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A Computer-Based Transmission Monitor and Control System

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A COMPUTER-BASED TRANSMISSION MONITOR AND CONTROL SYSTEM

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This paper describes a minicomputer-based communication system monitor used by the U.S. Department of Defense to improve the performance and reduce the operating costs of the new multi-channel digital transmission systems. A brief history of the development of the monitor and a description of the present-generation hardware and software are included.

Key words: communication system control; computer monitor; digital transmission; information display; software development

1. INTRODUCTION

In any competitive environment, certain information has a value that is in inverse proportion to the number of people who have access to it. This is particularly true in a military situation, where the disclosure of sensitive information can have lethal consequences. In order to increase the security of wide-band multi-channel communication systems, there is a strong interest in encrypting the information carried on these systems. Since information in digital form is much easier and less expensive to encrypt than the same information in analog form, military communication planners have decided to convert much of the overseas military communication plant so that on these systems, both voice and data traffic is carried in an encrypted digital form through much of the system.

The conversion of the Defense Communication System European wide-band communication system to an all-digital communication scheme started with the installation in 1975 of the Frankfurt-Koenigstahl-Vaihingen (FKV) microwave links that carried a digital baseband signal on converted frequency-modulated analog radio equipment. The next step in the conversion was the installation of the Digital European Backbone, Phase I (DEB-I) system that used the same technology. Current plans are to convert the entire European wide-band system to digital transmission over the next several years.

The planning and development of these first two digital microwave systems indicated that an improvement in system effectiveness and a decrease in operating costs could be realized by reexamining the traditional methods of communication system control. In the past, each radio site in a system had a number of people

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assigned to operate the site 24 hours a day. This practice was recognized as being wasteful of both money and trained personnel. Furthermore, modern communication equipment is reliable enough that continuity of service can be assured by installing redundant electronic equipment with automatic switching. This makes reduction or complete elimination of the personnel at repeater sites practical. As a consequence, both the FKV and DEB-I systems were commissioned with certain relay sites that were not staffed. Maintenance and restoral at these sites was to be done by dispatch of trained, skilled maintenance personnel from one or more central locations. In order to permit system operators to know the status of the equipment at these unstaffed sites, an alarm monitoring system was installed to report site conditions to the location of the responsible system operator.

The initial alarm remoting equipment was a wired-logic poll-response type system. A master unit requested information from the remote sensing unit and displayed the conditions of the remote radio site as an array of alarm and status indicator lights at the master location. This system had two serious drawbacks. First, the information available from the remote site was only an "on" or an "off" so that continuous functions such as received signal level could not be monitored. This meant that only very rudimentary remote site fault or failure analysis was possible. The second problem area was the technique of displaying the remote-site information at the control location. The master unit display consisted of over a hundred indicator lights arranged in a dense matrix. As remote sites were polled, the array of lights changed constantly and the operator had difficulty determining the conditions at any one remote site and had no opportunity to get an idea of the status of the entire communication system.

In order to make the remote site information more complete and accessible to the human operators, the Air Force system engineers decided to use a computer to do some data processing and put the information in the desired format for presentation to the operators. The development of this improved alarm remoting system, called the Enhanced Fault Alarm System or EFAS, was begun in 1977.

The EFAS development consisted of preparing hardware and software to allow the minicomputer to replace a fault alarm master terminal. The computer sent poll messages to the remote units and received and decoded the responses. The information in the responses was analyzed and used to generate displays on a CRT terminal. These displays presented the alarm, status, and parameter data gathered from the remote sites in English text designed to show site and entire system conditions in an easily understood format.

The deployment of the minicomputer master units of the enhanced fault alarm system was done in parallel with the DEB-I installations in southern Germany and northern Italy during early 1979. This, the DEB-I EFAS, consisted of 13 remote data acquisition units and 3 minicomputer-based master units. Each communication site, even those where a master unit was located, was equipped with one of the remote data acqusition units.

The displays of communication equipment and system conditions that were provided initially were based on requirements developed by the Air Force Operation and Maintenance commands and the DEB-I system engineers. As the operators on site used the EFAS and became familiar with its capabilities, they were able to provide many excellent ideas about the displays and what information should be provided. Thus, during the course of four years of operation, the set of EFAS displays has developed as a result of user experience into a valuable tool for communication system operation and management. In fact, with the termination of the Automated Technical Control (ATEC) program in late 1980, the enhanced fault alarm system, renamed the transmission monitor and control (or TRAMCON) system was approved by the Defense Communication Agency for worldwide deployment.

The next major development in the TRAMCON concept was the decision to deploy a second-generation minicomputer with a fully revised software package in support of the next two stages of the Digital European Backbone, namely the DEB-IIA segment and the Frankfurt-North Berlin troposcatter segment. This is an opportune time for a change since these later DEB stages will use a completely new digital multiplex, a new digital line-of-sight link radio, and a new digital troposcatter link radio.

The most important changes in the TRAMCON system will not primarily affect the display of information, but rather the way information is stored in the computer. The changes will make the TRAMCON able to monitor any type of communication link, even satellite or fiber optic technology, carrying data in either analog or digital form.

This report will deal primarily with the development of the second-generation system and will include a description of both hardware and software.

2. OBJECTIVES

The basic reason for the establishment and continuation of the system monitoring project is to reduce the per-channel-mile cost of communication services by increasing the productivity of the communication operation and maintenance personnel. The increase in productivity is expected to occur as a result of requiring fewer operation and maintenance workers to provide the increased communication capacity being provided by the installation of the Digital European Backbone. To make this improvement in productivity possible, the communication system operators need new tools and techniques to permit them to monitor and control entire segments of a communication network and to isolate problems at any site quickly and accurately so that remedial action can be taken before total communication outage or failure occurs. The TRAMCON system is seen as the tool that will make the improvement possible and support the development of new operation and maintenance doctrine and techniques.

In order to narrow the focus of the TRAMCON development effort, and to keep the emphasis on the parts of the communication system where the use of a segment-wide monitor would be most effective, certain restrictions were agreed upon by the groups that manage the TRAMCON development. These were in their historical order of adoption: first, no monitoring would be done at levels lower than the first-level multiplex which handles 24 voice channels; second, the computer itself would perform no functions on its own that could interrupt traffic, and third the communication system operational data in the computer would be made available for analysis on a multisegment or network basis, but that the TRAMCON computers would not do any of the data manipulation required by higher levels of communication network monitoring and operation.

The reason the decision was made to exclude the monitoring of the performance of individual voice channels by TRAMCON was that the requirements for properly monitoring and controlling voice channels are considerably different than for the parts of the system that are monitored. The idea of a segment of the overall communication network, limited in extent and geographically compact, is natural for radio links and for higher-level multiplex sections. In contrast individual voice channels typically traverse the entire network or considerable parts of it and are frequently changed as traffic conditions require. Thus it would be difficult to associate a voice channel with a particular small segment of the DCS network, particularly on any sort of a permanent basis. The decision was made that EFAS and later TRAMCON would not monitor nor report on the condition of individual voice or data channels.

The decision that the TRAMCON computer would not be allowed to perform autonomous system control functions was based on the doubtful reliability of the TRAMCON 8 control channels if the system were disturbed and the difficulty of developing computer programs that would not interrupt the communications systems in any circumstance.

The intent of TRAMCON is not to displace or reduce the responsibility of human operators but rather to increase their span of control by placing information of a more refined quality at their disposal to allow them to make better control decisions.

The third restriction, that data manipulation for the use of communication network operations and management would be limited to making the segment data available for such use, was dictated primarily by the need to keep the TRAMCON concept from an uncontrolled growth. The use of a multitasking general-purpose computer in TRAMCON makes it a tempting target for any sort of record keeping or data analysis task that comes to hand. Such tasks, if the TRAMCON computers were to handle them, would further complicate the computer software to be developed and by so doing, increase the cost and reduce the reliability of the TRAMCON system itself.

The success of the transmission monitor and control systems up to this time can be ascribed in no small part to the fact that a well-defined objective was set out and that a system was designed to move in evolutionary steps toward that objective.

3. TRAMCON SYSTEM CAPABILITIES

3.1 General Capabilities

The basic purpose of the transmission monitor and control system is to gather information on communication equipment status from a number of sites and present this information in a useful format to a communication system operator. The information is presented to the operator in the form of displays on a computer CRT terminal. These displays report on the functioning of the communication system in English text and can present data from a single communication terminal within a station or can present an overview of the operation of an entire segment.

3.1.1 TRAMCON System Operation

The monitoring process starts when the controlling master unit sends an addressed poll message to each of its remote units in turn. The remote unit replies with a formatted message that contains all of the alarm, status and parameter information about its communication site. The master unit disassembles this message and places the information in local data files. The CRT terminal displays are generated from these data files at the request of the operator. Some of the data are processed for long-term archive storage. Examples are received signal level measurements, other parameter measurements, and the occurrence of alarms of major significance.

Another function the TRAMCON equipment performs is remote control switching of certain equipment at the remote sites. To perform a remote switching function, the system operator enters the request on the CRT terminal keyboard. The master sends a command message to the indicated remote site unit, and the remote unit performs the switch operation. The remote unit reports the changed site status to the master, which provides confirmation to the operator that the change occurred. This function is used generally to switch between redundant communication equipment elements or to reset a function that may have been disabled by an equipment failure. To enhance communication reliability, the master unit will not permit the operator to select switch combinations that would cause the mission traffic to be interrupted or otherwise cause a communication failure.

