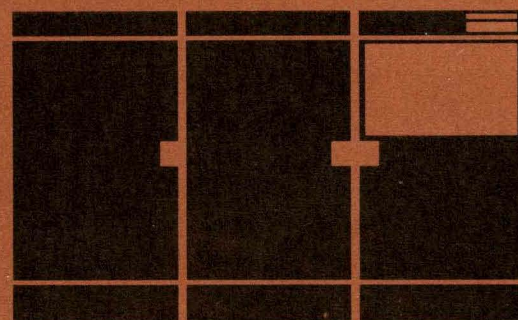
DATANET-30 Implementation of a Switching Center



GENERAL ELECTRIC

CPB-1099

82 pp

DATANET-30 IMPLEMENTATION OF A SWITCHING CENTER

A CASE HISTORY

February, 1965

GENERAL ELECTRIC
COMPUTER DEPARTMENT

PREFACE

Any successful systems installation project requires the skills and talents of many professional contributors who may not be acquainted with the intricate world of message-switching systems. It is to these people that this publication is directed.

DATANET-30 Implementation of A Switching Center is an introductory text designed to acquaint the reader with the experiences of installing a DATANET-30 in a message-switching system and to give some indication of the benefits it provides.

As a case history, and in some respects an application study, this document can be effectively used to develop a comprehensive course on message-switching applications. For this purpose, reading of the DATANET-30* Half-Duplex Message Switching System Manual CPB-1018 is recommended for the complete documentation of an operating program.

Comments on this publication may be sent to Technical Publications, Computer Department, General Electric Company, P. O. Box 2961, Phoenix, Arizona 85002.

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ILLUSTRATIONS

1. GENERAL DESCRIPTION

Included in the implementation of a switching center are three documents that were presented to and discussed with the customer at various stages of the project. These three documents are:

1. System specifications
2. System operating characteristics
3. System installation and cutover procedures

Documents of this type are necessary to properly and adequately define the system implementation to both the customer and General Electric. Without system definition, very little productive work can be accomplished.

The original implementation schedule for installing the DATANET-30 is shown in Figure 1. This was to be a "turnkey" job in which General Electric had the responsibility for implementation. The programs shown as complete were to be taken from another operating system and used with minor modifications. The total effort to be expended on the job was to be 18 months using three experienced real-time programmers.

The schedule shows that the programming effort for the system was divided into two parts. The first part included the basic programs necessary to switch messages (the on-line program). The second part involved the secondary programs necessary to a complete switching system, but not necessary to switch messages (the off-line program).

In retrospect, the schedule was valid and would be used again under similar circumstances. There were some adjustments made due to unforeseen events such as delays in receiving the Teletype test equipment, illness, and crash work on more critical jobs. The projected date of April 13, 1964, was missed by only 21 days as the system was cutover on May 4.

Prior to the start of the schedule, discussions were held with the customer to determine the general definition of the system. From these discussions, the system specifications were developed into a final document used as the guide for further work on the system. As the flow charting and programming progressed, various changes, additions, and deletions to the specifications occurred. Before system debugging could take place, these changes had to be discussed and resolved. The operating characteristics were documented in fiscal week 45. This was the final system document and only minor changes were made before cutover. Approximately two months before the system cutover, discussions were started on the cutover procedures and the system installation and cutover procedures were released during fiscal week 8.

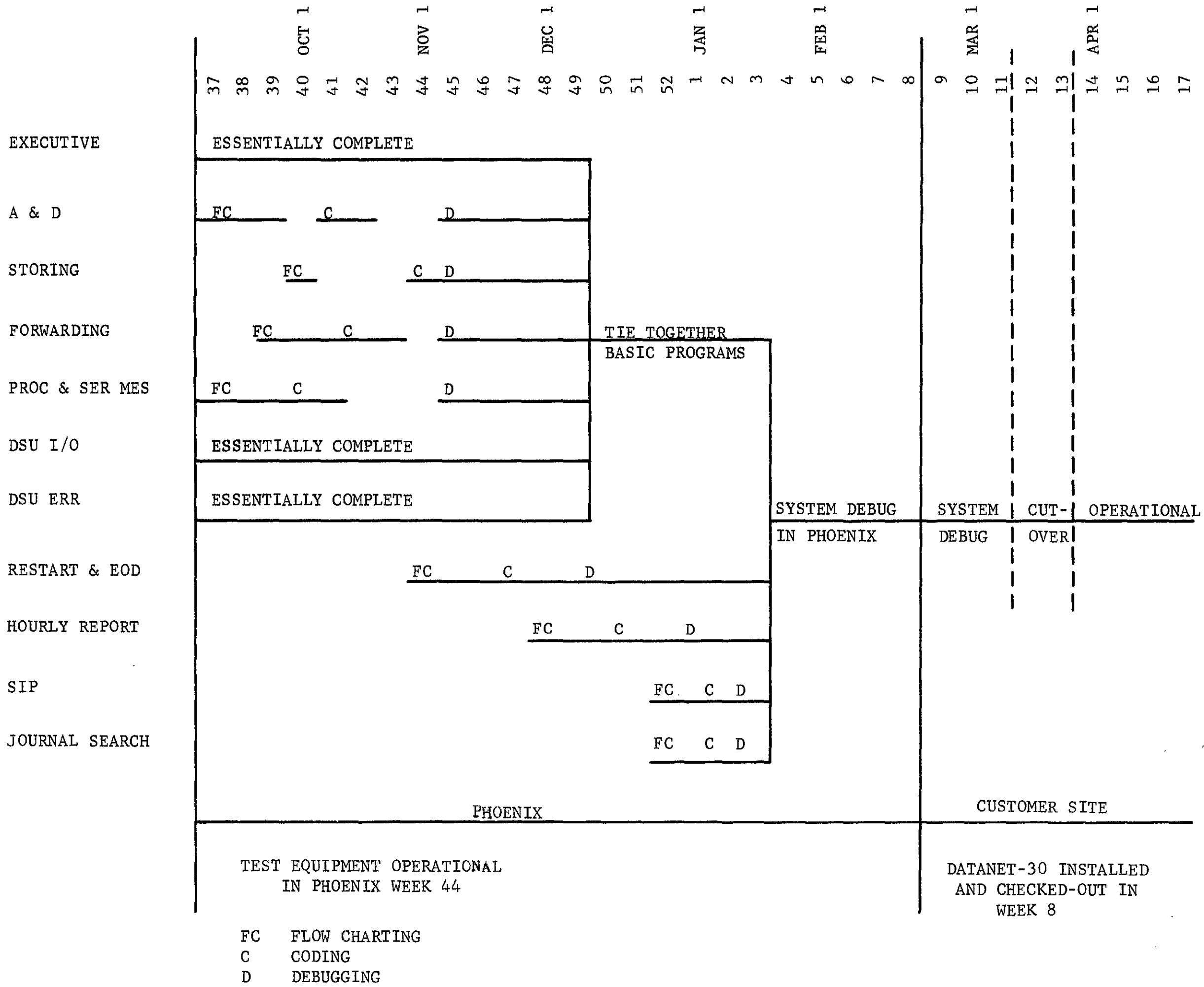


Figure 1. Implementation Schedule

Two months after the system was cutover and fully operational to the initial specifications, the customer started to incorporate several additions to the system. The additions incorporated because of the experience gained in operating the switching center were:

1. A service message to select the next station to poll on a circuit.
2. A service message to put a station on SKIP (not to poll that station).
3. A service message to put a line on SKIP (not to poll that line).
4. A sum of traffic sent and received by station, and subsequent totals in the traffic report.
5. An automatic hourly printout on the monitor of the stations on intercept.
6. Rush priority for all traffic originating at network control.

2. SYSTEM SPECIFICATIONS FOR A DATANET-30 SOLID-STATE SWITCHING CENTER

MESSAGE SWITCHING NETWORK

The DATANET-30 located in the relay center is a stored program computer that will perform the message switching function. The basic message switching system to be implemented is a Store and Forward system. This system dictates the need of an auxiliary storage media for intercept, queue, and journal storage; a disc storage unit (DSU) is used as this auxiliary storage. The DSU is shared with a GE-225 through a dual access controller (DAC) which in turn is connected to the DATANET-30 through the controller selector.

Messages enter the DATANET-30 through the buffer selector (see Figure 2). Initially, there were 20* half-duplex lines of 100 speed with 83B2 line operation connected to the DATANET-30. The DATANET-30 controls these lines and switches messages between them. The system was designed to accept messages from the GE-225 via the DSU.

There are six long lines under way circuit control with 60 remote stations, each station being equipped with a Model 28 Automatic Send/Receive Unit. Because several stations on a line are polled more often than the others, and the relay center is considered a station on the line, there are, in effect, 100 stations in the polling pattern.

The six* Automatic Send/Receive Units (ASR) at the relay center are used to transmit messages to the remote stations. Each ASR is on a separate bit buffer channel and each has a selector attached. This allows the DATANET-30 to poll the ASR's and gives system control to the DATANET-30.

The four Receive Only Units (RO) at the relay center are used to receive messages sent to the relay center. Each RO is on a separate bit buffer channel allowing the DATANET-30 to recognize an answerback from the RO. The messages are distributed proportionately to each RO. The two* local lines are 83B2 half-duplex; the remote stations are located at various local sites. The supervisory position (Network Control Station) at the relay center is an ASR and RO*, each on a separate BBC.

The six long lines can be expanded to at least nine long lines under way circuit control. The 60 remote stations can be expanded to 90 stations and the polling pattern can be expanded from 100 effective stations to 150 stations. However, certain tradeoffs can be made in expansion. For example, more than nine long lines are possible if the polling pattern does not exceed 150 stations. The total number of stations is important because a finite area must be reserved in core memory for expansion to store the polling and routing tables.

* In all instances an asterisk denotes where changes were made in the specifications as a system designed progressed.

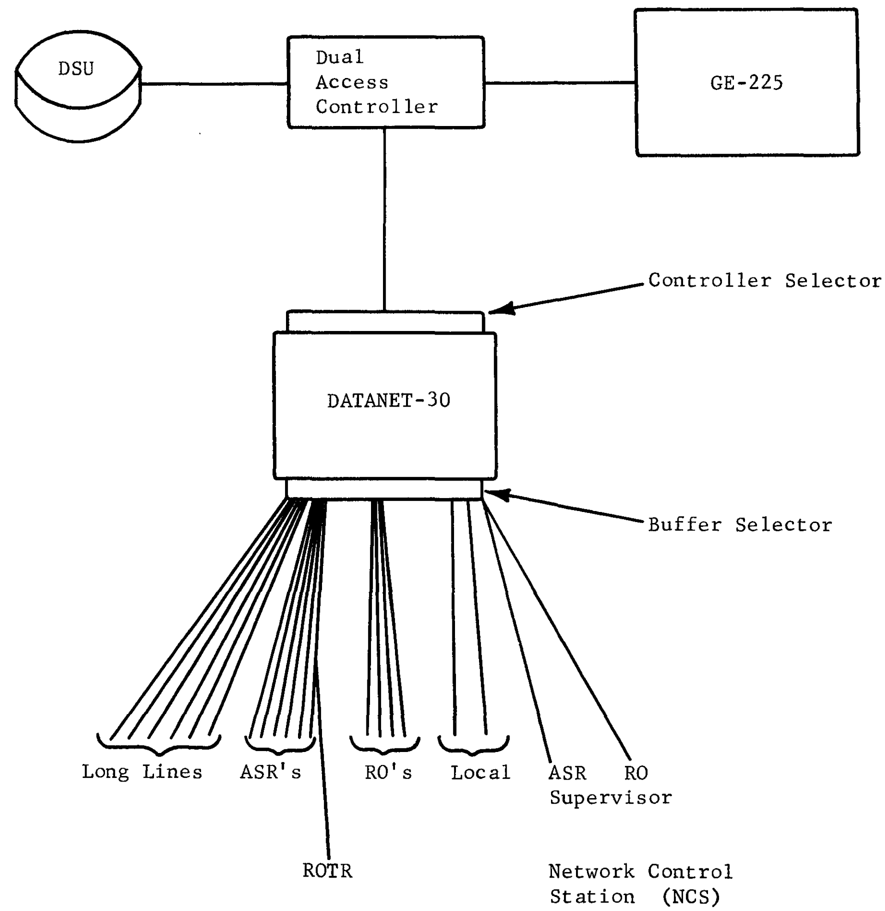


Figure 2. Relay Center Equipment Configuration

The estimated volume of traffic through the system is 1,000,000 characters per day. The average number of messages is 2000 per day. The combination messages comprise 11 percent of the total messages transmitted, however, 10 percent of the total messages transmitted are only two address and 1 percent of the total messages are three or more addresses.

