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16. Abstract

The motorist aid citizens radio service communications system (CB-AIDS) allows a CB radio user to have channel 9 emergency and assistance calls automatically connected to a responding agency, such as a local police department, via the switched telephone network. Then through use of this radio/telephone interconnect, the CB radio-user has a direct voice communication channel with the responding agency, thus eliminating an intermediate communicator, decreasing response time, and minimizing message errors.

The goals of this research program were accomplished through establishment of five major tasks: (1) definition of system requirements and specifications, (2) system design and fabrication for demonstrating technical feasibility, (3) system test evaluation and field demonstration, (4) pilot program design and implementation and (5) evaluation of the pilot program.

Design, fabrication and field evaluation of the CB-AIDS systems were successfully accomplished. Feasibility was demonstrated. Problem areas were define and consisted primarily of some equipment malfunctions and general logistic problems which are common when dealing with a cross-section of the general public

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FOREWORD

This report was prepared by the Engineering Experiment Station at Georgia Tech under contract No. DOT-FH-11-9232. The work described was conducted under the general supervision of Mr. D. W. Robertson, Director Electronics Technology Laboratory and Mr. R. W. Moss Chief of the Communication Systems Division. Mr. R. W. Wallace was Project Director, and Mr. C. S. Wilson was associate Project Director.

The guidance and assistance of Mr. Frank Mammano, Contract Monitor, Federal Highway Administration, is gratefully acknowledged.

We are also grateful for the cooperation and assistance of Chief Dick Hand, Lt. Perry Whitley, and other members of the Dekalb County Police Department. Considerable time and effort was provided on a volunteer basis by these individuals; efforts which significantly benefited project goals and objectives.

We are likewise appreciative of the cooperation and assistance of our numerous CB radio-user volunteers who actively participated in the program. Special mention is due members of Dual County and Capital City REACTS organizations.

A special thanks to Messrs. Archie Burnham, C. B. Collins and Bill Owens of the Georgia Department of Transportation for their time and valuable assistance.

The cooperation of various individuals at Shamrock, Sequoyah and Columbia High Schools, Dekalb County, Georgia is also acknowledged with appreciation.

The contributions of Messrs. Jeff Aaron, Bob Baggerman and Tom Jones of the Engineering Experiment Station are gratefully acknowledged.

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SECTION 1
INTRODUCTION

This is the final report of the research program "Motorist Aid Citizens Radio Service (CB) As a Wide Area Communication System," performed by the Electronics Technology Laboratory of the Georgia Tech Engineering Experiment Station for the Federal Highway Administration under Contract No. DOT-FH-11-9232. The system was designated as Citizens Band - Automatic Interconnect Digital System (CB-AIDS).

Basically the system allows a CB radio user to have channel 9 emergency and assistance calls automatically connected to a responding organization through the switched telephone network. Figure 1 illustrates the CB-AIDS concept. A disabled vehicle with a Digital Adapater is shown in contact with a Remote Station which provides automatic interconnection via the switched public telephone system to either a response agency for emergencies or a volunteer monitor for assistance information. The response agency provides the required action through existing services.

The research objective of this project was to "design, fabricate, demonstrate, implement, test, and deliver an automatic telephone interconnect device which can be used in conjunction with a CB radio link for motorists' emergencies and assistance." Furthermore, work included a determination of the viability of an automatic telephone interconnect system for CB radio through the design, operation, and evaluation of a pilot program which was conducted over an approximate 19 month period using prototype hardware.

Feasibility of the concept was considered from technical, regulatory, user, and response agency perspectives. Technical objectives were primarily directed toward the development of economically feasible hardware for both in- vehicle, Remote Station and Central Control Unit use. Regulatory aspects were concerned with digital modulation, telephone interconnection, and remote transmitter control of Class D Citizens Band Radio communications. User benefits were considered including ease of operation. System impact on the response agency was

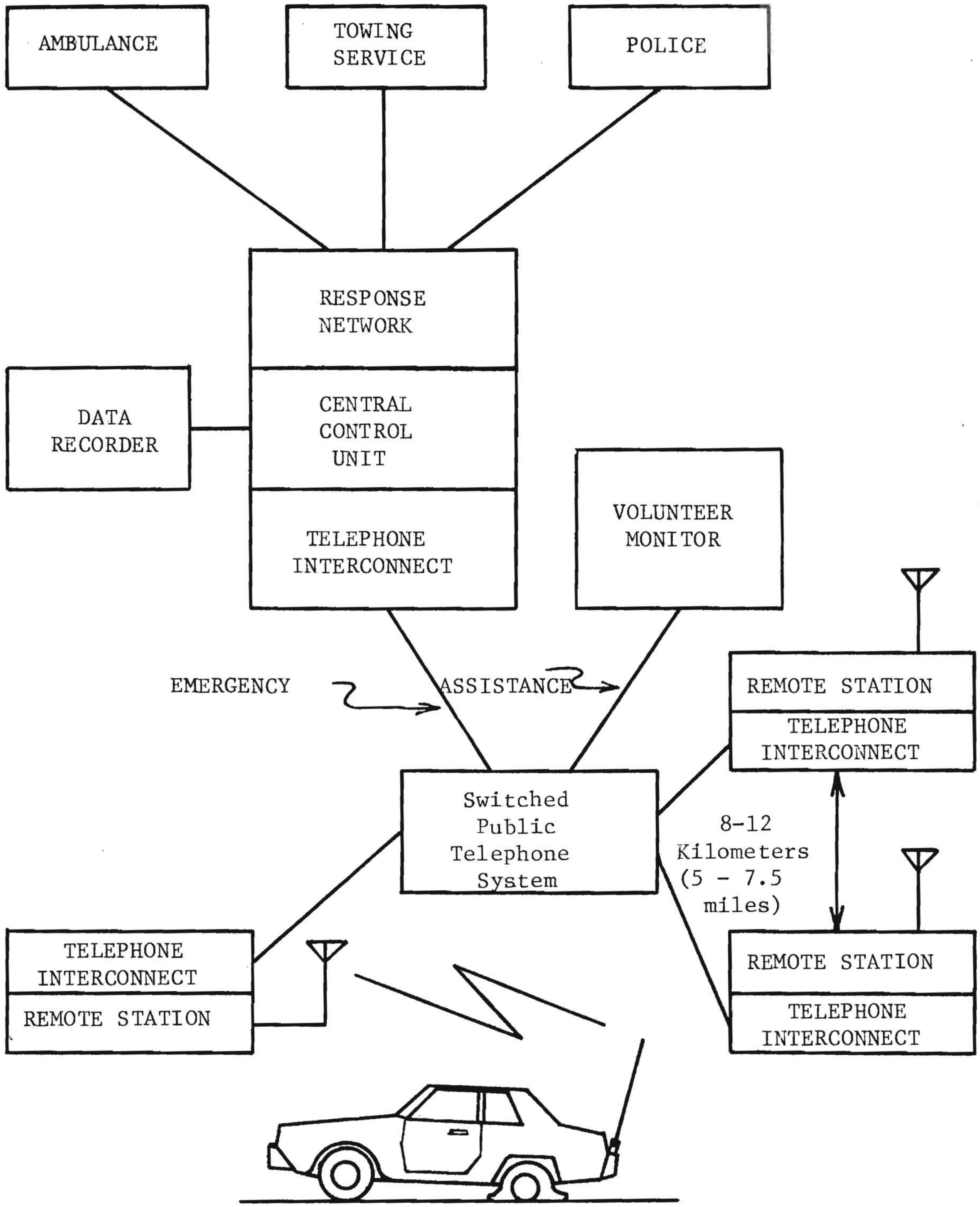

Figure 1. CB-AIDS System Network Diagram-Demonstrating Flow of Information to Assist Disabled Vehicle.

the final area of concern.

The steps necessary to accomplish the program are shown in the CB-AIDS Program Flow Chart of Figure 2. As shown by the chart, the program was divided into three major areas: systems planning, hardware development, and system demonstration.

The system planning area began with an explanation of the concept to agencies and user groups through a slide presentation and demonstration of prototype equipment. Following each presentation an open discussion period was used to gather the ideas of various participants concerning the implementation of a CB-AIDS type system. Appropriate ideas of both users and responding agencies were incorporated in the design for the pilot demonstration.

Hardware development proceeded concurrently with the systems planning activities. Under hardware development three types of items were designed and fabricated. These items were, first, a Digital Adapter which would fit on an ordinary CB radio, second, a Remote Station which was designed for unattended automatic telephone interconnect operation, and third, a Central Control Unit for placement in a response agency location. These were the primary hardware elements used in the CB-AIDS system. In the pilot program, two Remote Stations were originally installed with a third added at a later period in the program to extend the coverage area. Also, 100 Digital Adapters were produced for distribution to volunteers.

With the completion of systems planning activities and hardware development, a system demonstration phase was initiated. The system was used and data were gathered for a period of approximately 19 months; the results of this demonstration phase are included in this report.

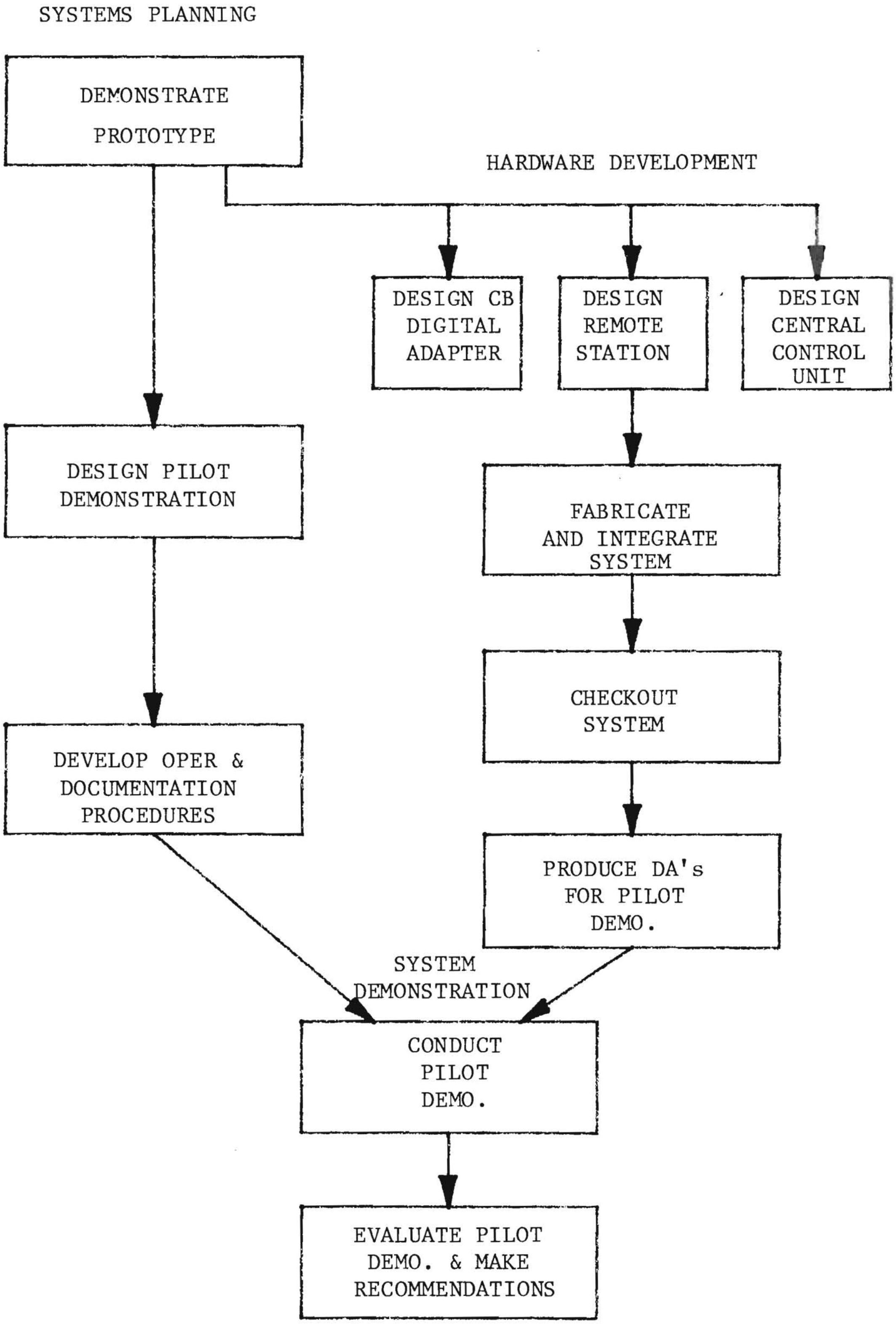

Figure 2. CB-AIDS Program Flow Chart - System Planning and Hardware Development Proceed in Parallel Leading to System Demonstration.

SECTION 2

BACKGROUND

Following a dormant period of over 30 years after its invention by Al Gross in 1939, CB radio has grown to be a major mass communications device for the American public. Today over 20 million transmitters are licensed by the FCC for Citizens Radio Service. With CB radio, the American motorist has learned the advantages of mobile communications which have long been recognized by professional users. Based on its responsibilities in the area of motorist aid systems for highway use, the Federal Highway Administration has sponsored research in the area of using CB radio for enhanced operation as a motorist aid system to provide assistance and emergency aid to motorists. The orginal work in using CB radio as a motorist aid system was performed by Honeywell under FHWA contract DOT-FH-11-8383. This program was initially oriented toward a special purpose motorist emergency communication system and involved the design of a 450 MHz transceiver. Due to cost considerations, emphasis under the program was re-directed toward a study of the feasibility of using CB radio for motorist aid communications. The CB-AIDS program resulted as a natural extension to the preliminary work for the purpose of developing prototype hardware and to establish a pilot program study of the conceptual system.

SECTION 3
RESEARCH OBJECTIVE

To accomplish the research objective, five tasks were undertaken. An additional task was added to extend the time period of system operation and the coverage area of the program. The six tasks performed for the CB-AIDS program were:

Task A: System Requirements and Specifications

This task required the development of presentation material in the form of 35 millimeter slides and handout materials. It also included scheduling presentations and demonstrating the system concept to interested agencies and user groups. The Digital Adapter and Remote Station used for demonstration purposes were those produced in the previous contract. Recommendations resulting from these discussions were considered and where appropriate were included in defining specifications for the pilot program demonstration.

Task B: System Design and Fabrication for Demonstrating Technical Feasibility

This task involved the design, fabrication, and enhancement of all elements of the CB-AIDS system including the Digital Adapter, Remote Station and Central Control Unit. The Digital Adapter designed was reviewed and modified to eliminate errors, improve system cost effectiveness, and to include design features compatible with low cost mass production. The Remote Station equipment design was enhanced to include the following: (1) the addition of circuits which would establish connection to a telephone line and automatically dial two programmable telephone numbers, one internally programmable - the other remotely programmable; (2) circuits which allowed the Remote Station CB transceiver to be operated by remote control via the telephone line; (3) circuits to store and forward the originating Digital Adapter identification code to the control center along with the Remote Station identification number; (4) interface and protection circuits as required by the telephone company and/or FCC. The Central Control Unit was designed and fabricated to provide a display for identifying both the Remote Station and Digital Adapter identification numbers, generate command signals to communicate with a Remote Station, allow control center activation of the Remote Station transmitter, and provide telephone line protection. This task also included the fabrication of two Remote Station units, one Central Control Unit, and two vehicular Digital Adapters for test purposes. Finally, other tasks would obtain FCC licenses and waivers, or authorizations, necessary to conduct system tests and demonstrations. A third Remote Station was added later in the program under Task F.

Task C: System Test Evaluation and Field Demonstration

This task was divided into basically two areas. The first was a laboratory test of the system interconnected over local telephone lines. The second was a field demonstration of this system to determine its feasibility at specific sites selected for the pilot program demonstration.

Task D: Pilot Program Design and Implementation

This task involved actual system deployment under operational field conditions. It included selecting a CB radio user sample, identifying test sites for installation of the Remote Stations, choosing a response agency for the Central Control Unit equipment and providing the necessary response to motorists calls. Operating procedures and methods of documenting system use were developed, approvals of all involved parties were obtained, and the pilot program was initiated.

Task E: Evaluation of Pilot Program

The purpose of Task E was to evaluate the pilot program and to produce conclusions and recommendations for future implementation of the CB-AIDS system.

Task F: Extended Data Collection

The purpose of Task F was to extend the data collection period by six-months and to add a third Remote Station in the southern part of the pilot program area. As a result of the extension, the system evaluation period was changed from the original 12 months to 19 months.

The performance and results of the tasks are discussed in detail in sections to follow.

SECTION 4
SYSTEM REQUIREMENTS AND SPECIFICATIONS
(TASK A)

An early objective of the program was to establish specifications for the pilot program demonstration. This was accomplished through discussions with agencies and user groups involved in motorist aid systems. Three basic types of groups were contacted: (1) CB users, (2) response agencies, and (3) regulatory and administrative agencies. Contacts were made individually, through special group presentations, and via forums provided by the Transportation Research Board and the Federally Coordinated Programs meetings. To present the CB-AIDS concept a 35 millimeter slide presentation was prepared and followed by a demonstration of the existing equipment. The slide presentation was designed to present the idea of motorist aid communications to audiences who had no previous knowledge of such systems. The first part of the slide presentation discussed the need for motorist aid systems. Next, a discussion of the elements of a motorist aid system was presented. It was followed by examples of some of the motorist aid systems currently in operation in the United States. The topic of CB radio was covered with a brief description of existing monitoring networks. The slide presentation concluded with a description of the CB-AIDS concept describing the potential advantages of this system. The set of slides describing the CB-AIDS system was assembled from existing slides of the Federal Highway Administration and from specially prepared slides produced by Georgia Tech. The second part of the presentation consisted of a demonstration of the existing Digital Adapter and Remote Station display equipment. A description of the presentation's slides and their associated script are included as Appendix A to this report.

For Task A a total of 12 separate demonstrations were made to the various groups. The organizations represented in the presentations are shown in Table 1.

TABLE 1

ORGANIZATIONS RECEIVING CB-AIDS PRESENTATION

Category	Organization
CB Radio Users	Capital City REACT Dual County REACT
Response Agencies	Georgia State Patrol DeKalb County Police Georgia RUSH Georgia Chapter of APSCO Michigan Emergency Patrol Baltimore Mayor's Office
Regulatory and Administrative Agencies	Federal Highway Administration FCC Georgia DOT Georgia Office of Telecommunications Tennessee DOT
General Information	Transportaion Research Board Annual Meeting Federally Coordinated Programs Annual Meeting Institute of Traffic Engineers Annual Meeting

After each slide presentation and demonstration, a discussion period was held in which participants were encouraged to express their opinions on system feasibility and to give additional ideas for improving system operation. From the demonstrations and discussions, the following recommended system concept evolved.

The recommendations focus on the three program development elements (see Table 2). These elements are (1) the Digital Adapter, (2) Remote Station, and (3) Central Control Unit. First of all, the Digital Adapter should be inexpensive both as original equipment and as an add-on to existing radios. Second, the automatic identification feature is a positive feature which should be included. Third, selective signaling should be included to allow the Digital Adapter user to place a call either for an emergency or for assistance. For the Remote Station, the antenna height and transmitted power output must be within regulatory limits. Next, positive indication that a call has been placed should be indicated to the person placing the call. Third, the assistance number should be capable of being programmed remotely. The last area is the Central Control Unit (CCU). The CCU should be easily integrated into the existing response network, it should be simple to operate by existing operators, and it should provide the capability for automatically gathering call data. These recommended features were all included in the pilot program CB-AIDS equipment.

Regulatory Considerations

The use of CB radios is licensed under Part 95 of Federal Communications Commission Rules and Regulations. The CB radio most commonly in existence is the Class D Citizens Radio, operating in the 27 MHz frequency band. The CB-AIDS system operates on Channel 9 (27.065 MHz) which has been authorized solely for (1) emergency communications involving the immediate safety of life of individuals or the immediate protection of property or (2) communications necessary to render assistance to a motorist. The CB-AIDS use of the system is generally under the latter category. Class D Citizens Radio operation has a number of limitations including power, antenna height,

TABLE 2

RECOMMENDED CB-AIDS PROGRAM FEATURES

Item	Feature
Digital Adapter	Inexpensive Automatic identification Selective signaling Easy to use
Remote Station	Keep transmitted power within FCC limits Keep antenna height within FCC limits Positive indicator of call receipts Remote number programming
Central Control Unit	Ease of integration Simple to operate Automatic data collection

modulation, and limitations on the capability to remotely control transmitters. The CB-AIDS system was designed to operate within the existing FCC regulations as much as possible; however, special temporary authority was required for certain aspects of station operation. The first type of special authority required was permission to transmit digital messages on Channel 9. Under the regulations, tone signals are allowed for the purpose of actuating receiver circuits for selective calling and thus could be considered as being the purpose of the signal produced by the Digital Adapter. As a result, special authority was requested and granted by the FCC to transmit digital messages over the CB radios. The digital message is used to indicate the Digital Adapter unit identifier and to indicate whether the call is an emergency or an assistance request. The second special authority was related to the area of remote control. Part 95 prohibits remote control of Class D Citizens Radio transmitters. Special temporary authority was requested and granted by the FCC to operate the Remote Station transmitters by wire-line remote control via the dial telephone network. The final area of consideration was that of telephone interconnection. Following the landmark Carterfone, decision of 1968 the restrictions on interconnection of electronic devices through the switched voice network have been considerably relaxed with a number of companies producing FCC type approved interconnection devices. For the CB-AIDS program, telephone couplers were purchased for each of the Remote Stations; the CCU coupler was provided by the telephone company on a lease basis.

SECTION 5

SYSTEM DESIGN AND FABRICATION FOR DEMONSTRATING TECHNICAL FEASIBILITY (TASK B)

The work included in this area of the contract consisted of design and fabrication of two prototype Digital Adapters, design and fabrication of two operational Remote Stations, design and fabrication of the Central Control Unit, selection and purchase of commercial CB radio equipment for the CB-AIDS system, and determination and application for necessary FCC authorization for conducting system tests as well as continued operation under the pilot program.

During this task technical manuals were prepared for the Digital Adapter, Remote Station, and Central Control Unit. These manuals have been completed and delivered to the Federal Highway Administration.

The Task B effort is described in the following paragraphs.

Digital Adapter

The purpose of the Digital Adapter is to provide a user (having a Digital Adapter attached to his CB radio) with the ability to access a nearby Remote Station in order to contact either the police or a volunteer monitor. The Digital Adapter performs this function when initiated by transmitting a digital sequence. This sequence includes a Digital Adapter user's identification number and indication of whether an emergency or assistance type call is being made. Specifications of the Digital Adapter are included in Table 3. Figure 3 shows the signal format produced by a Digital Adapter. Basically the signal is a digital sequence using frequency-shift-keyed (FSK) modulation with the data in a pulse-width modulation format. Four thirty-two bit words are sent when a DA is activated. The first word consists of all ones, allowing transmitter and receiver synchronization. The second word contains the emergency or assistance request and the Digital Adapter ID number. The third and fourth words are repeats of the second word. The entire sequence requires 768 milliseconds for transmission. Although this new digital adapter design was based on an existing

TABLE 3

DIGITAL ADAPTER SPECIFICATIONS

Power Required	10-15 volts DC @ 90 mA.
Microphone Input	Matches the input of the CB radio to which digital adapter is installed.
Microphone Output	Connects to CB radio's microphone receptacle.
Signal Format	Pulse duration coded, audio frequency shift keying.
Tone Frequencies	
Mark	2100 Hz $\pm$ 100 Hz
Space	1750 Hz $\mp$ 100 Hz
Information Bit Rate	167 bits/second, nominal
Format of Output Signal	String of 32 data 0's followed by a repeating BCD (Binary Coded Decimal) sequence consisting of transmitter ID code, and emergency or assistance request. Sequence is repeated three times.
Output Impedance	1 MΩ or greater
Trigger	May be wired to trigger on either positive-going or negative-going transition on CB radio's push-to-talk signal line from microphone, depending on type of CB radio used.

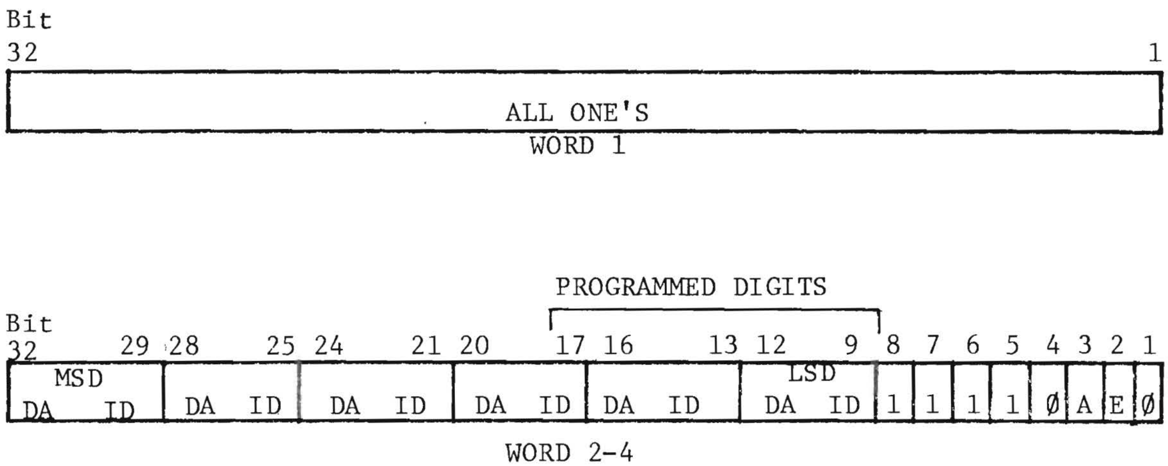

Figure 3. Digital Adapter Signal Format

digital adapter produced by the previous contract, a number of important modifications were made. Of greatest significance was the required universality of the new Digital Adapter. It had to be produced inexpensively and in a manner that would allow for easy addition to existing CB radios. Considerable early design effort went into establishing the basic Digital Adapter configuration. Ease of operation of the existing Digital Adapter was continued through use of two pushbuttons and by using mike-keying to initiate the Digital Adapter sequence. However, a complete package redesign was required since the original digital adapter was custom made to be fitted with a particular CB radio. It was decided to restrict use of the Digital Adapter to radios which had microphone connectors in order to avoid having to internally rewire CB radios. The Digital Adapter package selected was a standard chassis with a front panel 5.1 centimeters (two inches) high by 15.2 centimeters (six inches) wide and a depth of 7.6 centimeters (three inches). Power for the Digital Adapter was provided either via the twelve volt connection through the microphone interconnect or by a separate external wire leading into the Digital Adapter. Ground return for the power is taken from the CB microphone connection. The Digital Adapters were physically attached to the existing radios by use of double-sided tape having sufficient adhesive quality to ensure a firm connection.

