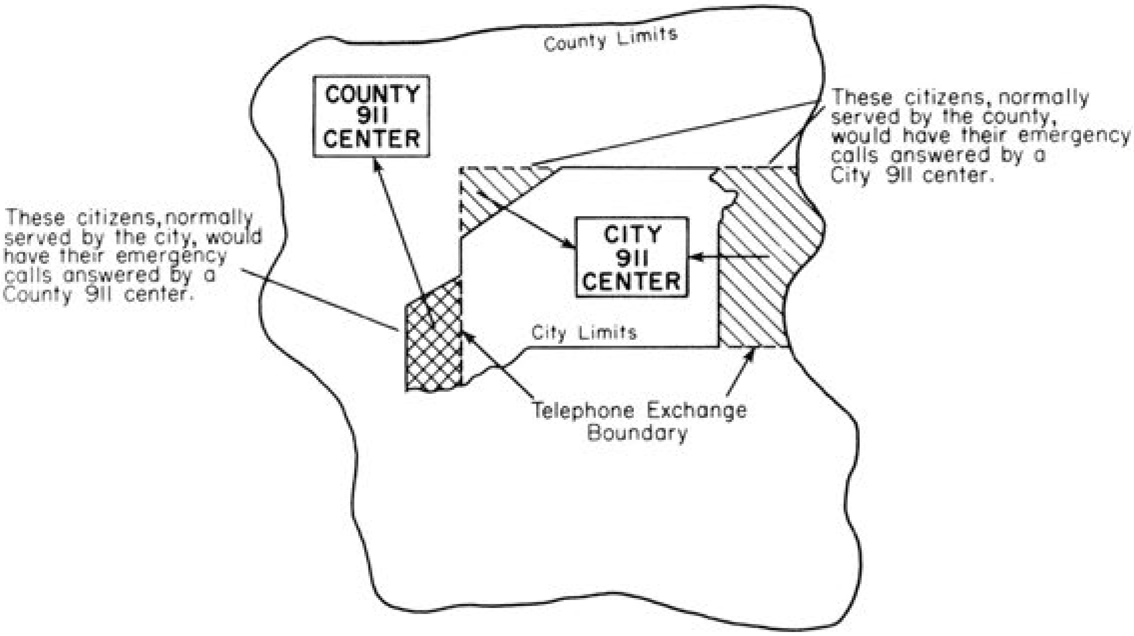


Figure 32. A city-911 and county-911 boundary mismatch problem.

- o Noting these agencies and jurisdictions with which it is linked by the telephone central office boundaries,
- o Determining the number of people in each agency service area that are affected by a mismatch.

Based on these factors, the planner and the 911 Committee should develop some preliminary 911 system alternatives.

6.4.2. Alternative 911 configuration and PSAP's

Having carefully laid the groundwork through the preceding planning steps, the 911 Committee should next address the issue of selecting alternative 911 system configurations (and their associated PSAP's) for final evaluation. At this point in the planning process, it will be evident that solutions to the boundary mismatch problem will require interagency and interjurisdictional 911 agreements. The vital elements for the success of this planning step are, therefore, a solid understanding of the local situations (developed through the previous planning steps) and a spirit of cooperation among the participants in the planning process.

In evaluating the alternatives, the 911 Committee should proceed through a three-step process:

- Study the boundary mismatch problem in each central office area to identify requirements for interagency and interjurisdictional cooperation.
- Identify candidate agencies for PSAP's and identify all included agencies for each 911 alternative. Determine the call-handling mechanism to be used for each included agency.
- Study the total costs and individual elements cost for each alternative.

Normally, without using costly unique solutions such as selective routing, the technique for accommodating boundary mismatch is to build up alternatives using combinations of telephone central offices.

Basically, this means that the 911 Committee should develop 911 systems by grouping central offices in such a way as to minimize boundary mismatch. Note that the larger the area included in a given 911 system, the smaller the cost of the system to each participant, i.e., central office combinations should be as large as is feasible.

Rural counties

In those counties of a state where the population, number of cities, and size of cities is small, the boundary mismatch problems are not generally severe. The 911 systems that include all central offices in a county or a region are probably reasonably consistent with the service areas of the principal law enforcement (sheriff), fire protection (rural FPD's), and emergency medical (municipal, private, and volunteer ambulance) agencies.

Mixed counties

As the population of the counties and the size of their included municipalities increase, the possibility that the municipalities may want separate 911 systems also increases.

In these intermediate-sized counties, the selection of central offices to be included in each 911 system becomes more complicated as the number of jurisdictions and agencies in each central office area increases.

Urban counties

In urban counties, the number of large and/or heavily populated jurisdictions in a given central office area can be significant. Additionally, the fragmenting of jurisdictions into several central office areas is more common. In these counties, even the best configured alternatives may have the calls of single jurisdictions handled by two PSAP's.

In general, the problems caused by boundary mismatch are potentially the most difficult in urban counties with abutting jurisdictions and the least difficult in lightly populated rural counties. Each 911 Committee should clearly identify the magnitude of its particular boundary mismatch problems by studying the correspondence of jurisdictional/agency/ telephone company boundaries.

6.4.3. Call-handling techniques and standards

Each agency in the 911 planning area should provide the 911 committee with sufficient information, usually in the form of group discussion, about its operations so that realistic 911 alternatives can be developed. This second planning step should be undertaken only after the committee has developed descriptions of the local jurisdiction, agency and telephone configurations. Discussion in this section relates to the operational rather than technical characteristics. Technical characteristics and requirements should be addressed to telephone company representatives and/or an engineering consultant.

There are four basic, generally accepted, 911 operational methods: direct dispatch, call transfer, call relay, and call referral. It should be noted that Public Safety Answering Points are simply points of contact at which emergency calls are received. The composition of the PSAP may utilize any one or a combination of all of the above techniques depending on the particular agency application.

In the direct dispatch method, as shown in Figure 33, two of the emergency communication system functions--911 call answering and radio dispatching--are collocated. For example, the PSAP could be collocated with a centralized multi-agency radio dispatch center that handles emergency calls for police, fire, and emergency medical services. Alternatively, it could be collocated with a single agency (most commonly, a police department) that provides one type of emergency service. In the direct dispatch method, call answering and radio dispatching may be performed by separate individuals (two stage) or the same individual (single stage). Transmission of information from the PSAP to agencies that are not directly dispatched can be accomplished using one or a combination of the remaining three basic operational methods: call transfer, call relay, or call referral.

Figure 33. Direct dispatch.

Call transfer, Figure 34, requires that the citizen first dial 911 to reach the PSAP. The PSAP then obtains, as rapidly as possible, the location and nature of the problems and determines which public safety agency should respond to the incident. Then, by direct tie line, the PSAP connects the citizen to the proper agency. The PSAP functions as a switchboard, and the citizen gives the complete explanation of his problem to the proper agency.

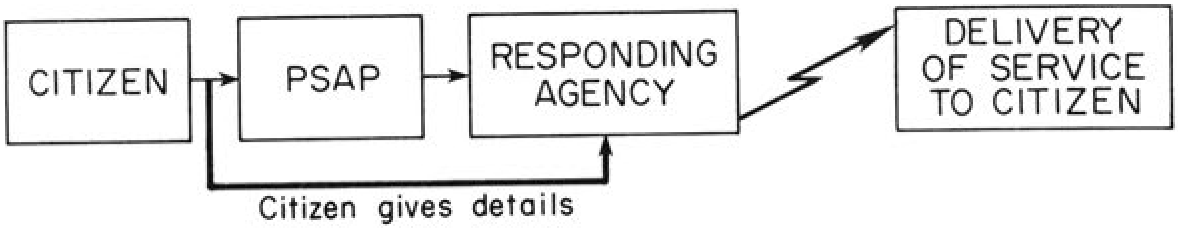


Figure 34. Call transfer.

The major advantage of call transfer is the lack of inter-agency coordination necessary after implementation. Its most common application is in situations involving core-city fire protection agencies and for public safety agencies in outlying cities. That is, situations where the particular emergency service agency wants to perform its own screening of calls and preserve its organizational identity in the eyes of the public. It has two major disadvantages. First, the response time is longer than that of the direct dispatch method. Second, the citizen must repeat parts of the incident details, a problem that is often frustrating to a citizen under stress.

Similar facilities are required for call relay and call transfer as shown in Figure 35. In call relay, however, the information rather than the caller is transferred to the proper agency. The information is obtained from the citizen by the PSAP and relayed to the proper dispatch center by voice or digital communication. The citizen does not perceive any difference between call relay and direct dispatch because the PSAP relays the information to the proper agency, and the citizen is spared the necessity of repeating incident details.

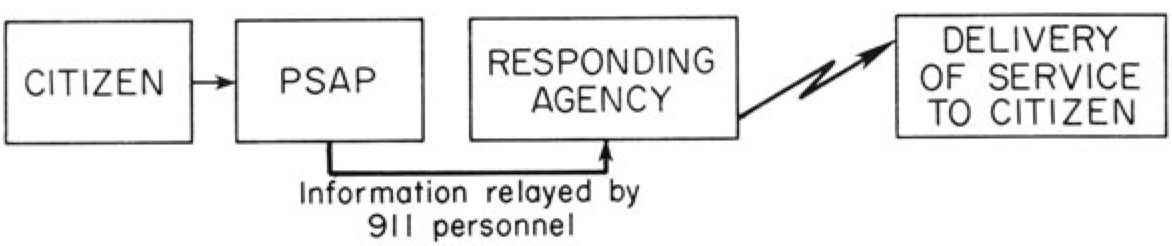


Figure 35. Call relay.

The major advantage of call relay is that the response time is essentially the same as that of two stage direct dispatch, and citizen frustration is minimized. Call relay also has the advantage of leaving dispatch operations under the control of individual agencies, who view the dispatch function as a management and control function rather than a more neutral "resource allocation" function. A disadvantage of call relay is that proper operation requires explicit call-answering policies for the various agencies. This necessitates a degree of cooperation which many agencies find difficult to achieve.

Finally, the call referral method, shown in Figure 36, in which the PSAP provides the citizen a seven-digit number to dial, is used for two purposes. First, certain agencies may not have the volume of urgent calls to warrant the potentially expensive equipment necessary for call transfer or call relay. Common examples of such agencies are the Coast Guard, the FBI, public works departments, and utility companies. Second, citizens should be discouraged from using 911 for non-emergency calls so as to keep the lines free for emergency calls. Therefore, call referral is also a means of informing the public, in a polite and professional manner, that they should not use 911 except in the case of an emergency.

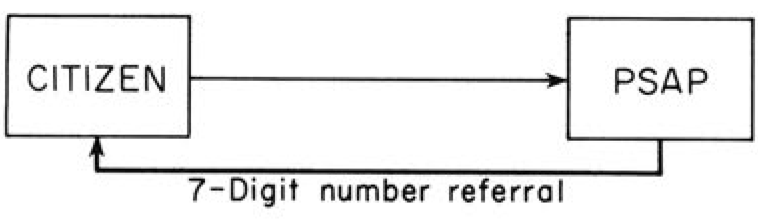


Figure 36. Call referral.

Figure 37 (from a Stanford Research Institute study) illustrates the approximate time requirements for the various 911 call handling techniques. Research has established that certain steps in the communication process take a standard amount of time. For example, it takes about five seconds to dial 911. It takes about 60 seconds for the citizen to relate incident details, and it takes about 10 seconds for car dispatch. These standard times

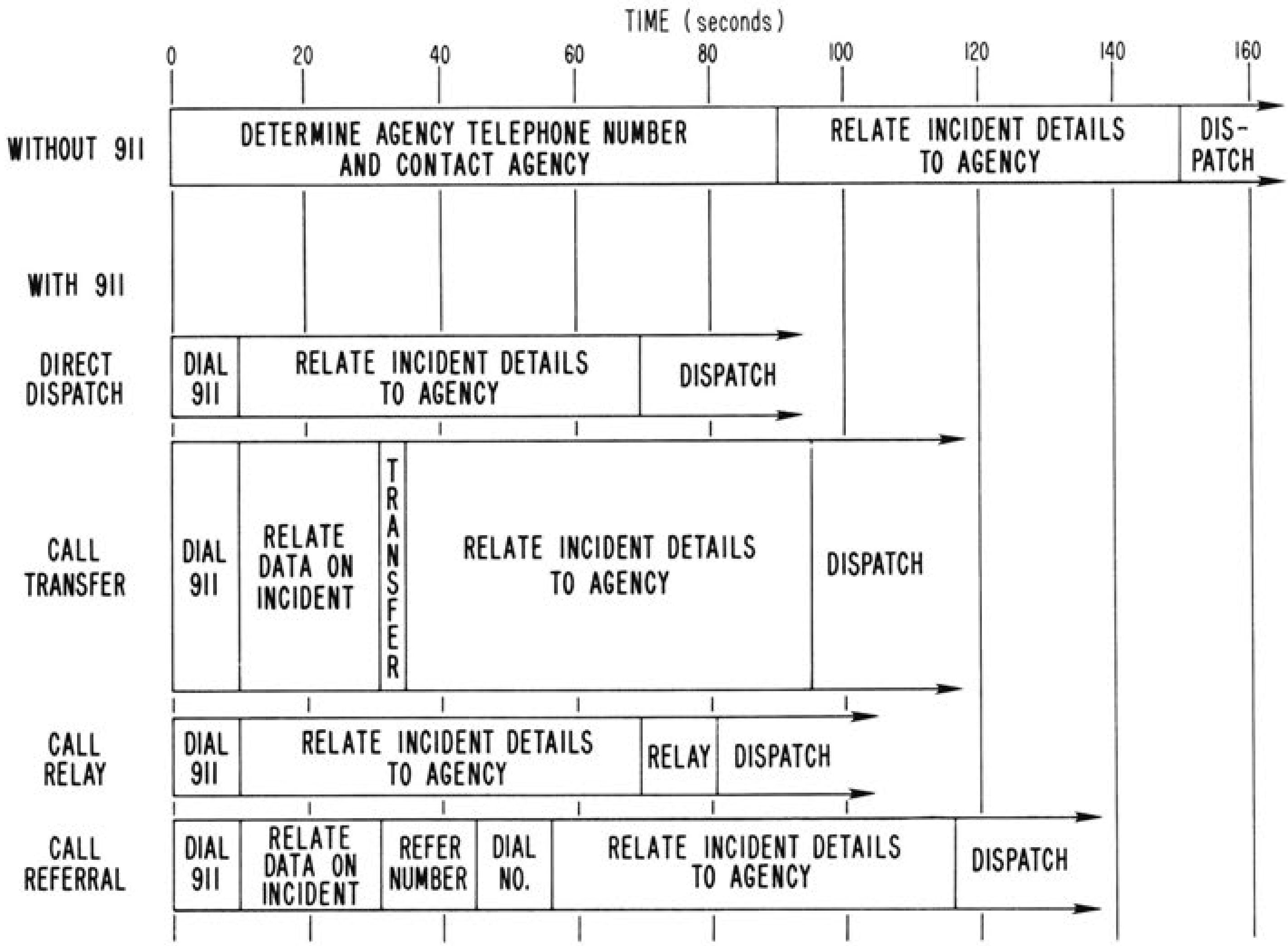


Figure 37. Comparison of average times for conventional and 911 operations.

appear in Figure 37 in conjunction with variable event times--that is, those times which are unique to each call handling method. Included at the top of figure 37 is the average amount of time delay incurred by callers without 911. This average delay without 911 is the delay resulting from a need for approximately 50% of resident citizens to look up the number of the correct agency, to go through the telephone operator, or, for more than 20% of the citizens, to be transferred from one agency to another. The amount of time from citizen recognition of an incident (the left end of the time bars) to completion of a dispatch (the right end of the time bars) is composed of the standard times plus times required for operations that are specific to each 911 call-handling technique.

Direct dispatch is the fastest 911 call-handling technique. Approximately 80 seconds are required from the time the incident is recognized by the citizen to the time the dispatch is completed. This time (80 seconds) is only one-half of the time required (160 seconds) for many citizens without 911 systems.

Call transfer 911 adds two operations to the direct dispatch method: (1) obtaining incident data and selecting the correct agency to receive the transferred call, and (2) transferring the caller to the correct agency. These two operations add about 25 seconds to the time required to direct dispatch 911. Call transfer has a resultant overall time of 105 seconds. This is still nearly a minute faster than non-911 systems.

Call relay 911 takes more time than direct dispatch 911 and less time than call transfer 911. With call relay, the 911 call answerer tranfers the information rather than the caller. Thus, the citizen does not have to repeat part of his story as he does with call transfer. A time of about 90 seconds is thus spent on call relay which is fully a minute less than non-911 systems.

Even call referral 911 is faster than non-911 systems by more than half a minute. In call referral 911, the PSAP is only involved with the caller for about 45 seconds which is only one-half the time it takes over 50% of the callers to obtain the correct agency with non-911 systems.

The 911 committee members should evaluate these various times for 911 call-handling techniques to determine the impact on the selection of a technique suitable for their agencies and jurisdictions. Telephone company representatives should discuss the telephone system requirements for these techniques with the members, as desired.

Depending on the configuration of the local telephone system equipment, certain 911 options are available. Several excellent studies are cited in the bibliography. The application to and availability of these options for local 911 systems should be coordinated with the local telephone company representatives.

The Public Safety Answering point should have the capability to communicate with individuals having auditory handicaps and to communicate in the language of the predominant population groups with limited English speaking ability in the systems service area.

Alternative 911 configurations

In their study of the various 911 alternatives, the 911 committee should address a number of questions regarding the alternatives:

- Are boundaries between the major agencies recognized in one or more of the alternatives?
- To what extent do the areas covered by the 911 alternatives match those of the agencies and jurisdictions?
- Are the agencies and jurisdictions in the various 911 configurations compatible in terms of operations and political/management conditions?
- Do the 911 configurations recognize natural boundaries?
- Are central offices which straddle the county boundaries assigned to the public safety agencies (generally sheriffs) responsible for the bulk of the population in those exchanges?

This set of questions will serve to focus the considerations of the 911 committees on key aspects of the alternative configurations.

6.4.4. Selection of PSAP's and call-handling techniques

Frequently, PSAP's are located in the largest law enforcement agency or existing joint dispatch facility in the 911 planning area. This is based, in part, on the fact that the law enforcement agencies normally receive 80% to 90% of the emergency calls and are generally the best equipped to assume the 911 communications load. In some areas, however, this may not be the best selection, so the 911 committee is encouraged to analyze each alternative on its own merits.

PSAP locations can also be determined by maximizing the population to be served by direct dispatch. A single, properly trained person can handle all 911 call answering and dispatching for up to 18,000 people. Therefore, to provide maximum use of personnel, the 911 committee will want to use 911 personnel in the direct-dispatch mode to the maximum extent possible. For somewhat smaller population bases, a 911 operator can provide 911 answering for all agencies, dispatch for some agencies, and provide call transfer, call relay, or call referral for the balance of the agencies.

The final consideration in PSAP selection is to minimize telephone line costs. Most of these costs are computed on a per-mile basis so there are cost advantages to selecting PSAP locations that reduce PSAP-to-agency and PSAP-to-central-office distances.

Each 911 committee should, then, go through the following process in completing the descriptions of alternatives to be considered for final selection:

- In each 911 system area, identify agencies that want to operate with either direct dispatch, call transfer, call relay, or call referral.
- Determine the dispatch locations of the largest (in terms of call volume) agencies desiring direct dispatch 911.

- Evaluate space availability in the dispatch centers for the 911 personnel and possible dispatch for additional agencies, if desired. Include consideration of direct dispatch of ambulance.
- Determine distances from these dispatch centers to central offices and other agencies.
- Determine relative capabilities of central offices in candidate PSAP locations.
- Select PASP's based on the above consideration.

6.4.5. Costs of alternative systems

The costs of alternative 911 systems must be considered in terms of both implementation costs and, more importantly, ongoing operational costs. The principal implementation costs are: new facilities and equipment (if required), telephone system implementation, and telephone logging recorders. The principal operational costs are the salaries for call answering personnel and the telephone system repair and maintenance costs.

Facility and equipment requirements are heavily dependent on the number of call answering and dispatch position requirements. A common rule of thumb is that each position requires approximately 5.5 sq m (60 sq ft) of floor space to allow for the console and passage space, and that one operator can handle a population of approximately 18,000 persons.

The telephone system is componsed of: incoming 911 lines, outgoing private lines, listed and unlisted business lines, and the call-answering telephone equipment. To determine the installation and recurring costs of these lines and equipment, the telephone company serving the PSAP must know the number and type of telephone lines, the distances between points to be interconnected by dedicated lines, the number of answering positions, and the total number of lines to be terminated at each position. The telephone company serving the proposed PSAP can assist in developing this information and can provide estimates of the telephone system installation and operating costs.

The cost of logging recorders can vary significantly depending on the type of recorder and the features provided. Exact costs must obviously be obtained from the various manufacturers at the time of system implementation. There is a choice of two basic configurations which may be used to connect the telephone system to the logging recorders. The first method is to connect each 911 line to a separate logging recorder channel. This method records the entire conversation on the 911 line, even if the call is transferred. The second method is to connect the telephone set of each call-answering position to the logging recorder. Using this second method, only that portion of the call answered on the 911 line is recorded (no recording is made after a call is transferred). This system requires less recording channels and is less costly. Finally, an existing dispatch center may have a recorder with unused capacity which could be incorporated into the 911 system. The 911 committees should determine which configuration they will use for each alternative in order to determine the cost of logging recorders.

The number of personnel required to staff a 911 system depends on the configuration of the alternatives, however, an estimate can be developed using either call data or population-based data. The number of personnel needed to provide the 911 function must then be compared to the number of personnel available in existing public safety communications facilities in order to determine the need for new personnel.

This section has described the rather complex process of evaluating, configuring, and costing alternatives. Each 911 committee should make a major effort to assure that the alternatives that emerge from this process are those that have support from some segment of the council.

6.4.6. Management techniques

There are two basic management forms (joint powers and contract) commonly used to implement and operate a multi-agency 911 system. Even a single city 911 system will require some form of interagency agreement because fire, police, and ambulance agencies must be included. The most basic management form is a contract between the sheriff and a town when the sheriff provides law enforcement for the town. Joint powers agreements are generally rather more complex and often involve a number of participants.

Although this is a technical planning guide, the importance of a sound, agreed-upon management concept is a major factor in achieving a successful telecommunication system. The degree of influence which the EMS planner will have on the organizational management structure will depend upon how well he understands the constraints and operational problems involved in different communication management structures.

6.4.7. Selection of alternatives

The 911 committee should now be ready to use the information it has accumulated as a basis for selecting 911 systems to serve its planning area. Each 911 system to be evaluated will have five basic features: (1) a specific geographic area which contains a number of jurisdictions, agencies, and telephone exchanges (plus, perhaps, parts of other jurisdictions and agencies), (2) a set of call-handling procedures for the included agencies, (3) a selected PSAP, (4) estimated initial and recurring costs, and (5) a method of management. This section will provide a method for ranking these (and other) 911 system features.

Form B-4 in Appendix B contains a matrix which the 911 committees can use to rank the alternatives. It is probable that members of the 911 committee will not all agree on the ranking of benefit measures for each alternative, particularly, benefits which are not easily measured, so each member should have the opportunity to rank them independently. After its individual members have ranked the alternatives, then a 911 committee should meet to evaluate the rankings and develop a consensus of the committee members.