SYSTEM ORGANIZATION

Figure 3 illustrates the basic organization of the DATANET-30 Switching Center. The system is divided into seven areas:

1. Executive control
2. Message accumulating
3. Message storing
4. Message processing
5. Message forwarding
6. Message distributing
7. Off-Line processing

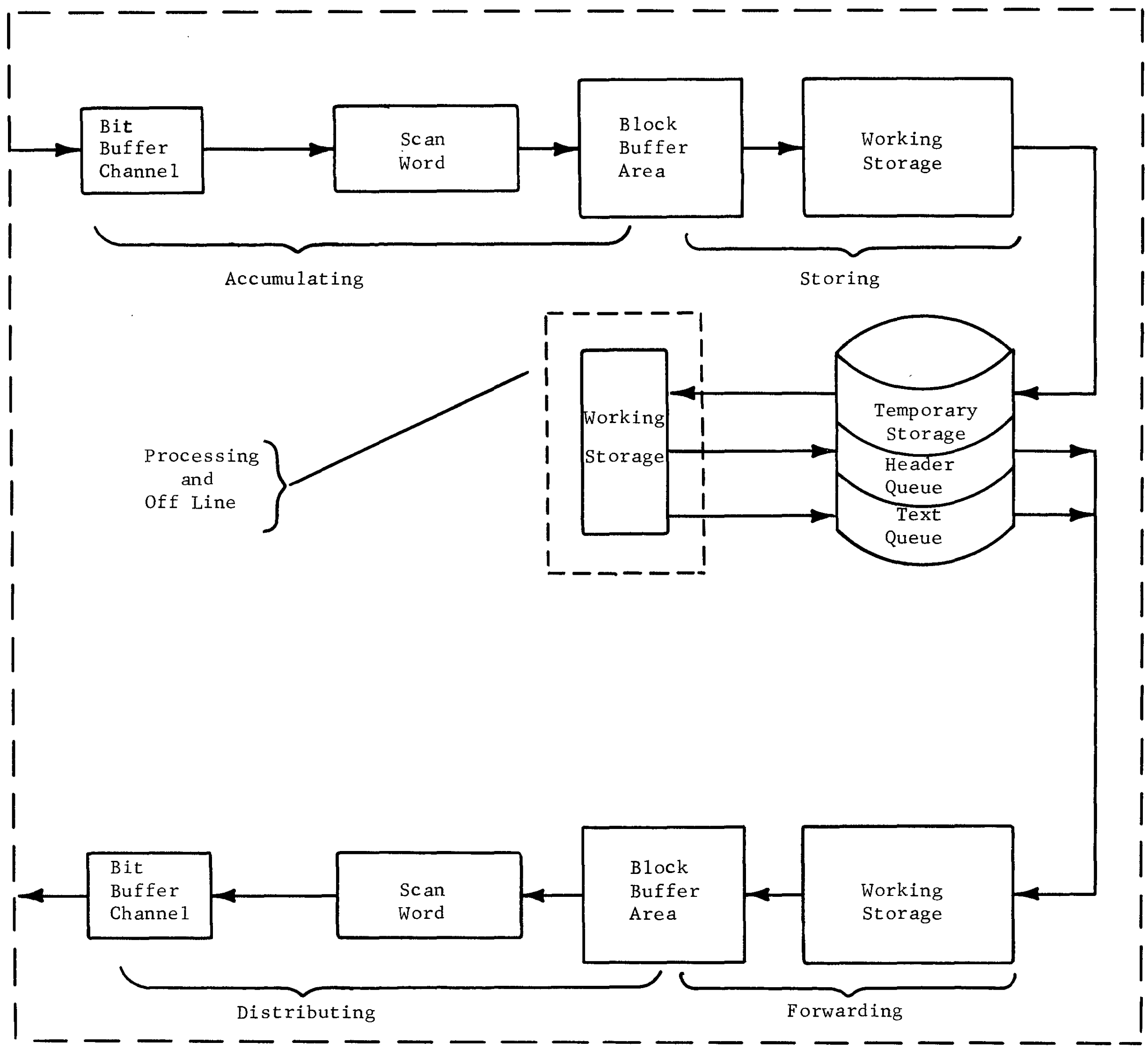


Figure 3. System Functional Block Diagram

Executive Control

The executive control oversees and directs the entire system operation using the various programs as they are needed to perform message switching.

Message Accumulating

Message accumulating scans each input line and transfers data from the bit buffer channel (BBC) to a character buffer area in the scan words (channel tables). The program assembles characters into words in the block buffer area (BLBA). The message accumulating function is designed to accommodate traffic on all lines simultaneously without the loss of information.

Message Storing

Message storing transfers data from the block buffer area to disc storage unit records of 64 words, and stores these records in temporary storage on the DSU. Once the messages are captured on the DSU, message processing will continue on an average time basis.

Message Processing

Message processing performs the actual processing required on incoming traffic including:

1. Single address routing
2. Combination address routing
3. Message intercepting
4. Message journal keeping
5. Message format verification

Single address routing is the conversion of a mnemonic address to a line/station code and the attachment of the message to the appropriate outgoing message queue.

Combination address routing is the conversion of mnemonic addresses to multiple line/station codes and the attachment of the message to multiple outgoing message queues. If a transmitting station sends a message to two stations on another line, two headers will be created and the message will be transmitted separately to each station. The mnemonic addresses must be contained on one line.

Message intercepting is the intercepting of all traffic to a station which is not operating and the storing of that data in the intercept queue. If a station is on intercept, the message is routed and attached to the outgoing message intercept queue.

Message journal keeping is the sorting of the output headers, the complete text, and other information on the DSU.

Message format verifying is the checking of each incoming message to determine that the established standard format has been used.

Message Forwarding

Message forwarding transfers data from the queueing storage area on the DSU to the block buffer areas. The outgoing sequence number and time of day are inserted into the outgoing message.

Message Distributing

Message distributing scans each output line and transfers data from the block buffer area to the scan word to the BBC. The program removes words from the block buffer area and disassembles the words into characters and stores these in the scan words.

Off-Line Processing

Off-Line processing includes all jobs not actually necessary for the basic operation of a store and forward switching center.

DISC STORAGE UNIT ORGANIZATION

Disc Storage Unit Layout

The basic objective of a DSU layout is to minimize the access time to the data stored on the DSU. The access time is primarily a function of the number of positions (logical tracks) the actuator arm needs to move.

The temporary storage area is laid out to sequentially store messages from one incoming line on one logical DSU track. One logical DSU track is the storage area made available by one positioning of a DSU actuator arm. One track has 96 records, 64 words per record, 3 characters per word for a total of 18,432 characters. To fill 18,432 characters of storage will take 1,843 seconds or approximately 30 minutes per line (line speed is 10 cps). Temporary storage is a character stream of the messages entering the system from each line. Temporary storage is not in the queueing area; it is in a buffer area to allow all of the incoming traffic to be captured during worst case real-time conditions. This permits the balance of the program to process data on a time availability basis.

Queueing storage is actually composed of two separate areas--header storage and text storage. Header storage and text storage are laid out differently from temporary storage because the information will not necessarily be serviced sequentially. As the messages are processed out of temporary storage, they are routed, linked, and placed in either header storage or in text storage.

All 16 discs of the DSU are used for the message switching system. A shell or cylindrical technique is used for the DSU layout to minimize DSU access times. Figure 4 illustrates an estimated DSU allocation by disc and the number of actuator arm positions on each disc.

Temporary storage requires one position for each channel for a total of 30 sequential positions. Also on this disc is a program storage area of 4 positions and a transfer area from the GE-225 for the loading orders of one position*. The header queue area is 3 discs with 12 sequential positions on each disc. The header and text queue areas are based on expansion of traffic from 2000 to 3456* messages per day and an increase in volume from 1,000,000 to 1,500,000 characters per day.

The spare disc has 34* sequential positions reserved and is used for DSU recovery. There are five functions that will use DSU real-time of the system, namely:

1. Message storing
2. Message forwarding
3. Message processing
4. Off-Line processing
5. GE-225 DSU processing

Disc	Positions	Data Stored
0	0-34	Temporary Storage
1	0-11	Header Queue
2	0-11	
3	0-11	
4	0-11	Text Queue
5	0-11	
6	0-11	
7	0-11	
8	0-11	
9	0-11	
10	0-11	
11	0-11	
12	0-11	
13	0-11	
14	0-11	
15	0-34	Spare

Changes were made in the specifications as the system progressed.

Figure 4. Estimated DSU Allocation

Message storing has the highest priority and must be done on a worst-case design basis. Message forwarding, the second priority, is done whenever there is traffic in queue for any outgoing line. Message processing as the third priority is done whenever there is information in temporary storage to be processed. Off-Line processing has fourth priority and is done when there are off-line functions to perform. After all of the DATANET-30 functions are completed the DSU is released to the GE-225.

Dual Access Controller

The DATANET-30 and the GE-225 share a DSU through a dual access controller. The DATANET-30 operates in real-time. All system design characteristics must consider the fact that DSU access must be given to the DATANET-30 when access is requested or data may be lost. The GE-225 will be performing various batch processing jobs during the DATANET-30 operating time and some of these programs will require access to the DSU. The DATANET-30 will use most of the DSU real-time during the busy hours, causing the GE-225 programs to run slower.

The DSU is set up to operate on a cyclic basis of 18 seconds for both message storing and message forwarding in the DATANET-30. Eighteen seconds was selected because it allows enough real-time to do the message switching on a worst case basis and still have DSU real-time available for the GE-225.

The DSU programs in the GE-225 must not lock out the DATANET-30 for a time greater than 1-2 seconds. This means that a DSU seek, read, or write and all error checks done by the GE-225 have to be completed in 1-2 seconds and control returned to the DATANET-30. If the GE-225 does not release the DSU to the DATANET-30 when the DATANET-30 requires access, data will be lost.

Figure 5 is an example of a DSU subroutine for the GE-225. On entering the subroutine, the GE-225 becomes the master by setting a bit in a command word. The seek is then performed and error tested. Three seeks are attempted before an error exit occurs. If the seek is complete, the read or write is performed and error tested. Three read or writes are attempted before an error exit occurs. Before the exit from the subroutine occurs, the GE-225 is released from the role of master.

This subroutine for the GE-225 has the following DSU timings:

First Seek	300 ms
Second Seek	300 ms
Third Seek	300 ms
First Read/Write	52 ms
Second Read/Write	52 ms
Third Read/Write	52 ms
Release	100 ms
	1156 ms or 1.156 seconds

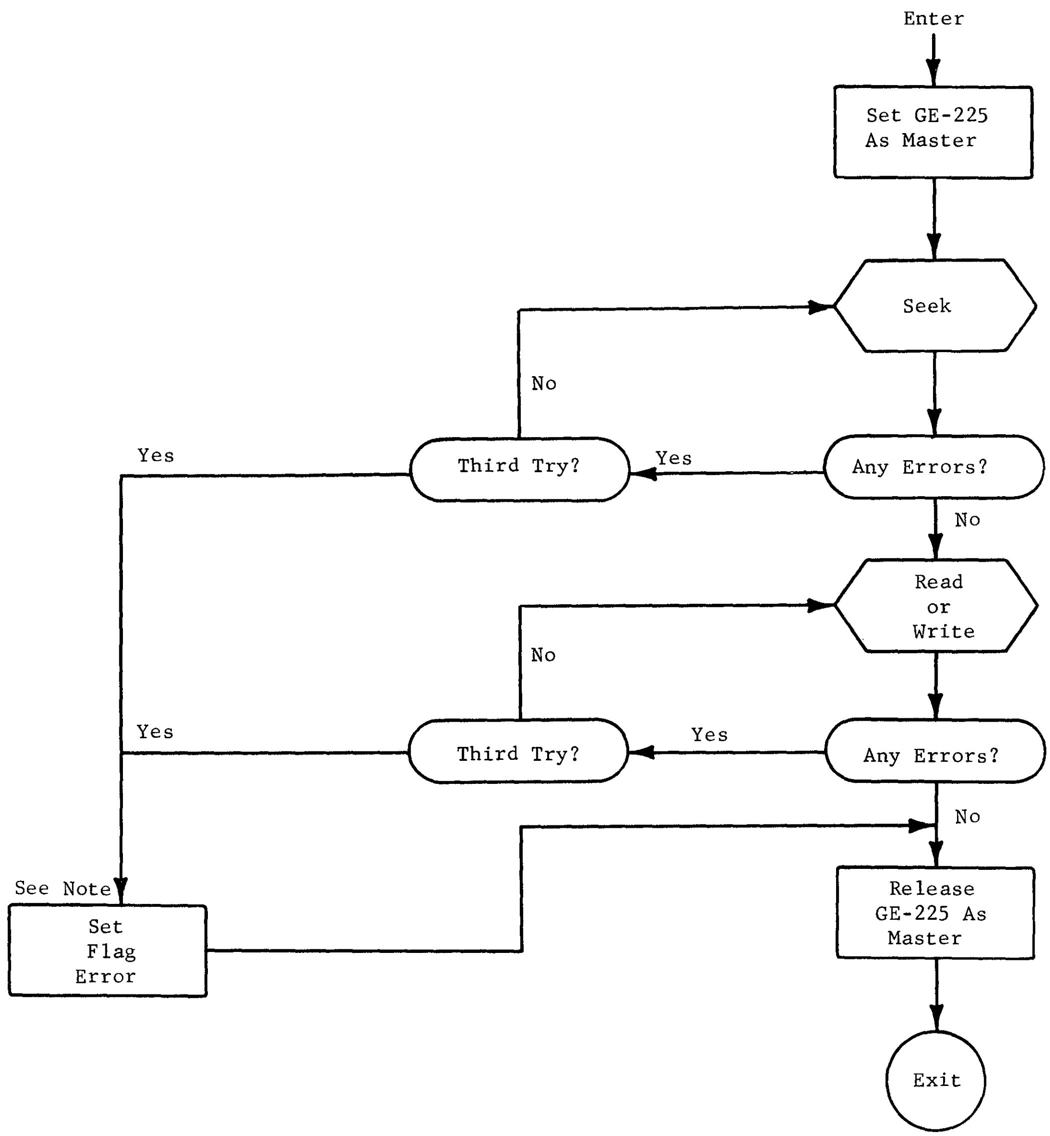
These are worst-case DSU times with GE-225 instruction time not included. The DSU must be laid out with preference to the message switching to keep the DSU access times to a minimum. Timing consideration must be given to the fact that the GE-225 may disrupt any pattern of DSU accesses by moving the actuator arms and causing an increase in access times.

