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Randy L. Blaisdell, Capt, USAF

Master of Science in Telecommunications, 1987

University of Colorado, Boulder

Quick Response Airborne Command Post Communications

National emergencies and strategic crises come in all forms and sizes ranging from natural disasters at one end of the scale up to and including global nuclear warfare at the other. Since the early 1960s the U.S. Government has spent billions of dollars fielding airborne command posts to ensure continuity of government and the command and control function during times of theater conventional, theater nuclear, and global nuclear warfare. Unfortunately, cost has prevented the extension of the airborne command post technology developed for these relatively unlikely events to the lower level, though much more likely to occur, crises such as natural disasters, terrorist acts, political insurgencies, etc.

This thesis proposes the implementation of an economical airborne command post concept to address the wide variety of crises ignored by existing military airborne command posts. The system is known as the Quick Response Airborne Command Post (QRAC Post) and is based on the exclusive use of commercially owned and operated aircraft, and commercially available automated data processing and communications resources. The thesis addresses the QRAC Post concept at a systems level and is primarily intended to demonstrate how current technology can be exploited to economically achieve a national objective.

(110 pages)

QUICK RESPONSE

AIRBORNE COMMAND POST

COMMUNICATIONS

by

Randy L. Blaisdell

B.A., Carroll College, 1980

A project submitted to the

Telecommunications Program of the

University of Colorado in partial fulfillment

of the requirements for the degree of

Master of Science

in Telecommunications

1988

This project for the Master of Science degree by

Randy L. Blaisdell

has been approved for the

Program in

Telecommunications

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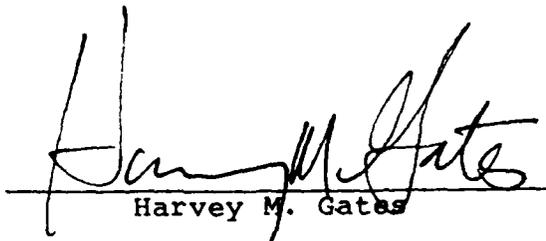
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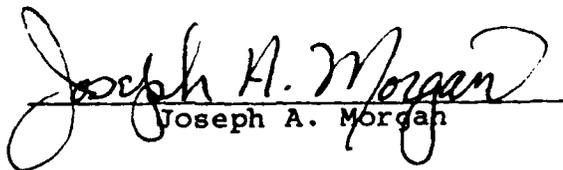
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Randy L. Blaisdell (M.S., Telecommunications)

Quick Response Airborne Command Post Communications

Thesis directed by Professor Harvey Gates

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CHAPTER I

INTRODUCTION

Background

The United States (U.S.) Government has, over the last 30 years, made a strong commitment to the use of airborne command posts for national emergencies and for providing a deterrent to conflict. In fact there has been at least one airborne command post aloft continuously since 1961.[1] Command posts such as the National Emergency Airborne Command Post (NEACAP) (See Figure 1-1), Looking Glass, Silk Purse, Scope Light, TACAMO, AWACS (See Figure 1-2), and Blue Eagle are just a few of those in operation today. Nevertheless, there is still a critical gap in the airborne command posts' ability to deal with national emergencies. This thesis proposes the implementation of a system to fill that gap using commercial aircraft coupled with commercial communications and computer assets. The proposed system is known as the Quick Response Airborne Command Post or QRAC Post (pronounced "Crack Post"), and will provide an economical, readily available, and efficient means of addressing the strategic crises and national

2

Figure 1-1 - National Emergency Airborne Command Post (NEACAP)[2]

Figure 1-2 – Airborne Warning and Control System (AWACS) [3]

emergencies ignored by current airborne command, control, and communications (C^3) systems.

The missions of todays airborne command posts are crucial to our nation's security. However, they are very narrow in scope and are primarily directed toward high-intensity conflicts, specifically theater conventional warfare, theater nuclear warfare, and global nuclear warfare. While these are without question valid missions, the probability of these events occurring is low in contrast with the more probable occurrence of other, lower-intensity national emergencies and strategic crises. As illustrated in Figure 1-3, the probability of crisis occurrence is indirectly proportional to the relative severity of the crisis. Today's airborne command posts represent a tremendous capability to deal with crises at the upper end of the continuum, at the end with the lowest probability of occurrence. Unfortunately, today's systems do nothing to address the remainder of the crises spectrum, that portion with the highest likelihood of occurrence. Since airborne command posts became active in the 1960s, the U.S. has experienced one theater level war and no nuclear level wars at all. On the other hand the number of insurgencies, terrorist actions, coups, political crises, and national
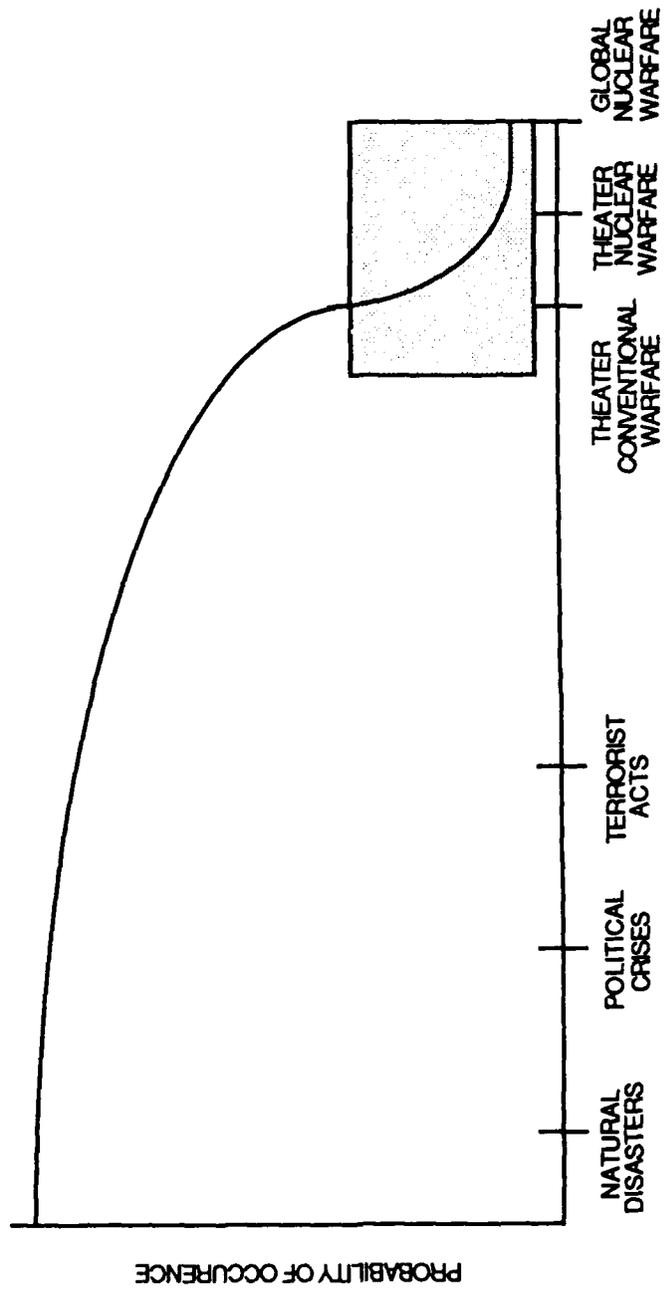
Figure 1-3 – Crises Continuum[4]

emergencies in the form of natural disasters that have occurred are almost too many to count.

To date, airborne command post technology has not been used for low-intensity crises. The reason is not that there is not a need or that no one is concerned (as evidenced by Presidential Directive 53 and Executive Order 11490). The reason is quite frankly money, in the past the technology required to field an airborne command post has been prohibitively expensive. NEACAP for instance has an initial cost of approximately $149 million for each of the four aircraft required for its mission (total price $596 million).[5] AWACS has a price tag of $150 million a copy for each of the 34 units ordered (total price $5.1 billion).[6] Unfortunately these amounts only represent the tip of the iceberg the real cost of these command posts is associated with their operation. All of the current command posts are owned and operated by the government. As a result, in addition to the initial expense of procuring the aircraft and the communications and computer equipment, there are also the aircraft operation and maintenance expenses and the expenses associated with maintaining aircrews, battle staffs, and support personnel. All told the incidental expenses associated with an airborne command post can

be expected to exceed the purchase price by several orders of magnitude over the life cycle of the system.[7]

As a result of the prohibitive expense, only a limited number of the systems have been approved by Congress and these dedicated to only the most critical missions. To justify the types of expenditures required to field a comparable, dedicated airborne command post for low intensity crises, is virtually impossible, particularly in the current, austere fiscal environment. Consequently, any new system proposed for handling low-intensity crises and emergencies must be not only technically capable, it must also be more economical than current systems.

Purpose

The purpose of this thesis is to propose such a system, one which can provide a cost effective, survivable airborne command, control, and communications capability for use during a wide range of strategic crises and national emergencies. The QRAC Post system proposed will make exclusive use of currently available commercial technology. In particular it will involve the use of commercially owned and operated aircraft, commercially available computer and video imaging equipment, and a unique

air-to-ground commercial communications system known as GTE Airfone. In government policy terminology this is referred to as a Non-Developmental Initiative (NDI), a program that requires no research and development, and which can literally be put together from "off-the-shelf" components. In order to do this the QRAC Post system will make use of the emergency and war powers provisions of the Communications Act of 1934 and the precedents established through use of the Civil Reserve Air Fleet (CRAF). Together these two sources will allow for the use by government agencies of common carrier assets such as airline and communications resources in the event of national emergencies as declared by the President or the President's representatives.

In order to demonstrate the viability of this proposal, the thesis will first examine the basic concept of operation for the proposed system. This will be followed by a chapter specifically focused on the recently developed commercial communications system which makes the QRAC Post a viable concept. The next section of the thesis will examine the issues involved with implementation of the proposed system as a national asset. Finally, the thesis will address the

conclusions and recommendations resulting from the research for the thesis.

Scope

The nature of this thesis is such that a number of extremely detailed thesis subjects could be derived from it. For example, a detailed examination of the propagation characteristics of the communications system could be made or an in-depth analysis of the political and regulatory aspects of using commercial carrier resources could be performed. However, this thesis is designed to address the subject at a systems level. While the thesis will address a number of technical issues associated with the system, it will do so from a high-level perspective and will not attempt to perform a detailed engineering analysis. In this manner I hope to convey to the reader a concept of how current communications and computer technology may be exploited to achieve a national objective rather than inundating the reader in technical detail.

CHAPTER I

NOTES

[1] Carter, Ashton B. "The Command and Control of Nuclear War." Scientific America January 1985, p. 35.

[2] Jane's All the World's Aircraft 1984-85. London: Jane's Publishing Inc., 1984, p. 348.

[3] Jane's All the World's Aircraft 1984-85. London: Jane's Publishing Inc., 1984. p. 347.

[4] Information extracted from an unnamed research project conducted by the BDM Corporation for the U.S. Department of Defense, 1979.

[6] "Early-Warning Aircraft; Up in the Air." Economist, 15 February 1986, p. 62.

[7] Strategic Air Command (SAC) Public Affairs Office. Telephone interview, 20 November 1987.

CHAPTER II

QRAC POST CONCEPT

Operating Environment

The basic idea behind the Quick Response
Airborne Command (QRAC) Post is to make use of the
existing emergency and war powers provisions of public
law and precedents established through existing
agreements to quickly and economically establish
temporary airborne command posts for low-intensity
crises on an as-needed basis. This is essentially an
extension of the current military airborne command post
concept to lower-intensity crises. The basic QRAC Post
scenario is for a small "crisis management team" to
board a commercial airliner with carry-on compute power
and make use of the existing commercial communications
services aboard the aircraft to establish an impromptu
command post. The functions performed by military
airborne command posts and the QRAC Post are
essentially the same with variations being in scope
rather than function. The major distinction between
the two types of command posts is associated with the
environment in which each performs its mission.

The QRAC Post is intended for use over a wide range of low-intensity scenarios, from the point at the extreme left on the crises continuum (See Figure 1-3), up to and including transition to high-intensity crises. However, at no point is the QRAC Post intended for operation in a high air threat environment. Current military airborne command posts on the other hand are optimized for operation in and near high threat environments. As a result many are heavily militarized (e.g., with the addition of electromagnetic pulse protection), thereby adding a great deal of expense that would be unnecessary for aircraft operating under the QRAC Post concept.

Description of Proposed System

To establish a QRAC Post, or any other airborne command post, there are essentially four elements that are required.[1]

1. An airborne platform.

2. Crisis management personnel to provide the command and control function.

3. Automated Data Processing Equipment to assimilate and correlate information and to assist the decision making process.

4. An air-to-ground communications capability which allows interconnection between airborne crisis management teams and the variety of ground networks essential to the collection and dissemination of information.

In the past these items have collectively hindered the fielding of a low cost airborne command post. However, recent technological innovations and the QRAC Post concept itself may serve to remove these barriers.

Airborne Platform

Airborne command posts to date have always been based on commercial airframes, albeit highly modified airframes. For instance NEACAP is based on the Boeing 747 airframe,[2] AWACS and Looking Glass on the Boeing 707 airframe,[3] and TACAMO on the Lockheed EC-130Q airframe.[4] The QRAC Post concept takes this idea a step further. With the QRAC Post concept literally any aircraft owned and operated in the commercial airline fleet could be used as an impromptu command post. The concept is that in an emergency situation a commercial airliner and its crew could be commandeered to provide the airborne platform needed.