In addition, the master unit performs a number of other functions that support the TRAMCON mission. These involve maintaining information on communication system configuration, information on the status of communication system elements, and the necessary calibration and threshold tables for processing the input data from the remote communication sites. These data bases are established specifically for operation of the TRAMCON system but such data can be obtained from the computer so that other analyses can be performed.

A new capability of the TRAMCON system is for the connection of a number of CRT terminals in addition to the system console. These extra terminals called remote displays or maintenance dispatch terminals will be used to provide communication system monitor information to other than the system operator. Examples of a user of a remote display would be staffed sites in a segment with no master unit or maintenance shops from which teams are dispatched to effect equipment repair or restoral. Such additional terminals will be able to call any display from the master unit but would not have the capability to initiate remote control switching. The remote control function would only be performed by the system operator at the polling master location.

3.2 TRAMCON System Hardware

The TRAMCON system includes both master and remote units. To improve the the reliability of the monitoring system, at least two master units are able to monitor each segment or group of communication sites. The polling master will actually control the remote units on a segment while any other masters will operate in a listen-only mode. The polling line is broken at segment boundaries so that only polling messages intended for a particular segment's remote units appear on the segment poll line. Figure 1 is a block diagram of a typical arrangement of TRAMCON master units and the remote unit which are located at each communication site.

3.2.1 The TRAMCON Master Unit

The hardware that makes up a master unit is shown in Figure 2. The computer is a general-purpose minicomputer with a 16-bit word length. It is equipped with 128 kilo-words (256 kilo-bytes) of main memory. The disc unit is a 19.4 megabyte (M-byte) capacity, two-platter unit with one of the discs in a removable cartridge. The tape storage unit is a 9-track, half-inch, 1600 bits-per-inch drive. The system console CRT terminal is capable of acting as a stand-alone microcomputer system. At the request of the operator, the information on the display terminal can be printed on the hard copy device as a permanent record for the station or as a part of the site and system reports which are sent to higher headquarters.

Communication between the various TRAMCON masters and between each master and its remote units is carried on voice channel synchronous or asynchronous data modems at speeds of 300 to 9600 b/s depending on the capability of the assigned communication channel.

Figure 3 is a functional block diagram that shows some of the capabilities of a TRAMCON master unit. The master software includes a real-time operating system, file handling utilities, various language compilers, and communication handlers and drivers for the various input/output devices. The TRAMCON data acquisition, manipulation, storage, and display programs that were written at ITS are described in Section 4.

3.2.2 The TRAMCON Remote Unit

All data acquisition done by the TRAMCON system is handled through the wired-logic remote units, which also perform the remote switching mentioned previously. Figure 4 is a functional block diagram of a remote unit. As shown, three types of input can be accommodated, namely two-state status or alarm indications, continuously varying voltages which correspond to analog parameters, and pulse train or random pulse occurrences. In addition, the remote unit provides for contact closures, either momentary or latching as required, to perform the remote switching functions. As the TRAMCON remote units are now

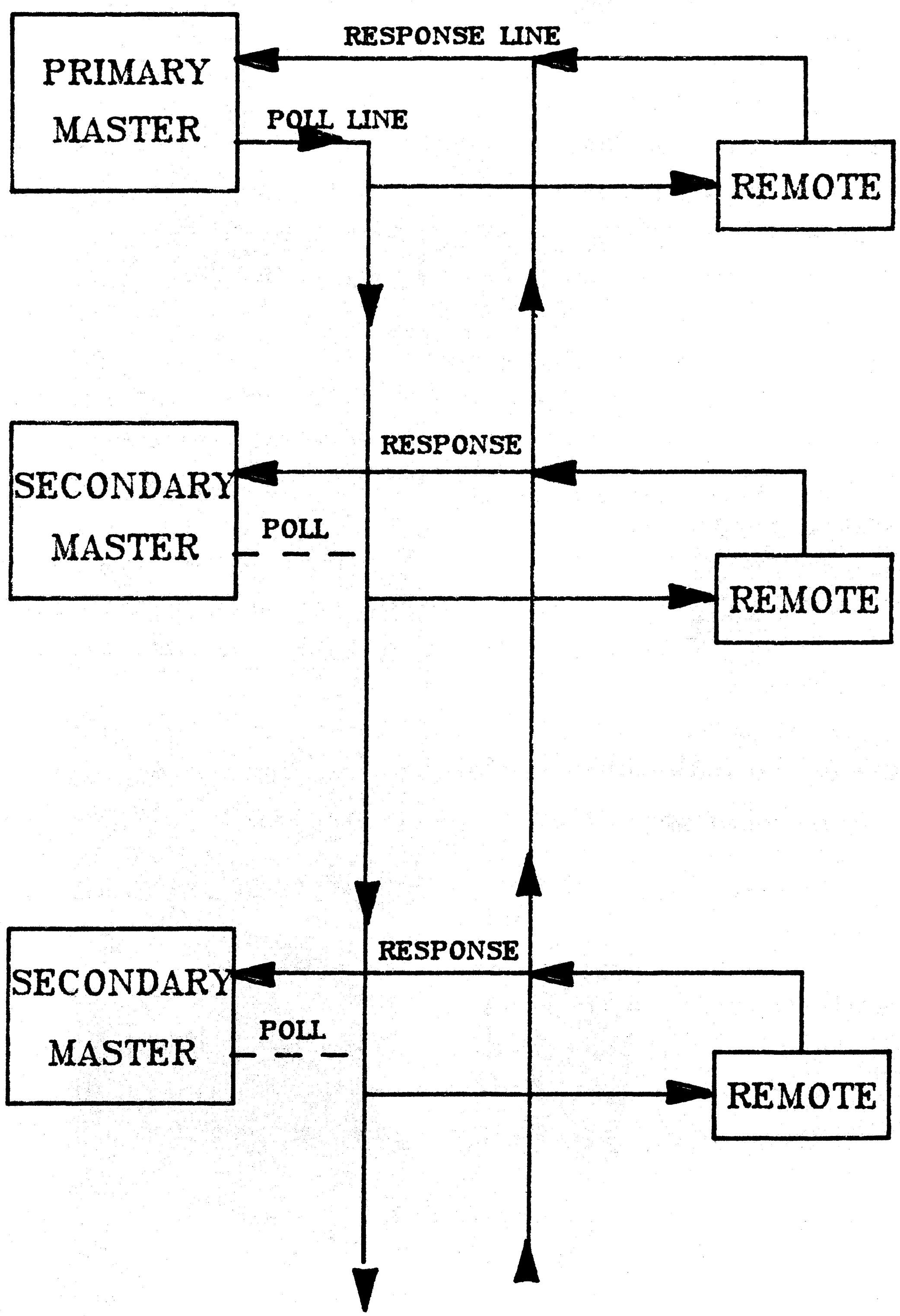

Figure 1. Interconnection of master and remote units.