PROGRAM ORGANIZATION

The total program organization for the DATANET-30 is divided into six areas:

1. The executive program
2. The message accumulating and distributing program
3. The message storing program

4. The message forwarding program
5. The message processing program
6. The off-line processing program



Note: Error messages (to typewriter, for example) must be written after release of DSU to DATANET-30.

Figure 5. Sample DSU Subroutine for GE-225

Executive Program

The executive program is entered and executed every 13 ms under control of the Q-counter and program interrupt. Hardware timing provides the basis for executing the message accumulating and distributing program as required every bit period (13 ms) for bit servicing, and every character period (91 ms) for character servicing. Software timing provides the basis for executing the message storing and forwarding programs as required every block time (18 seconds). The message processing and off-line processing programs are executed as frequently as required.

A count is updated and checked each bit period for possible initiation of the message storing programs. Initiation of the message storing program cannot take place until the program in progress can be interrupted (primarily a function of DSU). The actual interrupting is determined by the executive program and requires writing on the DSU the program linkage of the program in progress.

Message Accumulating and Distributing Program

The message accumulating and distributing program will do detail line control and perform the bit and character accumulation and distribution. The program follows the requirements of the 83B2 way circuit specifications.

Message Storing Program

The message storing program transfers information from each input BLBA in core memory to temporary storage on the DSU. A record is read, updated, and written back on the DSU. Occasionally it is necessary to form and fill a second record and then write two records back on the DSU. After all lines are handled, the count maintained by the executive program is set to zero and a return to the program in progress is made.

Message Forwarding Program

The message forwarding program retrieves information from header and text storage areas on the DSU, assigns proper output sequence numbers and fills the output BLBA's. The headers are updated with the sequence number and written back on the DSU.

Message Processing Program

The message processing program translates information from the format of the temporary storage area to that required in the header and text storage areas. This program divides into two basic sections, one for the header and one for the text.

Off-Line Processing Programs

Off-Line processing programs consist of those required for actual operation, aside from the message storing, forwarding and processing. Off-Line programs will be executed on an as-needed basis under control of the supervisor.

Examples of Off-Line Processing are:

1. Journal searching
2. Message accounting
3. Changes to routing tables
4. Report programs

DATANET-30 Core Memory Allocation

Figure 6 illustrates the DATANET-30 core memory allocation. The block buffer area is determined by the cycle time. The cycle time of 18 seconds gives a size of 60 words.

$$\frac{18 \text{ seconds} \times 10 \text{ characters/second}}{3 \text{ characters/word}} = 60 \text{ words}$$

		Core Memory
Block Buffer Area	60 words x 30	1800 words
Polling and Routing Stations	150 stations x 4 words per station	600
Channel Tables	32 x 16 polling stations	512
Common Data Bank		512
Accumulating and Distribution		400
Message Sorting		200
DSU Input/Output		300
Executive		400
Overlay Area		2048
		6772

Figure 6. Estimated DATANET-30 Core Memory Allocation

The polling and routing tables are 150 stations long and are estimated to require four words per polling station. The channel tables contain control and data information that are of the same nature for each line; 16 channel tables are estimated to be required. The common data blank is the first 512 words of core memory and is used for common constants, variables, and subroutine linkage. The 2048 word overlay area is used to overlay programs from the DSU. These programs will include message processing, message forwarding, and off-line processing, message accumulating and distribution, message storing, DSU Input/Output and the executive must be in core memory at all times.

Various Conditions and DATANET-30 Responses are as follows:

TSC SENT AND NO RESPONSE--Wait two seconds and resend TSC. If no response again, place station on SKIP and notify network control station (NCS). Resume polling pattern.

CDC SENT AND NO RESPONSE--Wait two seconds and resend CDC. If no response again, place station on INTERCEPT, notify NCS. Message is stored and is delivered when station is taken off INTERCEPT.

TAUT TAPE, JAMMED TAPE, BROKEN TAPE, OR NO END-OF-MESSAGE--Wait 10 seconds and send FIGS H LTRS. Message is treated as a good transmission and routed.

a. Partial message (including a full header) is treated as good transmission

b. Partial header results in improper message condition and is routed to NCS.

STUCK TAPE--Compare characters for 100 characters (10 seconds). If all the same, send three character times (300 ms) of space with no stop bit (create an open-line condition) and then send FIGS H LTRS. Place station on SKIP and notify NCS.

GROUP CODES--None for this application

ALL STATION BROADCAST--Broadcast messages originate from a central location and are delivered simultaneously to each station on a line. The broadcast CDC must be the same for each station in the system.

HORIZONTAL TAB, VERTICAL TAB, AND FORMS FEED-OUT--Horizontal tab, FIGS G LTRS; vertical tab, FIGS J LTRS; and forms feed-out FIGS Z LTRS; will cause a two-second delay when detected by the DATANET-30 in the switched messages.

NO END-OF-DIRECTING CODE--Wait 10 seconds and send FIGS H LTRS. Place station on SKIP and notify the NCS.

OPEN LINE CONDITIONS--DATANET-30 detects open line conditions. Transmission from the DATANET-30 halts and the NCS is notified.

INCOMING SEQUENCE NUMBER IS LOWER THAN THE EXPECTED SEQUENCE NUMBER ROUTE MESSAGE NORMALLY--this is treated as a retransmission.

INCOMING SEQUENCE NUMBER IS HIGHER THAN THE EXPECTED SEQUENCE NUMBER ROUTE MESSAGE NORMALLY--notify transmitting station of missing sequence numbers.

MESSAGE FORMATS

The incoming message format is as illustrated below:

1. AA LTRS CR LF LTRS
2. XX SP YY SP....TTSP FIGS NNNN CR LF LTRS
3. TEXT
4. Signature SP FIGS YYYYY FIGS H LTRS

Line 1. This line contains the CDC of the transmitting station and the end of directing code.

Line 2. This line contains the receiving station mnemonic codes, the station mnemonic code of the transmitting station and the incoming sequence number.

Line 3. The text can be any length.

Line 4. After the end of the text is the signature. Immediately following the signature are the mail station number and the end of message code.

The outgoing message format is as illustrated below:

1. BB LTRS CR LF LTRS
2. FIGS MMMM SP LTRS RR CR LF LTRS
3. XX SP YY SP .... TT SP FIGS NNNN CR LF LTRS
4. TEXT
5. Signature SP FIGS YYYYY FIGS H LTRS

Line 1. This line contains the CDC of the receiving station and the end of directing code.

Line 2. This line contains the outgoing sequence number and the receiving station mnemonic code.

Line 3, 4 and 5. These lines are the same as the incoming message format, lines 2, 3, and 4.

The transmitting operator assigns the incoming sequence number and the DATANET-30 assigns the outgoing sequence number. Also inserted in the outgoing message by the DATANET-30 are the receiving station CDC and the receiving station mnemonic. *

REPORTS GENERATED BY THE DATANET-30

The reports will be prepared each hour by the DATANET-30 and can be printed, on request from the NCS, for a specific hour. At the end of the day, the complete report can be requested from the NCS.

There are three reports:

1. Traffic--This is printed by line, by station, by hour and gives the total number of characters received and the number of characters transmitted.

2. Message Count--This is printed by line, by hour and gives the number of messages in queue and in intercept at the start of the hour, at the end of the hour and the maximum peak during the hour.

3. Program Use--This is printed by program, by hour and gives the total time used, the number of cycles, and the average time period.

3. SYSTEM OPERATING CHARACTERISTICS

The system operating characteristics are, of necessity, developed in close cooperation with the customer to define system operation. Only through these efforts can this document be prepared and finalized. An asterisk (*) denotes where changes were made after preparation of the first system operating characteristics specification.

SERVICE MESSAGES

A service message is defined as a communication from a station in the system to the DATANET-30. There are six types of service messages, each one designed to perform a specific function. Upon receiving a service message, the DATANET-30 will do the following:

Perform appropriate function

Acknowledge receipt of the service message

Log on the system monitor (except for repeat messages).

The standard incoming format is used for all service messages. When preparing the service messages, the mnemonic for the desired function is to be inserted into the station mnemonic address code field of the standard format.

Examples:

Station message

SGM SP FIGS 0000 SP LTRS TT SP FIGS DDDDD CRLFLTRS

FIGS H LTRS

DATANET-30 Response

AA LTRS CRLFLTRS

TT NNNN TTTT D30 RRRR SSSS CRLFLTRS

MESSAGE

FIGS H LTRS

TT OUTGOING STATION MNEMONIC

NNNN OUTGOING SEQ NO.

TTTT OUTGOING TIME

RRRR DATANET-30 SEQUENCE NUMBER

SSSS TIME MESSAGE RECEIVED IN SYSTEM

Good Morning

Mnemonic Code--SGM

Function--This message indicates that the specific station is initially on the air and operational for the day. The station is now available to receive traffic that is stored in queue. *

DATANET-30 Message: GOOD MORNING YOU ARE NOW REMOVED FROM INTERCEPT

Good Night

Mnemonic Code--SGN

Function--This message indicates that the specified station has completed its day's operation. The station will be placed on intercept and all traffic destined to the station will be stored in queue.

DATANET-30 Message: YOU ARE NOW ON INTERCEPT GOOD NIGHT

Station Intercept Request For Maintenance

Mnemonic Code--SMT

Function--This message indicates that the specified station is requesting to be placed on intercept for maintenance reasons. The station will be placed on intercept and all traffic destined to the station will now be stored in queue.

DATANET-30 Message: YOU ARE NOW ON INTERCEPT FOR MAINTENANCE

Station Intercept Request For Paper Change

Mnemonic Code--SPC

Function--This message indicates that the specified station is requesting to be placed on intercept to facilitate a paper change. The station will be placed on intercept and all traffic destined to the station will be now stored in queue.

DATANET-30 Message: YOU ARE NOW ON INTERCEPT FOR PAPER CHANGE

Remove Station From Intercept

Mnemonic Code--SRI

Function--This message indicates that the specified station is again operational and desires to be removed from intercept. Traffic that is stored in queue for this station will now be delivered to the station. *

DATANET-30 Message: YOU ARE NOW REMOVED FROM INTERCEPT

Repeat Message

Mnemonic Code--SRP

Function--This message indicates that the specified station is requesting the DATANET-30 to retransmit a message which was previously delivered to the specified station. The DATANET-30 will search through the journal of transmitted messages and find the requested message. It will then retransmit the message to the station. The input for this service message is slightly different from the other service messages in that parameters are required. The format for the header portion of the message is standard but the second CR LF LTRS <u>must</u> be followed immediately by two additional fields. The first field after the CR LF LTRS will indicate the station requesting the repeat message and the second field will contain the outgoing sequence number of that message. Each station may request a repeat of only those messages which were previously received.

DATANET-30 Message: The response from the DATANET-30 will be a standard format message which will be the repeat of the requested message.

SYSTEM MONITOR MESSAGE FORMAT

A system monitor message is a message generated by the DATANET-30 and printed on the monitor RO. This message is used to maintain a complete log of all changes in operational conditions. The status of the system at any particular time may be ascertained from this log.

The following definitions serve to specify the fields contained in the system monitor message:

Field Name	Field Definition	Description
Spacing	The first six characters of the message	Consists of the character sequence CR LF LF FIGS FIGS FIGS
Time of day	The first field of the message	This field indicates the time of day which this condition occurred
Mnemonic function code	The second field of the message	This field indicates the condition which has occurred
Spacing	Characters between the second and third fields	These characters are used for proper spacing
Circuit number	The third field of the message	This field indicates the DATANET-30 circuit number on which the condition occurred
Station Mnemonic Code	The fourth field of the message	This field indicates the station of the system at which the condition occurred.
Specific information as required	All fields between the fourth field and the end-of-message field	These fields contain additional information and instructions pertaining to the given condition
End of Message	Last field of the message	This field indicates the end of this monitor message

The following is the System monitor message format:

Function	Character Sequence
Call directing code*	XXLTRS CR LF LTRS*
Spacing	LF FIGS FIGS
Time of day	FIGS X X X X LTRS Sp
Mnemonic function code	A A A Sp
Spacing	Sp Sp FIGS FIGS
Circuit number	FIGS X X LTRS Sp
Station mnemonic code	Sp Sp Sp X X
Specific information as required	
End of message	FIGS H LTRS

Example of a System Monitor Message

An example of the system monitor message as it appears on the system monitor RO follows.

0830 SGM 05 LP

The 0830 is the time of day which the condition SGM (Good Morning) occurred. The good morning was received from station LP, which is on circuit number five. Another example illustrates a system monitor message where additional specific information is required:

0914 NRT EN NC

In this example the function change routing tables NRT for station EN was performed at 0914. All messages destined for EN will now be delivered to station NC. Since the circuit number has no real meaning for the function NRT, nothing is placed in that field.