The form contains a mix of quantitative (measurable) benefit measures and qualitative (unmeasurable or subjective) benefit measures. For example, the cost of the telephone system is a quantitative measure, while the desires of an agency for a particular configuration is usually a qualitative measure.

In using the form, the 911 committee members should rank the alternatives for each benefit measure. The best alternative should receive the lowest number (one), the worst alternative should receive the highest number (equal to the total number of alternatives being considered), and the other alternatives should receive rankings in ascending order of undesirability. All benefit measures need not be used. Each 911 committee can select a subset of these measures that they wish to use. Clearly, additional benefit measures can also be selected.

6.4.8. Preparation of preliminary 911 plans

After an alternative has been selected, it will be necessary to develop a tentative 911 plan. Each 911 plan should address at least the following minimal topics since the success of the resultant system can be seriously jeopardized if complete inter-agency and interjurisdictional understanding is not reached.

Configuration of the 911 system

It is most important that the proposed 911 service area be clearly described to all affected agencies prior to any definitive implementation action. Consequently, a list of concerned agencies should be compiled, and a representative of each agency should sign it to demonstrate that agency's acceptance. This will prevent situations where one area is blocked in its 911 development because of actions taken by another jurisdiction. Concerned agencies will include:

- All member agencies with their service areas. A member agency is one with the bulk of its 911 calls for that area processed through the system PSAP. These agencies will have to cooperate closely in the 911 center management.
- All agencies should be listed, together with their service areas, in the exchanges. Fringe-area agencies are those with most of their service area

in another PSAP area. For example, if ten percent of agency A's service area falls within an exchange wired into a PSAP, this condition should be described. Call handling for the ten percent of the calls (e.g., calls transferred between PSAP's), a special line to the appropriate PSAP, and radio relay of the information, also should be described.

- The affected exchanges should be clearly listed so that there is no doubt about <u>all</u> prefixes accessing this particular answering point (PSAP).

<u>Technical/operational components</u>

The following points, which should be covered separately in each local public safety answering agreement, are assumed to comply with any state or Federal requirements:

- Call handling by call type for each agency must be specified for each PSAP.
- Call handling procedures for each agency should be specified, along with any hardware requirements. For example, if an agency wishes its calls transferred, the PSAP will need dedicated lines for transfer and call transfer equipment. (The lines are to be specified in conjunction with telephone representatives.)
- The interconnection with any additional resources (i.e., other than law enforcement, fire, or emergency medical) should be specified, as should connections to adjoining PSAP's.
- PSAP manning levels and response times should be clearly described and any differences from the recommended standards should be described.
- If answering positions are to be equipped with instant playback recorders, this should be specified.
- Any additional technical features, such as alternate telephone cable entrances into PSAPs, underground

or buried cable entrance facilities, or alternate power sources for the PSAP, should be specified.

6.5. The EMS Command and Control Center

A major weakness of the emergency medical services system in the past has been the lack of efficient coordination among the different agencies which provide emergency assistance. Most areas have traditionally utilized independent operation of ambulance and hospital services as well as other emergency services (fire, law enforcement, etc.). Often the only common communication interface available between these agencies has been the public telephone system which has been operated much like the citizen opening the telephone book and scanning the multitude of "emergency service numbers". Implementation of a single number (911) will ease citizen access to emergency systems, however, effective utilization of EMS resources requires a command and control center, which can coordinate emergency services. As mentioned in Section 3.1.3, this center should be accessed via a Public Safety Answering Point (PSAP) for all emergency services. This section considers the problems and techniques for coordinating the emergency resource agencies. Figure 38 depicts typical telephone and radio links in an emergency system. Each community, however, must define its own needs.

6.5.1. Command and control

In order to understand better the distinction between command and control and medical control (Section 7) the following paragraph is quoted from the DHEW guidelines (HSA 77-2036, 1977):

> "Generally EMS Communications are divided into two major categories: Citizen Input and Response (CIR) such as a 911 answering and dispatch system and Medical Control (MC) such as ambulance to hospital, hospital to hospital, hospital to Medical Resource, and MC to CIR. Although these may be combined, it is usually best if they are separate but cooperating organizations. The EMS Communications System thus provides the means by which emergency resources can be accessed, mobilized, managed, coordinated, directed and accounted for."

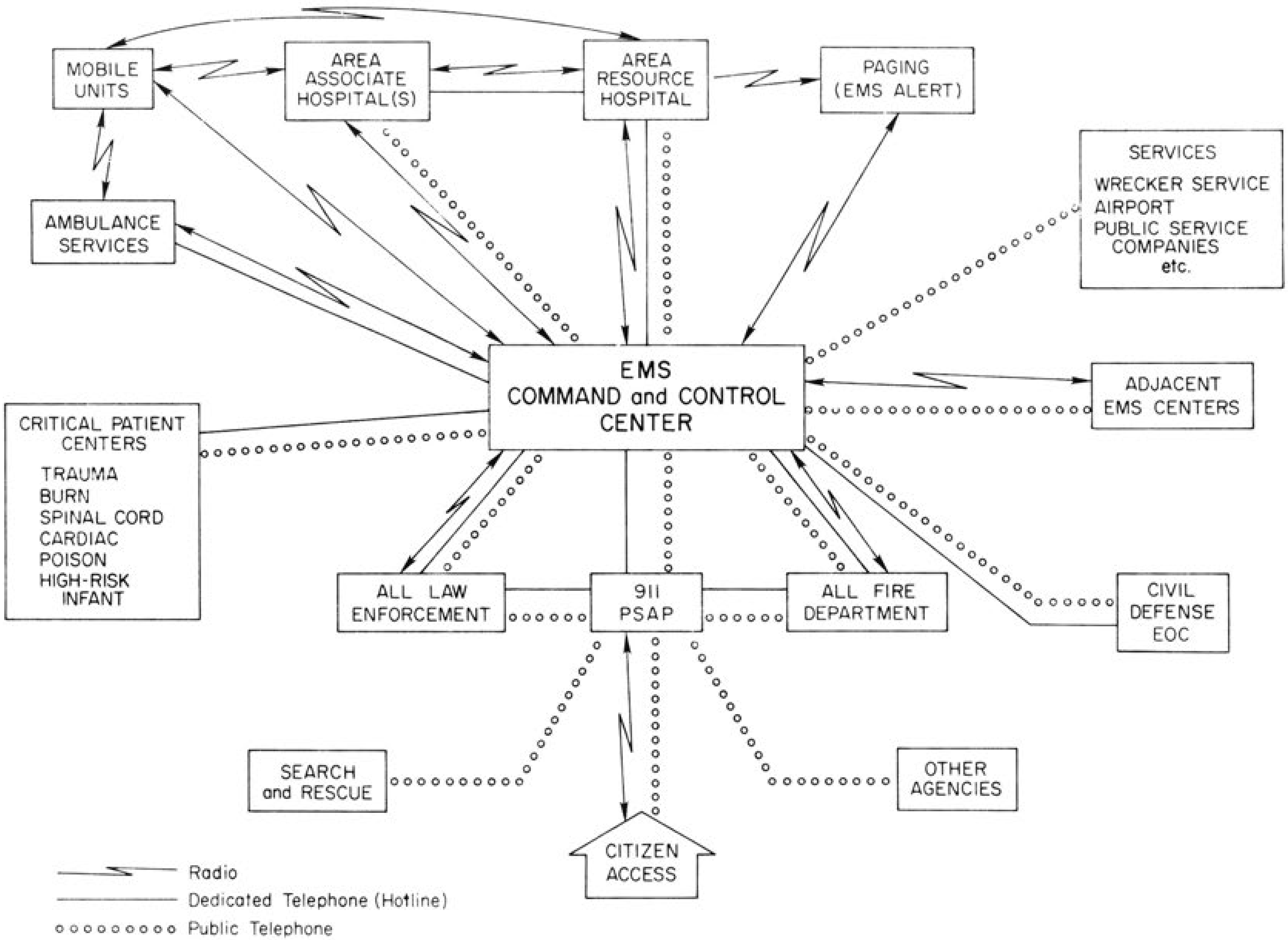


Figure 38. Typical system telephone and radio links.

The Command and Control center should be responsible for selection of the communication channels to be utilized by the participants and allocation of those public resources essential to the most effective and efficient management of the immediate problem. In other words, as stated in the NHTSA (1978) guide:

> "Emergency vehicles requesting a medical coordination channel to the most appropriate hospital do so thru the communication control center. Using the channel established for initial contact with the communication control center for vehicle coordination purposes, the control center directs the vehicle to the channel selected for medical coordination with the most appropriate hospital. The communication control center notifies the hospital of the incoming call and the selected channel and maintains supervisory contact until the link between the vehicle and the hospital has been properly established."

Quoting again from the DHEW guidelines:

> "A communications center for CIR and for MC are inherent to the provision of effective EMS. These centers should have the links required to satisfy and effectively perform their individual function. The real-time (channel trunking) concept for assignment of channels necessitates a communications center and is the method which makes most effective use of the block frequency allocation structure of the FCC rules. Geographical assignment of frequencies may be justified in low traffic volume areas where an existing system is meeting most requirements. Even with the geographic concept, a communications control center is necessary for coordinating and disciplining operations. Command and control is a function of management. The national emergency telephone number ("911") can enhance citizen access by providing a nationwide uniform telephone number. The "911" system encourages those providing communications services and those providing emergency assistance to coordinate their efforts and facilities and work together. A central communications call answering facility is also inherent to the "911" system."

From these guidelines, then, the response (dispatch/coordination) command and control radio subsystem is assumed to be functionally independent of the medical control subsystem (medical supervision, telemetry). The Command and Control function is designed to direct the medical unit(s) and to coordinate other appropriate resources to the emergency scene. The medical control function is to provide professional medical advice and direction to personnel at the scene and en route to the primary care unit.

The availability and flexibility of EMS UHF frequency allocation are strong incentives for incorporating the Command and Control and the Medical Control subsystem into a single radio system. In so doing, however, the planner must analyze the needs and conditions at the local, operational level to determine:

- The operational loading and capacity of the two functional subsystems. For example, can medical control telemetry be interrupted for dispatch and coordination by the Command and Control Center?
- The operational procedure requirements between the two functional subsystems.
- The availability of additional UHF channel assignments for the dispatch function of Command and Control.
- The best way to utilize existing radio inventories.
- The cost/benefit impacts of the various alternatives.

Some EMS systems have elected to retain their existing EMS VHF subsystem for the Command and Control function and add the UHF subsystem for medical control; however, the transition to a total UHF system is encouraged. The optimum configuration for any specific EMS system must be determined by the local EMS council in cooperation with regional and state plans.

6.5.2 Command and control center functions

The design of the EMS command and control subsystem should include a minimum set of functions which in turn will dictate certain interfaces with other agencies. These are:

- Be responsible for establishing and allocating those communications channels and coordinating the response of those public resources essential to the most effective and efficient EMS management of the immediate problem.
- Have the necessary equipment and facilities to permit the immediate interchange of information essential for the EMS system's resource management and control.
- Be interfaced with all Public Safety Answering Points (PSAP) within its area of responsibility by direct

telephonic and or radio communications interfaces unless the EMS Command and Control and all PSAP's are operated at the same control point.

- o Have radio communications capabilities with all personnel, facilities, and equipment of the EMS system and with other appropriate EMS systems in accordance with applicable state, regional, and local plans for emergency medical services communications.
- o Have the capability for establishing telecommunication conference connections to allow a caller and the EMS Command and Control operator to speak with poison control centers, emergency medical resource centers, or other locations which can provide information outside the scope of knowledge of the EMS Command and Control operator.
- o Provide for continuous and uninterrupted operation by regularly assigned personnel trained in public safety and EMS telephone and radio operating procedures and familiar with public safety and EMS resources within the center's area of responsibility.

As discussed previously, each EMS system will configure their resources in different ways to satisfy their needs, however, these basic functions should not be compromised in the process of agency accommodation.

6.5.3. <u>EMS command and control center call processing functions</u>

Incoming emergency calls which require the dispatch of medical personnel may be handled in several different ways. However, no matter which way is chosen, the steps are basically the same. The difference depends upon the way in which the individual steps are performed. The steps in the processing of an emergency call are:

(1) Receive the call on incoming telephone trunk lines or automatic private lines from the PSAP.

(2) Request and record the type of emergency. (Note: by requesting the type of emergency such as fire, medical,

etc., the PSAP operator may transfer the caller to the appropriate agency with a minimum amount of redundant information and corresponding amount of time saved. This is particularly important for the mental well-being of an excited, anxious caller.

(3) Transfer the information to the radio dispatcher.

(4) Dispatch the appropriate EMS response.

Calls received on 911 which are not of an emergency nature are not transferred to an agency. The caller is given the administrative number of the particular agency and asked to redial the appropriate agency administrative number.

The simplest way in which to carry out the above steps is to have one person handle all four. However, when the work load becomes too great for one operator/dispatcher, the calls can be divided among two or more persons having the same duties. The process may also be divided by giving different duties to each operator such as having operator 1 handle steps 1, 2, and 3 and operator 2 handle step 4. In step 4, the transfer from emergency operator to dispatcher may be accomplished in a number of ways (hand-off, messenger, conveyor belt, pneumatic tube, computer terminal, etc.)

Only the most obvious features of these various arrangements have been discussed. The choice among them depends on other factors, including the volume of telephone calls and radio messages, the size of the population and area being served, the nature of the demands made on the system by the community, the boundaries of the telephone exchanges in the community, etc. No single rule of thumb can be stated to make the choice an automatic one. General experience indicates that communities with populations below about 40,000 to 50,000 normally use one person for all four steps. Communities with populations between about 50,000 and 100,000 generally use two. The addition of the second person is made only during the busiest shift for the departments near the lower end of this range. When the population is near or beyond 100,000, a third person is usually added to the busy shift and, as community size increases, more personnel are added to the other shifts. As additional operators are employed in the communication center, the more likely it is that the complement on each shift will differ according to the system's needs. There are, of course, many exceptions to these guidelines, caused by particular local conditions.

The decision to give all additional personnel the same duties or to divide the four-step process into two or more stages is less dependent on population size than on some of the other factors mentioned above.

6.5.4. EMS command and control telephone configurations

Section 6.4 discussed the operational and technical requirements for the PSAP and dispatch telephone configurations. This included 911 trunk line requirements to the PSAP from the central telephone exchanges as well as hot-line or dedicated telephone circuits from the PSAP to the various agency command and control centers. This subsection will discuss additional telephone circuit and termination equipment requirements.

The EMS Command and Control Center usually requires four distinct types of telephone service:

- o Incoming emergency calls from the PSAP (unless the PSAP and Command and Control Center are colocated).
- o Incoming administrative or business calls on the public telephone system.
- o Outgoing calls of all types on the public telephone system (usually unlisted telephone numbers).
- o Automatic private lines to expedite coordination with key agencies other than the PSAP.

NOTE: Telephone private lines (wire pairs) for remote base-station control are not considered in this subsection.

Incoming emergency calls from the PSAP are usually via automatic private or dedicated telephone lines. With these lines, whenever either station lifts its receiver, the other station is signaled (rung) automatically and no dialing is required. Such lines are also used for quick, dependable communication with other agencies such as police, sheriff, fire, poison center, etc. Incoming administrative or business lines provide for non-emergency access to the center. The "unlisted" outgoing lines provide dispatcher access to the public telephone network. This is especially vital during major emergencies and disasters when the center administrative and business circuits may be overloaded. The local configuration of telephone trunks, circuits and lines will depend, however, on a particular community's operational concepts and interagency cooperation.

The particular type of telephone terminal equipment used at the dispatcher's location depends on the preference of the agency and of the people using the telephone. Ordinary desk telephones are often used, but many dispatchers find the use of headsets in place of the telephone handset more convenient, because it leaves their hands free. The telephone headset can be shared with the radio system, with the radio push-to-talk switch automatically selecting telephone or radio capability. Besides the standard dial or push button telephone, there are various types of dialing equipment available.

When several telephone lines are required, push-button or "key" telephones offer flexibility and effective handling of the telephone lines. Features available include pick-up and holding, intercommunication between lines, visual and audible signals, cutoff, exclusion, and signaling. Illuminated and optionally colored push-buttons on the telephone set give a visual indication of incoming calls, held or busy lines. The hold key enables the user to hold any line picked up. The cut-off and exclusion features can provide privacy or emergency override of other users on the line, by enabling the user to disconnect other extension telephones from that line.

It is usually possible to consolidate the telephone equipment into a communication console, if desired. This is sometimes convenient from an operational viewpoint, because it reduces clutter at the console and the equipment can be arranged for the most convenient use.

Maintenance on the telephone equipment is almost always performed by the telephone company since the equipment is usually leased from them; however, recent FCC Rules and Regulations and innovations in the telephone equipment terminal market are providing other options to leasing.

6.5.5. EMS command and control center design considerations

The primary functions of the operator/dispatcher are receiving, processing and transmitting information. It is the responsibility of the planners and designers to insure that the environment (both physical and mental) enables the operator/dispatcher to perform those functions in an efficient and expedient manner.

Some of the major items which should be addressed with regard to design are:

- Space - does the configuration allow space for administration, rest, equipment, etc.
- Environment - can the temperature and humidity be controlled for maximum and minimum work loads? Have the floor, ceiling, wall coverings, and colors been selected to provide a comfortable environment?
- Noise - are construction materials used which will provide relief from both internal and external noise and vibration?
- Illumination - can the level of lighting be changed to accommodate different activities and personnel needs?
- Maintenance Access - has "computer flooring" been considered for maintenance, expansion, and operational flexibility to insure a minimum of operational disturbance?
- Physical Security - is the facility capable of handling severe weather, earthquakes, internal and external fire, flood, and/or intentional sabotage? Is the fire extinguisher system compatible with the electrical and electronic equipment?

- o Emergency Power - is the primary power backed up with generator and/or battery sources?
- o Flexibility - is the design of the center flexible enough to allow reconfiguration of the operational equipment (moving of consoles and other equipment)?

Figure 39 shows a typical small control center configuration.

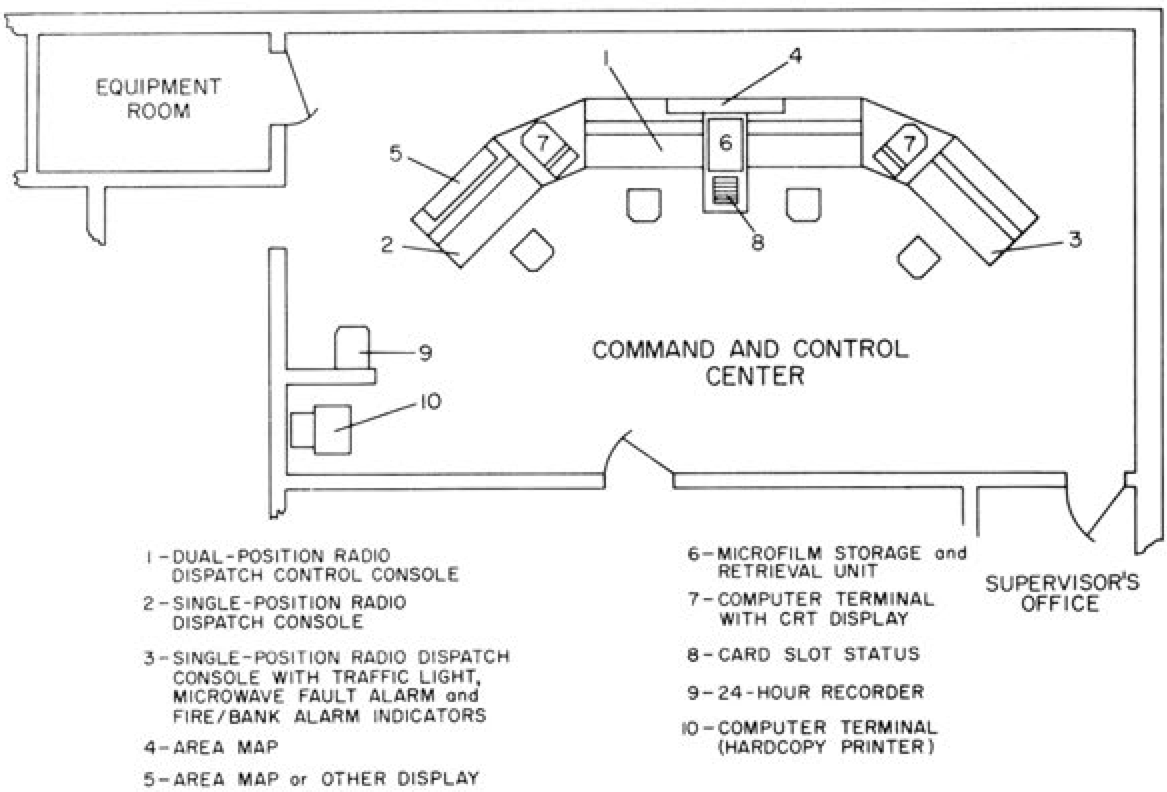


Figure 39. Typical medium-sized communication center.

7. MEDICAL CONTROL COMMUNICATIONS SUBSYSTEM

The medical control subsystem involves communications between medical personnel at or en route to or from the emergency scene and a medical care center (a hospital, clinic, . . .). The purpose of this communications subsystem is to extend the knowledge and expertise of the medical professional to the emergency scene in order to reduce the possibility of premature death and disability. It is the planner's responsibility to understand the communications needs of the local medical community and to translate those needs into a workable plan, consistent with the planning principles expressed in Section 4.

In an effort to optimize the operational and organizational concept of medical control, the DHEW EMS Communication Plan (HSA-77-2036, 1977) sets forth certain assumptions, definitions, and operational guidelines with which the planner must also be familiar. Whether these medical control guidelines meet the needs of the local system in full or in part, is a decision for the local medical community.

The DHEW document (HSA 77-2036, March 1977) defines medical control (MC) as follows:

> "Directions and advice provided from a centrally designated medical facility staffed by appropriate EMS personnel, operating under medical physician supervision, supplying professional support through radio or telephonic communication for onsite and transit, basic and advanced life support services given by field and satellite facility personnel."

The Plan further elaborates on the medical control operational and organizational concepts:

> "In most urban areas, medical supervision is provided through a central base hospital resource. It is emphasized here that it is quite impractical in terms of available frequencies and from the standpoint of expense to have every hospital in an urban area providing medical supervision to ambulances bringing patients to each individual hospital. Most importantly, personnel at each of the receiving hospitals cannot be expected to be familiar with the radio equipment and communications procedure with resultant communication failures. Furthermore, where multiple users . . . (may be forced to share) a frequency (such as during a disaster), information may become interchanged which may lead to errors in diagnosis and treatment. Therefore, for urban areas it is imperative that medical supervision be regionalized and confined to one base hospital communication center as appropriate to the EMS authority of the State in response to the needs of the region. . ."

As emphasized in Section 6.5, the dynamic coordination of EMS channels is the responsibility of the Command and Control Center. This allows the medical professional to concentrate on medical considerations. In addition, it enables the system designer to employ operationally simpler hardware configurations in the medical facility thereby reducing training costs, operator error and other related problems.

> "The supervising medical resource facility must be responsible for notification of the other receiving associate hospital so that it will be aware of the problem, and what has already been done in order to expeditiously assume responsibility for the care of the patient immediately upon arrival. Furthermore, this medical resource facility should be responsible for decisions that relate to transportation triage of a patient to a special care unit in accordance with previously developed patient transfer guidelines and agreements. It should have the capability of hospital-to-hospital communications for the purpose of determining Emergency Department capability and bed availability information which is necessary in effective coordination of patient disposition. There must of course be a linkage between this Regional medical resource facility and the Regional command and control center responsible for dispatching of all emergency vehicles."