By using commercial common carrier resources in this way two things are accomplished. First, the need

for purchasing a dedicated airframe is eliminated.
Consequently, the cost of operating and maintaining the
airframe is also eliminated. In fact, the only cost
incurred is reimbursement to the airline for the
temporary use of their resources, essentially a
"pay-as-you-use" approach. Secondly, the number of
potential airborne command posts is greatly increased.
At present there are approximately 3,000 aircraft in
the commercial fleet.[5] Consequently, the availability
of command posts, and their proximity to the crises
management personnel who would need access to them is
significantly enhanced.

In the past the use of purely commercial
aircraft for command posts has been severely hampered
due to a number of factors. First is the high threat
scenario under which most command posts have operated
in the past, a point already addressed by the QRAC Post
concept. Secondly, has been the extensive
modifications required to support large battle staffs,
extensive computer arrays, and the sophisticated
militarized communications equipment required for the
mission. The following sections will address each of
these in turn and explain how the QRAC Post approach
resolves these problems.

Crisis Management Personnel

The crisis management team is obviously the heart of any command post operation. These are the people who take the information available and make the critical decisions necessary for crisis resolution. The size and make-up of the team is obviously dependent on the mission to be performed. In the case of NEACAP the crew complement is 63 people per airplane.[6] The crisis management team for a QRAC Post can be expected to be far smaller than this due to the more limited nature of the crises to be addressed. In fact, depending on the scenario a crisis team could consist of as few as one or two people.

As a result of the smaller crew complement, the support requirements are by default smaller. The support requirements are also restricted by the nature of the aircraft. With NEACAP the aircraft can, with aerial refueling and oil replenishment, stay aloft for as much as 72 hours.[7] Consequently, crews must be provided rest areas, meal facilities, etc., in order to maintain optimal performance. Since QRAC Posts would operate out of commercial airframes without aerial refueling capability, their time aloft would be limited to the amount of fuel onboard. This would in-turn eliminate the need for provision of crew support items

other than those already installed aboard commercial passenger aircraft.

The most critical difference between the crisis management teams of military airborne command posts and those associated with a QRAC Post is the team's composition. For military command posts the teams perform a specific function and team membership is consistent. QRAC Post crisis management teams are an anomaly in this respect. In all probability each time a QRAC Post is activated the mission of the team, the team's composition, and the origin of the team will be different. This is due to the fact that QRAC Posts can be used for a wide variety of low-intensity crises. In one instance a crisis team of political negotiators may be airborne to Europe, in another instance a team of Federal Emergency Management Agency (FEMA) personnel may be orbiting over an area devastated by flood or earthquake. This type of versatility and its inherent ability to provide service over a wide range of crises scenarios is the key behind the value of the QRAC Post concept.

Automated Data Processing Equipment

In a crisis one of two situations usually exists, either no information is available, or so much information is available, from so many different

sources that it is impossible to correlate and comprehend it all without computer assistance.[8] To address the latter situation military airborne command posts have made extensive investments in computer power. Most incorporate bulky mainframe or large "mini-computers," of late 1960s or early 1970s vintage. In addition to being limited in terms of capability this equipment is also much larger than currently available technology.

To incorporate the technology of the 1960s and 1970s aboard a QRAC Post is, at best, inconvenient. Fortunately, this is unnecessary since current technology has reduced the size and expanded the capability of the 1960s and 1970s mainframes and minis into a desk top size package (See Figure 2-1). An Intel 80386 based personal computer (PC), for instance, has capabilities similar to those of current large VAX minicomputers.[9] This allows QRAC Post crisis teams to carry aboard extensive computer capability that has previously required expensive "real-estate" aboard military airborne command posts.

An exact determination of the carry on computer power needed by a QRAC Post team is difficult to determine. Since each QRAC Post mission can be vastly different than the last, so too can the computer,
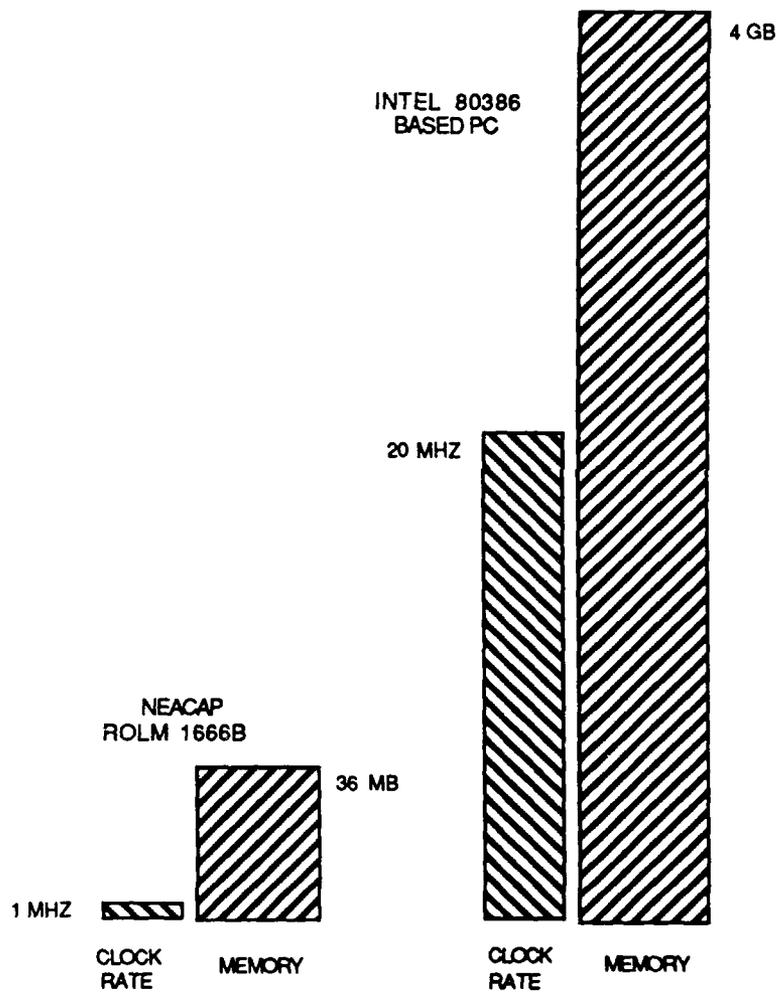
Figure 2-1 - Raw Compute Power of the Rolm 1666B
Minicomputer Aboard NEACAP Versus
the Power of an Intel 80386 Based
PC[10]

peripheral equipment, and video imaging configuration
required. Consequently, this thesis will not attempt
to give or propose a definitive configuration.
However, the types of equipment currently available
that may be useful include:

1. Portable Intel 80386 based computers such
   as the "Compaq Portable 386." The Compaq
   Portable offers a 100 megabyte hard disk
   drive, 10 megabytes of 32-bit RAM, a 20 MHz
   central processing unit, and an 80387 math
   coprocessor.[11]

2. Portable facsimile devices such as the
   Harris/3M "Faxit 111 Personal Facsimile."
   This portable facsimile machine has all the
   features of most full size models, is
   compatible with Groups 1, 2, and 3, and is
   small enough to fit into a briefcase.[12]

3. Video transmission systems such as the
   Cannon "Still Video System"[13] and the
   Interand "DISCON Imagephone."[14] Both of
   these systems allow for transmission of
   high quality black and white or color video
   images over standard telephone circuits at
   speeds ranging from 300 to 9600 bits/second

and can be transported in a large suitcase size package.

4. Portable cryptographic devices such as the National Security Agency approved "STU-III." The STU-III is currently available through three different vendors and comes in a variety of sizes including a desk top model with a "foot-print" the size of a standard file folder which can be easily transported. The system provides voice and data encryption capability from 2400 to 9600 bits/second.[15]

Airborne Communications

The ability to communicate from an airborne command post is crucial to its operation. Because of their missions most military airborne command posts carry a wide variety of communications systems. NEACAP for instance employs VLF, LF, HF, VHF, UHF, and SHF communications systems in order to maintain contact with or through ground installations (e.g., underground command posts, missile silos), other aircraft, satellites, and submarines.[16] Because of their low-intensity missions QRAC Posts do not require this same type of communications capability. What is required to support the QRAC Post mission is basic

telephone service and the network interconnectivity it can provide.[17] Until recently, obtaining basic telephone service from aboard commercial airliners was an impossibility. However, the advent of a service known as GTE Airfone has now made it possible and consequently opened the door to implementation of the QRAC Post concept.

GTE Airfone is essentially a commercial air-to-ground telephone system which allows airline passengers voice and data access to the Public Switched Telephone Network (PSTN) while in-flight. The value of Airfone to the QRAC Post concept is that it provides the crucial communications link from the aircraft to the rest of the world via the PSTN. By using the PSTN a number of benefits are derived with respect to the QRAC Post. First is the fact that the PSTN literally allows world-wide connectivity. Consequently, QRAC Post crisis management teams can maintain contact with consultants, data bases, etc., from anywhere in the world while airborne. Second is survivability of the PSTN as a result of its size, incredible interconnectivity, and its ability to be adaptively rerouted. Even in the event of a natural disaster or terrorist act damaging a portion of the network, the system overall is likely to survive and remain

functional with only localized outages. Both the mobility provided by the QRAC Post concept and the network structure of the Airfone system allow localized outages to be bridged by the system. Finally, the QRAC Post derives economical benefit from use of Airfone and the PSTN. This is due to the fact that a separately owned and operated communications system similar to those aboard current airborne command posts is unnecessary to provide QRAC Post connectivity.

GTE Airfone is currently available anywhere over the continental United States, and by the end of 1988, it will be installed aboard virtually every commercial passenger aircraft in the U.S. fleet.[18] As the GTE Airfone network expands overseas to Europe, the Middle East, and the Pacific, the potential operating areas for QRAC Posts will also expand, thereby allowing the U.S. to project crisis management teams world-wide on an economical basis.

Operational Scenarios

The nature of the QRAC Post concept makes it nearly impossible to describe all of the scenarios under which it might be deployed. However, in order to demonstrate some of the potential uses for the system this section will describe four scenarios. Each of the

scenarios will demonstrate a possible use for the
system, and the four scenarios together will vividly
point out the versatility of the system. While each
scenario is presented as a distinct case, the readily
available nature of QRAC Post resources would make it
conceivable to deal with all four, or any combination
of the four, at the same time.

Scenario I - Political Crisis

A high level defector has requested and been
granted political asylum at an American embassy in
Europe. The defector's country of origin has filed
political protests, and the U.S. ambassador has
requested help from the State Department. The U.S.
State Department in Washington DC immediately
dispatches a crisis team to Europe to deal with the
situation. The crisis team contacts the airlines and
commandeers the first class section of a trans-Atlantic
flight, thereby activating the QRAC Post concept. The
team then boards the airplane carrying a lap-top Intel
80386 based computer, a portable printer, a video
imaging device (e.g., a DISCON Imagephone), and a
STU-III encryption system. Once aboard the team leader
inserts a card into the Airfone system which invokes a
prioritization routine thereby allowing the crisis team

complete uninterruptable access to the Airfone channels onboard.

During the course of the flight the crisis team could maintain contact via secure voice and data with both the State Department in Washington and the embassy in Europe. With the equipment carried aboard they could also have received such things as computer data files concerning the defector, copies of finger prints and photographs for verification of identity, and a variety of other State Department records concerning the situation. Additionally, the team could have been kept informed of the situation on the ground as it developed and have given direction to the embassy staff on the best course of action.

In this scenario the crisis team would have been able to provide command and control from their seats aboard a commercial aircraft while enroute to the location of the crisis. Under any other situation the team would have been totally isolated from the situation while enroute, or would have had to resort to the use of a dedicated government owned aircraft, if available, for transportation and communications support. In political crisis situations, as with most other crises as well, a great deal could have occurred during the six hour trans-Atlantic trip. Consequently

to have been without communications during that time frame would have put the crisis management team at an extreme disadvantage upon landing in Europe. In this instance the expenses associated with operating the QRAC Post are the cost of reimbursing the airline for lost revenue on the seats in the first class section of the flight[19] and the usage costs for the Airfone circuits used while in-flight.[20] This would in all probability equate to far less than the operations costs of sending the team via a dedicated government owned aircraft.[21]

Scenario II - Natural Disaster

The State of California has experienced major earthquakes along all of its known fault lines. There is extensive damage to buildings, a high number of personal injuries, and a complete loss of telephone circuits exiting the area of the disaster. Islands of communications within the local area have survived but are essentially useless since outside help cannot be contacted. To alleviate the problem a crisis management team and its carry-on equipment are dispatched from Las Vegas aboard a commercial Boeing 737. The aircraft establishes an orbit over the Sierra Mountains and the crisis management team uses the Airfone system onboard to establish contact with the

personnel on the ground in the disaster area through the surviving local telephone network.

In this mode the crisis management team can serve as a consolidation point for command and control of the situation. The team could gather information from the various sources both inside and outside the disaster area, correlate it and provide the necessary command and control functions. This could include such things as relay of damage assessment information, the dispatch of outside resources into the area, and the coordination of forces on the ground inside the disaster area. Additionally, the Airfone system could be reconfigured to allow the airborne portion of the system to serve as a relay allowing personnel on the ground to dial directly out of the area through the QRAC Post and back into the surviving portion of the PSTN outside of the disaster area. In effect this would form a bridge over the circuits damaged by the earthquake.[22]

In this scenario one QRAC Post would be replaced by another as the fuel for the first became low (a Boeing 737 has a loiter time of approximately 5 hours[23]). The cycle would continue until reconstitution of ground capability had been accomplished either through repair of the land lines or

establishment of a microwave or satellite bridge.
Operation of the QRAC Post in this scenario would
without doubt be expensive since it would entail
"rental" of the entire aircraft(s) and crew(s) for the
duration of the mission. However, it would
nevertheless be relatively cheap in comparison to the
purchase, operation, and maintenance of one or more
aircraft specifically for that purpose. Aircraft that
would for the most part sit idle on the ground waiting
to be used.[24]

Scenario III - Military Mobilization

A full scale military mobilization is in
progress. Troops are being transported from the U.S.
to Europe aboard commercial aircraft in accordance with
the Civil Reserve Air Fleet (CRAF) agreements between
the Air Force and the commercial air carriers. The
officers in charge aboard each aircraft establish a
QRAC Post by carrying aboard an Intel 80386 based
personal computer, a high resolution video imaging
device (e.g., a Cannon Still Video System), and a
STU-III encryption unit. While in transit the Airfone
system is used to establish communications between the
aircraft and ground based command and control and from
aircraft through the ground network to other aircraft
operating under the QRAC Post concept.