Printout of Service Messages in the System Monitor

One of the functions which the DATANET-30 performs upon receipt of a service message is to update the system monitor log. The following are examples of responses printed on the log for each of the types of service messages. All of these responses follow the standard system monitor format.

GOOD MORNING

Mnemonic Code--SGM

0914 SGM 12 LP

GOOD NIGHT

Mnemonic Code--SGN

1635 SGN 06 EN

STATION INTERCEPT REQUEST FOR MAINTENANCE

Mnemonic Code--SMT

1123 SMT 05 AL

STATION INTERCEPT REQUEST FOR PAPER CHANGE

Mnemonic Code--SPC

1124 SPC 12 CV

REMOVE STATION FROM INTERCEPT

Mnemonic Code--SRI

1127 SRI 12 SL

REPEAT MESSAGE

Mnemonic Code--SRP

No message is logged for this service message

NETWORK CONTROL MESSAGES

A network control message is defined as a communication from the Network Control Supervisor to the DATANET-30 which furnishes the DATANET-30 with control information. There are seven types of network control messages, each one designed to perform a specific function. All network control messages must be entered at the network control station (NC). When the DATANET-30 receives such a message, the function will be performed and logged on the system monitor.

The standard incoming format is used for all network control messages. When preparing these messages, the mnemonic for the desired function is to be inserted into the Station Mnemonic Address Code field of the standard format. The second CR LF LTRS (end of header), is followed by two (2) fields hereafter referred to as Field 1 and Field 2 respectively.

Example--Network Control Message:

BB LTRS CR LF LTRS

NGM SP FIGS 0000 SP LTRS NC SP FIGS DDDDD CR LF LTRS

FIELD 1 SP FIELD 2 FIGS H LTRS

Network Control Good Morning

Mnemonic Code--NGM

Function--This message is used to initiate polling in the system. It sets the date and time clock to the specified values given in Fields 1 and 2. Field 1 contains the time and Field 2 contains the date.

The following would be logged on the Station Monitor.

Time NGM Time1 DATE

Time, Time message transmitted. Time1, Time from Field 1.

Network Control--Put Station on Intercept

Mnemonic Code--NPI

Function--This message will place the station specified in Field 2 on intercept. All traffic destined for that station will now be stored in queue. Field 1 must be the character STA.

The following would be logged on the Station Monitor.

TIME NPI CN XX

CN DATANET-30 Circuit Number

XX Station placed on intercept.

Network Control--Remove From Intercept

Mnemonic Code--NRI

Function--This message will remove the station specified in Field 2 from Intercept. All traffic which was stored in queue for that station will now be delivered to that station. Field 1 must be the characters STA.

The following would be logged on the System Monitor.

TIME NRI CN XX

Network Control--Change Routing Tables

Mnemonic Code--NRT

Function--This message will change the routing of messages destined for the station specified in Field 1 and route them to the station specified in Field 2. To return the routing tables to their original state, another NRT message must be given with the original station mnemonic in both fields.

The following would be logged on the System Monitor.

TIME NRT YY XX

YY Station specified in Field 1 (Routed "FROM" Station)

XX Station specified in Field 2 (Routed "TO" Station)

Network Control--Retrieve Message From Journal

Mnemonic Code--NMJ

Function--This message has the same function as a Repeat Message (SRP). The difference lies in that a Service Repeat Message can only retrieve messages destined to the requesting station whereas the Network Control Message can retrieve messages destined for any station in the system.

Field 1 contains the mnemonic of the station and Field 2 contains the outgoing sequence number of the particular message that is desired. No print out on the System Monitor will occur.

Network Control--Retrieve Requested Reports

Mnemonic Code--RHR

Function--This message is used to retrieve specified reports and print them on the System Monitor. Field 1 contains the type of report desired and Field 2 contains the desired hour.

See traffic analysis reports for more information.

Network Control--Reset Errors

Mnemonic Code--RER

Function--This message will reset the RAM Alert count and Hash Total count back to zero.

No parameter fields are needed for this message.

Network Control--Stop Polling

Mnemonic Code--NSP

Function--Stops polling all stations except network control.

The following would be logged on the System Monitor.

TIME NSP

ERROR MESSAGES AND RECOVERY PROCEDURE

Error analyis on both the hardware and the input to the system is performed by the DATANET-30. Should error conditions occur, certain internal effects to the system take place and error messages are generated which record the stated conditions. The following is a list of the error messages, their causes and effects, and the appropriate actions to be taken by the operator or network control supervisor:

1. No response

Reason	The Teletype machine is not responding to the polling sequence.
Response to station:	YOU HAVE BEEN PLACED ON INTERCEPT DUE TO NO RESPONSE FROM YOUR STATION. CHECK TO CORRECT CONDITION AND SEND SRI. IF THIS CONDITION PERSISTS, CONTACT YOUR TELETYPE REPAIR MAN
Response to system monitor	TIME ENR CN XX
Effect internal to the system	The station is placed on intercept.
Operator action	Check the Teletype to be certain that the machine is plugged in and is turned on. An SRI service message must be sent in to remove the station from intercept.

2. No "V" answerback during selection

Reason	The Teletype machine is not responding to the CDC.
Response to station	None by DATANET-30. Network supervisor must place phone call or send message to another station.
Response to system monitor	TIME ENV CN XX
Effect internal to the system	The station is placed on intercept.
Operator action	Wait for information from network supervisor. Then check the Teletype to be certain that the machine is plugged in and turned on. An SRI service message must be then sent to remove the station from intercept.

3. Open line

Reason	A sequence of blank characters has been received by the DATANET-30 from the Teletype line.
Response to station:	YOU ARE ON INTERCEPT FOR OPEN LINE CONDITION. CHECK FOR: 1. two blank characters 2. multilated tape 3. bad splice 4. open line from your machine CORRECT CONDITION AND SEND AN SRI.
Response to system monitor	TIME EOL CN XX
Effect internal to the system	The station is placed on intercept and emergency stopped.
Operator Action	The operator must check the tape for two blank characters, a multilated tape or a bad splice. If none of these conditions prevail, then the repair man must be called as a true open line condition does exist. After correcting condition, enter an SRI service message.

4. Hundred characters detected

Reason	A sequence of one hundred characters, all the same, has been received from the Teletype device.
Response to station:	HUNDRED CHARACTER CONDITION DETECTED. CHECK FOR: 1. 100 identical characters in a row 2. torn tape 3. stuck tape CORRECT CONDITION, RESET TAPE TO BEGINNING OF MESSAGE.
Response to system monitor	TIME EHC CN XX
Effect internal to the system	The station is emergency stopped.
Operator action	The operator must check the tape for one of the three possible conditions given in the response message and correct the condition.

5. Tight Tape

Reason	The tape is caught in the transmitter.
Response to station:	TIGHT TAPE CONDITION DETECTED. RESET TAPE TO BEGINNING OF MSG AND RESET ALARMS.
Response to system monitor	TIME ETT CN XX
Effect internal to the system	The station is emergency stopped.
Operator action	The operator must open the gate and reset the tape into the transmitter.

6. Buffer full

Reason	The Teletype transmitter is running too fast or there is a DATANET-30 malfunction.
Response to station:	YOU ARE ON INTERCEPT FOR MACHINE MALFUNCTION. RESET YOUR MACHINE AND SEND AN SRI.
Response to system monitor	TIME EBF CN XX
Effect internal to the system	The station is placed on intercept and emergency stopped.
Operator action	Reset alarms on the ASR and send an SRI service message. If the condition persists, notify the Teletype repairman and have him check the transmitter for excessive running rate.

7. Disc storage alert

Reason	An error has occurred on the DSU but the frequency of occurrence is within the design specifications.
Response to station:	None
Response to system monitor	TIME RAL D-30 TOTAL ALERTS 0000 RAM ADDRESS 000000 ALERTS: One or more of these five alerts will be printed. AE Any Error CD Count Down FE File Error MA Memory Access PE Parity Error
Effect internal to the system	None
Operator action	None

8. Fifty alerts have been detected

Reason	Possible trouble with the DSU.
Response to station:	None
Response to system monitor	!!!!! CALL PRODUCT SERVICE !!!!! AN ABNORMAL NUMBER OF DISC STORAGE UNIT ERRORS HAVE BEEN DETECTED.
Effect internal to the system	None
Operator action	The network control supervisor must notify the service engineer that an excessive amount of DSU errors have occurred.

9. One hundred alerts have been detected

Reason	There is a malfunction in the DSU.
Response to station:	None
Response to system monitor	DUE TO AN EXCESSIVE NUMBER OF ERRORS, HAS BEEN STOPPED.
Effect internal to the system	The polling of stations has been stopped in preparation of cycling down the system.
Operator action	The network control supervisor must call the service engineer if he has not already been contacted.

10. One hundred-fifty alerts have been detected

Reason	There is a malfunction in the DSU.
Response to station:	None
Response to system monitor	RESTART RE
Effect internal to the system	All stations are placed on intercept and the system is automatically shut down.
Operator action	The system is automatically down until the service engineer has checked the DSU and given the okay to restart the system, at which time the network control supervisor will initiate the restart procedure.

11. Improperly terminated message

Reason	The incoming message was not terminated by a FIGS H LTRS.
Response to station:	THIS MESSAGE WAS IMPROPERLY TERMINATED. CHECK AND IF NECESSARY REQUEST ORIGINATING STATION TO RETRANSMIT.
Response to system monitor	None
Effect internal to the system	The operator must determine if all the pertinent information of the message was received and, if it was not, then a request must be sent to the originator to retransmit the message.

12. Invalid traffic

Reason	Header is garbled or invalid.
Response to station:	LAST GOOD TRAFFIC FROM YOUR STATION WAS NUMBER NNNN. CHECK HEADER AND RETRANSMIT.
	X (This an alphabetic code that denotes the type of error.)
	A No outgoing station mnemonic.
	B Too many outgoing station mnemonics
	C Invalid incoming station mnemonic
	D Invalid outgoing station mnemonic
	E Out of sequence condition
	F Header not complete
	G No end of directing code
Response to system monitor	TIME INX CN XX
Effect internal to the system	None
Operator action	The operator must check the tape to see if it contains valid information and then retransmit the message.

13. Header linkage error

Reason	A record on the DSU cannot be read.
Response to station:	None
Response to system monitor	TIME EHL CN
Effect internal to the system	The messages in queue for stations on the designated line are temporarily lost for automatic switching. New linkage for this line is automatically established.
Operator action	The network control supervisor may send a message to all stations on the designated line requesting that each operator enter a SRP service message with a sequence number of 0000 or the network control supervisor may send the SRP for each station. This message will retrieve all of the temporarily lost messages.

14. Bad Format on Service Messages

Reason	Either the operator failed to send the second CR LF LTRS on the SRP, request for retransmissions, or network control messages; or a remote station operator attempted to send in a network control message.
Response to station:	BAD FORMAT. RESEND MESSAGE NUMBER NNNN.
Response to system monitor	None
Effect internal on the system	The message was not accepted by the system
Operator action	Correct the message and retransmit.

TRAFFIC ANALYSIS REPORTS

Description of Reports

The following are three reports printed out on the Monitor RO on a requested basis.

TRAFFIC REPORT--A report by station of the number of characters received and transmitted by each station during a given hour. The stations are grouped on the report by line and totals are shown by line. Summary traffic reports which may be requested, show all traffic going through the system up to a given hour.

The traffic report shows the station mnemonics, the number of characters sent by the station, and the number of characters received by the station during the hour for which the report was rendered.

MESSAGE IN QUEUE REPORT--A report by line of the number of messages backed up in normal and intercept queue during a given hour. The report shows the number of messages backed up at the beginning, at the end of the hour for which requested and the maximum back up during the hour.

The message in queue report is organized on a line basis, showing for each line the number of messages contained in both intercept and normal queues at the start of the hour, at the end of the hour and maximum for the hour of the report.

PROGRAM TIMING REPORT--A report by program of the elapsed time the computer has used and the percentage of total time used by each function during a given hour, by program.

The report shows the program name and the time in seconds taken by that program during the hour. The percentage is calculated on the basis of time used by the computer during the hour and is calculated to the nearest one hundredth.

DESCRIPTION OF PROGRAMS--An RHR type service message from the network control station initiates the request for an hourly report to the system. Upon entering the system, it is checked for possible errors, and if acceptable to the system, stored in the system until the computer has time to prepare the requested report. In the meantime, SIP (statistical information program) automatically collects counters (which become the figures shown by the reports) maintained by the system and stores them on the DSU file each hour, thus saving them for later use by the reports program.

When the hourly reports request reaches the reports program, it is analyzed to determine which type of report and for which hour it will report. The counters which were stored by SIP for that hour are brought in, edited and the figures are inserted in a report format. The report is set up as a message to the monitor EO and stored in queue for the monitor. The reports are then sent out to the monitor as regular traffic.

REQUESTING HOURLY REPORTS--Hourly reports are requested by the use of an RHR type service message from the network control station. Field 1 is the type of report, and Field 2 is the hour of the report.

Field 1. RLS--Traffic report

RCL--Messages in queue report

RPU--Program timing report

RED--Daily summaries of the traffic and program timing reports

Field 2. The hour is for the hour in which the activity took place. Thus, if the hour requested is 8:00, the traffic report would show the number of characters received and transmitted between 8:00 and 9:00. Since all the figures for any hour are not available until the end of the hour, a report for an hour cannot be requested until the next hour.

