Natural Hazard Research

The Utilization of Amateur Radio in Disaster Communications

Lynn Ellen Edwards

Graduate School of Engineering
University of Colorado at Boulder

Working Paper #86

The Utilization of Amateur Radio in Disaster Communications

Lynn Ellen Edwards

Graduate School of Engineering
University of Colorado at Boulder

May 1994

Working Paper #86
Natural Hazards Research and Applications Information Center
Institute of Behavioral Science
University of Colorado

The purpose of this working paper is to explore the use of amateur radio as a provider of supplemental communications for disaster relief and disaster control agencies. Amateur radio operators, or hams, are skilled communicators willing and able to volunteer their time and equipment for emergencies. They also offer their skills and additional frequencies; thus, it makes sense to plan for and include them in disaster training and preparation and to use them when disaster strikes. In Colorado, hams participate with the Mile High Chapter of the American Red Cross and the Boulder County Amateur Radio Emergency Services (BCARES) as disaster communications providers. Although these two groups play different roles in a disaster, both show how hams can work together with agencies to provide more effective communications during a disaster.

Preface

This paper is one of a series on research in progress in the field of human adjustments to natural hazards. The Natural Hazards Working Paper Series is intended to aid the rapid distribution of research findings and information. Publication in the series is open to all hazards researchers and does not preclude more formal publication. Indeed, reader response to a publication in this series can be used to improve papers for submission to journal or book publishers.

Orders for copies of these papers and correspondence regarding the series should be directed to the Natural Hazards Center at the address below. A standing subscription to the Working Paper series is available. Papers cost $3.00 per copy on a subscription basis, or $4.50 per copy when ordered singly. Copies sent beyond North American cost an additional; $1.00.

The Natural Hazards Research and Applications
Information Center
Institute of Behavioral Science #6
Campus Box 482
University of Colorado at Boulder
Boulder, CO 80309-0482
(303) 492-6819

Table of Contents

List of Figures viii
List of Tables viii

CHAPTER 1
INTRODUCTION 1
Purpose 1
Scope 3
Summary 3

CHAPTER 2
DISASTERS 5
Their Existence 5
Their Scope 5
Geographical 5
Financial 6
Their Increasing Potential 6

CHAPTER 3
DISASTERS AND THE NEED FOR COMMUNICATIONS 9
The Need For Communications 9
Disaster Management 10
Disaster Control Services 11
Public Service 11
Forecasting and Diagnostic Services 11
Transportation Companies and Agencies 12
Public Utilities 12
Disaster Relief Services 12
The Public 13
Financial Services 13
Commercial Services 14
Special Networks 14
Types of Communications 15
On-site communications 15
Intra-agency communications 15
Inter-agency communications 16
Coordination 16
Definition of Disaster Communications 16

CHAPTER 4
PROVIDING COMMUNICATIONS 18
Modes of Communications 18
Voice 18
Record 18

Means of Communications 20
Issues Involved 21
Personnel 21
Technological 22
Regulatory 22
Policy 22
Financial 22

CHAPTER 5
PRIMARY DISASTER SERVICES COMMUNICATIONS SYSTEMS 25
The Mile High Chapter of the American Red Cross 25
The Washington, D.C. Metro American Red Cross Chapters 26
The Boulder Regional Communications Center 27

CHAPTER 6
SUPPLEMENTARY COMMERCIAL COMMUNICATIONS SYSTEMS 29
The Cellular Phone System 29
Introduction 29
Drawbacks 31
Commercial Satellite Systems 32
Current Systems 32
Proposed 33

CHAPTER 7
AMATEUR RADIO 35
Introduction 35
Provisions 36
Personnel 37
Technological 42
Spectrum 42
Systems 42
Voice Communications 42
Data Communications 42
Image Communications 44
Radio Communication Links 46
Equipment 48
Regulatory 50
Policy 54
Financial 55
CASE STUDIES
The Mile High Chapter of the American Red Cross 55
Provisions 56
Summary 56
Metro D.C. Chapters of the American Red Cross 57
Provisions 57
Summary 57
BCARES 58

Provisions 59
Summary 64

CHAPTER 8
ANALYSIS 65
Issues 65
Personnel 65
Technological Issues 66
Regulatory Issues 67
Policy Issues 67
Financial Issues 68
Applicability to Disaster Communications 68
Proposal 69
Summary 70

SOURCES CONSULTED 73

APPENDIX A
MEMO OF UNDERSTANDING BETWEEN BCARES & BRCC 79

List of Figures

FIGURE

6.1 Cellular Structure 30
6.2 Mobile Service Interconnection 30
6.3 Basic Satellite Interconnectivity 33

7.1 U.S. Amateur Frequency Allocations 40
7.2 A Typical Packet Radio Station 43
7.3 A Typical Amateur TV Station 45
7.4 The Five Principles of Amateur Radio 51

List of Tables

TABLE

7.1 Amateur Radio Operator Licenses 39
7.2 Satellites in Public Service Communications 47

CHAPTER 1

INTRODUCTION

Purpose

The Boulder Valley School District security division received a phone call stating that three bombs had been placed in Nevin Platt Middle School—one located in the boy's locker room and two near the metal shop. Shortly after the call, an explosion shook the locker room. There were approximately 25 to 30 people in the school. Many were injured by the explosion, which also created fire and smoke.

School security notified the Boulder Regional Communications Center at the same time school neighbors called 911 to report the explosion. Communications dispatched Cherryvale Fire Protection District, AMR Ambulance, the Boulder County Sheriff's Department, the Boulder County Bomb Squad, and Emergency Services.

Arriving units reported broken windows, smoke, and mass casualties in the school. They established command and requested additional resources. Responders determined two remaining explosive devices near the metal shop did not detonate. In addition, most of the injured were located in the boy's locker room, gymnasium, and classrooms in the center of the building.

Law enforcement personnel secured the area, located the two bombs, and began to defuse them. Firefighters, using rescue dogs, patiently searched the building for fires and took measures to evacuate smoke from the building. Victims were transported by ground and air ambulance to Boulder Community and Avista hospitals.

Command provided incident information to the community. Victim's advocates and the Red Cross consulted with parents and citizens responding to the scene. Information on patient status was obtained from those treated and released at the scene and from hospitals. In addition, an alternate Emergency Operations Center (EOC) was established on site to provide resources and take calls concerning the injured.

Once the incident was over, a debriefing was held to evaluate response, command, and management.[1]

Fortunately, the above events describe the scenario for the Simulated Emergency Test (SET) held on Saturday, November 20, 1993. It could have been a wildfire or flash flood training exercise, and it could have easily been a real emergency.

The purpose of this thesis is to explore the use of amateur radio as a provider of supplemental communications for disaster relief and disaster control agencies. This discussion covers all relevant aspects, including the parameters of disaster communications, important issues, and communication providers, including amateur radio operators. The paper concludes with a proposal for incorporating amateur radio into the communications strategy for disasters.

---

1. Simulated Emergency Test, Boulder, Colorado, November 20, 1993.

Scope

Emergencies and disasters can either occur suddenly, such as in a flash flood, or gradually worsen, such as in slow rising flood waters. This study deals only with sudden-onset disasters and emergencies, crises that "give little time for warning, are relatively short in duration and require rapid reaction on the part of responding organizations."[2]

The primary distinction between an emergency and a disaster is one of degrees. In handling either, studies have shown that treating an incident as a local situation, utilizing local agencies and local resources first, works best. Response and recovery are most effective when outside help is brought in only after local resources reach their limits. For this reason, this paper discusses emergencies and disasters from a local perspective. In particular, an emergency is a situation where a city or county public safety agency decides there is actual or imminent danger of loss of life and property that requires immediate action. A disaster is an intensified, more widespread emergency. The focus shall be on disasters because the need for communications is both more intensive and extensive in a disaster than an emergency; therefore, communications used in disasters can also be applied in emergencies.

Summary

Chapter 1 discusses the purpose, scope, and approach of the paper. Chapter 2 discusses disasters, emphasizing that disasters can and do affect everyone and that their potential is increasing. Chapter 3 explains the need for communications following an emergency or

---

2. *Communication When It's Needed Most*, Northwestern University: The Annenberg Washington Program, 1989, p. 92.

disaster and the categories and divisions of communications necessary; it concludes by defining the parameters of disaster communications for this study.

Chapter 4 discusses the provision of communications—both voice and record methods as well as some general aspects of wireless communications. It also addresses several related issues, including personnel, technological, regulatory, policy, and financial aspects.

Chapter 5 focuses on primary disaster services communications systems and discusses disaster relief and disaster control agencies, specifically those in the Boulder, Colorado, area and in the Washington, D.C., metro area.

Chapter 6 examines commercial supplemental disaster communications providers—cellular phone and commercial satellite systems.

Chapter 7 explores amateur radio and its role in disaster communications. The case studies presented at the end of the chapter show the utilization of amateur radio in specific agencies.

Chapter 8 analyzes the findings of the research and offers conclusions. A proposal is then made, presenting a plan for incorporating amateur radio in the disaster agency's communications.

CHAPTER 2

Disasters

Their Existence

Emergencies and disasters include earthquakes, floods, hurricanes, wildfires, riots, search and rescue operations, landslides, bomb threats, chemical spills, nuclear radiation, and war. Some are caused by natural forces, some result from human error, and some are deliberate acts of violence.

Their Scope

Geographical

No place and no one on earth is free from the threat of disasters. Just in the last few years alone the United States has experienced Hurricane Hugo, the Loma Prieta Earthquake, the Oakland Fire in California, Hurricane Andrew in the southeast, Hurricane Iniki in Hawaii, the Los Angeles riots, the terrorist bombing of the World Trade Center in New York, and the widespread flooding of major rivers in the Midwest. Closer to home, Colorado experienced the Big Thompson Canyon Flood in 1976, and in recent years Boulder County endured the Old Stage Road wildfire, the Black Tiger wildfire on Sugarloaf Mountain, and potentially hazardous situations such as the Halloween Mall Crawl on Boulder's Pearl Street Mall and anti-war demonstrations.

Financial

Such incidents have caused great loss of lives and property. In 1992, insurance companies paid a record $23 billion in damages. This figure does not include uninsured losses; and 1993 figures, although not yet complete, indicate more of the same.[3]

Increasing Potential

The probability of disasters is increasing; this can be attributed to several factors, including increasing population, technological advances, and nature.

The percentage of people in urban areas is increasing. Today, the world population is 5.2 billion, with 41% living in urban areas; predictions estimate that by the year 2020, 60% of the total population of 10 billion will be urban dwellers. Due to this increase, urban areas are encroaching onto wildlands, either as city limits move further beyond existing boundaries or as city dwellers increasingly move into wilderness areas for the ambiance of the location.[4] As a result, according to Julie Reynolds of the National Fire Protection Association, the risk of wildfires is increasing.[5]

Technology is another factor. Formerly, only the highly industrialized nations had the capability to engineer, manufacture, and thus, possess weapons of mass destruction. This is no longer true. Today, dangerous and deadly technology is more readily available to anyone

---

3. Kathi Whitley, "Out of the Blue: What Causes Natural Disasters and How to Prepare for Them," *Aide Magazine,* August 1993, p. 10.

4. Thomas E. Drabek and Gerard J. Hoetmer, editors, *Emergency Management: Principles and Practice for Local Government,* Washington, D.C.: International City Management Association, 1991, p. 63.

5. Whitley, pp. 17-18.

with money or connections, creating a highly volatile environment and a higher probability of accidental or intentional disaster.

As well, *not* using the available technology will continue to cause problems. For instance, failure to implement recommended construction specifications for buildings in a high risk area can result in more damage when a disaster occurs than if adequate construction standards had been used. Shelby County, Tennessee, which lies near the New Madrid Seismic Zone, provides a positive example of mitigation practices at the local level.[6] By adopting a new building code as strict as the one in the city of Los Angeles, an estimated 3,078 lives and $6.9 billion in property may be saved during a major earthquake.[7]

Industrial pollution also causes concern. In 1989, the World Meteorological Organization (WMO) confirmed that there was "clear evidence that human use of chlorofluorocarbons (CFCs, freons) had significantly affected the ozone layer over the globe."[8] (However, under a UN-brokered agreement called the Montreal Protocol, cooperating nations are phasing out the use of harmful CFCs. Nevertheless, increasing climate change increases the risk from severe weather, WMO predicted,[9] and global warming will result in greater and more frequent natural disasters.