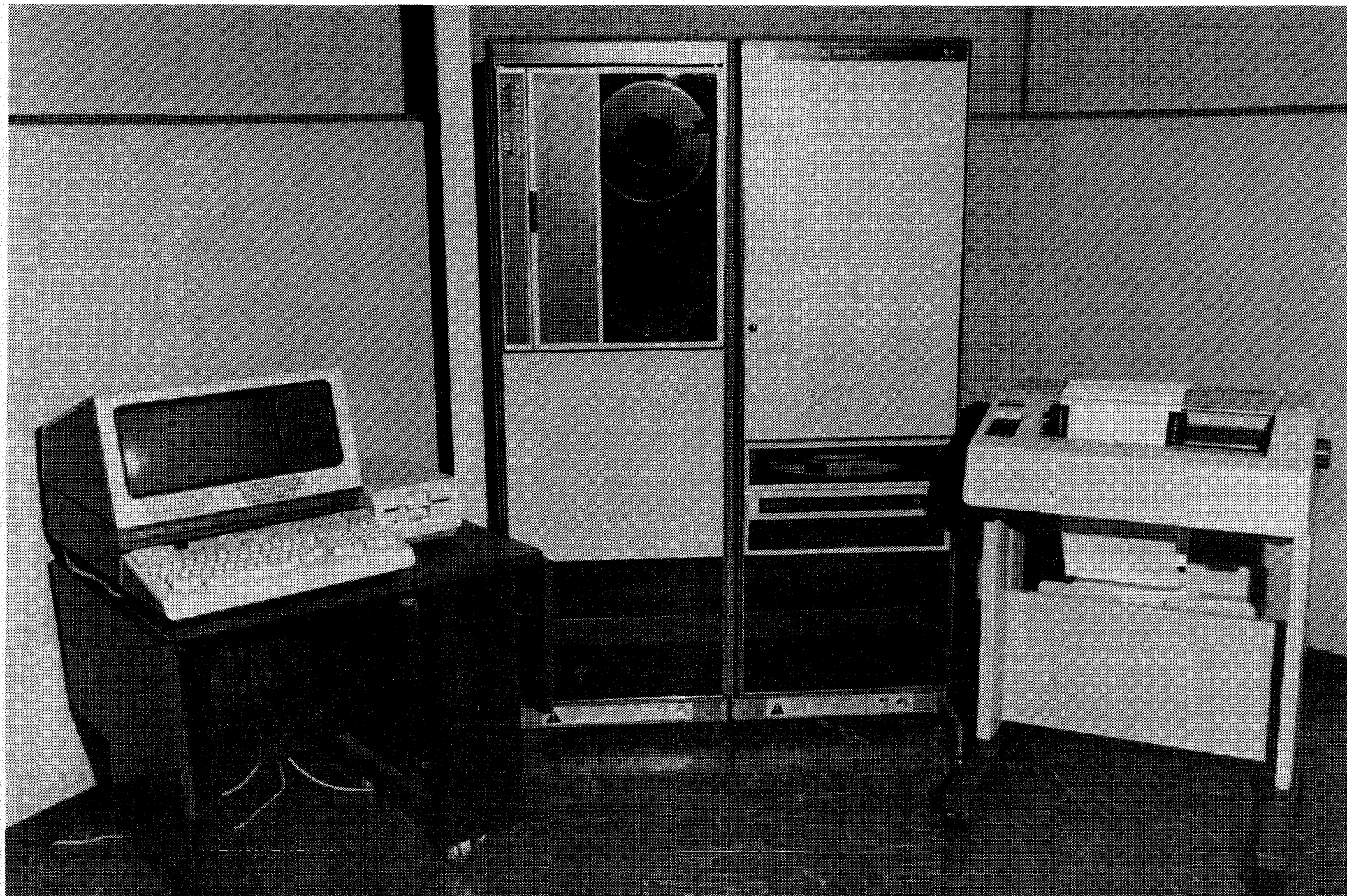

Figure 2. The TRAMCON master hardware.

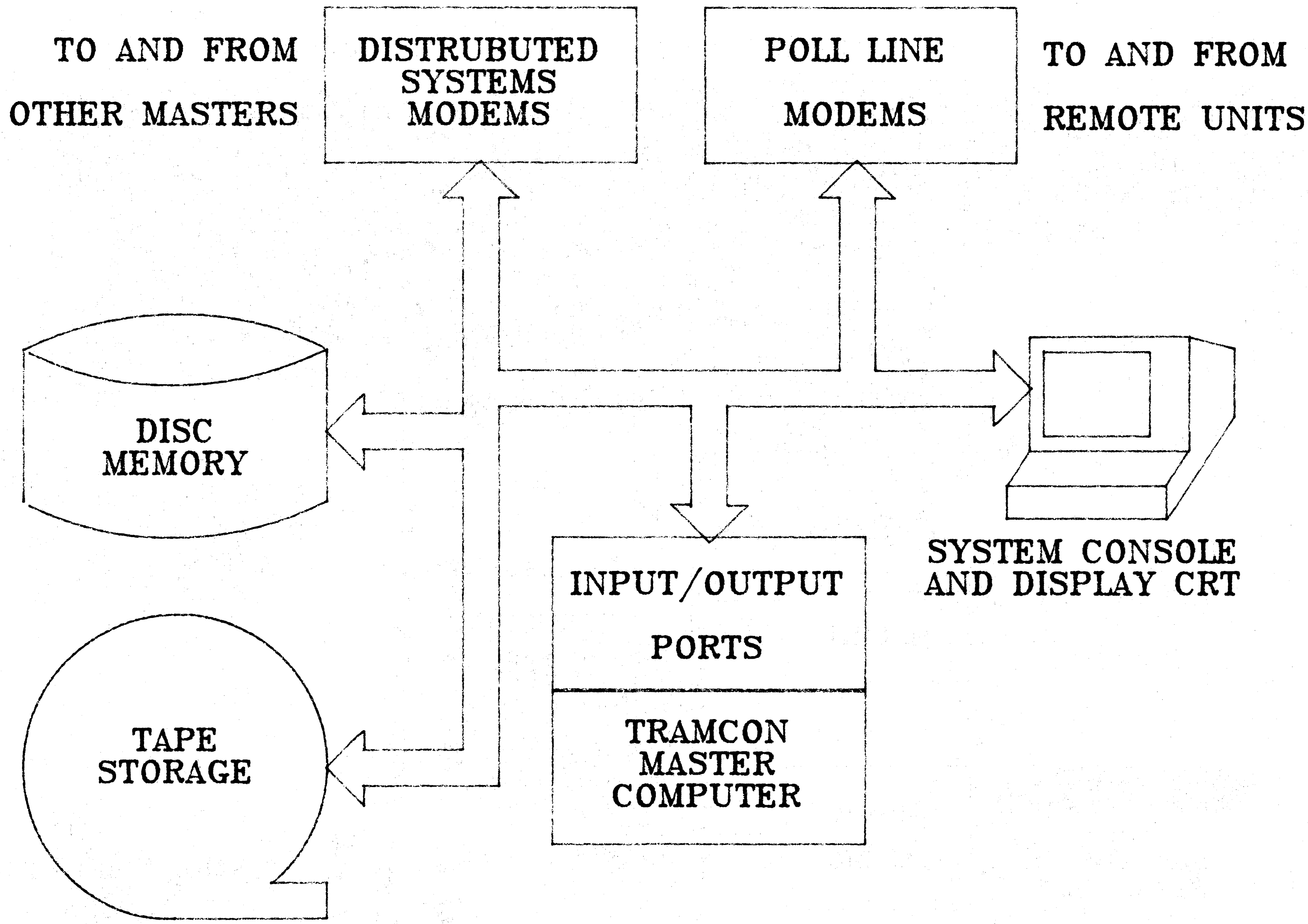

Figure 3. Functional block diagram of a TRAMCON master.

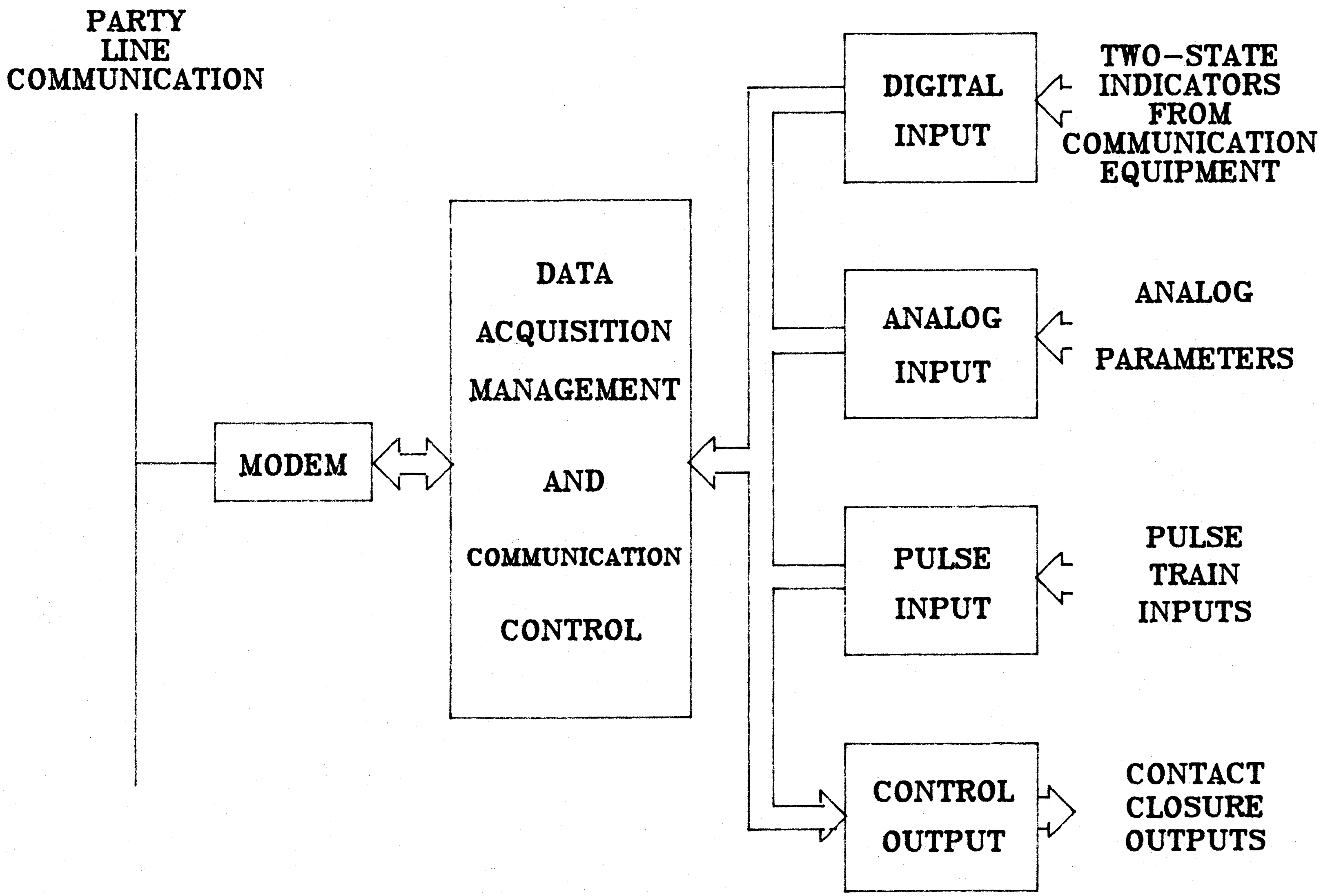

Figure 4. Functional Block Diagram of a TRAMCON remote.

designed, all of the functions they drive or monitor are those that are built into the communication equipment as status and alarm indicators and remote switching points.