From these guidelines, a number of local medical control configurations might evolve, one such example is presented in the following paragraphs. It is recommended that the communications system design be flexible enough to allow Medical Control to be reassigned to any hospital in the event of a major disaster or other unusual circumstance.

The medical control communications subsystem would require a resource hospital to serve as the Medical Control Center. This center is usually located in or near the resource hospital's emergency department. The center maintains contact with the medical field personnel (i.e., EMT, paramedic, or nurse) and provides medical consultation through the delivery phase as seen in Figure 40a. The resource hospital may or may not receive the patient for further treatment. If the emergency scene is closer to an associate hospital, capable of accepting the patient, he or

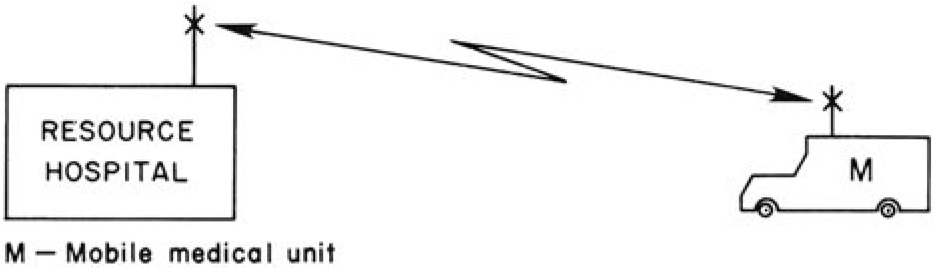


Figure 40a. Medical control--mobile communication.

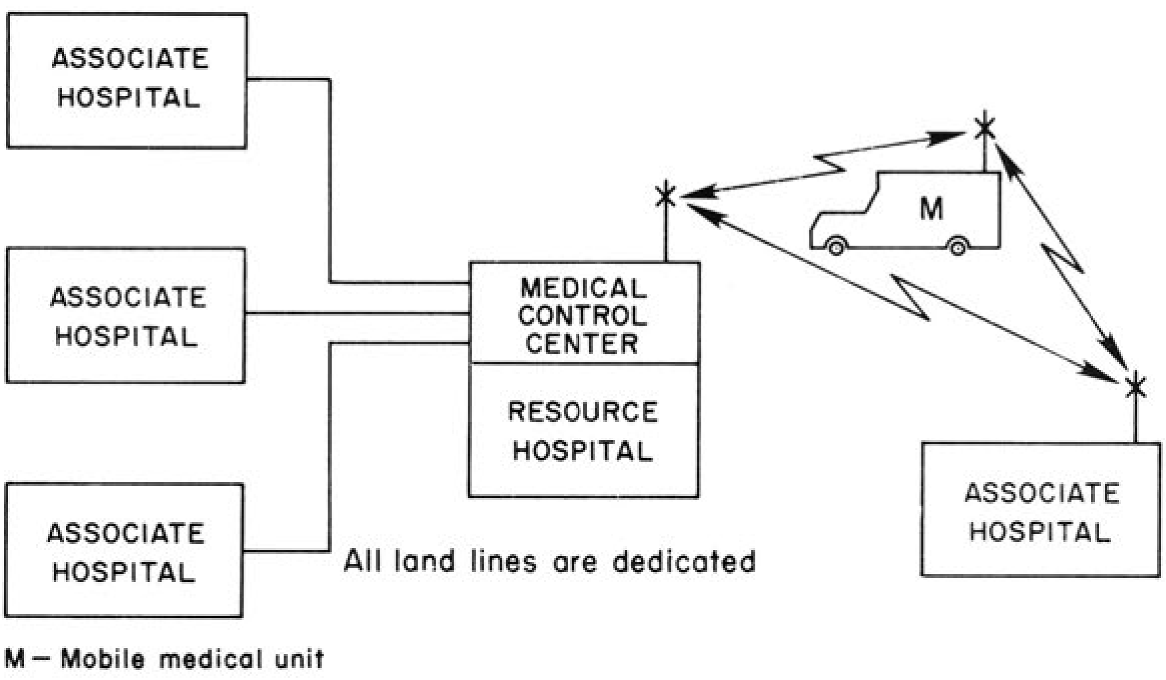


Figure 40b. Medical control--mobile--associate hospital communication.

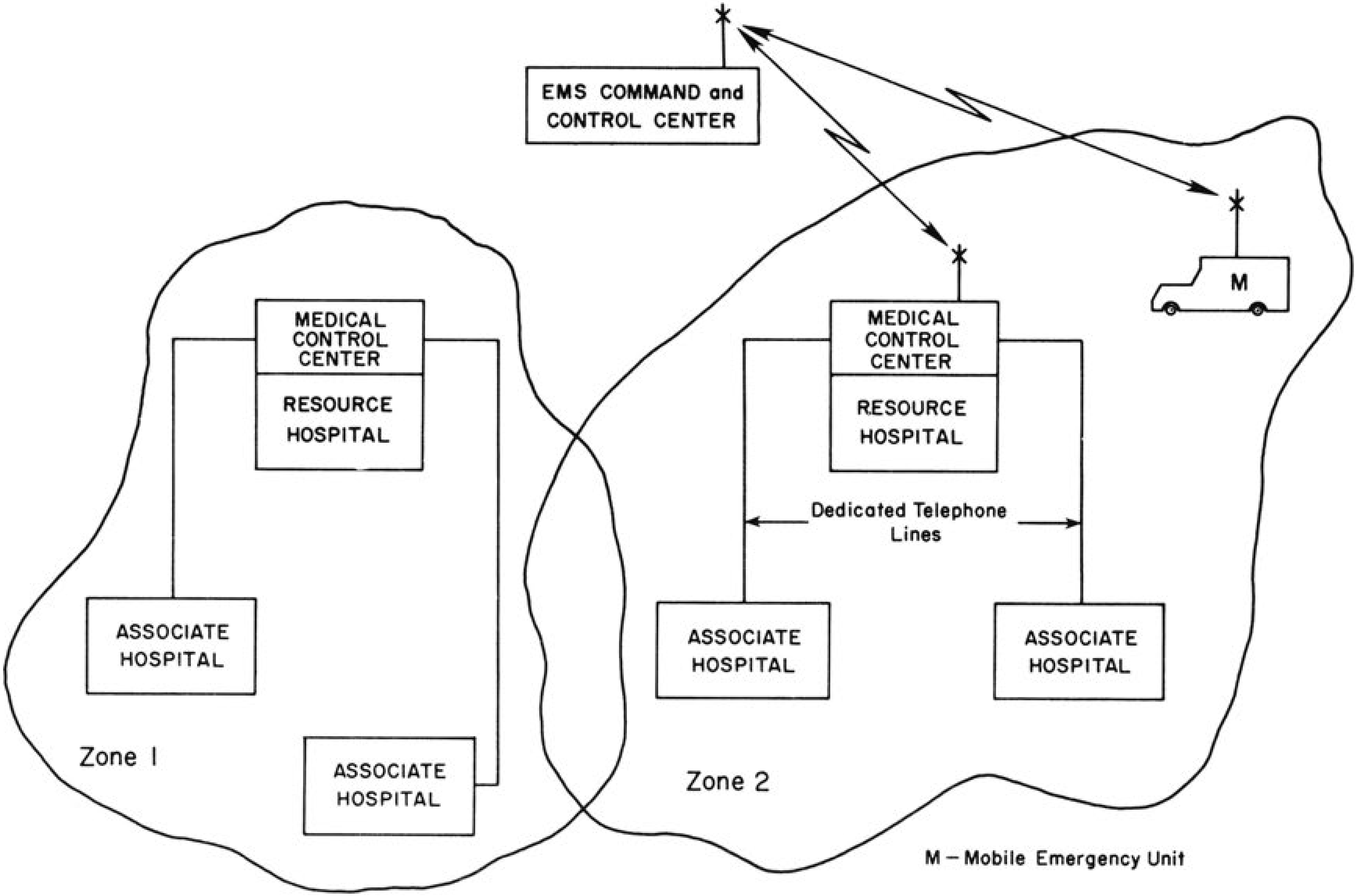


Figure 41. Frequency assignment and coordination.

she may be transported to that hospital. Operational considerations of hospital selection such as patient choice, local ordinances, and state laws must be considered in subsystem design but are beyond the scope of this document. The associate hospital receives information concerning the patient from the medical control center at the resource hospital over the telephone or radio interface or, when necessary and authorized by the MC center, by direct radio communication with the medical field personnel on their own (associate hospital) EMS base station and/or control console. Only a control console would be required if a common EMS base station is employed. These configurations are seen in Figure 40b.

In large urban areas, the EMS command and control center or appropriate alternative may act as the EMS frequency assignment center. In this capacity, the center would notify both the medical field personnel (ambulance) and the appropriate medical center resource hospital as to which EMS channel to use for a specific emergency event as seen in Figure 41. The EMS command and control Center might also be responsible for coordinating with neighboring EMS systems to minimize interference and maximize EMS channel utilization. The method and formalization of coordination is usually governed by the sophistication of the system.

The decision as to which hospitals are "resource" and which are "associate" is determined by Federal and state guidelines as coordinated and agreed upon by the local facilities and is beyond the scope of this document. The planner should be aware, however, that medical control of a local EMS system has political and economic ramifications which, if ignored, can inhibit system development. To implement an efficient EMS system requires understanding, cooperation, and a strong commitment to emergency patient care.

7.1. Medical Control Communications Design Considerations

It is highly probable that the EMS planner will find some configuration of EMS radio subsystem already in operation. If such is the case, the planner will be responsible for recommending alternative methods of modifying or updating the existing EMS radio subsystems. As emphasized previously, this requires that the planner have a clear understanding of the Command and Control and Medical Control communications requirements as developed and agreed upon by the local EMS Council.

System flexibility

The flexibility of an EMS medical control radio system is an intangible attribute of the system. In general, flexibility consists of a system's ability to adapt to rapid changes in demand and unforeseen events. Demands produced by individual events concern one aspect of flexibility. This area of flexibility has been enhanced by revised FCC rules which encourage dynamic channel assignment in the EMS UHF paired frequency allocations. For instance, a flexible system will provide communication for a portion of the system or a segment of the service area which is involved in an extraordinary event, without seriously disrupting the communications in its own area. This is related to having sufficient system capacity to absorb a sudden increase in the communication load.

Another aspect of flexibility involves adaptation to slower, but more permanent changes in demand. Growth of the community, and demands for service and an increase in the number of EMS providers constitute this type of change. Shifts in population within the system's service area, introduction or loss of industrial or business facilities, changes in political boundaries, and introduction of new communication technologies are all sources of permanent changes in communication system demands.

Both aspects of this flexibility requirement can be met if the system has enough capacity. If the system barely meets the current demands, flexible response to new or changing demands is difficult. If, however, some capacity is available for increased demands, system flexibility can be achieved by careful planning in the system areas of operating procedures, personnel resources, and system configuration.

7.2. EMS Radio Network Design Considerations

Type of channels

In any radio network, the types of channels which are used greatly affect its suitability to the needs of its users. Therefore, it is worthwhile to consider the characteristics of channels by themselves apart from any network, in an effort to define their influence within a network.

The two basic tradeoffs which one must consider in selection of a radio channel for EMS telecommunication are:

1. Should the channel contain one, two or more frequencies?
2. Should the operation of the channel be one-way, simplex or duplex?

While there are some special situations in which more than two frequencies are used in one channel, these seem to be unusual cases requiring individual consideration. Therefore, channels with more than two frequencies will not be discussed. The combinations of the remaining tradeoffs yield the following five possibilities:

- A single-frequency one-way channel in which one frequency is used in a broadcast or paging mode and communication is in one direction only.
- A single-frequency, simplex channel in which the base stations and mobile units share the same frequency. At any given time, communication is possible in one direction only.
- A two-frequency, simplex channel in which the base transmits on one frequency and the mobiles on another. Again, at any given time, communication is possible in one direction only.
- A two-frequency, half-duplex channel in which two transmitting frequencies are used, one by the base

and one by the mobiles. At any given time only the base station can both transmit and receive.

- o A two-frequency, full-duplex channel in which two transmitting frequencies are used, with simultaneous transmission and reception in both directions possible.

7.3. Medical Control Channel Configurations

UHF band

The UHF, paired frequency allocations authorized by the FCC are designed for duplex operation. As discussed previously, a duplexed radio station (either portable, mobile, or base station) is one in which special equipment and circuitry have been included to allow the station simultaneously to transmit and receive information. Two radio frequencies are employed, one for incoming information and a second for outgoing information. Employing two duplexed stations in a system allows two persons communicating to interrupt each other. Such a system is referred to as a "full duplex" station, see Figure 42.

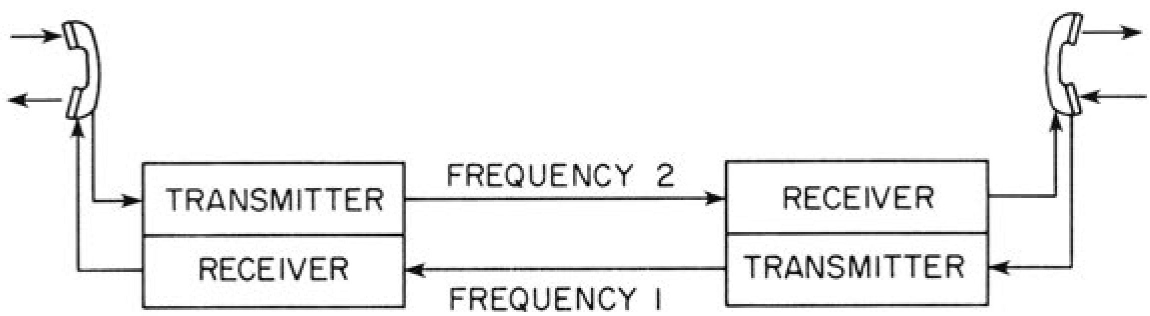


Figure 42. "Full duplexed" radio system simultaneous information exchange.

If one of the stations is duplexed and the other is not, it is possible to break in or interrupt only the duplexed station. Many times in EMS communications, the ambulance or field radio equipment is duplexed and the hospital equipment is not. This configuration allows a physician to talk to his ambulance team even if the ambulance is transmitting. This type of system is sometimes referred to as a "doctor priority" or "physician interrupt" system and is usually less costly and less complicated than a full duplex system. In EMS radio systems, duplex operation is only possible in the UHF spectrum where the FCC has designated two frequencies to be used together as a matched pair. These pairs are designated as MED channels by the FCC, as shown in Appendix A, Table A-1. This table should help the planner become familiar with the rules and serve as a quick reference; however, this summary is not a substitute for reading and understanding the appropriate FCC Rules and Regulations.

A duplexed radio station which is designed to retransmit automatically what it receives is called a "relay" or repeater station. Just as in the base or mobile duplexed station, the unit is capable of simultaneous reception and transmission of information. This technique is usually employed to increase the effective radio range of a lower powered mobile or portable unit. It additionally allows "mobile-to-mobile" communication in a duplexed system, a condition that does not exist in an ordinary normal UHF base-station configuration and is due to the fact that the mobile units do not transmit and receive on the same frequency.

When a relay station is at a fixed location and employed to relay information from a mobile station, it is referred to as a mobile relay station. If the relay station is mounted in a vehicle and used to relay information from a portable unit back through the vehicle to a base station, it is referred to as a vehicular repeater station or a mobile repeater. This technique increases the range of low power portable units that may be carried into a house or other patient location.

In Figure 43, incoming information on frequency 1, say from an ambulance or mobile unit, is automatically connected to the transmitter and relayed to the hospital or another mobile unit on frequency 2.

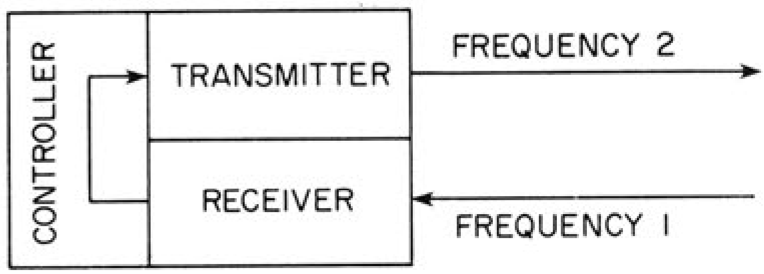


Figure 43. Duplexed radio station information relay.

A radio station that is both a mobile relay and a wireline controlled base station, as in Figure 44, is sometimes referred to as a base-station repeater. In this type of system, a radio transmission received on frequency 1 is heard at the remote control location and is additionally retransmitted on frequency 2. This allows mobile stations to hear and communicate directly with other mobile units and also with the remote control location. For example, incoming information from a mobile unit on frequency 1 is connected to both the transmitter (for rebroadcast on frequency 2) and, by way of the telephone control wireline, to the remote control device located in the hospital, dispatch center or ambulance center.

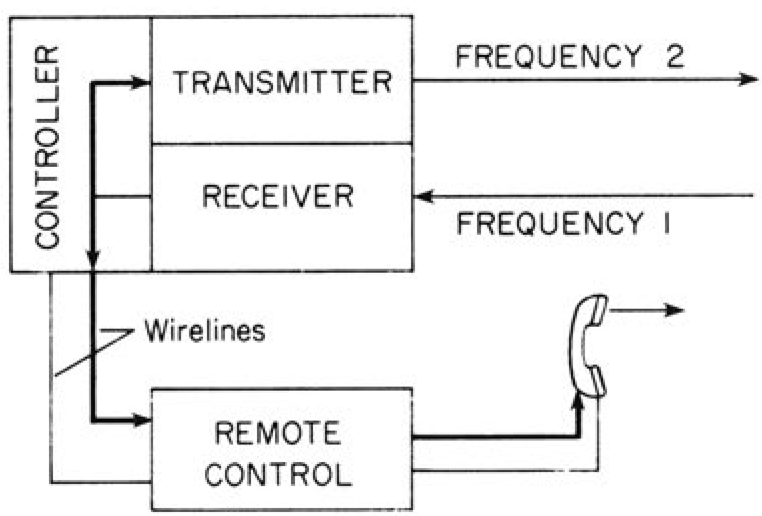


Figure 44. Base station/repeater receive-repeat mode.

However, when the remote control location transmits, the repeater portion of the circuit is overidden and the remote control message is heard, as shown in Figure 45.

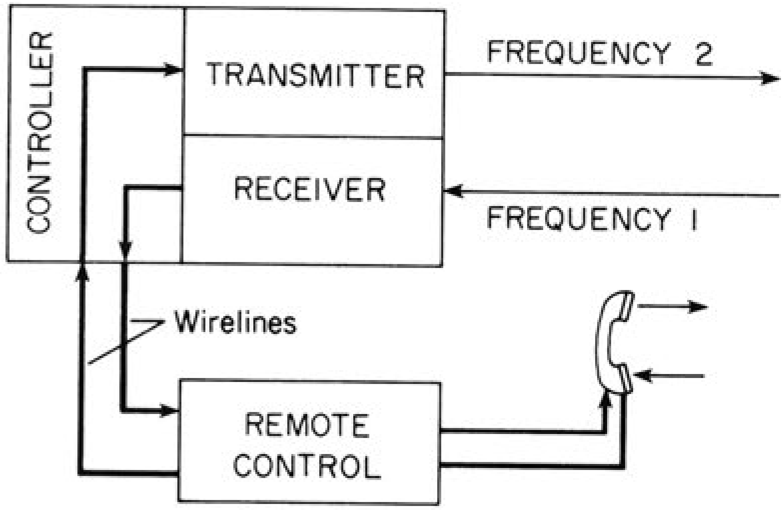


Figure 45. Base station/repeater transmit mode.

Additional configurations and variations of the above are available for special applications. Each of the applications has its own associated economic and operational tradeoffs.

VHF band

The high-band VHF frequencies available for EMS systems are set forth in Table A-1, Appendix A. Although present EMS development emphasizes the use of the UHF band, many rural systems function efficiently on the VHF allocations. The basic channel configuration for VHF is single-frequency simplex. The frequency assignments for the EMS function at VHF high band, as seen in Table 8, do not differ significantly from system to system.

The frequency 155.340 MHz is generally dedicated to communication between ambulance and hospital personnel for directing treatment of patients prior to arrival at a hospital or treatment facility. This channel is for emergency medical care of the sick or injured, and information exchanged on this channel should be

Table 8. VHF Frequency Utilization

Type of Communications	Frequency Usage: Local	Frequency Usage: Out-of-Area
Ambulance ↔ Hospital	155.340 MHz	155.340 MHz
Ambulance ↔ Dispatch	Local Dispatch*	155.280 MHz
Ambulance ↔ Ambulance	Local Dispatch*	155.280 MHz
Hospital ↔ Hospital	155.280 MHz	
MCC ↔ MCC	155.280 MHz	
MCC ↔ Hospital	155.280 MHz	

MCC - Medical Control Center

*Frequency to be selected by local authority

pertinent to the treatment of the patient. To prevent interference and frequency congestion during medical emergencies, this frequency is not generally used for dispatching, paging, or alerting.

The frequency 155.280 MHz is primarily for mutual aid and coordination. The frequency may be utilized for dispatch purposes only on a secondary non-interference basis. However, for new or modified systems, a third frequency from Table A-1 should be selected for dispatching.

7.4. Medical Control Center

A medical control center is generally located in the EMS area resource hospital with the size of the area EMS system dictating the complexity and sophistication of the center. Most emergency medical resources (i.e., hospital emergency rooms, ambulance, etc.) are staffed by personnel who are not professional communicators. These personnel view the communications system as a tool for improving patient care and are not overly impressed with the intricacies of the equipment. Of greater importance, is a simple operational design which provides reliable communication. Medical Control is usually assigned to a Resource hospital which acts as the chief disciplinarian of medical communications for a designated region. Dynamic EMS frequency allocation performed by the Command and Control Center (see Section 6.0) personnel allows greater design simplicity at the Medical Control Center. It also allows greater flexibility in shifting medical control from one facility to another in the event of a disaster. Some medical control centers may employ only a simple desk-top radio control console, while large urban EMS area centers may employ multi-control console systems.

7.4.1. Medical control radio system configurations

This subsection illustrates some of the more common EMS system radio configurations utilizing the allocated VHF and UHF emergency medical frequencies. Separate diagrams are developed for the EMS command and control and medical control subsystems to maximize clarity and purpose of each diagram.

Figure 46a shows an EMS subsystem utilizing VHF simplex operation for the command and control portion of the system. An arbitrary selection of 155.220 MHz has been made for the dispatching of the mobile unit. Figure 46b depicts the "other half" of the system which pertains to medical control.

In the UHF range, as discussed earlier, EMS communication is used in frequency pairs in either half- or full-duplex modes or a combination of both. Figure 47a illustrates the half-duplexed command and control portion of the system while 47b shows its medical control counterpart. Note, in these drawings and from the FCC Rules and Regulations, that base stations cannot transmit on either 467 MHz or 468 MHz while the mobile units can utilize any of the frequency pairs in the transmitting mode.

The above figures depict EMS communications in their simplest form. But, as the size, complexity, and needs of the systems become more complex, so must the equipment requirements become more complex. With the addition of duplexing equipment at both the resource hospital and the command and control center, the total system becomes full-duplex as seen in Figures 48a (command and control section) and 48b (medical control section).