Natural disasters are another, if not the greatest, concern. According to UN Disaster Relief Co-ordinator M'Hamed Essaafi, "The trend is quite clear. From the 1960s to the

---

6. Shelby County, Tennessee, includes the city of Memphis and is located along the New Madrid fault.

7. Robert Litan, Fredrick Krimgold, Karen Clark, and Jayant Khadilkar, *Physical Damage and Human Loss: The Economic Impact of Earthquake Mitigation Measures*, Boston: The Earthquake Project, 1992, p. 3.

8. Anne-Christine d'Adesky, "Preparing the World for Disaster," *UN Chronicle,* June 1991, p. 43.

9. Ibid.

1980s . . . there has been a fivefold increase in the frequency of great natural disasters, and a threefold increase in total economic losses.''[10]

10. Ibid.

CHAPTER 3

DISASTERS AND THE NEED FOR COMMUNICATIONS

The Need For Communications

> The good news is, you can prepare for catastrophes. The urgent news is, you *must* prepare.[11]

Planning and preparing for disasters takes time, but it is time well spent. Two key components in the process are knowing what is needed and planning for communications.

When communication is lost, the ability to coordinate rescue efforts, fight fires, evacuate areas in imminent danger, and marshal relief personnel is hindered. Immediately following a disaster, the ability to disseminate information is essential, particularly on the scope and severity of the damage, the number and types of casualties, and the relief effort required. Indeed, the first 24 hours after a natural disaster are the most critical for saving lives.[12]

Without communications, the effectiveness of the response effort is greatly impaired. Either responders do not know about the situation or do not know what other response measures have been taken. In the former case, nothing gets done and no aid is given,

---

11. Whitley, p. 10.

12. David Webster, "An Introduction with Four Proposals," *Communication When It's Needed Most*, Washington, D.C.: The Annenberg Washington Program, 1989, p. 5.

resulting either in an even bigger emergency or greater damages that could have been prevented. In the latter, confusion, chaos, duplication of efforts, and inefficient, even wasted, use of resources result.

Disaster Management

There are four stages of emergency management: 1) preparedness, 2) response, 3) recovery, and 4) mitigation. Because this paper is examining the use of various forms of disaster communications, we will only examine the first three stages. Disaster management coordinates the actions taken by all responding groups in each of these stages as they relate to the emergency phase. The first stage, before a disaster occurs, involves planning and preparation. The second stage, during a disaster, requires the immediate action by such groups as public safety agencies and the Red Cross. The third stage includes activities like providing continued relief and aid, assisting with recovery, and evaluating the effectiveness of activities undertaken in the first two stages.

The groups and organizations active in any of the three stages are widely varied, but they all have one common need: communications. Some of these groups include financial services, the general public, commercial institutions, disaster relief services, and disaster control services. Their specific requirements for communications may differ, but their main goals are to meet the needs of the affected area and return to normal as quickly as possible.

Disaster Control Services

The primary groups responding to a crisis are disaster control services, including public service agencies, forecasting services, privately and publicly funded transportation companies, and public utilities. All of these organizations play vital roles in responding to and assisting in recovery from catastrophic events.[13]

Public Service

The fire department, police department, sheriff's department, emergency medical services, and similar agencies constitute the public service group. Each group needs to be able to communicate with its control site and with other groups. Responsibilities include responding to and controlling the emergency, assessing property and land damage, rescuing and reporting on casualties, requisitioning and obtaining supplies, routing traffic, and requesting additional assistance.

Forecasting and Diagnostic Services

Groups that might be overlooked in their need for communications include forecasting and diagnostic services. Depending on the cause of the emergency, meteorologists, seismologists, or experts on the cause of the crisis need the capability to forecast similar occurrences. Experts knowledgeable about any potential aftereffects, such as aftershocks or flash floods, also need access to communications.

---

13. Art Feller, interview with author.

Transportation Companies and Agencies

Whether an event requires an evacuation of people from a dangerous area, a rescue operation, or simply coordination of the arrival and disbursement of supplies, those involved in transportation need the ability to communicate in order to effectively coordinate their actions.

Public Utilities

In almost every emergency, some area is affected by problems with public utilities, including phone, electric, and gas lines, and water and sewer mains. As a result, public utilities crews work around the clock to make repairs, in part to allay additional dangers such as broken gas lines that can cause fires or explosions. Therefore, all repair vehicles need to report to their control center on damages, traffic problems, and technical difficulties.

Disaster Relief Services

Finally, adequate communication is critical to disaster relief services, such as the Red Cross, the Federal Emergency Management Agency (FEMA), church groups, and any other organization that works directly with victims, assesses damage, and handles other aspects of victim assistance such as health and welfare inquiries (HWIs) or disaster welfare inquiries (DWIs) by the Red Cross).

The Public

Public information needs fall into three categories: 1) emergency-related information; 2) health and welfare inquiries; and 3) curiosity. The first is crucial and includes current weather information, announcements from the mayor or other high ranking officials, and emergency instructions; it is handled with one-way communications. The second, important but usually not life-threatening, can take a lower priority. The third should be lowest priority.

Financial Services

Not only must people be able to communicate with others, but machines must also be able to exchange information. "In today's information-intensive society, it is no exaggeration to regard telecommunications as the nation's economic life-blood."[14] Three of the more important groups in this area are financial institutions, commercial services, and special networks such as seismology and traffic-control networks.

Although not critical to the immediate crisis response, financial services and institutions need their communications links working as soon as possible. Frequently in an emergency, credit cards cannot be accepted as payment for goods, and cash becomes necessary. Therefore, banks must be able to restore commercial capital flow, which is also necessary for handling foreign capital inflow as well as health and welfare donations.

---

14. Kenneth L. Garret, "Statement," Subcommittee on Telecommunications and Finance Hearing on Telephone Outages, Washington, D.C., October 1, 1991, p. 2.

Commercial Services

Just like every other industry and workplace, commercial services are increasingly dependent on service-oriented networks to keep their businesses in operation. These services include water purification and air traffic control systems.

Special Networks

Other, miscellaneous networks can also be important in a crisis. These networks can include meteorological and seismological networks, and traffic-control, dam/flood-control, police-database, and prison-control systems.

Types of Communications

When an emergency arises, agencies establish an Emergency Operations Center (EOC), which is the command center for initiating major actions in response to the crisis. Centers are also established close to the disaster scene if the emergency is great enough. This procedure is followed by the primary agencies, specifically the public safety and disaster relief agencies. Together, these two groups manage the response to the situation.

The communications needs for these groups can be divided into four basic areas: 1) on-site—tactical communications; 2) intra-agency—between disaster site(s) and the EOC; 3) inter-agency—among involved agencies and the EOC; and 4) coordination among all groups,

such as police and fire.[15] Within these areas, communications operate on five levels: tactical, command, logistical, support, and health and welfare inquiries.[16]

On-Site Communications

On-site, or tactical, communication is the most vital link. Those at the disaster site have the responsibility to gather accurate information concerning the amount and kinds of damage; number, types, and names of casualties; and location of damages and casualties. The workers in the field must be able to maintain constant communication with those at the base site for their own and the safety of those they are trying to help, and to execute their duties as efficiently as possible.

Intra-Agency Communications

Those nearest the scene of the incident have the most accurate information. It is of great importance that they relay this information to the EOC effectively and efficiently. The EOC needs all the pieces from the disaster sites to "see the big picture" in order to efficiently direct the response. The EOC also needs to be able to supply the field site(s) with such information as the arrival time of supplies, the progress of the emergency (i.e., if the forest fire is moving dangerously close to their position) and when shift changes occur.

---

15. Drabek and Hoetmer, p. 63.

16. Feller, interview with author.

Inter-Agency Communications

Reports on and verifications of damages and casualties can be used to anticipate the amount and type of supplies that will be required. The EOC can then contact involved agencies to request supplies and determine distribution strategies.

Coordination

As the size of the situation and number of involved groups and individuals grows, coordination becomes increasingly important. A predesignated hierarchy of control and management must be followed to avoid confusion and chaos. Everyone involved in the response stage, i.e., disaster relief and disaster control agencies, must be familiar with this process. There must also be a plan that explains, step by step, the correct procedures and responsibilities of those involved. "To some extent, emergency communication follows planned guidelines, but . . . a disaster often calls for improvisation as well."[17] This coordination is key to successful emergency management, and communication is key to successful coordination.[18]

Definition of Disaster Communications

Although the communications used by all these groups can be termed "disaster communications," the focus of this paper is on the types of communications utilized by primary response and recovery groups, specifically, disaster control and relief agencies. In

---

17. Drabek and Hoetmer, p. 63.

18. Drabek and Hoetmer, p. 77.

other words, the means of communication and technology or equipment used by these groups are part of disaster communications.

CHAPTER 4

PROVIDING COMMUNICATIONS

Modes of Communication

Communications can be categorized by two basic modes: 1) voice, and 2) record communications. While voice communications can be recorded, if the information can be retrieved either in the original form or in exact duplication, it is considered record communications.

Voice

Audio communications, such as telephone and two-way radio, rely on the voice to transmit and the ear to receive the message. These messages are usually uncomplicated, faster, and easier to authenticate point of origin. Most people know how to use a phone and find it easier and quicker to speak than to write a message. Dialogue is possible, allowing for immediate verification of the message. Because voice recognition is also possible, the individual receiving the message can immediately determine who is making a request or giving an order and whether the individual carries the required authority.

Record

Record communications are those that are placed into a recorded medium and can be subdivided into two main forms: 1) image and 2) data. Image communications include videos and photographs; data communications include written forms and facsimiles.

"A picture is worth a thousand words" is an old but valid saying as well as one of the advantages of image communications. Viewing live video of a forest fire makes analysis easier than listening to or reading written communications from someone in the field. Even still shots of the scene can result in more accurate understanding of damage than written or voice verification. Thus, a response is often easier, faster, and more appropriate to the situation. Some applications include identification of the optimal spot to drop slurry during a wildfire, confirmation of the size of an area in which an event such as wildfire is occurring, and monitoring of a developing or potential problem such as a anti-war protest.

While data communications may be slower and more difficult, e.g., the time required to fill out a form, they still have several advantages over voice and image communications. There is always a written record verifying an order and the person authorizing it. Written communications contain fewer errors and more message clarity. (There is less chance of being misunderstood than there is with a quick voice request). Sometimes, as in the case of individual and drug names, written forms can actually make reception of and response to a message occur more quickly. Another major advantage to written communications, such as faxes, is that neither the transmitter nor the receiver must be interrupted from their immediate task to handle the message; both can respond when events permit. As a result, the message is not an intrusion that could cause further problems. Likewise, when it is handled, the message can receive full attention, reducing the chance of error and misunderstanding.

Means of Communication

In a disaster where prompt response is demanded, the method of communicating is as important as the type of the communication. The critical requirements of technology chosen to provide communications are:

1. rapid deployment to a distressed area;
2. easy setup and operation capability;
3. provision of at least voice and data services to the Emergency Operations Center, so that the disaster control agency or relief organization can quickly disseminate the information.[19]

There are two basic categories of communication: wire-based and radio-based. Wire-based communications generally involve the telephone system; radio-based communications cover systems like two-way radios and satellites. Based on the three requirements, radio-based communications are the appropriate choice. "Radio has the advantages of portability, availability, and versatility. Battery-powered radios are not susceptible to downed wires, loss of power, damage to switching stations, or inundation of switchboards."[20] For these reasons, public safety agencies and disaster relief organizations generally rely on radio communications.

The two primary modes of radio communications are AM (amplitude modulation) and FM (frequency modulation). AM adds information to a carrier wave by systematically altering, or modulating, the amplitude, of the carrier wave. The resulting frequencies, known

---

19. David Robert Glenn, *Low Earth Orbit Satellites for Disaster Relief Communications,* Master's Thesis, University of Colorado, 1992, p. 4.

20. *Communication When It's Needed Most,* p. 9.

as sidebands, are "symmetrically spaced above and below the carrier."[21] In standard AM, both sidebands are transmitted. In single-sideband AM (AM-SSB), only one band is transmitted. The carrier itself is suppressed in both cases, thus utilizing less bandwidth.

FM adds information to a carrier wave by modulating the frequency of the wave. Unlike AM, FM requires the transmission of the carrier and is, therefore, more bandwidth intensive than AM. Its main advantages over AM are its high fidelity and its relative insusceptibility to electrical noise interferences due to a high signal-to-noise ratio. Thus, FM in the VHF (very high frequency) spectrum is the most commonly used mode in radio communications, including amateur radio, and is preferred for tactical communications.[22]

Three types of wireless, or radio-based, communication systems are currently in use—satellites, cellular telephones, and terrestrial two-way radios. These systems are discussed in more detail in Chapters 6 and 7.