The hour must be specified using a 2400 hour system. For summary reports the hour represents up to which hour the daily figures are accumulated.

Examples of Traffic Analysis Reports

Traffic Report--(RLS)

The following would be logged on the system monitor.

TRAFFIC REPORT

HOUR 1100 DATE 110463

LINE NO.	STATION	SENT	RECEIVED
	NC	2046	926
1	TOTAL	2046	926
	MT		1023
2	TOTAL		1023
	LP	2039	1041
	LW	4068	2001
	OG	3027	1503
3	TOTAL	9134	4545
	TOTAL	11180	6494

Messages in Queue Report--(RCL)

MESSAGES IN QUEUE REPORT

HOUR 1100 DATE 110463

LINE #	START Q	START I	END Q	END I	MAX Q	MAX I
1	0	0	1	0	3	0
2	2	0	0	0	3	1
3	3	4	0	4	2	5

Program Timing Report--(RPU)

PROGRAM TIMING REPORT

HOUR 1100 DATE 110463

PROGRAM	TIME	PER CENT
STORING	642	17.89
SIP	1	.02
FRWRDG	741	20.59
PROC	871	24.01
DIAG	1345	37.49

FORMAT AND MESSAGE CONTROL*

Incoming Message Format Control*

Strict compliance is made to incoming message formats and any deviation from the incoming message format will be treated as invalid traffic such as, incorrect incoming sequence number, incorrect outgoing station mnemonic or mnemonics, etc. Past experience has shown this to be the best method for system control.

Sequence Numbering*

Incoming sequence numbers must be correct. The six ASR's at the relay center will have different station mnemonics. This allows each ASR to have a distinct sequence number and therefore comply with the strict incoming message format procedure.

The loading orders are originated by the GE-225 and will have six pseudo station mnemonics to allow the loading orders to have distinct sequence numbers. The GE-225 programs will sequence number the loading orders as they are being prepared.

Multiple Address Transmission*

When the DATANET-30 is to transmit the same message to two or more stations on the same line, individual headers will be created and the message will be transmitted to each station individually.

On the incoming header the maximum number of multiple addresses is limited to ten.

All Stations Broadcasts*

All station broadcasts are for the entire system and not by line and individual headers will be created for each station in the system.

AUTOMATIC TURN-ON *--All ASR's will be equipped with the "automatic turn-on" function. That is, when a TSC is sent and the ASR has a message in the transmitter, the TSC will turn on the page printer of that ASR. The Incoming Message Format is changed and the originating station CDC is eliminated.

4. INSTALLATION AND CUTOVER

INSTALLATION REQUIREMENTS (NON-GENERAL ELECTRIC)

The equipment required for cutover to the DATANET-30 is listed below and illustrated in Figure 7.

Long Lines

1. Install one loop board
2. Install six local channels and terminate in the loop board.
3. Re-terminate existing 28 RO Monitor in new loop board.

Associated Company

1. Install seven 28 ASR's.
2. Install four 28 RO's on rotary.
3. Install one 28 RO (supervisory).
4. Install one aux. ROTR.
5. Install two loop boards.
6. Install twelve station control units.
7. Install assign TSC's and CDC's.

CUTOVER PROCEDURE

The DATANET-30 will cutover the system one line at a time. The line being cutover will have a ROTR monitoring the line to provide protection against lost messages. The other lines will continue to operate on the torn tape system.

NOTE: Old equipment of long lines and associated company to be kept intact for approximately one month after the DATANET-30 goes into service.

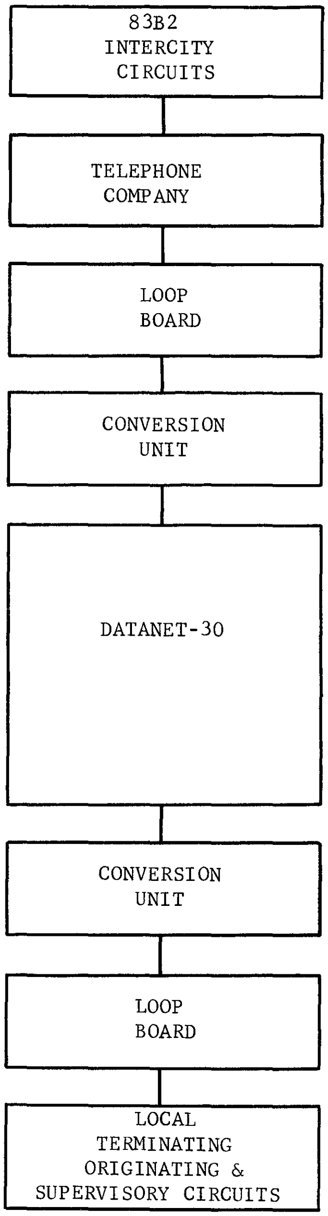


Figure 7. Cutover Equipment Block Diagram

All messages to be transmitted from the line being cutover to other lines are transmitted to a ROTR designated for that specific line. A new header must be cut to the torn tape system format and the message inserted in the torn tape system. Messages from the other lines to the line being cutover are received at the relay center in the torn tape system. A new header must be cut to the DATANET-30 system format and inserted in the DATANET-30 system through one of the six ASR's at the relay center. Messages from one station on the line being cutover to other stations on the line are switched by the DATANET-30.

This procedure is followed until the entire system has been cutover to the DATANET-30 system.

The System cutover is divided into three phases.

The first phase is made on the intrastate 83B2 circuits to Quality Control and Production Control at the relay center.

1. Turn off existing transmitters and ROTR's.
2. Turn on all existing 28 ASR's and put them in the monitoring position.
3. Turn off all auto station control units.
4. Testboard patches new local channels into existing Intrastate circuits.
5. All local "originating, terminating, and supervisory" equipment are wired to loop board--conversion unit and DATANET-30.
6. Traffic can now be sent and received at the relay center and at the local outlets, "Quality Control and Production Control."
7. Using the above local intrastate, request the testboard to patch these services to the new local channels. This will check the DATANET-30 through all Teletype equipment and local channels.

The second phase is made on two intrastate and six long line 83B2 (100 wpm circuits).

1. Testboard to patch and add the above circuits in series with the new local channels.
2. It is now possible to make a complete system check.
3. Tapes are prepared locally by the customer's operators with the new format and then mailed to all stations.

4. At the relay center, turn on all 28 ASR's and six spare ROTR's that monitor and record all traffic. This gives a visual picture of the traffic as it passes in, through and out of the DATANET-30.

5. The Monitor ROTR tapes can be used to re-enter traffic into the system if desired.

The third phase will cover the types of tests that are made in the overall shake-down of the system.

1. Each station sending to all other stations on the same line and also to the relay center.
2. Each station on the system that sends to TWX points and Data points via a relay at the relay center, must send a test tape to the Aux ROTR at the relay center.
3. A test tape from a station on 80 to a station on 81, 82, 83, and 84. One at a time (single).
4. A test tape from 81 to all circuits, same as (3) above.
5. A test tape from a station on 80 (multiple address) to 2 stations on 81 and 83 etc.
6. A test tape from a station on 81 (multiple address) to 2 stations on 80 and 83, etc.
7. Performs various queries from the supervisory position to the DATANET-30.

CUTOVER SCHEDULE

Phase 1		Installation Date
Install and check out DATANET-30		
Load Programs		+2
Check out supervising ASR		
Monitor		
Six ASR's		
Four RO's		
Prepare tapes with new formats to be mailed to remote stations.	+2	
Check out intrastate 83B2 (PC, QC and WH and BK)	+3	
Mail tapes and instructions	+3	
Program corrections, reassembly etc.	+4-5	

Phase 2	Installation Date
Test Circuit--80 during not busy hour	+6
Test Circuit--81 during not busy hour	+7
Test Circuit--83 and 84 during not busy hour	+8
Test Circuit--86 during not busy hour	+9
Test Circuit--82 during not busy hour	+10
Phase 3	
Test total system for one day	+11
System cutover	+13

MESSAGE FORMAT

The message format for the transmitting stations must be as follows:

1.	10 LTRS	
2.	CR LF LTRS	Start of message
3.	EN SPACE[1]	Receiving station mnemonic
4.	FIGS NNNN	Transmitting sequence number, four characters maximum
5.	NY SPACE	Transmitting station mnemonic
6.	FIGS DDDDD	Date, five characters maximum
7.	Space	Field definition character
8.	CR LF LTRS	End of header
9.	TEXT	Any length.
10.	H	End of message
11.	6 LTRS	

The message format for the messages at the receiving station is as follows:

1.	AM LTRS	Call Directing Code (does not print)
2.	CR LF LTRS	End of Directing Code
3.	FIGS NNNN SPACE	Receiving station sequence number

[1] Up to a maximum of ten receiving station mnemonics can be used in one message. They must be separated by a SPACE.

4. LTRS EN	Receiving station mnemonic
5. SPACE FIGS TTTT	Receiving time
6. CR LF LTRS	End of receiving header
7. TRANSMITTING HEADER	Same as transmitting header
8. TEXT	Text
9. H	End of Message

TEST MESSAGES

The test messages to be prepared at the relay center and mailed to the transmitting station conform to the message format. Each transmitting station receives four test messages.

Message 0001. From the station to NC (network control)

TEXT: Test message 1 from_______.

Message 0002. From the station to MP central

TEXT: Test message 2 from_______.

Message 0003. From the station to another station on that circuit.

TEXT: Test message 3 from_______.

Message 0004. From the station to another station on another circuit.

TEXT: Test message 4 from_______.

Message 0004 is entered into intercept queue because only one longline circuit is in the DATANET-30 at this time. This message is checked by changing the routing tables to have the message redirected to NC.

The line being tested has a RO riding the line. Personnel at the relay center can check the intraline message delivery.

CUTOVER

The installation and cutover procedures were written after a series of discussions with the customer, the local telephone representatives, and the long lines representatives. The cutover schedule was followed for the most part and was a reasonable schedule for this installation. The exact procedure and some of the more unique problems and solutions that occurred during the cutover are noted in this description of the cutover.

The long line representative provided for a patch panel in the Teletype room that would allow an RO to be connected to any of the multi-station lines so that the RO could monitor the line. That is, any transmission on that line, either from or to the DATANET-30 could be recorded on the RO. This patch panel and RO were to be permanent at the center.

The TSC's and CDC's could also be recorded for the line being monitored. This was useful in testing the polling pattern from the DATANET-30 to insure that correct TSC's were being transmitted and that correct CDC's were used during the selection of the stations. This was done prior to the actual cutover.

The present 83B2 system had KSR's at the center on the multi-station circuits to allow control at the center (Figure 8). These KSR's were used to monitor the lines during the actual cutover. ROTR's also monitored the multi-station circuits during the first three days of operation. With this equipment, traffic could not be lost. The KSR's produced a page printout of all transmissions on the circuit and the ROTR's produced paper tape of all transmissions on the circuit. If by reading the page copy, it was determined that a message was lost, that message could be located on the paper tape from the ROTR for that circuit and re-entered into the system.

When the basic switching system was debugged and operating on the local circuits in the Teletype room, the multi-station circuits were then tested. During a nonbusy hour for the particular circuit to be tested, a message to all stations on the line was transmitted from the KSR informing the stations that this circuit was being transferred from the operating 83B2 system to the DATANET-30. The physical transfer of the circuit was done by long line at their master patch panel at their office. After a circuit transfer was complete, the supervisor from the network control station of the DATANET-30 then sent a message to the stations on the circuit telling them to transmit test message number 1. The message from network control was observed on the KSR monitor going to the stations. Likewise, the responses were observed going to the DATANET-30. After satisfactory responses were obtained from test message number 1, a request for next test message was transmitted. The same procedure followed for all of the remaining test messages.

The test messages were all previously tested in the local test configuration before they were mailed to the remote stations. If the messages were not accepted by the DATANET-30 during the multi-station circuit test, either the remote transmitting equipment was bad or the Teletype line was bad. During this portion of the cutover, it was found that a local line in another city was bad and the DATANET-30 was receiving garbled messages. The local telephone people in that city were contacted and they corrected the situation. Also several of the remote ASR's and RO's required maintenance to bring them up to operating specifications.

After the test messages were transmitted, the remote operators were instructed to transmit any messages using the new format. They now had to cut their own headers for the messages. If any errors in the headers occurred, the DATANET-30 would notify the operator of their error. After all of the operators had entered valid messages and it was determined that the remote equipment was operating satisfactorily or the malfunctions had been pinpointed, a message was sent to the remote stations telling them that the circuit was being transferred back to the present 83B2 system.