Under this scenario command and control information can be updated while enroute via secure voice and data connections. Additionally, terrain and weather maps as well as reconnaissance photographs could be transmitted to the aircraft over an Airfone link with the video imaging equipment.[25] Records stored in computer memory, or transferred to the computer from the ground while enroute, could be reviewed to update commanders on such things as troop training status, orders of battle, status of forces agreements, logistics requirements, and equipment inventories.

While not specifically designed with that intent in mind, the QRAC Post concept envisioned in this scenario satisfies another national objective. Namely the objective of installing a secure command and control capability aboard CRAF resources in order to provide positive control of forces during mobilizations, as directed by Presidential Directive 24 and National Strategic Decision Directive 280. The QRAC Post concept, in concert with the fact that Airfone will soon be installed aboard CRAF resources as a commercial offering, provides an economical and readily available means of satisfying this vital national objective.

Scenario IV - Supplemental C^3 Role

A major Soviet military exercise is being conducted in Eastern Europe. The Commander in Chief of U.S. forces in Europe (CINCEUR) has been called to Washington for an emergency meeting with the President. CINCEUR places his deputy in charge, commandeers the first class section of a British Airways Concorde (the fastest trans-Atlantic passenger aircraft available), and boards the plane with his personal staff and a suite of QRAC Post equipment. Throughout the trans-Atlantic crossing the General is able to maintain contact with his deputy in Europe and the NCA in Washington.

After his meeting with the President, CINCEUR reverses the process, again using the QRAC Post concept to maintain contact. During the course of the flight, Soviet forces begin crossing the border into West Germany. Using QRAC Post resources the General is able to maintain contact with both ground and airborne command posts in Europe. In this mode of operation the QRAC Post, while still in a low-threat environment, would be serving as a supplement to military airborne command posts dealing with a high-intensity crisis in a high treat environment. In other words the QRAC Post would be operating in the transition phase (as

illustrated in Figure 1-3) between low-intensity crises
and high-intensity crises.

National Policy

National policy supports the implementation of
a QRAC Post-like concept in a number of ways. First is
the commitment on the part of the Government to
addressing national emergency telecommunications needs
across the entire crises continuum, as evidenced by
such documents as Presidential Directive 53 (National
Security Telecommunications Policy) and Executive Order
11490 (Assignment of Emergency Preparedness Functions
to Federal Agencies and Departments). These documents
emphasize the importance of such things as:

1. Maintaining continuity of government and
   command and control during and after wars
   and natural disasters.[26]

2. Recovery of the nation after wars and
   natural disasters.[27]

3. Support of the vital functions of
   intelligence collection and diplomatic
   affairs during all levels of crises.[28]

4. Support of military mobilizations in all
   circumstances.[29]

Unfortunately, the goals addressed by these
policies have been faced with a virtually

insurmountable obstacle, money. Over the last 20 years
appropriating funds through Congress has become
progressively more difficult and the costs of
survivable communications systems have skyrocketed.
Consequently, agencies given the responsibility for
emergency telecommunications have been unable to afford
doing a great deal about it. Further, cuts in the
budget have prompted another policy called the
Non-Developmental Initiative (NDI). In essence this
policy encourages acquisition of systems from
off-the-shelf components in order to avoid the expense
and time required to perform Research and Development
(R&D). As a result programs to provide emergency
telecommunications requirements which require R&D will
find it very difficult to acquire the funds necessary
for implementation.

The QRAC Post concept is unique in that it
supports the policy for providing emergency
telecommunications requirements and at the same time
addresses the NDI policy of procuring systems from
off-the-shelf. By providing an airborne C^3 platform
which consists entirely of commercially available
resources, the QRAC Post concept provides the
capability required by national policy at a cost
acceptable to the national budget.

CHAPTER II

NOTES

[1] Strategic Air Command (SAC) Public Affairs Office. Telephone interview, 20 November 1987.

[2] Jane's All the World's Aircraft 1984-85. London: Jane's Publishing Inc., 1984, p. 348.

[3] Ibid, p. 347.

[4] Ibid, p. 436.

[5] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Telephone interview, 23 October 1987.

[6] Strategic Air Command (SAC) Public Affairs Office. Telephone interview, 20 November 1987.

[7] Jane's All the World's Aircraft 1984-85. London: Jane's Publishing Inc., 1984, p. 349.

[8] Disasters and the Mass Media. Washington D.C.: National Academy of Sciences, 1980.

[9] Rosch, Winn L. "Heavy Metal 386s Weigh In." PC Magazine 29 September 1987, p. 91.

[10] Alvarez, Bobbie. Product Manager, 16-Bit Products, Rolm Milspec Computer Division of Loral. Telephone interview, 4 December 1987.

[11] Thompson, Tom. "The Compaq Portable 386." Byte November 1987, p. 134.

[12] Harris/3M Document Products Inc. Faxit 111 Personal Facsimile. N.p.: Harris/3M Products, Inc., August 1987.

[13] Cannon Inc. Cannon Still Video Transceiver RT-971. N.p.: Cannon Inc., 1986.

[14] Interand Corporation. Show & Tell, DISCON Imagephone. N.p.: Interand Corporation, 1987.

[15] Boensch, Charles. Presidential Communications, White House Communications Agency.

[16] Hirst, Mike. "E-4B: The Supreme Airborne Commander." Flight International 3 June 1978, pp. 1703-1704.

[17] The University of Colorado's Institute of Behavioral Sciences Natural Hazards Research and Applications Information Center has and is continuing efforts to precisely define the communications requirements for the entire crises continuum. However, at present basic telephone service appears to be the one communications form common to all forms of crises management.

[18] Goeken, Sandra, Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Telephone interview, 23 October 1987.

[19] The cost of buying the entire upper deck (20 seats) of a 747 trans-Atlantic flight from New York to London is $30,000 per British Caladonian Airways New York Executive Sales Office.

[20] Airfone usage costs for the six hour flight would be approximately $1800 (4 channels X 360 minutes X $1.25/minute).

[21] Fuel alone for the NEACAP to make a trans-Atlantic crossing would cost approximately $31,565 based on fuel weights and costs list in Jane's All the World's Aircraft 1984-85, p. 349.

[22] Capability demonstrated during activities associated with earthquake exercise "Response 87" conducted by the California Office of Emergency Services, 15 October 1987.

[23] Jane's All the World's Aircraft 1984-85. London: Jane's Publishing Inc., 1984, p. 338-339.

[24] During the last 10 years, California has experienced 2 earthquakes (7.0 and over on the Richter scale) during which an airborne command post capability would have been of use, according to the National Earthquake Information Center in Denver Colorado.

[25] Capability demonstrated during activities associated with earthquake exercise "Response 87" conducted by the California Office of Emergency Services, 15 October 1987.

[26] Presidential Directive 53, National Security Telecommunications Policy. 15 November 1979.

[27] Ibid.

[28] Ibid.

[29] Ibid.

CHAPTER III

THE AIRFONE SYSTEM

Introduction

The ability to communicate from commercial
aircraft in-flight is the key to the viability of the
QRAC Post concept. In order to provide a better
understanding of how GTE Airfone is able to provide
this capability, this chapter will describe the system,
its development, structure and capabilities. As the
reader progresses through this description, Airfone's
potential as a QRAC Post communications asset will
become obvious.

Basic Concepts and Background

Basically, GTE Airfone is an in-flight
telephone service which provides direct-dial
air-to-ground communications links from commercial
aircraft to the ground based, world-wide Public
Switched Telephone Network (PSTN). Airfone, the first
system of its kind developed specifically for
commercial air travellers, was first put into service
on 15 October 1984.[1] Since then it has been providing

quality, air-to-ground telephone service to passengers in-flight over the continental United States, allowing them to place calls from their seats aboard commercial aircraft, to virtually anywhere in the world.

Airfone was originally founded in 1975 by John D. Goeken, who was also the founder and former president of the MCI Corporation. After several years of concept development work, Airfone Inc. petitioned the Federal Communications Commission (FCC) in 1979 for an experimental license. The license was granted in October 1980 and development of the technology to implement the system began.[2] In 1981, the Western Union Corporation joined with Airfone Inc., in a joint venture, and by 1983 the Airfone concept had entered the manufacturing stage.[3]

By September 1984, the first commercial aircraft was equipped and enough ground stations had been installed to begin full scale testing. Actual commercial operation began, as mentioned earlier, a month later in October 1984. During its first year of operation Airfone was designated one of Fortune magazine's top 10 new products of the year for 1985.[4]

Initially, implementation of the system proceeded at a relatively slow pace, due primarily to funding constraints. However, on 15 December 1986

Airfone Inc. was purchased in whole by the GTE
Corporation, a _Fortune_ 25 company.[5] Since then GTE's
relatively "deep pockets" have allowed Airfone, as a
wholly owned subsidiary assigned to the Business
Services Group of GTE's Telephone Operations, to
proceed with implementation at an amazing pace.

As of 23 October 1987, Airfone was installed
aboard 524 commercial aircraft owned by 15 major US air
carriers (See Table 3-1).[6] This number represents
approximately 17.5% of the entire US commercial air
fleet, at present a relatively small percentage.
However, GTE Airfone has contracts to install the
system aboard an additional 2376 aircraft by the end of
1988,[7] bringing the total number of aircraft equipped
to 2900.[8] This represents roughly 97% of the entire US
fleet, and approximately 36.3% of the entire world's
commercial fleet. Additionally, Airfone is expanding
its market internationally and has received serious
inquiries from over 20 international airlines in
Canada, Europe, the Middle East, the Far East, and the
South Pacific.[9]

Since the system's implementation in 1984, it
has been used to place over 2 million billed calls (See
Figure 3-1).[10] Further, GTE estimates that with the
current number of systems installed over 100,000 calls

are made each month.[11] As the number of systems

installed increases, it is reasonable to assume that

the monthly calling figure will also rise as the

service becomes available to more of the 415 million

commercial air passengers each year.[12] As more of the

systems are installed, Airfone will become another of

the basic telecommunications services that people in

today's telecommunications era have come to expect and

rely upon.

Table 3-1 - Airlines Currently on Contract with GTE
Airfone

Air Cal[13]	Midway
Air Canada	Northwest
American	Pan American
Continental	Pan American Shuttle
Delta	Piedmont
Eastern	TWA
Jet America	United
MGM Grand	

Source: Goeken, Sandra. Vice President for
Corporate Affairs/New Business Development and Managing
Director of Airfone International, GTE Airfone Inc.
Telephone interview, 26 October 1987.

The concept of Airfone, and the capability of

providing travellers enroute an economical means of

communicating with their homes and work places,[14] has

resulted in two other profitable spin-offs for GTE

Airfone. The spin-off systems are Railfone and

Marinefone. These systems, as their names infer, are
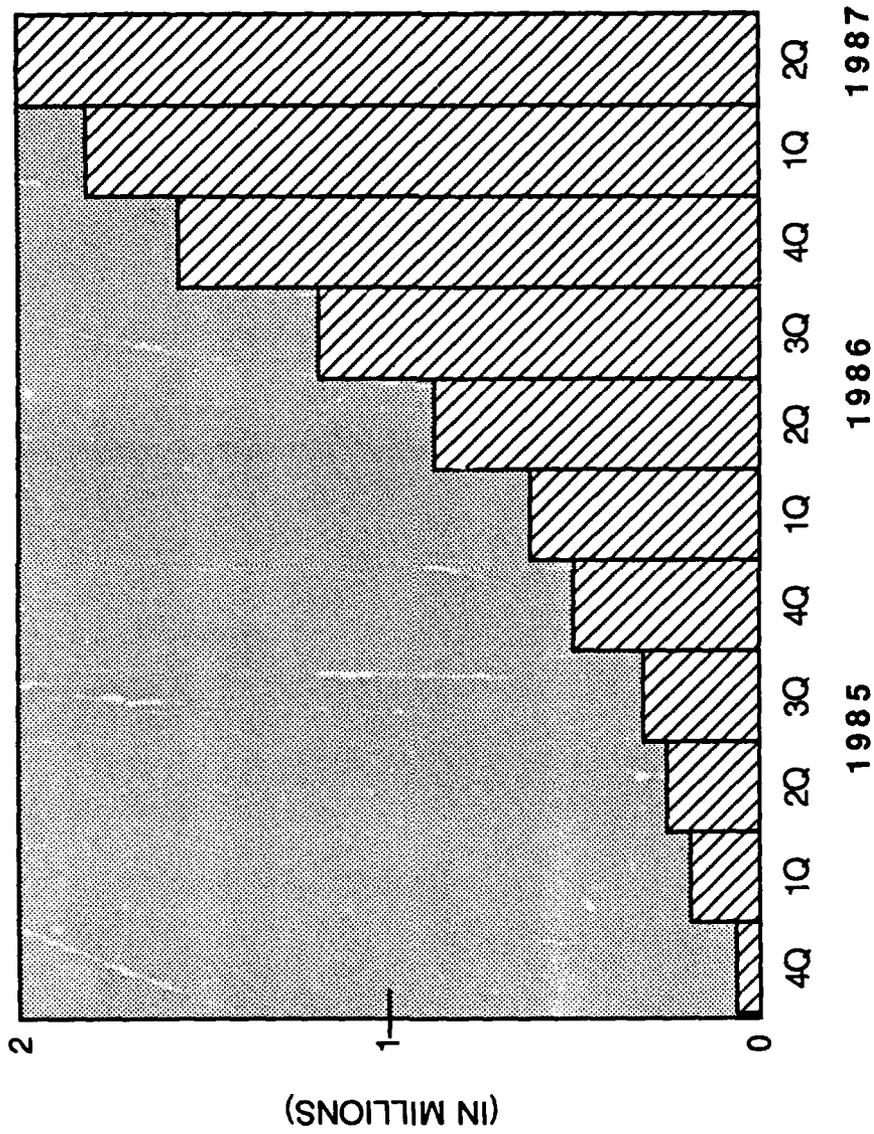
Figure 3-1 - GTE Airfone Cumulative Calls Billed as of 2nd Quarter 1987[15]

located aboard trains and boats. Namely, the commuter trains and ferries which operate in the heavily trafficked business corridors near our country's major cities. GTE Airfone sees these systems as a natural extension of Airfone and the concept of keeping the business traveller in touch with the world.[16]