Use of the Digital Adapter is very straightforward since user-accessable controls are limited to only two pushbuttons. In order to operate the Digital Adapter, and thus access a Remote Station, the user first determines if the incident to be reported appropriately comes under an emergency or an assistance category. For reporting an emergency-type incident the user presses the red pushbutton (labeled "E"); for an assistance-type incidence the yellow, or "A", pushbutton is pressed. When one-of-the-two buttons are pressed, an internal button lamp is activated providing positive feedback to the user that a desired status has been initiated. Note that a status has only been initiated however, and actual transmission of the digital word has not occured at this time. Transmission of the digital word begins when the user operates his mike key; transmission continues through the complete digital sequence, so long as the mike key is held depressed. The mike key must be operated within 12 seconds after a Digital Adapter pushbutton is pressed, otherwise automatic time-out will occur.

If the user inadvertly presses the incorrect pushbutton on the Digital Adapter, immediately pressing the other button will de-activate the first and activate the second. If on the other hand, a pushbutton was inadvertly pressed when the user did not intend to use the system at all, automatic time-out will occur in approximately 12 seconds. Termination of this active condition can also be accomplished by very rapidly pressing and releasing the mike key. Automatic time-out is preferred, however, since a Remote Station could be activated if the user is within range and if the mike key is not depressed and released rapidly enough.

When the user is within range of a Remote Station, then transmission of the digital word will activate the Remote Station which, in turn, will secure the telephone line and "dial", via Touch-Tone signals, the appropriate responding agency. Note that after the initial digital word has been transmitted the Digital Adapter is, in effect, removed from the users radio system and normal voice communications are possible.

A simplified block diagram of the Digital Adapter is provided in Figure 4. A complete schematic diagram is available in a separate document entitled "CB-AIDS Digital Adapter Technical Manual." As shown, the Digital Adapter consists of seven major elements: (1) clock, (2) sequencer, (3) shift register controller, (4) shift register, (5) Pulse Duration Modulation (PDM) forming logic, (6) FSK oscillator, and (7) voice/data switch.

The only user inputs are the emergency and assistance select which determine the status of bits two and three within the second digital word as shown in Figure 3. When decoded at the Remote Station these two bits determine which one of two telephone numbers is dialed. The user identification (ID) number is contained in bits 9 through 32 of the same digital word. This ID number is fixed with no ability on the

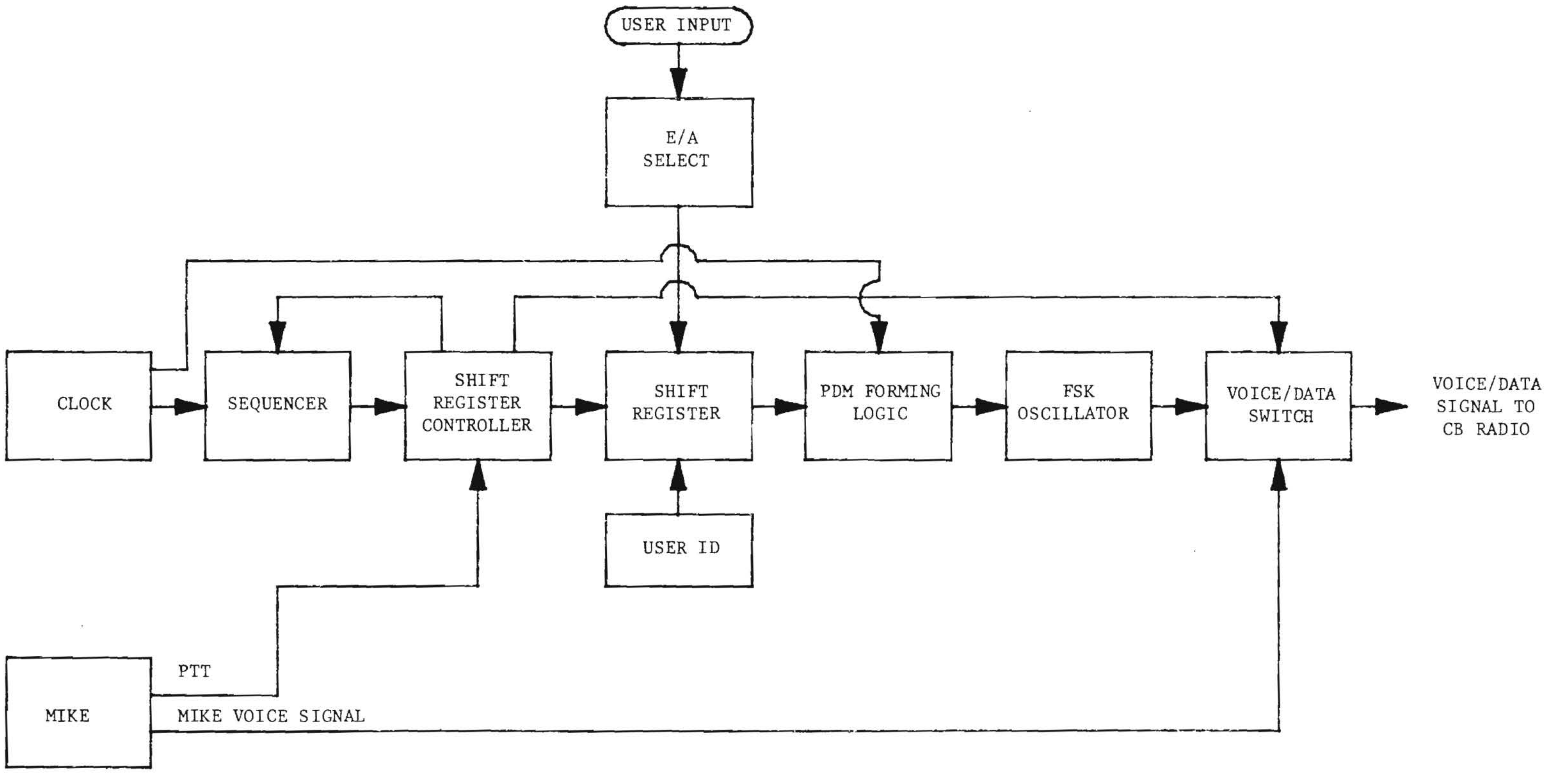

Figure 4. Simplified Block Diagram of the Digital Adapter.

part of the user to alter the number. Bits 18 through 32 are the same for all Digital Adapters, whereas bits 9 through 17 are "one-time" programmable and are a unique sequence for each unit. During printed circuit board manufacture, bits 9 through 17 are hard-wired to both the +V and ground lines by plated-through holes. Programming is then accomplished by selectively drilling out specific holes to open circuit either the +V or ground lines. The complete user ID number is then

1 2 3 X Y Z

where X is BCD programmed as either a 4 or a 5; Y and Z are programmed for any number between 0 and 9. The first three ID numbers (i.e. 1, 2 and 3) are the same for all Digital Adapters.

Referring to the block diagram of Figure 4, the clock in conjunction with the sequencer, provides the basic timing signals for subsequent generation of the data signal. The clock circuit outputs (consisting of 3-phase signals) control both the sequencer and the PDM forming logic with the output from the PDM forming logic being the modulating signal for the FSK oscillator.

The data transmission sequence begins when the user selects either an emergency or assistance request by pressing the appropriate pushbutton. When one of the two pushbuttons is activated, then bits two and three of the second data word (Figure 3) are parallel loaded into the shift register. Operating either of the pushbuttons also resets the sequencer and begins the 12 second time-out period If no further action is taken by the user (e.g. pressing the push-to-talk key on the mike), the Digital Adapter will revert to the quiescent state after the 12 second time-out period and await a new user response.

In normal operation, when the user has selected either an emergency or assistance request, the push-to-talk mike switch will be activated for tansmission of the digital word. Activating the push-to-talk switch on the microphone begins the data transmission sequence by arming the shift register controller, which in turn provides control signals to the sequencer, shift registers, and voice/data switch. The shift register controller, in conjunction with the clock and sequencer, result in a serial shift of the digital word (contained in the shift register) to the PDM forming logic. The voice/data switch is transferred to pass the data signal while blocking any signals from the microphone during the data transmission period.

As a result of the action on the part of the sequencer and shift register controller, four 32-bit digital words are transmitted. As illustrated in Figure 3 the first 32-bit word consists of all ones and is for synchronizing the receiver within the Remote Station while the second digital word contains the user identification and emergency/ assistance request information. The third and fourth words are repeats of the first and second.

The PDM forming logic provides to the FSK oscillator a modulating signal of the form shown in Figure 5. Shown in this figure are three illustrative waveforms with the waveforms being (1) a PDM signal containing all ones, (2) PDM with all zeros, and (3) PDM with alternating ones and zeros. Unique characteristics of this PDM format are

- A positive transition at the start of each bit period.
- A high level always exists for the first one-third of the bit period.
- A low level always exists for the last one-third of the bit period
- The middle one-third of the period defines either a one (high) or a zero (low).

The PDM waveform modulates the FSK oscillator in such a manner as to provide mark and space frequencies of 2100 $\pm$ 100 Hertz and 1750 $\pm$ 100 Hertz respectively. The resulting mark and space frequencies are connected to the microphone input of the users CB radio through the voice/data switch of Figure 4.

After transmission of the four sequential digital words, the voice/data switch is restored for normal transfer of the microphone voice signal to the CB radio and the Digital Adapter automatically reverts to a quiescent state.

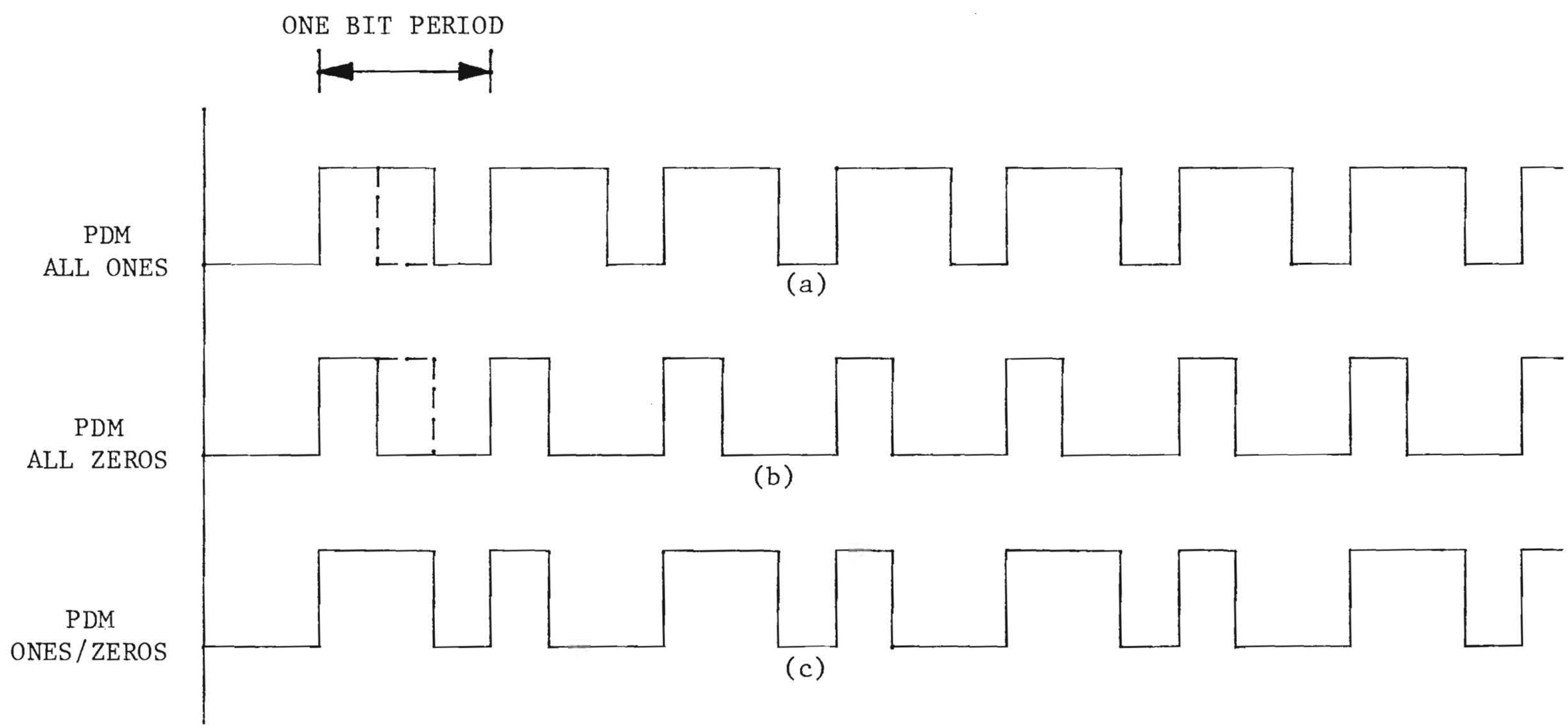

Figure 5. Illustration of Pulse Duration Modulation Format

Remote Station

The second major hardware element of the CB system is the Remote Station. It is the Remote Station which provides the automatic telephone interconnect portion of the CB-AIDS system. The Remote Station is capable of receiving, processing, and retransmitting both voice and digital signals. A simplified block diagram of the unattended Remote Station and its associated equipment is shown in Figure 6. The input signals to the Remote Station are produced by a co-located CB transceiver which has been set to receive on Channel 9. The audio signal output from the CB transceiver, which consists of both voice and digital transmissions from an associated Digital Adapter, is received and processed by the Remote Station. If a valid data transmission is received, the Remote Station then establishes a telephone patch enabling the the Digital Adapter user to communicate with a selected telephone via the normal dial telephone network. In establishing this telephone patch, the Remote Station must perform several functions. These functions include determining if a valid digital word has been received, determining from the encoded signal if the Digital Adapter user is requesting assistance or emergency type help, dialing either the assistance or emergency telephone number as required, establishing a voice patch between the called telephone set and the Digital Adapter, and providing an automatic command capability through which the called telephone set may control the operation of the CB transceiver remotely via signals sent over the telephone line. In addition to this telephone interconnect capability, as initiated from a Digital Adapter, the Remote Station also has the capability of being accessed by the Central Control Unit for the purpose of receiving Touch Tone telephone signals which are stored in memory at the Remote Station. This telephone number is for use when assistance is requested by the calling Digital Adapter.

Remote programming is required since this number may be changed frequently. Secure communications techniques are used to prevent illegal access into the telephone number memory element. The following paragraphs describe the Remote Station hardware elements in more

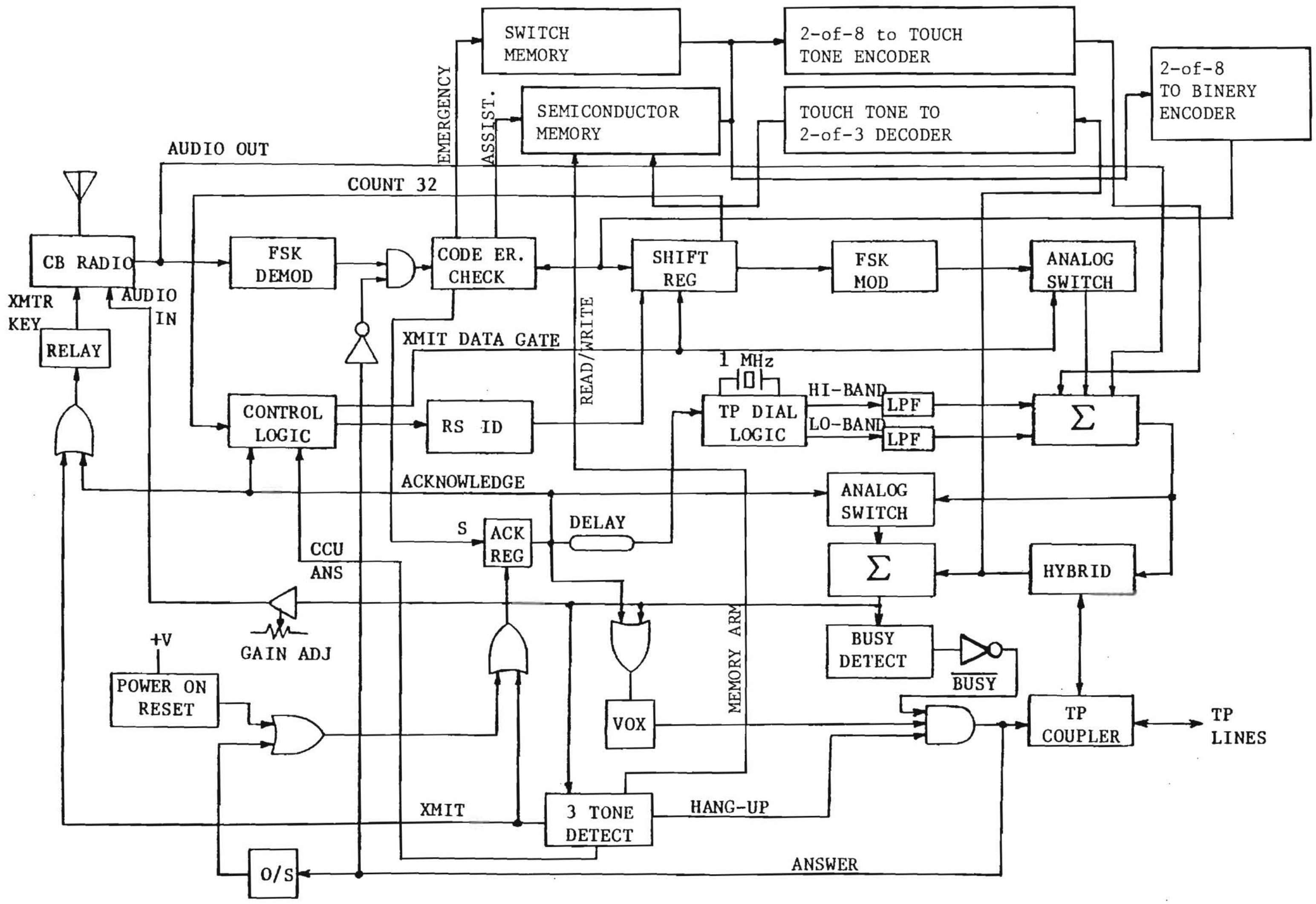

Figure 6. Remote Station Block Diagram.

detail.

The Remote Station consists of four subsystems in addition to the power supply. These four subsystems are the FSK Demodulator, the Word Processor, the Telephone Interconnect and Signaling, and the Telephone Number Store and Dial. A brief functional description of each sub-system follows.

The FSK demodulator accepts the baseband audio signal from the CB transceiver. When the CB transceiver is receiving a transmission from one of the Digital Adapters, this input signal will consist of both the FSK data word, voice transmissions, and in general, certain amounts of unwanted signals such as in-band noise and adjacent channel interference. During the time a Digital Adapter is transmitting data, the output from the FSK demodulator will be the 32-bit baseband data word, so long as the signal received by the CB transceiver is of sufficient quality to be detected by the demodulator.

The word processor accepts the baseband signal from the FSK demodulator and continuously tests for a valid data word. For the word processor to accept the data word as valid, a predetermined format must exist. When this predetermined format does exist, the word processor holds the word in a shift register, loads a Remote Station identification number into the data word, and provides both an "acknowledge" command and either an emergency or assistance command to the telephone signaling and interconnect (TS/I) sub-system.

After a telephone interconnect has been established, the data word is clocked out of the shift register to an FSK modulator which then provides the output signal that is subsequently sent over the telephone line to the called party.

Receipt of an "acknowledge" command from the word processor causes the telephone signaling and interconnection circuit (TS/I) to secure the telephone line and commands the telephone number store and dial (TS/D) sub-system to output the proper tone signals which then "dial" the assigned telephone number.

In addition to securing the telephone line and transmitting the tone signals, the TS/I also provides: (1) the audio input and output signal processing between the CB transceiver and the telephone coupler of Figure 6; (2) the telephone line monitoring for busy and non-answer conditions leading to automatic disconnect; (3) a voice operated relay (VOX) that also provides for automatic disconnect from the phone line upon termination of the verbal exchange between the mobile unit (Digital Adapter) and the called party; and (4) a 3-tone sequential receiver and decoder that provides command outputs for various operating modes of the Remote Station.

The telephone number store and dial (TS/D) sub-system contains the two telephone numbers required to access the telephone sets assigned to the emergency and assistance requests. The telephone number for emergency is programmed via switches on the TS/D circuit board. The telephone number assigned for an assistance request is stored in a semiconductor memory and can be programmed only from the Central Control Unit.

To program memory storage for an assistance telephone number, the Central Control Unit operator calls the Remote Station, ensures that telephone interconnect has been established, and accesses the memory by sending a coded "memory arm" signal. The operator then "dials," via Touch-Tone signals, the number to be stored. The TS/D accepts the Touch-tone signals, converts them to a 2-of-8 digital number, and stores the number in semiconductor memory. The memory then automatically reverts to a read mode and outputs the digital number (last digit first) to a 2-of-8 to binary encoder. The resulting binary number is converted from a parallel to a serial format and coupled through the same shift register and the FSK modulator that is normally used for re-transmission of the data word derived from the Digital Adapter. The last digit of the telephone number is read out first in order that the digital display on the Central Control Unit will present the stored telephone number from left to right.

When a telephone number read command is sent to the TS/D from the TS/I, the appropriate number (assistance or emergency) is read out of either the semiconductor memory or the switch-programmed memory and fed to a 2-of-8 tone encoder which generates the proper

Dual-Tone-Multiple-Frequency (DTMF) analog signals. The analog signals are then fed to amplifiers and signal conditioning circuits in the TS/I sub-system prior to being coupled over the telephone line.

Two flow charts and a system block diagram are provided to assist in understanding total operation of the Remote Station.

The first flow chart presents the normal mode of operation for the Remote Station, that is, when the Remote Station is accepting signals from one of the Digital Adapters within the CB-AIDS System. This flow chart is presented as Figure 7 with a simplified block diagram of the Remote Station illustrated in Figure 6.

Referring to the flow chart of Figure 7, the Remote Station continuously monitors the audio output from the co-located Citizens Band transceiver. Once a valid data word has been received, the word is held in the shift register and a 30 second automatic disconnect timer is initiated. The purpose of this 30 second timer is to automatically reset the entire Remote Station system if a telephone interconnect is not established within the alloted time. The Remote Station then loads its identification number into the data word which is being held in the shift register. Following this process, the co-located Citizens Band transceiver is placed in the transmit mode of operation. With the transceiver in the transmit mode the mobile operator is able to hear the telephone line being secured and hears the Touch-Tone signals as they are coupled to the telephone line. This operation provides the mobile operator with a positive indication that his request for emergency or assistance-type help has been acknowledged and that a telephone call is being placed to the appropriate location.