Issues Involved

Personnel

Communication, particularly disaster communication, involves several personnel considerations, particularly the size of the workforce needed. The number of workers and their availability are important when dealing with volunteers. In addition, the level of expertise of each worker is as significant as their training in both communications operations and disaster planning.

---

21. Harry Newton, *Newton's Telecom Dictionary,* New York: Telecom Library, Inc., 1991, p. 575.

22. Allen Mottershead, "Radio," *On-Line Encyclopedia,* Denver: Colorado Alliance of Research Libraries (CARL), 1993.

Technological

Deciding on the technology for providing communications in a disaster requires considering more than just the method of delivery. For instance, are the equipment resources required to operate the communications system available? Are the allocation and availability of the spectrum sufficient? What about interoperability among systems and equipment used by different groups and agencies? "How well the communications system will work depends upon how it interlinks. During the Mount St. Helens operation (and in many foreign disasters), a major problem was the inability of different systems to communicate with one another. The Washington State Police, for example, couldn't talk to the National Guard."[23]

Regulatory

Systems must follow established regulatory guidelines in order to ensure better coordination and cooperation among involved groups. The FCC governs several issues surrounding communications in the United States, including spectrum allocations, licensing, regulations on their use, and guidelines on coordination of relief efforts among all agencies and organizations, both public and private.

Policy

The two primary policy issues for disaster response agencies are 1) having a current known and operable plan for each potential disaster that could affect the community, and 2)

---

23. *Communication When It's Needed Most*, p, 9.

having an understanding, preferably written, between an agency and each organization with which it interacts. Liability and task assignment issues must be addressed in the disaster plan(s), including an established chain of command, points of contact, and detailed, procedural instructions on responding to an event.

A memorandum of understanding (MOU) is an agreed-upon written plan detailing the interaction among the different agencies and individuals. It includes logistical concerns and legal issues relating to the commitments of each party, such as:

- assigned equipment use for each task,
- insurance,
- responsibility for maintaining operability of the systems, and
- command and authority.

Internal policy is "the structure and mission of the . . . organization, i.e., how is the . . . agency structured to obtain and disseminate information."[24] External policy can be defined as "the political will to coordinate."[25]

Financial

Cost-effectiveness is always an issue—and usually one of the greatest concerns.

> Developers of high-tech emergency communications systems must keep in mind the cost of equipment and the time required to get it in place. Especially, those relief agencies that depend on public contributions must pay attention to cost-effectiveness. If, for example, it takes 24 hours—including truck or helicopter transportation—to get a satellite uplink into place and set up, is the uplink's cost justified? This question is

---

24. Glenn, p. 5.

25. *Communication When It's Needed Most*, p, 21.

> critical, especially if less sophisticated systems could handle the immediate emergency.[26]

The costs of equipment purchase, maintenance, upgrade, and operation should be considered. Personnel costs, including set up and operation, must also be calculated as well as miscellaneous expenses such as the cost of transporting equipment and the time required to set up and operate the system. To be viable, the communications system, including skilled personnel, must be affordable.

---

26. *Communication When It's Needed Most*, p, 19.

CHAPTER 5

PRIMARY DISASTER SERVICES COMMUNICATIONS SYSTEMS

The most obvious means of communication in a disaster is the primary system owned by the disaster management agency. This chapter will discuss the Mile High Chapter and the Washington, D.C., metro area Chapters of the American Red Cross and the Boulder (Colorado) Regional Communications Center (BRCC).

The Mile High Chapter of the American Red Cross

The Mile High Chapter has 80 paid staff and 3,000 volunteers. The chapter is responsible for providing services to two million people in seven counties, including Boulder County.

The communications system owned by the chapter has two parts: 1) an FM mobile radio system, and 2) cellular phones.[27] With eight cellular phones, a maximum of eight simultaneous phone conversations can take place. In Boulder, the cellular phones are the only equipment that are funded, although cost is still an issue. While useful for small-scale emergencies, cellular can quickly become inoperable in a larger-scale disaster. These and other limitations of the cellular phone system are discussed in Chapter 6.

The FM system consists of a radio in each Red Cross vehicle and one in each of the six branch offices. Each radio has two channels, which are assigned by the FCC on a national

---

27. Since pagers are incapable of two-way communications and require an additional line of communication, they are not included in this discussion.

level and are restricted to Red Cross use. Although both are available to the Red Cross in a disaster, one channel is for general use, e.g., dispatch communications, and the other is exclusively for disaster communications. A maximum of two radio conversations can take place at any given time, and the chapter has no data communications capabilities on this system. Also, the radios are mobile but not portable—they do not leave the vehicle. This restricts communications only to places reachable by vehicle.

Also, no interoperability of this system currently exists with other agencies, such as police and fire, on the assigned frequencies. Such communications must occur via cellular, if it is available, or some other system.

The Washington, D.C., Metropolitan American Red Cross Chapters

Several chapters cover the metropolitan Washington, D.C., area and have varying numbers of staff and volunteers. For example, the Arlington Chapter has no paid staff and 16 volunteers. The National Capitol Chapter has 63 paid staff and 72 emergency services volunteers.

The communications systems in metro Washington are much the same as those used by the Mile High Chapter in Denver. The Arlington Chapter has an FM radio system with four mobile units and two hand-held units. The FM radio system used by the National Capitol Chapter has eight mobile radios.

The Boulder Regional Communications Center

The Boulder Regional Communications Center (BRCC) coordinates communications among the police, sheriff, and fire departments. The BRCC provides communications for 45 different public safety agencies; of these, approximately 30 are volunteer groups. The center handles all 911 emergency calls made in Boulder County except for the city of Longmont and the University of Colorado at Boulder, both of which have their own public safety departments.

The BRCC has several voice communication options, including a VHF FM two-way radio system as well as cellular and Improved Mobile Telephone Service (IMTS) phones. The two-way radio system includes mobile and portable radios that operate on four assigned frequencies for primary law enforcement communications and four frequencies for fire communications; they also have access to other frequencies if necessary. IMTS is a commercial VHF wireless phone system, which is a predecessor to today's cellular system. Although lacking the high fidelity of cellular, it provides better extended coverage in mountainous regions.[28]

All of these systems offer voice communications only. The sole data communications option is a single portable facsimile machine that is dependent upon the operational status of both the cellular and wireline phone systems.

The BRCC also employs a mobile communications van, which carries the IMTS mobile phone, cellular phones, and two-way voice radio. Additional equipment in the van is owned and operated by BCARES (Boulder County Amateur Radio Emergency Service)—the amateur

---

28. Don Schaffer, interview with author.

radio group that assists with emergency communications—and includes a TV receiver and packet and voice stations.

CHAPTER 6

SUPPLEMENTARY COMMERCIAL COMMUNICATIONS SYSTEMS

The Cellular Phone System

Introduction

Cellular has been in existence since the early 1980s and is growing in popularity. The technology is easy to use and available in nearly all metropolitan areas. Cellular phones are available in three forms: mobile, portable, or transportable. Mobile phones operate from within a car while portable phones can be hand-carried. Transportable phones are a hybrid of mobile and portable phones. In each case, "the power and range of the unit are inversely proportional to the portability."[29]

A Cellular Geographical Service Area (CGSA) is constructed as a grid of "cells." Each cell has a base station that can handle approximately 96 phones.[30] A cellular phone establishes a two-way radio link with the base station; the base station connects it to the Mobile Telephone Switching Office (MTSO). The MTSO "controls call signaling and processing, and coordinates the hand-over of the mobile connection from one base station to another as the mobile roams around."[31] The MTSO then connects the call into the Public Switched Telephone Network (PSTN) or to another cellular phone. Figure 6-1 diagrams the

---

29. Daniel Briere, "Cellular Service Options Merit Close User Scrutiny," *Network World,* (January 15, 1991):1.

30. Richard Chandler, *Cellular and Wireless Communications*, Class lecture, June 25, 1992.

31. Moe Rahnema, "Overview of the GSM System and Protocol Architecture," *IEEE Communications Magazine,* 31 (April 1993):93.

general structure of a cellular system. Figure 6-2 shows the various points at which the MTSO can gain access into the PSTN.

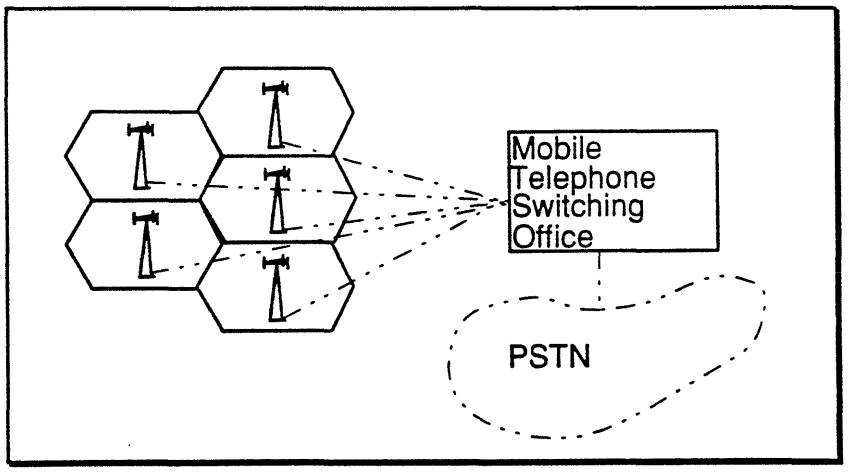

Figure 6-1[32]
Cellular Structure

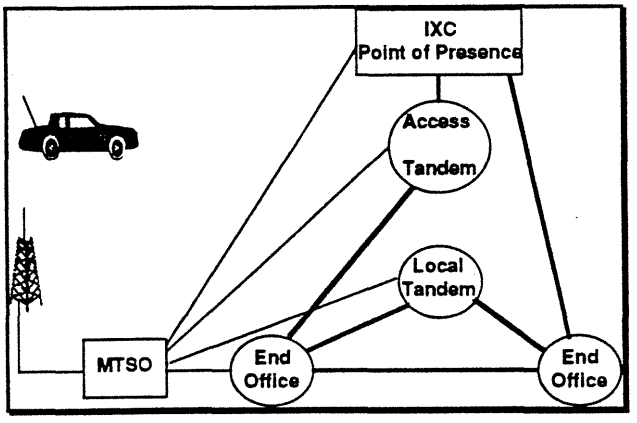

Figure 6-2[33]
Mobile Service Interconnection[34]

---

32. George Calhoun, *Digital Cellular Radio,* Norwood, MA: Artech House, 1988, p. 99.

33. "BOC Notes on LEC Networks - 1990: Mobile Services Interconnection," *Bellcore*. SR-TSV-002275, Issue 1 (March 1991):16-4.

34. IXC: Interexchange Carrier, such as AT&T, Sprint, and MCI.

At first glance, cellular seems an ideal communications system for disaster situations. However, upon closer examination, several technical and financial problems present themselves.

Drawbacks

Cellular functions as a wireless link into the public switched telephone system. While this can allow remote access into the phone system, it is dependent upon the condition of the wireline system. If the system is either damaged by the disaster or overloaded with calls from the public in response to an event, a mobile phone cannot provide access.

The cellular phone system can operate without the wireline system. However, there are substantial limits to its usability. When links are made between two mobile units, each unit occupies a channel of the two-way link, thus occupying two available channels. If all conversations are mobile to mobile, the system capacity is reduced by half—both an inefficient use of spectrum and very impractical.

The limited coverage of the cellular phone system is another drawback. While cell sites are increasing in number, coverage is still limited. Not only does blanket coverage not exist across the entire country, but cellular coverage is also limited even within areas where service is provided. A Cellular Geographical Service Area (CGSA) does not necessarily cover 100% of the FCC-defined market boundaries.[35] There is no guarantee that a disaster will only strike in a location that has cellular coverage.

---

35. Chandler, Class notes, June 25, 1992.

Making a call from a cellular phone costs more than a call from a wireline phone. The "Occasional" CellularOne package offered in Colorado costs $40 per month and includes 50 minutes of usage. The charge for each additional minute is 49¢ during peak calling times and 25¢ during off-peak times.[36]

Commercial Satellite Systems

Current Systems

Commercial satellite systems are considered by some to be the solution to communications needs, including disaster communications. Satellites allow communications to bypass the local phone system completely. (See Figure 6-3 for the basic structure of a satellite system.)