Figure 49a shows a system expansion for medical control which includes a portable unit and utilizes the mobile unit as a vehicular repeater. This configuration allows field personnel,

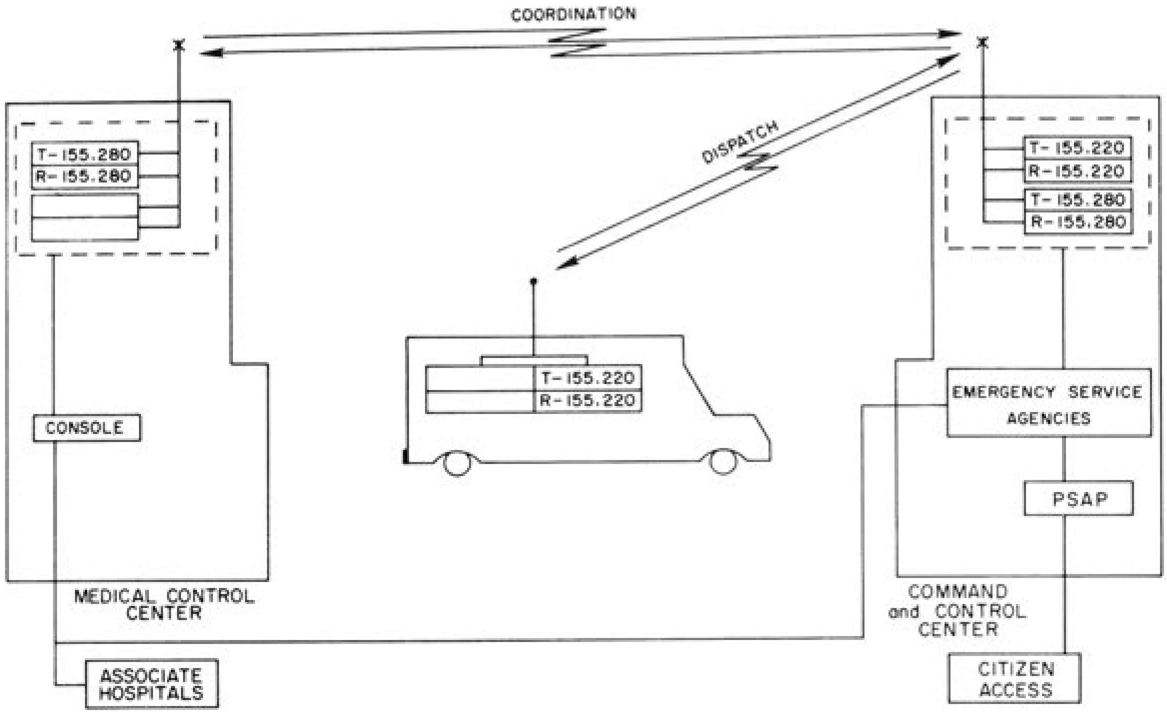


Figure 46a. VHF command and control (simplex).

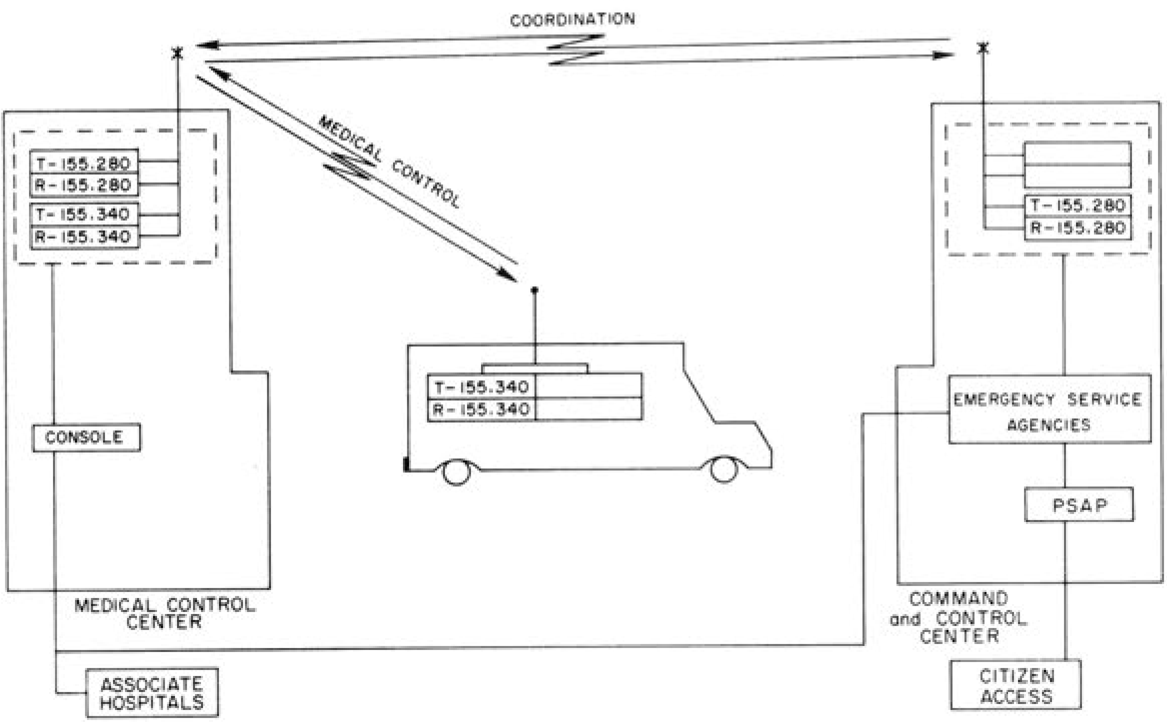


Figure 46b. VHF medical control (simplex).

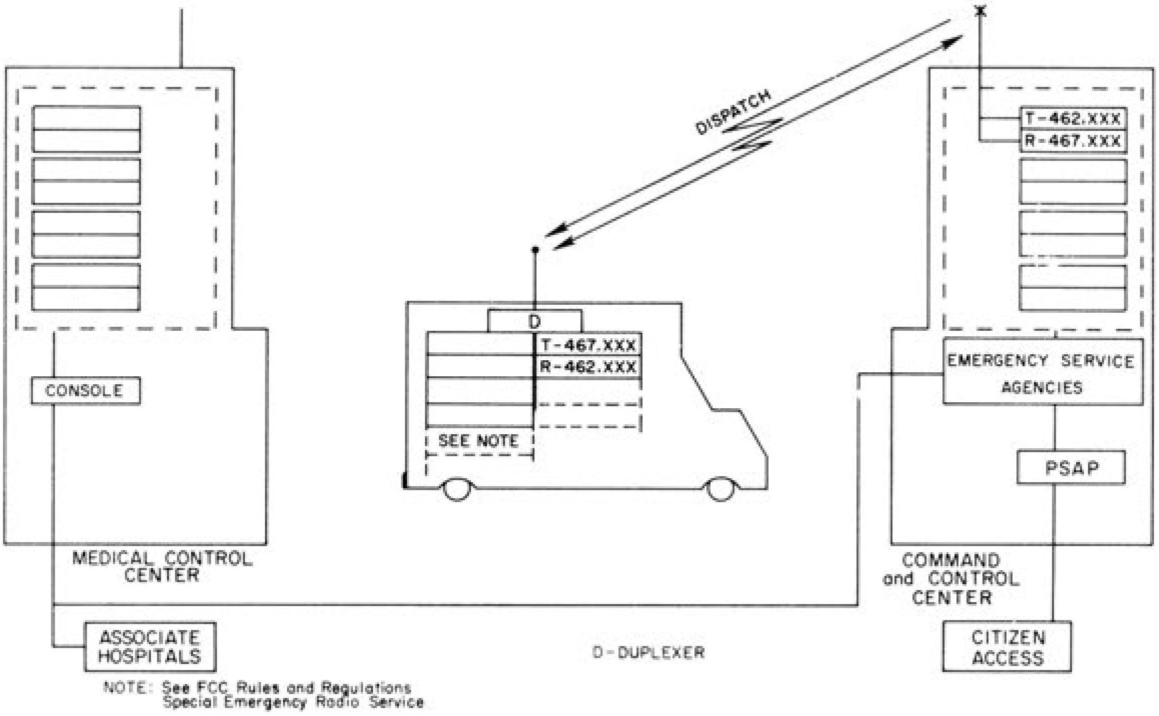


Figure 47a. UHF command and control (half-duplex).

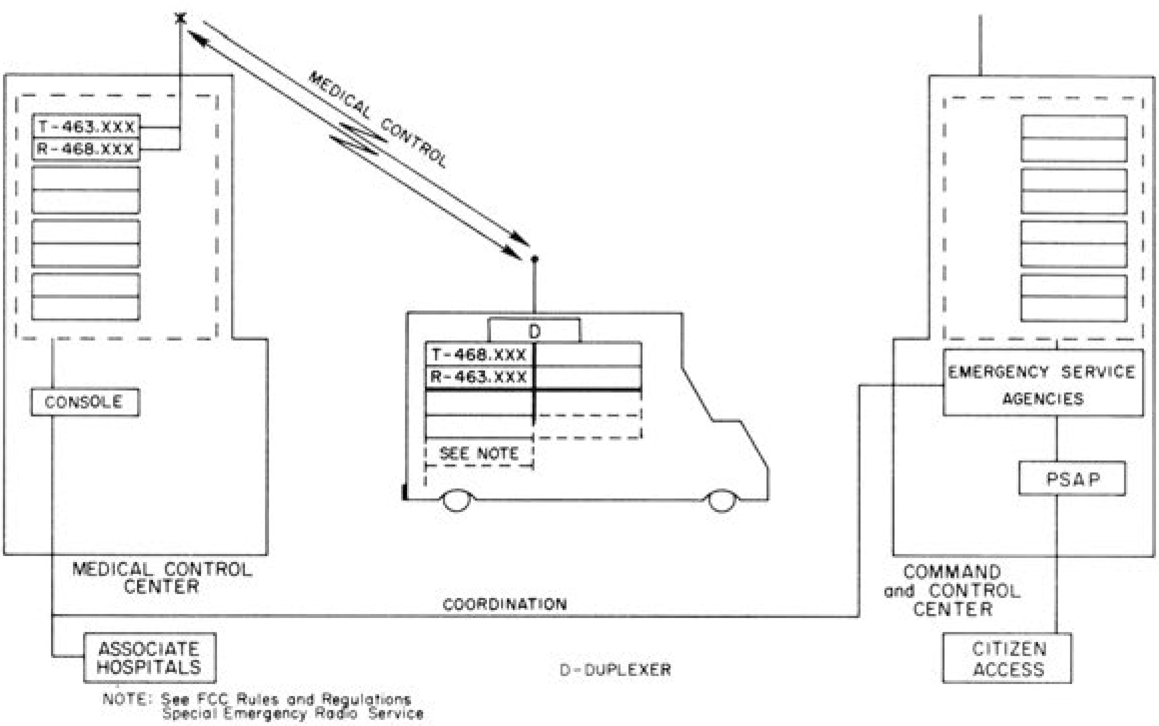


Figure 47b. UHF medical control (half-duplex).

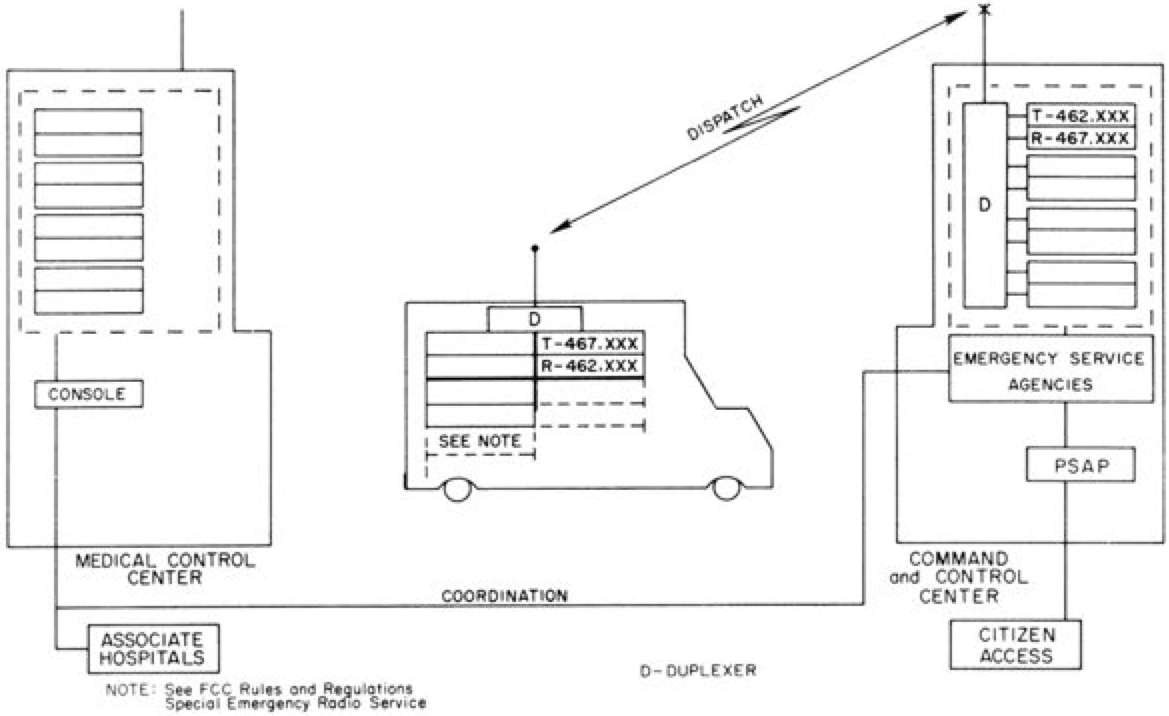


Figure 48a. UHF command and control (full duplex).

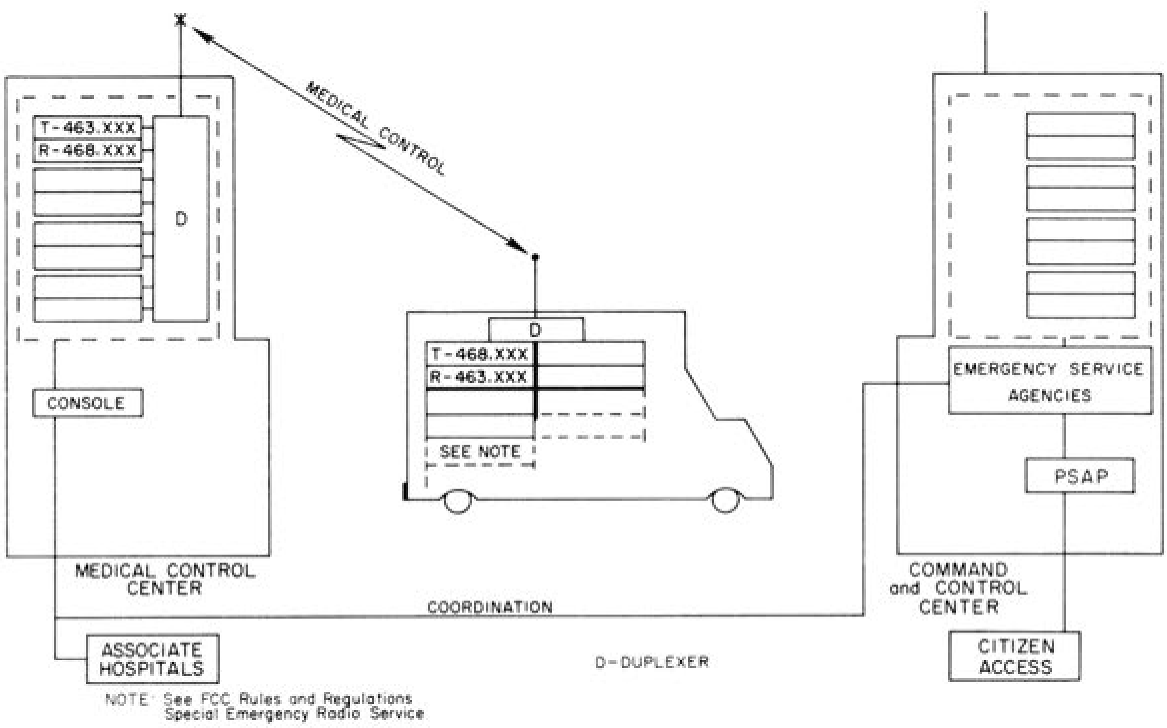


Figure 48b. UHF medical control (full duplex).

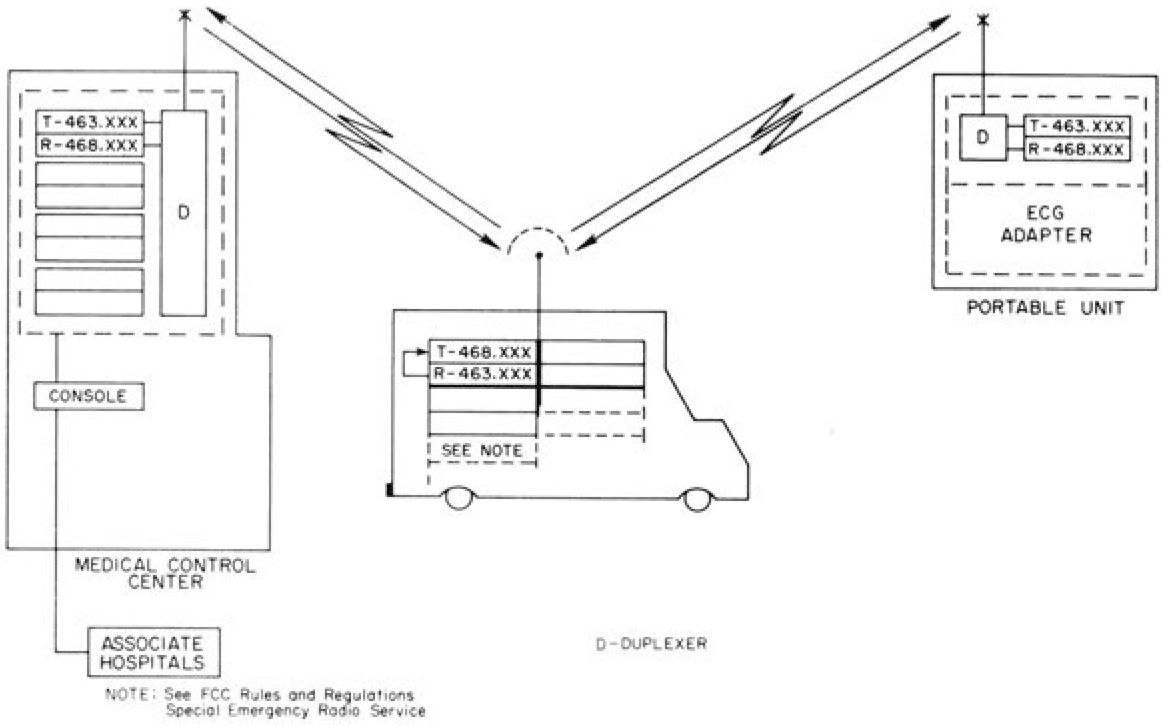


Figure 49a. UHF vehicular repeater concept (simplex one-way repeater).

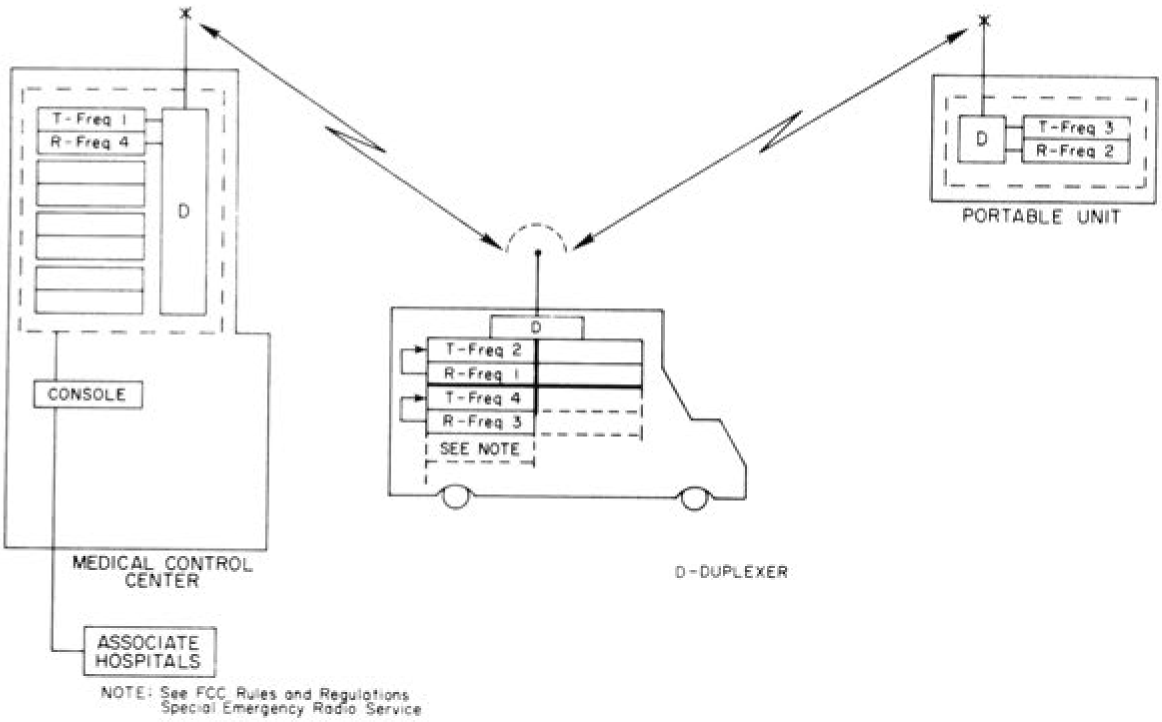


Figure 49b. UHF vehicular repeater with portable unit (full-duplex two-way repeater).

who are not attendent at the mobile and cannot transmit directly to the base station on their portable unit, to communicate (voice and/or ECG) with the resource hospital via the vehicular repeater. Note that the use of the vehicular repeater as shown in this figure changes the operation from duplex to simplex (push-to-talk). Figure 49b shows a vehicular repeater with full duplex operation. For full duplex operation, four frequencies are required. In this configuration, the base station transmits on f_1, which is then repeated on f_2 to the portable unit. The portable unit transmits on f_3, which is repeated on f_4 to be received by the base station. The justification for full duplex in the repeater mode must be carefully analyzed at the local level prior to implementation.

Figure 50a depicts the medical control portion of a full duplex system which utilizes a UHF vehicular repeater in an ambulance to extend the effective range of a portable unit. Although repeaters have certain advantages in some applications, undesirable side effects can create major operational dissatisfaction with system performance. The planner is cautioned to evaluate other operational repeater systems and seek professional assistance before proceeding with implementation plans. Figure 50b depicts a remotely controlled full duplex base station.

7.5. Ancillary EMS System Considerations

7.5.1. Coded squelch and tone coding

Coded audible and subaudible tones, sent prior to or during transmission time, are used in radio systems to implement a number of functions which are not obtainable with voice alone. Coded squelch, recall, automatic mobile identification, radio relay control, and remote transmitter keying are examples of tone coding applications. Tone coding techniques often require optional equipment not usually a part of an ordinary system. An encoder is needed for transmission of the coded tones, and a decoder is necessary in the receiver to interpret the coded tone properly.