Referring again to the flow chart, one of two telephone numbers will be dialed according to the information contained in the data word as was transmitted from the Digital Adapter. After the telephone number has been dialed, the Remote Station then monitors for a busy tone. The monitoring capability is accomplished by use of two phase-locked-loop tone decoders. If the telephone line is busy, the Remote Station disconnects from the telephone line, resets the entire system, and reverts to the mode where the Remote Station is again

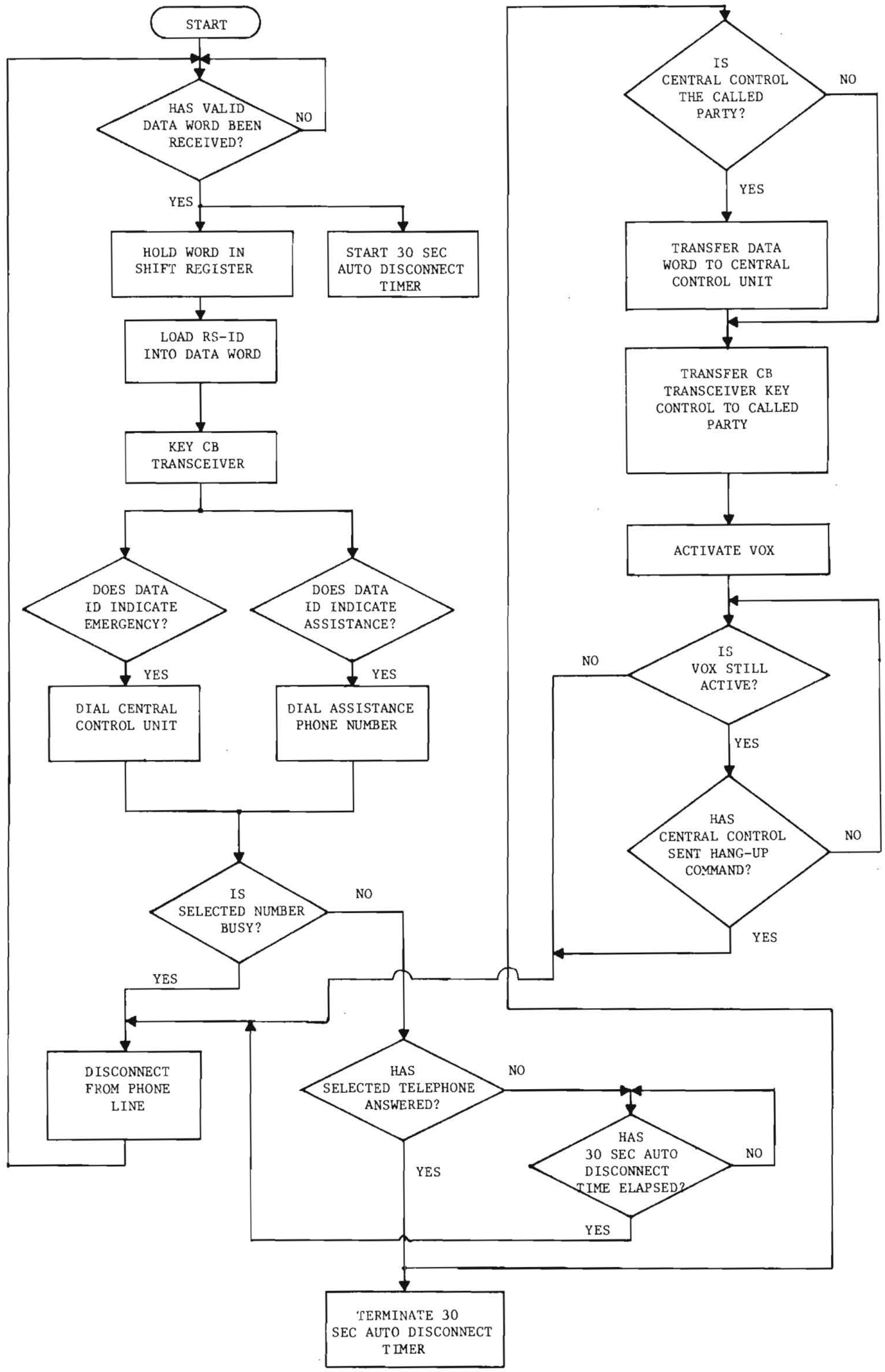

Figure 7. Remote Station Flow Chart.

waiting for a valid data word from the Citizens Band transceiver. Because the CB transceiver has been in a transmit mode during this entire portion of the operation, the mobile operator will know that the telephone line was busy, and after a brief pause, can again attempt to make the required telephone connection. If the telephone line is not busy, the Remote Station allows the remaining 30 second interval for the called telephone to be answered. If the called telephone does not answer within this remaining time, an automatic disconnect occurs and the Remote Station again reverts to the data word search mode. When the telephone call is answered within the 30 second interval, the timer is automatically terminated.

When the called telephone is the Central Control Unit, a sequential three-tone command signal is automatically sent from the Central Control Unit to the Remote Station as the call is answered. This three-tone command signal activates the shift registers containing the data word. The data word is delivered to the FSK modulator and then coupled from the modulator over the telephone line to the Central Control Unit which will then display and record the data.

For the situation where assistance-type help is requested, there will be no automatic data recording equipment at the assigned telephone set. Likewise, there is no command capability to cause the Remote Station to output the data word contained in the shift register. As a result, only verbal communication can be established between the mobile operator and the operator located at the telephone set assigned for assistance-type help.

Once a telephone interconnect has been established between the Remote Station and the called party, the CB transceiver is then taken out of the transmit mode and operation is placed under control of the called party. If the called party is the operator assigned to the assistance telephone set, the CB transceiver will be placed in a transmit mode only when the assistance operator is speaking. This function is implemented by use of a voice operated switch (VOX) having a fast attack time to minimize leading syllable clipping. In addition to this voice operated switch, there is a second voice operated switch which is activated by either party. This VOX has a time constant of approximately 16 seconds. If there exists no verbal or digital transmission during any 16-second interval, then this voice operated switch times out and automatically disconnects the Remote Station from the telephone line.

When the called party is at the Central Control Unit, then placement of the CB transceiver into a transmit mode is automatically accomplished when the Central Control Unit operator depresses the push-to-talk switch on the microphone associated with the Central Control Unit. Depressing the push-to-talk switch transmits a unique three-tone sequential commannd to the Remote Station. Receipt of this control signal is detected and causes the transceiver to go into the transmit mode. In a similar manner, when the push-to-talk switch is released, a second three-tone sequential code is transmitted which reverts the CB transceiver back to the receive mode. When the verbal exchange between the mobile operator and the CCU operator is completed, the Central Control Unit initiates a hang-up sequence that automatically transmits a sequential three-tone signal to the Remote Station. The Remote Station responds by disconnecting from the telephone line and reverts to the data-word-search mode of operation. Approximately three seconds after the CCU has transmitted the hang-up command, it also automatically disconnects from the telephone line.

The flow chart of Figure 8 presents the operation of the Remote Station when called by the Central Control Unit for the purpose of storing an assistance telephone number in semiconductor memory. From the flow chart it can be seen that this number storage process is initiated by the CCU operator dialing the telephone number assigned to the Remote Station. When the number has been dialed, the telephone coupler associated with the Remote Station answers with a pulsing 2125 Hz tone. The CCU operator then responds by pressing the number "3" button on his associated touch tone telephone set. Pressing the number "3" button results in a tone being transmitted to the telephone coupler with the coupler responding by connecting the telephone line to the Remote Station. (Note that once a telephone interconnect has been

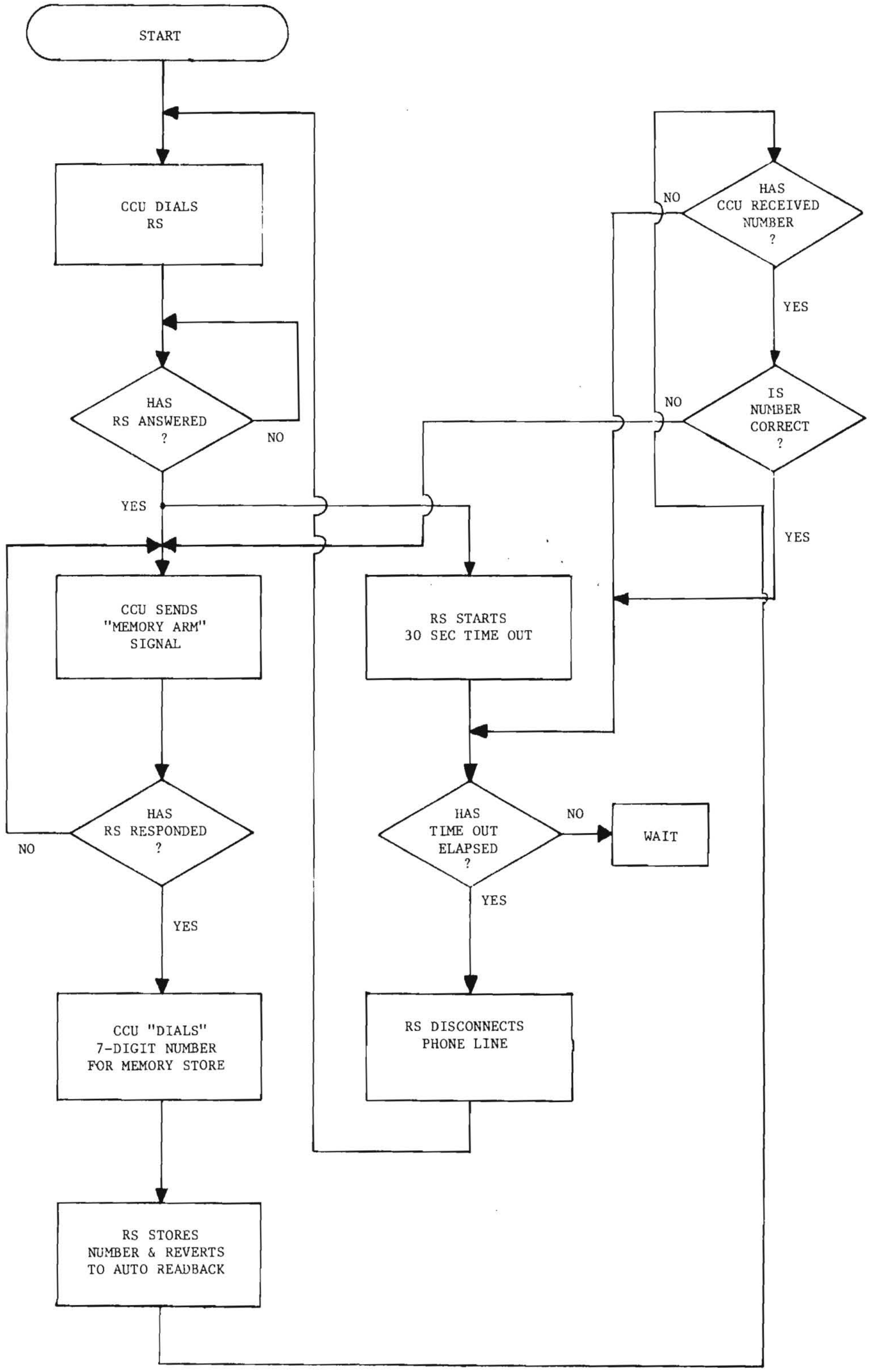

Figure 8. CCU/RS Telephone Number Store Flow Chart.

established with the Remote Station, a 30 second time-out interval is initiated. All remaining functions must be accomplished within this 30 second interval. At the end of 30 seconds, the Remote Station automatically disconnects from the telephone line.) The CCU operator then presses the memory arm button located on the front panel of the Central Control Unit. Pressing this button causes the Central Control Unit to send out a unique 3-tone sequential signal which is received and detected by the Remote Station. The Remote Station automatically responds by transmitting a 1500 Hz tone of two seconds duration to the Central Control Unit. Receipt of this memory arm signal by the Remote Station causes the semiconductor memory to go into a write mode of operation. The next step in the sequence is for the operator at Central Control to "dial" the seven digit number that is to be stored in memory. As the Central Control operator "dials" the seven-digit number, the resulting tone signals are received, converted to a 2-of-8 digital format and stored in the semiconductor memory by the Remote Station equipment.

After the Remote Station has received all seven tone signals, the semiconductor memory automatically reverts to a "read mode". With the memory then in a read mode, the stored telephone number is automatically read from memory and coupled over the phone line to the Central Control Unit. The Central Control Unit receives, demodulates, and decodes this FSK signal with the telephone number then presented as a digital readout on the front panel of the Central Control Unit. This automatic read-back and display feature allows the operator at Central Control to be assured that the proper telephone number has been stored in memory at the Remote Station.

From the flow chart of Figure 8, it can be seen that if, at this time, the operator at Central Control failed to enter the correct telephone number, and the 30 second time interval has not expired, the operator can reinitiate the memory arming process and make a second attempt at storing the proper telephone number. If the time interval has expired, it is then necessary for the operator to again dial the telephone number associated with the Remote Station and restart the

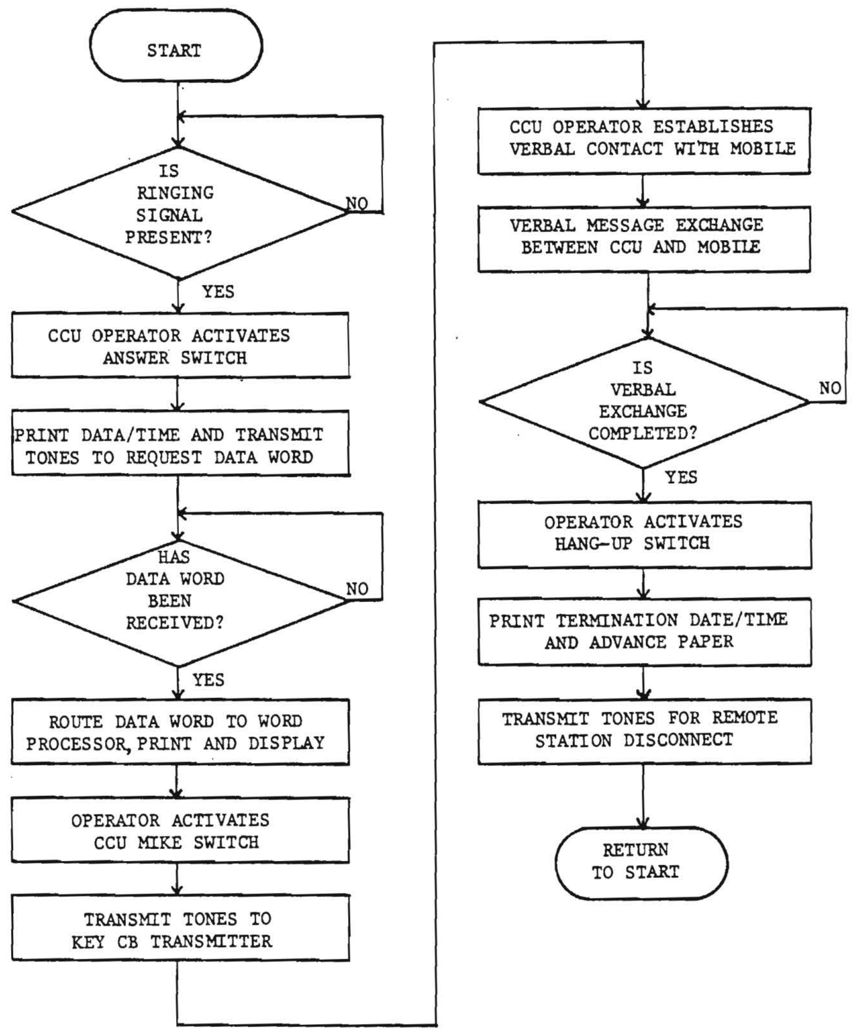

Figure 9. Flow Chart of the CCU.

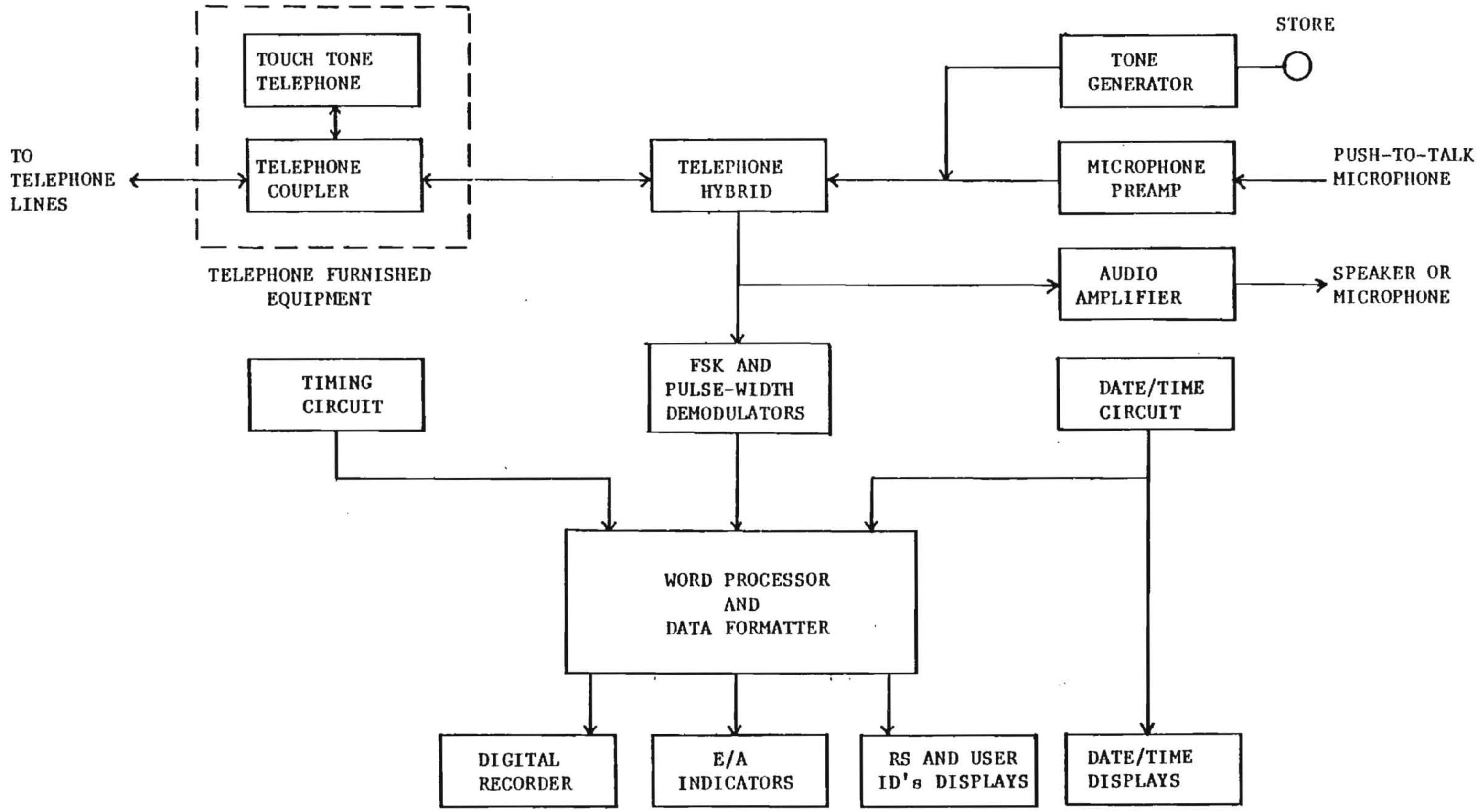

Figure 10. Functional Block Diagram of Central Control Unit (CCU).

1. Telephone hybrid
2. Tone generator
3. Microphone preamplifier
4. Audio amplifier
5. FSK and pulse-width demodulators
6. Timing circuit
7. Clock/calendar circuit
8. Word processor and data-formatter
9. Digital displays and indicators

The system is comprised of both TTL and CMOS type integrated circuits. A brief description of each element is given in the following paragraphs.

The telephone hybrid provides the necessary isolation between transmitting and receiving portions of the CCU. The hybrid allows voice and tone data to be routed to and from the telephone coupler while providing the required input/output signal isolation.

The tone generator produces a sequential three-tone code which is transmitted over the telephone lines to the Remote Station. The specific code to be transmitted is dependent on the mode of operation to be established at the Remote Station, i.e., data dump, transmit, receive, memory arm or disconnect.

The microphone preamplifier simply amplifies the transmitted voice to a level suitable for transmission over the telephone lines. In a similar manner, the audio output amplifier provides sufficient drive to the CCU speaker to enable the operator to hear and understand verbal transmissions from the mobile user.

The function of the FSK demodulator is primarily to recover the 32-bit data signal transmitted via telephone interconnect from the Remote Station. The demodulator is comprised of a phase-locked-loop followed by an operational amplifier. The recovered baseband data signal is subsequently applied to a pulse-width demodulator which in turn reduces the data to serial BCD format. The 32-bit binary-coded-decimal (BCD) data are then routed to the word-processor along with a data-ready strobe for indicating a complete word has been received.

The function of the timing circuit is to provide necessary strobes for the formatter circuit and provide print and paper advance commands in the correct sequence for the digital recorder. The timing circuit is a gated six- state binary counter. Three sequential events are gated with a 5 Hz free running clock to change states of the binary counter. The sequence of events are: 1) acknowledgement of the CCU operator answer response, 2) data-ready strobe from the pulse-width demodulator, and 3) indication of telephone hang-up activated at termination of the message. Upon receipt of the hang-up strobe the counter advances two states thus supplying two paper advance commands to the digital recorder. The counter is then reset and awaits the next sequence of events. Should the counter miss an event within the sequence, a reset button on the front panel can be used for setting the counter to its quiescent state.

The date and time are derived from a dedicated CMOS clock chip. The clock chip is multiplexed both internally and externally to provide a continuous display of the date and time. The external multiplexing rate is based on five internal multiplexing cycles. For every fifth internal cycle, the ouput of the clock chip will alternate between the time and date. The time and date data are routed to the front panel display via BCD-to-seven-segment decoder/drivers. Also, the BCD data are distributed to the data-formatter via 10 quad latches which are strobed at the proper time to hold the date and time for printing purposes. Controls for setting the correct date and time are provided on the front panel.

The word-processor includes four serial-to-parallel shift registers. The shift registers accept the 32-bit serial data from the pulse-width-demodulator. The output is 32-bits of parallel data which is distributed to the data-formatter and to the display-decoder-latch-drivers. The data-formatter consists of 10 multiplexers which are controlled by the timing circuit. The formatter routes the appropriate data, i.e., the date/time or the Remote Station and user ID's plus the call category (E/A), to the digital recorder.

The date, time, Remote Station ID, and user ID are visually provided through use of 7-segment LED displays. The call category indicators are simply lamps which indicate an "E" or "A" type call. Inputs for driving the various displays and indicators are derived from the clock/calendar and word-processor circuits, respectively.

SECTION 6

SYSTEM TEST, EVALUATION, AND FIELD DEMONSTRATION

(TASK C)

The activity in this area included three major items. The first was to conduct a complete test of the CB-AIDS System, including Digital Adapters, Remote Stations, and the Central Control Unit on the Georgia Tech campus. The second major item was to make arrangements with a responding agency for installing the CCU in a response network and make arrangements for installation of the remote station in the selected area and then to coordinate with the telephone company for installation of appropriate service. The third major item was to perform a field demonstration with the system installed in the pilot program area.

The first part of the system test at Georgia Tech concerned installation of the Digital Adapters with the mobile CB radios under field conditions. During these tests some radio frequency interference and ignition noise were noted. Modifications to the Digital Adapter for correcting these problems included the addition of by-pass capacitors to the input and output lines to the Digital Adapter to eliminate the 27 MHz interference. The effects of the ignition noise varied considerably depending on the CB radio used in the test. The by-pass capacitors placed on the input and output lines also substantially reduced the effect of the ignition noise.

Next the laboratory test was configured with the Remote Station connected to one local centrex line and with CCU connected to another local centrex line. A Digital Adapter was used at a remote location to initiate a call to be received by the Remote Station. These tests were performed and the Remote Station correctly dialed the central control number and communications were successfully carried on through the system. During the early tests some voice quality problems were noted which were corrected by adjustment of the line levels in both the Remote Station and CCU equipment and by more accurately matching the telephone line impedance.

Following the preliminary laboratory setup a field test of the system was performed using a moving vehicle (containing a Digital Adapter), a Remote Station, and the Central Control Unit. The test setup is shown in Figure 11. This field test involved having the Remote Station and Central Control Unit co-located within the laboratory. Each unit, however, was connected to a separate telephone line via its respective telephone coupler. The Remote Station was also interconnected with a CB transceiver which in turn was connected to a roof-mounted antenna. Although the Remote Station and CCU were co-located for this preliminary test, the electrical interconnection between the two units was as would be done in the full scale evaluation phase of the research program. One exception to the operational configuration was that the communications were placed over Channel 37 to avoid communicating over Channel 9 with non-emergency transmissions.

For test purposes, a CB radio with a Digital Adapter was installed in a vehicle which was then driven to numerous locations within a 0.4 km (0.25 mi) to an 8 km (5 mi) radius of the laboratory-located Remote Station. The test route and the results are shown in Figure 12 and Table 4, respectively. In general, good-to-excellent results were obtained for communications within a 5 km (3 mi) radius. For greater than 5 km (3 mi) radius the resulting voice quality was only fair-to-poor. The Digital Adapter signal was received successfully by the Remote Station for most locations. The only exceptions were at Location 15 which was 3 km (4.6 mi) away and Location 19 which was 2.9 km (4.6 mi) away. Other locations, specifically, locations 16 through 18 and 20, required several initiations of the Digital Adapter before the digital signal was accepted by the Remote Station. It should be noted that the voice communications from these locations was judged as poor. These tests were conducted in the downtown Atlanta area; an area with extremely high noise levels in the CB radio band. As expected, it was noted during the tests that the quality of speech was quite satisfactory with the telephone interconnect so long as the radio link remained satisfactory and that the major determining factor on speech quality was the radio signal and not the signal over the telephone lines.

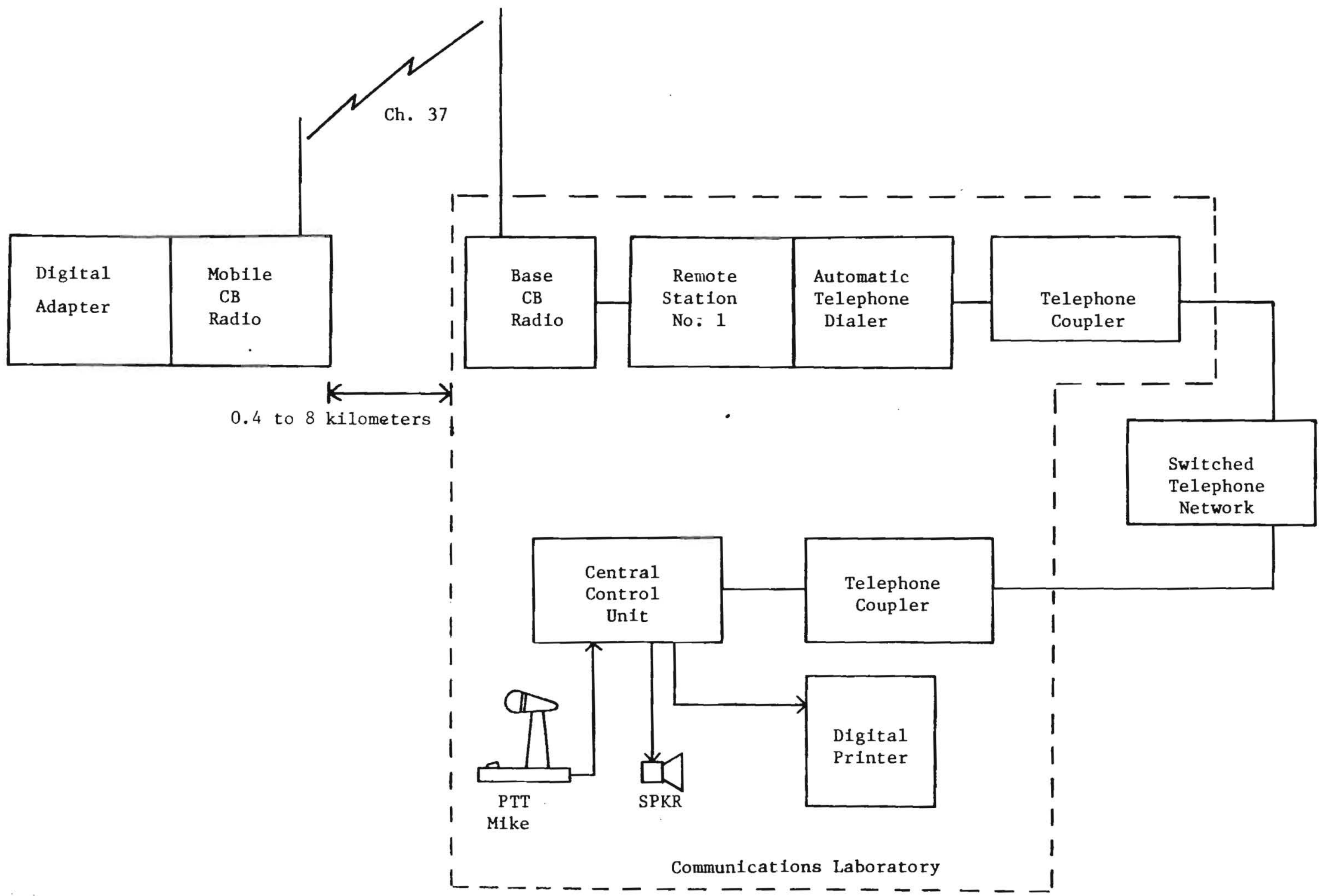

Figure 11. CB-AIDS Field Test Configuration.