Most current systems are either very small aperture terminal (VSAT) or Inmarsat. VSATs have been in existence since the mid-1980s, are widely used, and are capable of voice, data, and video communications. They also have transportable remote terminals that make transportation and setup relatively easy.[37] However, the time required to transport and setup the system is a disadvantage, as is the cost of the system, which requires a terminal and hub, and payment for access charges.[38]

Inmarsat is also capable of voice, data, and video communications as well as facsimile transmission and electronic mail.[39] It also provides transportable terminal stations and is

---

36. CellularOne price listing, Colorado, October 1993.

37. Glenn, p. 51.

38. Glenn, p. 54.

39. Glenn, p. 55.

globally available. Access charges have dropped from $10/minute to $6.50/minute since 1979.[40] However, as with VSATs, the main drawback lies in the time required to deploy a terminal station.[41]

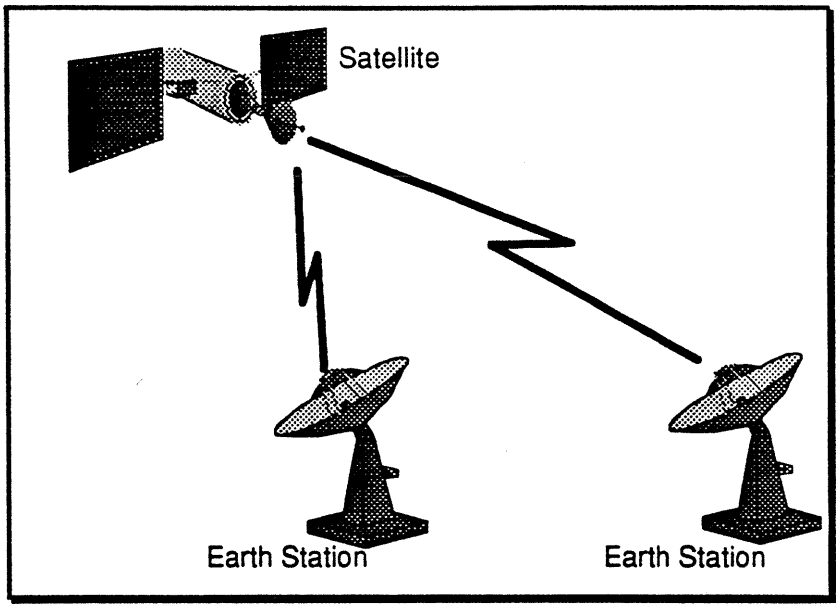

Figure 6-3[42]
Basic Satellite Interconnectivity

Proposed

The satellites of these two systems are in geosynchronous orbit, that is, traveling at the same speed as the earth's rotation and therefore remaining in the same position relative to the earth. Systems using a Low Earth Orbit (LEO) are currently under consideration. These

---

40. Glenn, p. 56.

41. Glenn, p. 57.

42. Steven W. Sweeney and Frank S. Zimmerman, "Satellite Communications Disaster Recovery," *Telecommunications* 22 (February 1988):88.

LEOs have the advantages of requiring lower transmitter power and possessing a smaller mobile unit antenna due to the satellites' closer proximity to earth,[43] both of which contribute to the development of smaller hand-held units.[44] While these satellite systems do have technical potential, several regulatory and financial issues must be addressed before implementation. The major players in the development of these LEO systems include Motorola's Iridium, Loral/Qualcomm's GlobalStar, Ellipsat's Ellipso, TRW's Odyssey, and Constellation Communications' Aries.[45]

There is no denying the potential of LEO satellite systems as disaster communications providers. "These systems will provide instantaneous, global voice and data services in a small, easily transported unit, allowing rescue and relief workers access to needed information anywhere in the world."[46] However, these systems are years away and none has received approval and licensing from the Federal Communications Commission.[47]

---

43. Glenn, p. 7.

44. Glenn, p. 8.

45. Ibid.

46. Glenn, p. 107.

47. For more specific information on commercial Low Earth Orbit satellites systems, see Glenn, David Robert. *Low Earth Orbit Satellites for Disaster Relief Communications*. Master's Thesis, University of Colorado, 1992.

CHAPTER 7

AMATEUR RADIO

Introduction

Amateur radio is the hobby of ''amateurs'' or ''hams.'' Amateur radio operators are licensed individuals involved in all aspects of radio communications, including ''self-training, intercommunication and technical investigations,'' but who receive no monetary compensation.[48] Some of their activities include ''DXing,'' or communicating with people across long distances; experimenting with the latest radio and communications technologies, such as satellites and amateur television (ATV); building their own equipment; and inventing new techniques and technologies, such as moonbounce, which bounces a radio signal off the moon.

In addition, many hams are dedicated to public service. ''Public service has been a ham tradition since the very beginning.''[49] Hams all across the country and around the world are always quick to respond when an opportunity to provide assistance arises, such as for a community-sponsored marathon or bike race, a hospital experiencing a communication

---

48. Jim Kearman, et al., editors, *Now You're Talking! Discover the World of Ham Radio,* Newington, Connecticut: American Radio Relay League, 1991, pp. 2-4.

49. Kearman, pp. 1-6.

system failure, a motor-vehicle accident, severe-weather spotting, a flood, a hurricane, or a fire. In addition, hams provided assistance in response to the:

- **Mexico City earthquake, September 1985:** Amateur radio communications were the only link in some locations, particularly rural areas.[50]
- **Hurricane Hugo, September 1989:** "Through volunteer amateur radio networks, shipments of relief and medical supplies were coordinated . . . Amateur radio 'jump teams' even sped to the affected areas to help restore communications."[51]
- **Loma Prieta earthquake, October 1989:** Hams handled health and welfare inquiries about victims.[52]
- **Old Stage Road Fire, October 1990:** Hams, with amateur television capability, transmitted live video of this wildfire in Boulder County to the communications center.[53]
- **Texas Flood, December 1991:** Amateur radio operators provided personal equipment to coordinate communications between the responding agencies.[54]

Provisions

There are many components to successful disaster communications, all of which fall into the five basic categories of issues discussed in Chapter 4:

1. personnel,
2. technological,
3. regulatory,
4. policy, and
5. financial.

---

50. Ibid.

51. Ibid.

52. Juanita Lewis, interview with author.

53. BCARES ATV video of recent events.

54. O. Wolf and J. Wolf, "Radio Amateurs Help in Texas Flood Relief," *QST*, LXXVI, 4 (April 1992):79.

Amateur radio, recognized by many disaster organizations for providing communications in disasters, readily lends itself to service for several reasons.

Personnel

Operators should possess skills in basic radio communications and operations as well as disaster communications and operations, availability, and other issues that are volunteer-related. In most cases, amateur radio operators are well qualified to handle disaster communications: they are skilled in communicating, operating radios, and working with equipment, and are also often skilled in disaster communications. In addition, they can be found in every region of the country.

Most hams know how to relay messages succinctly, accurately, and in a timely manner. "Amateur radio operators recognize their responsibility to provide these public service communications. They train in various ways to be effective communicators in times of trouble."[55] They gain this training through personal experience, from other hams, in group activities and contests designed to test their operating skills and ingenuity, and through practice exercises dealing with emergency communications.

This field of interest covers more than just operating a radio. All hams have a license assigned by the Federal Communications Commission (FCC) to operate. In order to obtain a license, an applicant must demonstrate basic knowledge in several areas, including regulation, radio theory, electrical components and circuits, antennas, and operating information. There are five classes of amateur operating licenses: novice, technician, general,

---

55. Kearman, p. 1-5.

advanced, and amateur extra. The requirements and privileges associated with each are shown in Table 7-1 and Figure 7-1.

There are two options to become a licensed amateur radio operator. The first option is to become a novice by passing a written exam and code test. The exam covers basic radio theory and regulations; the code test requires correctly receiving/transcribing a transmission of Morse code at a rate of five words per minute. The second is to obtain a ''technician-no code'' license, which requires passing two written exams, but no code test. The first exam is the same as the one for the novice license. The second, more comprehensive, exam covers radio theory and regulations in more detail.

Table 7-1[56]

AMATEUR RADIO OPERATOR LICENSES

Class	*Code Test*	*Written Examination*	*Privileges*
Novice	5 WPM (Element 1A)	Novice theory and regulations (Element 2)*	Telegraphy on 3675-3725, 7100-7150 and 21,100-21,200 kHz with 200 watts PEP output maximum; telegraphy, RTTY and data on 28,100-28,300 kHz and telegraphy and SSB voice on 28,300-28,500 kHz with 200 W PEP max; all amateur modes authorized on 222.1-223.91 MHz, 25 W PEP max; all amateur modes authorized on 1270-1295 MHz, 5 W PEP max.
Technician		Novice theory and regulations; Technician-level theory and regulations. (Elements 2 and 3A)**	All amateur privileges above 50.0 MHz. Technician-class licensees who have passed a 5-WPM code test also have HF Novice privileges.
General	13 WPM (Element 1B)	Novice theory and regulations; Technician and General theory and regulations. (Elements 2, 3A, and 3B)	All amateur privileges except those reserved for Advanced and Advanced Extra class; see Table 7-2.
Advanced	13 WPM (Element 1B)	All lower exam elements, plus Advanced theory. (Elements 2, 3A, 3B, and 4A)	All amateur privileges except those reserved for Advanced Extra class; see Table 7-2.
Amateur Extra	20 WPM (Element 1C)	All lower exam elements, plus Extra-class theory. (Elements 2, 3A, 3B, 4A and 4B)	All amateur privileges.

* A licensed radio amateur will be required to pass only those elements that are not included in the examination for the amateur license currently held.

** If an operator holds a valid technician class license issued before March 21, 1987, he or she also has credit for Element 3B, but must be able to prove the technician license was issued before March 21, 1987.

56. Kearman, pp. 2-7, 2-8.

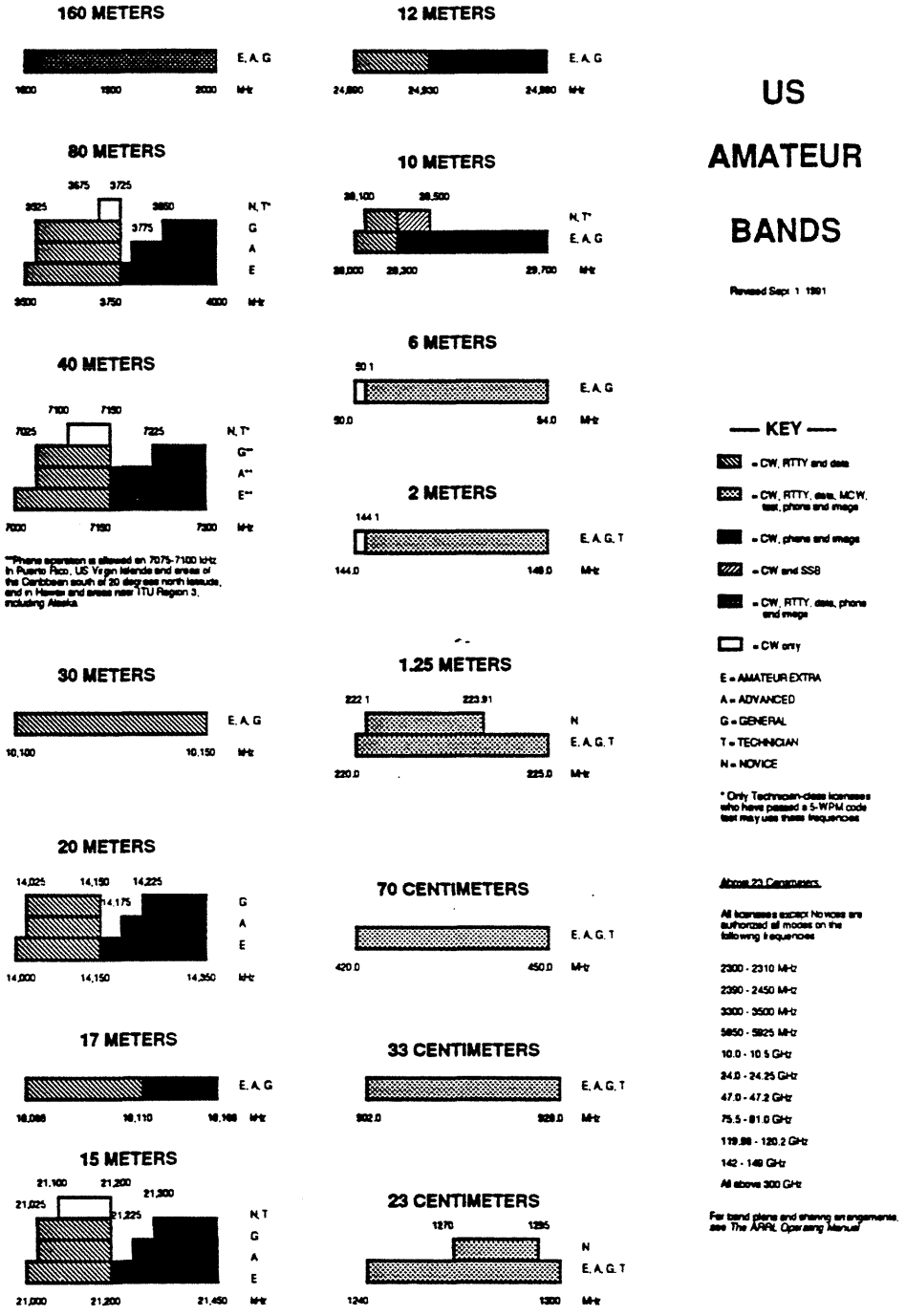

Figure 7-1[57]
U.S. Amateur Frequency Allocations

57. Kearman, pp. 2-7, 2-8.

Because this is their hobby, hams tend to spend time improving their skills. Also, since many enjoy experimenting with and even building their own equipment, they are usually quite adept at identifying and fixing problems.