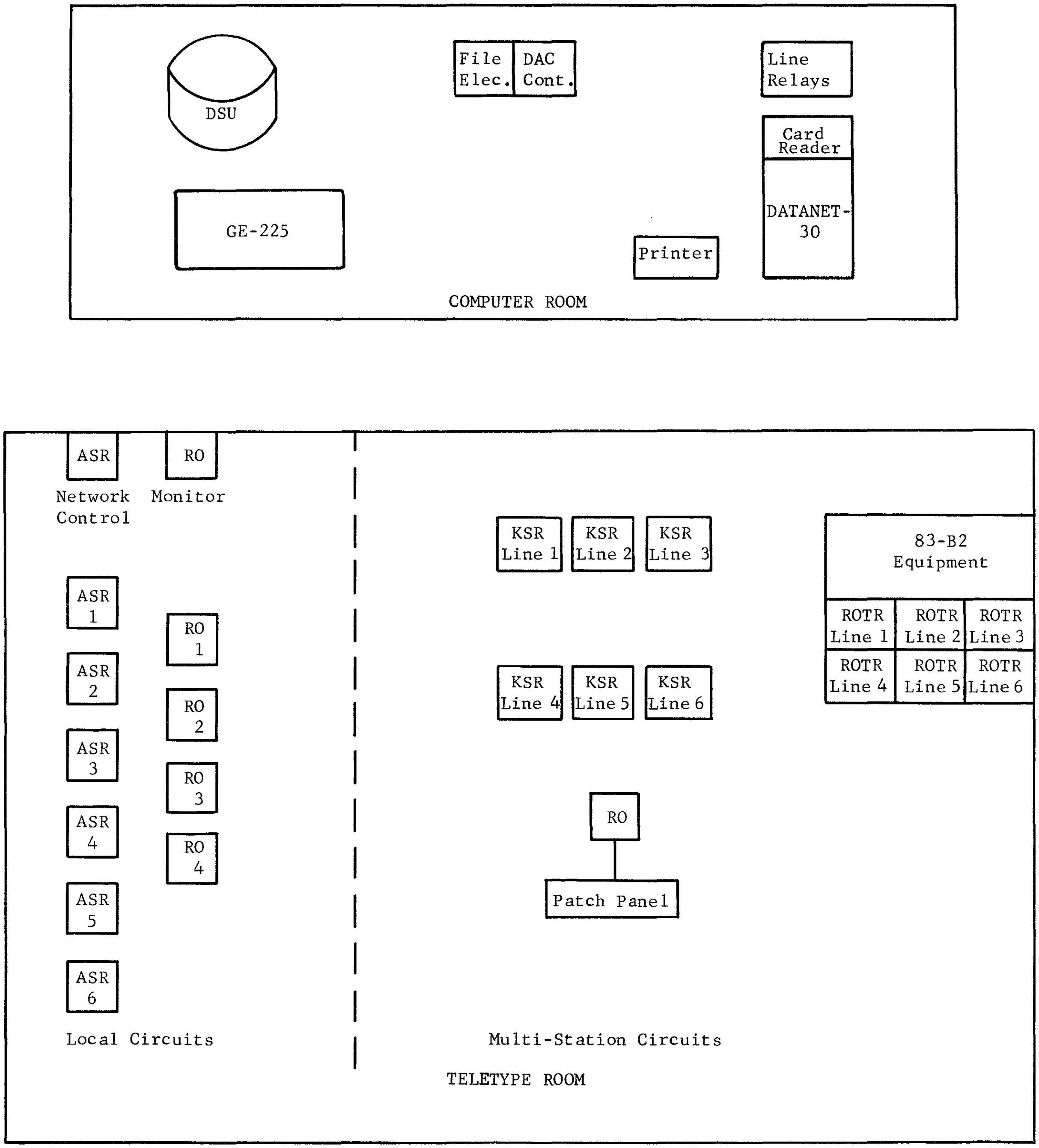


Figure 8. Equipment Layout

All of the multi-station circuits were tested this way. By the end of the week, satisfactory results had been obtained in the operation of the DATANET-30 and the remote equipment. On Saturday, the entire system was run for four hours on the DATANET-30. Approximately 75 percent of the remote station operators were able to take part in this test. The system was started as it would be on a normal day. The operators sent in their "service good morning" messages and they were on the air. The Saturday test was primarily a volume test of the system to see how the programs reacted under a load. Several program bugs were uncovered during the test; however, since the test was successful, it was decided to cutover the following Monday. The weekend was spent in correcting the known program bugs.

The following Monday morning at 0600 the system was started and the electronic Teletype system was operational. It became apparent fairly soon that there were an abnormal number of error messages being generated by the DATANET-30 on bad headers. It was assumed that this was caused by the new header format which was unfamiliar to the operators. The abnormal number of error messages became the immediate major concern because the available header storage area was being quickly depleted. An organized shutdown of the system was planned to allow the End of Day program to be run in order to delete the transmitted messages and thereby create new header storage. This was done and the system was restarted and messages were being switched once again. A further analysis of the problems revealed that the abnormal number of error messages were not only due to the operator errors, but also to a program bug that would, under specific instances, misdirect error messages or insert invalid codes in the error messages. This, quite naturally, greatly confused the operators and caused many false error messages to be delivered.

After the programs were corrected and the error messages were no longer being misdirected or invalid, the header area was still being quickly depleted. The initial design of allocation of the header area was based on inaccurate data and the header area was too small. The reassembly would be necessary to increase the header area as several tables and program changes had to be made. Rather than reassemble at that time, the system was allowed to operate to further debug the systems.

However, a new function was added to the system to permit easier planned shutdown and restarts. This function was a remove all from intercept (RAI) service message. Each day during the nonbusy hour at noon, the system was shutdown and End of Day program was run to repack the DSU.

After the system was restarted, the RAI message was entered and all stations were automatically removed from intercept. Therefore, the station did not have to send in another SGM to remove themselves from intercept.

From all of this, the header report was created and entered into the next assembly. The header report automatically on the hour prints on the Monitor the number of available headers and the total number of messages transmitted. It was now possible to have an accurate message count.

During the first two weeks of operation, hash totals were created and checked on all program overlay DSU writes and reads when 150 hash total errors occurred, the system was designed to halt. This happened five times one day. After the entire switching system was operating, a concentrated effort was devoted to the solution of the hash total problem. A confidence factor had to be first established in the operating programs because the hash total errors could possibly have been due to program bugs. The hash total errors were found to be caused by hardware during the transfer of data from the core memory to the controller selector unit. A minor rewire change was made to correct this problem.

At the end of the first two weeks, the entire operating program was reassembled to incorporate all of the changes. The reassembly and debug of the assembly was accomplished over a weekend; and, because of well documented octal patches, on the following Monday the new assembly was used to operate the system. Some minor program changes had to be made to this assembly and four weeks later a final assembly was made.

Since the first Monday of cutover, the DATANET-30 handled all of the traffic. Not once did the message switching have to revert to the 83B2 system. Four weeks after the first day of operation, the 83B2 equipment was removed from the center.

5. FUNCTIONAL OPERATION

The system is started by loading the Beginning of Day bootstrap routine through the paper tape reader. The bootstrap routine calls in the Beginning of Day program from the DSU and this program performs a linkage check of all undelivered traffic, moves the operating programs to a working storage area from the permanent storage area, reads the main line programs into core and transfers program control to the system Executive program.

Initially all stations except the network control station and the Monitor are on intercept and traffic will not be delivered until the stations are taken off intercept. Prior to entering a network good morning (NGM) control message, the only station being polled is the network control ASR. The network good morning (NGM) sets the time and date for the system and begins polling all stations in the network. The stations can now send in their service good morning (SGM) messages that will remove them from intercept. The DATANET-30 acknowledges every SGM with a message back to the sending station and a message to the Monitor.

In polling the stations on a circuit, the DATANET-30 sends out the transmitter start code (TSC) to connect a station's ASR to the circuit. If there is no message in the transmitter, the ASR responds with a "V" answerback. If there is a message in the transmitter, the transmitter starts and the message is transmitted to the DATANET-30. If there is no response to the TSC, the TSC is sent the second time. If still there is no response, an error message is sent to the Monitor.

The polling of outstations follows a predetermined polling pattern. The polling pattern can allow selected stations to be polled more frequently than others, if traffic volumes so warrant. Built into the polling pattern is the DATANET-30 message queue for messages to be transmitted to stations on that circuit from the DATANET-30. In this way neither incoming nor outgoing traffic has priority over the other.

The messages from the outstations must follow a strict header format. The first characters, after a leader of LTRS, from a station must be a CR LF LTRS to put all stations on that circuit in a nonselect condition. If any other characters are transmitted, that transmitter is stopped by transmitting a series of blanks from the DATANET-30 to open the line.

The DATANET-30 receives the messages by character and this allows for immediate recognition of line conditions. Each character is examined for the end of message code (FIGS H LTRS) which will disconnect the transmitter from the circuit. If traffic stops without a FIGS H LTRS, the DATANET-30 times out for 10 seconds and then transmits the FIGS H LTRS. Incomplete messages are routed to the destination if a valid header is received. A message is added later by the DATANET-30 to the improperly terminated messages,noting this condition to the receiving station.

The traffic is stored on the DSU in a large buffer area and this removes the validity checking and processing functions from the real-time environment. The first processing that is performed is the header verification, and if the header is correct, the message is then routed. The header must contain the destination station mnemonics, the origination sequence number, the origination station mnemonic and the date. Non-network points, such as TWX, are assigned psuedo-mnemonics and are routed to the refile point which is a ROTR at the center. The header must be correct or the message will not be accepted by the DATANET-30. A message will be sent to the transmitting station describing what was wrong and the monitor will also be notified. A header is created for each destination station mnemonic and is linked to the header queue on the DSU for the outgoing line. A multiple address message will have several headers linked to a common text. No checks are made on the text of the message.

When the DATANET-30 transmits to an outstation, the header is read from the DSU and the call directory code (CDC) of the destination station, the outgoing sequence number, and the present time are inserted in the header. The header is then written back on the DSU and this message is now part of the journal. The DATANET-30 transmits the CDC and the remote station is put in a print condition. The station responds with a "V" answerback if it is ready to receive traffic. If the DATANET-30 does not receive the "V" answer back, the message is linked to intercept queue and an appropriate message is sent to the monitor. If the "V" answer back is received, the message is transmitted. If the end of message code, FIGS H LTRS is not detected, the DATANET-30 waits for 10 seconds and then sends the improperly terminated message.

At the end of the day the system must be shutdown to clear out the journal, repack the unsent messages, and initialize the incoming and outgoing sequence numbers. The shutdown procedure is started after the outstations have sent their service good night (SGN) messages to the DATANET-30. The network good night (NGN) is entered into the system with the time polling is to stop. When that time occurs, the executive calls in the End of Day program to perform the end of day functions. A message is sent to the monitor when the End of Day program has completed the function. The next day the system is started as previously described.

6. TEST AND DEBUG EQUIPMENT

The equipment to test and debug a switching system can be considerably smaller than the final operating system. This is due to the unique feature that one station is similar to another station, one line is similar to another line. Therefore, it is possible to debug the programs and have an operating system with only a partial remote line and station configuration if the partial configuration is properly used.

Figure 9 shows the actual test equipment in Phoenix used to debug the system. The network control station and the monitor were necessary because the control and monitoring of the system station are performed there. There were two circuits under way circuit control, one with two ASR's and the other with an ASR and an RO. With this line configuration, the system could switch messages and do everything the actual 30 lines, 100 stations system could do. For example, to test the TSC's of the way circuits on the system, an ASR or RO could monitor the polling patterns for circuits by being plugged to the proper bit buffers. Likewise the CDC's could be tested. The only test not possible with a partial configuration is a volume test.

When ordering Teletype equipment from AT&T for debug use in Phoenix, a minimum of three to four months lead time is necessary to ensure installation and proper operation of the Teletype equipment. This may vary in other parts of the country. The Teletype equipment must be tested by the programmers to insure correct operating characteristics before actual program debugging can start.

The card reader and high-speed printer are necessary to debug the programs. Most of the software uses the card reader and all of the operating programs are initially loaded through the card reader. The printer is invaluable for the various memory and DSU dumps. It would be a considerable chore to debug a real-time system without these two peripherals. The dual access controller and the GE-225 were necessary to establish the actual operating environment of the switching center if this equipment is included in the final configuration.

Each Teletype line requires a line relay (LR) to interface with the DATANET-30. The line relay converts the current changes of state of the Teletype character code to corresponding voltage changes. The DATANET-30, or most any other processor, operates on a voltage change and this conversion is necessary to allow the DATANET-30 to recognize the Teletype transmission. An advantage of the line relay is that it isolates the DATANET-30 from the Teletype line to eliminate contact noise. The line relay also serves as a well defined dividing point for vendor responsibility.