The first type of signal monitored -- the two-state indicators -- are the status and alarm conditions used by an operator or maintenance person to assist in diagnosing problems with the communication equipment. They are of two types. The first is a status indicator that reports which of two redundant units is currently carrying traffic. The second type is an alarm indicator that notifies the operator that some operating parameter within the communication equipment such as oscillator frequency, power supply voltage, or signal level has passed a threshold into a region that will result in degraded equipment performance or equipment failure. Each of these two types of indication has different significance for the performance of the communication system. Though they are electrically the same indication and are indistinguishable to the remote unit, they are treated differently by the TRANCOM master.

The second type of signal the remote unit is equipped to monitor is a slowly-varying DC voltage. The communication equipment generates these voltages as analogs of parameters of interest to the operators such as radio received signal level and mission traffic signal-to-noise ratio. The remote unit samples and measures the voltage and sends the measurement to the TRAMCON master for conversion to a value in the units of the parameter being monitored for display and for further analysis or archiving.

The third type of signal monitored by the remote unit is the pulse or pulse train. The remote unit collects this data in two ways. The first is simply to count the number of pulses during the interval between poll messages from the master and to report the number in the poll response (up to the maximum count capability of the remote). The second way is to count the number of seconds between poll messages during which one or more pulses were detected. This second measure, called the number of "errored seconds" is again sent to the master unit for processing and display.

The control outputs of the remote unit that will be used to control the communication equipment are metallic relay contacts, both normally open and normally closed, without any voltage on the contacts that originates in the remote unit. Either latching or momentary contact closure is available so these outputs are able to handle a wide variety of external switch functions.

4. TRAMCON MASTER SOFTWARE

The master unit is a general-purpose minicomputer with a number of peripheral devices for large-scale data storage, information display, and communication. The computer operating system which is the software that controls the basic functioning of the computer and allows other programs to be run was purchased from the manufacturer. In addition, high-level language compilers for FORTRAN and PASCAL and a number of other useful software utilities were obtained. Manufacturer-provided software will be used to develop instructions for polling, data collection, analyses, storage and display.

The deployment of the enhanced fault alarm system on the DEB-I segment has provided a thorough test of the software used. The new TRAMCON software heavily relies on that effort for polling programs and display generation but the data storage techniques will be completely rewritten. Since the TRAMCON is intended to be used throughout the world on the Defense Communication System, the communication and data storage programs must be easily adaptable to many different types of communication equipment. Another feature that must be available is a technique for easy field entry of a communication system configuration data base. This configuration data will include such segment-peculiar items as segment identifier, number of sites, site names, communication equipment configuration, communication equipment type, trunk identifiers, and any other information needed to define the operational status of the communication system.

As the TRAMCON is more widely used, there will be further evolution of the software and displays to enhance the usefulness of the system. To make trend analysis easier for the operator, display software is planned that will summarize system performance on an hourly and daily basis. This summary will be updated each hour and the oldest hour's data will be deleted. The software will also provide for displaying any of the data on more than one terminal and for making any data available for use by other elements of network control.

4.1 TRAMCON Commands and Displays

The primary device for providing assistance to the communication system operator is the CRT terminal and hard-copy device. For this reason, a great deal of planning and testing has been done to make the formatted data displayed on the CRT terminal informative and understandable. The data displays were provided to system operators with the request that any suggestions for improvement or simplification to make the data display more easily understood be sent to the programmers for consideration. Most of the displays have been revised a number of times and the current formats are the result of considerable operating experience. In subsequent sections the formatted data presentations will be simply referred to as displays.

4.1.1 Menu of Operator Commands

The menu has a list of 38 commands, most of which evoke the various displays. Some of these commands, however, perform a specific action without regard to what display is on the screen. Table 1 shows which commands call up displays and which commands do not.

The commands can also be divided into five categories depending on the purpose and effect of the command. The first category includes those commands which are intended to assist the operator in using the TRAMCON system. The menu and help commands fit this description. The next category includes those commands which directly show or influence communication system operation. These commands would include the map, the segment status, the remote unit status alarm, and the switch commands among others. The third category comprises a set of utility commands which support the communication system operation commands. Examples of this category are the calibration curve and operator identification commands. The fourth category includes those which request information about the communication system or TRAMCON configuration, such as list or CRT status. The fifth (and final) category includes all other commands. These are commands to set the clock, switch a CRT to session monitor, and to run the diagnostic and simulator functions. Table 2 shows the commands in these various categories.

Table 1. Display and Nondisplay Commands

DISPLAY COMMANDS

AL	ALARM/STATUS DISPLAY FOR ONE OR MORE REMOTES
AR	ARCHIVE RECORD REVIEW FOR SINGLE REMOTE
CC	CALIBRATION CURVE ENTRY FOR SINGLE LINK END
CN	COUNTED TWO-STATE ALARM OR STATUS OCCURRENCE
CO	CONFIGURATION DATA BASE CHANGE FOR SEGMENT
CR	CRT STATUS FOR THIS TRAMCON MASTER UNIT
DI	DIAGNOSTIC ROUTINE, TURN ON OR OFF
DT	DATA TRANSFER TO ANOTHER REMOTE
HE	HELP WITH TRAMCON OPERATING PROCEDURES
HI	HISTOGRAMS OF A/D AND COUNT DATA FOR ONE REMOTE
LS	LIST ALARM/STATUS DEFINITIONS FOR SINGLE REMOTE
MA	MAP DISPLAY OR SEGMENT STATUS, ALL REMOTES
ME	MENU OF OPERATOR COMMANDS
MS	MESSAGE ENTRY, FOR ANOTHER TRAMCON OPERATOR
NM	NETWORK MAP SHOWING MANY SEGMENTS
PA	PARAMETER DISPLAY OF A/D AND COUNT DATA
PC	PCM ALARM SUMMARY
PM	POLLER/MONITOR/INACTIVE SELECTION FOR THIS MASTER
SC	SCENARIO MODE START FOR TRAINING
SD	SITE DIAGRAM OF COMMUNICATION SIGNAL FLOW
SE	SEGMENT NAMES IN SHORT FORM FOR COMMAND ENTRY
SS	SEGMENT STATUS TABULAR DISPLAY, ALL REMOTES
SW	SWITCHING DISPLAY FOR REMOTE RELAYS FOR ONE REMOTE
TH	THRESHOLD SET FOR A/D AND COUNT ALARM LEVELS
TR	T-1 DIGROUP FAULT MAP FOR SEGMENT
TS	SEGMENT ALARM HISTORY, SHORT TERM

NONDISPLAY COMMANDS

AC	ACKNOWLEDGE ALARMS FOR ONE OR MORE REMOTES
DE	DEFAULT DISPLAY SELECTION
EN	ENABLE ALARM NOTIFICATION FOR SINGLE REMOTE
IN	INHIBIT ALARM NOTIFICATION FOR SINGLE REMOTE
OL	ON-LINE/OFF-LINE TOGGLE COMMAND, THIS TERMINAL
OP	OPERATOR IDENTIFICATION ENTRY, THIS TERMINAL
PO	POLLING SEQUENCE CHANGE ON SEGMENT
PR	PRINT CONTENTS OF CURRENT CRT DISPLAY
SI	SIMULATOR COMMAND ENTRY FOR TRAINING
SM	SESSION MONITOR ACTIVATED AT THIS TERMINAL
SR	SYNCHRONIZE CLOCK WITH NETWORK TIME
ST	STOP TRAMCON COMMANDS AT THIS MASTER UNIT

Table 2. Command Categories

CATEGORY I, OPERATOR ASSISTANCE COMMANDS

ME	MENU OF OPERATOR COMMANDS
HE	HELP WITH TRAMCON OPERATING PROCEDURES

CATEGORY II, COMMUNICATION OPERATION COMMANDS

MA	MAP DISPLAY OF SEGMENT STATUS, ALLREMOTES
SS	SEGMENT STATUS TABULAR DISPLAY, ALL REMOTES
AL	ALARM/STATUS DISPLAY FOR ONE OR MORE REMOTES
AR	ARCHIVE RECORD REVIEW FOR SINGLE REMOTE
PA	PARAMETER DISPLAY OF A/D DATA AND COUNT DATA
HI	HISTOGRAMS OF A/D AND COUNT DATA, SINGLE REMOTE
PC	PCM ALARM SUMMARY
CN	COUNTED TWO-STATE ALARM OR STATUS OCCURRENCES
SW	SWITCHING DISPLAY FOR REMOTE RELAYS, SINGLE REMOTE
PO	POLLING SEQUENCE CHANGE ON SEGMENT
PM	POLLER/MONITOR/INACTIVE SELECTION FOR THIS SEGMENT
AC	ACKNOWLEDGE ALARMS FOR ONE OR MORE REMOTES
IN	INHIBIT ALARM NOTIFICATION FOR SINGLE REMOTE
EN	ENABLE ALARM NOTIFICATION FOR SINGLE REMOTE
TR	T-1 DIGROUP FAULT MAP FOR SEGMENT
TS	SEGMENT ALARM HISTORY, SHORT TERM