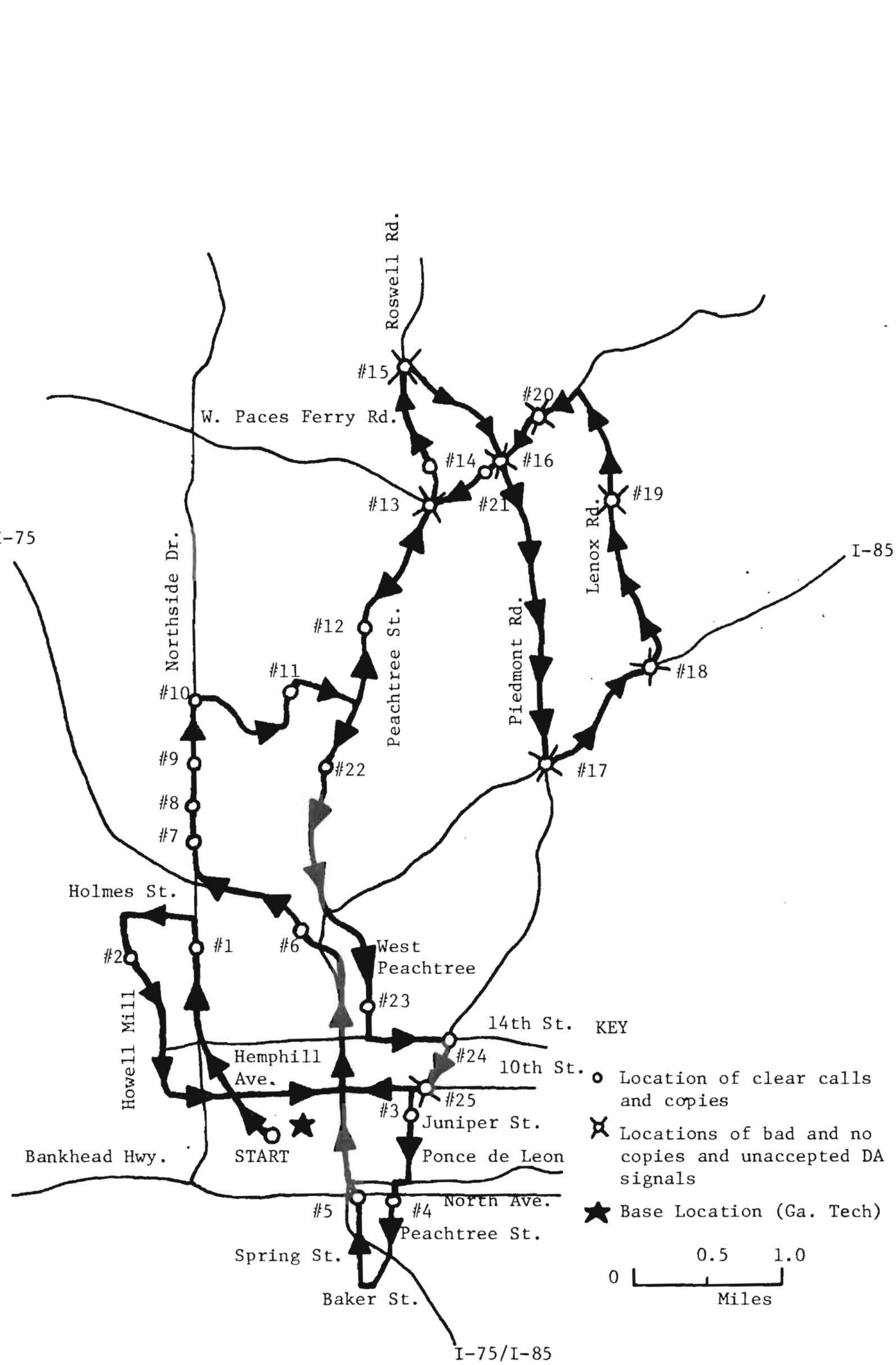

Figure 12. CB-AIDS Field Test.

TABLE 4

CB-AIDS FIELD TEST RESULTS

Location Number	Range In Miles	Voice Quality	DA Signal Received	Demod. Mode	Notes
1	1.4	Excellent	Yes	ID	
2	1.5	Excellent	Yes	ID	
3	1.0	Excellent	Yes	ID	
4	0.8	Excellent	Yes	ID	
5	0.6	Excellent	Yes	ID	Also tested busy tone
6	1.3	Excellent	Yes	ID	
7	2.0	Good	Yes	ID	
8	2.2	Excellent	Yes	ID	
9	2.5	Good	Yes	ID	
10	2.8	Good	Yes	ID	
11	2.8	Good	Yes	ID	
12	3.3	Good	Yes	C	
13	4.1	Poor	Yes	C	
14	4.4	Fair	Yes	C	
15	5.0	Poor	No	C/ID	No Lock in Either Mode
16	4.6	Poor	No/Yes	C	Signal accepted on 3rd try
17	2.8	Fair	No/Yes	C	Signal accepted on 2nd try
18	3.7	Poor	No/Yes	C	
19	4.6	Poor	No	ID	
20	4.9	Poor	No/Yes	ID	Signal accepted on 2nd try
21	4.5	Good	Yes	ID	
22	2.4	Good	Yes	ID	
23	1.7	Excellent	Yes	ID	
24	1.1	Excellent	Yes	ID	

Another feature that was tested was for the remote programming of an assistance number into the Remote Station by the CCU operator. After doing this, the system function was tested by the user with a Digital Adapter in his vehicle. The function performed satisfactorily, dialing the number which had been placed in the memory of the Remote Station by the CCU. The same tests were also performed using the 23 channel CB radio and the second Remote Station. However, it was noted that the voice quality of this CB radio was not as good as the voice quality of the 40 channel unit.

The next major area discussed in this section involves the installation of equipment at the selected Central Control Unit location and the test site areas. Actual selection of the pilot program test area will be covered in the next section; this section describes equipment installation at the selected areas.

The Central Control Unit equipment was placed in the Communications Center of the Dekalb County Police Headquarters. A diagram of the facilities is included as Figure 13 showing the CCU location in the special services console. This console includes fire alarms, burglar alarms, a base station CB radio and the CB-AIDS equipment operated by special monitor. A separate private business telephone line was installed in the Dekalb Police Communications Center for the CB-AIDS equipment. This line had a protective coupling arrangement provided by the telephone company. After some initial problems with the originally-supplied telephone coupler, the proper coupler was provided by the telephone company and successful operation was initiated. The initial sites selected for the Remote Stations were two public schools within the pilot program test area - Shamrock High School and Sequoyah High School. Following the approval of the school superintendent's office and of the principals at the two high schools, appropriate locations were selected within the buildings for placement of the Remote Station equipment. The locations selected in each of the schools were in supply areas which also contained fire alarm, burglar alarm, telephone, and intercom equipment. The CB base station antenna was located on the roof of the building with the coax cable routed

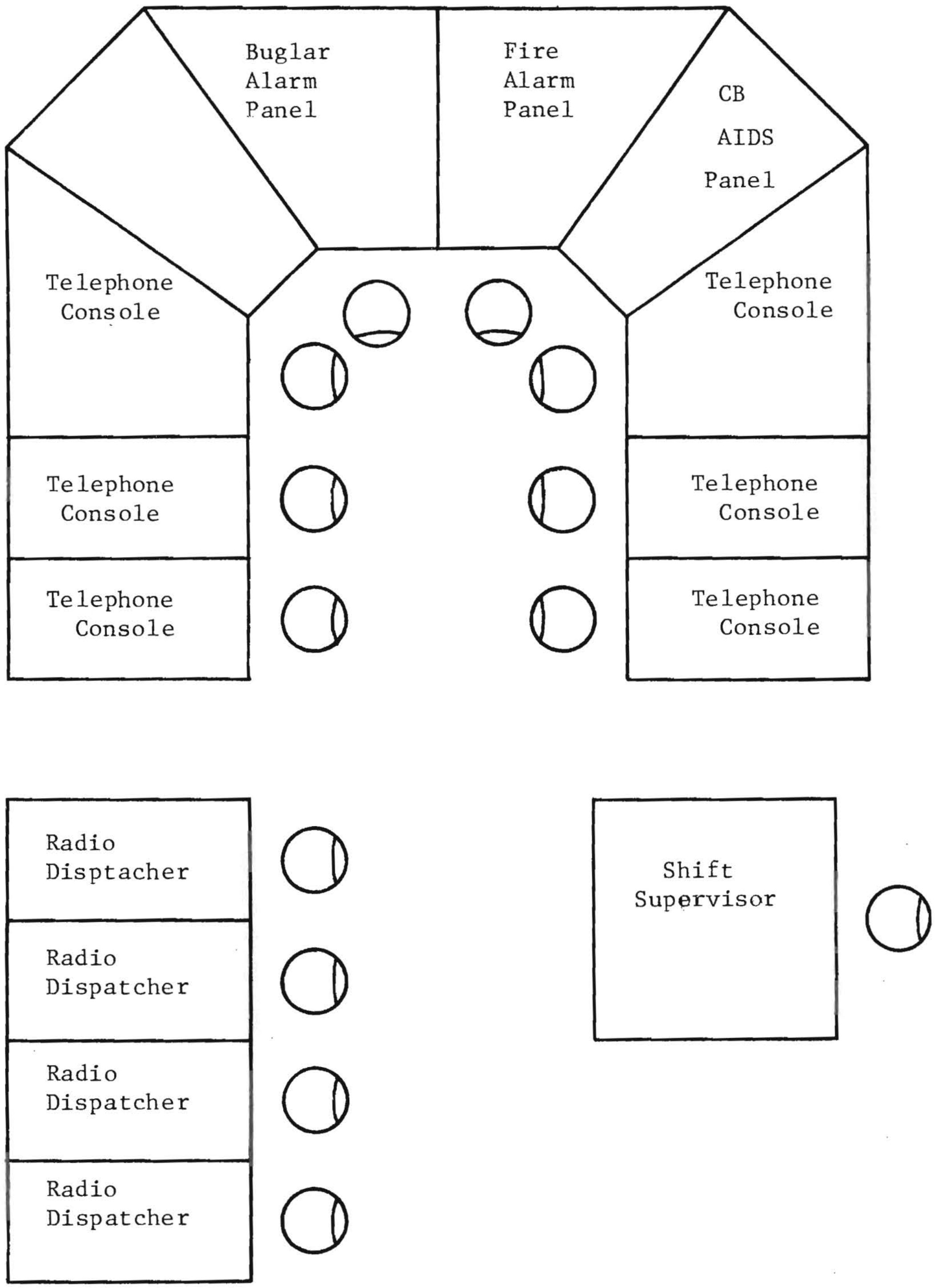

Figure 13. DeKalb Police Communications Center Layout

through the same openings used for the burglar alarm antennas. As with the CCU, separate business telephone lines were installed at each of the high school locations. The service ordered was a standard business line, Touch-Tone service with an unlisted number. Some initial interference problems were noted with one of the school's intercom system in which calls on the CB radio would be received over the intercom system. This problem was corrected by placement of the antenna and associated radio equipment further away from existing lines for the intercom equipment.

Following the installation, field tests were conducted in the area of both Remote Stations. Calls were initiated within a 5 km (3 mi) radius of each station. Reception at the Sequoyah station was excellent with telephone interconnection completed on most attempts. Reception at the Shamrock remote station showed intermittent operation. Over several days the range at the which the Digital Adapter tone sequence would initiate a telephone connection varied from 3.2 km (2 mi) to less than 1.6 km. This station was the one which utilized the 23-channel CB radio. After some experience, it was determined that the squelch setting was intermittent and would vary considerably from day-to-day. The decision was made to purchase another 40 channel base station radio to replace the existing 23-channel unit. After installation of the new radio the intermittent problems no longer occurred and excellent results were obtained with the Sequoyah station over most of the 5 km (8 mi) coverage area.

SECTION 7
PILOT PROGRAM DESIGN AND IMPLEMENTATION
(TASK D)

This part of the program focused on the design and implementation of a pilot program that would demonstrate the technical and operational feasibility of the CB-AIDS concept. The system design included each of the activities of traditional motorist-aid systems - detection, definition, dispatch, service and recording. Detection was in one-of-two categories. First the CB-AIDS user could require use of the system for himself or he could use the system to assist another motorist. The latter was the more frequent occurrence. Definition was facilitated, since the dispatcher of the emergency service had a two-way voice contact with the initiator of the call. Dispatch was a function of the responding agency. The use of an existing organization facilitated dispatch since the CB-AIDS system was able to fit into an existing organizational response. In a similar manner, service was provided by the existing service organizations. Finally, recording of each incident was provided both automatically and manually. Automatic recording was provided via a digital printer which printed the time, user ID, Remote Station ID, and type of call. An additional data log was provided by the CCU operator and also was requested from each system user.

One major effort in this part of the program was to select the pilot program test area. Site selection criteria were developed to include the items listed below. It should be noted first, however, that an operational CB-AIDS system could be implemented in any location which has a mobile CB-user population, telephone lines, and cooperating response agencies. However, for the pilot program other factors were required in order to maximize the probability of a meaningful demonstration. These factors were included with necessary technical criteria for test site selection. The criteria were:

(1) Cooperative Government Leaders and Agencies. The test site selected was required to have government leaders and agencies such as Governor, Public Safety Agency, State DOT, and local police who would provide support for the program.

(2) Available Facilities. The test site was required to have an existing response facility for responding to the emergency calls. This facility had to agree to include the CCU, the response console, and to answer CB-AIDS calls at no charge.

(3) Available Volunteer Monitors. It was required that the test site have an existing organization of volunteer monitors who would agree to provide assistance in the program.

(4) A Large CB-User Population. In order to provide adequate use of the system the test site was required to include a CB-user population large enough to provide an adequate sample and general awareness of CB use. Although rural areas may have had a greater need for an operational CB-AIDS system on certain occassions due to the distance a stranded motorist would be from help, the pilot program had to be based on a larger population base since the number of Digital Adapters and Remote Stations were limited to 100 and two, respectively. (A third Remote Station was added later.)

(5) Available System Maintenance Facilities. It was required that the site have the resources to provide timely hardware maintenance and monitoring of the system's operation.

(6) High Number of Incidents. The area covered by the Remote Stations had to have a high daily average of incidents which would require a response through CB-AIDS. The high number of incidents was required to increase the probability-of-detection of a sufficient number of incidents by CB-AIDS users.

(7) Availability of Power and Telephone Facilities for Remote Station Installations. The test site was required to have power and telephone circuits available for installation of the Remote Stations. In addition, it was required that these sites be situated at a locally high elevation point to provide needed range coverage.

Following the consideration of a number of areas east of the Mississippi and within the state of Georgia, including both north and south Georgia, which met the site selection criteria, the test site was selected to be in the suburban Atlanta (North Dekalb County) area. In addition to meeting the site selection criteria, the county police officials in this location had worked with Georgia Tech researchers on previous programs, and an excellent working relationship had been established. Following the selection of this general area, the specific area was discussed further with the Dekalb County Police, Federal and State DOT representatives and RUSH representatives (Radio Users Send Help - a volunteer CB monitoring organziation sponsored by the Georgia DOT and the Georgia State Patrol). The consensus area based on the site selection criteria was determined to be in North Dekalb County, including Interstate 85 and Interstate 285, and an area including highways US-23,US-29, and US-78. Specific locations were investigated by use of area topographical maps. Following an initial request of an industrial organization that was located in a particularly promising location, but was subsequently turned down, an effort was made to contact representatives of public schools in the area. This effort was successful and ended with the selection of two high schools in the North Dekalb area, i.e., Shamrock and Sequoyah High Schools as previously indicated. The later added, third Remote Station was installed at Columbia High School, located in the southeastern part of DeKalb County. A preliminary trip was made to each high school, meeting with representatives of each school's facilities department, in order to investigate possible locations for the Remote Station equipment. Following the preliminary investigation of the two schools, range tests were conducted from each location. These tests were strictly audio tests performed to determine the voice quality at varying distances and locations from the schools. In performing these tests, a CB radio was located at the specific school, with the antenna on the roof, while the mobile unit placed calls at frequent intervals along the test route. Operators in the mobile unit and at the school recorded their assessment of the voice quality of each call. The route and voice quality results at remote station one (Shamrock High School) are given by Figure 14 and Table 5, respectively. While the routes and results of remote station two (Sequoyah High School) are given by Figure 15 and Table 6, respectively. Based on these results, the schools were determined to be reliable sites which would provide excellent coverage of pilot program area.

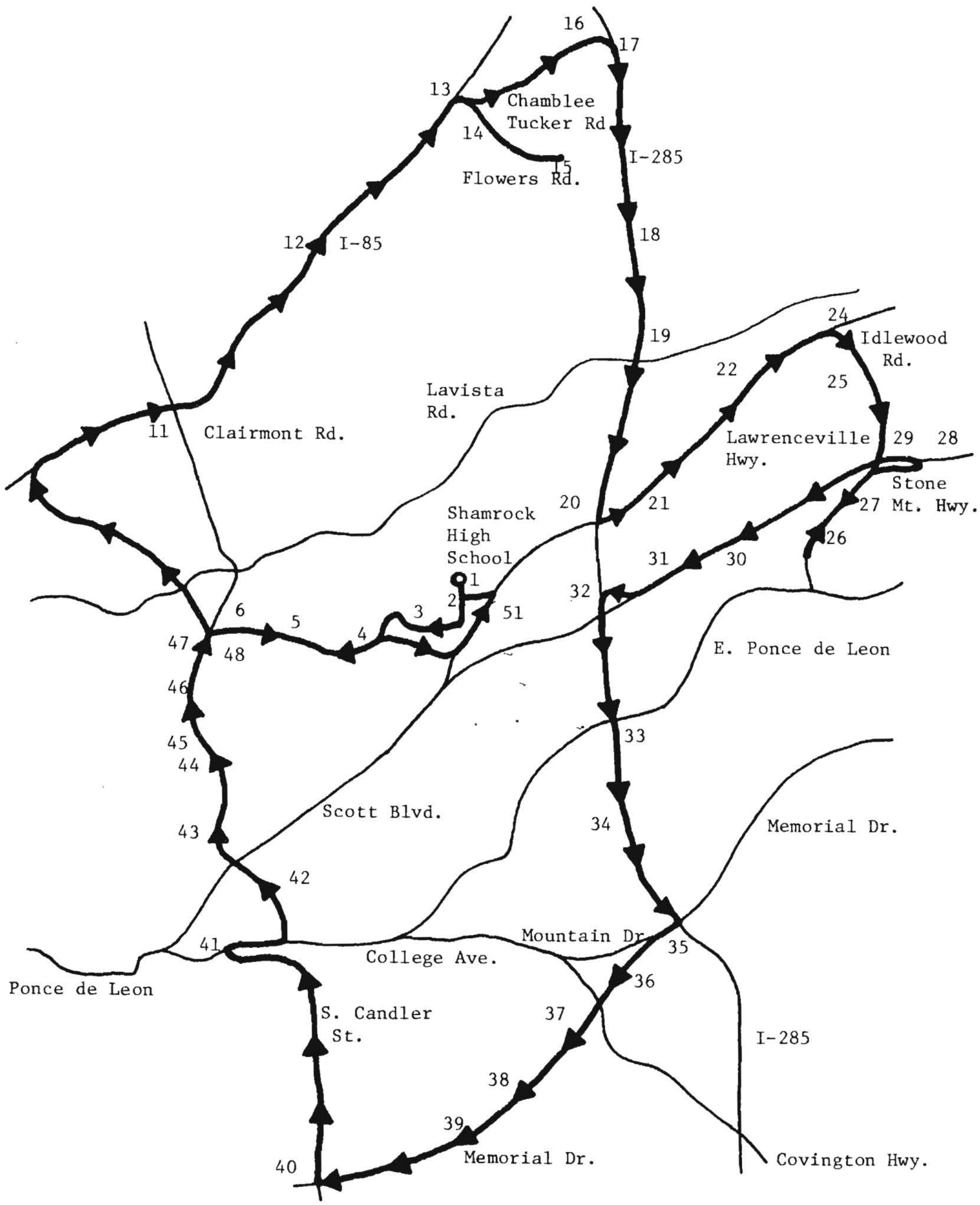

Figure 14. Shamrock Remote Station Test Route.

TABLE 5. RANGE TEST-SHAMROCK REMOTE STATION.

CALL SIGN KDZ 3740

DATE January 24, 1978

CHANNEL 37

BASE STATION READABILITY — MOBILE UNIT ONE READABILITY — 1 SHAMROCK HIGH SCHOOL

Location	E	G	F	P	No Copy	E	G	F	P	No Copy	Comments
Parking Lot-Shamrock HS	x					x					
Mt. Olive & Harcourt Dr.	x					x					
Mt. Olive & N. Druid Hills		x				x					
N. Druid Hills & Birch	x					x					
N. Druid Hills & Sprind Creek	x					x					
N. Druid Hills & Clairmont		x					x				
N Druid Hills & Berkley Ln.		x					x				
N Druid Hills & Kinoh Hill Dr.		x					x				
N Druid Hills & Briarcliff		x					x				
N Druid Hills & I-85		x					x				
I-85 & Clairmont Rd.		x					x				
I-85 & Shallowford Rd.		x					x				
I-85 & Chamblee-Tucker Rd		x					x				
Chamblee-Tucker & Flowers			x					x			
Flowers at N Fork Pch't Crk				x						x	
Chamblee-Tucker & Buckeye		x						x			
Chamblee-Tucker & 285											
285 & Evans Rd.			x					x			
285 & Lavista Rd		x					x				
285 & Lawrenceville Hwy		x					x				
Lawrenceville & Montreal		x					x				
Lawrenceville & Cooledge			x				x				
Lawrenceville & Shady Ln			x				x				
Lawrenceville & Fellowship			x						x		
Idlewood & Fellowship				x					x		
Idlewood & Idlevale Dr.			x					x			
Idlewood & Sare Pkwy				x					x		
Sare Pkwy. & Mt Industrial		x							x		
Mt Industrial & Stone Mt. Pk				x					x		
Stone Mt. Pk & Cooledge Rd			x					x			
Stone Mt Pk 1 mi from 285		x					x				
Stone Mt Pk & 285	x						x				
285 & E Ponce DeLeon Ave	x					x					
N Decatur Rd at Police Hdq	x					x					
Memorial Dr & Covington Hwy		x					x				tried channels 12 & 13 too busy now on 5
Memorial Dr & Covington Dr		x					x				

TABLE 5 (Continued). RANGE TEST-SHAMROCK REMOTE STATION.