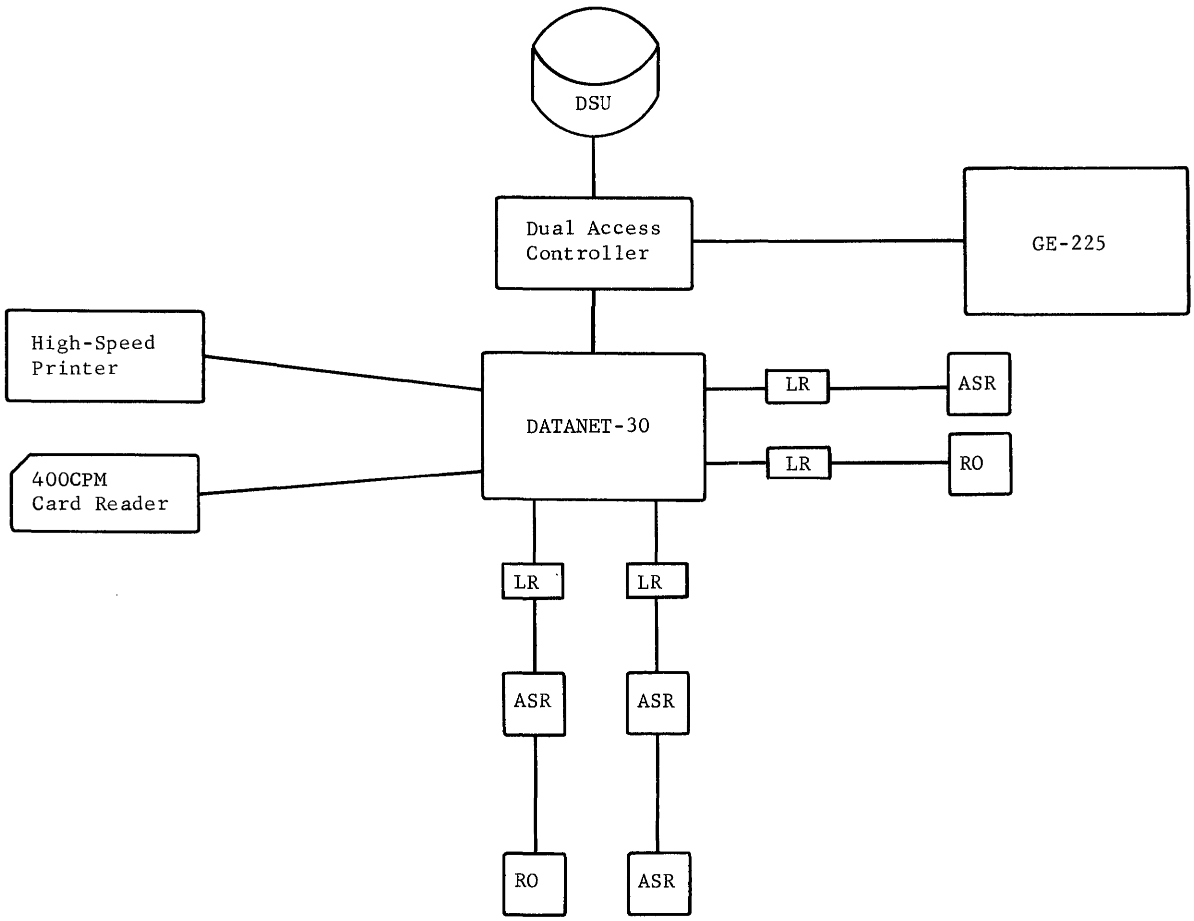


Figure 9. Test and Debug Equipment

7. SOFTWARE

It is quite obvious that to debug a system various software and debug aids have to be used. The following is a list of this and other software that has been developed. Additional software and debug aids are presently being developed and are not included in this list.

DYDUMP is a debug aid that permits dumping the DSU transfers in real-time on the printer. It also permits DSU updates and moves.

BINARY-OCTAL CARD LOADER loads binary and octal cards into memory. This is a paper tape loop for the tape reader of the DATANET-30.

ZERO DSU is for Zero selected areas of the DSU under console switch control.

DSU TO PRINTER is the printout in octal and Baudot of selected sequential DSU records.

CORE MEMORY DUMPS - Octal and Baudot
Octal and BCD
Octal and mnemonics

DATANET-30 ASSEMBLER ON GE-225

DATANET-30 ASSEMBLER ON THE DATANET-30

PRINT TAPE 3 OR 5 allows printing of tape 3 of the final pass of the assembler for additional listings.

MAGNETIC TAPE DUMPS

CARD TO PRINTER 80 x 80

CARD TO CARD run on GE-225 and will reproduce object deck and convert octal patches to binary cards to be entered in the DATANET-30.

MAGNETIC TAPE LOADER writes subroutines and operating programs on magnetic tape from card reader.

MAGNETIC TAPE BOOTSTRAP calls subroutines and operating programs from magnetic tape under console switch control.

DSU INPUT/OUTPUT ROUTINE

MAGNETIC TAPE INPUT/OUTPUT ROUTINE

GENERALIZED PRINT ROUTINE

MULTIPLY SUBROUTINE

DIVIDE SUBROUTINE

CONVERSION ROUTINES

Hollerith to BCD	Binary to BCD
Baudot to BCD	Binary to Baudot
BCD to Baudot	Baudot to Binary
BCD to Binary	Octal to Baudot

TRACE PROGRAM prints every instruction of a non-real time program and the state of the working registers after each instruction is executed.

MIXED BINARY OCTAL CARDS TO MAGNETIC TAPE writes DATANET-30 object programs on magnetic tape.

MEMORY LOOKUP searches memory for specified bit patterns entered through the switches and lists on the printer all locations where the bit pattern appears. Will also list all references to a specific memory location.

8. TRAFFIC AND TIMING CHARTS

The traffic and timing charts were developed from the Traffic Reports and the Program Timing Reports (See "System Operating Characteristics, Chapter 3") during the actual operation of the system. The purpose of these charts is to give an indication of the external load of a switching system and the effect of the load on the operations of the internal program. The traffic charts developed here were by hour for the system. A more detailed traffic analysis can be performed from the traffic reports because the reports are by station, by circuit, by hour. Traffic charts could be developed for each hour by circuit or by station. The data necessary to do this is contained in the traffic reports.

The traffic charts are important to the operating manager of a switching system to show the peak hours and the traffic flow during the day. A customer can reallocate the circuits based on the traffic reports to more economically distribute the traffic. The timing charts illustrate the efficiency and operation of the internal programs. When program changes are to be incorporated in the system, an indication of how the system will perform with these changes can be taken from the timing charts.

The information presented in this section is not meant to be indicative of the maximum throughput of a DATANET-30. The maximum throughput is a function of system design and this system was not designed to have maximum throughput.

The traffic chart for May 18, shown in Figure 10, shows that there were two peaks during the day, one at 1000 and the other at 1400, and a low at 1200. The two peaks are as typical of a switching system as the low is about noon. This system has a considerably higher peak in the afternoon than in the morning because order traffic is generated by the GE-225 after 1200 and is entered into the switching system. The orders are long messages which contain 2000 or more characters.

The total characters received by the stations in the system are greater than the total characters sent, because of multiple address messages. By dividing the characters received by the characters sent, a fanout factor of 1.24 is calculated for May 18. Averaging the fanout factor for a period of days will give an indication of the multiple address fanout for future system design changes.

The sum of the total characters sent and the total characters received is the throughput of the system per day. The throughput was 2,105,352 characters on May 18. The peak hour throughput of 381,942 characters occurred at 1400.

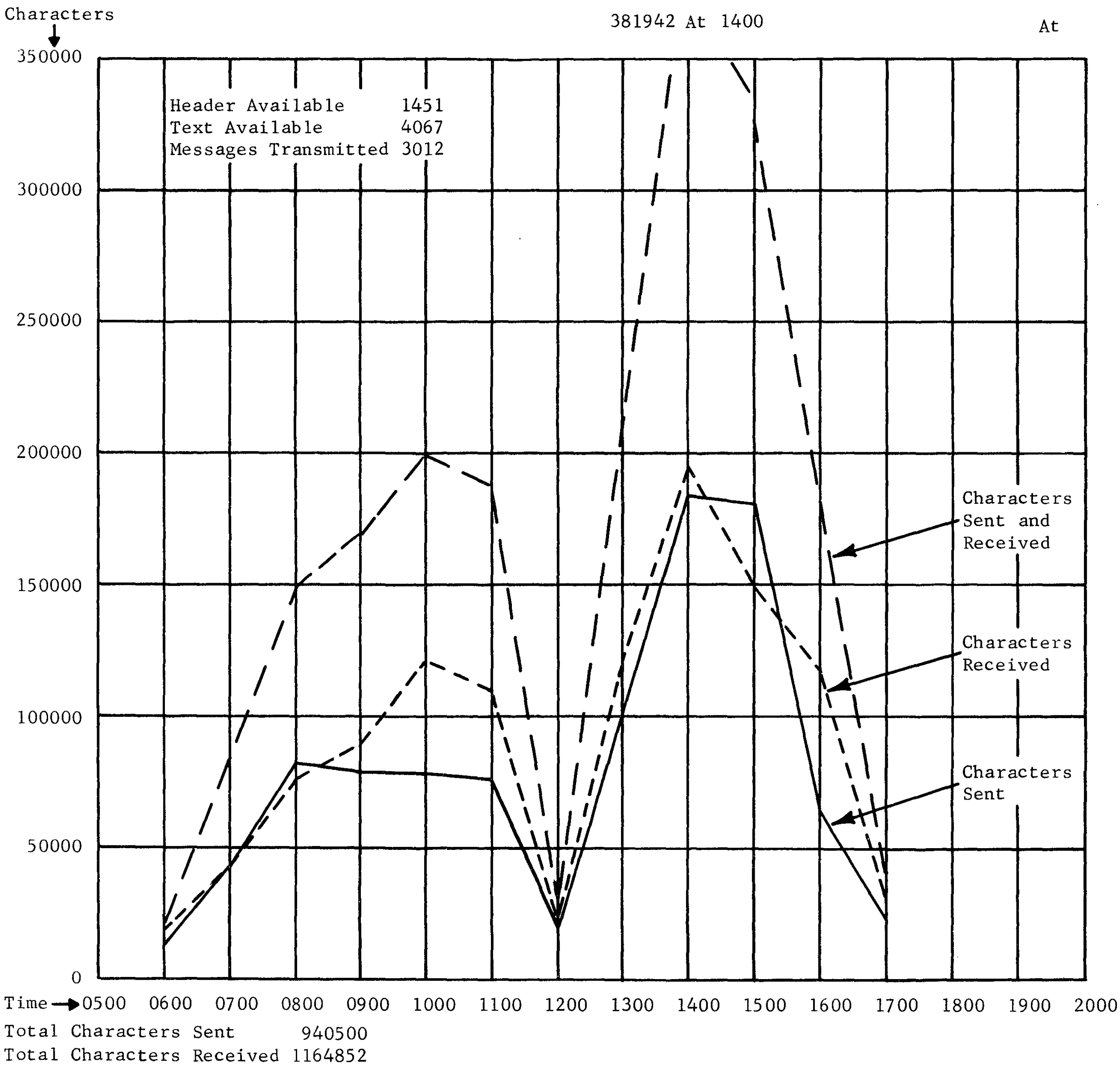


Figure 10. Traffic Chart, May 18

The header report is generated by the statistical information program (SIP) each hour and automatically prints on the monitor the number of remaining empty header records, the number of text blocks available and the total number of messages transmitted. The final count for the day is shown on each traffic chart. If an average message length is to be used in a system redesign, this can be readily calculated. Dividing the total characters received by the messages transmitted, an average message length of 387 characters is calculated for May 18.

The data accumulated by the traffic reports was easily and accurately compiled because the switching center was controlled by a computer. Most communications managers do not have accurate traffic counts, do not have accurate fanout factors, do not have accurate message volumes, and do not have even an accurate estimate of the average message length. To obtain the data to approximate the above on torn tape systems or on non-computer automatic systems, the manager must not only rent traffic counters from the carrier and place them on each line, but also use several people to maintain and analyze the information. This an added expense, and may not be accurate nor complete. On a computer controlled system this requires no additional equipment and the processor does an accurate, "real-time" analysis as the system operates.

Many other reports can be generated from the data gathered. As an example, one customer is automatically billing the remote stations at the end of each month based on the number of characters transmitted by each station.

The traffic chart for May 19, Figure 11, shows that three peaks occurred during that day. The reason for the second peak in the afternoon was that many of the orders had to be retransmitted due to an operating error. The throughput for the day was 2,326,590 characters and the peak hour throughput was 350,200 characters. The fanout factor was 1.26 and the average message length was 433 characters, both higher than the previous day because of the order retransmission.

The traffic chart for May 20, Figure 14, was a "normal day;" that is, no shutdowns of the system occurred and no gross operating errors occurred. The throughput for the day was 1,931,619 characters and the peak hour throughput was 306,000 characters. The fanout factor was 1.24 and the average message length was 399 characters, both of which are quite close to those for May 18 when no retransmission of orders occurred.