CATEGORY III, COMMUNICATION SUPPORT COMMANDS

CC	CALIBRATION CURVE ENTRY FOR SINGLE LINK END
CO	CONFIGURATION DATA BASE CHANGE FOR SEGMENT
DE	DEFAULT DISPLAY SELECTION
DT	DATA TRANSFER TO ANOTHER MASTER
MS	MESSAGE ENTRY, FOR ANOTHER TRAMCON OPERATOR
PR	PRINT CONTENTS OF CURRENT CRT DISPLAY
TH	THRESHOLD SET FOR A/D AND COUNT ALARM LEVELS

CATEGORY IV, INFORMATION COMMANDS

CR	CRT STATUS FOR TRAMCON MASTER UNIT
LS	LIST ALARM/STATUS DESCRIPTIONS FOR SINGLE REMOTE
NM	NETWORK MAP SHOWING MANY SEGMENTS
SD	SITE DIAGRAM OF COMMUNICATION SIGNAL FLOW
SE	SEGMENT NAMES IN SHORT FORM FOR COMMAND ENTRY

CATEGORY V, TRAMCON SYSTEM SUPPORT COMMANDS

DI	DIAGNOSTIC ROUTINE, TURN ON OR OFF
OL	ON LINE, OFF LINE TOGGLE COMMAND, THIS TERMINAL
OP	OPERATOR IDENTIFICATION ENTRY, THIS TERMINAL
SC	SCENARIO MODE START FOR TRAINING
SI	SIMULATOR COMMAND ENTRY FOR TRAINING
SM	SESSION MONITOR ACTIVATED AT THIS MASTER UNIT
SR	SYNCHRONIZE CLOCK WITH NETWORK TIME
ST	STOP TRAMCON PROGRAMS AT THIS MASTER UNIT

These commands are all entered at the "ENTER COMMAND" prompt and most of them have one or more required and optional fields that define the specific effect the command is to have. The command entry format is described for each of the commands in the individual menu assistance displays.

4.1.2 The TRAMCON Displays

The information collected by the TRAMCON system is presented to the system operator in the form of a number of displays on the console CRT terminal. These displays are selected by the various operator commands shown in Table 3. These displays may be shown in any sequence and those that contain current data are updated as new information becomes available.

The basic requirements for the displays were developed by the Air Force Communication Service who decided that the TRAMCON displays would provide the following features:

- a menu of operator input commands for requesting displays, entering data, or operating the remote control feature with prompting on the individual display as required
- visual tabular and graphic displays that provide data on multiple page presentations with roll-up and roll-down features
- a single display that presents an overview of major and minor alarms, site alarms, and a summary of parameter threshold transgressions
- a display that shows the alarm and status indicators for a single site, classified by link number and distant site name
- a display that shows the parameter information collected from each site, classified by link number and distant site name
- a keyboard to accept operator input commands and data
- a printer to record the contents of any of the displays
- the capability to store alarm information for later recall for trouble shooting or further analysis
- the capability to inhibit the display of alarm data from a specified site and when desired, to enable the display of this data again

Each of the displays shows a particular set of associated data either for a single parameter, a single link or site, or an overview of the entire segment. In addition, those displays that require further operator entry provide prompts to assist in these actions. The following sections provide detailed discussions of certain of the individual displays shown in Table 3.

Table 3. List of TRAMCON Displays

AL	ALARM/STATUS DISPLAY FOR ONE OR MORE REMOTES
AR	ARCHIVE RECORD REVIEW FOR SINGLE REMOTE
CC	CALIBRATION CURVE ENTRY FOR SINGLE LINK END
CO	CONFIGURATION DATA BASE CHANGE FOR THIS MASTER
CR	CRT STATUS FOR THIS TRAMCON MASTER UNIT
DI	DIAGNOSTIC ROUTINE FOR REMOTES, TURN ON OR OFF
DT	DATA TRANSFER TO ANOTHER MASTER
HE	HELP WITH TRAMCON OPERATING PROCEDURES
HI	HISTOGRAMS OF A/D AND COUNT DATA, SINGLE REMOTE
LS	LIST ALARM-STATUS DEFINITIONS FOR SINGLE REMOTE
MA	MAP DISPLAY OF SEGMENT STATUS, ALL REMOTES
ME	MENU OF OPERATOR COMMANDS
MS	MESSAGE ENTRY, FOR ANOTHER TRAMCON OPERATOR
NM	NETWORK MAP SHOWING MANY SEGMENTS
PA	PARAMETER DISPLAY OF A/D AND COUNT DATA
PC	PCM ALARM SUMMARY
PM	POLLER MONITOR INACTIVE STATUS SELECTION FOR A SEGMENT
SC	SCENARIO MODE START FOR TRAINING
SD	SITE DIAGRAM OF COMMUNICATION SIGNAL FLOW
SE	SEGMENT NAMES IN SHORT FORM FOR COMMAND ENTRY
SS	SEGMENT STATUS TABULAR DISPLAY, ALL REMOTES
SW	SWITCHING DISPLAY FOR REMOTE RELAYS, SIGNLE REMOTE
TH	THRESHOLD SET FOR A/D AND COUNT ALARM LEVELS
TR	T-1 DIGROUP FAULT MAP FOR SEGMENT
TS	SEGMENT ALARM HISTORY, SHORT TERM

4.2 TRAMCON Display Details

Since many of the displays shown in Table 3 are used to support the TRAMCON operation indirectly, we have selected ten of the displays which are used in system operation for detailed discussion. The list of these displays is given in Table 4.

The first two displays are intended to help site personnel use TRAMCON to operate the communication system. The next seven displays show how the communication system is operating, and the last display is an example of a communication support display.

4.2.1 Menu of Operator Commands

The menu of commands is more than a simple list since there are now a total of 38 commands, many of which have somewhat elaborate entry formats. For this reason, a brief discussion of the purpose and effect of each command is kept in an internal file that can be called by an operator to refresh his memory. The ME command now provides this capability. If the operator simply enters "ME", the screen will show a list of all of the two-letter commands in alphabetical order with a one phrase command title. Figure 5 shows this command list. If his entry is "ME,CA", the screen will show a list of commands with title by category as was shown in Table 2. If he enters either "ME,P" or "ME,CA,P", a printed list of commands will be produced in the appropriate order. For help with a command entry format, the operator types in "ME", followed by the two-letter command. The screen will show the correct entry syntax and if a printed copy is needed, ",P" is appended to the command. Figure 6 shows the assistance provided when "ME,CC,P" is entered. The assistance is provided for reviewing or entering calibration curve information.

4.2.2 Help with TRAMCON Operating Procedures

The purpose of this display is to provide assistance to an operator in performing a function for which a definite protocol is to be followed. For the operator to discover what help is available, he enters the "HE" command and a list of titles of assistance paragraphs is displayed. Since there are only very few paragraphs written at this time, the list is not shown but the assistance provided when "HE,BOOTUP,P" is entered is shown in Figure 7. As with the menu command, we do not expect these aids to make the system self-teaching but the assistance they provide will be very useful in training operators.

Table 4. Primary TRAMCON Displays

ME	MENU OF OPERATOR COMMANDS
HE	HELP WITH TRAMCON OPERATING PROCEDURES
SS	SEGMENT STATUS TABULAR DISPLAY, ALL REMOTES
MA	MAP DISPLAY OF SEGMENT STATUS, ALL REMOTES
AL	ALARM/STATUS DISPLAY FOR ONE OR MORE REMOTE
PA	PARAMETER DISPLAY OF A/D AND COUNT DATA
SW	SWITCHING DISPLAY FOR REMOTE RELAYS, SINGLE REMOTE
PC	PCM ALARM SUMMARY
HI	HISTOGRAMS OF A/D AND COUNT DATA, SINGLE REMOTE
CC	CALIBRATION CURVE ENTRY FOR SINGLE LINK END

*** TRAMCON Operator Command Menu ***

Category I, Operator Assistance Commands

ME Menu of Operator Commands
HE Help with TRAMCON Operating Procedures

Category II, Communication Operation Commands

MA Map Display of Segment Status, All Remotes
SS Segment Status Tabular Display, All Remotes
AL Alarm/Status Display for One or More Remotes
AR Archive Record Review for Single Remote
PA Parameter Display of A/D and Count Data
HI Histograms of A/D and Count Data, Single Remote
CN Counted two state alarm display
PC PCM Alarm Summary
SW Switching Display for Remote Relays, Single Remote
PO Polling Sequence Change on Segment
PM Poller Monitor Inactive Status Selection for a Segment
AC Acknowledge Alarms for One or More Remotes
IN Inhibit Alarm Notification for Single Remote
EN Enable Alarm Notification for Single Remote
TR T-1 Digroup Fault Map for Segment
TS Segment Alarm History, Short Term

Category III, Communication Support Commands

CC Calibration Curve Entry for Single Link End
CO Configuration Data Base Change for This Master
DE Default Display Selection
DT Data Transfer to Another Master
MS Message Entry, for Another TRAMCON Operator
PR Print Contents of Current CRT Display
TH Threshold Set for A/D and Count Alarm Levels

Category IV, Information Commands

CR CRT Status for This TRAMCON Master Unit
LS List Alarm-Status Definitions for Single Remote
NM Network Map Showing Many Segments
SD Site Diagram of Communication Signal Flow
SE Segment Names in Short Form for Command Entry

Category V, TRAMCON System Support Commands

DI Diagnostic Routine for Remotes, Turn On or Off
OL On-Line/Off-Line Toggle Command, This Terminal
OP Operator Identification Entry, This Terminal
SC Scenario Mode Start for Training
SI Simulator Command Entry for Training
SM Session Monitor Activated at This Terminal
SR Synchronize Clock at Remote or Master Specified
ST Stop TRAMCON Programs at This Master Unit
TM Time/Date Set for Master Computer Clock

Figure 5. The menu of 38 operator commands.