CALL SIGN KDZ 3740

DATE January 24, 1978

CHANNEL 37

2

SHAMROCK HIGH SHCOOL

Location	BASE STATION READABILITY					MOBILE UNIT ONE READABILITY					
	E	G	F	P	No Copy	E	G	F	P	No Copy	Comments
Memorial Dr & Beech Dr		x					x				5 got too bad; back to 37
Memorial Dr & Columbia Dr		x						x			
Memorial & S Candler St.			x						x		
Ponce de Leon & Nelson Ferry		x					x				
Ponce de Leon & Clairmont		x					x				
Clarimont & Lamont		x					x				
Clairmont & Powell Ln		x					x				
Clairmont & Williams		x					x				
Clairmont & Mason Mill Rd		x					x				
Clairmont & N Druid Hill	x						x				
N Druid Hills & Spring Creek		x					x				
N Druid Hills & Asbury Ct		x					x				
N Druid Hills & Mistletoe Rd	x					x					
Lawrenceville Hwy & Harcourt	x					x					

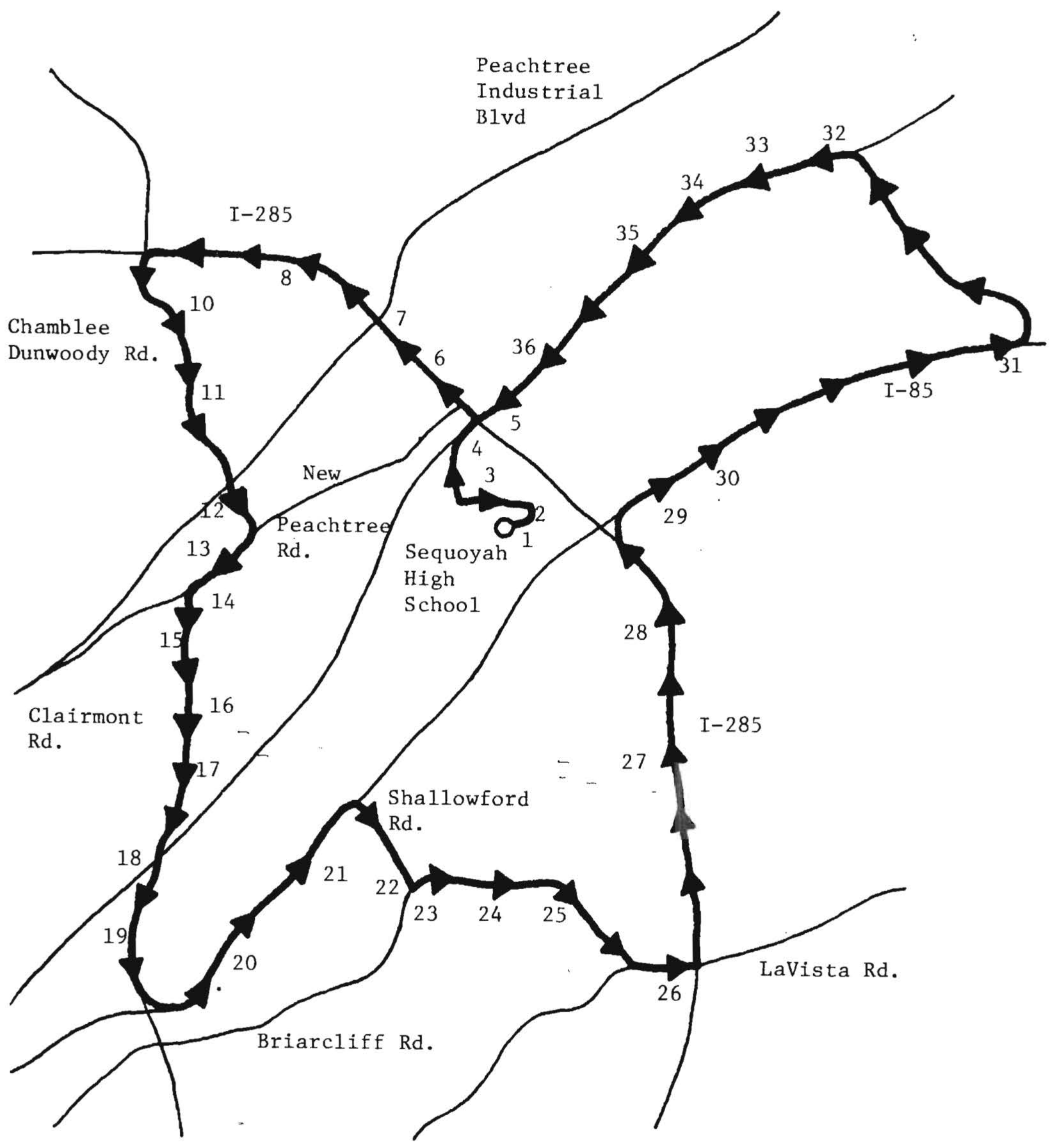

Figure 15. Sequoyah Remote Station Test Route.

TABLE 6. RANGE TEST-SEQUOYAH REMOTE STATION.

CALL SIGN KDZ 3740

DATE January 31, 1978

CHANNEL 37

Location	BASE STATION READABILITY E	G	F	P	No Copy	MOBILE UNIT ONE READABILITY E	G	F	P	No Copy	SEQUOYAH HIGH SCHOOL Comments
1. Sequoyah High Pkg lot	x					x					
2. Santa Fe & Cherokee	x					x					
3. Chestnut & Beechwood	x					x					
4. Chestnut & Buford Hwy	x					x					
5. Buford Hwy & 285		x				x					
6. 285 & General Mtrs Assbly		x					x				
7. 285 & Peachtree Inds.				x				x			
8. 285 & No. Peachtree Rd				x				x			
9. 285 & Chamblee Dunwoody		x					x				
10. Chblee-Dunwdy & Ashentree		x					x				
11. Chblee-Dunwdy & Harts Mill		x					x				
12. Chble-Dunwdy & Pct'e Ind		x					x				
13. Pct'e Ind. & Decree Rd		x					x				
14. Pct'e Rd & New Pct'e Rd		x					x				
15. N. Pct'e Rd & Clairmont		x						x			
16. Clrmt at DeKb Pch. Airport			x					x			
17. Clrmt & Georgian Dr				x				x			
18. Clrmt & Buford Hwy				x				x			
19. Clrmt Rd & Wilmont Dr.				x					x		
20. 85 bet. C'mt & S'ford				x						x	
21. S'ford Rd. & 85		x							x		
22. S'ford & Lk Flair Cir.		x						x			
23. S'ford & Braircliff		x						x			
24. Braircliff & Payton Rd.		x						x			
25. Braircliff & Briarcrest		x						x			
26. Lavista & 285		x					x				tried chl. 11, too busy, now on 7
27. 285 & Henderson Rd		x						x			
28. 285 & Chamblee-Tucker		x					x				
29. 285 & 85		x					x				
30. 85 & Northcrest Rd.	x						x				
31. 85 & Rock Bridge Rd		x					x				
32. Rock Br. & Buford Hwy		x					x				
33. Buford Hwy & Jones Mills			x					x			
34. Buford Hwy & Pleasantdale		x					x				
35. Buford Hwy & New Pch't		x					x				
36. Buford Hwy & 285		x				x					
37. Chestnut Dr. & Pineland	x					x					

The selection of CB-AIDS system users and the distribution of Digital Adapters was a major item under this task. A CB-AIDS User Information Form was developed in order to solicit information from potential users. The criteria for being selected as a volunteer in the system included the fact that the applicant lived, worked, or drove frequently within the pilot program area, that the user have a CB radio with a standard four pin or five pin microphone connection, that the user be operating under an FCC license, and that the user would agree to not make illegal calls over the system or use illegal equipment in conjunction with the CB-AIDS system. A final criteria was that the applicant be approved by the participating response agency, the Dekalb County Police Department. Initial contact in attempting to select volunteers was made through the CB radio clubs in the area. Information was also released through Georgia Tech employee publications to solicit users from among the Georgia Tech professional staff. After an insufficient number of volunteers were located by these means, a general news release was produced and was distributed to local radio stations and newspapers in the area. Also, CB-user information forms were placed in CB radio sales and service stores throughout the pilot program area. An attempt was made to distribute Digital Adapters to professional drivers, such as drivers of delivery service vehicles, taxi cabs, and others of the like. This effort met with little success due to two basic reasons. First, a number of the companies used business radio and had no desire to have a CB radio placed in their delivery vehicles. The second reason was that vehicles owners which did have CB radios installed did not desire that their drivers be involved in a motorist-aid type system because of possible legal problems. Through all these devices a total of 75 Digital Adapters were placed on volunteers radios. One of the major surprises of the program was the small number of volunteers agreeing to use the Digital Adapters. It is felt that some of the reasons for the small number of volunteers were a desire to not be involved in a test program of this nature, a wish to not take the trouble to have a Digital Adapter installed on the vehicle, a reluctance to use Channel 9 for reporting emergencies, and general suspicion of government-sponsored programs in the area of CB radio. However, these reasons can only be conjectured in view of the lack of a survey of CB radio users.

During Task D some additional design modifications were made to the Digital Adapters as a result of experiences in installing the Digital Adapters in the users' CB radios. Microphone pin configurations varied considerably for the four pin microphone but were more standard for the five pin microphone although variations did occur there also. As a result, a custom installation was required for each user. Significant problems were encountered with the push-to-talk line levels and with RF interference in some radios. While most radios used a push-to-talk configuration which changed the level of the push-to-talk line from + 12 volts to ground when the microphone was keyed, other radios used electronic push-to-talk which produced a voltage change of some 9 to 6 volts. Since this voltage change was a signal used to trigger a one-shot multivibrator in the Digital Adapter (having a threshold of six volts), proper operation was not obtained. Correction of this problem necessitated in a change in the input circuit in order to produce a level change which would provide proper operation of the one-shot. RF interference varied considerably among the different radios. Usually the interference was eliminated by placing a 0.01 microfarad bypass capacitor across the audio input line. Another design change resulted from an experience in which a user disconnected his Digital Adapter, then reconnected it in a reverse polarity (causing several chips to be destroyed). The design change involved placing a power diode in series with the voltage lead coming into the digital adapter. The diode then protects the circuits from such reverse voltage connections. A final modification was the addition of an RF choke and filter capacitor to eliminate ignition noise interference which was noted on a number of the radios.

During the field tests, some problems were noted with the assistance mode of operation. Primarily, this was intermittent operation in that sometimes the called party would be able to key the remote station transmitters, and at other times this keying would not take place. As a result of these problems, a number of lab tests were performed. The objective of the lab tests was to determine the following:

(1) Passive (transformer), telephone hybrid isolation over the voice frequency band, 300-3000 Hz.

(2) Matching network impedances required for passive hybrid balance over the voice frequency band.

(3) Active hybrid isolation over the voice frequency band.

An active hybrid was built and tested based on a suggestion that this approach would result in greater input-to-output isolation. A full report on the test is included as Appendix B to this report. The main conclusions reached were that the passive hybrid actually showed greater isolation over the voice frequency band than the active hybrid and further that hybrid isolation is considerably reduced at frequencies other than specific frequencies used for setting the null. This reduction in isolation held true for both active and passive hybrids. These results impact the assistance mode of operation in the following manner. In the assistance mode, the CB transmitter is keyed on by use of a voice-operated-switch (VOX) which detects incoming signals from the telephone line. Since a two-wire telephone circuit is used and both incoming and outgoing signals are on the telephone line, the telephone hybrid circuit is used to isolate outgoing voice signals from incoming voice signals, thus converting a two-wire system to a four-wire system. In the Remote Station, the signal received from the CB radio is connected to the outgoing lines of the hybrid, and the incoming lines are connected to the microphone input of the CB radio and to the VOX which activates the push-to-talk switch. With perfect balance of the hybrid, total input-to-output isolation is achieved and the system works well. Without perfect balance, some of the received audio from the CB radio is coupled back to the incoming lines of the hybrid. If the VOX sensitivity is low enough, this coupled signal will key the transmitter, thus turning off the receiver which in turn releases the VOX. As this occurs, the receiver signal is again present, the VOX is once more activated and a condition of oscillation results. Decreasing VOX sensitivity eliminates this condition. However, if the sensitivity is reduced too much, then the desired incoming signal will not control the VOX and the transmitter will not turn on as required. In practice a very narrow VOX sensitivity range exists, resulting in a critical adjustment. With some circuits and speakers (i.e., people), the incoming signal is less than the cross-coupled signal and the VOX cannot be set for proper operation. Based on these conditions, the remote stations were set for optimum operation with the recognition that perfect operation would not be achievable under all conditions.

Another major area in this task was the production of appropriate forms for recording both the use of system equipment as well as other forms needed for data collection and record keeping. Two forms were developed for the Digital Adapters users. The first form was a Digital Adapter Users' Guide. This briefly explained the purpose of the program, instructed the user on proper operation of the Digital Adapter, illustrated premissable communications over Channel 9, and included a diagram of the pilot program test coverage area. The second form involved incident reporting. Digital Adapter users were requested to fill out this data in order to determine the usage of the CB-AIDS system. A CCU operator's form was also prepared to gather information on system usage. A malfunction report form was developed for documenting any hardware problems with the Digital Adapters, Remote Station, or Central Control Unit. Other forms developed were a Digital Adapter log to indicate location of each Digital Adapter and, a user agreement form which each participant was required to sign indicating that he or she would abide by FCC regulations on Channel 9 communications and would not hold Georgia Tech or the Federal Highway Administration responsible for any damage to his or her CB radio by the Digital Adapters.

SECTION 8
EVALUATION OF PILOT PROGRAM
(TASK E)

The purpose of this final task of the project was to (1) summarize and analyze quantitative data and qualitative information from the responders and users of the CB-AIDS system, (2) provide an analysis of the system implementation and operating costs compared with other motorist aid systems, and (3) include recommendations for system specifications and future implementation and direction of CB-AIDS type systems.

The technical feasibility per se of the CB-AIDS system was established by the fact that four Remote Stations were sucessfully placed in operation, and a variety of CB radio operators used the system under actual field conditions. However, in addition to this technical feasiblity, there are other topics of interest that were evaluated during the pilot program. The data that were collected during the program are included in figures and tables associated with this section along with appropriate descriptions. Basically the information gathered may be placed in either the quantitative or qualitative category. The quantitative data aspects of the program will be discussed first.

Table 7 indicates the categories of calls received over the CB-AIDS system as based on users incident reports. The highest number of calls were placed as a result of accidents without injuries with the callers reporting the accidents to the police. These calls represented more than 25 percent of all calls made. The next highest category was in the area of stalled vehicles (with occupants), accounting for 23 percent of calls reported. Next in percentage of calls completed, and the most urgent type calls placed on the system was that of accident with injuries which accounted for about eight percent of all calls made through the CB-AIDS system. The remainder of calls were spread among such potentially dangerous situations as traffic equipment

TABLE 7

CB-AIDS CALL CATEGORIES

Category	Percent
Accident with Injuries	6.9
Accident without Injuries	26.6
Stalled Vehicles-Occupied	22.8
Stalled Vehicles-Unoccupied	9.2
Road Obstruction	4.6
Traffic Equipment Malfunction	8.4
Reckless Driver	4.6
Information Request	2.4
Other	14.5

malfunctions, road obstructions, reckless drivers and unoccupied stalled vehicles. One minor category was that of information request which accounted for only 2.4 percent of all calls. It may be assumed that the number of information calls is lower than would expected from the typical population of CB users due to the fact that selection of Digital Adapter users was based on people who lived and traveled in the area frequently and would thus require little routing information.

Appropriate comments are provided below for each major category of calls over the CB AIDS system.

(1) Accident with injuries, 6.9 percent of all calls. This is the most urgent type call that was made through the CB-AIDS system and the most urgent type call made for any Channel 9 use. This call requires police and ambulance response and time saved here may be essential in life or death situations.

(2) Accident without injuries, 26.6 percent of all calls. The occurence of an accident on a major street or interstate highway represents an urgent situation both for those involved in the accident and for other motorists. This is generally a situation that requires police response; the use of a CB-AIDS type system will help speed that response and possibly prevent further damage or injury to individuals.

(3) Stalled vehicle occupied, 22.8 percent. This category is more difficult to analyze as it could range from a broken down vehicle with a bona fide malfunction to merely a motorist pulling over to the shoulder of the road to consult road maps or to attend to other personal business. However, it should be noted that an occupied stalled vehicle is typically the type incident that a police vehicle will investigate when encountered in normal patrol activities. Therefore, the CB-AIDS system would speed the response to this type of incident and possibly resolve the problem earlier than would normally be the case.

(4) Unoccupied stalled vehicle, 9.2 percent. This category could present a problem of varying impact depending on location of the stalled vehicle. For example, a stalled vehicle blocking the only travel lane, forcing cars into an opposing lane of traffic, could be extremely hazardous whereas a stalled vehicle on the shoulder of the road, not blocking traffic, would present a lesser hazard to motorists. However, these type incidents should be reported to the police and would require police response in order to reduce the hazard potential to other motorists.

(5) Road Obstruction, 4.6 percent. The category of road obstruction

covers the existence of objects in the roadway creating a hazard to motorists. This type incident requires a police response and/or a transportation agency response in order to clear the obstruction. In this category, a more rapid response may prevent an accident which could result in property damage and injury.

(6) Traffic Equipment Malfunction, 8.4 percent. Generally, the problem reported in this category was a traffic signal either being without power or malfunctioning in its cycling. Depending upon the location, this could potentially be an extremely dangerous situation and a rapid police and transportation agency response would be useful.

(7) Reckless Driver Report, 4.6 percent. This also is a widely variable category and the utility of a police response is not always known. If it is merely a case of a driver who ran over into the shoulder area but corrected the manuever and was not actually driving in a reckless manner, then a police response would be of no value. However, if the situation was one in which a driver has entered the incorrect ramp on an expressway and is driving in the wrong direction, for example, a very serious problem potentially exists and police response could be extremely important.

(8) Information request, 2.4 percent. This is a function that is not normally handled by the police department and may even not be best handled by police dispatch personnel. This type call is probably best answered by local channel 9 monitors who know the area well in which the information is requested. However, a centralized operation with a dispatcher having an updated map indicating any possible detours or traffic problems could possibly be of value for this information request category.

In all these categories an issue that should be considered is that of multiple calls for a single incident. Obviously, the first call on an incident is extremely important in order to notify the police or other proper authorities of the incident in order to clear the problem. However, all calls after the first are redundant and could interfere with response action by tying up the incoming line to the police or the response dispatching operation. It has been noted that in general, mobile CB-users do not keep their radios on Channel 9 but maintain them on another listening channel, only going to Channel 9 in case of incidents which require a response. Therefore, they miss the fact that a caller previously reported the same incident on Channel 9 or, in the case of the traveling public, a number of motorists moving through the area could report the incident based on the fact that they were not within range of a previous transmission. However, multiple calls may have one positive effect in that they indicate to the response agency the urgency of the situation and may help the agency in placing its priorities.

The next area considered is that of the geographical distribution of calls. A scatter diagram of the calls placed on the CB-AIDS system is included as Figure 16. This figure shows both the distance of a Digital Adapter user from the Remote Station accepting the call and the time-of-day that the call was placed. It may be seen that the majority of calls were placed within an approximate 5 km (3 mi) range of each remote station. This range is consistent with the reported range for CB radios during high in-band noise conditions. Calls from more distant ranges were placed on the system during the course of the pilot program; however, the increased ranges could not be consistently supported. Even within the 5 km (3 mi) range there were certain times of the day and certain atmospheric conditions in which skip interference became extremely high, substantially limiting the range, sometimes down to approximately 2 km (1 mi). Figures 17 through 21 illustrate the time versus distance distribution of calls as reported by users with noise qualities of excellent, good, fair, poor, and unsatisfactory. The indicated decrease in noise quality with increased range was as expected. Additionally, a decrease in quality for the late afternoon was observed. The communicating range of a given Remote Station was heavily dependent upon both the noise background and the geographical area in which the Remote Station was located. It has been shown that in urban areas this range will be severely limited due to a large number of both co-channel and adjacent channel users of CB radio transmitters. It has also been shown that during solar cycle peaks, the effects of heavy usage may extend from urban locations even into rural locations (and vice versa) based on the skip phenomena. The impact of noise on radio system performance operation is a result of the fact that signal reception quality is a direct function of the signal-to-noise ratio, i.e., a high signal-to-noise ratio is necessary

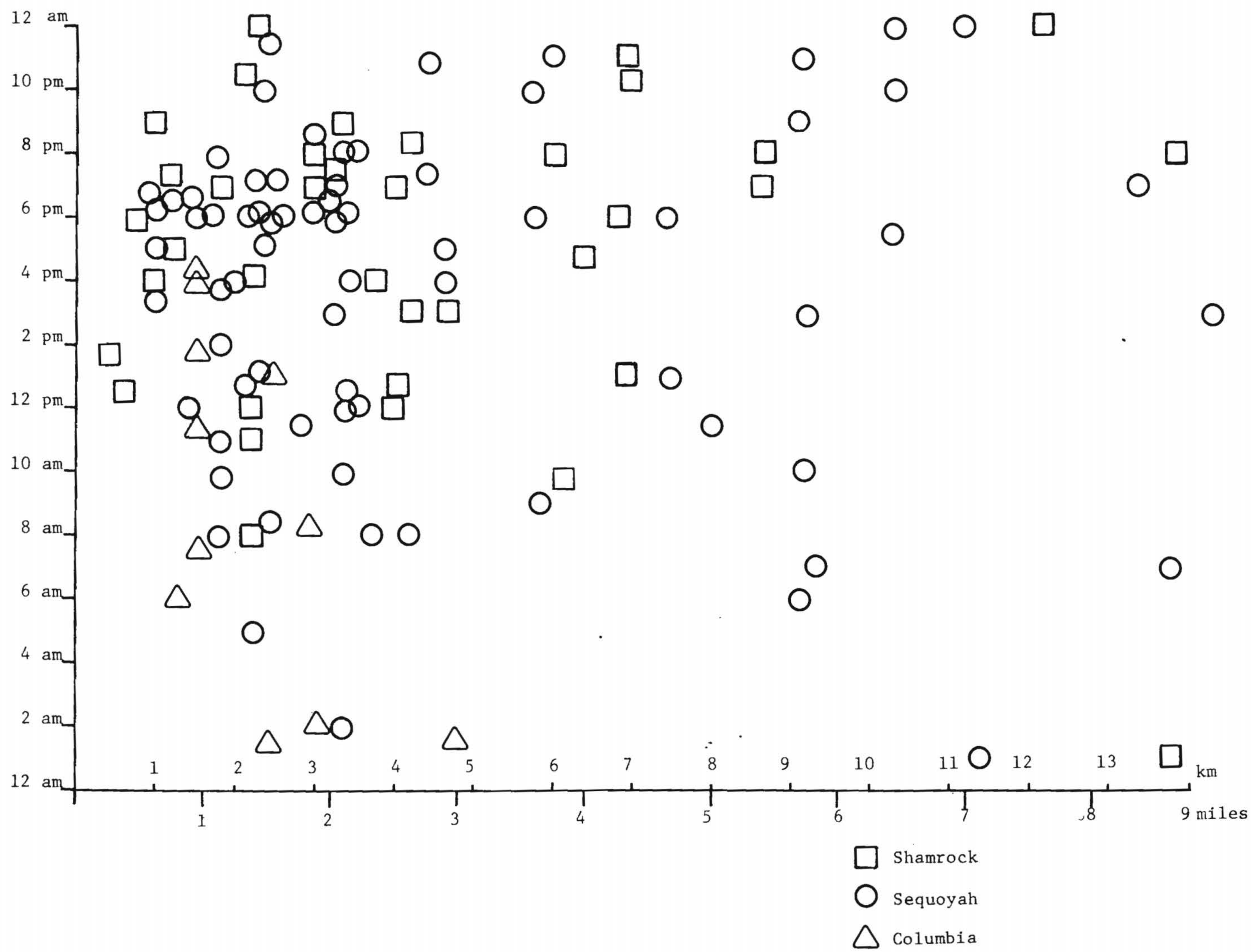

Figure 16. Scatter Diagram of CB-AIDS Calls.

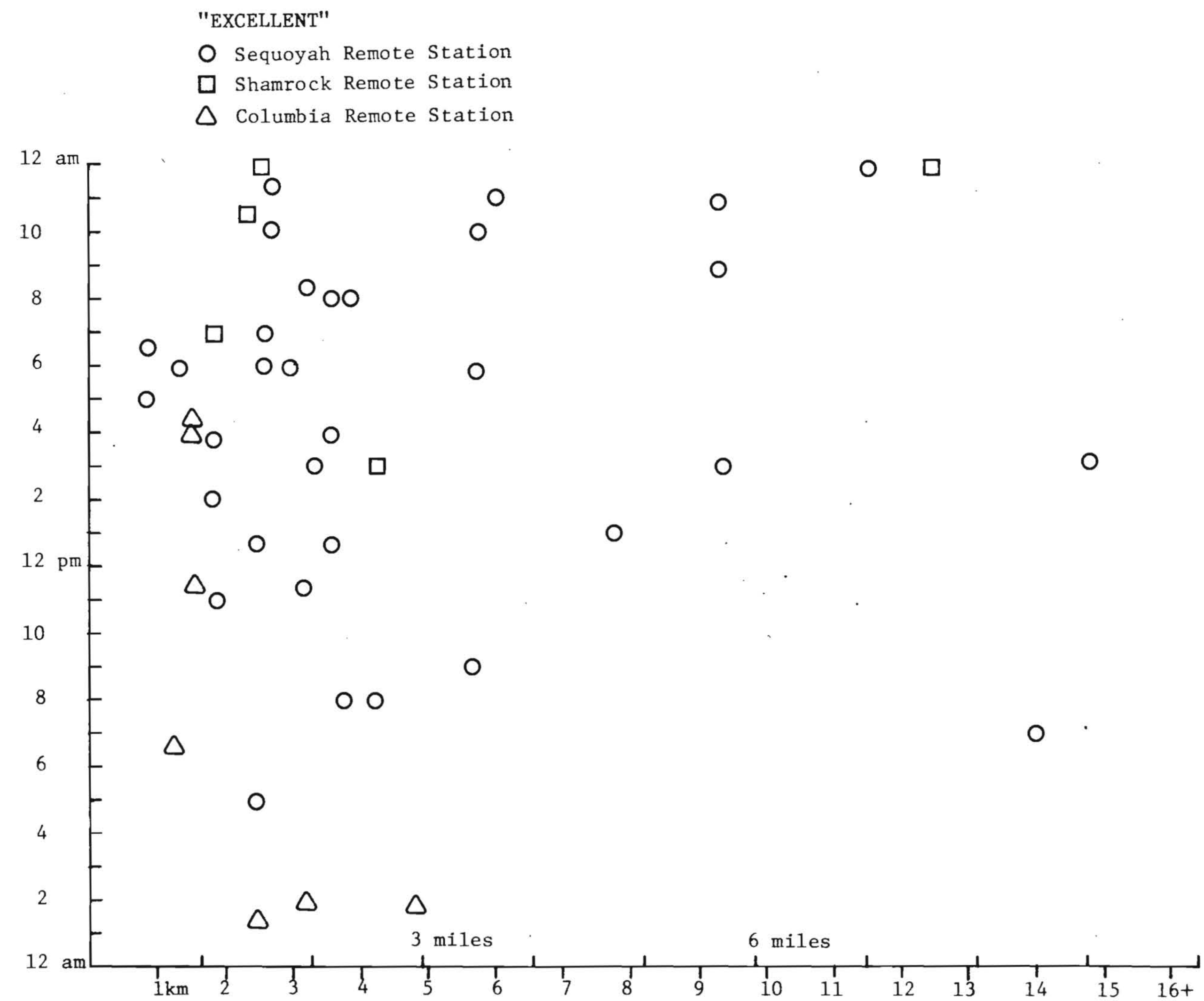

Figure 17. Users Reporting Excellent CB-AIDS Voice Quality.