System Capabilities

In addition to providing normal air-to-ground telephone service, GTE Airfone has a number of other demonstrated and potential capabilities. Among those currently available for passengers or likely to be available in the near-term are the following.[17]

1. Seatfone - This service went into operation on 12 October 1987 and allows passengers to make Airfone calls directly from their seats via hardwired handsets which are installed in the backs of the seats in front of them.[18] This service is much more convenient for the passenger and provides better quality service due to the elimination of the radio link to the wireless handsets and the elimination of the attenuation in that link. Additionally, Seatfone incorporates a

standard RJ-11 jack so that travellers can "plug-into" the system with portable computers. Further, Seatfone will allow extension of other Airfone services directly to the passengers seat.

2. Ground-to-Air Telephone Service[19] - Presently the system is limited to air-to-ground service due in large part to the airlines' reluctance to allow calls to be made to the aircraft while in-flight. Many of the airlines feel that, by allowing ground-to-air calling with the current system their stewards and stewardesses would become airborne answering services. With the advent of Seatfone, Airfone Inc. is investigating methods for allowing calls to be place directly to a passengers seat. This would eliminate the need for crew members to answer calls, thereby eliminating the airlines' major objection to the service. Further, this capability will open the door for air-to-ground-to-air calls, thereby allowing passengers in-flight aboard different aircraft to call each other.[20]

3. Data Transmission - The ability to transmit data over the Airfone system has been demonstrated at a variety of data rates up to and including 14.4 Kbps. This capability is the basis upon which a number of the other service offerings can be provided.

4. Facsimile Service - The ability to provide facsimile service through Airfone has been demonstrated. However, a definitive market for the service has yet to be identified.

5. Electrocardiogram (EKG) Transmission - This capability has already been demonstrated and can be made available on request. It allows for an EKG device onboard the aircraft to communicate with a medical facility on the ground, thereby allowing continuous monitoring of a patient while in-flight. This same capability can be made available to support other types of medical parametric data.

6. In-Flight Reservation Service - This service will allow passengers to make airline, rental car, and hotel reservations

while in-flight using special toll-free numbers.

7. In-Flight Shopping - This service will allow passengers to select gift items from an in-flight magazine and order them directly by using the Airfone keypad, without operator or order taker intervention.

8. Telex and Telegram Service - Airfone is investigating the possibility of installing a computer terminal aboard aircraft to allow passengers to send both telexes and telegrams while in-flight.

9. Stock Quotations Service - This service would also involve the installation of a computer terminal from which passengers could obtain stock quotations while airborne, thereby allowing investors to keep track of the market while travelling.

10. Voice Store and Forward - This service would offer passengers a capability to call a computer service, leave a recorded voice message, and have the message forwarded to a designated party via normal phone lines.

Additionally, less marketable capabilities have also been demonstrated. However, their applicability is limited to a small number of users. These capabilities include the use of National Security Agency (NSA) approved analog encryption devices, the ability to hand off calls between ground stations allowing a call to be maintained from coast to coast, the ability to prioritize both ground station and airborne equipment for special users, and the ability to use an airborne system as a relay to bridge a gap produced by ground based PSTN outages. While these capabilities are promising, their applicability to the public at large is rather limited. Consequently, they are not likely to be made available as standard service offerings, but are more likely to be made available to specialized, primarily government users on a demand basis.

Overall the Airfone system is capable of providing a wide array of communications capabilities for passengers in flight. In fact, with few limitations (primarily associated with lack of allocated bandwidth', it is capable of extending virtually all of the communications capabilities available with ground based systems into the air.

System Description

To better understand how the GTE Airfone system is able to provide "normal" telephone service to airborne travellers, a brief description of the system itself (as opposed to a description of the service) and the technology involved is necessary.

The GTE Airfone system is composed of three major components: an airborne segment, a ground-entry segment, and a control segment (See Figure 3-2). The overall relationship between the segments is relatively simple. The airborne segment provides the interface to the user via the Airfone handset. The ground-entry segment provides the interface between the airborne segment and the PSTN. Finally, the control segment allows a mechanism for monitoring system performance and "trouble shooting" the entire network. While seemingly simple, each of these components actually performs a number of functions essential to the operation of the system.

Airborne Segment

While it is the most obvious piece of the system to the user, the airborne portion of the system involves a great deal more than initially meets the eye. The user usually only sees the bulkhead mounted
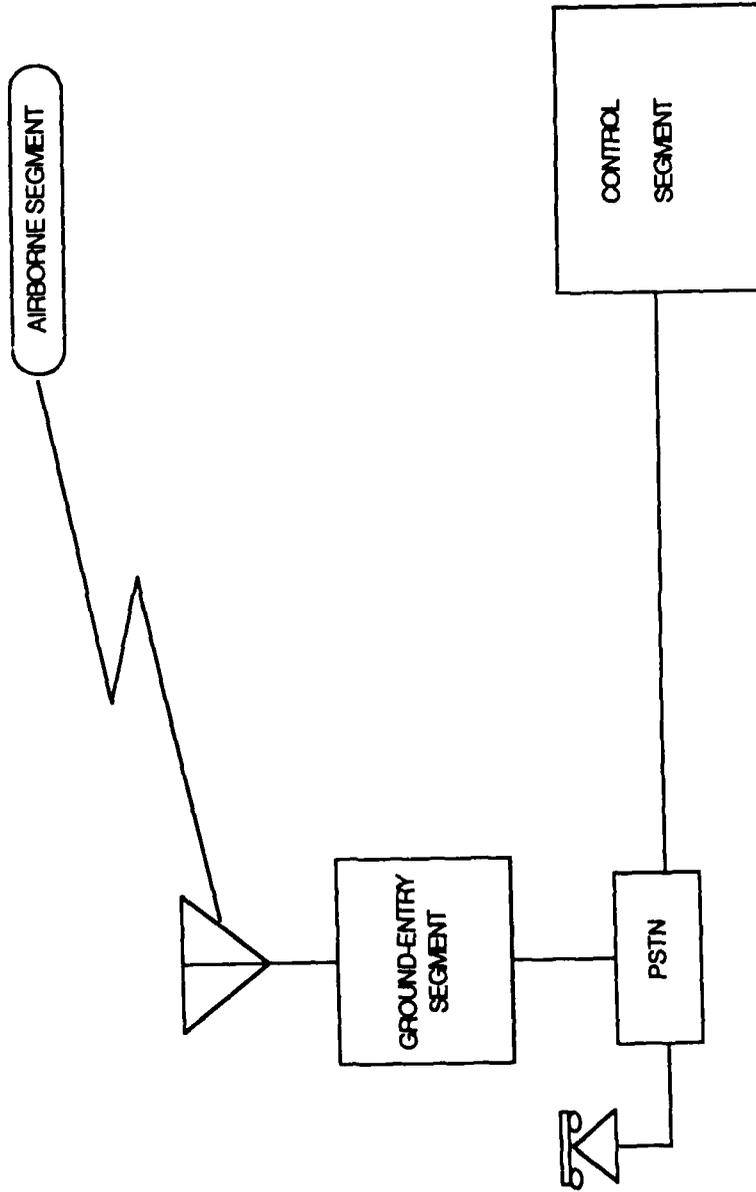
Figure 3-2 - Airfone System Block Diagram[21]

cabin handset holders, of which there are usually four to eight depending on the specific configuration of the airplane. However, in reality there are many other components involved in the process. Figure 3-3 and Figure 3-4 illustrate the various components of the airborne system and Figure 3-5 demonstrates how the components are interconnected in relation to each other. The numbers in Figure 3-3 and Figure 3-4 correspond to the numbers of the components in the following list which briefly details each component and its function.[22]

1. Antenna Matching Assembly - Serves as an interconnection between the antenna mounted in the ceiling of the aircraft, for communication with the cordless handsets, and the transmit and receive feeder cables leading to the equipment tray.

2. Ceiling Antenna Assembly - Composed of 20-gauge antenna cable running the length of the cabin ceiling, and tuned to the frequencies used by the cabin handsets.