Although the licensing procedure is standardized, the term "ham" does not guarantee skill level. Amateur radio allows for many diverse interests; thus, different hams are experienced in different areas. Also, as with most areas, those new to amateur radio or not very active in it are not as experienced as those who have dedicated many hours to their hobby. Having individuals skilled in different areas can be beneficial, but variability in quality of skills can also present problems, particularly for a responding agency. If those requiring communications assistance are not familiar with the hams in their area, they can make inaccurate assumptions about what services hams are able to provide.

There are an estimated 600,000 ham operators in the United States. Therefore, a communicator can be on the scene of an emergency in a relatively short period of time. They often provide long-term support as well. However, hams are volunteers. In several cases, the opportunity to be of public service influences many to become hams. On the other hand, they are not paid and are therefore not required to be present. Consequently, it is difficult to count on specific numbers of volunteers in a crisis. Also, ham radio support can be difficult if many of the operators are personally affected by the crisis. In Ellicot City, Maryland, the Howard County Office of Civil Defense arranged beforehand for local hams to assist in an emergency. However, when Hurricane Agnes struck in 1972, none were available because they were dealing with their own emergencies.[58]

---

58. Art Feller, interview with author.

Technological

There are several aspects of amateur radio technology that make it ideal for emergency communications, including frequency availability; equipment interoperability, portability, and availability; voice, data, and video transmission capability; and satellite as well as terrestrial communication link availability.

Spectrum

Frequencies are the ''wires'' or conduits for wireless communications. Because the spectrum is finite, frequency allocation is an important issue. The International Telecommunications Union (ITU) allocates spectrum on an international basis. The FCC then makes national assignments. Both groups recognize the importance of amateur radio—a major reason amateur radio still has its spectrum allotments.

The frequency bands presently allocated for amateur radio span the spectrum, including HF, VHF, and UHF. These frequency bands are summarized in Table 7-2. Using these channels greatly increases the number of frequencies available for communications, and thus, increases communications capability by decreasing the overloading of the agencies' channels.

Systems

Voice communications. The most popular method of disaster communications is voice. It is more practical, easier, and faster in many cases than record communications. However, voice-only communications are often not the best or most efficient. As described in Chapter 4, the optimal disaster communications system includes data and image capabilities as well as voice. Most

agencies have only voice capabilities for disaster communications, but amateur radio can, in addition to voice, provide data and video and images.

Data communications. There is a growing movement to switch from analog to digital transmissions. With analog transmissions, noise and distortion accumulate and increase as distance and the number of amplifiers and relays increase. This does not occur with digital transmissions because digital signals are regenerated, not just repeated, at each link.

The obvious advantage of this technology is data communication, transmitted by packet radio, which can offer many benefits to disaster communications. It is capable of very fast, error-free transmission of large amounts of data, facilitating the generation of messages in hardcopy form. It makes efficient use of the spectrum and even works under noisy conditions. The typical setup for this wireless communications system includes a computer (or dumb terminal and keyboard), a transceiver (radio), and a terminal node controller (TNC) (see Figure 7-2).

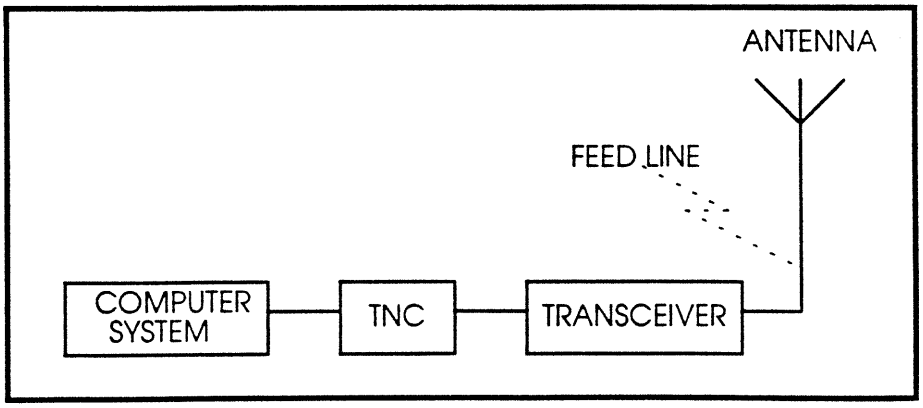

Figure 7-2[59]
A Typical Packet Radio Station

59. Kearman, p. 5-5.

The TNC interfaces between the computer and the radio and acts, in essence, as an intelligent modem because it breaks the data from the computer into small portions and adds address, error-checking, and control information to each portion, thus creating packets. These packets are then transmitted to another computer.

Packet stations can establish a direct connection with each other, or many stations can connect into a bulletin board system. When more than two stations are involved in communications operations, a bulletin board system is the best option. Using the direct connect method requires connecting and disconnecting every time a message needs to be sent. The use of a bulletin board system eliminates this need, allowing each station to send a message to any other connected station.

Packet radio can also transmit messages over long distances by linking together multiple stations or bulletin boards. Amateurs are presently working toward the development of a global packet network using this method.[60]

Image communications. In this global network, image, data, and voice communications are under development. Yet, image communications capability already exists in amateur radio. Presently, hams are active with three different image systems:

1) *Fast-scan television (FSTV)*: moving pictures are displayed on a standard TV set, and sound is included. Its performance is similar to commercial broadcast TV pictures and is used predominately in the UHF bands (70 and 23 cm) to provide local area coverage. This is also known as ATV, or amateur TV. (See Figure 7-3 for the basic setup.)

2) *Slow-scan television (SSTV)*: low-resolution still pictures are displayed on a standard TV set. Used in the HF bands, it provides worldwide coverage.

---

60. Kirk A. Kleinschmidt, ed., *The ARRL Handbook for the Radio Amateur*, Newington, Connecticut: American Radio Relay League, 1990, pp. 19-23.

3) *Facsimile (fax)*: A high-resolution still picture produced on paper or photographic film is used for weather-satellite reception and in the HF bands to provide worldwide coverage.[61]

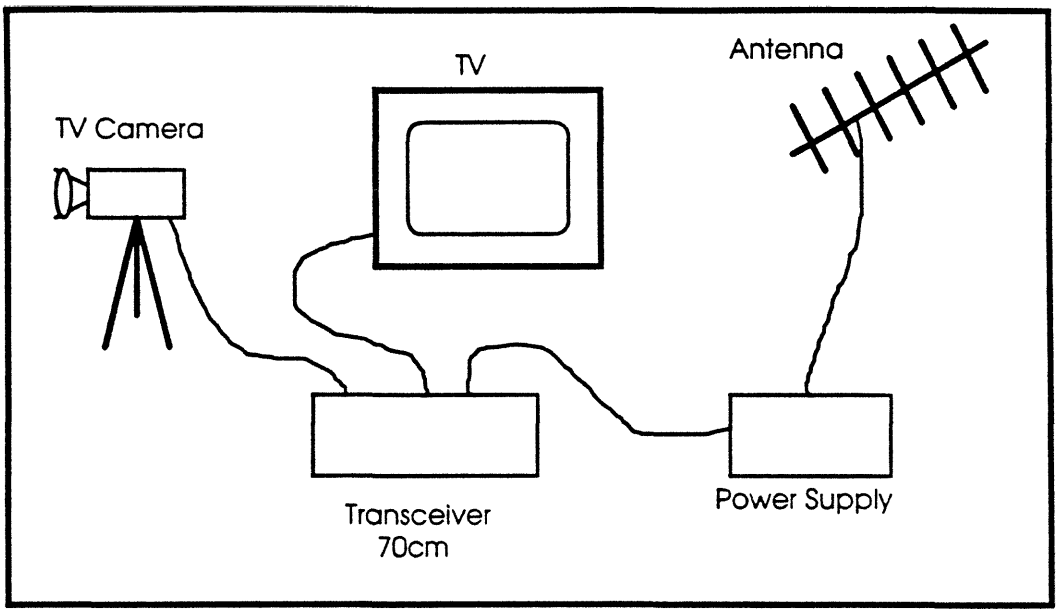

Figure 7-3[62]
A Typical Amateur TV Station

Video compression is a major component in the development of high quality video transmissions. Broadcast-quality video requires a minimum bit rate of 10 Mbps. In comparison, high-quality stereo sound only requires 1.4 Mbps. With the limited availability of spectrum, these data requirements illustrate the need for video compression.

---

61. Kleinschmidt, p. 20-1.

62. Ralph E. Taggert, "An Introduction to Amateur Television: Part 2—The Basic ATV Station," *QST*, LXXVII, 5 (May 1993):43.

There are several algorithms being developed for achieving acceptable levels of video data compression, with their compression ratios ranging from 20:1 to 100:1.[63] Because of the work currently underway in this field, the capability for improved video communications is increasing.

Radio Communication Links

Two types of wireless links exist: terrestrial and satellite. Terrestrial links are point-to-point communications, possibly through a repeater. A satellite link is between two earth-bound transceivers through a satellite. Most amateur communications are through terrestrial links because of their availability, simplicity, and applicability.

The number of ham radios that can communicate via terrestrial links far exceeds that for amateur satellite communications. Also, the repeaters and radios are, for the most part, stationary and readily available; satellites, by nature, are not.

Communicating via a terrestrial link is much simpler than communicating via satellite. With satellites, the operator must point the receiving antenna in the correct direction; use the proper monitoring frequency; insure that sufficient receiving power is available; and operate at the proper time in order to be effective. However, amateur radio enthusiasts enjoy a challenge, and many are part of AmSat, the Amateur Radio Satellites Corporation. Several satellites known as OSCARs (Orbiting Satellite Carrying Amateur Radio) are in orbit. Nevertheless, many hams familiar with this technology will be quick to say that satellites

---

63. Peng H. Ang, Peter A. Ruetz, and David Auld, "Video Compression Makes Big Gains," *IEEE Spectrum* 28, 10 (October 1991):16-17.

have no place in emergency communications because of their limited availability and operational difficulties.

The only viable application for OSCARs in emergencies is in data communications. As a store-and-forward system, satellites can be used as part of a worldwide message-handling network, where messages from one location are transmitted to satellite, and then from there to another location when it comes into range. This system can be used for health and welfare inquiries (HWIs) and other nonessential communications, but is not feasible for real-time communications. A summary of the pros and cons of satellites for emergency communications is shown in Table 7-2.

Table 7-2[64]
Satellites in Public Service Communications

Item	*Advantage*	*Disadvantage*
Availability	If the bird is visible, it's usable Not affected by propagation conditions	Must be in operating mode compatible with earth stations
Emergency power	Satellites are always on "emergency power" (battery operation)	Limited by level of activity and solar charging windows
Emergency net linking	Alternate to terrestrial repeater links	Requires available satellite station and gateway in affected areas
Signal levels/quality of communication links	Link-signal in excess of 10dB easily achieved with current technology	Low elevation angles to satellite can degrade S/N

64. Bill Burden, "Amateur Satellites as a Resource for Public Service Communications," *QST* LXXVI, 4 (April 1992):78.

Nevertheless, as with many rules, there are exceptions. In New Hampshire, for example, due to the terrain, terrestrial links cannot be made between two emergency nets and thus satellites are being tested. By using a satellite as a gateway between the Nashua Area Radio Club (NARC) emergency net and the New Hampshire Office of Emergency Management in Concord, messages can be relayed between the two locations and the repeaters can remain available for tactical communications.[65]

Equipment

One of the major advantages of amateur radio equipment is its portability. While the majority of hams have "shacks" with stationary systems, the majority also have portable or mobile equipment, which can include all the electronics components necessary to have an operable communications station. The basic voice station consists of a transceiver and an antenna. A packet station has, in addition, a computer and a terminal node controller. (See Figure 7-2.) Components of an ATV station include a transmitter, video camera, antenna, and receiver (see Figure 7-3.) A repeater can be included as part of any of these systems. All of these components can be taken to and operated from almost anywhere.