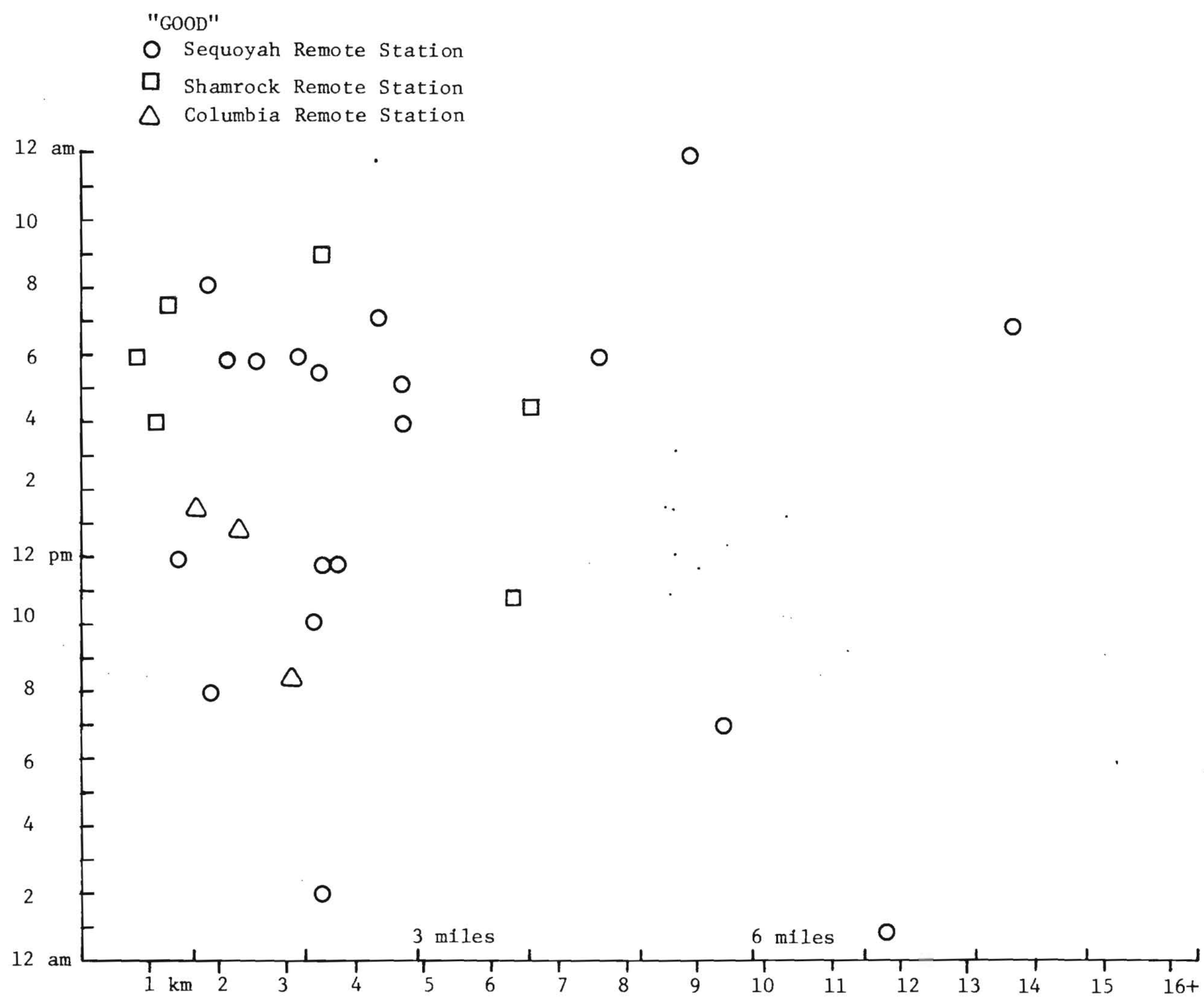

Figure 18. Users Reporting Good CB-AIDS Voice Quality.

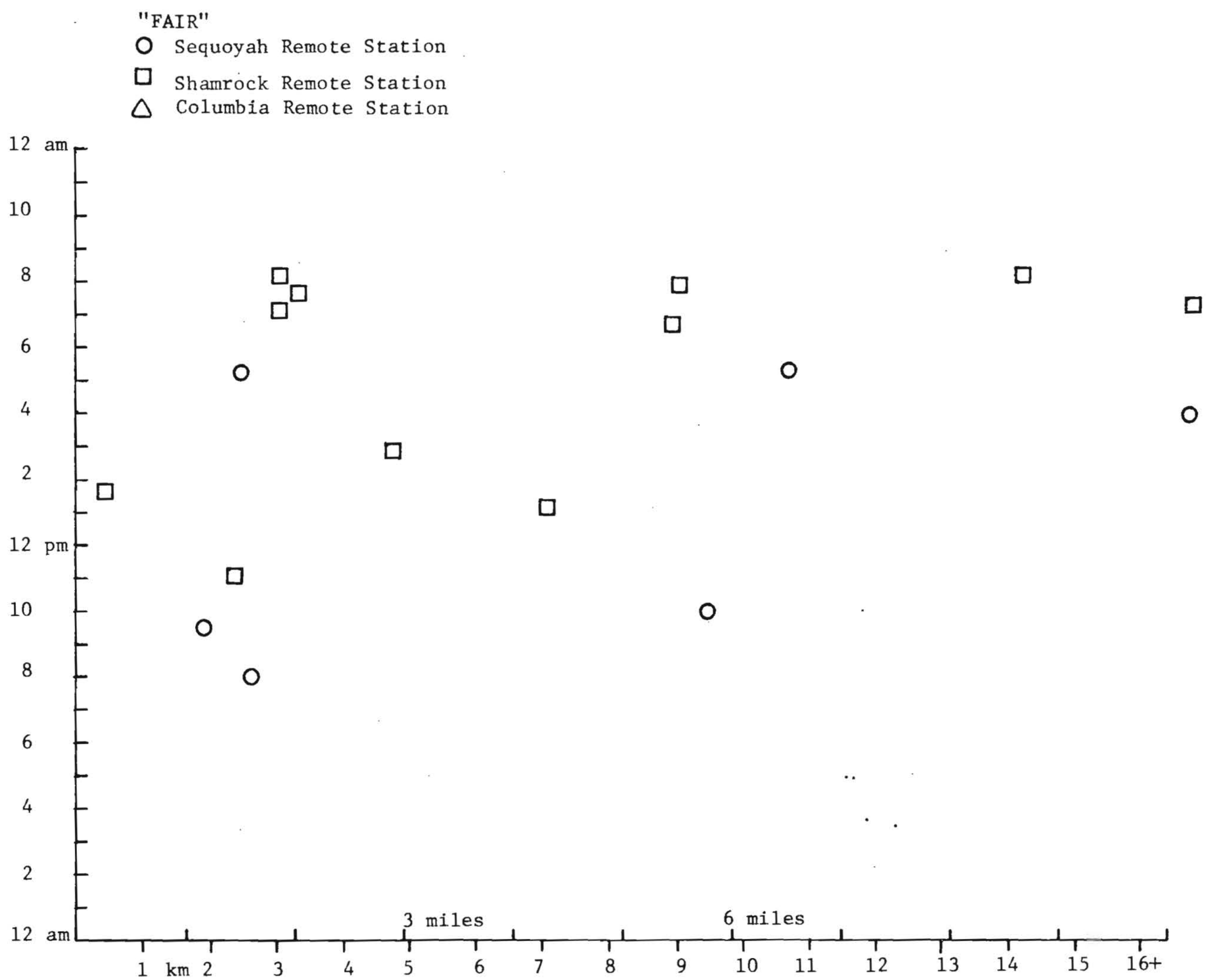

Figure 19. Users Reporting Fair CB-AIDS Voice Quality.

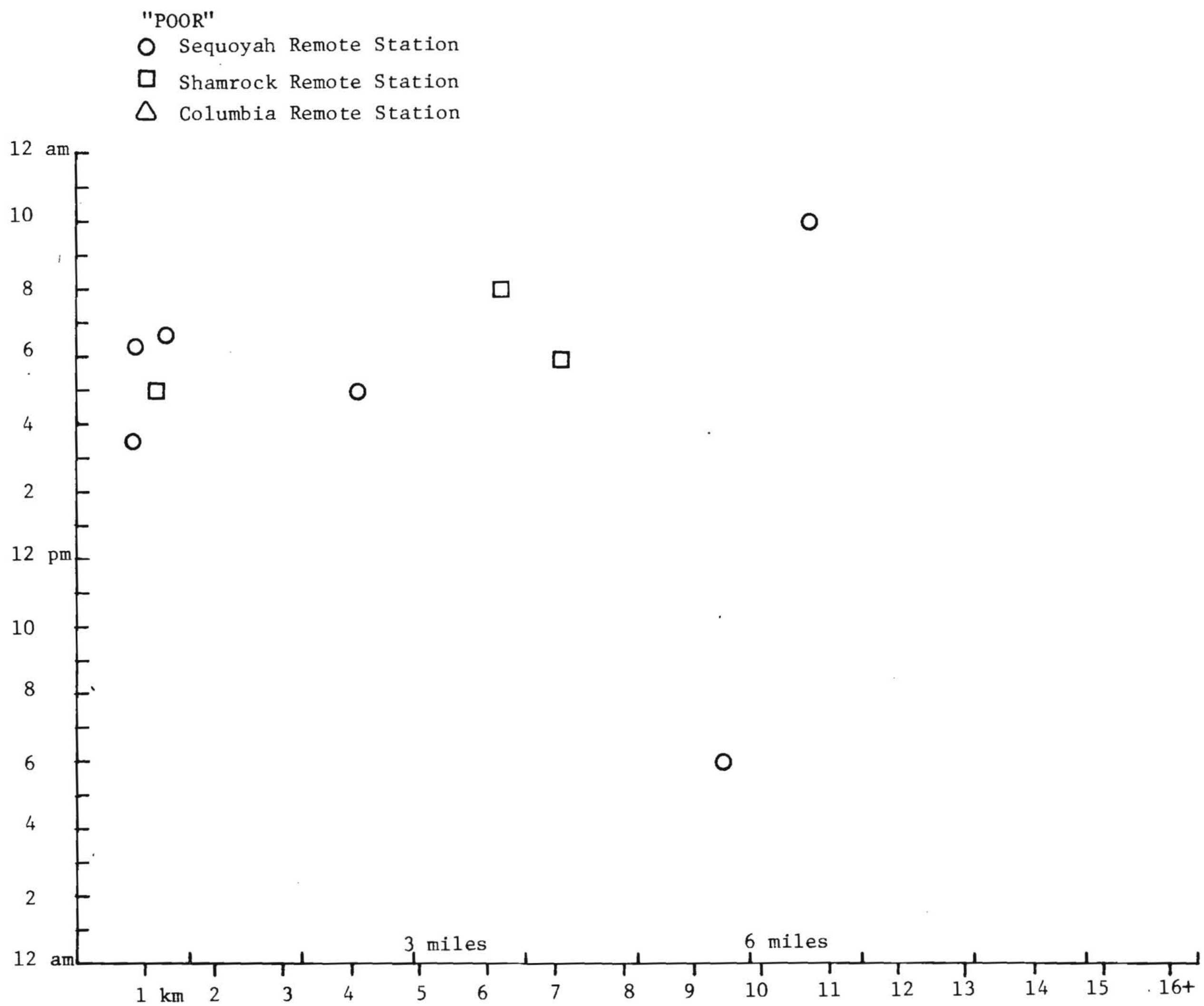

Figure 20. Users Reporting Poor CB-AIDS Voice Quality.

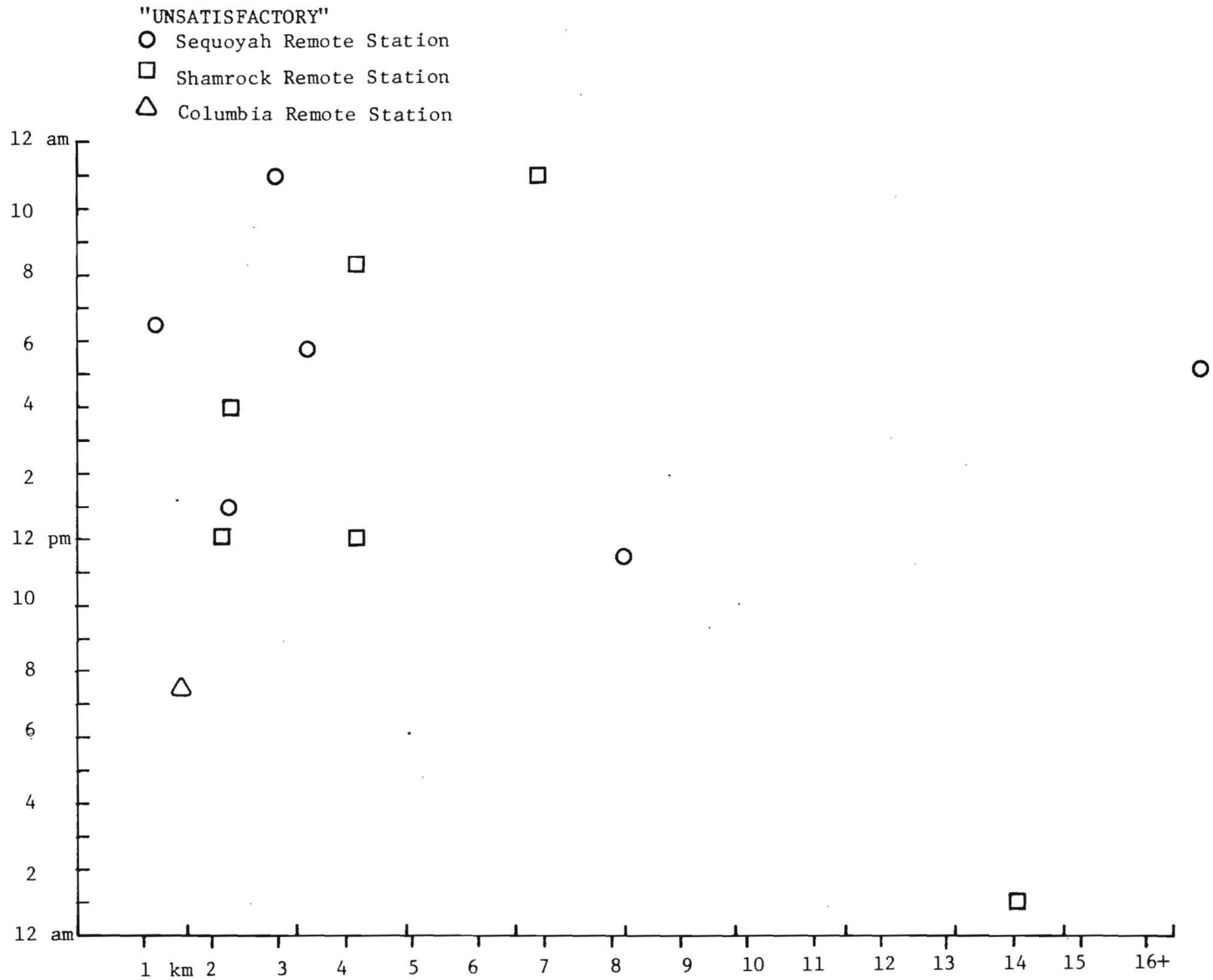

Figure 21. Users Reporting Unsatisfactory CB-AIDS Voice Quality.

for good communications. As the signal-to-noise ratio decreases, the point is eventually reached where the noise overpowers the signal and communication becomes difficult-to-impossible. Therefore, with high in-band noise there is a limited range due largely to the limit of approximately four watts of output power allowed for CB transmissions. It is well known, however, that some CB users improve their talk-out capability by increasing transmitted power beyond this legal limit.

Data were also collected to determine typical response time. Numbers represented here are based on the CCU paper tape which indicates the time the call was received at the agency and the time the call was completed. This time includes the time required for the user to report the incident, then for the response agency to define the incident and to verify user-supplied information. It is shown from Figure 22 that the distribution of response times centers about a median value of 55 seconds duration with an average value of 67 seconds per call. This represents a significant reduction in the amount of time required to define an incident when compared with a multiple relay-type transmission which may require several mobile relays to finally reach a base station having land-line capability. Although no data were gathered for this latter situation, it can readily be seen that with a call going from a single mobile unit to a single base station operator (who would then use a telephone to access the local response agency) would require at least a doubling of the time here indicated. Since the message would have to repeated, this doubling would certainly be a minimum increase with more time required for the case where additional information was needed and additional verification must be relayed by a base station monitor.

A further consideration is that of equipment reliability. First, the mean-time-between-failure is calculated for the Digital Adapter, Remote Station and Central Control Unit equipment. Then the actual experience with failures in these three items of equipment over the pilot program period is given. The reliability calculations are based on methods as presented in Mil Handbook 217A with failure rates as shown in Table 8.

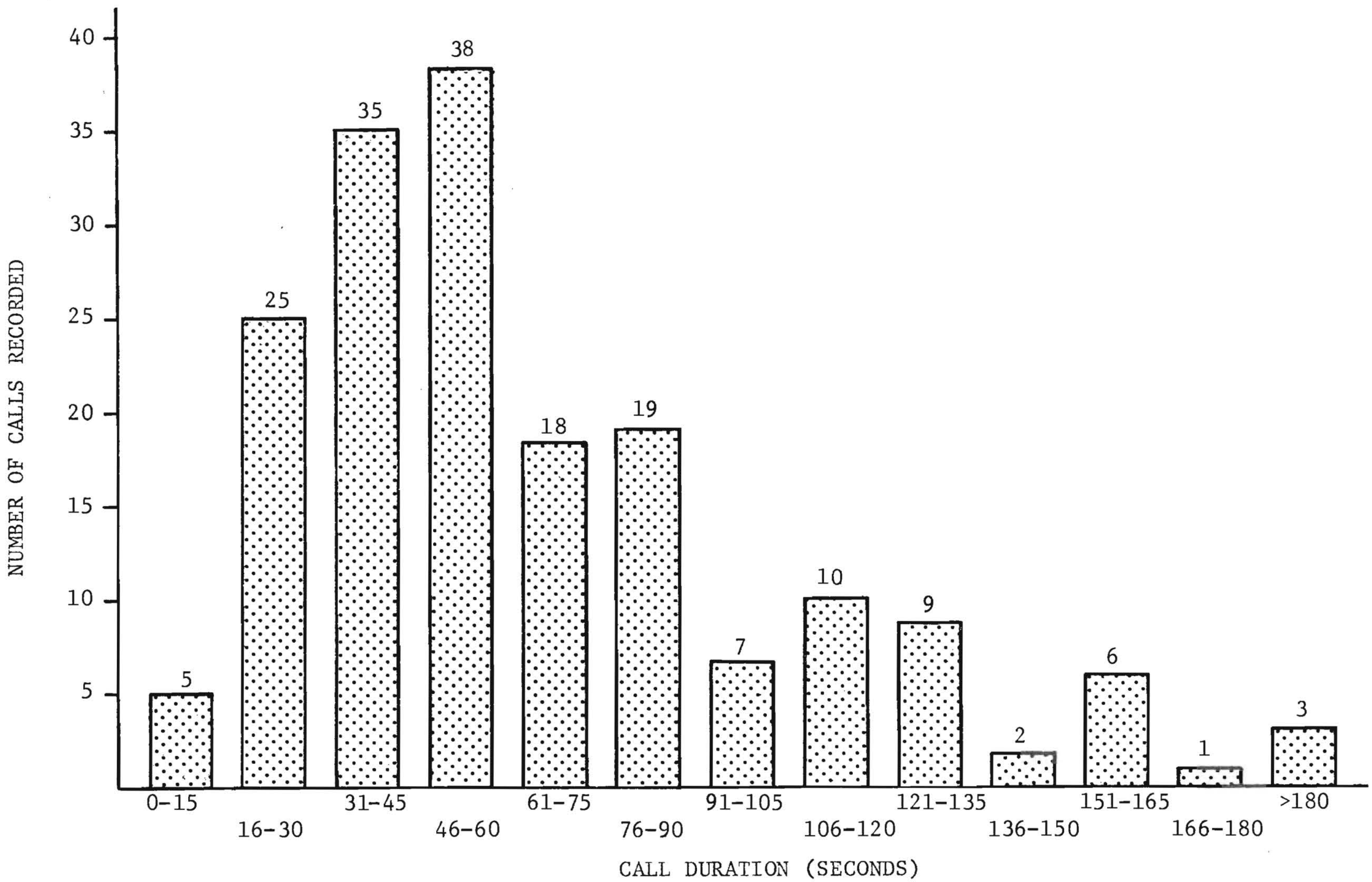

Figure 22. Call Duration Distribution

TABLE 8

FAILURE RATES OF ELECTRONICS COMPONENTS

Device	In 10^6 Hours
Diode	1
Transistor	3
Microwave Diode	10
Resistor	
Composition	0.005
Film	1.5
Capacitor	
Paper	0.11
Mica	0.05
Ceramic	0.03
Mylar	0.0035
Connector	0.1
Relay	0.01
Switch	0.2
IC	0.4

From these basic figures, the MTBF of the Digital Adapter, Remote Station, and the Central Control Unit were calculated to be the following:

Digital Adapater - 26,270 hours
Remote Station - 7,920 hours
CCU - 4,110 hours

The actual failure rates were calculated based on the experience with malfunctions during the pilot program period. First, for the Digital Adapter, the MTBF can only be estimated, because of a lack of knowledge of the total amount of time all digital adapters were on. However, this may be estimated in the following manner. It is assumed that the average user is in his car with his CB radio on for two hours per day. With an average of 70 users for a period of 12 months a total on-time of 51,100 hours is calculated for the Digital Adapters. During this period, eight failures were experienced resulting in an MTBF of 6,388 hours. The Remote Stations and the Central Control Unit were on 24 hours a day for 15 months, resulting in an on-time of 10,800 hours for each of these items. Based on four failures for the CCU, four failures for the Shamrock Remote Station, and three failures for the Sequoyah Remote Station, the MTBFs for these items are 2,700 hours, 2,700 hours, and 3,600 hours, respectively.

The next area covered is that of qualitative information based on user and response agency experiences with the CB-AIDS system. First, based on reports from Digital Adapter users, a category that was reported through the CB-AIDS Incident Form was that of voice quality. Several graphs presenting this information are included in this section and indicate voice quality versus time-of-day and versus range. As would be expected, the figures show that voice quality generally decreases as the range increases. Also shown is the fact that the voice quality is dependent upon the time-of-day. These time-of-day effects can be correlated with decreased voice quality in the afternoon period when there are both increased vehicular traffic and associated radio traffic and also when the skip phenomenon appeared to be more severe.

The next major area in evaluation of the pilot program was to analyze the system implementation and operating costs and compare these with other motorist aid systems. Costs are developed in two basic areas - agency costs and motorist costs. The agency costs include elements required for implementing the Remote Station and Central Control Unit equipment as well as telephone costs. Motorist costs are those required for the in-vehicle Digital Adapter.

In developing the agency costs, a hypothetical system is postulated which covers 100 km (62 mi) of interstate highway in a suburban/rural environment with gentle rolling hills. Due to the nature of radio systems, costs will vary with differing demographic and terrain features. Hilly areas and large urban populations will require more closely spaced remote stations with a consequent increase in system cost; whereas flat, rural areas will allow more distant Remote Station locations at a corresponding decreased system cost. The system here postulated results in an average Remote Station spacing of 10 km (6.2 mi).

A Remote Station consists of a Citizens Band transceiver with antenna, a digital decoder, a code processor, a telephone dialer, telephone interface and controller, audio processing circuits, and power supplies all housed in a weather tight enclosure. Estimated cost of the Remote Station is developed to include all parts and labor as detailed in Table 9. As shown in the table, a Remote Station may be completely fabricated for $6400, including provision for a profit of approximately 20 percent. This is the total assembled cost requiring only the connection to a power source and telephone line for operation.

The installation cost for a remote station is calculated as shown in Table 10, along with the total monthly cost which includes lease charges, maintenance costs, and capital cost amortization over 10 years at an 8 percent interest rate. From this the total annual cost for a remote station is estimated to be $2250.

In a similar manner, Central Control Unit equipment and system

TABLE 9

REMOTE STATION FABRICATION COST ESTIMATE

Item	Parts	Labor	Profit	Total Cost
CB Radio and Antenna	$ 200	$ 0	$	$
Control Circuits	600	3000		
Telephone Interconnection	200	0		
Enclosure	200	0		
Fabrication	100	1000		
Complete RS	$1300	$4000	$1900	$6400

TABLE 10

OPERATIONAL RS COST CALCULATION

Item	Capital Cost	Annual Lease	Total Annual Cost *
Remote Station	$6400	$ 0	$ 932
Power	500	180	253
Telephone	300	420	464
Maintenance		600	600
Total	$7200	$1200	$2250

* Capital costs amortized over 10 years at 8%.

costs are calculated as shown by Tables 11 and 12. The CCU equipment is less complex than RS equipment and is installed in the responding agency's communications room, resulting in a lower cost than the RS. The resulting CCU cost per year is $1200. This cost does not include any labor charges for operating personnel; cost of maintenance personnel is included.

For the postulated 100 km (62 mi) system, a total of 10 Remote Stations and one Central Control Unit are required. Table 13 indicates total system cost calculations. Based on a 10 year lifetime with an eight-percent cost of money, the total annual cost is projected to be $23,700 or $395 per mile.

This cost is compared to published costs of various installed and projected systems as shown in Table 14. Costs of call-box systems have been taken from a 1976 study by Fullerton et al. [1], and patrol costs have been taken from Molnar et al. [2]. For consistent comparisons, the call-box cost data were revised to 1978 dollars based on an eight-percent per year inflation rate. The annual costs were also revised to indicate a 10 year capital cost amortization with an eight percent per year cost of money. The patrol costs were revised from the given 1968 figures to 1978 dollars based on an inflation rate of five-percent per year from 1968 to 1973 and eight-percent per year from 1973 to 1978.