3. Feeder Cable Assembly - Consists of two coax cables (transmit and receive) which connect the equipment tray to the ceiling
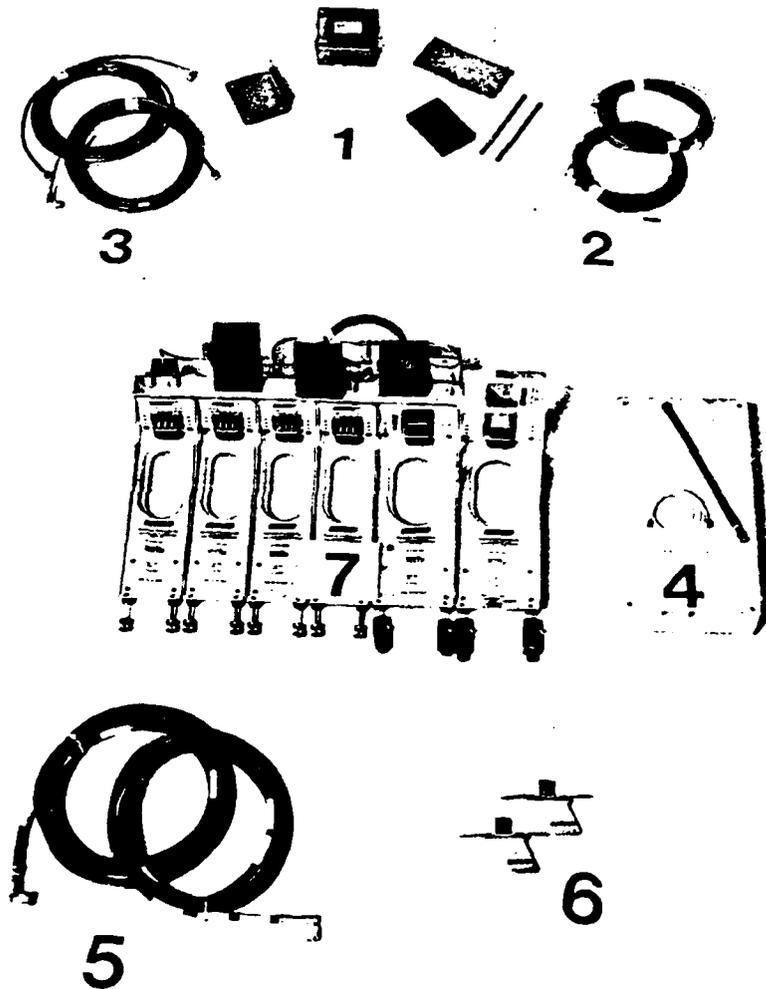
Figure 3-3 - Components 1 through 7 of the
Airborne Segment[23]
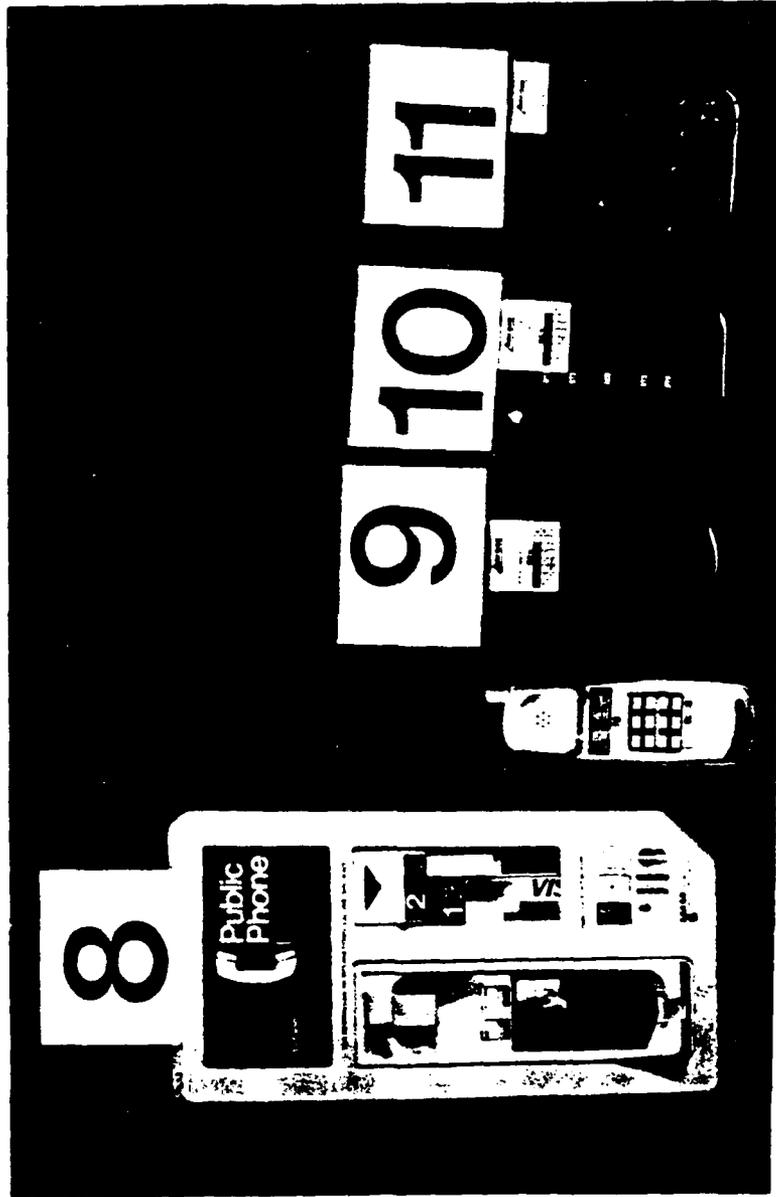
Figure 3-4 - Components 8 through 11 of the Airborne Segment[24]
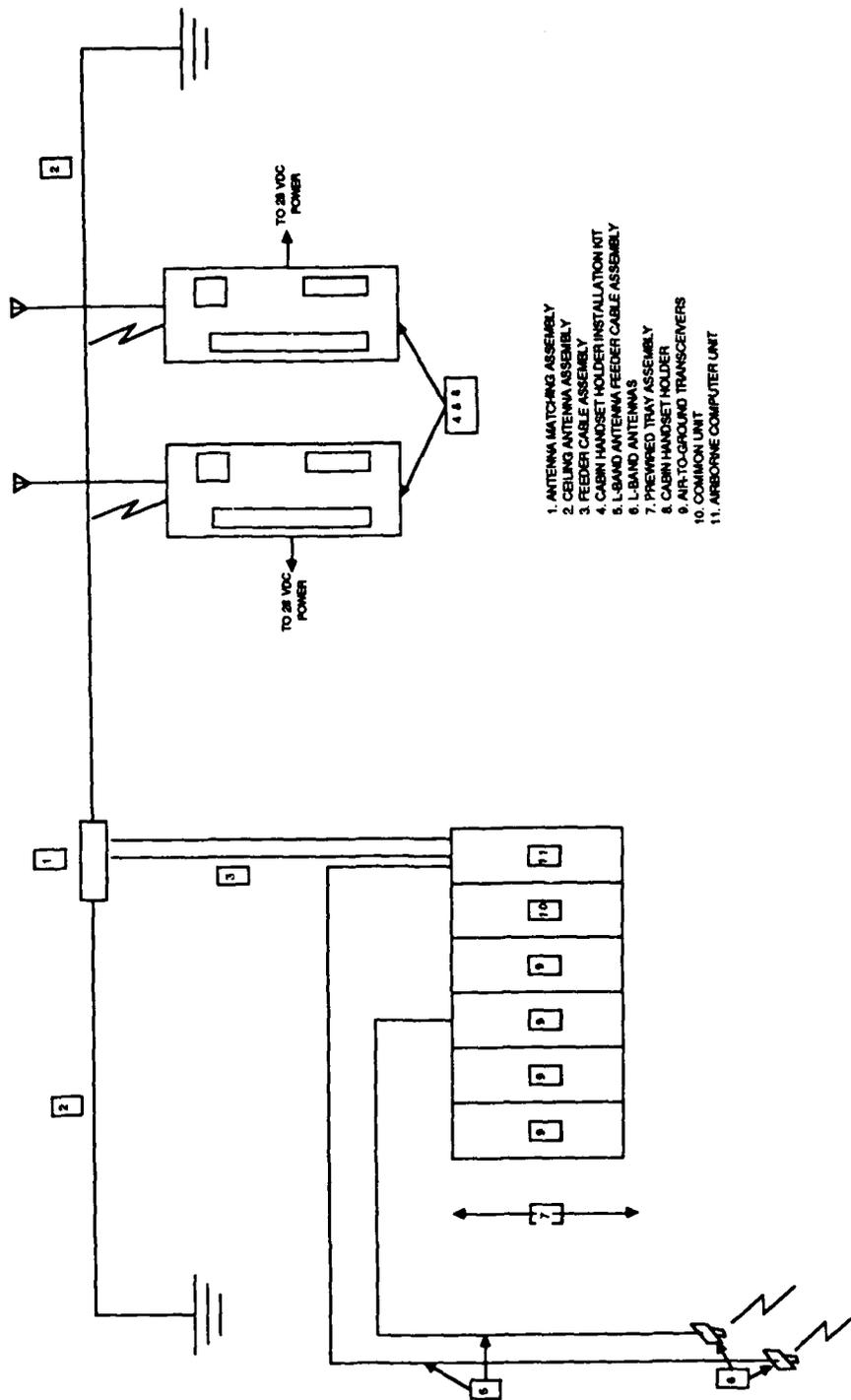
1. ANTENNA MATCHING ASSEMBLY
2. CEILING ANTENNA ASSEMBLY
3. FEEDER CABLE ASSEMBLY
4. CABIN HANDSET HOLDER INSTALLATION KIT
5. L-BAND ANTENNA FEEDER CABLE ASSEMBLY
6. L-BAND ANTENNAS
7. PREWIRED TRAY ASSEMBLY
8. CABIN HANDSET HOLDER
9. AIR-TO-GROUND TRANSCEIVERS
10. COMMON UNIT
11. AIRBORNE COMPUTER UNIT

Figure 3-5 - Airborne Segment Block Diagram[25]

antenna assembly via the antenna matching assembly.

4. Cabin Handset Holder (CHH) Installation Kit - Includes the CHH mounting bracket, the 28 VDC power supply lines, and a 49 MHz antenna connection.

5. L-Band Antenna Feeder Cable Assemblies - Two coax cable assemblies which interconnect the externally mounted, blade style, L-Band antennas to the equipment tray.

6. L-Band Antennas - Two blade style antennas which operate in the L-Band for communications with the ground-entry segment of the Airfone network (See Figure 3-6). Each antenna will accommodate two transceivers, hence a two blade configuration would support four transceivers.

7. Prewired Tray Assembly - Serves as a prewired base for holding the air-to-ground transceivers, the common unit, and the airborne computer unit. Tray differs for various aircraft, depending upon the amount of space available for installation.
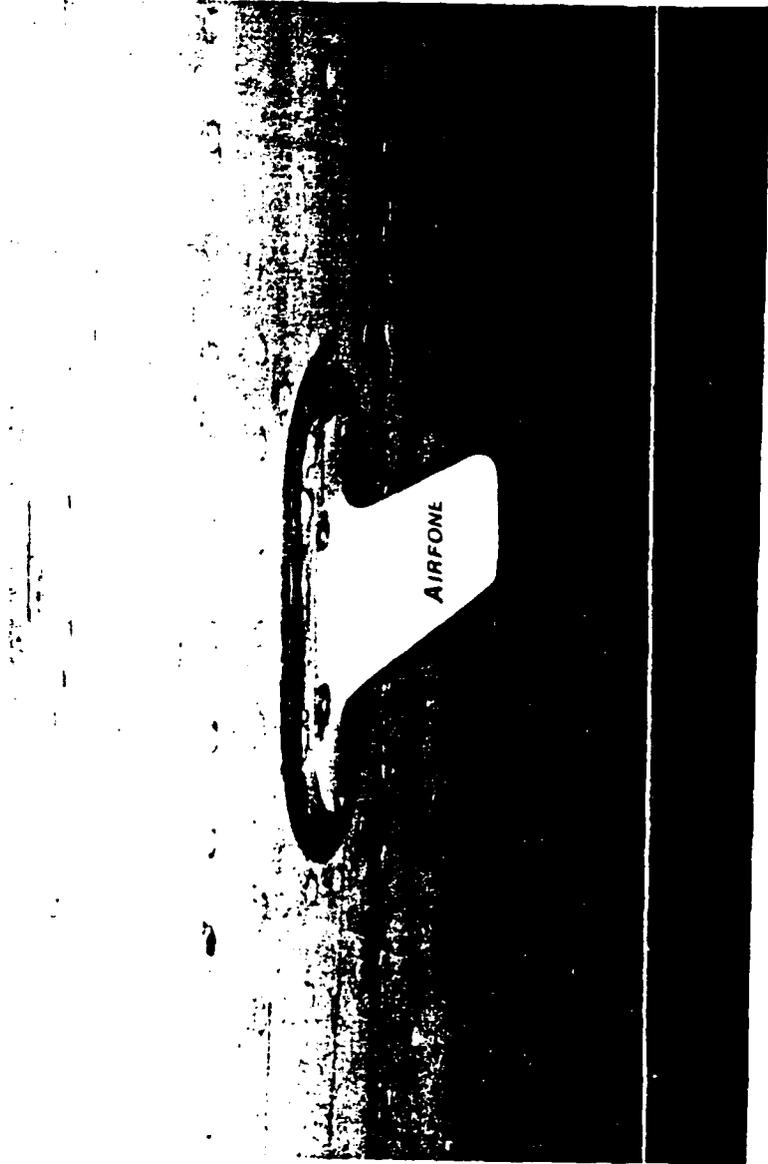
Figure 3-6 - L-Band Airborne Antenna, Blade Style[26]
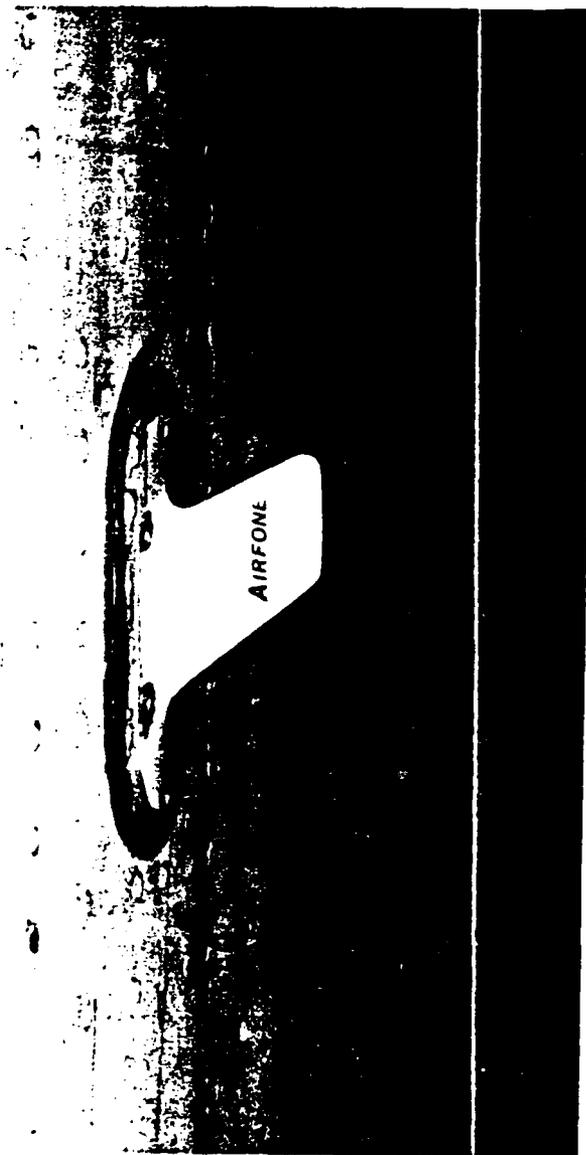
Figure 3-6 - L-Band Airborne Antenna, Blade Style[26]

8. Cabin Handset Holder (CHH) - Serves as a
    base for the cordless handset. Usually
    four to eight aboard each aircraft,
    depending on the aircraft configuration.
    CHH houses a credit card reader, a
    microprocessor, an alphanumeric display for
    prompting the user, a battery charger to
    charge the cordless handset, and the
    cordless handset itself. The handset
    provides the link between the passenger and
    the air-to-ground 900 MHz radio. It
    operates in FM mode, transmits in the 49
    MHz band and receives in the 1.7 MHz band.
    Each handset operates on an assigned pair
    of fixed frequencies and radiates
    approximately 17 milliwatts via an internal
    antenna which protrudes 5/8 inches from the
    top of the unit. The handset operates off
    of battery power and will hold a charge for
    approximately three hours of continuous
    use. To avoid ingestion of cabin noise
    into the system handsets are equipped with
    noise canceling microphones.

9. Air-to-Ground Transceivers (R/Ts) -
    Operate in the compatible single sideband

mode, with a transmitter frequency of
899-901 MHz and a receive frequency of
944-946 MHz. Frequencies will be shifted
to 849-851 and 894-896 MHz respectively
over the next year, per FCC direction.
Frequency agility allows the R/Ts to
operate on any of 310 possible voice
channels. Typically four R/Ts are
installed aboard a wide body aircraft,
thereby limiting the number of simultaneous
voice conversations from the aircraft to
four despite the number of handsets which
may be installed.

10. Common Unit (CMN) - Contains the equipment
common to the various other components in
the system, including a three-phase power
supply operating off of the aircraft's 400
Hz power, the master oscillator used for
generating the frequencies used for the
R/Ts, and the RF down converters to handle
the shift in frequency between the handsets
and the R/Ts.