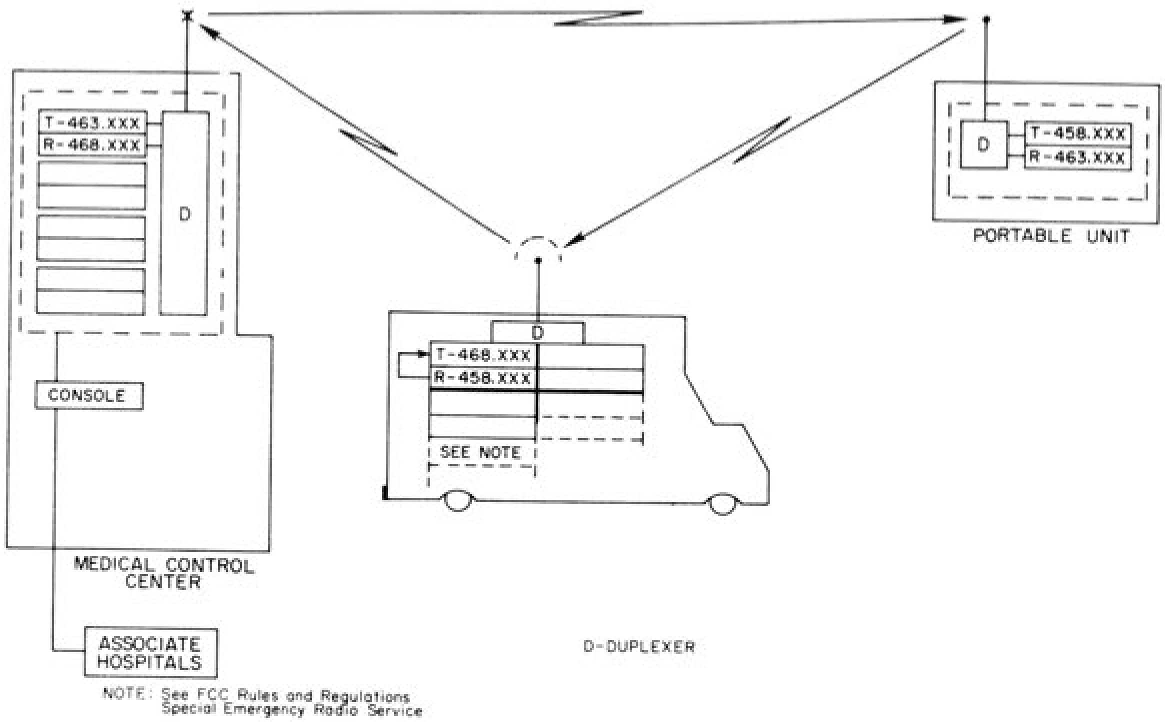


Figure 50a. UHF vehicular repeater concept with portable unit (full duplex).

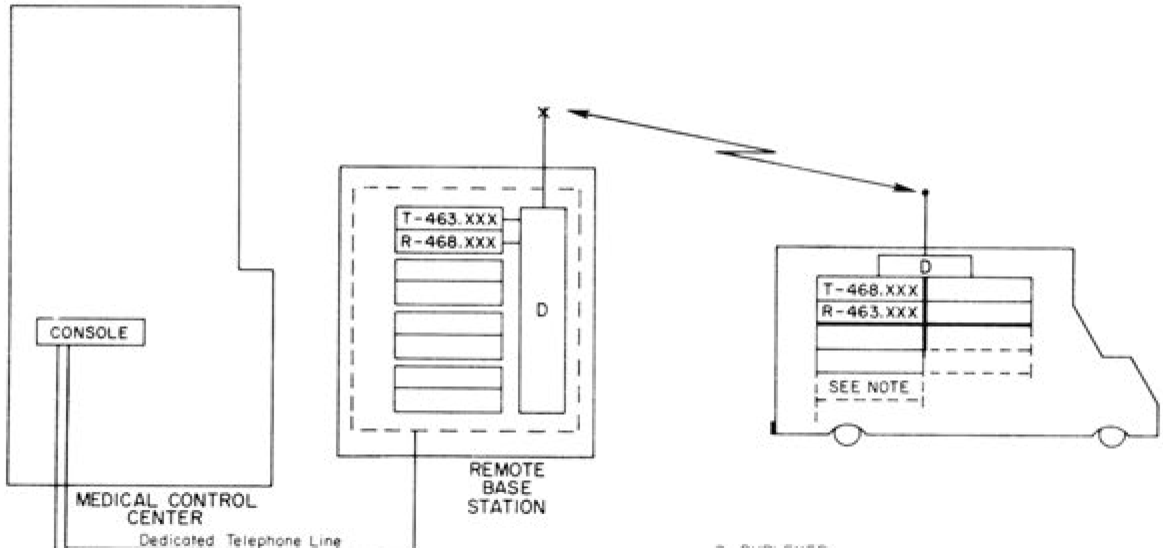


Figure 50b. UHF remote base station (full duplex).

Some tone-coding schemes employ single tones which are sent continuously with the regular voice transmission, while some schemes use two simultaneous tones with different frequencies. In another variation, two sequential tones are sent, first one and then the other. The first sequential tone has a short duration, usually a fraction of a second, whereas the second tone may or may not continue throughout the voice transmission, depending upon the specific application.

The number of tones employed in a system depends on the number of codes, that is, distinct messages, required. The more tones used, the more codes are possible.

One purpose of coded squelch is to eliminate nuisance interference caused by other users of the radio channel.

Interference may be categorized as two types, either nuisance or destructive. Nuisance interference is caused by undesired signals on the same channel which are weak compared to the desired signal. An undesired signal which is too weak to override a desired signal may still be sufficiently strong to open the receiver's carrier squelch in the absence of the desired signal. It will then be heard by the operator, causing him annoyance and distraction which will eventually produce fatigue.

Nuisance interference is eliminated through the use of coded squelch. In this case, the desired signal contains one or more coded tones in addition to the voice information. The receiver is equipped with a decoder that responds only to the proper tone coding. When a signal with the correct coding is detected, the receiver squelch opens and the desired signal is heard by the operator. However, the squelch cannot be opened by signals without the correct coding. Therefore, messages not intended for a particular operator are not heard and this distraction is eliminated.

The second type of interference, destructive interference, results from undesired signals on the same channel which are as strong as, or even more powerful than, the desired signal at the receiver. The effect on the output of a receiver <u>without</u> coded squelch is either severe garbling of the desired signal or total "capture" of the receiver by the other signal. In the second case, only the undesired signal is heard at the receiver output, the desired signal being totally suppressed.

In a receiver with coded squelch, the output may also be garbled in cases where the undesired signal has about the same strength as the desired signal. However, if the undesired signal is stronger, it usually captures the receiver, distorting and/or suppressing the desired signal. In this case, the squelch is not opened since the other signal does not contain the proper tone coding. Because the receiver is quiet, the operator may not know that a message was sent; the message will not be received. This situation can only be overcome if there is a central communication control center keeping track of all communications so as to avoid cochannel interference. Therefore, it is seen that coded squelch does improve operation in the presence of nuisance interference but not in the presence of destructive interference.

One common tone-coding method is a "continuous tone-coded squelch system" (CTCSS) depicted in Figure 51. This type of system requires a receiver which is equipped with CTCSS to receive a subaudible (unheard) tone before it presents any sound from the speaker. When the proper tone is not presented to the receiver by an on-frequency radio signal, no voice emits from the speaker. When the tone is present on the frequency, then the speaker turns on and communication on that frequency will be heard.

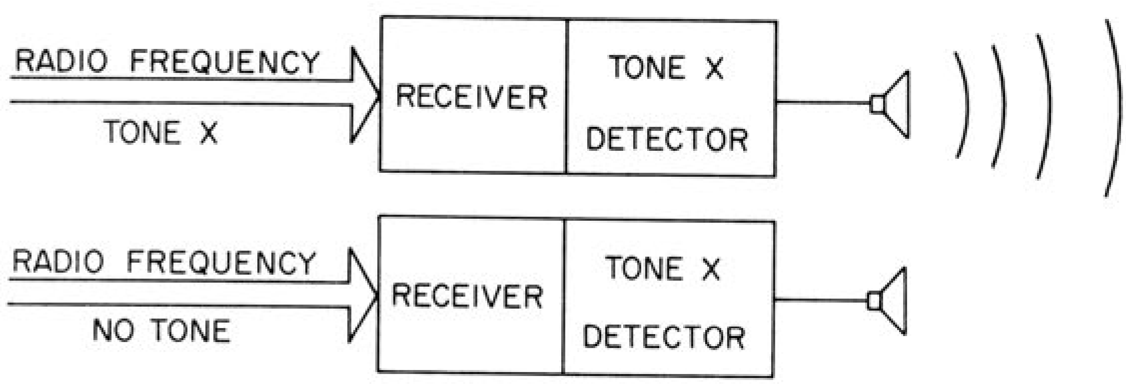


Figure 51. Continuous tone-coded squelch.

The term "subtone" is a generic shortening of subaudible tone, hence, the often used term "subtone squelch". Most manufacturers of communications equipment offer continuous tone-coded squelch under one trade name or another and the planner should not be uncomfortable when separate names are used to identify this capability. Coded squelch, however, has both advantages and disadvantages which should be carefully considered by the planner before including it in a system.

Other uses of tone coding

Tone coding is used in a variety of ways in radio systems. A few of these are briefly discussed below:

Selective Calling and Recall: In a system with selective calling, the mobile and/or base station is equipped with tone-encoder equipment capable of generating a number of different code combinations. The desired code is selected by a dial or touch-pad as used on telephones, or push-button switches. Particular receivers and mobile radios may be provided with unique decoders corresponding to the selectable codes. The decoder allows only the properly coded signal to be heard at the receiver output. This system gives the base station the ability to call all units simultaneously. Most selective call decoders also provide a "recall" feature which alerts field personnel to a message when they are outside of the vehicle. In the recall mode, the receipt of a properly coded signal causes activation of a call-indicator light, the horn, headlights, or dome lights of the car to inform the attendent that the base station has called.

Automatic Mobile Identification: Tone coding is used in some radio systems to identify automatically the mobile unit which is calling the base station. In such systems, each mobile radio unit is equipped with a unique encoder which codes all transmissions. The base station is provided with a decoder which determines the mobile unit from which the coded transmission originated. The decoder output is used to actuate some type of unit-identification device, such as a message on a video display.

Remote Transmitting Keying: Tone coding techniques are used for remote control of base station transmitters. In this way the need for special and costly telephone lines for transmitter keying from a remote dispatch point is eliminated. The ordinary voice grade telephone line which carries the voice information to the transmitter is used to carry the tone also. A simple encoder at the dispatch point generates a tone when the push-to-talk switch on the microphone is actuated. This then is sensed by a decoder at the transmitter, causing the transmitter to be keyed on.

Repeater Control: Tone coding may be used in systems with repeaters to insure that the repeater will be activated only by transmissions from the desired system and not by signals from other channel users.

Selective calling is the most common EMS application. This allows a mobile or base station equipped with an encoder to call a particular hospital or dispatch center equipped with the proper decoder. Digital encoders are usually employed, as seen in Figure 52, because they are inexpensive and easy to operate. Digital encoders look and operate like telephone sets and are available in dial and touch-pad configurations. The typical telephone dial type (1500 Hz interrupted tone) is not as efficient as the touch tone (dual tone multifrequency) because of the radio time and interference created in dialing seven digit codes. The dial configuration is also more prone to falsing than the dual tone multifrequency (DTMF) code.

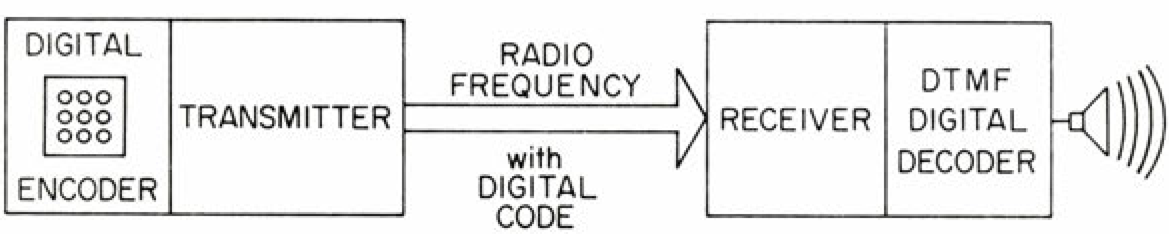


Figure 52. Digital signaling.

When the proper number is encoded, the decoder receiving the signal will turn on the speaker. The decoder can be reset in a number of different ways (i.e., timed absence of the carrier frequency, replacing the handset in its cradle. . .).

To prevent selective signaling devices from interfering with other stations using the channel, the radio operator is required to monitor the channel before transmitting the encoded signal. An equipment feature usually disables the decoder circuit when the handset or microphone is removed from the cradle or hook.

Many states have developed compatibility standards for EMS selective signaling by specifying the encode type (1500 Hz interrupted tone, DTMF, . . .), by encoding allocation and assignment EMS region or area and by enforcing operational policy to minimize interference.

Paging

Personal or group paging implies that the individual or group being paged is not capable of replying. This is another application of selective signaling. As noted earlier, many of the FCC frequency allocations for paging are "base only", denying the use of the frequency allocation to "mobile" unit operation.

The paging base station is generally operated in a simplex/single-frequency mode with an appropriate encoder as illustrated in Figure 53.

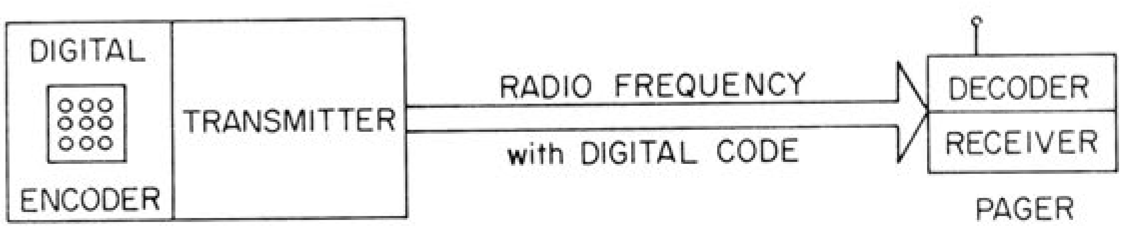


Figure 53. Paging base station.

The paging receiver is designed to be lightweight, rugged, and to require very little current drain for squelched receiver operation. When the base station "pages" a personal unit, the particular code unsquelches the receiver and provides a short audio message and/or tone. The encoding design can provide hundreds of code assignments which can be shared for group call or assigned individually. The EMS planner should understand the operational use of paging to design a more flexible EMS communication system.

7.5.2. Receiver voting

In EMS radio systems, the base station's design and location should provide coverage for a high percentage of the normal EMS service area. However, the transmitter power capabilities of portable and personal two-way radios are much less than those of base stations and also less than those of vehicle radios. As a result, the medical personnel in the field using a personal radio might not be able to talk back to the hospital or dispatch base station if the system were conventionally designed. This is especially true when the field personnel are in a poor radio signal area such as a building, alley, rolling or mountainous terrain.

An arrangement which provides more reliable communications is one which employs several "satellite" receivers for each channel situated at scattered locations throughout the coverage area. The satellite receiver arrangement decreases the distance from the hand carried unit to the nearest receiver and thus compensates for the lower available transmitter power and also for operation in poor signal areas. Radio links or wirelines are usually employed to convey the receiver audio output to its proper destination, the base station or a mobile repeater.

It is highly probable that several satellite receivers can pick up the same transmission. When this occurs, several audio output signals are produced and appear at the base station or repeater unit. In general, the audio output signals of the different receivers vary in signal-to-noise ratio, amount of distortion, and thus, overall quality. If the several audio signals were simply added to produce a combined output, the resulting signal would generally be poor in quality and sometimes unintelligible. Rather than combine the signals, a better method is to select the one signal with the highest quality. This selection process is called "voting", and the unit which performs the voting operation is called a "selector" or a "comparator". A block diagram of a radio system which employs receiver voting is shown in Figure 54. Transmitter voting is also employed in certain systems where a single base station does not provide adequate radio coverage. However, plans to employ voting systems should be subjected to extensive design/engineering scrutiny before a final course of action is decided upon.

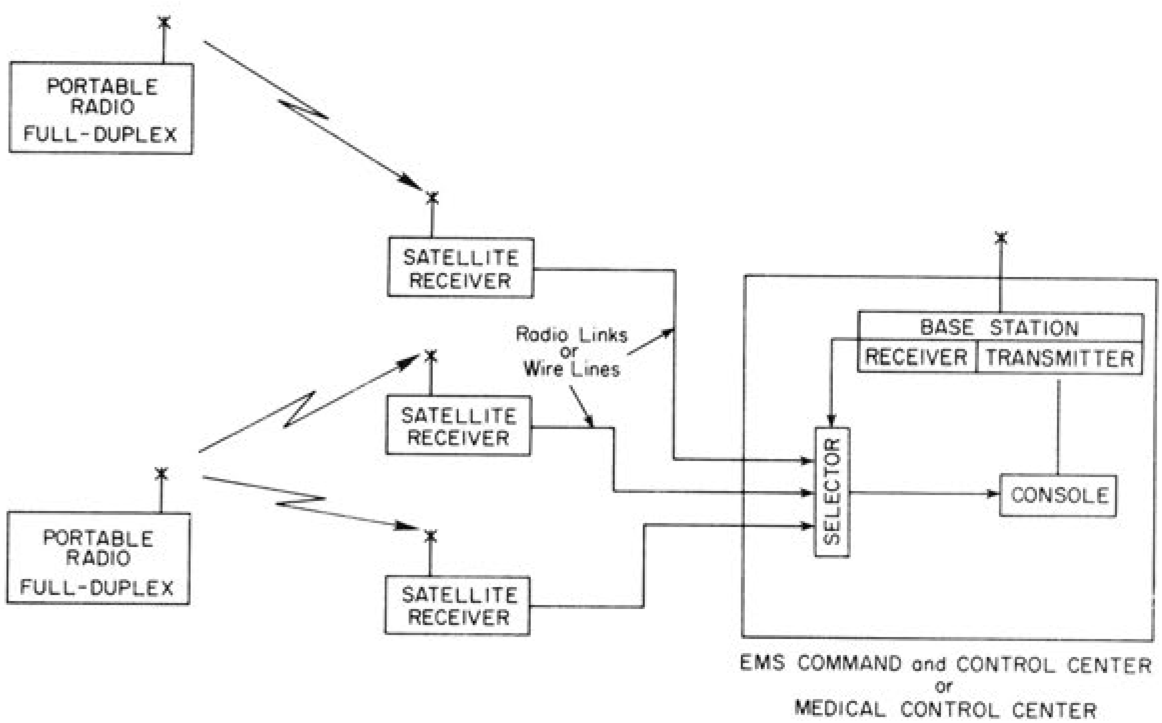


Figure 54. Satellite receiver voting system.

7.5.3. Scanning receivers

A scanning receiver provides the capability of monitoring several channels automatically with a single unit. To illustration of a two-channel scanning receiver. Assuming initially that transmissions are absent on both channels, the receiver samples each channel sequentially, waiting for a signal to appear. As soon as a signal is detected on a channel, say Channel 1, the receiver "locks on" to that channel and stops scanning. Channel 1 is then held for as long as the signal remains, even though a signal may appear on Channel 2.

When the signal on Channel 1 ends, the channel is released and Channel 2 is sampled. If a signal is detected, Channel 2 is held for the duration of the signal; otherwise, the scanning of the channels occurring in some preselected sequential order which may be determined by the operator.

An optional feature on some scanning receivers is scanning with priority. This feature is useful where it is desirable to give one channel precedence over the others when signals appear simultaneously on the "priority" channel and another one. If the receiver is already locked onto the priority channel (as the result of a signal) and a second signal appears on another channel, no change occurs and the first signal is still heard at the receiver output. However, if a "non-priority" channel is being held (as a result of a signal) and a second signal then appears on the priority channel, the non-priority channel is released and the priority channel held. For the case where no signal is detected on a sampled channel, the scanning of the remaining channels proceeds in preselected sequential order as in the case of scanning receivers without the priority feature.

Scanning receivers with multichannel capabilities usually have switches on the front panel to include or delete channels from the scanning process. Thus one, several, or all of the channels may be monitored, allowing operational flexibility for different situations.

Scanning receivers are used in both base stations and vehicles where it is desirable to monitor several channels automatically without having a separate receiver for each channel. Some vehicle two-way radios also offer scanning, with or without priority, as an optional feature for the receiver section.

7.5.4. Radio - telephone patching

Phone patch permits a telephone line to be selected for patching to a radio channel, allowing a mobile unit to communicate directly with a telephone caller. The caller may then transmit and receive directly over the radio channel without operator assistance. This feature allows medical personnel to provide medical control and direction to field personnel from their offices, homes, or other locations which have a public telephone. In the past, many phone patch systems utilized the voice operated relay (VOX) to interconnect the telephone and radio circuits. Recent changes in national telecommunication policy and technological advances in switching hardware have expanded the scope, transmission quality and operational ease of radio telephone patching or interconnect. This more sophisticated method of interfacing land mobile radio and the switched public telephone system employs a radio-telephone switch. This configuration allows ambulance attendants to encode their mobile radios with an assigned code and gain access to the switched public telephone network. After receipt of a dial tone, the ambulance attendant can encode a standard telephone number or access a radio base station to contact and coordinate with the Command and Control Center, Medical Control Center and other appropriate medical providers. The EMS planner should be aware that certain switching configurations can undercut the common system approach in bypassing the communication control function; therefore, a clear understanding of the switching function must be carefully reviewed to determine the impact and implication on EMS system control.

7.5.5. Telephone - telephone patching

Telephone-telephone patching is accomplished in the same way that an operator on a typical telephone switchboard connects a calling party with a called party by plugging in appropriate cables ("patchcords") or by using other more sophisticated telephone switching equipment. Such patching might be used when a dispatcher desires to connect a physician at home with a caller on an emergency department hot line.

7.5.6. Radio - radio patching

This is used when it is desirable to place two radio units in contact that are operating on different frequencies; e.g., an ambulance radio transmitting and receiving in the UHF band and a police cruiser using the VHF band. Again, this can be accomplished with special equipment at a central dispatching point where transmissions from both vehicles are being received. In this case, the dispatching center serves as a two-way repeater station between the vehicles.

8. CONCLUSIONS

Although many of the technical intricacies of telecommunications have not been addressed in this document, the EMS planner should now be able to converse with the user community, consultants, suppliers and the technical community with the background and basic understanding of the total involvement of Emergency Medical Services. As stated previously, the ideas and concepts within this report have been drawn from a wide range of material and expertise in hopes that the non-technical EMS system planner will be able to take the task of building or upgrading a viable EMS system and to carry that task through to completion.

The planner should not try to utilize this document alone. He or she should feel a need to draw upon many reports, papers and other reference materials in order to develop an EMS system which will meet the needs of the community.

Many pitfalls await the planner. He or she should base the proposed system on the requirements of the community and not on the gadgetry of the industry. Intelligent planning and coordination by the various personnel and committees at the start of the program will pay high dividends during the approval and implementation stages. Failure to confront and resolve important, even if unpleasant, conflicts early in the planning process may delay or even condemn the entire program. Again, the planner should encourage a flexible system design which will meet not only present needs, but be economically and operationally expandable for the needs of the future.