A power supply is required for any electronic equipment to operate (either AC or DC). Most ham equipment is capable of running off basic, or alternating, current (AC) of 120 volts. However, ham radio was developed to be portable, and it is standard procedure to power a station with an alternate power source. Therefore, most hams know how to power

---

65. Burden, pp. 78-79.

their equipment from a car battery, gel battery, generator, or other DC power supply, such as windmills or solar panels.

Amateur radio also offers equipment that is interoperable, that is, works on various frequencies. Each disaster control and relief agency has its own assigned frequencies and equipment, and there is a wider range of frequencies allocated for amateur radio. Additionally, both data and voice communications are interoperable.

Regardless of the usefulness of the communication equipment, to be of any value it must be available when and where needed. Amateur radio communications systems are readily available almost anywhere, particularly in North America. Every ham, with very few exceptions, owns and operates a portable two-way radio, also called an HT (''handi-talkie'') that operates on VHF FM. There is also an abundance of repeaters, which facilitate better and longer distance communications and are capable of patching into the phone system. There are 118 two-meter (144-148 Mhz VHF FM) repeaters in Colorado, with seven in Boulder County and 28 in Denver County.[66]

Potential problems include lack of systems capabilities in a given area, lack of coverage, and fewer hams than necessary to achieve a viable communications system. Lack of systems capabilities occurs when not all the available amateur radio systems are in use by hams in a given locale. If the area government sees a need for an unavailable system, then its procurement becomes a policy issue regarding funding, maintenance, operation, etc.

Lack of coverage can result from several things. With HF communications, atmospheric conditions may make reliable communications impossible. However, this is not the case with

---

66. *ARRL Repeater Directory*, 1993-94, pp. 112-115.

VHF FM, the primary mode of communications. With this method, problems are more likely to result from either not enough repeaters and transceivers in a given area to provide adequate coverage (i.e., a limited number of hams in the area), or the geographical characteristics of the area could inhibit direct line-of-sight communications, such as in a mountainous region. This problem may be solved by placing repeaters in locations high enough to provide coverage or using other types of communications systems. As mentioned earlier, local amateurs in New Hampshire turned to satellite technology.[67]

Regulatory

In 1901, Guglielmo Marconi listened to a wireless transmission of Morse code across the Atlantic—the product of years of experimentation. As a result, many electrical hobbyists attempted to duplicate his feat, building their own wireless equipment and experimenting with wireless communications. They became the first hams.

Widespread interest in this wireless, or radio, communications technique, brought about in 1927 the creation of the Federal Radio Commission by Congress to "unravel the confusion and assign specific frequencies for specific uses."[68] Realizing the potential of amateurs, they assigned several frequency bands specifically to amateur radio. The Federal Communications Act of 1934 established the Federal Communications Commission (FCC) as the successor to the Federal Radio Commission.[69] The FCC, in recognition of amateur

---

67. Burden, pp. 78-79.

68. Kearman, pp. 1-5.

69. M.D. Paglin, ed., "A Legislative History of the Communications Act of 1934," *On-Line Encyclopedia*, Denver: Colorado Alliance of Research Libraries (CARL), 1990.

radio, directly addresses amateur service in Part 97 of its Rules. In Section 97.1, the purpose of amateur service is summarized in five principles, listed in Figure 7-4.

Figure 7-4
The Five Principles

1. Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

2. Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

3. Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.

4. Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

5. Continuation and extension of the amateur's unique ability to enhance international goodwill.[70]

Of primary interest is Principle #1, with the emphasis on the phrase "*particularly with respect to providing emergency communications.*[71] Thus, according to the governing body of U.S. amateur radio, one of its primary purposes is providing emergency communications.

Within the amateur radio service are two groups created specifically to further the utilization of amateur radio in disaster communications: Radio Amateur Civil Emergency Service (RACES) and Amateur Radio Emergency Service (ARES). RACES was chartered by the government; ARES was chartered by amateurs. RACES was created by the FCC to

---

70. Part 97.1, FCC Regulations.

71. Part 97.1, FCC Regulations.

provide communications for civil defense purposes as specified in Principle #3. At that time, the term "civil defense" generally applied to times of war. However, the term is now expanded to apply to any occasion of "local, regional or national civil emergencies . . . defined in section 97.407 of the FCC regulations."[72] RACES is governed by the Federal Emergency Management Agency or a local government's office of emergency management.

The Amateur Radio Relay League (ARRL) was founded in 1914. Located in Connecticut but involved in both international and national matters, the league "operates strictly as a nonprofit, educational and scientific organization dedicated to the promotion and protection of the privileges that ham operators enjoy."[73] To better address the needs and requirements of providing good emergency communications, the ARRL created the Amateur Radio Emergency Service (ARES) in 1914. ARES consists of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service when disaster strikes. Usually ARRL charters ARES groups on the local level.

Each local ARES group is headed by an emergency coordinator (EC). The responsibilities of the local EC include the following:

- Manage and coordinate the training, organization, and emergency participation of interested amateurs.
- Establish an emergency communications plan for the community that will effectively support the city agencies.
- Establish a viable working relationship with the city government and all private agencies operating within a city.

---

72. Kearman, p. 2-22.

73. Kleinschmidt, pp. 1-4.

- Establish local communications networks run on a regular basis, and periodically test those networks by conducting realistic drills such as the Simulated Emergency Test (SET).

- In times of disaster, evaluate the communications needs of the city and respond quickly to these needs. The EC will assume authority and responsibility for emergency response and performance.[74]

The local EC works under the district EC, who is in charge of the county; the district EC, in turn, works under the section EC, who is in charge of an entire region.

Although created as two separate entities by different groups with distinct purposes, RACES and ARES now frequently perform many of the same functions. Often, the membership for both groups is the same and the two groups operate as one. In Boulder County, the ARES chapter, known as BCARES, is also recognized as the official RACES group.

However, this is not always the case. Because RACES is government sponsored and run, there are more regulations and services provided to government entities, while little or none are provided directly to the public. ARES, which is not tied by governmental regulations, is more apt to provide service directly to the public. This difference can sometimes create friction between the two groups. As a result, they remain separate entities with two distinct functions that may even provide more service to an area.[75]

When working with volunteers, there are three main issues of liability that must be addressed—the actions, property, and dependents of the volunteers.[76] As in Good Samaritan

---

74. *ARES Emergency Responder Manual*, Revised November 11, 1990, p. 7.1.

75. There also exists the Military Amateur Radio Service (MARS), a group of amateurs dedicated to providing service to military personnel and their families.

76. Feller, interview with author.

Samaritan Laws, a volunteer has good intentions and cannot be held liable by the community for any accidentally damaging actions. The community, represented by the specific agency for which the volunteer works, must take responsibility for all of his or her actions. In a similar manner, if the volunteer's personal property is damaged while providing service to the community, the community should cover the cost of the damages. This includes providing worker's compensation or temporary insurance coverage for injuries the volunteer sustains while working.

The third liability issue surfaced in the aftermath of the Mount St. Helens volcano eruption, when two amateur radio operators died while on duty, leaving families who depended on them for financial support. The debate arose over whether the community owed compensation to the dependents; however, in this instance, compensation was paid. Nonetheless, it is an issue that is rarely considered until after a tragedy occurs.[77]

Policy

When two or more groups work together on a project, it is imperative that each group—and all members of each group—fully understand the divisions of responsibility, particularly in an emergency where lives are at stake. There must also be mutual understanding of rules, regulations, and the policies of the involved agencies. For example, the Mile High Chapter of the American Red Cross has a verbal understanding with the hams that assist them, and BCARES and the BRCC have a memo of understanding (MOU) that details assignments and responsibilities. In most cases, an MOU is the best approach.

---

77. Ibid.

Along with MOUs, written disaster plans are important in predisaster planning. Such a plan, in addition to outlining step-by-step responses to a disaster, clarifies policy and logistical issues such as the chain of command and where to obtain resources. When assignments and responsibilities are in black and white, later confusion regarding these issues is avoided.

Financial

Hams offer their time, skills, and equipment for free. Most disaster control and disaster relief agencies have limited budgets and resources, and replacing or paying for these elements would cost more money than most agencies can afford. By providing their equipment, frequencies, skills, and time, amateur radio operators help mitigate these financial limitations.

CASE STUDIES

The Mile High Chapter of the American Red Cross

Amateur radio has historically assisted in communications during emergencies, and one group they've assisted more than most is the Red Cross. Examples of involvement with the Mile High Chapter include:

- North Port Apartments fire, Boulder, June 1993.
- Old Stage Road fire, October 1990.
- Limon tornado, June 1990.
- Loma Prieta earthquake, October 1989.
- Black Tiger/Sugarloaf fire, October 1989.
- Hurricane Hugo, September 1989.

Provisions

There are 28 core hams that handle the communications for the Mile High Chapter, all of whom are also experienced in Red Cross emergency communications procedures. In addition to possessing personal radio experience, they participate in Red Cross training. They have always been available when needed and have proven very capable. Through their continued involvement with the Red Cross over the years, their skills and expertise have become known and appreciated by the chapter. Also, many of the hams who work as communicators are Red Cross volunteers, even Disaster Action Team (DAT) members, who have had at least minimal training in Red Cross procedures and operations.

The Red Cross utilizes VHF FM radios for voice communications and packet radios for hard-copy. Both are critical to their operations. The hams provide all the equipment; none is purchased or maintained by the Red Cross. Conversely, this equipment leaves when the hams leave, regardless of the absence of a replacement system.

An MOU does not exist between the hams and the Mile High Red Cross; there is simply an understanding. This has worked for them so far, and the Red Cross sees no need to change. The service the hams provide is invaluable since the chapter has no finances for purchasing equipment or training operators.

Summary

The hams that act as communicators for the Mile High Chapter of the American Red Cross provide a critical service. Without their skills and equipment, the Red Cross could not

operate effectively. As Juanita Lewis, Disaster Services Specialist of the Mile High Chapter, put it, "If it weren't for them, I'd be dead in the water."[78]

Metro D.C. Chapters of the American Red Cross

Provisions

The level of amateur radio support is not the same in all Red Cross chapters. The Arlington Chapter has 16 volunteers, most of whom are hams. A local amateur radio club exists on site at the Red Cross chapter office, and the chair of the Arlington Red Cross Disaster Action Team is in the process of obtaining her license.[79]

Just a few miles away, however, is a different story. The National Capitol Chapter has very minimal support from local hams. Juan Rios, the Emergency Services Specialist for the chapter, would like to see this change. In an effort to gain support from local hams, the chapter is working to obtain a repeater and antennas to facilitate better amateur radio communications.[80]

Summary

While amateur radio operators do actively support the local Red Cross chapters in the metro D.C. area, it does not seem to be to the same extent as in the Denver metro area. As Juan Rios suggested, there is probably a direct relationship between the frequency of occurrences of major disasters in a given area and the extent of amateur radio activity.[81]

---

78. Juanita Lewis, interview with author.

79. Elspeth Zaayengaa, interview with author.

80. Juan Rios, interview with author.

81. Ibid.

BCARES

In 1976, a wildfire burned on Comforter Mountain in Boulder County. Bill McCaa, then director of the communications center and also a ham, called some local amateur radio operators for assistance when the available communications were not enough. As a result, the benefits of amateur radio were clearly demonstrated and the staff of the communications center, in talking with members of local amateur radio clubs, determined they wanted a group of amateurs dedicated to working with the center. Thus, the Boulder County Amateur Radio Emergency Service (BCARES), an organization of amateurs geared specifically to providing emergency services to public agencies, was born. BCARES provides volunteer personnel and equipment under a unique arrangement. They rendered assistance, for example, during the following:

- Antiwar demonstrations, January 1991
- Limon tornado, June 1990.
- Old Stage Road Fire, October 1990
- Sugarloaf/Black Tiger Mountain Fire, October 1989[82]

Provisions

BCARES meets all the requirements to provide emergency communications. The group has 72 members and is supported by all three local amateur radio clubs—the Boulder Amateur Radio Club, the Longmont Amateur Radio Club, and the Rocky Mountain VHF Club. BCARES members are also trained. In addition to individual experience, they receive training through three main venues: 1) On-the-air Net meetings; 2) simulated emergency tests; and 3) training classes.