11. Airborne Computer Unit (ACU) - Constitutes
the brains of the airborne system.
Contains the microprocessor used for

control purposes and the base station radio
channels used to communicate with the
cordless handsets. Performs monitoring
functions for the onboard Airfone
equipment, collects performance data and
digitally communicates with the ground
stations. Incorporates battery-backup to
insure processor will not lose its memory
during aircraft power sags.

To make a call with the Airfone system, a user
merely inserts a major credit card[27] into a cabin
handset holder, waits a few seconds for credit
authorization, removes the cordless handset from the
CHH and proceeds with the call. Overall a very simple,
user friendly public phone system. However, a number
of things transpire aboard the airplane during the
process of the call, all transparent to the user.

In order for a call to be placed from an
aircraft, the R/Ts aboard must be in contact with an
Airfone ground station. In order to determine which
ground station to access, the ACU uses a patented
Doppler shift technique to automatically select the
best ground station within range. The selection is
based on signal strength, the aircraft's relative
position, and its direction of travel. Whenever

possible the system attempts to select a ground station in front of the airplane to ensure maximum connection time. For most aircraft, the Airfone system will provide a minimum of twenty minutes of connectivity and a maximum of forty-five minutes. The faster the aircraft the shorter the connectivity time due to the fact that the coverage area for the ground station is traversed faster and vice versa. Since the average Airfone call is less than fifteen minutes, the limited connectivity time of the system is not a critical factor in providing service. The process of locating the optimum ground station and performing self-diagnostic checks occurs continuously while the system is in operation. Once a ground station is located, the ACU "reads" the ground station's pilot signal to determine which of the 310 possible channels are available for use, any system update information, etc.

When a user initiates a call by placing their credit card in the handset holder, the CHH reads the credit card information to determine its type, account number, and expiration date. At the same time the system verifies the health of the radio connection between the ACU and the cordless handset. If the circuit is not functional the handset will not be

released and an error message will be displayed. When
the user pushes the "dial tone" button on the cordless
handset, the ACU selects which of the available
channels to use and "patches" the handset into one of
the R/Ts to establish a duplex circuit through the
ground station, into the PSTN, and returns dial tone to
the user. The circuit remains active until the "hang
up" button is depressed by the user. When the handset
is returned to the holder the ACU verifies that the
handset returned is the correct one for that CHH and
releases the users credit card. Credit card and
billing information (e.g., call duration) is
transmitted to the ground station by the "pilot" signal
along with the aircraft's identification number and
general diagnostic information about the onboard
systems' performance.

While any number of R/Ts could be placed aboard
an aircraft depending on the anticipated demand for
service, a typical aircraft installation will include
four R/Ts. Hence four possible simultaneous
connections. However, for the sake of passenger
convenience, more than four CHHs may be installed.
Consequently, it is possible for a caller to get a
message indicating that channels are not currently
available. Revenue from the system is split between

GTE Airfone and the air carrier, with 10 - 14% going to the airlines depending upon the volume of calls processed. The average cost of installing the system aboard a widebody aircraft is approximately $40,000, including equipment and installation costs, with the airline paying for the installation costs and GTE Airfone paying for the equipment itself. The system is currently installed, with FAA and FCC approval, aboard a wide variety of aircraft as indicated in Table 3-2. Airfone expects the system to be installed aboard 97% of the commercial passenger aircraft in the United States fleet by the end of 1988, making it a standard feature for the air traveller rather than the novelty that many view it as today.

Table 3-2 - Commercial Aircraft Approved for Airfone Operation

Air Canada 727	Air Canada 767
AirCal 737	American Airlines DC-10
American Airlines 767	British Airways Concorde
Continental DC-10	Delta Airlines L-1011
Eastern Airlines L-1011	Eastern Airlines A-300
Jet America MD-80	Midway Airlines DC-9
Northwest DC-10	Northwest 757
Ozark Airlines DC-9	Piedmont Airlines 727
Republic Airlines 727	TranStar DC-9
TWA L-1011	United Airlines DC-10
United Airlines DC-10	United Airlines 767
United Airlines DC-8	Western Airlines 727

Source: GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, pp. 107-134.

Ground-Entry Segment

The ground-entry segment of the Airfone system is a network composed of 71 ground stations within the continental United States (CONUS), which serve as the system's entry points to the PSTN. Sixty-eight of the sites are fully licensed for commercial operation, while the other three serve as experimental sites only (See Figure 3-7).[28] Currently, the only ground stations in the network are located in the CONUS. However, Airfone has plans for and is currently negotiating to install ground stations world-wide in order to cover all of the major air corridors (See Figure 3-8). The ground stations are unmanned and each operates independently of the others in the network. Consequently, if one site fails the others remain unaffected.

Each of the ground stations has an operating range of approximately 200 miles (400 mile diameter) for aircraft at an altitude of 20,000 feet. Since the system operates using Compatible Single Sideband (CSS) its use is restricted to line of sight. Consequently, the operating diameter of the ground station increases as the altitude of the aircraft (the radio horizon) increases, as illustrated in Table 3-3. The Airfone ground network is designed such that, with aircraft
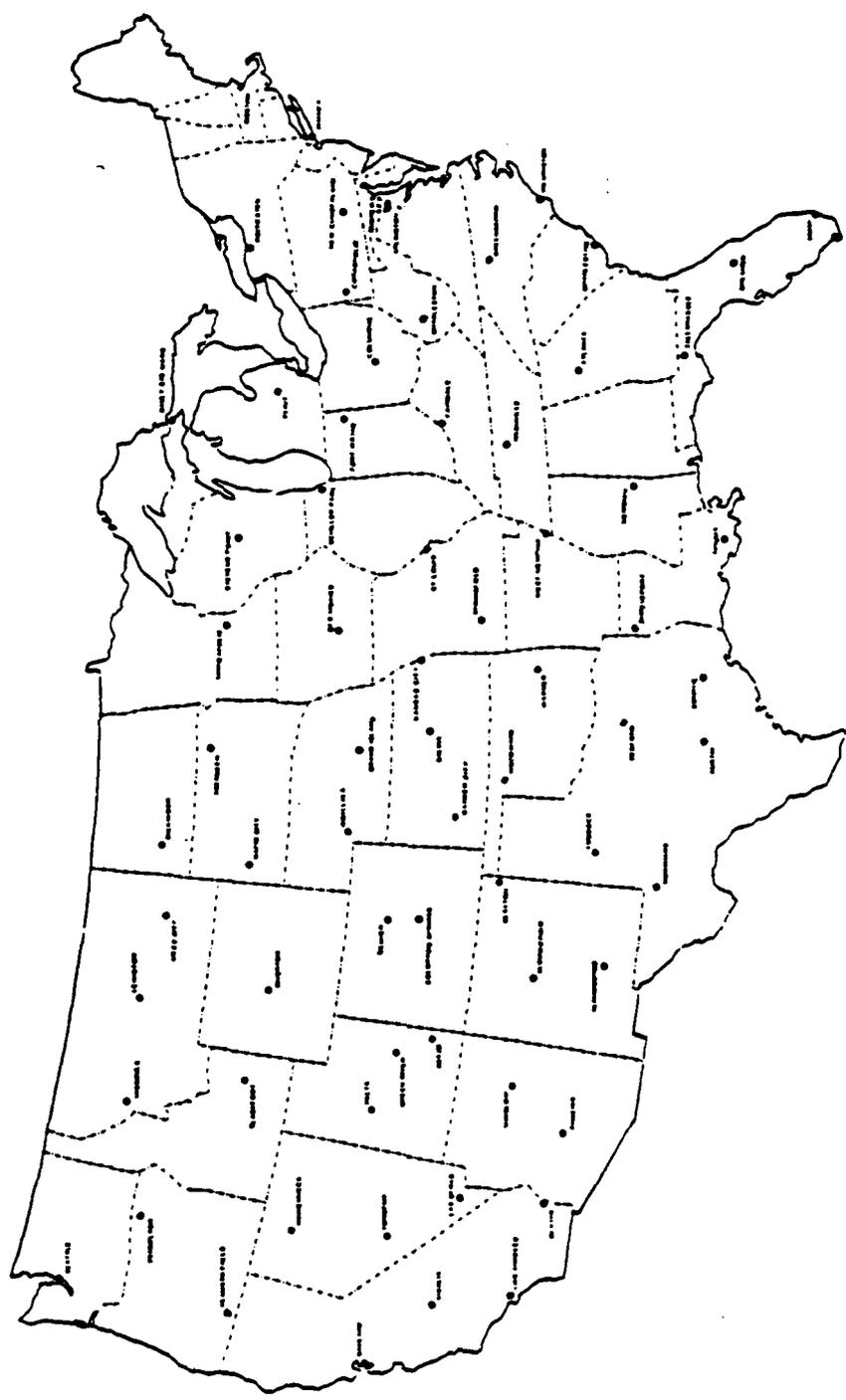
Figure 3-7 - Airfone Ground Station Map[29]

Figure 3-8 - Proposed World-Wide Airfone Ground Station Coverage[30]

Table 3-3 - Radio Horizon Versus Altitude

Altitude in Feet	Radio Horizon in Miles	Altitude in Feet	Radio Horizon in Miles
40,000	280.00	20,000	197.99
39,500	278.24	19,500	195.50
39,000	276.48	19,000	192.98
38,500	274.70	18,500	190.42
38,000	272.91	18,000	187.83
37,500	271.12	17,500	185.20
37,000	269.30	17,000	182.54
36,500	267.47	16,500	179.83
36,000	265.63	16,000	177.09
35,500	263.78	15,500	174.30
35,000	261.92	15,000	171.46
34,500	260.04	14,500	168.58
34,000	258.15	14,000	165.65
33,500	256.24	13,500	162.67
33,000	254.32	13,000	159.62
32,500	252.39	12,500	156.52
32,000	250.44	12,000	153.36
31,500	248.48	11,500	150.13
31,000	246.50	11,000	146.83
30,500	244.50	10,500	143.46
30,000	242.49	10,000	140.00
29,500	240.46	9,500	136.45
29,000	238.41	9,000	132.82
28,500	236.35	8,500	129.07
28,000	234.26	8,000	125.22
27,500	232.16	7,500	121.24
27,000	230.04	7,000	117.13
26,500	227.90	6,500	112.87
26,000	225.74	6,000	108.44
25,500	223.56	5,500	103.83
25,000	221.36	5,000	98.99
24,500	219.13	4,500	93.91
24,000	216.89	4,000	88.54
23,500	214.62	3,500	82.82
23,000	212.32	3,000	76.68
22,500	210.00	2,500	70.00
22,000	207.65	2,000	62.61
21,500	205.28	1,500	54.22
21,000	202.88	1,000	44.27
20,500	200.45	500	31.30

Source: Zachrel, Norm. Manager, Test and Evaluation, GTE Airfone Inc.

operating at normal commercial altitudes, virtually the
entire CONUS is covered (See Figure 3-9). The ground
network was also designed to ensure coverage for
aircraft making approaches to major airports within the
U.S. With very few exceptions the ground network is
positioned to provide continuous communications support
for the onboard systems anywhere in the U.S. The
exceptions to this are associated with aircraft being
blocked from direct line of sight communications with a
ground station while on the ground at some airports.

The 4 MHz bandwidth allocated to GTE Airfone
for experimental operation is divided into two pieces,
a 2 MHz bandwidth for transmitting from the airplanes
(899-901 MHz) and a 2 MHz bandwidth for transmitting to
the airplanes from the ground stations (944-946 MHz).
The airborne units have enough frequency agility to
operate over the entire allocated bandwidth. However,
each ground station is limited to transmission within a
200 KHz band. This effectively allows for the creation
of 10 separate pilots, and consequently the possibility
of 10 separate ground stations within the same
geographical area, without interference between the
stations (See Figure 3-10). Each ground station's 200
KHz is subdivided into 31 subchannels or audio channels
and one pilot channel. Each audio channel is 6 KHz