*** TRAMCON Operator Command Detailed Descriptions ***

CC Calibration Curve Entry for Single Link End

CC[,short_segment_name],remote_id

This command displays the calibration curves for the analog parameters. These calibration curves, or more accurately, calibration tables are used to convert the voltage levels read by the TRAMCON remote units and sent to the master into receiver signal levels and distortion readings in dBm (decibels referenced to one milliwatt). The purpose of the display is to allow an operator to enter new values into the tables or to correct old ones. The calibration table values are determined at the remote units by injecting a known signal level into a radio receiver and reading the output of the analog to digital converter in the TRAMCON remote unit. These values are brought to the master and entered into the tables. The command has an optional field and a required field. The optional field permits a short segment name to be entered if the link of interest is not on the current segment. The remote identifier defines the site for which the curves are to be shown. The display allows all calibration curves for an entire remote to be reviewed and provides soft-key prompts to assist the operator in selecting the desired curve and in making any required changes.

Figure 6. Operator assistance for the CC command.

*** TRAMCON and SITE Operating Procedures ***

BOOT-UP System boot-up procedure

The procedure given here is used to re-start the computer if after a repair or other problem situation the "RUN" light on the computer is not lighted.

PROCEDURAL STEPS

1. Press the computer "HALT" button.
2. Select the "S" register.
3. Set bits 15, 14, 12, 9, 7, 1 (151202 octal) ON in the "S" register.
4. Press "STORE".
5. Press "PRESET".
6. Press "IBL".
7. Press "PRESET" (again).
8. Press "RUN".

This procedure will start the computer if the proper programs are loaded. The disc memory will rattle a bit, the default display will be shown on the terminal and TRAMCON will be running. If this result is not observed, it may be necessary to reload the system software tape following the "TAPE LOAD" help procedure, and if this doesn't correct the problem, it may be necessary to follow the "TRAMCON MASTER FAILURE" procedure to have the computer restored to service.

Figure 7. TRAMCON operator assistance for BOOT-UP.

4.2.3 Segment Status Tabular Display, All Remotes

The display TRAMCON scheme has been designed to present an overall picture of system operation and then, at the desire of the operator, to present detailed information about a particular site or a particular aspect of site performance. The development of the segment status display was an initial effort to present enough information about each site on the segment at once to indicate whether the mission traffic was passing through without degradation. Figure 8 shows the segment status display in its current form. The sites are identified by site name and 3-letter designator and indications are provided for site not being polled, site not answering, site currently being polled (shown by the moving cursor as can be seen next to the HST site), and indication of the occurrence of major and minor site and equipment alarms. As alarms occur, the display is changed to indicate that an alarm in one of the categories has occurred. An audible indicator will sound each time the site with an alarm is polled. Site alarms are categorized as major or minor on the basis of the impact on the mission traffic. A major alarm generally indicates problems in a subsystem that could cause failure of the primary and redundant equipment and interruption of mission traffic. A minor alarm is indicative of a problem in only one of two redundant elements or a failure of an equipment that would not impact all of the mission traffic. The appearance of the alarm indication is changed and the audible indicator silenced once the operator acknowledges the alarm condition at the site by the appropriate keyboard entry.

The display also shows the Julian day and time, the operator's identification and which of the masters on the segment is the polling master. The segment status display will also usually be the default display, although the choice of the default display is made by the operator. The default display is the one that will return to the CRT automatically if any other display has been on the screen and no operator commands have been entered for 180 seconds.

4.2.4 Map Display of Segment Status, All Remotes

The segment status display provides a good picture of the condition of the segment presented in a text format but suggestions from the users indicated that a more graphic depiction of segment operation would be useful. Since the CRT terminals purchased for use on the TRAMCON have a graphic capability, a schematic map of the segment was developed that gives all of the status display information in a geographic form. The final development of the segment map display will

15
332/12:13:48 *** DEB2A Segment Status *** Opr:

	Site		Equipment		Parameter	
	Major	Minor	Major	Minor	Status	
DON Donnersberg						DON
LKF Langerkopf						LKF
FRI Friolzheim						FRI
SGT Stuttgart						SGT
HST Hohenstadt		1		8		HST
BST Bonstetten						BST
RAG Reese-Augsburg						RAG

Enter Command: pr

Monday 28 November 1983

Figure 8. Segment status tabular display.

include improvements suggested by the communication system operators as has been the case with all current displays. Figure 9 is an example of the current state of development of the map display.

4.2.5 Alarm/Status Display

To give the communication system operator a detailed picture of conditions at a site, this display provides a list of all status conditions and all active alarms at a site. Information is presented for all link ends located at the indicated site and are on the segment of interest. Figure 10 shows the display intended to satisfy this requirement. The display first shows the alarms that are general site functions and not associated with any particular link end or direction. Next in order are the alarms and configuration status information listed by terminal end for each link. Within each link end group, the major alarms are presented first, next the minor alarms, and finally, the communication system status or configuration indicators.

This display has a header that shows which site the information being displayed applies to, the time and day, and the operator identification. The leftmost part of the display shows the link number and 3-letter abbreviation of the site at the distant end of the link. In addition, a Julian day and time group is listed following each line of information on alarm or status. This time marker indicates when the alarm was first detected or when the indicated system configuration was established. Not shown on the figure, but a part of the display, is an indication of "new" following the date-time indication for each alarm or status which was activated just prior to the current poll cycle. An indication of "clear" in the same location indicates that an alarm or status was deactivated since the current poll cycle. A short-term history of alarm occurrences is maintained in the computer files extending for one or two days in the past. The alarm indications in these files can be inspected by requesting them by time of occurrence. The resulting display looks like the Site Alarm and Status Display and contains the same information.

4.2.6 Parameter Display of Analog and Count Data

The signal quality parameter display, shown in Figure 11, shows the analog parameters and pulse totalizer or frequency counter data acquired from each remote location. The display heading shows the date and time, the site, the display title and the operator identification. The most significant of these parameters is the received signal level for each receiver shown in the figure

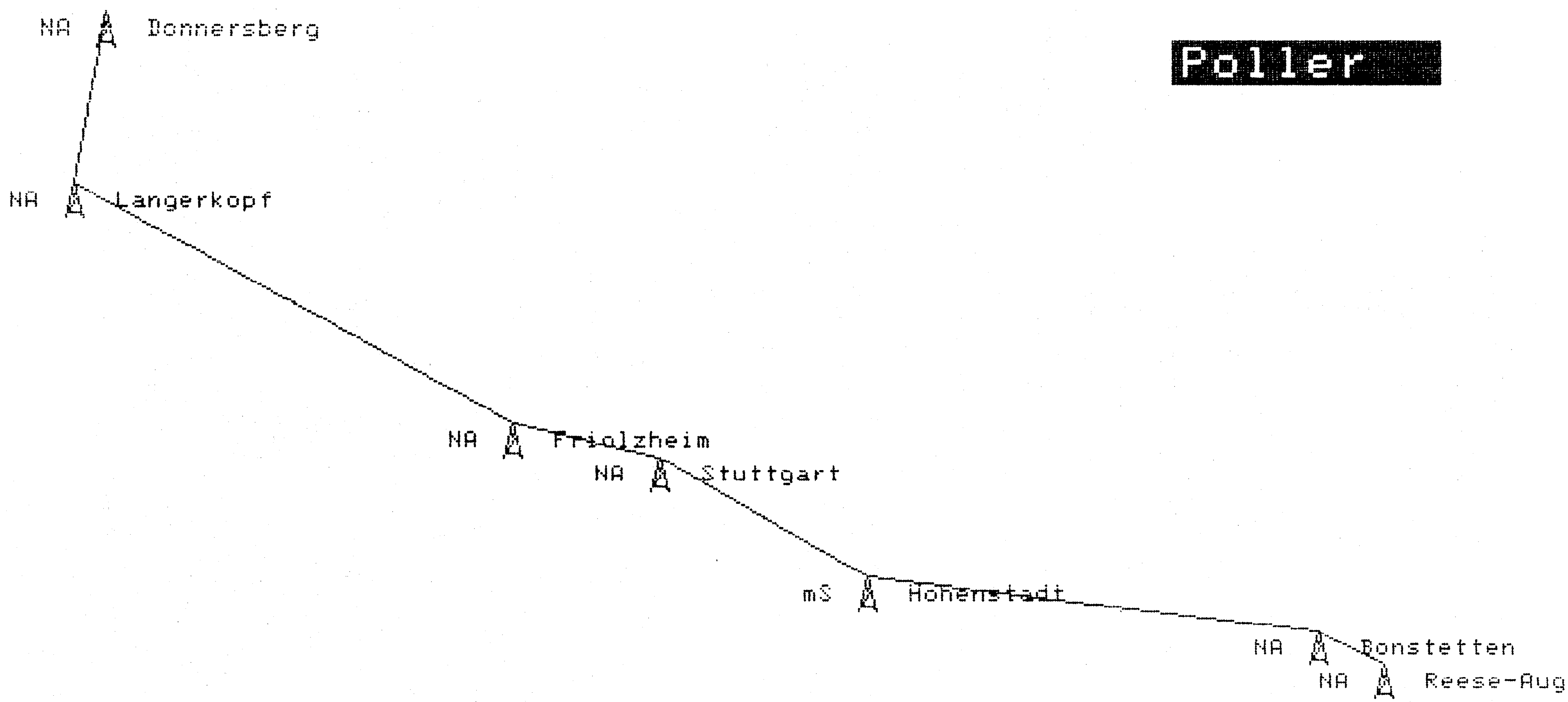

Figure 9. Map display for segment.