APPENDIX A. FCC LICENSING AND RULES AND REGULATIONS

A.1. FCC Licensing and Frequency Coordination

The statutory authority that governs communication and provides the basis for the management of electromagnetic frequencies is the Communications Act of 1934, which established the FCC and delineated its primary functions. It is printed in Title 47 of the U.S. Code, beginning with Section 151. Revised pamphlet copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

The FCC is the governmental agency concerned with the administration of rules and regulations governing the operation of radio stations, including those in use for EMS activities. Its rules and regulations govern many areas of radio usage (called "services" by the FCC). Of primary concern to the EMS communication systems planner is the "Special Emergency Radio Service" Section 89, Subpart P, Rules and Regulations Governing Emergency Medical Services Radio Communication of the Federal Communication Commission. Also of interest in the overall "Public Safety Radio Service" which provides for the use of radio communication systems by local governmental public safety entities.

The FCC must allocate frequencies among commercial broadcast uses and non-broadcast services, such as EMS radio. The Commission's prime resource, the radio spectrum, is not available without prior restrictions, since the Federal Government claims large portions of spectrum space for military and other operational uses. The Interagency Radio Advisory Committee (IRAC) under the National Telecommunications and Information Administration performs functions similar to the FCC's, but only for Federal agencies. Further limiting effects are the many international treaties which apportion spectrum space world-wide.

Many of the problems which beset system planners are attributable to the lack of usable frequencies. Competition for frequencies in some areas is intense, not only between broadcast and non-broadcast users but, for example, between public-safety and business and industrial radio users. The Special Emergency Radio Service is only one part of the land-mobile group. The most recent FCC action to make additional frequency allocations for all land-mobile radio services was the granting of frequencies between 470 MHz and 512 MHz on a shared basis with UHF TV Channels 14-20 in the ten largest U.S. metropolitan areas, through approval of FCC Docket 18261. Also made available to land-mobile radio were the frequencies between 806 MHz and 960 MHz, through approval of FCC Docket 18262.

The FCC has established certain basic technical requirements and specifications for radio equipment characteristics. The basis for most of these characteristics is the need for provisions to reduce or eliminate harmful interference and to conserve the use of the radio frequency spectrum as much as possible. When entering discussions with radio equipment manufacturers, the system planner must have a general knowledge of certain basic provisions of FCC regulations that deal with such factors as frequency stability, type of emission, power levels, and acceptable equipment. The full provisions are set forth in Part 89 of Volume V of the FCC Rules and Regulations. A copy of these provisions may also be obtained from the Superintendent of Documents, U.S. Government Printing Office.

In the interest of reducing or eliminating harmful interference, the FCC has established certain operating rules. These rules are basic to any station operation. Supervisory functions should ensure that these rules are constantly observed. Violations of these rules could result in violation notices from the FCC and possible suspension of service. The basic operating rules are as follows:

- All communications, regardless of their nature, are restricted to a minimum practical transmission time.
- Continuous radiation of an unmodulated carrier is prohibited except when required for test purposes.
- The FCC expects each licensee to take reasonable precautions to prevent unnecessary interference. If

harmful interference does result, the FCC may require any or all stations to monitor the transmitting frequency before transmission.

- o Tests may be conducted by any licensed station as required for proper station and system maintenance, but such tests are to be kept to the minimum. Precautions are to be taken to avoid interference to other stations.

The responsibility for actual determination of how many and which frequencies shall be assigned to an EMS agency rests with the Federal Communications Commission. It is, however, assisted in this task by the voluntary Associated Public-Safety Communications Officers (APCO) Frequency Advisory Committees. These ommittees can perform a frequency coordination advisory function which can be quite helpful to the EMS system planner. Frequency coordination is the process of selecting and recommending to the applicant and the FCC one or more radio frequencies for use by the applicant, which will cause the least amount of interference to other radio users, to the applicant himself, and yet provide serviceable channels.

Thus, the function of these committees is essentially to minimize the likelihood of harmful interference being caused to other systems by the operation of a proposed system. An application may require the committee to perform extensive research in determining matters such as physical separation, propagation paths and the existence of other systems licensed on adjacent channels but in another service (usually local government). If the application is favorably commented upon by the Frequency Advisory Committee, the statement of the committee accompanies the application to the FCC, where it is processed.

Obtaining a letter of clearance from a Frequency Advisory Committee is generally considered the most satisfactory method for processing the application. If a dispute arises or other considerations merit the action, an application may be forwarded to the FCC without a clearance letter. However, it must then be accompanied by a statement that all licensees within 120 km (75 mi) and operating within 30 kHz of the proposed system have been notified of the intended operation, and by a report, based on a field study, of the likelihood of interference. Section 89.15(c) of the FCC Rules and Regulations limits the authority of the Frequency Advisory Committees. It points out:

> The functions of Frequency Advisory Committees are purely advisory in character, their comments are not binding upon either the applicant or the Commission, and must not contain statements which would imply that. . . (they) have any authority to grant or deny applications.

These committees can help in coordinating license applications and potential interference problems and should be, at least, contacted. In addition to the Frequency Advisory Committee one of the features of the new medical communication services, is the FCC requirement for coordination of radio frequency assignments among the users in a given area that replaces the previous requirement of cooperation. To share efficiently and effectively the EMS frequencies requires coordination of activities between all of the EMS agencies operating in a given area. As a result of this coordination, an area-wide EMS operational plan is written and agreed upon by all participating agencies. This coordination applies to the standardization of emergency medical vehicle equipment, standards for hospital emergency departments, disaster planning and the kinds and uses of communications.

The FCC will assist in the coordination of radio communication operations for the EMS systems. A provision of Docket 19880 states that any communication plans which are voluntarily submitted to the Commission for EMS systems will be made available for public inspection at the FCC Headquarters in Washington, DC, or Park Ridge, IL. The value of having these plans in the files of the FCC is that applicants for a station license in areas that have filed a plan can be so advised. This will help the applicants insure that their proposed communications operation will be compatible with an existing plan.

A.2. FCC Rules and Regulations for Special Emergency Radio Service

There are many configurations of base stations, mobiles and portable equipment which may be used to provide the required medical control communications channels for proper medical supervision of EMT personnel at the emergency site and during transportation to a receiving hospital. The following is not intended as a recommendation for system design but rather as a discussion of some possible alternatives. The actual system design for a specific region should be performed or reviewed by a qualified consultant who is capable of selecting the optimum configuration and equipment design which is most appropriate for the needs of that specific region.

Prior to discussing specific UHF and VHF Medical Control configurations, the planner must have a sufficient understanding of the specific FCC Rules and Regulations.

One recent FCC Docket that affects the EMS communications field is Docket No. 19880, entitled Medical Communications Services. In summary, this Docket states that new rules provide for the establishment of a medical services category in the Special Emergency Radio Service. This category authorizes the licensing and operation of medical radio communication systems for the delivery of medical care to the public. Hospitals, ambulance companies, and physicians are eligible to apply under this category, as well as public health organizations, nursing homes, institutions and organizations which regularly provide medical services.

The additional frequencies allocated are primarily in the Ultra High Frequency (UHF) band. The FCC emphasizes the flexibility of the types of communication now allowed on these frequencies by identifying the primary and secondary uses permitted to meet different requirements in specific areas. Allocations are made in paired frequencies for duplex operation. Two frequency pairs are allocated for dispatch and common calling, or mutual aid communications; five frequency pairs are available primarily for general medical requirements and, secondarily, for telemetry and other medical or medically related communications; and four frequencies for extended portable operations in telemetry systems. These latter four frequencies are shared with the highway call-box system. The present Very High Frequency (VHF) allocations are retained and are augmented by three additional frequencies to be used for one-way medical paging systems. Two frequencies in the VHF band are also available for low-power extended portable radio operations.

Mobile relay operations are authorized in the UHF band, and are presently precluded in the VHF Special Emergency Radio Service category, except as required to crossband UHF and VHF medical communications systems.

It must be emphasized that the newly allocated UHF frequencies which are to be used in the medical services are shared by all of the licensees in an operating area. It is the expectation of the FCC that efficient and effective use of these new frequencies in the UHF band will be achieved by cooperation among the users in the development of a common communication system having a central dispatch and control center for the coordination of all EMS operations under area-wide communications plans. The common communication system approach for all of the area users promotes full capacity operations and is emphasized and encouraged in the new rules.

Changes effected in Docket 19880 replace the previous fragmented structure for medical communications with a more unified and comprehensive medical radio service category. The FCC does not contemplate that licensees of present EMS communication systems operating in the VHF band will be required to change the radio frequencies they are now using. It is believed, however, that the advantages of being part of an area-wide consolidated communication system will encourage the change.

Most of the present EMS radio communications are in the VHF band and will continue to be for some time. Many of these systems are providing satisfactory service for the agencies they are serving. Others may desire to take advantage of the changes in the FCC rules and regulations, but need to amortize their investment in the present system before procuring new communication equipment. Recognizing that this status will remain for a considerable period of time, the FCC has adopted a number of rule changes to improve the EMS communication capability of those operating in the VHF band.

Table A-1 is a compilation and brief description of the basic frequencies allocated for emergency medical service. In some cases, variance from these basic uses may be allowed by the FCC. The planner must read and understand Volume 5, Part 90. Jan. 2, 1979 Subpart C, Special Emergency Radio Service to insure compliance with the latest FCC Rules and Regulations. Any revisions or updates should be obtained by the planner. A thorough understanding of the Rules and Regulations may allow the planner to take advantage of rule changes which have recently provided far greater EMS operational flexibility.

To encourage maximum, efficient ulitization of the new UHF allocation, the FCC imposed certain equipment requirements. The intent of these requirements was to increase flexibility in system design and operation. The Rules and Regulations require that:

- o 90.53(b)(15)(ii) . . . mobile or portable stations must employ equipment which is both wired and equipped to transmit/receive, respectively, on each of these eight frequency pairs with transmitters operated on the 468 MHz frequencies.

- o 90.53(b)(15)(iii) . . . base or control stations must employ equipment which is both wired and equipped to transmit/receive, respectively, on at least four (three, if biomedical telemetry operation is not employed in the system) of these eight pairs.

Table A-1. FCC Rules and Regulations Summary

UHF Frequencies (MHz)

I. **Command Control and Dispatch:** (Also available for intrasystem and intersystem mutual assistance).

Base and Mobile	Mobile Only
462.950	467.950
462.975	467.975

II. **Doctor Talk and Telemetry:**

a. Base and Mobile	Mobile Only	Channel Name	Primary Use *1
463.000	468.000	MED One	Telemetry
463.025	468.025	MED Two	Telemetry
463.050	468.050	MED Three	Telemetry
463.075	468.075	MED Four	Doctor Talk
463.100	468.100	MED Five	Doctor Talk
463.125	468.125	MED Six	Doctor Talk
463.150	468.150	MED Seven	Doctor Talk
463.175	468.175	MED Eight	Doctor Talk

*1 NOTE: On a secondary, noninterfering basis all eight medical channels may be utilized for any other permissible communications consistent with FCC Rules and Regulations for the Medical Communication Service.

For example:

Authorized users may use these frequencies for administration of organizations and facilities engaged in medical services operations.

Mobile Only *2
458.025
458.075
458.125
458.175

*2 NOTE: Only available for retransmission of telemetry or voice from a portable (maximum power out of 1 W) through a vehicular repeater to a medical facility.

Notes on
UHF Frequencies

1. Concerning all of these frequencies, no frequency coordination is required since the user groups are obligated to operate on a noninterference basis.
2. The base and control stations must employ equipment which is both wired and equipped to transmit and receive on at least four of these eight MED channels if biomedical telemetry operation is employed or three for Doctor Talk only. These channels may be in one base station or split up in any combination of base stations as long as all of the required channels are used.
3. Mobiles must employ equipment which is both wired and equipped to transmit and receive on each of the eight MED channels.
4. Portables with no more than 2.5 W output are not required to be wired and equipped for operation on all eight MED channels.
5. The FCC and DHEW require that an EMS user be licensed in accordance with a State, Regional or Area plan for coordinating communications.
6. No paging is allowed in UHF

HB Frequencies (MHz)

I. **Base and Mobile**

Base and Mobile	Ref. FCC Notes	Comments
155.160	16	
155.175	16	
155.205	16	
155.220		
155.235	16	
155.265	16	
155.280		
155.295	16	
155.340		May be designated by common consent as an intersystem mutual assistance frequency under and area will plan.
155.325	16	Hospitals and ambulances which submit a showing that they render coordination and cooperation with hospitals are authorized on this frequency.
155.355	16	
155.385	16	
155.400	16, 17	

II. **One Way Paging**

Base Only	Comments
152.0075	
163.250	
157.450	Power output limited to 30 W.

III. **Through Vehicular Repeater** (Mobile will transmit on a regular mobile frequency – Ref. FCC Note 14)

Mobile Only	Comments
150.775	Power output limited to 2.5 W from portable
150.790	

LB Frequencies (MHz)

I. **Base and Mobile**

Base and Mobile	Comments
33.02	Shared with highway maintenance
33.04	
33.06	Shared with highway maintenance
33.08	
33.10	Shared with highway maintenance
37.90	Shared with highway maintenance
37.94	Shared with highway maintenance
37.98	Shared with highway maintenance
45.92	
45.96	
46.00	
46.04	
47.42	Only for national organizations established for disaster relief
47.46	
47.50	
47.54	
47.58	
47.62	
47.66	

II. **ONE WAY PAGING**

BASE ONLY	Comments
35.64	Limited geographically
35.68	(Ref. FCC Note 13)
43.64	
46.68	

Notes on
HB Frequencies

(16) Any application for use of this frequency shall be accompanied by a signed statement that all licensees in other radio services who operate on a frequency 15 kHz removed and are located 15 to 35 mi from the proposed base station have been notified of the applicant's intent to file, together with an acceptable engineering report indicating that harmful interference to the operation of existing stations will not be caused. In no instance will an application be granted where the distance between the proposed station and the existing base station is less than 10 mi.

Other Frequencies

2000 to 3000 bHz	Fixed	Ref. FCC Note 9
2726 kHz	Base/Mobile	Shared with State Guard
3201 kHz	Base/Mobile	
72.00 to 76.00 mHz	Operational Fixed	Ref. FCC Note 3
952 MHz & above		Ref. FCC Rules Paragraph 89.101

This Table taken from IEEE Transactions on Vehicular Technology, November 1976.

- 90.53(b)(15)(iv) Multi-channel equipment requirements for use of these frequency pairs are intended to afford capability for alternating use of the individual frequencies, and ability to conduct simultaneous operations is not required. These requirements may be met in a single equipment unit or in combination of equipment units suitable to a licensee's operations. The multi-channel requirements may be satisfied by several single-channel base stations in a mobile relay system provided that each control station can access all of the base stations and that any mobile unit located anywhere in area of coverage can activate each of the base frequencies involved.

As originally conceived, the UHF frequencies for EMS were to be assigned in a block to each licensee and shared between all EMS systems. Under these provisions, mobile EMS units (ambulances) would have the capability to communicate with any other EMS station regardless of where the vehicle was located or who the licensee was. If one channel was being used, all that would be needed to obtain the necessary clear channel would be to switch to one of the other frequencies. To enforce the common system concept of operations in the UHF spectrum, the FCC, in Docket 19880, originally proposed:

> "Licensees operating on the paired 463/468 MHz frequencies in this block must utilize equipment that is type-accepted for eight channel capacity, i.e., capability for all respective transmit or receive frequencies in either the 463 or 468 MHz band."

The implication of this equipment capability requirement was that <u>any ambulance</u> would be able to communicate with <u>any station</u> (base station or hospital) in the EMS system <u>on any of the eight MED channels</u> from <u>any location</u> covered by the UHF common system.

Based upon appeals from equipment manufacturers, when the rules implementing Docket 19880 were first published, the FCC imposed requirements that mobile and portable station (ambulance) equipment be able to transmit/receive on each of eight medical pairs and for base and control stations to be able to transmit/ receive on at least four (three, if biomedical telemetry is not employed in the system) of the medical frequency pairs. This relaxation of the equipment capability requirement for base and control stations has been interpreted as an authorization for the creation of EMS communications systems having no more than three or four channel capability in any particular area of an EMS region or throughout a particular EMS region. The FCC has licensed UHF EMS communications systems embodying only four MED channels. These limitations cause compatibility problems when attempts are made to plan for UHF communications in adjacent EMS regions. Avoidance of interference in the base station communications of adjacent EMS regions using this "split system" approach can become very complicated. In addition, the split system approach may require that an ambulance proceeding from one four-channel coverage area to an area covered by four different channels, change communications channels in mid run. The planner must understand the implications of this policy and how it impacts the local EMS system.

APPENDIX B. DATA GATHERING FORMS

This Appendix incorporates several forms designed to compile telephone and radio usage data. The included forms are examples only, and the planner is encouraged to modify these or other forms to suit the data-gathering needs of the local program.

Form B-1. Call Handling, Systems, Procedures and Policies

Item #	Description
1, 2	The "name of the agency" is that of the agency providing the communication service. It is not restricted to public safety agencies and can include multi-agency and/or multi-jurisdictional communication centers, joint switchboards, or other entities providing communications service for public safety and private agencies that provide emergency services to the public.
3	The names, addresses and hours of call answering and/or dispatch services provided to other agencies.
4	The address of the telephone answering locations if it differs from Item 2.
5, 6	The telephone number(s) of all agencies completing this form.
7	This item can be answered with the assistance of the telephone company representative (if necessary). What is needed is a description of the type of answering and call handling equipment--such as a key set with the number of buttons and model number, a cord board with similar data, or other answering system--that is used in each communication center.
8, 9, 10	Self explanatory.
11, 12	These items request descriptions of systems in which the telephone call initiates an action other than a direct response to the call by the agency. Radio alert systems key pocket receivers carried by volunteers. A 911 center will have to be able to dial the number, or to radio-encode those receivers upon receipt of an emergency call. Similarly, if the current system rings a bell or activates an alarm upon dialing an emergency number, the 911 center will also have to be able to dial, or to radio-encode, that number.
13	This item requests information on whether the system is one stage (call answering and dispatching are performed by the same person) or two stages (call answering and dispatching are performed by two people).

14 This item requests information on the type of equipment used to record incoming calls. Although information on an analog magnetic tape system is desired, even if calls are logged by hand, that information should be provided.

15 Self explanatory

16, 17, 18 These items are used to provide an initial basis for determining the types of calls or events to be handled by the 911 centers.

Form B-1. CALL-HANDLING, SYSTEMS, PROCEDURES, AND POLICIES

1. Name of Agency ______________________________

2. Location of Agency (address) ______________________________

3.

Names and Locations of Served Agencies						
Name of Agency	Location of Agency				Hours of Provided Service	
	Number	Street	City	County	From	To

4. Location of Phone Answering (address) ______________________________

5. Emergency Phone Number(s) ______________________________

6. Administrative Phone Number(s) ______________________________

7. Type of Telephone Answering Equipment ______________________________

____

8. Number and Type of Incoming Lines ______________________________

____

9. Manned Answering Positions per Shift: Day __________

Afternoon __________

Midnight __________

Form B-1 (Continued)

10.

Tie Lines to Other Agencies					
No. of Lines	Connected Agency	Address of Agencies			
		Number	Street	City	County

11. Is Communication System a Radio Alert Type? ____ If yes, describe below ________________________________
____
____

12. Is Communication System an Alarm Type? ____ If yes, describe below ________________________________
____
____

13. Number of Communications Stages? One____ Two____ Three____

14. Type of Call Recording Equipment ________________________________
____

15. Emergency Power System and additional capacity (if any) ___
____

16. List Types of and Codes of Calls and/or Events Handled as High Priority or Emergency ________________________________
____
____
____

Form B-1 (Continued)

17. Do these calls correspond to those you want handled by 911?

Yes____ No ____

18. If no, describe additions to or deletions to the list

Form B-2. Telephone Tally Instructions

Item #	Description
1.	CITY--Enter the name of the city in which the tally is conducted.
2.	DATE--Enter the date on which the tally is conducted.
3.	POSITION--Enter the assigned position number at which the tally sheet is being utilized. For example, if there are two positions at which telephone calls are processed, each must be provided with a tally sheet and assigned a position number. The POSITION entry for the first position would then be "1 OF 2," and the entry for the second position would be "2 OF 2."
4.	SHIFT--Enter the eight-hour time span representing the shift over which the tally is conducted.
5.	TRUNK--Incoming and outgoing calls must be tallied according to the type of trunk (line) on which they are processed. As a result, space for five categories of trunks has been provided. The following trunk types are representative of the categories which have been utilized in the past: o Emergency--A trunk or set of trunks on which calls are dialed directly using the special emergency number listed in the telephone directory. o PBX Transfer--A trunk or set of trunks on which calls initially screened by a PBX Operator are then transferred to the dispatch center. o Direct Line--A trunk or set of trunks which consist of special direct lines. o Other--Any trunk that cannot be classified into one of the types previously described. Careful consideration should be given to the identification of trunk types since the resulting data may be of value to other types of analyses, as well as the traffic study.
6.	MESSAGE TYPE--Calls on a particular set of trunks must be further classified according to type of message. The four telephone message types are: o Dispatch--A call that results in the dispatch of a unit. o Multiple call--A call pertaining to an incident which has already been reported.

- o Administrative--A call pertaining to the administrative business of the department.
- o Other--Any call that cannot be classified into one of the types previously described.

7. <u>HOURLY TALLIES</u>--This portion of the sheet is used to tally telephone calls actually processed in the dispatch center. However, before beginning the tally, the appropriate hour time-interval must be entered in each of the eight column headings under HOURLY TALLIES (e.g., 8-9, 9-10, etc.). Once this has been completed, the tally may be conducted.

As each telephone call is processed, it must first be categorized according to type of trunk, then according to type of message, and finally, according to hour of the shift (day). As a result of this procedure, a specific box will be located in which to record the tally. Each call is tallied by entering a small vertical tick mark. Typical examples are:

/ = 1	𝍸 = 5
// = 2	𝍸/ = 6.

The tally should be conducted for a period of from 21 to 28 days to ensure that the collected data are representative of the actual telephone traffic loading.

Take great care in tallying each call because the accuracy of the communications study is primarily dependent upon the accuracy with which the tallies are made. An accurate tally will result in an improved system which is more responsive to the needs of dispatch personnel.