64

20,000 FT LINE OF SIGHT
200 MILE PROPAGATION CIRCLES
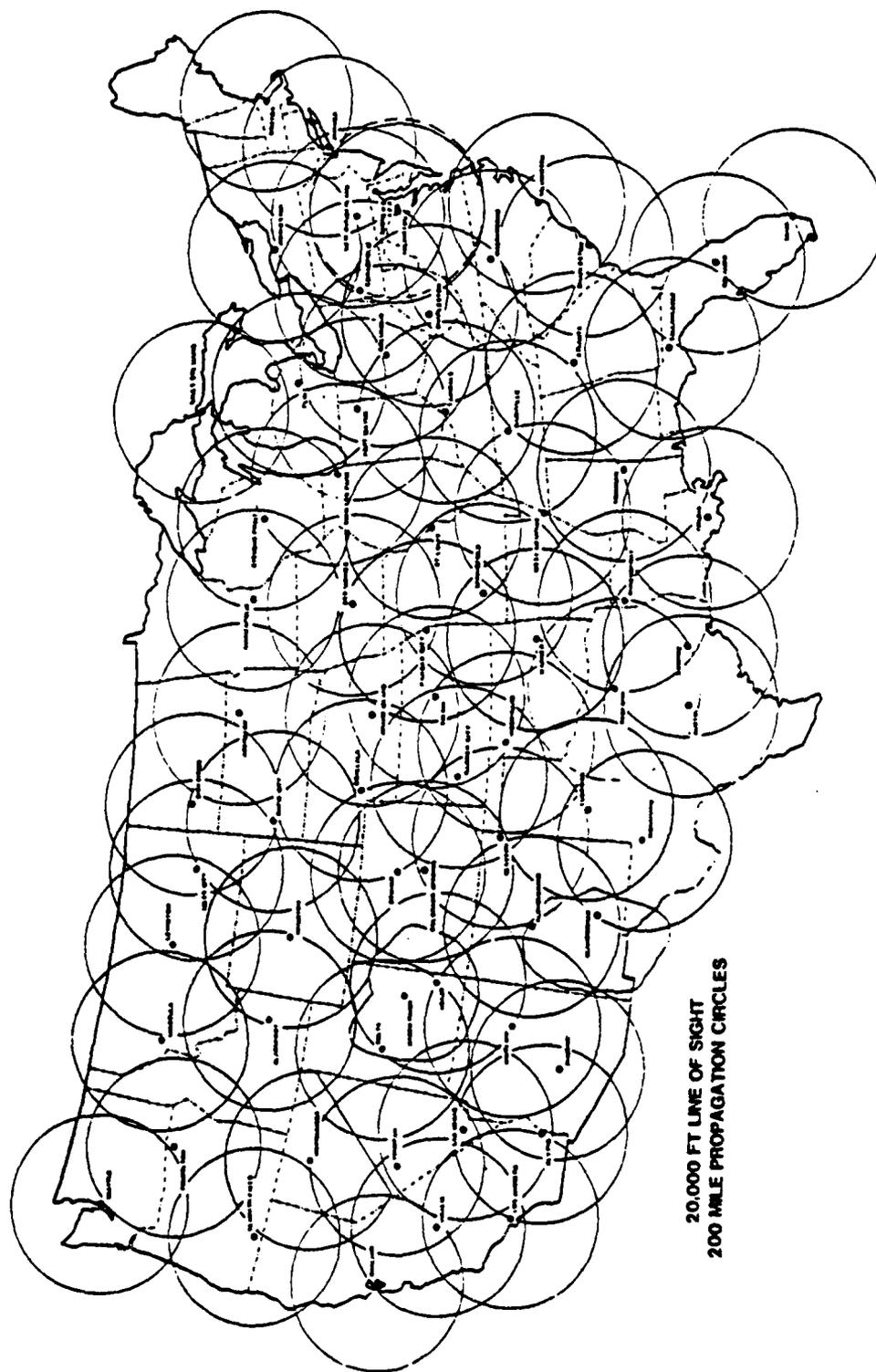
Figure 3-9 - U.S. Ground Station Propagation Map[31]
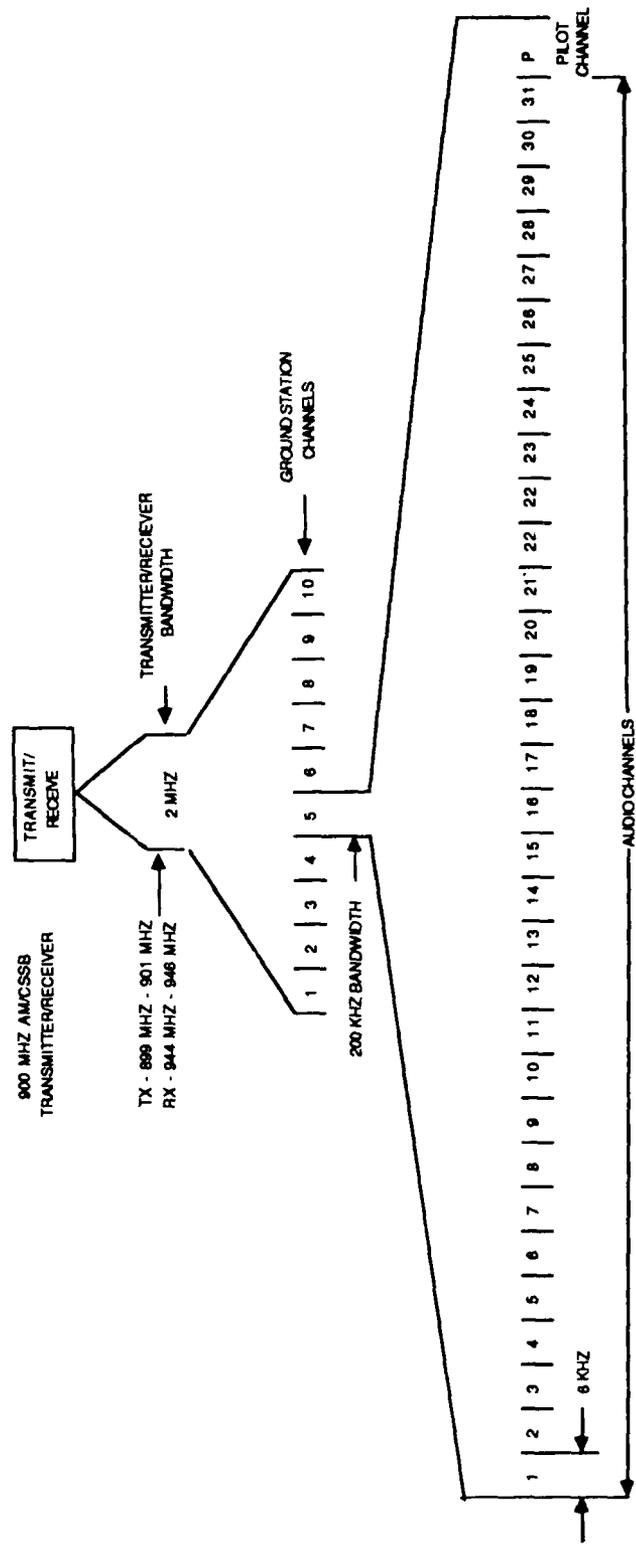
Figure 3-10 – Airfone Channel Plan[32]

wide with 3 KHz dedicated to the audio transmission, 2
KHz of guard band, and 1 KHz for Doppler. The pilot
channel serves two principle uses, it enables the
airborne unit to search for and select the best ground
station, and it broadcasts information about which of
its 31 channels are available for use.

Once a link has been established between a
ground station and an airborne unit, the ground
station's role becomes one of translating between the
radio signal to/from the airplane and the public
switched network, and gathering billing and diagnostic
data from the aircraft. The interface to the PSTN is
via "normal" 2-wire business class telephone lines. As
a result, the PSTN sees Airfone as merely another
business customer and does not recognize that the call
is emanating from an airplane. Billing and diagnostic
data are stored on hard disk at the ground station for
retrieval by the central control facility during
off-hours.

Each ground station costs approximately
$93,000-104,000 and can be located in an area as small
as 10' X 10'.[33] In fact, many of the current
installations are in (what amounts to) little more than
a large closet (See Figure 3-11 and Figure 3-12). GTE
Airfone is currently working to reduce this size even

Figure 3-11 - Airfone Ground Station in Chicago[35]

Figure 3-12 - Airfone Ground Station in Chicago[36]

further and soon expects to produce a ground station
contained within a single equipment rack. The intent
is to produce a "portable" version to be used for
system reconstitution in the event a permanent ground
station experiences catastrophic failure. The antennas
used for the ground station consist of two seven foot
masts (See Figure 3-13). For the current ground
stations these masts are permanently fixed to the
highest point available to ensure maximum coverage.
However, the "portable" version is being designed with
the intent of operating with a quick-mount mast antenna
and has even been tested with a magnetically mounted
whip antenna.[34]

Control Segment

The control segment of the system consists of
the Customer Service Operations Center (CSOC) and the
Airfone Operational Control Center (AOCC) which are
co-located with GTE Airfone headquarters in Oak Brook,
Illinois.

The CSOS provides 24 hours/day, 7 days/week,
multilingual operator service for Airfone customers.
This includes fielding of customer complaints,
questions, and comments. The service can be reached
from aboard the airplane by dialing "0" (at no charge)
or from the ground by dialing a toll-free number.
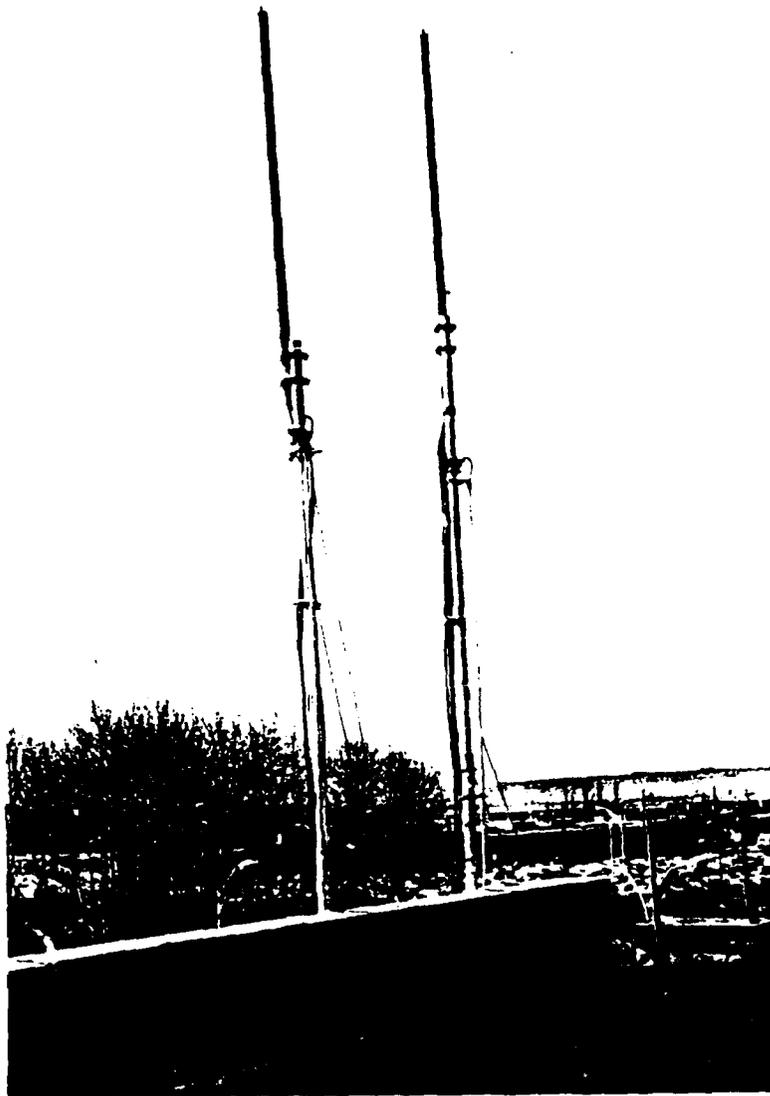
Figure 3-13 - Ground Station Antennas[37]

Operator consoles are equipped with computer terminals which allow the operators to provide world-wide directory assistance, correct billing information, etc. The center also generates written responses to the customer for all complaints, comments, and inquiries.

The AOCC is responsible for performing a number of technically oriented functions including:

1. Real-time monitoring of ground station status.

2. Status monitoring of airborne equipment.

3. Dispatch of maintenance personnel.

4. Collection, processing, and distribution of billing information.

5. Development and distribution of hardware and software updates.

The AOCC operates 24 hours/day and is designed to ensure the health of the Airfone system. From the AOCC it is possible to monitor, via a DAQ Electronics remote alarm system, every component of the network either directly or through relayed information. Depending on the nature of the problem, the AOCC can correct it remotely (including problems aboard a specific aircraft) or can dispatch maintenance personnel to the ground site to meet an aircraft as it lands. Additionally, the AOCC builds maintenance

histories for every component in the system, and conducts trend analyses to predict where and when problems are likely to occur. The system is automated to the maximum extent possible to ensure prompt response and to minimize the human intervention required.

Another feature of the AOCC is that it is capable of down-line loading software changes to both the ground stations and the aircraft. Since the overall system is still in an experimental and development stage (according to the FCC license), Airfone has opted to leave many of the system's features in a software versus hardware form, allowing a great deal of system flexibility. In fact, the system is so flexible that it can, on a near real-time basis, be remotely modified for "special" applications.

The control segment is obviously an important part of the Airfone system. However, for the short term, it is not a critical part of the system. Since both the airborne and ground segments operate with 98% plus reliability, it is possible for the system to continue operation for extended periods of time without the intervention of the control segment. For the long term, the control segment plays a vital role in monitoring and controlling the health of the network.

As the system expands world-wide this segment of the system will become even more important.

Overall the Airfone system constitutes not just a specific service, with specific discrete components, but rather an entire common carrier network. One which, according to plan, will soon be available world-wide, providing a global communications asset.

CHAPTER III

NOTES

[1] GTE Airfone Inc. GTE Airfone Backgrounder. N.p.: GTE Airfone, Inc., 3 June 1987, p. 1.

[2] GTE Airfone was awarded experimental and development frequencies for use in proving the viability of the Airfone Concept. The frequencies awarded were 899-901 MHz for transmission and 944-946 for reception. Use of these frequencies was expire in December 1987. However, in August 1987 the FCC extended Airfone's experimental license and allocated, on an experimental basis, the frequencies of 849-851 MHz for transmission and 894-896 MHz for reception.

[3] GTE Airfone Inc. GTE Airfone Backgrounder. N.p.: GTE Airfone, Inc., 3 June 1987, p. 2.

[4] "Products of the Year." Fortune 9 December 1985, pp. 106-112.

[5] GTE Airfone Inc. GTE Airfone Backgrounder. N.p.: GTE Airfone, Inc., 3 June 1987, p. 2.

[6] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Telephone interview, 23 October 1987.

[7] GTE Airfone is capable of installing one airborne system per day per carrier. Consequently, it would be conceivable that all 2900 planes could be equipped as early as June 1988.

[8] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Telephone interview, 23 October 1987.

[9] Guif, S.E. Vice President Engineering, GTE Airfone Inc. Interview, 30 September 1987.

[10] "Airfone's Service Offerings Soar, But Firm Has Yet to Hit Paydirt." Communications Week 24 August 1987.

[11] Ibid.