332/12:23:16	*** DEB2A Alarm/Status *** Opr:
HST - Hohenstadt	Drama Pulsecom
Hohenstadt Site	DEB-2A Site Equipment
MINOR Tower Light Out	Previous
Status Generator #1 On	Previous
Status Tower Light On	Previous
Hohenstadt link to Stuttgart	FRC-171
MINOR TDM B Mux A Input Loss	320/12:31: 4
MINOR Mission Bit Stream A PCM #1 Failed	320/12:31: 4
MINOR Mission Bit Stream A PCM #3 Failed	320/12:31: 4
MINOR Mission Bit Stream A PCM #4 Failed	320/12:31: 4
MINOR Mission Bit Stream B PCM #1 Failed	320/12:31: 4
MINOR Mission Bit Stream B PCM #7 Failed	320/12:31: 4
MINOR Mission Bit Stream B PCM #8 Failed	320/12:31: 4
Status Transmitter B Operating	320/12:31: 4
Status Receiver B Operating	320/12:31: 4
Status TDM A Mission Bit Stream B	320/12:31: 4
Status TDM B Mission Bit Stream B	320/12:31: 4
Status TDM MBS A Switch-over Automatic	320/12:31: 4
Status TDM MBS B Switch-over Automatic	320/12:31: 4
Hohenstadt link to Bonstetten	FRC-171
MINOR Mission Bit Stream A PCM #1 Failed	320/12:31: 4
Status Transmitter A Operating	320/12:31: 4
Status Transmitter B Operating	320/12:31: 4
Status Receiver A Operating	320/12:31: 4
Status TDM A Mission Bit Stream A	320/12:31: 4
Status TDM B Mission Bit Stream A	320/12:31: 4
Status TDM MBS A Switch-over Automatic	320/12:31: 4
Status TDM MBS B Switch-over Automatic	320/12:31: 4
Status Transmitter Manual Mode	320/12:31: 4

Figure 10. Alarm/status display for one remote.

332/12:19:25 *** DEB2A Signal Quality Parameters *** Opr:

HST - Hohenstadt		Drama Pulsecom
Hohenstadt Site		DEB-2A Site Equipment
Site Battery	-48.57 volts	
Hohenstadt link to Stuttgart		FRC-171
Receiver A RSL	-29 dBm	
Receiver B RSL	-34 dBm	
Receiver A Signal Quality	-55 dBm	
Receiver B Signal Quality	-39 dBm	
Frame Error Seconds Receiver A	12	
Frame Error Count Receiver A	139	
Frame Error Seconds Receiver B	13	
Frame Error Count Receiver B	141	
Frame Error Seconds TDM A	13	
Frame Error Count TDM A	142	
Frame Error Seconds TDM B	0	
Frame Error Count TDM B	0	
Hohenstadt link to Bonstetten		FRC-171
Receiver A RSL	-37 dBm	
Receiver B RSL	-46 dBm	
Receiver A Signal Quality	-29 dBm	
Receiver B Signal Quality	-46 dBm	
Frame Error Seconds Receiver A	0	
Frame Error Count Receiver A	0	
Frame Error Seconds Receiver B	0	
Frame Error Count Receiver B	0	
Frame Error Seconds TDM A	0	
Frame Error Count TDM A	0	
Frame Error Seconds TDM B	0	
Frame Error Count TDM B	0	

Figure 11. Parameter display of analog and count data.

under that heading. The value shown is the signal level in dBm of the receiver input at the time of the most recent poll. The value is acquired as a dc voltage at the remote unit and converted at the master to an equivalent power level in dBm via the calibration curve. The resulting value is compared with preselected threshold values. If a threshold value has been passed, the condition is noted as an "A" for amber or "R" for red next to the numerical value. Further, an underline is shown under one of the two received signal level values for each link. This underline on the display, which appears as an inverse video block on the CRT display, is used to indicate which receiver is carrying the mission traffic.

Below the received signal level readings are values for an analog parameter derived as a mission data stream quality monitor that is presented in the same way as the received signal level.

The count parameters show the results of monitoring the DRAMA radio and the time division multiplex frame integrity. The first value of each pair shows the cumulative number of seconds within the current poll cycle that one or more frame errors were detected. The second value shows the total number of frame errors detected during the last poll cycle. This display is called by site so that it shows all of the link ends on a segment at the named site.

4.2.7 Remote Control Switching

This display is the one through which remote interaction of the communication system operator with site electronic equipment is permitted. The remote TRAMCON units are equipped with relays that have either momentary or latching contacts to perform site and equipment control functions. These are individually activated by control messages originating in the TRAMCON master when the operator makes the appropriate keyboard entries. Figure 12 shows the remote control switching display. The functions are selected by letter and before sending the switching message, the computer requires confirmation that the switch function requested is the one intended. As a further safeguard of system integrity, certain switch combinations that could be requested are detected by the computer and will not be performed since they would result in a system outage. The forbidden combinations are those that would place both radio receivers in an off-line condition or disable both radio power supplies, for example. The algorithms that prevent such incorrect switching actions can be expanded as the number of remote functions increase to any contemplated extent.

306/ 9:07:13 Remote Relay Switching for Hohenstadt to Stuttgart Link

A. Select Radio Transmitter A
B. Select Radio Transmitter B
C. Select Radio Receiver A
D. Select Radio Receiver B
E. Resynchronize TED A
F. Resynchronize TED B
G. Restart TED A
H. Restart TED B
I. Mission Bit Stream A TDM Switch-over
J. Mission Bit Stream B TDM Switch-over
K. TED A Bypass Latching
L. TED B Bypass Latching

Issuing Broadcast Clear , Please WAIT

Figure 12. Switching of remote relays.

4.2.8 PCM Alarm Summary

Customer service availability is one of the most important measures of communication system performance. In order to provide the operators with a measure of how well the customers are being served in this regard, a display was developed that provides a measure of the time during which the first level multiplex and digroup PCM equipment is in an alarm condition. The digroup alarm is connected to a latching input on the remote data acquisition unit so that if the alarm comes on any time during a poll cycle (about 45 seconds) the alarm will be reported "on" when the site is polled. The latching alarm input is reset when the site is polled so if the alarm in the PCM unit is clear, the next poll of the site will not report this alarm. The occurrence of these alarms is accumulated for one hour and reported as "Alarm-Scans/Hr". The number of hours during the calendar week (168 hours, starting at 0000 hours Sunday) when one or more loss of frame alarm scans were observed are recorded. Figure 13 shows the display of this information. The header gives the time and date, the display title, and the number of alarm-scans per hour that will cause a system alarm condition. The trunk number and the site and port number of the trunk identify the equipment involved. Alarm scans per hour are accumulated for PCM digroup equipments at both ends of the trunk and a nonzero entry in either of these columns will add a count to the alarm-hour column at the end of the clock hour. As an aid in trouble shooting the communication system, a list of intervening sites (excluding the end points) is provided. An operator should suspect that a site common to a number of trunks (digroups) with many alarms might be the location of the problem. The Figure 131 in the count column gives the number of alarm scans since the last reset.

4.2.9 Histograms of A/D and Count Data

In addition to monitoring status and alarm occurrences, the TRAMCON system obtains readings of analog parameters that influence system performance. These parameters are radio link received signal level and digital baseband signal-to-distortion ratio. These parameters are random variables but do show statistical regularity so the data are handled in a statistical manner. The samples of each received signal level and baseband distortion from each link end are obtained in terms of voltage by the remote units and converted to decibel units by the master. These converted values are quantized into 3 dB bins and assembled into separate hourly histograms which become the data which is retained for display. Figure 14 is an example of this display showing totalized values of received signal level for each hour in the preceding 24-hour period. The 20 3-dB intervals of signal

332/12:41:43 *** DEB2A PCM Digroup Alarms *** Opr: R Statz

Trunk-id	Digroup	Count		Intermediate Sites
45UNBE	CLO-A5:SGT-B5		0	MEA-MTC-MCA-PAG-CIM-ZUG-HST
44UNPA	DON-A6:VHN-A5	0		LKF-FRI-SGT-HST
44UNLA	LDL-A7:SGT-A5		0	DON-LKF-FRI
44CNJ3	DON-A4:LKF-A4	0	0	
45UNDA	DON-A3:CLO-A3	0		LKF-FRI-SGT-HST-ZUG-CIM-PAG-MCA-MTC-MEA
44CNJ2	DON-A1:LKF-A1	0	0	
44CNJ1	DON-A1:LKF-A1	0	0	
44UNPZ	DON-B8:HST-B8	0	131	LKF-FRI-SGT
44UNPB	DON-B6:VHN-B6	0		LKF-FRI-SGT
44UNLB	LDL-A6:VHN-A7			DON-LKF-FRI-SGT
44CNJ6	DON-B4:LKF-B4	0	0	
44CNJ5	DON-B3:LKF-B3	0	0	
44UNE8	DON-B2:SGT-B2	0	0	LKF-FRI
44CNJ4	DON-B1:LKF-B1	0	0	
44CNZ2	LKF-A7:HST-A7	0	0	FRI-SGT
45CNCA	LKF-A4:CLO-A4	0		FRI-SGT-HST-ZUG-CIM-PAG-MCA-MTC-MEA
44CNP8	LKF-A2:VHN-A4	0		FRI-SGT
44CNP1	LKF-A1:SGT-A2	0	0	FRI
44CNZ3	LKF-B7:HST-B7	0	131	FRI-SGT
44CNP9	LKF-B3:VHN-B3	0		FRI-SGT
44CNP2	LKF-B1:SGT-B1	0	0	FRI
44UNX4	SGT-A5:RAG-A5	0	0	HST-BST
44UNYJ	SGT-A2:VHN-A3	0		HST
44UNYA	SGT-A1:HST-A1	0	131	
44UNX5	SGT-B6:RAG-A6	0	0	HST-BST
44UNX3	SGT-B4:RAG-A4	0	0	HST-BST
44UNYK	SGT-B2:VHN-A4	0		HST
44UNYB	SGT-B1:HST-B1	0	131	
44UNX2	HST-A2:RAG-A2	0	0	BST
44UNX1	HST-A1:RAG-A1	131	0	BST

Figure 13. PCM alarm summary.