---

82. Jim Andrews, Interview with author.

Every Monday at 9:00 p.m., the BCARES Net convenes on the air. The purpose of the Net is to make announcements, facilitate discussions about group matters, and receive training in BCARES emergency communications. Following the voice net is a training net for people in packet radio communications.

A simulated emergency test (SET) is held at least once a year. This full-blown training exercise is usually coordinated with those of other public safety agencies. BCARES members provide communications.

BCARES members also attend training classes, where proper "disaster mode" operations and procedures are taught. Also, those who do not have access to some of the communication systems, like packet and amateur TV (ATV), receive training in operating them. These classes allow BCARES to improve the quality of services they provide and increase the number of skilled operators.

BCARES has all the technological resources necessary for quality disaster communications. Several voice repeater frequencies cover the county, and every member is required to own an HT that operates on the same frequencies. BCARES also has a HF SSB transceiver at the 911 Dispatch Center.

BCARES can capably handle data and image communications. The group has systems for both packet radio and ATV. The packet system consists of three portable stations, one permanent station in the dispatch center, and two permanent stations in the Sheriff Department's mobile communications van. All BCARES packet stations include a second two-way radio for voice communications, facilitating more efficient troubleshooting and monitoring of the packet

network. It is also used for voice acknowledgments of messages. By not using the packet system for these acknowledgments, the efficiency of the system greatly increases.

The BCARES packet system uses PacketCluster, a bulletin board system, which allows for smoother and faster delivery of messages and the interconnection of many stations at the same time.[83] BCARES has also tested linking this system to others for long-distance data communications.

> December 1991 Test of linked PacketClusters: Three PacketClusters, each with their own 2-meter frequency, connected on 440 MHz. This test was very successful; even the skeptics were impressed. Fifty stations connected at the same time, with 15 stations throughout the area involved in the exercise. Messages flowed transparently and rapidly from cluster to cluster; the system truly operated like one big bulletin board! We plan to use this system for major disasters involving packet traffic between counties.[84]

For providing image communication services, BCARES has two portable TV transmitters and a portable television repeater for transmitting from remote sites. For receiving the video transmissions, one TV receiver is located in the communications center situation room and one in the mobile communications van. ATV has been, in fact, the primary form of communication provided to the communications center by BCARES in the last couple of years. The center understands the applicability of this technology and has financially supported its development.

Linking these systems together are the hams who try to be on the leading edge of technology. Over the years, BCARES has repeatedly provided the Boulder Regional Communications Center (BRCC) with a technology or system unavailable, but very useful, to them. First, the BRCC just needed more mobile communications because hand-held units were not prevalent. When hand-

---

83. Richard Ferguson, "Packet Radio and Emergency Communications: Public Safety Enters the Digital World," *73 Amateur Radio Today,* (October 1992):44.

84. Ibid.

held radios became more available, BCARES offered telephone patch capability through their radios and repeaters. Then, when cellular phones started becoming available, BCARES offered the data communications system packet radio. Now, there are portable faxes and digital pagers with text readout capabilities. Although packet is still very much in use, ATV has now entered the scene. Controlled live video from a disaster scene is only possible through amateur radio. It is not known what the next technological development will be, but Don Schaffer of the BRCC believes that hams will be ahead of public safety agencies in this area.[85]

BCARES was chartered by the Boulder County communications center, not the Amateur Radio Relay League. It is a nonprofit, public service corporation, registered under the Office of Emergency Management. BCARES is the legal local RACES organization, and although BCARES is government-chartered, the head of BCARES is the official ARRL Emergency Coordinator for Boulder County.[86] Among other things, members are required to:

1. Have a valid FCC amateur radio license at technician class or higher.
2. Pass a computer background check and be approved by the Boulder County Sheriff's Department for an emergency services identification card.
3. Be approved by the board of directors.
4. Participate in an initial individual training session, which includes a tour of the 911 dispatch center.
5. Own a two-meter FM hand-held and/or mobile radio.
6. Actively participate in various BCARES training exercises. These include the weekly radio net, SETs, annual meetings, and individual training sessions.[87]

---

85. Don Schaffer, Interview with author.

86. *BCARES Manual*, pp. 20-21.

87. Ibid.

Because it is a government-chartered organization, BCARES is more accountable than most volunteer groups. The memorandum of understanding (MOU) with the BRCC states that BCARES will handle the communications needs of the BRCC first and foremost, even if the group receives an outside request for communications assistance. Health and welfare inquiries are not handled by BCARES but are left to the Red Cross. (The complete MOU is in Appendix A.) Some of the primary issues addressed by the agreement are response time, equipment provision and maintenance, staffing, and training.

BCARES has existing MOUs with other group as well, including the Mile High Chapter of the American Red Cross; however, since the chapter has its own group of hams, BCARES is only called when they have a shortage of help. In that case, BCARES will provided assistance after they have met their obligations to the BRCC.

BCARES follows disaster plans established by the BRCC, particularly specific plans for wildfires and flash floods. If other types of disasters occur, the group follows one of these two plans. The wildfire disaster plan is followed if the current disaster is limited in area and number of affected people; the flash flood plan is used if the disaster is more widespread and affects many people.

Activation of either of these plans starts with a page from the dispatch center to the three BCARES officers, each of whom wears a beeper. In the event of an emergency, they contact other BCARES members as necessary for the size and severity of the situation.

The financial state of BCARES is stated plainly below:

> BCARES is a non-profit corporation. It does not charge its members dues. BCARES' sources of funding consist of non-taxable, charitable donations from corporations and private individuals and government grants from the agencies served and FEMA. BCARES' funds are used solely to purchase communications equipment and supplies.

> None of the directors, officers or members receive compensation from BCARES. All are volunteers.[88]

Although the BRCC has no budget for BCARES operations, they do fund equipment purchase and installation of systems, antennas, and other items as needed. However, primary funding is received through donations. IBM, a major local business, has on more than one occasion donated money for purchasing communications equipment, and a private patron donated an HF SSB radio.

Another, and perhaps primary, means of funding BCARES equipment is governmental "reimbursement for services provided." The federal government compensates financially for local resources, both personnel and equipment, used on federal land such as a national forest. The BRCC bills for the time and equipment used, for example, in fighting a forest fire. The rate assigned to BCARES is the same as the one assigned to the volunteer fire departments. Because by federal regulation hams cannot receive payment for services rendered, reimbursement for services in these events is given to BCARES, which in turn purchases additional equipment to provide better service to the BRCC.

Additional funding for BCARES has come through a FEMA matching-grants program called "State and Local Warning and Communication Systems." Its objective and uses are stated as follows:

> OBJECTIVE: To maintain the civil defense readiness of State and local governments by furnishing matching funds for the purchase of equipment and supporting materials for State and local direction and control, alerting and warning systems and to upgrade State and local emergency communications networks.

---

88. *BCARES Manual,* p. 17.

USES AND USE RESTRICTIONS: This provides for up to 50 percent in matching funds and technical assistance to State and local governments for upgrading statewide emergency and warning communications systems.[89]

Summary

Since its inception, BCARES has provided the BRCC with technology and services otherwise unavailable to county public safety agencies. Because of the experiences with BCARES, in an emergency, "the dispatch center calls the hams before they order the food."[90]

89. FEMA, "State and Local Warning and Communication Systems," p. 32.

90. Ferguson, p. 45.

CHAPTER 8

ANALYSIS

Issues

Personnel

There are three primary personnel issues required for successful disaster communications—availability, ability, and proper use of volunteer expertise. In the first instance, individuals in charge of providing communications must be available. Without them, communications do not happen. Hams are usually available for any local emergency; however, because they are volunteers, they are not *always* available, particularly if they are affected by the disaster.

Second, those responsible for handling communications must possess training and expertise in two areas: 1) general communications, including both technical and operational; and 2) disaster response, which involves communications as well as understanding and following the policies and rules of the disaster services agencies. Most hams have the necessary skills for general communications; more often than not, hams also have experience with emergency communications. Although skill level can vary, many of the hams involved in public service constantly upgrade their technical and operating skills through personal work, amateur radio contests, and training sessions. Every year, at least one simulated emergency test is held in

which all disaster services groups, including public safety agencies, Red Cross, local hospitals, and amateur radio operators test their ability to respond to an emergency.

Third, those in charge of the overall disaster response need to know the communicators and their levels of expertise in order to effectively incorporate them. Hams have a good working relationship with disaster service agencies, and most hams are willing to demonstrate their abilities to any group. A training exercise provides the best opportunity for an agency to learn about the usefulness of amateur radio.

Technological Issues

Disaster service agencies have their own communications systems, but they need a backup, if not a supplemental, system. The three requirements of these systems are 1) capacity for rapid deployment, 2) easy setup and operation, and 3) capability of both voice and data transmission. The three technologies that provide these capabilities are cellular phone, satellite, and amateur radio.

The two commercial alternatives, cellular and satellite, each have merit. However, cellular phone systems are not a viable option for the reasons discussed in Chapter 6, primarily due to their current limited coverage and capacity, particularly when under heavy load situations like a disaster. The Low Earth Orbit satellite systems that could have applications in emergencies are still in the development stage and waiting for approval from the Federal Communications Commission.

Ham radio is a viable alternative. A ham can be on the disaster scene within an hour or two. Hams are also at ease with the setup and operation of either their own equipment or that on

which they have been trained. Also, as previously discussed, amateur radio systems are fully capable of providing voice, data, and video transmissions.

Amateur radio offers two additional benefits. First, the additional spectrum available to hams supplements the frequencies assigned to disaster service agencies by the FCC. Second, amateur radio systems are interoperable, that is, voice, video, and data communications can be operated on the same systems.

Regulatory Issues

According to the FCC, a primary purpose of amateur radio is to provide emergency communications to the public. Hams established the Amateur Radio Emergency Service (ARES) as a national organization with the Amateur Radio Relay League (ARRL) to help meet this goal. The Radio Amateur Civil Emergency Service (RACES) was established as a government-regulated group of amateurs specifically dedicated to providing emergency communications. In some areas, the local ARES chapter also operates as the local RACES chapter. In others, due to their perceived differences in objectives, they operate as distinct entities.

Policy Issues

Two policy concerns must be addressed for successful, reliable disaster communications. Each involved group must have an operable disaster plan as well as a mutual understanding of liabilities and responsibilities. These elements become even more important when dealing with volunteers who are not always available or adequately trained. As volunteers, the control and command exerted over them is subject to their approval and consent. While this is usually not

a major problem since they are there to help, it is still something that must be remembered. A disaster plan is a critical element of disaster planning and management. A written agreement is not mandatory as some groups have shown they can manage quite well without one. However, an MOU is recommended for handling issues of liability and responsibility.

Financial Issues

Of primary importance when considering a communications system is its affordability. Since hams, by legal charter, are restricted from receiving financial compensation for services, amateur radio is easily both cost effective and affordable. If another group considers a plan similar to one used by BCARES, the only potential costs are related to worker's compensation insurance coverage and equipment purchase.

Applicability to Disaster Communications

Disasters and emergencies are growing in magnitude and frequency, and they have the potential to impact every human being. Thus, there is a need for disaster communications, especially for disaster control and disaster relief agencies. These agencies have their own equipment and systems, but these are rarely adequate. Amateur radio is a viable *supplemental* disaster communications resource. Although it is used heavily by many Red Cross chapters with great success, amateur radio is not recommended as the primary—or even backup—source of communications. There are too many variables with volunteers to justify amateur radio as anything but supplemental.

Despite this limitation, amateur radio should not be overlooked. Since its development, amateur radio has proven to be an effective emergency communications service provider. It can fill the communications gaps in disasters and provide skilled personnel, equipment, and additional frequencies and technology otherwise unavailable to an agency.

Proposal

Amateur radio is a critical resource when planning for and managing the response to disasters. The following section suggests a plan for incorporating amateur radio into a local agency's disaster communications plan. This proposal is applicable to both disaster relief and disaster control agencies.

First, analyze the existing emergency communications system, determine its problems and limitations, then decide what is needed for additional communications support. The agency's financial status should also be considered.