City/County:		TELEPHONE TALLY SHEET						DATE:	
POSITION: OF								SHIFT:	
TRUNK	MESSAGE TYPE	HOURLY TALLIES							
T1:	DISPATCH								
	MULTIPLE CALL								
	ADMINISTRATIVE								
	OTHER								
T2:	DISPATCH								
	MULTIPLE CALL								
	ADMINISTRATIVE								
	OTHER								
T3:	DISPATCH								
	MULTIPLE CALL								
	ADMINISTRATIVE								
	OTHER								
T4:	DISPATCH								
	MULTIPLE CALL								
	ADMINISTRATIVE								
	OTHER								
T5:	DISPATCH								
	MULTIPLE CALL								
	ADMINISTRATIVE								
	OTHER								

Form B-3. Radio Tally Instructions

Item #	Description
1.	CITY--Enter the name of the city in which the tally is conducted.
2.	DATE--Enter the date on which the tally is conducted.
3.	POSITION--Enter the assigned position number at which the tally sheet is being utilized. For example, if there are two positions at which radio calls are processed, each must be provided with a tally sheet and assigned a position number. The POSITION entry for the first position would then be "1 OF 2," and the entry for the second position would be "2 OF 2."
4.	SHIFT--Enter the eight-hour time span representing the shift over which the tally is conducted.
5.	FREQUENCY--Radio messages must be tallied according to the frequency (channel) on which they are processed. Space is provided to record up to four frequencies (i.e., F1, F2, F3 and F4). However, if any or all frequencies have been given a specific name, this name must also be entered in the FREQUENCY column.
6.	MESSAGE TYPE--Messages on a particular frequency must be further classified according to type. The five radio message types are: o Dispatch--A message that directs a unit or units to respond to a particular incident. o Status Change--A message that changes the status of a mobile unit. o Coordination--A message that is generated by field personnel requesting information or action (e.g., police support, fire support, etc.). o Repeat--A message that cannot be understood as transmitted, and which, therefore, requires the individual receiving the message to ask that the sender repeat it. o Other--Any message that cannot be classified into one of the types previously described. It is important to note that a message, as defined for the traffic tally, consists of the two-way conversation, between a dispatcher and a unit located in the field, regarding one subject (message type). For example, a unit in the field may first request information. At some later time, the

dispatcher would then relay the required information back to the unit. Even though there was a time lag between these two conversations, they must be counted as only one message.

7. HOURLY TALLIES--This portion of the sheet is used to tally radio messages actually processed in the dispatch center. However, before beginning the tally, the appropriate hour time-interval must be entered in each of the eight column headings under HOURLY TALLIES (e.g., 8-9, 9-10, etc.). Once this has been completed, the tallies may be conducted.

As each radio message is processed, it must be categorized according to frequency, then according to type of message, and finally, according to hour of the shift (day). As a result of this procedure, a specific box will be located in which to record the tally. Each call is tallied by entering a small vertical tick mark as on Form B-2.

The tally should be conducted for a period of from 21 to 28 days to ensure that the collected data are representative of the actual radio traffic loading.

Take great care in tallying each radio message because the accuracy of the communications study is primarily dependent upon the accuracy with which tallies are made. An accurate tally will result in an improved system which is more responsive to the needs of dispatch personnel.

City/County:		RADIO TALLY SHEET							DATE:
POSITION: OF									SHIFT:
FREQ	MESSAGE TYPE	HOURLY TALLIES							
F1:	DISPATCH								
	STATUS CHANGE								
	COORDINATION								
	REPEAT								
	OTHER								
F2:	DISPATCH								
	STATUS CHANGE								
	COORDINATION								
	REPEAT								
	OTHER								
F3:	DISPATCH								
	STATUS CHANGE								
	COORDINATION								
	REPEAT								
	OTHER								
F4:	DISPATCH								
	STATUS CHANGE								
	COORDINATION								
	REPEAT								
	OTHER								

Form B-4. Ranking of Alternatives

The use of this is explained in Section 6.4.6.

Benefit Measures	Alternative Number								
	1	2	3	4	5	6	7	8	9
Installation Costs									
Facility Costs									
Personnel Costs									
Monthly Telephone Costs									
Costs to Telephone Companies									
Boundary Match									
Calls Using Direct Dispatch									
Match to Current Agreements									
Central Office Capabilities									
Reliability of Power									
Personnel Utilization									
Agency Desires									
Jurisdiction Desires									
Public Benefit									
System Management									
Total Initial Costs									
Total Recurring Costs									
Average Benefit Ranking									

APPENDIX C. ACRONYMS

ac: Alternating Current
ACD: Automatic Call Distributor
ALS: Advanced Life Support or Advanced Life Support Services
ALERT: Automated Law Enforcement Response Team
ALI: Automatic Location Identification
AM: Amplitude Modulation
ANI: Automatic Number Identification
APB: All Points Bulletin
APCO: Associated Public Safety Communications Officers
ASCII: American Standard Code for Information Interchange
ASTRA: Automated Statewide Telecommunications and Records Access

BPS: Bits Per Second
BSC: Binary Synchronous Communications

CB: Citizens Band
CCH: Computerized Criminal History
CCSA: Common Control Switching Arrangement
CCTV: Closed-Circuit Television
CCU: Coronary Care Unit or Critical Care Unit
CDC: Cooperative Dispatch Center
CG: Channel Guard
CNIL: Calling Number Identification and Location
CO: Central Office
COAM: Customer Owned and Maintained
COR: Coronary Observation Radio
CJIS: Criminal Justice Information System
CTCSS: Continuous Tone Controlled Squelch System

dB: Decibel
dBm: Decibel referenced to one milliwatt
dBW: Decibels relative to one watt
dc: Direct Current
DCS: Division of Computer Services

DDD: Direct Distance Dialing

DID: Direct Inward Dialing

DOD: Direct Outward Dialing

DOT: U.S. Department of Transportation

DTMF: Dual-Tone Multifrequency

EACOM: Emergency and Administrative Communications System

EAS: Extended Area Service

EAX: Electronic Automatic Exchange

ECC: Emergency Cardiac Care

ECG: Electrocardiogram

EDP: Electronic Data Processing

EIA: Electronic Industries Association

EKG: Electrocardiogram

EMS: Emergency Medical Service

EMSS: Emergency Medical Service System

EMT: Emergency Medical Technician

EMT-A: Emergency Medical Technician--Ambulance

EMT-P: Emergency Medical Technician--Paramedic

EMT-IV: Emergency Medical Technician--Intraveneous Certified

EOC: Emergency Operating Center

ERCC: Emergency Resource Coordination Center

ERP: Effective Radiated Power

ESS: Electronic Switching System

FCC: Federal Communications Commission. Also, Frequency Coordination Center

FEMA: Federal Emergency Management Agency

FET: Field-Effect Transistor

FM: Frequency Modulation

HEAR: Hospital Emergency Administrative Radio

HF: High Frequency

HYSIS: Highway Safety Information System

Hz: Hertz

IF: Intermediate Frequency
ICU: Intensive Care Unit
ICX: Intercity Link
IRAC: Interdepartment Radio Advisory Committee
ISPERN: Illinois State Police Emergency Radio Network

kbps: Kilobits Per Second
kHz: Kilohertz

LMR: Land Mobile Radio
LEAA: Law Enforcement Assistance Administration
LETS: Law Enforcement Teletypewriter Service
LOS: Line Of Sight
LP: Liquid Petroleum
LSU: Life Support Unit

MAST: Military Assistance to Safety and Traffic - or in Traffic
MC: Megacycles per second (now called megahertz)
MCC: Medical Communications Control
MCCU: Mobile Coronary Care Unit
MF: Medium Frequency
MHz: Megahertz
MICT: Mobile Intensive Care Technician
MICU: Mobile Intensive Care Unit
MRCC: Medical Resource Coordination Center

NCIC: National Crime Information Center
NCMCN: North Carolina Medical Communications Network
NEAR: National Emergency Aid Radio
NHTSA: National Highway Traffic Safety Administration
NLETS: National Law Enforcement Telecommunications System
NNX: See definition in Glossary Section, Appendix D
NPA: Number Plan Area

O-D: Origin-Destination

ONI: Operator Number Identification

OTP: Office of Telecommunications Policy, Executive Office of the President

PABX: Private Automatic Branch Exchange

PBX: Private Branch Exchange

PL: Private Line (telephone term)

PM: Pulse Modulation

PSAP: Public Safety Answering Point

PTT: Press to Talk or Push to Talk

QEI: Quantifiable Evaluation Indicator

rf: Radio Frequency

SAR: Search and Rescue

SERS: Special Emergency Radio Service

SMSA: Standard Metropolitan Statistical Area

SPA: State Planning Agency

TCAM: Telecommunications Access Method

Telco: Telephone Company

TELPAK: See definition in Glossary Section, Appendix D

TPL: Terminal Per Line

TPS: Terminal Per Station

TSPS: See definition in Glossary Section, Appendix D

UHF: Ultra High Frequency

VHF: Very High Frequency

VOX: Voice Operated Relay

VSWR: Voltage-Standing-Wave Ratio

VU: Volume Unit

APPENDIX D. GLOSSARY

Advanced Life Support Services (ALS): The advanced care services which may be planned for areawide EMS systems. In addition to all of the basic life support services, ALS includes sophisticated transportation vehicles with full equipment and telemetry staffed by advanced EMTs (paramedics) providing onsite, pre-hospital, and inter-hospital mobile intensive care, specialized physician and nursing staffs, operating critical care units and emergency departments, and full regional implementation of the 15 mandatory components. The specific adaptations of ALS services will of necessity be different in varying geographic areas.

Ambulance: Any publicly or privately owned vehicle that is specially designed, constructed, or modified and equipped, and is intended to be used for, and is maintained or operated for the transportation upon the streets and highways of persons who are sick, injured, wounded, or otherwise incapacitated or helpless.

Ambulance Attendant: The individual who is responsible for the operation of the vehicle and rendering assistance to the Emergency Medical Technician at any time during the mission.

American Standard Code for Information Interchange (ASCII): An eight level code for data transfer adopted by the American Standards Association to achieve compatibility between data devices.

Amplitude Modulation (AM): Modulation in which the amplitude of the carrier-frequency current is varied above and below its normal value in accordance with the audio, picture, or other intelligence signal to be transmitted.

Analog: Physical representation of information such that the representation bears an exact relationship to the original information.

Analog Communication: System of telecommunications used to transmit information other than voice which is sometimes used in telemetry.

Antenna: A system of wires or electrical conductors employed for reception or transmission of radio waves. Specifically, a radiator which couples the transmission line or lead-in to space for transmission or reception of electromagnetic radio waves.

Assigned Frequency: The frequency appearing on a station authorization from which the carrier frequency may deviate by an amount not to exceed that permitted by the frequency tolerance.

Associated Public Safety Communications Officers (APCO): A non-profit public-safety radio users group composed of administrators and communications technical, operations, and command personnel.

Attenuation: The decrease in amplitude of a signal during its transmission from one point to another. It may be expressed as a ratio or, by extension of the term, in decibels.

Audible Signal: Buzzer or bell to indicate an incoming call.

Audio: Pertaining to frequencies corresponding to a normally audible sound wave. These frequencies range roughly from 15 cycles per second (Hz) to 20,000 cycles per second (Hz).

Automatic Location Identification (ALI): Identifies the origin of a telephone call.

Automatic Number Identification (ANI): Equipment for recording the calling party's number without operator intervention.

Band (radio frequency): A range of frequencies between two definite limits By international agreement, the radio spectrum is divided into nine bands. For example, the very high frequency (VHF) band extends from 30 MHz to 300 MHz.

Bandwidth: 1. The width of a band of frequencies used for a particular purpose. Thus, a bandwidth of a television station is 6 MHz.

2. The range of frequencies within which a performance characteristic of a device is above specified limits. For filters, attenuators, and amplifiers these limits are generally taken to be 3 dB below the average level. Half-power points are also used as limits (3 dB is half-power).

Base Station: An item of fixed radio hardware consisting of a transmitter and a receiver.

Basic Life Support (BLS): The minimal acceptable level of care services available in an areawide EMS system. Services include universal access and central dispatch of approved national standard ambulances, with appropriate medical and communication equipment, operated by a complement of EMTs (EMT-A), availability of a category II hospital facility staffed by physicians and nurses with emergency medical knowledge and skills and full areawide implementation of the 15 mandatory components.

Beeper: A pocket paging receiver that emits a beeping sound upon receiving a page specifically directed to it.

Bid: A response to a published Request for Bids or Request for Quotation in which full disclosure of the wanted goods or services is made by public advertisement and price alone is the determining factor for contract award.

Biomedical Telemetry (Biotelemetry): The technique of monitoring or measuring vital biological parameters and transmitting data to a receiving point from a remote location.

Broadcast: Radio or television transmission intended for general reception.

Cable: One or more insulated or non-insulated wires used to conduct electrical current or impulses. Grouped insulated wires are called a multi-conductor cable.

Call Answerer: The initial answerer of a 911 call (911 operator).

Call Referral Method: Calling party is referred to a secondary number.

Call Relay Method: The call is answered at the PSAP where the pertinent information is gathered and then the interrogator relays that information to the proper public safety agency for their action. This can be accomplished by radio, intercom, telephone, etc.

Call Transfer Method: The PSAP interrogator determines the proper responding agency and connects the user to that agency which then performs the necessary dispatching in accordance with prearranged plans with cooperating agencies.

Called Party Hold: Enables the public safety answering point to control the connection for confirmation and tracing of a call.

Cardiopulmonary Resuscitation: Opening and maintaining a patient airway, providing artificial ventilation by reserve breathing, and providing artificial circulation by means of external cardiac compression.

Carrier: A radio signal generally without voice or other information imposed.

Carrier Frequency: The frequency of an unmodulated electromagnetic wave.

Categorization: A system used to identify the readiness and capabilities of a hospital and its entire staff to receive and treat, adequately and expeditiously, emergency patients. The four basic American Medical Assoc. categories are: I-Comprehensive, II-Major, III-General, IV-Basic. Many states have developed their own categorization schemes which identify levels of urgent and critical care capability.

Central Office: Sometimes called a wire center; the smallest subdivision within the telephone system which has relatively permanent geographic boundaries.

Certifying Agency: The State or Local Agency responsible for assuring that the EMT-A and the EMT-P are qualified to provide their respective levels of emergency medical service.

Channel, Point-to-Point: A radio channel used for radio communications between two definite fixed stations.

Channel, Radio: An assigned band of radio frequencies of sufficient width to permit its use for radio communication. The necessary width of a channel depends on the type of transmission and the tolerance for the frequency of emission.

Class of Service: Service order code designation of the combination of telephone service features (equipment, calling area units, dial types) to which business and residence customers subscribe. It is used for rating, identification and assignment purposes.

Coaxial Cable: A transmission line in which one conductor completely surrounds the other, the two being coaxial and separated by a continuous solid dielectric or by dielectric spacers. (Also called coaxial line, concentric line.)

Code Dialing: A method of signaling or encoding and decoding address codes by the use of standard telephone dial.

Command and Control Center (Central Communications Operations): A system which is responsible for establishing communications channels and identifying the necessary equipment and facilities to permit immediate management and control of an EMS patient. This operation must provide access and availability to public safety resources essential to the effective and efficient EMS management of the immediate EMS problem.

Communications Center or Dispatch Center: (See Command and Control Center.)

Communications Subsystem: Comprises those resources and arrangements for notifying the system of an emergency, for mobilizing and dispatching resources, for exchanging information, for remote monitoring of vital indicators, and for the radio transmission of treatment procedures.

Communication System: A collection of individual communication networks, transmission system, relay stations, control and base stations, capable of interconnection and interoperations that are designed to form an integral whole. The individual components must serve a common purpose, be technically compatible, employ common procedures, respond to control, and operate in unison.

Comparator: A circuit which compares two or more signals, and selects the strongest.

Console: A cabinet housing electronic circuitry normally used in controlling other equipment such as transmitters and receivers installed at remote locations.

Continuous Tone Controlled Squelch System (CTCSS): A system wherein radio receiver(s) are equipped with tone-responsive devices which allow audio signals to appear at the receiver audio outputs only when a carrier modulated with a specific tone is received. Said tone must be continuously present for continuous audio output. CTCSS functions are sometimes referred to by various trade names such as Private Line or PL (Motorola Communications and Electronics), Channel Guard or CG (General Electric Mobile Radio Department), or Quiet Channel (RCA).

Control Console: A desk-mounted, enclosed piece of equipment which contains a number of controls or circuits used to operate a radio station.

Control Head: A junction box with appropriate controls, that is microphone, volume, squelch, on/off, etc., used to control a mobile radio.

Coordination: That process by which something is arranged to happen in a good acceptable way in contrast to random occurrence.

Couple: To connect two circuits so that signals are transferred from one to the other.

Coverage: In a radio communications system, the geographic area where reliable communications exist; usually expressed in terms of miles extending radially from a fixed radio station.

Critical Care Unit (CCU): Sophisticated advanced treatment facilities in large medical centers and hospitals that provide advanced definitive care for the most critically ill patients. They are available for the diagnosis and care of specific patient problems including trauma, burn, acute cardiac, premature birth, poisoning, drug overdose and acute alcohol toxification, phychiatric emergencies and other specialized medical surgical problems.

Critical Patient Categories: Patients requiring care for trauma, cardiac, burns, poisonings, alcholism, drug overdoses, acute psychiatric problems and high risk infants. These victims are highly vulnerable to mortality and long-term convalescence. Target planning of these patient categories must be based on knowledge of demography, epidemiology, and specialized clinical requirements of these patients.

Crystal: An item of electronic equipment which determines the exact frequency to be utilized in a radio system.

Data Base: A collection of basic and factual information organized for rapid search and retrieval.

dBm: Decibel referenced to one milliwatt. Employed in communication work as a measure of absolute power. Zero dBm equals one milliwatt.

dBW: Decibels relative to one watt (1 dBW = 30 dBm).

Decibel (dB): A unit which expresses the level of a power value relative to a reference power value. Specifically, the level of a power value P relative to a reference value PR in decibels is defined as $10 \log_{10} (P/PR)$.

Decoding: The conversion and recognition by the addressed (receiving) unit of numerical address codes that have been transmitted through a communications system.

Dedicated Telephone Line: A telephone wire pair, originating at one point, and terminating at another point, operating in a closed circuit. Also called private line.

Defibrillator: An electrical device used to eliminate fibrillation of the heart muscle, by the application of high voltage impulses.

Demodulation: The process of recovering the modulating information from a modulated signal (wave).

Dial Tone First: Allowance of a 911 or "O" Operator calls to be completed without the deposit of a coin.

Digital: Data represented in discrete, discontinuous form, as contrasted with analog data represented in continuous form.

Digital Dial Code: A signaling technique generally used in EMS VHF radio systems to bypass a receiver CTCSS system. In North Carolina 1500 Hz interrupted signaling is standard.

Direct: In terms of communications circuits, this means a dedicated, instant method of communications. A dial telephone is not direct, while radio would be direct.

Direct Dispatch Method: All 911 call answering and radio dispatching is done by the personnel at the public safety answering point.

Direct Distance Dialing (DDD): Telephone service which permits subscribers to dial their own long distance calls.

Direct Leased Land Lines: Dedicated or designated point-to-point wire circuits (telephone) used in transmitting voice or data communications (see Dedicated Telephone Line).

Direct Trunking: An arrangement where a telephone line connection has no intermediate points before reaching the final destination (called) party.

Directional Antenna: An antenna which radiates radio waves more effectively in some directions than in others.

Directivity: The value of the directive gain of an antenna in the direction of its maximum value. Specifically, in the level of a power value p relative to a reference value P_R in decibels is defined as $10 \log_{10} (P/P_R)$.

Dish: A type of antenna, that is, parabolic reflector, used extensively in microwave systems.

Distortion: Unfaithful reproduction of audio or video signals due to change occurring in the wave form of the original signal, somewhere in the course it takes through the transmitting and receiving system. Classified as linear, frequency, and phase distortion.

Doctor-interrupt: The ability of a physician or hospital communicator to interrupt the voice or telemetry transmission from a radio in the field.

DOT/EMT-A Basic Course: A nationally accepted course for EMT-A instruction.

Dual-Tone Multifrequency (DTMF): The simultaneous generation of two audio tones generally compatible to AT&T's standard "touch-tone" frequencies. Used for control or signaling purposes.

Duplex: The operation of transmitting and receiving apparatus at one location in conjunction with associated transmitting and receiving equipment at another location, the process of transmission and reception being simultaneous.

Duplex Channel: A communication channel providing simultaneous transmission in both directions (for comparison, see simplex channel).

Duplex Operation: The operation of associated transmitting and receiving apparatus concurrently as in ordinary telephones without manual switching between talking and listening periods. A separate frequency band is required for each direction of transmission. (For comparison, see simplex operation.)

Duplexed/Multiplexed Telemetry Unit: A radio device capable of simultaneous transmission and reception and concurrent transmission of both voice and EKG information.

Duplexed Telemetry Unit: A radio device capable of simultaneous transmission and reception of information. The device may transmit voice or EKG information (not concurrently) and receive voice transmission while transmitting.

Duplexer: A device which is used in radio equipment to provide simultaneous transmit and receive capabilities (full duplex operation) on a single antenna.

Effective Radiated Power (ERP): Antenna input power times the gain, in dB, of the antenna, expressed in Watts ERP.

EKG Display (Medical) Console: A unit of electronic equipment located in hospital emergency rooms and/or cardiac care units which displays EKG and records voice and data information received from an EMS scene by transmission via radio or telephone path (demodulation console).

Electrocardiogram (ECG or EKG): A visual or hard copy trace of a patient's electrical heartbeat. Sometimes EKG or ECG.

Electromagnetic Energy: The type of energy contained in any electromagnetic wave such as radio waves, visible light, X-rays, gamma rays, or cosmic rays. The frequencies of radio waves go to about 300,000 MHz.

Electromagnetic Radiation: Radiation associated with a periodically varying electric and magnetic field that is traveling at the speed of light, including radio waves, light waves, X-rays, and gamma radiation.

Electromagnetic Wave: A wave of electromagnetic radiation, characterized by variations of electric and magnetic fields.

Emergency Call: A call that requires immediate action.

Emergency Medical Service (EMS): The service utilized in responding to the perceived individual need for immediate medical care in order to prevent loss of life or aggravation of physiological or psychological illness or injury.

Emergency Medical Service System (EMSS): A system which provides for the arrangement of personnel, facilities, and equipment for the effective and coordinated delivery of health care services in an appropriate geographical area under emergency conditions (occurring either as a result of the patient's condition or of natural disasters or similar situations) and which is administered by a public or non-profit private entity which has authority and the resources to provide effective administration of the system.

Emergency Medical Technician (EMT): Persons trained in emergency medical care in accordance with standards prescribed by the Department of Transportation.

Emergency Operating Center (EOC): An EOC is a secure (protected) facility designed and equipped for the use of community officials to manage response of a community in time of emergency.

Emergency Rescue Vehicle: A vehicle not designed for patient transport which contains advanced life support equipment and personnel capable of providing extrication and emergency care at the scene or in conjunction with transport.

Emergency Resource Coordination Center (ERCC): Generally a facility that has the resources and ability to coordinate all emergency services (police, fire rescue, ambulance, etc.) within a given geographic area.

EMS Region: The geographic area served by a given EMS System.

EMS Council: A formally established and responsible entity representing diverse groups of both providers and consumers of emergency medical services assembled for the purpose of reviewing and evaluating the provision of such services in a defined system's geographical area. Public input into "EMS Policy" may be achieved through this body.

EMT-A: Emergency Medical Technician--Ambulance.

EMT-Paramedic: Persons trained for advanced life support services to include sophisticated trauma, cardiac care, and other critical care elements for interventive treatment, shock therapy, drug administration, and cardiac rhythm detection control.

Encoding: The conversion of numerical address codes, such as telephone number of message codes, into a format of on-off pulses of audio tones for transmission over a communications link.

Exchange: A defined area, served by one or more telephone central offices, within which the telephone company furnishes service.

Facility: A communications facility is anything used or available for use in the furnishing of communications service.

Facsimile: The process by which pictures, images, and other fixed graphic materials are scanned and the information converted into electrical signals for local use or transmission remotely to reproduce a likeness of the subject copy.

Fading: The variation of radio field strength caused by a gradual change in the transmission medium.