These results show that, based strictly on agency cost, the CB-AIDS system compares favorably with both call-box and patrol motorist-aid systems, with only the Oklahoma Turner Turnpike call-box system costing less. However, it should be noted that this system's low cost resulted from a five-to-10 mile terminal spacing, meaning a disabled motorist would have to walk an average of about two miles to the nearest call-box provided that he knew in which direction he would find the closer call-box.

The other part of the CB-AIDS system cost is for the in-vehicle equipment, i.e., the Digital Adapter. Projected Digital Adapter costs have been developed for two configurations - an add-on Digital Adapter and an in-radio Digital Adapter. The add-on DA would be attached to

TABLE 11

CENTRAL CONTROL UNIT FABRICATION COST ESTIMATE

Item	Parts	Labor	Profit	Total Cost
Processor and Display	$ 600	$2000		
Telephone Interconnection	200	0		
Enclosure	150	0		
Fabrication	50	200		
Complete CCU	$1000	$2200	$650	$3850

TABLE 12

OPERATIONAL CCU COST ESTIMATE

Item	Capital Cost	Annual Lease	Total Annual Cost
Central Control Unit	$3850	$ 0	$ 561
Telephone	50	420	427
Maintenance		212	212
Total	$3900	$632	$1200

TABLE 13

SYSTEM COST FOR ONE CCU AND TEN REMOTE STATIONS

Item	Per RS	Total RS	CCU	Total Cost	Cost per Kilometer
Capital Cost	$7200	$72,000	$3900	$75,900	$759
Annual Lease	1200	12,000	632	12,632	126
Total Annual Cost	2250	22,500	1200	23,700	237

TABLE 14

MOTORIST AID SYSTEMS COST COMPARISON

Type System	Location	Annual Cost/Kilometer
CB-AIDS Radio/ Telephone	Proposed System	$ 237
Call Box - Coded		
	Maryland, I-495	$1,569
	Texas, I-45	2,864
	Florida, I-75	826
	Massachusetts, I-495	1,640
	Massachusetts, I-195	1,384
	Illinois I-55/I-70/I-270	1,714
	New Jersey Atlantic City Expressway	498
Call Box - Voice, Wire		
	Michigan, I-94	$1,608
	New York, I-87	975
	Illinois, I-80	1,260
	California, LA Freeways	1,009
	Delaware, I-95	4,892
	Oklahoma, Turner Turnpike	61
	Pennsylvania, I-80	989
Call Box - Voice, Radio		
	Florida, I-95/I-195	$1,118
	Connecticut, I-84/I-91	1,938
Patrol		
	Illinois (urban)	$9,738
	Ohio	2,144
	Nebraska	408
	Tennessee	543

existing CB radios in a manner similar to that used with the current prototype DA's, i.e., electrically through the microphone connector and mechanically through a simple adhesive or mechanical attachment. The in-radio DA would be included with the transceiver circuitry at the time of manufacture. Both approaches are based on the use of a custom LSI circuit to provide the signaling function. Both would also use panel-mounted push-button switches for calling. The add-on DA would also include a separate printed circuit board, case, and microphone connector hardware. Estimated costs of the add-on and in-radio DA's are $43 and $20, respectively, including provision for a profit of about 40 percent each. The cost details are shown in Table 15.

It is estimated that the development cost for an LSI circuit to provide the complete Digital Adapter function would be on the order of $50,000 to $80,000. This estimate is based on conversations with an LSI manufacturer.

The final item of the pilot program evaluation was to provide recommendations for future development of the concept. These recommendations are included in Section 10 of this report.

TABLE 15

DIGITAL ADAPTER COST ESTIMATE

Item	Add-On DA	In-Radio DA
Case	$ 3	$ 0
Hardware	8	4
Circuits	8	8
P. C. Board	2	0
Fabrication	10	2
Profit	12	6
Total	$43	$20

SECTION 9

RECOMMENDATIONS

A major area in evaluation of the pilot program was to include recommendations for system specifications, future implementation, and direction of a CB-AIDS type system. System specifications will be discussed first and will cover hardware elements of the Digital Adapter, Remote Station, and Central Control Unit Unit.

First, with the Digital Adapter, a primary requirement is that it be relatively inexpensive since this is a cost that must be borne by motorists who have indicated they will not pay large prices for items which have been perceived as being primarily for safety purposes. There are two major approaches to be considered in the area of the Digital Adapter. The first approach is to consider it as an add-on unit to an existing CB radio and the second, as an item to be included in a CB radio during manufacturing. The addition of a Digital Adapter to an existing CB radio is naturally the more expensive approach since it will require a separate housing, an attachment mechanism, a mechanism for coupling into the CB radio electrically, a method for providing power to the Digital Adapter, and protective circuits to guard against ignition noise and electromagnetic interference from radio transmissions. An estimated cost of the Digital Adapter components and of a complete Digital Adapter was shown in Table 15. The cost of an in-radio Digital Adapter was developed by postulating a large scale integrated circuit (LSI) chip. It is felt that a single such chip would be capable of providing all functions of the digital adapter quite readily.

The cost of this chip after initial design and prototyping is estimated to be \$4.50 in quantities of 100,000. Manufacturing cost to include this chip within CB radio circuitry and to include the manufacturer's profit will add an estimated \$20.00 to the price of a CB radio at the point of sale. Based on user feedback, this price is well within the amount most users would be willing to pay for a Digital Adapter.

Next, it is felt that although the digital signaling feature is a good feature and should be retained, the modulation format is not the most efficient available. However, the self clocking feature is important and should be included in the future modulation format. The selective calling capability is a feature that should be retained in an operational CB-AIDS type system with certain modifications, as indicated later, for the Remote Station and Central Control Unit.

Specifications for the Remote Station are considered next. The CB-AIDS pilot program used commercially available CB radios and antennas which were acceptable during this period. However, it is felt that for a full operational system it would be well to use higher quality CB radios having very low drift in level and squelch settings, thus reducing maintenance costs. Also the Remote Station CB radios should utilize an improved RF filter, located directly in the receiver front-end, for decreasing interference from adjacent channel users. The Remote Station should be designed to include all telephone interface circuitry within the processing chassis so that only a single package is placed between the CB radio and the telephone lines. This feature would make installation simple for unskilled personnel. The Remote Station itself should have more stable components and automatic adjustment capability in order to reduce maintenance costs. The design and use of a custom, channel-9-only transceiver with improved signal processing characteristics should be considered for Remote Station applications. This approach would require special FCC authorization since only 40 channel units are now allowed. And finally, the entire Remote Station configuration should be enclosed in a single environmental package which could then be placed within a pole-mountable unit having an integral antenna and requiring only the connection of telephone lines and power lines for a complete installation. A minimum of adjustments should be required for achieving a low cost of maintenance. Keying of the Remote Station transmitter should be provided via single-tone actuation rather than on-off keying as used in the pilot program. This feature would provide more positive keying capability for the system. The dial time on the Remote Station

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requirement of professional and volunteer monitors.

With ATIS there is some question of what format the identification code should take. The most efficient code would be one based on a binary type format (binary, octal, or hexadecimal). Although the greatest number of unique identifiers ($=2^n$ where n = number of bits) could be produced with the binary format, the utility of this code would be limited by the lack of alphabetic and special character capability. Digital Adapter identification numbers could be readily assigned with binary numbers; however, user call sign or radio manufacturers serial numbers could not be readily implemented with such a format. Also, assignment of numbers to Digital Adapters independent of user call sign or radio serial number could lead to an immense administrative task of maintaining a current list of Digital Adapter users.

The preferred approach would be to assign the ATIS number based on user FCC call sign or radio serial number; pros and cons certainly exist for each approach. Assigning the numbers in accordance with FCC call signs would result in simple coding since it is known that all CB call signs consist of three or four alphabetical symbols followed by four digits. Furthermore, since the first alphabetical symbol is always the letter K it could be omitted from the identification number.

Since five bits (32 symbols) are required for each alphabetical character and four bits (16 symbols) are required for each digit, the entire FCC call sign could be transmitted in 31 bits with an implicit K at the beginning of each ID word. Both the newer eight-symbol and older seven-symbol call signs would be transmitted in seven-symbols with extra symbol in the older call signs being transmitted as a null character. This coding scheme would have a capacity of over one-billion different codes which would be sufficient even for CB radio of the immediate future. The coding required to transmit the radio serial number would be the most complicated to implement since the various manufacturers do not follow a standard numbering practice. Thus for unique coding, several digits would be required to indicate a brand identification followed by eight to 20 digits typically for the unit serial number. This could easily result in a requirement to transmit from 100 to 110 bits of information for the ID code.

Another factor to consider is the permanency of the ID code. With the code number set to correspond to the Digital Adapter serial number or the radio serial number, it could be permanently wired into the adapter with no future changes required. However, if the number was set to indicate the user's FCC call sign, a capability to change this number would be necessary in order to allow a change in radio ownership. One potential method for accomplishing this code change would be by use of a magnetically encoded strip similar to the program strips used with popular programmable hand calculators. A method for distribution of the strips could be established to avoid their proliferation which would diminish their value as identifiers. One such method of distribution and control could be through the FCC. At the time of licensing, an applicant would receive one strip for each transmitter licensed. This strip could then be transferred to new radios as the owner changed equipment. For this method to be effective, the radios would have to be designed so they would operate properly with the strip installed; failure to comply would deny access to the CB-AIDS system.

Together with the curtailment of unauthorized system access, some perceived ATIS benefit should accrue to the users. One potential benefit could be that of theft reduction. By maintaining strict control on the distribution of ID chips, the substitution of chips in a stolen radio could be made difficult. When an ATIS equipped radio was reported stolen, the call sign could be entered into a stolen radio file. Operation of the radio could possibly result in apprehension of the thief. What if the thief applied for a license and merely substituted his ID strip? This certainly may be possible unless a more elaborate system of tying the call sign number to the radio serial number were established but this would likely not be necessary. The simple system described would probably tend to discourage most thefts of CB-AIDS identified radios.

A final recommendation concerns what should be the future direction of using the Citizens Radio Service for motorists aid. Despite the technical limitations of Class D citizens radio (high noise, skip signals, and limited range), use of this service for motorists aid has proven beneficial. The use of an automatic telephone connection with a response organization will significantly expand the benefits of CB radio use. The major problem is one of implementation. Obviously motorists will not purchase Digital Adapters if few Remote Stations are accessable. Likewise, response agencies are reluctant to install monitoring equipment if only a few motorists are served. Also response agencies must be willing to accept the additional responsibility of operating a system of this type since it will increase calls into their communications centers. For future development, the following steps are recommended.

- Establish a CB-AIDS task force including all interested parties involved in implementation of the system.
- Expand the pilot program to include the entire metropolitan Atlanta area.
- Survey response agencies to determine the support existing for a nation-wide CB-AIDS type system.
- Survey the public to determine the market feasibility of a CB-AIDS system.
- Produce a custom Digital Adapter integrated circuit chip to decrease unit cost.
- Produce a commercial Remote Station design for ease of production.
- Begin system implementation along vital interstate highways.

REFERENCES

[1] Fullerton, I. J., J. H. Kell, and E. A. Aiona, Jr., "Motorist Aid System Study" DOT-FH-11-8745, and JHK and Associates, August 1976.

[2] Molnar, D. E., C. B. Shields, and D. D. Robinson, Driver-Aid System for Controlled-Access Rural Highway, Final Report Phase I, Battle Memorial Institute, February 29, 1968.

APPENDIX A

CB-AIDS PRESENTATION SCRIPT

Slide 1 (Title Slide) - The following presentation will introduce a new concept in motorist aid systems in which a disabled motorist is able to communicate directly from his vehicle to a centralized response dispatcher. This system which is called the Citizens Band Automatic Interconnect Digital System, or CB-AIDS for short, is presently being developed by Georgia Tech under the direction of the Federal Highway Administration. But before describing the CB-AIDS system I would like to first discuss the need for Motorist Aid Systems, the elements of a MAS now being used in the U.S.

Slide 2 (Picture of Multilane Urban Expressway) - As one of the major advances in transporatation, the multi-lane, high-speed, limited access highway has become a familiar sight throughout the country providing efficient, trouble-free traveling most of the time. However, even on these highways motorists will occasionally encounter difficulties such as...

Slide 3 (Motorist with Flat Tire on Vehicle) - Tire problems...

Slide 4 (Hood Up with Car Radiator Boiling Over) - engine problems...

Slide 5 (Car Stuck in Snow Drift) - or weather problems...

Slide 6 (Disablement Data Shown) - Based on recent studies, 70 million disablement stops were experienced by motorists in 1976 out of 1.4 trillion miles traveled.

Slide 7 (Slide Shows Percentage of Federal Aid Primary Highway System Travel) - Since the Federal Aid Primary Highway System accommodates 50 percent of national highway travel it is estimated that 35 million disablement stops occurred on the Federal Aid System.

Slide 8 (Survey Results of Reasons for Disablement Stops) - Stopped vehicle studies and call box service requests indicate that the majority of stops are due to mechanical, tire, and gas, oil, and water problems. When a disablement stop does occur...

Slide 9 - (List of Problems Faced by a Disabled Motorist) - the motorist is confronted with

- o inconvenience and delay
- o fears and anxieties
- o inaccessibility of services
- o few good samaritans to assist, and
- o roadway hazards

Slide 10 (Disabled Motorist Shown in Despair) - All of which can sometimes be very frustrating to the affected motorist. In the attempt to help such motorists - Motorist Aid Systems have been developed to provide the following functions.

Slide 11 (Cartoon of spyglass on a Disabled Vehicle) - Detection - the awareness that a motorist at a certain location needs help.

Slide 12 (Cartoon of Disabled Motorist) - Definition - identification of the type of assistance needed.

Slide 13 (Cartoon of Police Car in Dispatch) - Dispatch - sending the appropriate vehicle.

Slide 14 (Cartoon of Tow Truck with Car in Tow) - Service - providing the assistance needed.

Slide 15 (Cartoon of Service Log) - and Recording - to provide the necessary documentation of assistance required and provided.

Slide 16 (Chain Shown Linking the Five Motorist Aid Functions) - These five functions must be linked by a communications network into an integrated system.

Slide 17 (List of Motorist Aid System Types) - There are bascially three types of motorist aid systems which have been developed. Roadside terminals and highway patrols have operated for several years in a number of states. In-vehicle communications is in its infancy and may be provided by volunteer organizations or government agencies.

Slide 18 (Signaling Bilingal Call-box Shown) - A wide variety of roadside terminal designs has been demonstrated. Shown here is a pushbutton terminal with which a stranded motorist may request one of four types of assistance. The types of assistance are identified by the pcitures at the four pushbuttons. The yellow button will call a tow truck, the black button an ambulance, the blue button will call the police, and the red button will call the fire department. With this particular roadside terminal there is no voice contact. When a button is pushed the speaker at the upper right corner of the box emits a tone to indicate that the message has been sent.

Slide 19 (Call-box with Telephone) - One variation of the roadside terminal includes a standard telephone with which the stranded motorist may establish voice contact with the aid dispatcher.

Slide 20 (List of Call-box Data) - In 1976 there were 47 call box systems operating over 19 hundred miles of highway in 19 states. 17 additional installations were then being planned but 8 projects had been abandoned. A serious problem with the call box system is vandalism. Roadside call boxes are also tempting targets for hunters.

Slide 21 (List of Service Patrol Pluses and Minuses) - Another motorist aid system is the service patrol These patrols provide experienced site control. Often the required assistance may be provided by the patrol, or if not, they can directly contact the aid dispatcher.

However, the patrols suffer from high costs, varying coverage, and interference with police duties when this is a police service.

Slide 22 (List of Cost Data) - Studies have shown the costs of the call box systems to vary from $2. to $30 per call with an average of around $12 per call while the cost of patrols ranges from $18 to $25 per call.

Slide 23 (CB Introduction Slide) - It has been suggested that the increasing use of citizens band radio could offer a more cost effective answer to the needs of the motorist in distress. Channel 9 has been designated for motorist aid mesages. But can the 30 million CB users be mobilized t utilize channel 9 in an effective manner? There are a number of public agencies and volunteer groups which monitor Channel 9. If the public can utilize channel 9 effectively, and if a reliable response system can be created to answer calls for help, then an effective motorist aid system might be possible.

Slide 24 (Cartoon of Car Clouded by CB Questions) - CB is not without its problems. There is channel congestion, there is adjacent channel interference, there are FCC rules violations, and the monitoring of Channel 9 may be sporadic.

Slide 25 (CB User with Ordinary Base Monitoring Shown) - The present CB motorist aid system can be represented as a CB operator trying to contact a motorist aid dispatcher who, if he receives the call for help, will contact a service provider. The service itself will then be sent to the motorist in need. An examination of the present system reveals a number of shortcomings. First of all, the present system is unstructured; that is, it consists of a large number of potential monitors who are more-or-less randomly located and who are active as monitors at random times. This means that the present system may not dependably provide continuous time coverage or total area coverage.

Slide 26 (List of CB Requirements) - Further examination of the present system permits a listing of requirements for an effective CB motorist aid system. These requirements are structure, effective use of Channel 9, selective calling, caller identification, and continuous time and total area coverage.

Slide 27 (System Diagram of CB-AIDS Network) - The CB-AIDS system being developed is designed to meet these requirements. The motorist shown in this slide is calling for help by depressing one of two pushbuttons, either an emergency or an assistance pushbutton. When a button is actuated, a coded message is transmitted through is CB radio and is received by an unattended remote station. The decoded message activates an automatic dialer in the remote station which dials the telephone number of the aid dispatcher. When the dispatcher depresses his microphonne push-to-talk button upon answering the call, he is in voice contact with the CB operator requesting help. The dispatcher determines the nature and location of the emergency and then telephones the nearest appropriate service organization which provides service to the disabled vehicle. The CB-AIDS system may use Channel 9 more effectively than the present system because the communication between motorist and dispatcher is direct. The adapters which are used to permit pushbutton selection provide positive caller identification. Continuous time coverage and total area coverage are feasible, depending only upon the density and the number of remote stations. The remote stations will be less prone to vandalism than roadside call boxes, since they do not require user access.

Slide 28 (Geographical Coverage by Normal Base Station Monitoring Urban Area Shown) - To compare the present CB system with the proposed CB-AIDS system, as an example, it has been posutlated that a certain urban network of interstate highway would be monitored on the average by nine CB base stations with three providing 24 hours of coverage, five providing 16 hours of coverage, and one providing eight hours of coverage. Only a small portion of the highway network would be monitored.

Slide 29 (Geographical Coverage of CB-AIDS Type Monitoring Shown) - A CB-AIDS system with 17 remote stations and one monitoring center would provide 24 hours coverage of the entire highway network.

Slide 30 (Histogram of Percentage Coverage Over a 24 Hours Period) - The graph indicates the continuous coverage of a potential CB-AIDS system as compared to the less effective present CB monitor system. It should be noted that in this example the CB-AIDS system would require only 24 man-hours per day for complete coverage whereas the present system requires 160 man-hours of monitoring time.

Slide 31 (Picture of Digital Adapter) - The equipment which adapts a CB radio or the pushbutton, code signal actuation can be small in size.

Slide 32 (Picture of Built-in Digital Adapter with Radio) - It can be mounted on the side of the radio, or incorporated in the radio cabinet.

Slide 33 (Picture of Attachable Digital Adapter) - Or it can be outboard unit, connected between the CB microphone and the radio set.

Slide 34 (Picture of Remote Station) - The basic remote station equipment is a CB radio, control circuit, annd automatic dialing circuitry.

Slide 35 (Picture of Central Control Unit) - For this demonstration project the dispatcher will be provided a telephone, a decoder display which identifies the callers ID number, a microphone, and an automatic record keeping printer.

Slide 36 (Picture of Dispatcher Position) - Centralizing the monitoring and dispatch function will permit the dispatch center to be fully implemented.

Slide 37 (List of Pilot Program Information) - When the system is operational at a selected site it will be evaluated. It is anticipated that 6 months will be required for a thorough and proper evaluation. A limited number of digital adapters will be provided to selected CB radio users in the test area for pilot program evaluation.

Slide 38 (End Slide) - The Federal Highway Administration realizes that the interstate highway system is used by people, who will sometimes require emergency assistance. CB-AIDS is a program designed to enhance the use of CB radio for motorist aid.

APPENDIX B

REMOTE STATION HYBRID TESTS

During the CB-AIDS program, a series of tests were performed on the CB-AIDS Remote Station telephone hybrid circuit. These tests are described below.

1.0 Remote Station Voice Connection Circuits

A simplified block diagram of the pertinent voice connection circuits within the Remote Station is shown in Figure 23. The signal paths may be described as follows. The audio output from the CB radio is routed through a summing network to an isolation (unity gain) amplifier. The amplifier output is connected to the input of the telephone hybrid through a 620 ohm resistor. The signal is then coupled through the hybrid to the telephone lines. Due to hybrid unbalance, some of the signal will also be coupled to the output of the hybrid. (The ratio of input signal to output signal is termed isolation.) The telephone line signal is then routed to the KS-20445 telephone coupler which is connected via the local loop to the telephone central office. Following appropriate trunk line switching, this routed signal is connected through a second KS-20445 telephone coupler to the Central Control Unit. In a similar manner, voice signals from the central control unit follow the reverse path back to the Remote Station hybrid. After being coupled through the hybrid, these signals are routed through a summing network to a 25 dB gain amplifier. The amplifier output signal is routed to an active attenuator, analog switch, as well as other locations. The output of the active attenuator is applied to the microphone input of the CB radio. The analog switch, when on, routes the signal to a syllabic detector which, when energized, keys the CB radio push-to-talk line.

Tests were performed to determine key elements involved in optimizing level settings in the RS for (1) reducing false keying created by hybrid unbalance while (2) increasing correct keying by voice signals over the telephone connection. The following tests were completed.

- o Passive hybrid isolation - phone line
- o Passive hybrid balance impedance - phone line
- o Passive hybrid isolation - coupler
- o Passive hybrid balance impedance - coupler
- o Passive hybrid isolation - coupler to office transformer
- o Active hybrid isolation - phone line

2.0 Hybrid Tests

The tests were performed on two basic types of hybrids - passive and active. The passive hybrid was the standard dual-transformer design as shown in Figure 20. The active hybrid used cross-coupled operational amplifiers with isolation transformers as shown in Figure 24. The test schedule is shown in Table 16.