Next, learn about and talk with local hams. Contact the local or state office of emergency management to obtain information about the local RACES chapter. If a chapter does not already exist, information on starting one can be obtained by contacting the national office.[91] For information on the local ARES chapter or how to start one, contact the ARRL.[92]

Determine how many amateur radio operators are in the area as well as how many are interested in serving the agency. Are there enough to make it worth the effort? Determine their capabilities and what they can provide, i.e., do they have a working packet radio system and

---

91. RACES: The Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472.

92. ARES: ARRL, 225 Main Street, Newington, CT 06111, (203) 666-1541.

ATV equipment? If they don't have a system that is desired by the agency, determine if the agency will purchase equipment and whether the hams will learn to use it. In addition to their capabilities, assess the hams' commitment level. Determine how many are willing to meet the desired level of service, including time for training, on-call availability, and provision of equipment and systems.

After assessing the availability of hams, mutually agree on exactly what their role will be. Spell out the expectations and responsibilities of each party to the other. In many cases, the best approach is to draw up a memo of understanding (MOU) between the parties that contains the functions and responsibilities of each. This approach is recommended to create a written foundation of trust; however, most hams enjoy providing this service and do not necessarily require a written understanding. The agreement should also be incorporated in the agency's disaster plan.

A final and very important issue is training. Hams usually hold their own training events in equipment and systems instruction and emergency response; however, this is not sufficient. As a disaster management agency, hold regularly scheduled training events that include the hams. This provides the opportunity not only to see the amateur radio operators in action but also to determine areas of improvement for all involved parties.

Summary

Amateur radio can be a very effective communications tool for responding to disasters. Hams have the skills, technology, and willingness to serve. It makes sense to plan for them, include them in the training and preparation for a disaster, and use them when disaster strikes. If the

issues in the proposal are addressed to the satisfaction of both the disaster services agency and the hams, then the community will benefit from the alliance.

SOURCES CONSULTED

Andrews, Jim
1992 *BCARES Disaster Action Plan*. March.

Andrews, Jim
1994 Interviews with author. Various dates.

Ang, Peng H., Peter A. Ruetz, and David Auld
1991 "Video compression makes big gains." *IEEE Spectrum* 28 (October):16-17.

ARES Emergency Responder Manual
1990 Revised November 11.

"ARES in USSR?"
1991 *QST* LXV (October):14-16.

BCARES ATV
1993 Video recording of recent events.

BCARES Manual
1992 Boulder, Colorado.

Bellcore
1991 "BOC Notes on LEC Networks—1990: Mobile Services Interconnection." SR-TSV-002275. Issue 1. March 1991.

Bergreen, Laurence (editor)
1993 "The Origins of Broadcasting—Radio." In *On-Line Encyclopedia*. Denver: Colorado Alliance of Research Libraries (CARL).

Bhatia, Keith
1993 "Global Public Safety Communications." *Global Communications* (July/August):23-26.

Briere, Daniel
1991 "Cellular Service Options Merit Close User Scrutiny." *Network World* (January 15):1.

Burden, Bill
1992 "Amateur Satellites as a Resource for Public Service Communications." *QST* LXXVI (April):78-79.

Burton, Captain Alan
1990 *A Basic Guide to Disaster Communications*. Medford, Oregon: Dispatch Publications.

Calhoun, George
1988 *Digital Cellular Radio*. Norwood, Massachusetts: Artech House.

Chandler, Richard
1992 Class notes from lectures in "Cellular and Wireless Communications." University of Colorado at Boulder Summer Session. School of Engineering.

Chandler, Richard
1993 Interview with author. October 15.

D'Adesky, Anne-Christine
1991a "Preparing the World for Disaster." *UN Chronicle* (June):40-45.

1991b "UNDRO: Coping with Disaster. . . A Fine Line." *UN Chronicle* (June):46-49.

1991c "HUGO: A Case Study." *UN Chronicle* (June):50-51.

1991d "Perfecting the Science of Disaster." *UN Chronicle* (June):52-53.

1991e "Interacting to Save Lives: 'A Cry for Help'." *UN Chronicle* (June):54-55.

Drabek, Thomas E. and Gerard J. Hoetmer (editors)
1991 *Emergency Management: Principles and Practice for Local Government*. Washington, D.C.: International City Management Association.

Drabek, Thomas E., Donald Q. Brodie, Jessica Edgerton, and Paul Munson
1979 *The Flood Breakers: Citizens Band Radio Use During the 1978 Flood in the Grand Forks Region*. Monograph No. 29, Environment and Behavior Program. University of Colorado: Institute of Behavioral Science.

Eichel, Larry
1993 Interview with author. October 20.

Elspeth Zaayengaa
1993 Interview with author. November 29.

Federal Emergency Management Agency
1991 *Guidance for Radio Amateur Civil Emergency Service*. Washington, D.C.

1950a *State and Local Warning and Communication Systems*. Federal Civil Defense Act of 1950, as amended.

1950b *State and Local Emergency Operating Centers*. Federal Civil Defense Act of 1950, as amended.

1950c *Civil Defense-State and Local Emergency Management Assistance*. Federal Civil Defense Act of 1950, as amended.

Feller, Art
1993 Interview with author. Various dates.

Ferguson, Richard
1992 "Packet Radio and Emergency Communications: Public Safety Enters the Digital World." *73 Amateur Radio Today* (October):42-45.

Garret, Kenneth L.
1991 Statement. Subcommittee on Telecommunications and Finance, Hearing on Telephone Outages. Washington, D.C. October 1.

Garrity, Martin Michael
1993 *Business Contingency Planning in the Public Switched Network Using Probability of Failure and Cost Modeling*. Master's Thesis. University of Colorado.

Glenn, David Robert
1992 *Low Earth Orbit Satellites for Disaster Relief Communications*. Master's Thesis. University of Colorado.

Hurder, Luck
1993 Interview with author. October 25.

Interdisciplinary Telecommunications Program
1993 *The Rural Healthcare Project: Telecommunications Technology, Terms and Concepts*. University of Colorado. October.

Johnson, Mark W.
1988 *Crisis Communications: A Handbook for Emergency and Survival Radio Monitoring*. Lake Geneva, Wisconsin: Tiare Publications.

Katayama, Tsuneo
1992 *Aftermath of the Loma Prieta Earthquake: How Radio Responded to the Disaster.* University of Tokyo: International Center for Disaster-Mitigation Engineering, March.

Kearman, Jim (editor)
1991 *Now You're Talking! Discover the World of Ham Radio.* Newington, Connecticut: American Radio Relay League, Inc.

Kerr, Douglas A.
1992 *AMPS: The North American Cellular Radio Telephone System.* Dallas, Texas: editions dak.

Kleinschmidt, Kirk A. (editor)
1990 *The ARRL Handbook for the Radio Amateur.* Newington, Connecticut: American Radio Relay League, Inc.

Lewis, Juanita
1993 Interview with author. October 19.

Litan, Robert, Fredrick Krimgold, Karen Clark, and Jayant Khadilkar
1992 *Physical Damage and Human Loss: The Economic Impact of Earthquake Mitigation Measures.* The Earthquake Project: Boston, Massachusetts.

Lutes, Julian
1993 "ARES: Topeka Case Study." *QST*, LXXVII, 4 (April):86-87.

Mabey, Jay (editor)
1993 *The ARRL Repeater Directory.* Newington, Connecticut: American Radio Relay League, Inc.

McCaa, Bill
1993 Interview with author. Various dates.

Miller, Joel
1992 "WARC-92 and Amateur Radio." *IEEE Spectrum* 29, 2 (February):26.

Moerner, Weo
1993 *Emergency BBS for Tactical EOC-EOC Packet Traffic.* ARRL HQ Automated Electronic Mail Server.

Mottershead, Allen
1993 "Radio." *On-Line Encyclopedia.* Denver: Colorado Alliance of Research Libraries (CARL).

Natural Disasters Organization
1991 *Communications: Australian Emergency Manual*. Dickson, Australian Capitol Territory.

Newton, Harry
1991 *Newton's Telecom Dictionary*. New York: Telecom Library, Inc.

N6MWD (@K3MC)
1990 *RE: Recommendations from the Earthquake*. ARRL HQ Automated Electronic Mail Server. January 16.

Paglin, M.D. (editor)
1990 "A Legislative History of the Communications Act of 1934." *On-Line Encyclopedia*. Denver: Colorado Alliance of Research Libraries (CARL).

QST
1991 "Soviet Hams Rally Against Coup." LXV, 11 (November 1991):15-19.

Rahnema, Moe
1993 "Overview of the GSM System and Protocol Architecture." *IEEE Communications Magazine* 31 (April):93.

Rios, Juan
1993 Interview with author. November 29.

Ruesch, K., and G.C. Cauderay
1989 "Telecommunication Network of the International Committee of the Red Cross." *Telecommunication Journal* 56:39-43.

Schaffer, Don
1993 Interview with author. October 22.

Simulated Emergency Test
1993 Participation by author. Boulder, Colorado. November 20.

Stetzer, Howard L., Jr., and Kenneth R. Witten
1973 *Emergency Communications: State of Colorado*. Master's Thesis, University of Colorado.

Sweeney, Steven W., and Frank S. Zimmerman
1988 "Satellite Communications Disaster Recovery." *Telecommunications* 22 (February):88.

5. BCARES will preassign certain, well qualified members to duties as operators at the BRCC dispatch center and the S.O. communications van. These members will visit these locations to test and operate these facilities at least once a month.

6. BCARES will maintain a cache of radio equipment at the BRCC dispatch center. This cache will include: 3 portable packet radio sets, 2 portable TV transmitters with TV cameras, 1 portable TV repeater, and 1 portable HF SSB radio. Two of the portable packet radio sets include 45 watt VHF-FM voice radios which are capable of operating on both amateur and public safety frequencies. BCARES will provide the maintenance for this equipment.

7. BCARES will have available for emergency use a minimum of 3 VHF voice radio repeaters. They are: 146.16/76 MHz, Gunbarrel Hill; 147.87/27 MHz, Longmont; and 146.10/70, NCAR. They provide coverage of most of Boulder County except for the NCAR repeater which covers only the city of Boulder and the eastern plains.

8. All BCARES members have their own hand-held and/or mobile VHF, 2 meter (144-148 MHz) FM voice radios. Some members also have available portable packet radio sets. These private packet radio sets will not be available for extended operations.

9. BCARES sometimes may have available ''autopatch'' repeaters for making out-going telephone calls via radio. These are not reliable and BRCC is advised to use instead mobile telephone services whenever possible.

10. BCARES will hold voice and packet radio net training sessions weekly to practice procedures. A half day Simulated Emergency Test (SET) will be held at least once a year in cooperation with BRCC. This will involve a call-out of all BCARES members and setting up and operating all the various BCARES/BRCC stations and equipment.

BRCC makes the following commitments to BCARES:

1. BRCC will supply 3 pagers to BCARES. BRCC will call BCARES on these pagers whenever it desires assistance from BCARES.

2. BRCC will provide storage space in the dispatch center for the BCARES radio cache.

3. BRCC will supply the maintenance for the W0IA, 145.09 MHz packet radio cluster digital repeater, packet radio digipeaters and the voice radios, packet radios and TVs in the dispatch center and the communications van.

4. BCARES members are covered by worker's compensation if injured while on an emergency operation or training exercise when BCARES has been authorized to participate by BRCC, or Boulder County Sheriff's Dept. or City of Boulder Police Dept. If the operation is a Boulder County jurisdiction, then Boulder County will provide the

workman's compensation. If the operation is a City of Boulder jurisdiction, then the City of Boulder will provide the worker's compensation.

Signed by
Ted Vratney, Director, BRCC 12 Feb 1992
Ronald K. Steward, Chair,
Boulder County Commissioners 5 Mar 1992
James R. Andrews, Chair, BCARES 12 Feb 1992
Stephen T. Honey, Boulder City Manager 30 Mar 1992

ARES MISSION STATEMENT

Within Boulder County, the Amateur Radio Emergency Service (ARES) has made commitments to provide disaster communications for the following public service agencies: Boulder County Regional Communications Center (BRCC), Office of Emergency Preparedness (OEP), Red Cross (RX), Longmont Police, and Longmont United Hospital. BRCC is the 911 emergency services dispatch center for most police depts., fire depts., ambulance & rescue groups within Boulder County.

There are five separate groups of radio amateurs that comprise the ARES. They are: the Boulder County Amateur Radio Emergency Services (BCARES), the Longmont Amateur Radio Club (LARC), the Boulder Amateur Radio Club (BARC), the Rocky Mountain VHF Society (RMVHF), and the ARRL National Traffic System (NTS). Unaffiliated amateurs are also included in ARES.