[12] GTE Airfone Backgrounder, p. 3.

[13] Air Cal was recently purchased by American Airlines. Those Air Cal planes previously equipped with Airfone are still equipped under American Airlines management.

[14] The rates for GTE Airfone service are $7.50 for the first 3 minutes (or fraction thereof) and $1.25 per each additional minute (or fraction thereof) for calls to anywhere in the US. International calls are $15 for the first 3 minutes (or fraction thereof) and $2.50 for each additional minute (or fraction thereof).

[15] "Airfone's Service Offerings Soar, But Firm Has Yet to Hit Paydirt." Communications Week 24 August 1987.

[16] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Interview, 30 September 1987.

[17] Rosenberg, Morris D. "Fearless Traveler: Airfone Update." The Washington Post 2 February 1986.

[18] Goeken, John. Chairman and Chief Executive Officer, GTE Airfone Inc. Interview 15 October 1987.

[19] This service is of particular importance to the QRAC Post concept in that it allows ground based facilities to initiate calls to the QRAC Post.

[20] This service will allow interconnection between aircraft employing the QRAC Post concept and can also serve as the medium by which C^3 can be handed off between QRAC Posts or from a QRAC Post to a military airborne command post.

[21] GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, p. 20.

[22] GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, pp. 9-18.

[23] Ibid, pp. 22-23.

[24] Ibid.

[25] Ibid, p. 21.

[26] Ibid, p. 57.

[27] The Airfone system accepts Air Travel Card, Amex, Carte Blanche, Citicorp, Diners Club, MasterCard, and Visa.

[28] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Telephone interview, 23 October 1987.

[29] GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, p. 100.

[30] GTE Airfone Inc. Proposed World-Wide Airfone Ground Station Locator. N.p.: GTE Airfone Inc., n.d.

[31] GTE Airfone Inc. Ground Station Propagation Map. N.p.: GTE Airfone Inc., n.d.

[32] Guif, S.E. Vice President Engineering, GTE Airfone Inc. Interview, 30 September 1987.

[33] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc. Interview, 30 September 1987.

[34] Zachrel, Norm. Manager, Test and Evaluation, GTE Airfone Inc. Interview, 13 October 1987.

[35] GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, p. 97.

[36] Ibid.

[37] GTE Airfone Inc. GTE Airfone In-Flight Telephone Service System Overview. N.p.: GTE Airfone, Inc., 1 November 1986, p. 99.

CHAPTER IV

QRAC POST IMPLEMENTATION

Introduction

There are a number of issues which must be
addressed prior to full scale implementation of the
QRAC Post concept. If the U.S. Government, or any
other entity, were to proceed without carefully
addressing these issues the results could be confusion
and frustration. This chapter will address those
issues most likely to cause concern.

Issues

Viability

Regardless of the fact that the QRAC Post
concept is technically feasible, there still remains
the question of whether or not it will work in
practice. Ultimately, there is only one way to answer
this question, the system must be formally tested and
evaluated in an operational scenario. This could be
done in a number of ways, including a test by the
Federal Emergency Management Agency (FEMA) during a
major disaster preparedness exercise, or a test by the

Office of the Joint Chiefs of Staff (OJCS) during a
military exercise or deployment. Only after testing
the system's viability in operation can a conscious and
equitable decision be made as to whether or not to
proceed with full scale implementation.

Availability of Aircraft

Use of commercial air carrier resources during
national emergencies is a subject which raises a number
of questions in terms of legality, politics, and
practicality. Public Law contains several passages
which provide for Government use of commercial
resources during times of declared war (e.g., Title 10,
United States Code, Chapter 947, Section 9742).
However, Public Law is at best "fuzzy" with respect to
use of these resources for crises short of declared
war. On the other hand, the Civil Reserve Air Fleet
agreements between the commercial air carriers and the
US Air Force which allow for the contracted use of
airline resources for mobility purposes would seem to
establish a precedence for use at the less than
declared war level. Politically commandeering
commercial aircraft in this "hazy" legal environment
could be very difficult, even though the carriers would
be reimbursed for use of their resources.

As a result of this uncertainty, the practicality of using commercial air carrier resources is in question. The general feeling is that in the event of a "legitimate" crisis the air carriers would be more than willing to cooperate and volunteer their resources. However, the lead time required to coordinate access to the resources could negate the "quick response" part of the QRAC Post concept.

In order to completely eliminate concerns over aircraft availability one of two actions would be necessary. Either Public Law would have to be modified to "clarify" the obligations of air carriers and the government during crises situations, or the current CRAF agreements would have to be modified to include deployment for a wider variety of situations. In either case the overhead for accessing the resources would have to be sufficiently reduced to avoid losing the advantage of quick response.

Availability of Communications

Public Law clearly allows for use of common carrier communications resources in the event of national emergencies (Title 47, United States Code, Chapter 5, Subchapter VI, Section 606, Subsections c and e). However, an availability problem still exists in that the communications common carrier in question,

GTE Airfone Inc., is operating under an "experimental" license from the FCC. Consequently, it is conceivable that the FCC could opt to not grant Airfone a permanent frequency allocation, thereby eliminating a vital component of the QRAC Post concept.

GTE Airfone has been involved with petitioning the FCC for frequencies since late 1979 (See Figure 4-1). To date permanent frequencies have not been allocated, and the Airfone system has operated under a continuing series of short term experimental licenses. As a result, all development work and fielding of equipment by GTE Airfone is done at the company's own risk.

The FCC has not formally stated a reason for not making a permanent frequency allocation. However, it appears that they are concerned about three things.[1] First and most importantly, is the fact that the frequencies in question are "prime" frequencies sought by a number of different potential services such as mobile satellite service and land mobile radio service. Consequently, the decision as to how to allocate a very limited amount of resource is problematic. The second apparent concern is over the impression that the service constitutes a luxury for a few business travelers rather than an essential communications

10/25/79 12/12/80 12/82 1/20/83 11/21/84 12/11/84 2/25/85 11/22/85 7/24/86 7/28/86 11/24/86 5/29/87 8/11/87 9/17/87

October 25, 1979 - Through a Petition for Rulemaking, Airfone, Inc. asked the FCC to allocate 4 MHz of UHF spectrum for an air-to-ground telephone system.
An application for Developmental Authority to conduct a market trial for air-to-ground telephone service was filed concomitantly.

December 12, 1980 - Two-Year Experimental license granted to Airfone, Inc. to design, test, and implement an air-to-ground telephone service for commercial airlines.

December 1982 - Two-year renewal of experimental license granted.

January 20, 1983 - FCC adopted a Notice of Proposed Rulemaking (NPRM) proposing the allocation of 4 MHz (896-899 MHz and 941-943 MHz) to Domestic Public Land Mobile Radio Service to allow air-to-ground telephone service.

November 21, 1984 - FCC declined to adopt the NPRM to allocate 4 MHz of UHF spectrum for an air-to-ground telephone service.

December 11, 1984 - Airfone, Inc.'s Experimental licenses were renewed for one year.

February 25, 1985 - Airfone, Inc. filed a Petition for Reconsideration of the Commission's Order denying the allocation of 4 MHz of UHF spectrum for air-to-ground telephone service.

November 22, 1985 - Airfone, Inc.'s Experimental authorizations were renewed for a period of two years.

July 24, 1986 - FCC adopts Report and allocating remaining 800-900 MHz reserve to various radio services. 4 MHz of spectrum left unreserved. The Commission stated its intent to consider allocating the 4 MHz left in reserve for Basic Exchange Telecommunications Service for rural use, an air-ground telephone service, or to a Mobile Satellite Service.

July 28, 1986 - FCC denied Airfone, Inc.'s Petition for Reconsideration.

November 24, 1986 - Airfone, Inc. filed a Petition for Reconsideration of the Commission's Order allocating reserve spectrum in the 800-900 MHz band. Airfone, Inc. asked the Commission to reconsider the portion of its Order which holds 4 MHz of spectrum in reserve, and instead allocate that spectrum to public air-ground telephone service.

May 29, 1987 - GTE Airfone filed an application with the FCC asking for a two-year renewal of its license and the authority to move the experimental air-ground service from its existing frequencies to the 4 MHz of UHF spectrum left in reserve.

August 17, 1987 - The FCC approved GTE Airfone's application granting the extension of GTE Airfone's license to December 1, 1989. Authorization was also given to move to the 4 MHz of UHF reserve.

September 17, 1987 - FCC denied GTE Airfone's Petition for Reconsideration filed in the 800-900 MHz allocation Order. However, the FCC did say it would consider allocation of 4 MHz for an air-to-ground service in a separate proceeding.

Figure 4-1 - Chronology of GTE Airfone Regulatory Activity[2]

service for the public good. The final source of concern seems to be over the fact that at present GTE Airfone is essentially an air-to-ground telephone service monopoly. In all probability this is not liable to change due to the fact that air-to-ground service for commercial aircraft lends itself to being a natural monopoly since it is unreasonable (in terms of space, expense, and FAA certification) to install more than one system aboard an aircraft.

Whatever the reasons, the lack of permanent frequencies for Airfone introduces an element of uncertainty in the availability of communications resources for the QRAC Post. To alleviate this uncertainty a means of encouraging the FCC to award permanent frequencies must be found. A commitment to the QRAC Post concept on the part of the U.S. Government may be the means necessary. By making a commitment to the QRAC Post concept, the Government would in effect be designating it, and consequently Airfone, a national emergency preparedness asset. As a result the Government, in the form of the Federal Emergency Management Agency (FEMA), the National Communications System (NCS), and the Department of Defense (DOD) would then be in a position to support allocation of frequencies to Airfone through the

auspices of the Interdepartmental Radio Advisory Council (IRAC).

Who's in Charge?

The question of who's in charge of national emergency telecommunications is an unfortunate but very real issue. As Robert Reinman identifies in his monograph on the subject the answer to the question "who's in charge?" is "no one."

Since the communications failures during the Cuban missile crisis of 1962, each administration has attempted to address the problem of emergency communications. Unfortunately, each has done so through a seemingly never ending series of reorganizations and redistributions of authority and responsibility. The result is that virtually every executive branch department and office has some emergency telecommunications responsibility, but very little actual authority or funding to do anything about it.[3]

Consequently, the question of who should be in charge of implementing the QRAC Post concept is a very real consideration. Without a distinct person or office in charge of implementation the possibility of the concept being able to meet it's full potential is marginal. If the Government recognizes the value of

the concept and decides to implement it, then they must also designate an office or agency responsible. In order to do so effectively the designation should come from as high in the administration as possible in order to demonstrate the resolve and commitment on the part of the administration to addressing the problems the QRAC Post concept is designed to counteract. The source within the administration for making this designation is the National Security Council Office of Telecommunications Policy which is responsible for advising the President on telecommunications matters. If the responsibility and authority for implementing the QRAC Post concept can be delegated from this level it will dramatically increase the probability of the concept's success.

CHAPTER IV

NOTES

[1] Guif, S.E. Vice President, Engineering, GTE Airfone Inc. Interview, 30 September 1987.

[2] Goeken, Sandra. Vice President for Corporate Affairs/New Business Development and Managing Director of Airfone International, GTE Airfone Inc.

[3] Reinman, Robert A. National Emergency Telecommunications Policy: Who's in Charge? Washington D.C.: National Defense University Press, 1984.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The QRAC Post concept is a technically and economically viable means of addressing those national emergencies and strategic crises most likely to be encountered by our nation. Its use of commercially available aircraft, automated data processing equipment, and communications resources in low air threat environments makes it an ideal solution to providing the necessary C^3 required for the wide variety of crises ignored by current military airborne command posts. In so doing, it satisfies not only the objectives of this thesis but also the national policy objectives of the U.S. Government. Even in the event that the U.S. Government opts not to implement the concept, it will still, in all probability, be used on an ad hoc basis by individual government agencies and by private industry as an expedient to dealing with the plethora of day-to-day crises faced in government and business.

Recommendations

In the process of developing this thesis a number of recommended courses of action were identified. While these actions are not themselves intrinsic to the validity of the QRAC Post as a concept, they are nevertheless vital to its eventual realization as a national emergency telecommunications asset. As the following list of recommendations indicates, there still remains much to be done before the QRAC Post concept can be put into use on a national or world-wide basis.

1. The concept must be tested over a broad range of operational scenarios in order to determine its validity in practice. Disaster preparedness and military exercises would provide an excellent test bed and would, at the same time, promote the use of the system with those most likely to benefit from it.

2. Public law must be examined in detail and, if needed, be clarified in order to delineate the responsibilities of the commercial air carriers and the U.S. Government with regards to government use

of commercial aircraft in the event of a national emergency or strategic crises.

3. The U.S. Government needs to support the allocation of permanent frequencies to GTE Airfone in order to ensure that the communications link vital to the concept is not eliminated. This support should not only focus on allocation of frequencies by our own FCC but should also look at ensuring frequencies are allocated to the system world-wide in order to promote the QRAC Post concept among our allies as a vital enhancement to their C^3 capability.

4. A definitive source within the Government needs to be identified to be responsible for testing and implementing the concept. That source should, in order to demonstrate resolve, be identified from the national policy making level. Once identified, the source should be given the authority and funding necessary to pursue the concept.

In the final analysis the QRAC Post concept is an idea with tremendous potential. However, it is an idea in search of a sponsor. If implemented at a

national level it promises the ability to satisfy a
number of national objectives. If not, it will no
doubt be implemented by others to fill a smaller niche
in the day-to-day lives of government agencies and
business concerns. Under whatever name or guise, the
idea is bound to be with us in the future. Now that
the technology exists, it will be exploited.
Consequently, the question becomes not if, but rather
by whom, and how, the concept will be used in the
future.

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