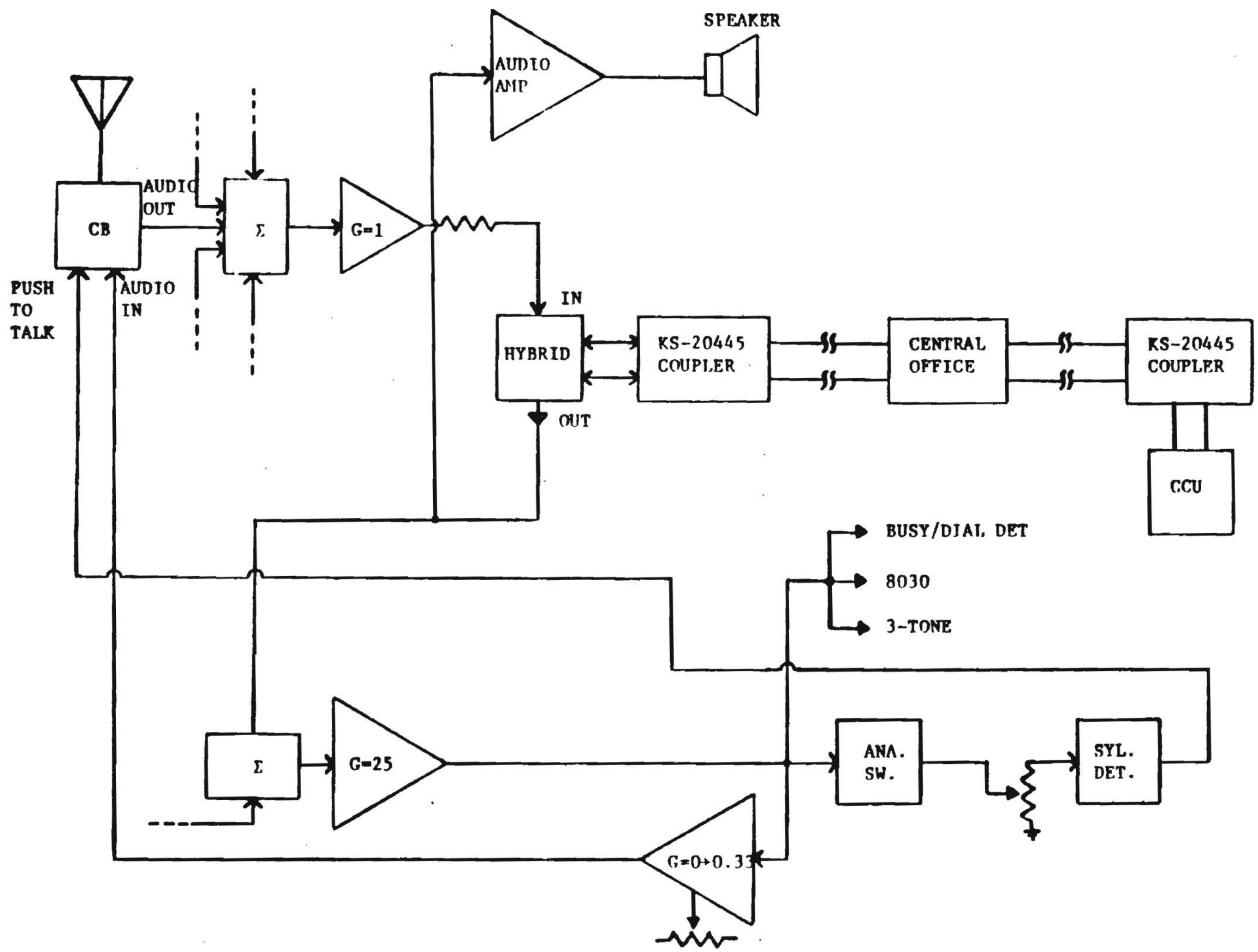


Figure 23. Simplified RS Voice Circuit Block Diagram

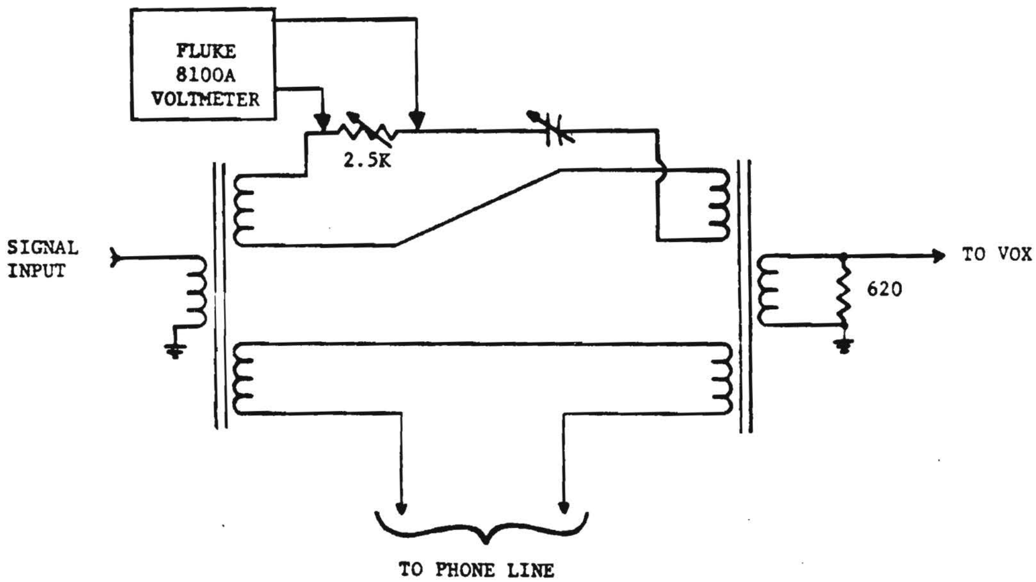


Figure 24. Passive Hybrid

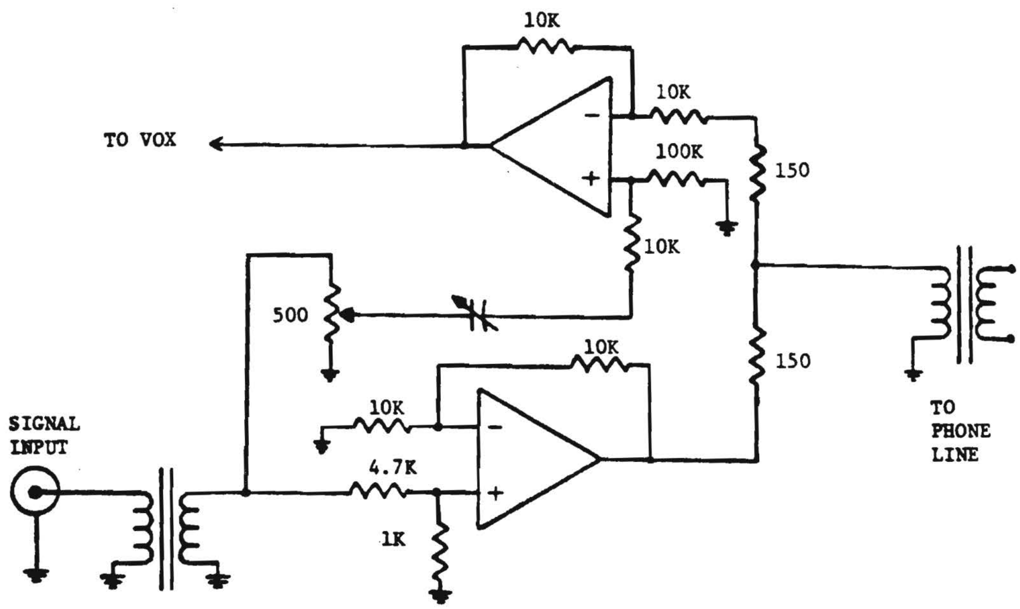


Figure 25. Active Hybrid

TABLE 16

HYBRID TEST SCHEDULE

Hybrid Test Name	Test Setup	Test Results
Passive Isolation - Phone Line	Figure 4	Table 2
Passive Impedance for Balance	Figure 4	Table 3
Passive Isolation - Coupler	Figure 5	Table 4
Passive Impedance for Balance	Figure 6	Table 5
Passive Isolation - Coupler to Transformer	Figure 7	Table 6
Active Isolation - Phone Line	Figure 8	Table 7

TABLE 17

PASSIVE HYBRID - PHONE LINE, ISOLATION TEST

Frequency (Hz)	Hybrid Input Signal Level (V_{p-p})	Phone Line Signal Level (V_{p-p})	Hybrid Output Signal Level (V_{p-p})	Hybrid Isolation -20 Log (dB)
200	1.8	1.0	0.08	27.04
500	2.0	1.0	0.13	23.74
750	2.0	1.0	0.09	26.94
1000	2.0	1.0	-	60.00
1250	2.0	1.0	0.08	27.96
1500	2.0	1.0	0.145	22.79
2000	2.0	1.0	0.23	18.79
3000	1.95	1.0	0.35	14.92

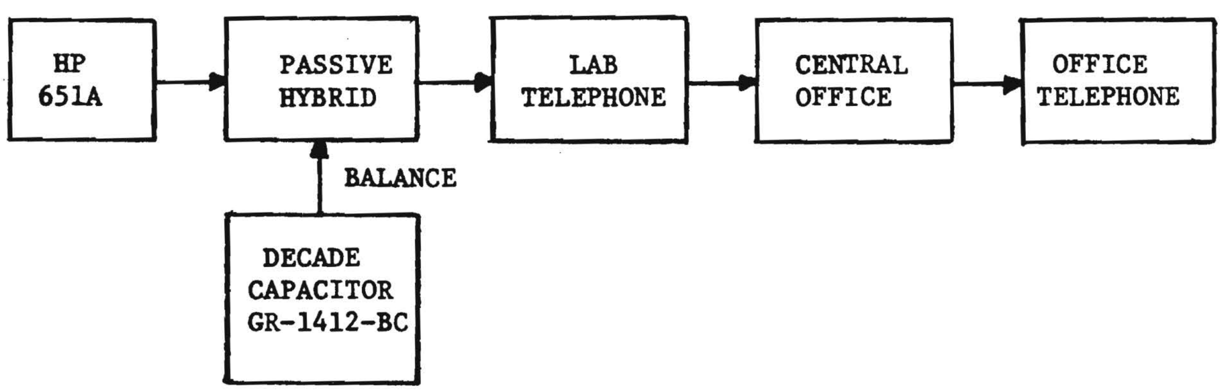


Figure 26. Test Setup - Passive Hybrid to Phone Line

TABLE 18

PASSIVE HYBRID - PHONE LINE,
IMPEDANCE REQUIRED FOR BALANCE

Frequency (Hz)	R (Ω)	C (μF)	Z (Ω)
200	-	0.440	1209-j723
500	1209	0.440	1209-j723
750	766	0.254	766-j835
1000	502	0.220	502-j723
1250	382	0.207	382-j615
1500	312	0.200	312-j531
2000	245	0.191	245-j305
3000	189	0.174	189-j305

Note: When the phone line is replaced with a series RC (620Ω & 0.1 μF ±5%, ARCO type PJ polystyrene) the R and C readings are R = 627, C = 0.097 μF and the null remains good over the 200 to 3000 Hz frequency range.

TABLE 19

PASSIVE HYBRID - COUPLER, ISOLATION TEST

Frequency	Hybrid Input Signal Level (V_{p-p})	Coupler Signal Level (V_{p-p})	Hybrid Output Signal Level (V_{p-p})	Hybrid Isolation -20 Log (dB)
200	2.0	1.10	0.180	20.92
500	2.0	1.20	0.075	28.52
750	2.0	1.20	0.035	35.14
1000	2.0	1.15	-	60.00
1250	2.0	1.10	0.028	37.08
1500	2.0	1.10	0.045	32.96
2000	2.0	1.10	0.075	28.52
3000	2.0	1.10	0.125	24.08

Note: For these tests it was necessary to connect the decade capacitor in parallel with the pot rather than series. At 1000 Hz R = 450Ω, C = 7000 pF for hybrid balance.

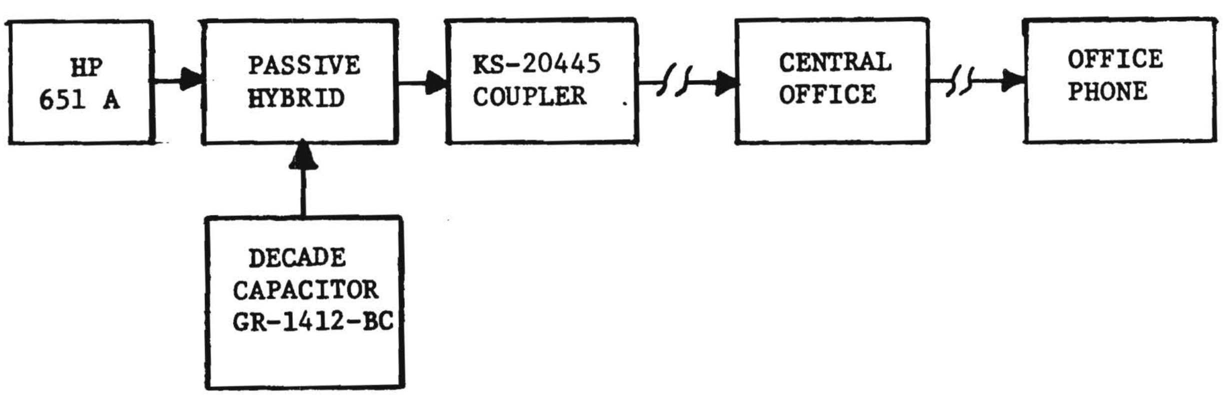


Figure 27. Test Setup - Passive Hybrid to Coupler

TABLE 20

PASSIVE HYBRID - COUPLER, IMPEDANCE REQUIRED FOR BALANCE

Frequency (Hz)	R (Ω)	C (μF)	L* (mH)	Z (Ω)
200	-	-	-	-
500	369	0.208	510	465 + j72
750	333	0.088	510	429 - j8
1000	275	0.049	510	371 - j44
1250	213	0.031	510	309 - j102
1500	144	0.0217	510	240 - j83
2000	26	0.0123	510	122 - j61
3000	-	-	-	-

*DC resistance = 96Ω

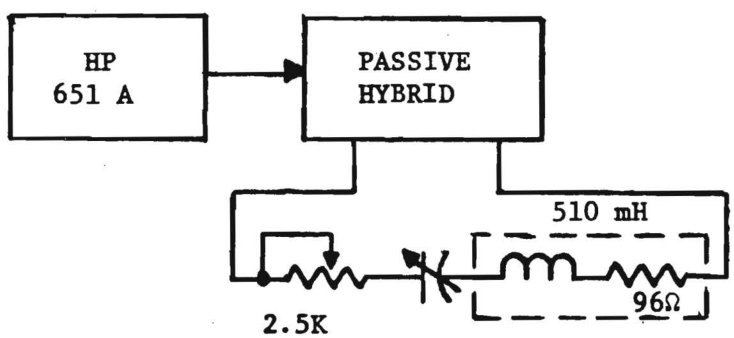


Figure 28. Passive Hybrid with KS-20445, LI Coupler Impedance Required for Balance

TABLE 21

PASSIVE HYBRID - COUPLER TO TRANSFORMER ISOLATION TEST

Frequency (Hz)	Hybrid Input Signal Level (V_{p-p})	Coupler Signal Level (V_{p-p})	Hybrid Output Signal Level (V_{p-p})	Hybrid Isolation -20 Log (dB)
200	2.0	1.12	0.18	20.92
500	2.0	1.16	0.07	29.12
750	2.0	1.16	0.04	33.98
1000	2.0	1.14	-	60.00
1250	2.0	1.10	0.02	40.00
1500	2.0	1.08	0.04	33.98
2000	2.0	1.06	0.07	29.12
3000	2.0	1.06	0.11	25.19

Note: **For hybrid balance at 1000 Hz R = 452Ω, C = 1000 pF with C in parallel with R**

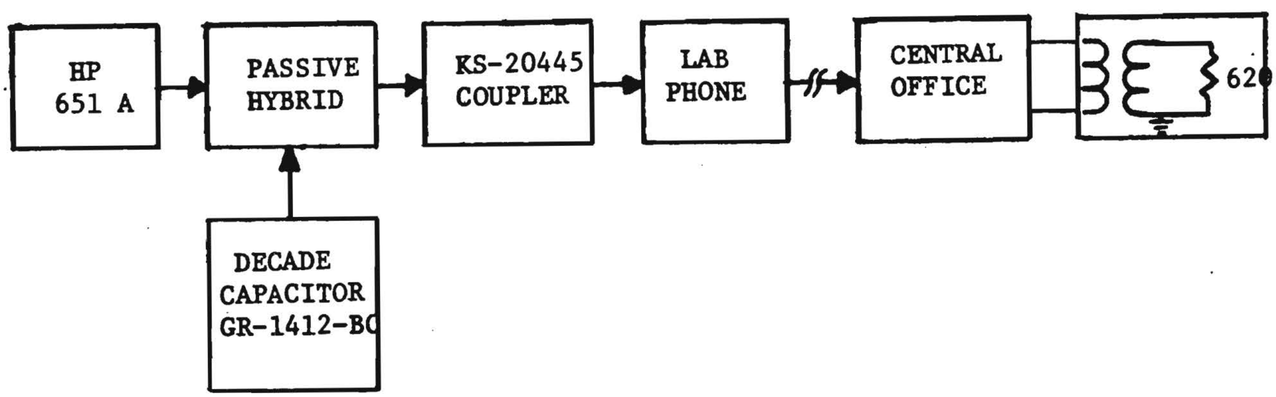


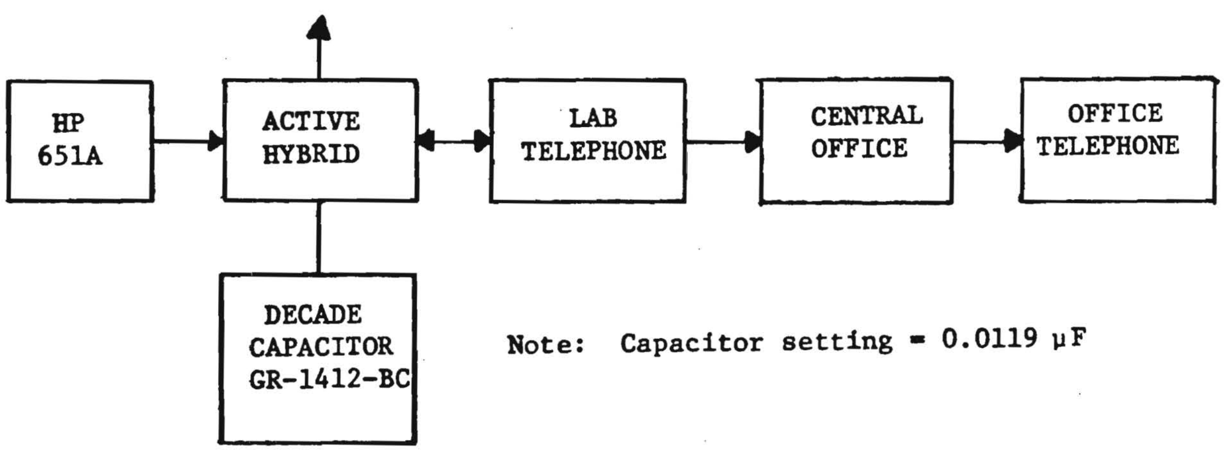
Figure 29. Test Setup - Passive Hybrid with KS-20445, L1 Coupler (to Office Transformer)

TABLE 22

ACTIVE HYBRID - PHONE LINE, ISOLATION TEST

Frequency (Hz)	Hybrid Input Signal Level (V_{p-p})	Phone Line Signal Level (V_{p-p})	Hybrid Output Signal Level (V_{p-p})	Hybrid Isolation -20 Log (dB)
200	1.04	0.56	0.26	6.66
500	1.04	0.84	0.16	14.40
750	1.04	0.90	0.065	22.83
1000	1.04	0.92	0.010	39.28
1250	1.04	0.92	0.050	25.30
1500	1.04	0.92	0.090	20.19
2000	1.04	0.88	0.150	15.37
3000	1.04	0.80	0.215	11.41

Note: GR capacitor and pot set for max hybrid isolation @ 1000 Hz.



Note: Capacitor setting = 0.0119 μF

Figure 30. Test Setup - Active Hybrid to Phone Line

APPENDIX C
CB-AIDS FORMS

A number of forms were used during the course of the program. These forms were for (1) providing information to the Digital Adapter users, (2) Digital Adapter user feedback to the program, and (3) general record keeping. A total of seven forms were generated and are as listed below.

Digital Adapter User's Guide This users' guide was provided to each volunteer at the time of Digital Adapter installation. The guide provided a general introduction to the CB-AIDS program, DA operating instructions, message examples, and the names and telephone numbers of responsible Georgia Tech project personnel.

CB-AIDS User Information This form was filled out by a prospective user and provided to Georgia Tech the necessary information for determining if the prospective user (1) had a CB radio compatible with the Digital Adapter and (2) normally traveled roadways in the area of one or more of the Remote Stations. Provision was also made on this form for listing the DA serial number, date installed, and date returned.

CB-AIDS Incident Report A number of these forms would be given to the user when a DA was installed. The incident report was filled out by the user each time the DA was used to report a specific highway incident. The form, when properly filled out, provided feedback to project personnel regarding the type of incident being reported and other pertinent information needed to determine the value of the CB-AIDS concept. Additional forms were provided to the users on an as-needed basis.

Digital Adapter Installation Data This form was used to provide pertinent installation data. Each Digital Adapter was listed according to ascending serial numbers along with general information regarding the specific CB radio to which the DA was interconnected.

Digital Adapter Location Data The DA location data form was primarily for listing each DA (according to serial number) along with its respective user. The user's name, address, telephone number, and FCC call sign was provided as a part of this form.

CB-AIDS CCU Log Copies of this log were kept with the Central Control Unit at the DeKalb Police Headquarters. The responding operator was requested to fill out the log for each call taken from a Digital Adapter user. This form, a companion to the CB-AIDS Incident Report form, provided further information to project personnel regarding each use of the CB-AIDS system.

Equipment Malfunction Report The equipment malfunction report was used by project personnel for documenting equipment problems. This documention was useful in identifying needed improvements, design changes or system modifications.

Examples of these CB-AIDS forms are provided in pages to follow.

CB-AIDS DIGITAL ADAPTER USER'S GUIDE

Introduction

The CB-AIDS pilot program has been initiated in order to test the technical feasibility of a CB radio to telephone interconnection system for motorists' aid. Therefore, this user's guide is prepared for your convenience and will explain how to initiate a call, via the digital adapter, to either an emergency or assistance operator. It is important to remember that even though the system provides a direct line to the police department, unnecessary calls should not be placed through this system.

Digital Adapter (DA) Operating Instructions:

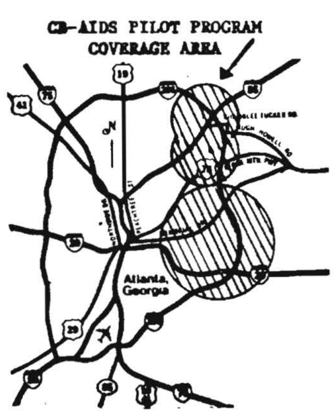
Before you initiate a call with your DA it should be carefully determined if the situation warrants either an emergency or an assistance call. To initiate an emergency or assistance call the following steps must be performed.

Step 1: Select Channel 9 on your CB radio,

Step 2: Press the E or A button once and release,
(The lamp will get brighter)

Step 3: Key your microphone until the E or A lamp goes dim and then release the mike key.

This procedure will initiate an emergency or assistance call when the mike key is released. You should then hear the Remote Station dial the emergency or assistance number. (If not, then repeat the above steps.) When the call is answered, you may then carry on the required conversation using your push-to-talk microphone and observing proper radio procedures. It is important to remember that this is a radio-to-telephone "link" and you should wait until the emergency or assistance operator finishes his instruction and says OVER before you key your transmitter. If you accidently push the E or A button, and do not wish to make a request for help, wait 12 seconds and the DA will reset. During this time DO NOT key your microphone.



Permitted Messages

User discression is advised when using the digital adapter and any other "Channel 9" transmission. There are explicit rules and regulations set forth by the FCC about the use of Channel 9, some examples of permitted messages are:

1. "I am out of gas on I-95",
2. "There is a fire at 4th and Main",
3. "There is an accident at 4th and Main",
4. "There is a drunk driver on I-95, between Exit 3 and 4 heading North."

Examples of messages not permitted on Channel 9.

1. "I am out of gas in my driveway",
2. "Traffic is moving smoothly on I-285",
3. "This is patrol unit number 1. Everything is quiet here",
4. "This is observation post number 1. No tornadoes sighted."

The following priorities should be observed in the use of Channel 9.

1. Communication relating to an existing situation dangerous to life or property, i.e., fire, automobile accident.
2. Communication relating to a potentially hazardous situation, i.e., car stalled in a dangerous place, lost child, boat out of gas.
3. Road assistance to a disabled vehicle on the highway or street.
4. Road and street directions.

If you suspect that the DA is not operating properly or if you have any questions PLEASE call:

Ron Wallace	-or-	Bob Wilson
Ga. Tech		Ga. Tech
EES/ETL/CTG		EES/ETL/CTG
894-3544 - Business		894-3544 - Business
394-1314 - Home		475-5893 - Home

CB-AIDS

GEORGIA INSTITUTE OF TECHNOLOGY

ENGINEERING EXPERIMENT STATION

FEDERAL HIGHWAY ADMINISTRATION

PLEASE RETURN TO: R. W. Wallace
Georgia Tech/EES/ETL
Atlanta, GA 30332

CB-AIDS USER INFORMATION

Name: ____
(First) (Middle I.) (Last)

Home Address: ______________________________________
(Street) (Apt. #)

____
(City) (County) (Zip)

Telephone: Home ____________________ Work ____________________

Occupation: ____

Place of Work: _____________________________________
(Company) (Location)

Major Routes Driven Daily: __________________________

____

Distance from Home to Work: _________________________

CB Radio Information: _______________________________
(Make) (Model)

____
(Type mike connection - 4 pin, 5 pin, direct wired, etc.)

CB Organization Affiliation: ________________________

How Long a CB User: _________________________________

FCC Call Sign: ______________________________________

Handle: ____

Vehicle Information: ________________________________
(Make) (Model) (Year)

____
(Battery Voltage) (Type Ground-Pos./Neg.)

I would like to participate in the CB-AIDS Program:

____
(Signature)

(Do NOT complete below this line)

DA Serial Number ____________________

Date Installed ____________________ Date Returned ____________________

DIGITAL ADAPTER INSTALLATION DATA

DA ID #	CB RADIO Make/Model	TYPE CONNECTOR	PIN LOC					TYPE PTT (+,-)	POWER (mike, ext)	NOTES
			GND	+12V	AUD +	AUD-	PTT			
123400										
123401										
123402										
123403										
123404										
123405										
123405										
123406										
123407										
123408										
123409										
123410										
123411										
123412										
123413										
123414										
123415										
123416										
123417										
123418										
123419										
123420										
123421										
123422										

CB-AIDS INCIDENT REPORT

NAME: ____________________

DATE OF INCIDENT: ____________________

TYPE OF INCIDENT: Emergency __________ Assistance __________

REPORTING LOCATION: ____________________

WEATHER/ROAD CONDITIONS: ____________________

TIME CALL WAS INITIATED: ____________________

WAS CALL ANSWERED: Yes ______ No ______

TIME SERVICE ARRIVED: ____________________

TIME OF SERVICE COMPLETION: ____________________

VOICE QUALITY OF PHONE PATCH: Excellent ____ Good ____ Fair ____

Poor ____ Unsatisfactory ____

SERVICE RESPONSE: Good ____ Adequate ____ Unacceptable ____

DESCRIPTION OF INCIDENT: ____________________

____

____

____

____

COMMENTS: ____________________

____

____

____

____

DIGITAL ADAPTER LOCATION DATA

DA ID #	Date Install/Return	Name	Address	Home Phone #	FCC Call Sign	Comments

CB-AIDS CCU LOG

Monitors Name: ____
Last First Middle Date

Time of Call				
User ID				
Other Motorist Call Sign/Auto License				
Type of Incident				
Accident				
- Injuries				
- Fatalities				
- No. Vehicles				
Stalled Vehicle-occupied				
Stalled Vehicle-unoccupied				
Road Obstruction				
Major Traffic Jam				
Traffic Equip. Malfunction				
Reckless Driver				
Information Request				
Vehicle on Fire				
Other				
Action Taken				
Called State Hwy. Patrol				
Called City Police				
Called County Police				
Called Sheriff				
Called Fire Dept.				
Called Ambulance				
Called Service St.				
Called Hwy. Dept.				
Called Utility Co.				
Gave Caller Info.				
None				
Other				
Time Motorist Notified				
Quality of Phone Pitch				
Excellent				
Good				
Satisfactory				
Fair				
Poor				

EQUIPMENT MALFUNCTION REPORT

DATE: ____________________

EQUIPMENT			IDENTIFICATION #
Digital Adapter			
Remote Station			
Central Control Unit			

PROBLEM: ____________________

REPAIR: ____________________

COMMENTS: ____________________