Fading Margin: The number of decibels of attenuation which can be added to a specified radio frequency propagation path before the signal-to-noise ratio of the channel falls below a specified minimum.

Federal Communications Commission (FCC): Established by the Communications Act of 1934 to formulate rules and regulations and to authorize use of radio communications.

Fixed Service: A service or radio communication between specified fixed points.

Fixed Relay Station: An operational fixed station established for the automatic retransmission of radio communications received from either one or more fixed stations or from a combination of fixed and mobile stations and directed to a specified location.

Forced Disconnect: The capability of the 911 center to disconnect a 911 call to avoid caller jamming of the incoming phone lines.

Frequency: The number of cycles, repetitions, or oscillations of a periodic process completed during a unit of time. The frequency of waves in the electromagnetic spectrum (radio waves) is designated in hertz (Hz), kilohertz (kHz = 1000 Hz). One hertz is equivalent to one cycle per second.

Frequency Band: See Band (radio frequency).

Frequency Deviation: Frequency deviation of an FM signal is the change in the carrier frequency produced by the modulating signal. The frequency deviation is proportional to the instantaneous amplitude of the modulating signal.

Frequency Modulation (FM): A method of modulating a carrier-frequency signal by causing the frequency to vary above and below the unmodulated value in accordance with the intelligence signal to be transmitted. The amount of deviation in frequency above and below the resting frequency is at each instant proportional to the amplitude of the intelligence signal being transmitted. The number of complete deviations per second above and below the resting frequency corresponds at each instant to the frequency of the intelligence signal being transmitted.

Gain, of an Antenna: The effectiveness of a directional antenna in a particular direction, compared against a standard (usually an isotropic antenna). The ratio of standard antenna power to the directional antenna power that will produce the same field strength in the desired direction.

Generator: A device which develops electrical voltage from mechanical energy.

Geographical Assignment: The assignment and use of communications channels on a dedicated user basis within a given geographic area.

GHz: gigahertz (billion hertz or 10^9 cycles per second).

Goal (See Objective): A statement of broad direction, general purpose, or intent. A goal is general and timeless and is not concerned with a particular achievement within a specified time period.

Guard Band: A narrow band of frequencies provided between adjacent channels in certain portions of the radio spectrum to prevent interference between stations.

Half-Duplex Channel: A communication channel providing duplex operation at one end of the channel, but not the other. Typically, the base station is operated in the duplex mode (for comparison see "simplex channel" and "duplex channel").

Half-Duplex Operation: Generally refers to the ability of directing medical personnel in EMS radio systems to interrupt or "break in" on radio transmissions from field personnel to give instructions or ask questions (requires "duplexed" equipment in the field).

Half-Wave Dipole Antenna: A straight, ungrounded antenna having an electrical length equal to half the wavelength of the signal being transmitted or received. Mounted vertically, it has a donut-shaped pattern, circular in the horizontal plane.

Harmful Interference: Any emission, radiation, or induction which endangers the functioning of a radio service or seriously degrades, obstructs, or repeatedly interrupts a radio communication service.

Hertz: A unit of frequency equal to one cycle per second (Hz).

Hot Line: Direct circuit between two or more points for immediate use without patching or switching (see Direct Leased Land Lines). The hot line can employ various signalling configurations (i.e., ringdown, audio amplifiers, etc.).

Impedance, Characteristic: The importance of characteristic impedance lies in the fact that when a transmission line is terminated, as with an antenna, in an impedance matching its own, then all of the energy or power flowing along the line is radiated by the antenna. If the impedance of the termination (antenna) is not matched to the transmission line, a portion of the energy will be reflected at the mismatch resulting in a lower output from the antenna.

Interface: A concept involving the specification of the interconnection between two equipments or systems. The specification includes the type, quantity, and function of the interconnection circuits and the type and form of the signals to be interchanged via these circuits.

Interference: Interference in a signal transmission path is either extraneous power which tends to interfere with the reception of the desired signals or the distribution of signals which results in loss of signal or distortion of information.

Intermittent: In connection with bio-medical telemetry, this word describes the momentary transmission of EKG and/or voice signals from the paramedic's equipment.

kbps: Thousands of bits per second.

Key Telephone Equipment: An instrument that has the capability of multiple line terminations. Each line is accessed by depressing associated button (key).

kHz: kilohertz (thousand hertz or thousand cycles per second).

Land Line: A generic term which refers to the public-switched telephone system.

Land Mobile: Communications between base stations and mobile radios, or from mobile radio to mobile radio.

Land Mobile Service: A mobile service between base stations and land mobile stations, or between land mobile stations.

Law Enforcement Assistance Administration (LEAA): An administration under the United States Department of Justice established by the Omnibus Crime Control and Safe Streets Act of 1968.

Leased Line: A pair of wires or a circuit, usually leased or rented from a telephone company, designed for exclusive use between two fixed points for various communication control functions (i.e., base station control, . . .). The leased line configuration bypasses the public telephone switching system.

Line of Sight (LOS): An unobstructed path between two points. Radio waves at those frequencies where signals travel in a straight line and are not reflected by the ionosphere.

Link: A channel or circuit designed to be connected in tandem with other channels or circuits.

Local Government Radio Service: A service of radio communication essential to official activities of states, possessions, and territories, including counties, towns, cities, and similar governmental subdivisions.

Local Service Area: That area that can be called without incurring multimessage units or a toll charge.

Loss: A decrease in power suffered by a signal as it is transmitted from one point to another, usually expressed in decibels.

Medical Control Center (MCC): A communications capability, usually located at a hospital, which provides for medical control and direction of an EMS system.

Medical Communications Control Console: An installation of communications control equipment, usually located at a hospital, which provides for control of the transmitting and receiving equipment necessary for the medical control and direction of an EMS system.

Medical Control: Directions and advice provided from a centrally designated medical facility staffed by appropriate EMS personnel, operating under medical physician supervision, supplying professional support through radio or telephonic communication for onsite and transit, basic and advanced life support services given by field and satellite facility personnel.

Medical Emergency: An unforeseen event affecting an individual in such a manner that a need for immediate medical care (physiological or psychological) is created.

Microwave: A term applied to radio waves in the frequency range of 1,000 megahertz and upward. Generally defines operations in the region where distributed-constant circuits enclosed by conducting boundaries are used instead of conventional lumped-constant circuit components.

Mobile Intensive Care Unit (MICU): An emergency vehicle unit staffed by paramedic or Mobile Intensive Care Nurses.

Mobile Relay: A fixed station established for the automatic retransmission of mobile service radio communications which originate on the transmitting frequency of the mobile stations and which are retransmitted on the receiving frequency of the mobile stations.

Mobile Relay Station: A base station established for the automatic retransmission of mobile service radio communications which originate on the transmitting frequency of the mobile stations and which are retransmitted on the receiving frequency of the mobile stations.

Mobile Repeater Station: A mobile station in the mobile service authorized to retransmit automatically on a mobile service frequency communications originated by hand-held portable units or by other mobile or base stations directed to such hand-carried units.

Mobile Service: A service of radio communication between mobile and land stations, or between mobile stations.

Mobile Station: A two-way radio station in the mobile service intended to be used while in motion or during halts at unspecified points.

Mobile Transmitter: A mobile transmitter is a radio transmitter designed for installation in a vessel, vehicle, or aircraft and normally operated while in motion.

Mobile Unit: A two-way-radio equipped vehicle or person. Also, sometimes the two-way radio itself, when associated with a vehicle or person.

Modem: A contraction of modulator-demodulator.

Modulation: The process of modifying some characteristic of an electromagnetic wave (called a carrier) so that it varies in step with the instantaneous value of another wave (called a modulating wave or signal). The carrier can be a direct current, an alternating current (providing its frequency is above the highest frequency component in the modulating wave), or a series of regularly repeating, uniform pulses called a pulse chain (providing their repetition rate is at least twice that of the highest frequency to be transmitted).

Multi-channel System: A radio system which uses more than one radio channel. Also known as multi-frequency system.

Multi-frequency Operation: Equipment capable of operation on two or more frequencies. These frequencies must be close together as it is not feasible to have equipment containing low band, high band, and ultra high band together since separate units are required for each band.

Multijurisdictional System: A system covering more than one political boundary or agency.

Multipath: The propagation phenomenon which results in signals reaching a radio receiving antenna by two or more paths resulting, normally, in a degradation of the original signal.

Multiplex: Simultaneous transmission of two or more messages in either or both directions over the same transmission path.

Multiplex Operation: Multiplex operation is simultaneous transmission of two or more messages in either or both directions over the same transmission path. Generally used in a medical communications context to denote a radio telemetry device capable of concurrent voice and EKG information transmission on one radio frequency.

Multiplexer: A device which simultaneously transmits two or more signals over a common carrier wave.

Network: An orderly arrangement of stations interconnected through communications channels in order to form a coordinated entity.

911 (nine-one-one): A three digit emergency telephone number accepted and promulgated by the telephone industry as the nationwide emergency number.

911 Center: (See Public Safety Answering Point).

NNX: The first three digits of a local telephone number that uniquely identifies that Central Office switching location within its Area Code number for nationwide long distance call routing.

Noise: Interference characterized by undesirable random voltages caused by an internal circuit defect or from some external source.

Objective (See Requirement): A desired accomplishment that can be measured within a given time frame and under specifiable conditions. The attainment of the objective advances a system toward a corresponding goal.

Ohm (Ω): An electrical unit of resistance.

Paging: Notification of an individual by means of a selective calling instrument such as radio, etc.

Patch: A means of connecting one system to another; i.e., radio to telephone.

Personal Radio: A small portable radio intended to be carried by hand or on the person of the user.

Phone Patch: An interconnection between radio and telephone communications circuits which permits direct voice interchange between telephone lines and radio system.

Police Radio Service: A public-safety service of radio communication essential to official police activities.

Portable: An easily transportable radio.

Portable Radio: A completely self-contained radio which may be moved from one position to another.

Primary Power: A reliable source of power (115 Vac, 220 Vac, etc.) normally serving the consumer's main power needs on a continual basis.

Private Automatic Branch Exchange (PABX): A telephone switchboard with many stations not individually identifiable to the telephone company's switching network not requiring an operator.

Private Branch Exchange (PBX): A telephone switchboard with many stations not individually identifiable to the telephone company's switching network requiring an operator.

Proposal: A written response to a Request for Proposal in which there is contained an offer to perform services and/or provide material according to previously provided specifications.

Propagation (electromagnetic): The travel of electromagnetic waves through a medium, or the travel of a sudden electric disturbance along a transmission line. Also called wave propagation.

Public Safety Agency: "Public safety agency" means a functional division of a public agency which provides firefighting, police, ambulance, medical, or other emergency services.

Public Safety Answering Point (PSAP): The initial answering location of a 911 call. Sometimes called a 911 center.

Push-to-Talk Operation (PTT) (Press-to-Talk): In radio or telephone systems, that method of communication over a speech circuit in which transmission occurs from only one station at a time, the talker being required to keep a switch operated while he is talking.

Radio: The transmission and reception of signals by means of electromagnetic waves without a connecting wire.

Radio-frequency Power: The power associated with any signal consisting of electromagnetic radiation which is used for telecommunications.

Radio Interference: Undesired disturbance of radio reception. Man-made interference is generated by electric devices, with the resulting interference signals either being radiated through space as electromagnetic waves or traveling over power lines or other conducting media. Radiated interference is also due to natural sources such as atmospheric phenomena (lightning). Radio transmitters themselves may interfere with each other (see intermodulation distortion).

Radio Network: A number of radio stations, fixed and mobile, in a given geographical area which are jointly administered or which communicate with each other by sharing the same radio channel or channels.

Radio Receiver: An instrument which amplifies radio-frequency (RF) signals, separates the intelligent signal from the RF carrier, amplifies the signal in most cases, then converts the intelligent signal back into its original form.

Radio Relay System (Radio Relay): A point-to-point radio transmission system in which the signals are received and retransmitted by one or more intermediate radio stations.

Radio Station: A complete assemblage of equipment for radio transmission or reception, or both.

Radio Transmitter: A radio-frequency power source which generates radio waves for transmission through space.

Range: Distance over which a radio signal can be transmitted for effective reception or the distance at which a usable signal can be received.

Receiver: An electronic device used to detect and amplify transmitted radio signals into sound waves.

Referral Method: Calling party referred to a secondary number.

Regional EMS System: An emergency medical service area (trade, catchment, market, patient flow) that provides essentially all of the definitive emergency medical care (95%) for all emergencies and for most critically ill and injured patients. Only highly specialized and limited use services should be obtained outside of the area. The area must contain adequate population and available medical resources to implement and sustain an EMS system operation. At least three major models exist: (1) multiple urbanized communities and their related suburban parts; (2) a metropolitan center and the surrounding rural areas; and (3) metropolitan center and extreme rural-wilderness settings. The models may be interstate or intrastate.

The EMS area must have sufficient population, size, and medical resources to justify the existence of an emergency medical service system. A village or small community unable to provide all of the functional components and necessary clinical services must be directed toward participation in an adjacent larger medically competent system with necessary services and capabilities. The availability of more specialized care in the large metropolitan areas will be reflected by the referral patterns of the system for specific clinical problems.

The area must also be of adequate size to provide the financial base for the establishment and continued operation of the total system. System planning should avoid the development of a highly sophisticated complex system in an area without sufficient economic capability due to a limited tax base and limited financial resources. The financial feasibility for the establishment and continued operation must be thoroughly examined by the responsible organizations and political entities involved to insure that the system has the capability of becoming self-sustaining and not dependent upon continued Federal support.

Relay: Transmission forwarded through an intermediate station.

Relay Station: Radio stations that rebroadcast signals the instant they are received, so that the signal can be passed on to another station outside the range of the originating transmitter.

Remote Base Station. A base station located away from the operating console, to take advantage of improved coverage offered by a better geographical location.

Remote Control: A device or system designed to control a base station from a location other than that where the transmitter and receiver are installed.

Remote Control Equipment: The apparatus used for performing monitoring, controlling, supervising, or a combination of these, a prescribed function or functions at a distance by electrical means.

Repeater: A combination of apparatus for receiving either one-way or two-way communication signals and delivering corresponding signals which are either amplified or reshaped or both. A repeater for one-way communication signals is termed a one-way repeater and one for two-way communication signals is a two-way repeater.

Repeater Station: An operational fixed station established for the automatic retransmission of radio communications received from any station in the mobile service.

Requirement (Task): A desired accomplishment that is subordinate to an objective. A requirement is attainable within a specified and immediate time limit, is consistent with the time frame of the objective, and is clearly measurable.

Resource Hospital: A supervising medical resource facility in a particular EMS region which is responsible for medical advice, consultation and transportation triage with other (associate) hospital and mobile medical units. There must be a communication linkage between this facility and the Regional Command and Control Center which is responsible for the dispatch of all emergency vehicles.

Resource Management Center: A center responsible for the allocation of those resources essential to the most effective and efficient resolution and/or management of the immediate problem. In most communities these resources would include police, fire and emergency medical services. The Resource Management Center is most effective when its responsibilities encompass the whole Public Safety response.

Ringback: Permits the answering point to ring the hung-up telephone on a held circuit; this feature is useful when a calling party has failed to provide all necessary information to the answering point before hanging up.

Selective Calling: Encoding devices used to alert, or signal, a particular individual or groups. See Channel and duplex.

Selective Routing: Selective routing terminates a call at a PSAP determined by the location of the calling telephone. This is accomplished by using a computer to process the calling telephone number.

Semi-duplex: See "half-duplex".

Sensitivity of a Radio Receiver: The minimum input signal required in a radio receiver to produce a specified output signal-to-noise ratio. This signal input may be expressed as power or voltage at a stipulated input network impedance.

Signal: The form or variation of a wave with time, serving to convey the information, message, effect, or other desired intelligence in communications.

Signal-to-Noise Ratio: Ratio of the intensity of the desired signal to that of the undesired noise signal, usually expressed in decibels.

Simplex (Simplex Operation): Single frequency operation whereby all base stations and mobiles operate on one common frequency. Transmissions in a simplex circuit can occur in either direction, but not in both simultaneously.

Simplex Channel: A communication channel providing transmission in one direction only at any given time (for comparison see "duplex channel").

Simplex Channel, Single-Frequency: A simplex channel utilizing only one assigned band of frequencies (for comparison see "simplex channel, two-frequency").

Simplex Channel, Two-Frequency: A simplex radio system utilizing two distinct assigned bands of frequencies (for comparison see "simplex channel, single-frequency").

Simple Operation: A method of radio operation in which communication between two stations takes place in only one direction at a time. This includes ordinary transmit-receive operation, press-to-talk operation, voice-operated carrier, and other forms of manual or automatic switching from transmit to receive. Also called simplex. (Compare with "duplex operation").

SINAD: The ratio expressed in decibels of signal plus noise plus distortion to noise plus distortion produced at the output of a receiver.

Solid State: Circuitry which utilizes transistors and other similar devices in lieu of vacuum tubes.

Special Emergency Radio Service (SERS): That portion of radio communications frequency resources authorized for use in the alleviation of emergency situations endangering life or property.

Spectrum: Any series of radiant energies arranged in order of wavelength or frequency. The entire range of electromagnetic radiation extending from the longest known radio waves to the shortest known cosmic rays.

Squelch: A circuit function that acts to suppress the audio output of a receiver when noise power exceeding a predetermined level is present.

Statewide EMS System: A network of EMS Systems, integrated and coordinated at the state level.

Station, Radio: A fixed installation or mobile unit which is equipped to transmit and receive radio signals.

Strip Chart Recorder: An electromechanical device used to make paperchart recordings of EKG information. Usually uses heat sensitive paper and a heated stylus.

Subcarrier: A frequency used to generate a modulated wave which in turn is applied as a modulating wave to modulate another carrier (e.g., 1400 Hz is used as a subcarrier in ECG telemetry transmissions).

Switched Network: A complex of diversified channels and equipment that automatically routes communications between the calling and called person or data equipment.

Tandem Trunking: An arrangement where a telephone-line connection has one or more intermediate points that are required or permitted (usually on a controlled dial pulse basis) before reaching the final destination (called) party.

Task: The smallest increment of self-achievable work that is identifiable, assignable, and measurable within an immediate time frame.

Telecommunications: All forms of electrical transmission of intelligence including: telegraph, telephone, radio, and television.

Telemetry: The sensing and measuring of information at some remote location and transmitting the data to a convenient location to be read and recorded.

TELPAK: AT&T Long-Lines Series 5000 Tariff Offering.

Telephone Line: A telephone line from a telephone company central office that is connected to key or non-key telephone equipment.

Teletypewriter: An electromechanical device, similar to a typewriter, such that messages typed on the keyboard of the transmitter unit are converted into electrical signals, which when conveyed to the receiver unit, are printed on paper.

Tone: An audio or carrier of controlled amplitude and frequency used in a selective signalling system, or for equipment control purposes.

Tone Code: Tone code specifies the character of the transmitted tone signal required to effect a particular selection or function.

Tone Coded Squelch: A system whereby a superimposed tone is transmitted with the radio carrier to protect against nuisance type interference.

Touch Pad: A method of signaling or encoding and decoding address codes by the use of a simple numerical push button keyboard.

Tower: A structure usually used when an antenna must be mounted higher than fifty feet.

Transceiver: The combination of radio transmitting and receiving equipment in a common housing, usually for portable or mobile use, and employing common circuit components for both transmitting and receiving. Generally used in push-to-talk operation.

Transfer Method: The PSAP interrogator determines the proper responding agency and connects the user to that agency. To perform the necessary dispatching in accordance with pre-arranged plans with cooperating agencies.

Transistor: An electronic device, similar to the electron tube in use, consisting of a small block of a semiconductor (such as germanium) that has at least three electrodes.

Transmitter: Apparatus for the production and modulation of radio frequency energy for the purpose of radio communication.

Transmission Line: A waveguide, coaxial line, or other system of conductors used to transfer signal energy efficiently from one location to another.

Triage: The sorting and classification of the ill or injured to determine priority of need and appropriate care or treatment.

Trunk: A circuit used for connecting a subscriber in a Central Office to all other services in/out of the switching equipment (e.g., Long Distance Trunk, Operator Trunk, Recorded Announcement Trunk, etc.).

Trunk Line: A telephone line which terminates at a switchboard rather than a telephone.

TSPS: An electronic operating position system whereby operator-handled traffic is routed to its final destination via a central switching machine.

Two-Way Radio: A radio which is able both to transmit and receive.

Ultra High Frequency (UHF): Frequencies between 300 MHz and 3000 MHz.

Vacuum Tube: An electronic device used in radio, television, etc., which consists of an evacuated enclosure containing two or more electrodes between which conduction of electricity can occur.

Vehicular Repeater Station: A mobile station in the mobile services authorized to retransmit automatically on a mobile service frequency, communications originated by hand-carried portable units or by other mobile or base stations directed to such hand-carried units.

VHF: Very High Frequency; frequencies between 30 MHz and 300 MHz.

Voting: Automatic selection of remote radio receiver. All incoming signals are compared for signal strength and the first signal found that meets or exceeds a pre-set level is "voted" or selected and sent to the audio amplifier.

Width, Channel: The difference of the upper and lower frequency limits of a channel, expressed in Hertz.

Wireline: See Leased Line

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FORM OT-29
(3-73)

U.S. DEPARTMENT OF COMMERCE
OFFICE OF TELECOMMUNICATIONS

BIBLIOGRAPHIC DATA SHEET

	1. PUBLICATION OR REPORT NO.	2. Gov't Accession No.	3. Recipient's Accession No.
	NTIA-SP-79-3		

4. TITLE AND SUBTITLE
EMERGENCY MEDICAL SERVICES (EMS) COMMUNICATIONS SYSTEM TECHNICAL PLANNING GUIDE

5. Publication Date
March 1979

6. Performing Organization Code
NTIA/ITS

7. AUTHOR(S) Joseph A. Hull, John M. Harman, Marylyn N. Olson, H. David Hunt

9. Project/Task/Work Unit No.

8. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Department of Commerce
National Telecommunications and Information Administration, Institute for Telecommunication Sciences, Boulder, CO 80303

10. Contract/Grant No.

11. Sponsoring Organization Name and Address
U.S. Department of Commerce
National Telecommunications and Information Administration, 1800 G Street, NW
Washington, DC 20504

12. Type of Report and Period Covered

13.

14. SUPPLEMENTARY NOTES

15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This document is intended to provide guidance in planning Emergency Medical System (EMS) communications by identifying the processes and procedures for obtaining technical assistance in designing and implementing such a system.

In addition, this report is designed to familiarize the non-technical person with common communication terms, concepts and helpful references. Fundamental elements of land-mobile radio are introduced, and details of citizen access and emergency medical responses are addressed. Planning a 911 emergency system is discussed. The development of an EMS command and control center is highlighted. Frequency-assignment regulations and selected circuit configurations for an EMS system are introduced.

16. Key Words *(Alphabetical order, separated by semicolons)*

Ambulance communications; emergency medical communications; emergency preparedness; health services; hospital communications; frequency allocation; land-mobile radio.

17. AVAILABILITY STATEMENT

[X] UNLIMITED.

[ ] FOR OFFICIAL DISTRIBUTION.

18. Security Class *(This report)*
Unclassified

20. Number of pages
206

19. Security Class *(This page)*
Unclassified

21. Price:

☆ U. S. GOVERNMENT PRINTING OFFICE 1979 - 679-471/409 Reg. 8

USCOMM-DC 29716-P73