284/15:06:38 Receiver A RSL Histogram , Hohenstadt to Stuttgart

hr	-28	-31	-34	-37	-40	-43	-46	-49	-52	-55	-58	-61	-64	-67	-70	-73
16			7													
17			58													
18			59													
19			59													
20			60													
21			57													
22			52	3	2	2										
23			49	5	1	2	1									
0			58													
1			59													
2			59													
3			57													
4			60													
5			59													
6			59													
7			58													
8			59													
9			60													
10			60													
11			59													
12			58													
13			58													
14			58													
15			59													

Figure 14. Received signal level histogram display.

level are shown on the second line of the display. These intervals are labeled as the received input signal power in dBm (decibels referred to one milliwatt) at the center of the interval. The lefthand vertical column shows the local time when the histogram was completed. The line for each hour shows the number of received signal level samples that fell into each interval. With this display, it is possible to determine the median or average value of received signal level over several hours or to examine the variation of RSL within each hour.

4.2.10 Calibration Curve Entry for Single Link End

The data on all analog parameters, that is those reported as a wide range of levels rather than just "off" or "on", are gathered as voltage readings each of which can be converted uniquely to a value of the parameter being monitored. The information that allows this conversion of values is a calibration table or a calibration curve. The table gives discrete values of the parameter in terms of the measured voltages while the curve gives continuous values so that any voltage reading within range could be converted to a corresponding parameter value. The calibration data stored in the computer is a calibration table of discrete values but the conversion algorithm permits interpolation between table values so, in essence, a calibration curve is available. The calibration table is developed on site and is simply a list of measured responses to known input levels. These calibration tables are entered by the operator with prompting from the calibration curve display shown in Figure 15. The displays are called by the entry of "CC", for calibration curves, the segment identification, the site identification for which the information is required, and the distant site to identify the radio link involved. The calibration tables are then entered or changed following the prompts given on the display. These changes are made to the stored calibration tables within the computer memory.

5. OPERATIONAL EXPERIENCE

The initial EFAS (now TRAMCON) installations were made four years ago, so some experience with the system has been gained. The primary users of the DEB-I TRAMCON have been the technical control personnel on the sites where the master units are located. In late 1981, a maintenance dispatch terminal was added to a site with no master unit but from which maintenance teams are dispatched to several unmanned sites in the area. The purpose of this installation was to learn some of the problems and possibilities of a remote terminal and to permit the maintenance dispatch personnel to use the remote terminal to develop

```
284/11:24:37  *** DEB2A  Parameter Calibration Curves *** Opr:

Category: Hohenstadt link to Stuttgart          Receiver B Signal Quality

            dBm  centiVolts
            -28     -239
            -31     -278
            -34   =)-317
            -37     -356
            -40     -395
            -43     -434
            -46     -473                RETURN - choose another parm
            -49     -512                "+"         next value
            -52     -551                "-"         previous value
            -55     -590                [SPACE BAR  to change value
            -58     -629
            -61     -668
            -64     -707
            -67     -746
            -70     -785
            -73     -824
```

Figure 15. Calibration curve entry for single link end.

operating procedures. As the TRAMCON program has developed, the military personnel who are and will be using the system have had a definite formal channel to assist in the design and development of the displays, the operator input commands, and the operating doctrines and procedures.

5.1 Uses of the TRAMCON Concept

The TRAMCON concept emerged from the realization that first, the type of communication equipment now being installed particularly for line-of-sight links does not require constant attention and second, that providing full staffing at all sites even relay sites with no voice break-outs was an expensive and inefficient use of trained operators. The opportunity for centralized control and maintenance dispatch over limited segments of the system was recognized but a prerequisite for taking advantage of the opportunity was a means for gathering information quickly from each site in the segment and presenting the information to a technical controller in a format that would allow one segment operator to monitor, control, and dispatch maintenance for all sites in a segment. The technique developed has allowed reduced staffing at many sites, particularly those which are difficult to reach in winter or which are colocated with other United States or NATO military functions. Maintenance teams are dispatched from central locations at the request of the segment operator to sites from which reports of faults or failures have been collected by the TRAMCON system. While this system has been in operation on the DEB-I segment, no decrease in communication channel availability has been observed that is both a testimonial to the equipment selection, link design, and installation as well as a justification for the faith which the MIL DEPS placed in the idea.

A dollar figure for the savings permitted by the TRAMCON system would be difficult to calculate precisely. If a figure of $100,000 to support a soldier in the European theater for one year is assumed, the release of one personnel slot at a site for 24-hours-a-day staffing can save the expense of five persons or $500,000 per year. The reduction of necessary personnel by 300 individuals in the theater would provide savings each year greater than the entire cost of the system.

5.2 Future Plans for TRAMCON

The introduction of computers into the operation and management of military wide-band strategic communication systems permits a new alignment of resources to perform the primary task of the communicator namely, to provide the best quality of communication service to the customer user at the lowest cost consistent with the established constraints of required service availability and available physical plant.

As the field experience with the DEB-I TRAMCON developed it became apparent that the computer could provide a degree of fault isolation. The alarm data was already being collected and fairly simple fault isolation algorithms could be developed to isolate equipment faults to major modules. This function will be part of the TRAMCON final software.

The original DEB-I CRT terminals were simple alphanumeric screens and all information was shown in this format. Suggestions were received from the users to the effect that graphical presentations might make the information easier for operators to grasp at a glance. An initial effort in this direction was a map display showing the segment status that was made up of ASCII characters such as hyphens, dashes, and slashes. This was so well received that the new TRAMCON terminals have full graphic capability and new displays will be developed that will present information in either text or graphic format at the choice of the operator.

The fact that each computer has available complete and current data on the segment it is monitoring suggests that such data could be gathered for many segments and collated to provide status information on communication system operation on a much wider geographical basis than a single segment. This would allow a network control technique to be developed that could permit much more rapid restoral of critical communications and improved operating procedures. The new TRAMCON computers will have a dedicated data port to which such a network monitoring system could be connected if this is desired.

Another enhancement of the TRAMCON system under active development is the replacement of the wired-logic data acquisition equipment by a microprocessor controlled unit that would permit some data processing to be done at each site to reduce the volume of information sent to the TRAMCON master during each poll cycle. This would have the advantage of permitting a more rapid poll cycle so that displayed information is as current as possible. This would more nearly approach a real-time display of segment status and permit more timely reaction to imminent system failure and in so doing, increase the reliability of communications. Another advantage of the intelligent remote unit would be the support for local maintenance and repair. Such a system would make possible some very sophisticated detailed fault isolation algorithms that would combine automatic data collection, computer prompting of the maintenance personnel, and hand entry of data for further analysis. Such a technique could considerably improve the speed and effectiveness of maintenance and repair actions and place much less stringent demands on maintenance personnel training.

6. CONCLUSIONS

The use of computer technology to improve the range and capability of the human operator of any process has been amply demonstrated. Many of the features of modern life would not exist or would be prohibitively expensive without computer assistance. Examples of tasks that depend heavily on computer assistance are banking, airline reservation systems, and long-distance telephone calling. In each of these areas, the present level of activity would be impossible without machine assistance.

The TRAMCON project started in a small way with limited objectives. As these were met, other desirable features were added but only in an orderly way so that adding some new feature would not cause TRAMCON system failure. During the development, the users were consulted frequently to get their reactions to the actual operation of TRAMCON and the information which it provided.

The result of this steady development is a monitoring scheme that is easy to use and has permitted savings in personnel costs. The success of the concept can be gauged by the fact that the TRAMCON system has been adopted by the Defense Communication Agency for worldwide deployment.

7. ACKNOWLEDGMENTS

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14. SUPPLEMENTARY NOTES

15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This paper describes a minicomputer-based communication system monitor used by the U.S. Department of Defense to improve the performance and reduce the operating costs of the new multi-channel digital transmission systems. A brief history of the development of the monitor and a description of the present-generation hardware and software are included.

16. Key Words *(Alphabetical order, separated by semicolons)*

Communication system control; computer monitor; digital transmission; information display; software development

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