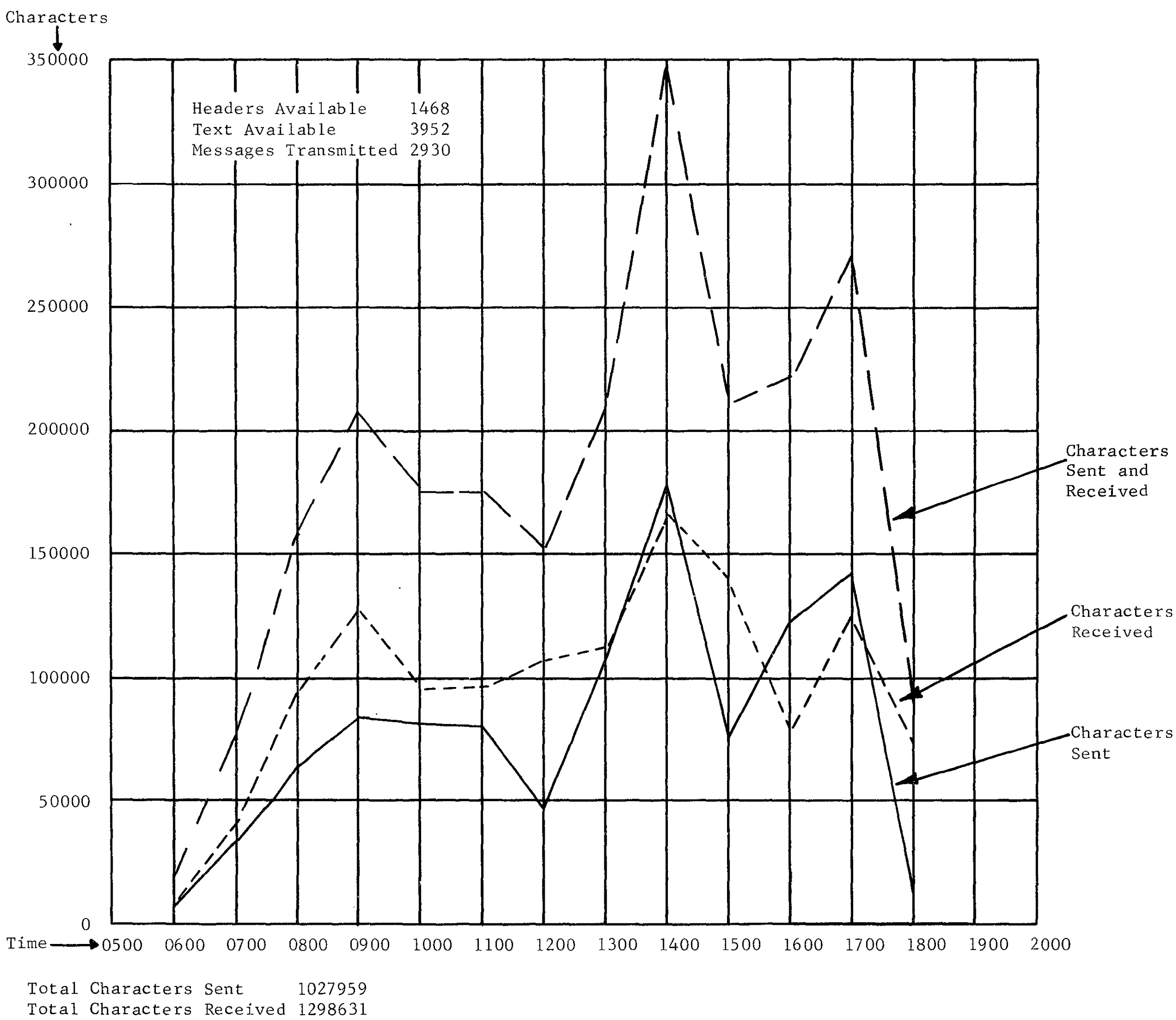


Figure 11. Traffic Chart, May 19

TRAFFIC REPORT
Hour 0900 Date 5/19

Line No.	Station	Sent	Received
	NC	1425	663
1	TOTAL	1425	663
	DN		4392
2	TOTAL		4392
	MA	1179	
7	TOTAL	1179	
	MB	5055	
8	TOTAL	5055	
	MC	5847	4032
9	TOTAL	5847	4032
	MD	4341	
10	TOTAL	4341	
	ME	5025	
11	TOTAL	5025	
	MP		32298
13	TOTAL		32298
	BK		28785
14	TOTAL		28785
	WH		699
	PC	6090	
15	TOTAL	6090	699
	BS	1167	2259
	NB	3045	2598
	NY	4914	5034
	LU	279	288
	BW	300	3330
	BM	2367	450
20	TOTAL	12072	13959
	DB	1785	4923
	AC	1263	159
	EN	1026	435
	DS	486	51
	OT	1404	657
	FT	324	
21	TOTAL	6288	6225

Figure 12. Traffic Report

TRAFFIC REPORT
Hour 0900 Date 5/19

Line No.	Station	Sent	Received
	NA	2394	1872
	CG	324	570
	CH	738	402
	AB	3864	4911
	GA		246
	LL		366
	NV	252	
22	TOTAL	7572	8367
	SI	3759	1200
	CB	453	8625
	DW	801	144
	PW	279	306
23	TOTAL	5292	10275
	SC	651	288
	OG	2784	3111
	SA	18	864
	LP	783	
	LA	3291	1557
	SF	336	114
	LF	3891	2241
24	TOTAL	11754	8175
	WE		345
	PB	6969	3507
	CI		1983
	HM	141	1932
	HB	174	363
	FW	1170	339
	EG	2364	
	CV	198	486
25	TOTAL	11016	8955
	TOTAL	82956	126825 V

Figure 13. Traffic Report

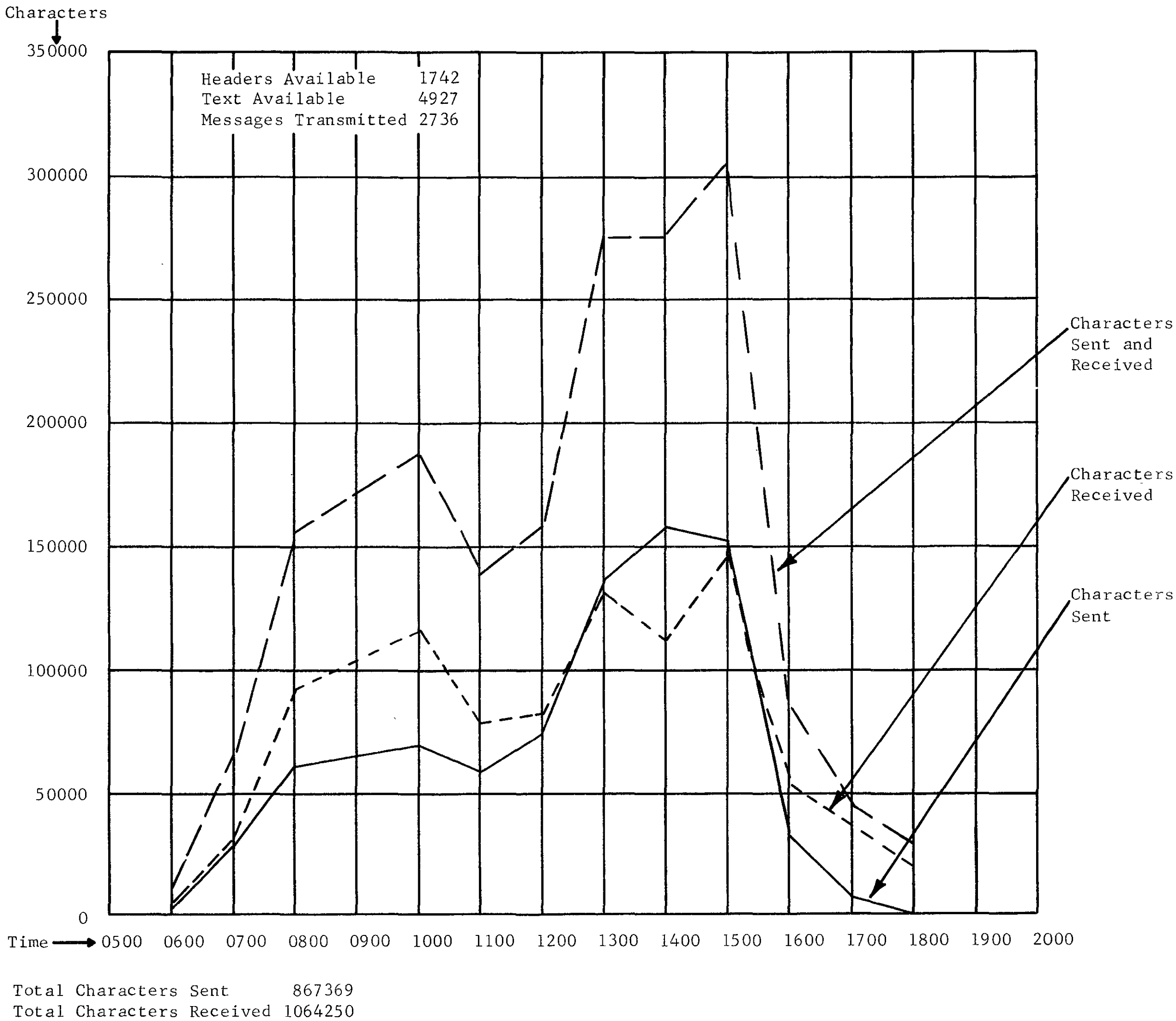


Figure 14. Traffic Chart, May 20

The timing charts per day were compiled from the program timing reports for each hour during that day. The "Daily Average in Percent" at the top of each timing chart were obtained from the summary report at the end of the day. The percentage of the time spent in each program is the DSU time and the processing time combined. The DSU time is the major time element. The idle time available in the charts is high and was designed to be high because it is during this time that the GE-225 can have access to the disc storage unit through the dual access controller. For each hour, the idle time should vary inversely with the traffic load on the system. However, this does not show to be true on the charts, because of the Journal Search program. Where the idle time sharply decreases, the journal search time sharply increases. The timing chart for May 18, Figure 15, illustrates this fact at 1400.

The idle time is really a function of the total time spent in the various programs of the system. Some of these programs do have a correlation to the traffic volume, and these are the on-line program, Storing, Processing, and Forwarding. Forwarding takes a greater percentage of the time available than the other two programs because all of the relinking is done in Forwarding. The off-line programs, Disc Storage Error (DSUERR), Statistical Information Program (SIP), Hourly Reports, and Journal Search are not necessary to perform the actual switching function, but are necessary from a total systems viewpoint.

Of these, only journal search takes a significant percent of the time available, because the header storage area must be searched to find the message requested. This of course, takes DSU time and if several journal search requests are processed in rapid succession a great deal of time is spent in that function. Neither the Executive nor the Line Servicing program use the DSU; therefore, they are not listed in the timing reports. The time spent in these two programs is included in the program listed. The timing charts show that even during the peak hours there was idle time in the system. If the same system was designed without a GE-225 and a dual access controller, the block buffer area per circuit would be reduced and more circuits could be added to the system. Or, maintaining the same buffer size, other off-line programs could be added to the system and not effect the throughput of the system. As an example, a DSU-to-magnetic tape routine could be added and called into operation by a message entered through the network control station.

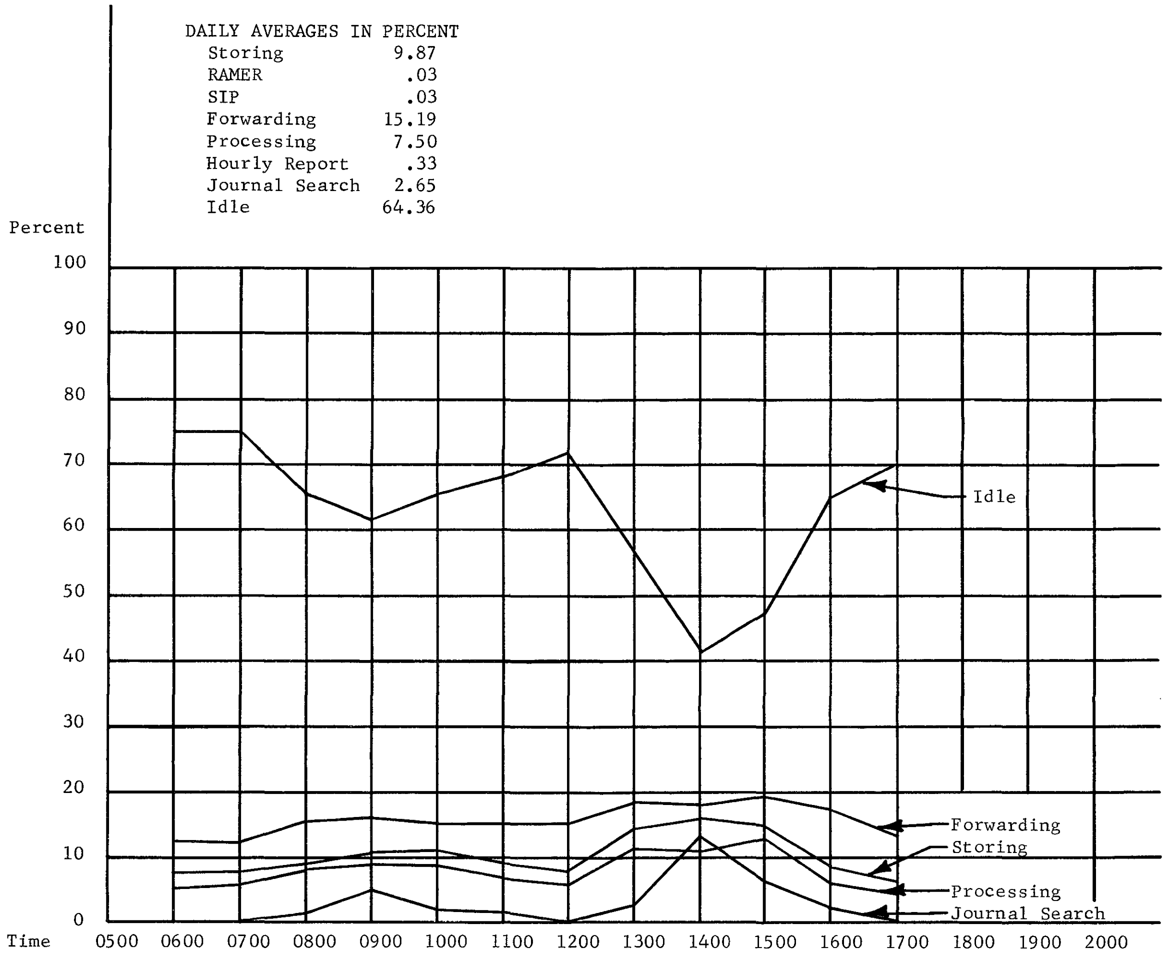


Figure 15. Timing Chart, May 18

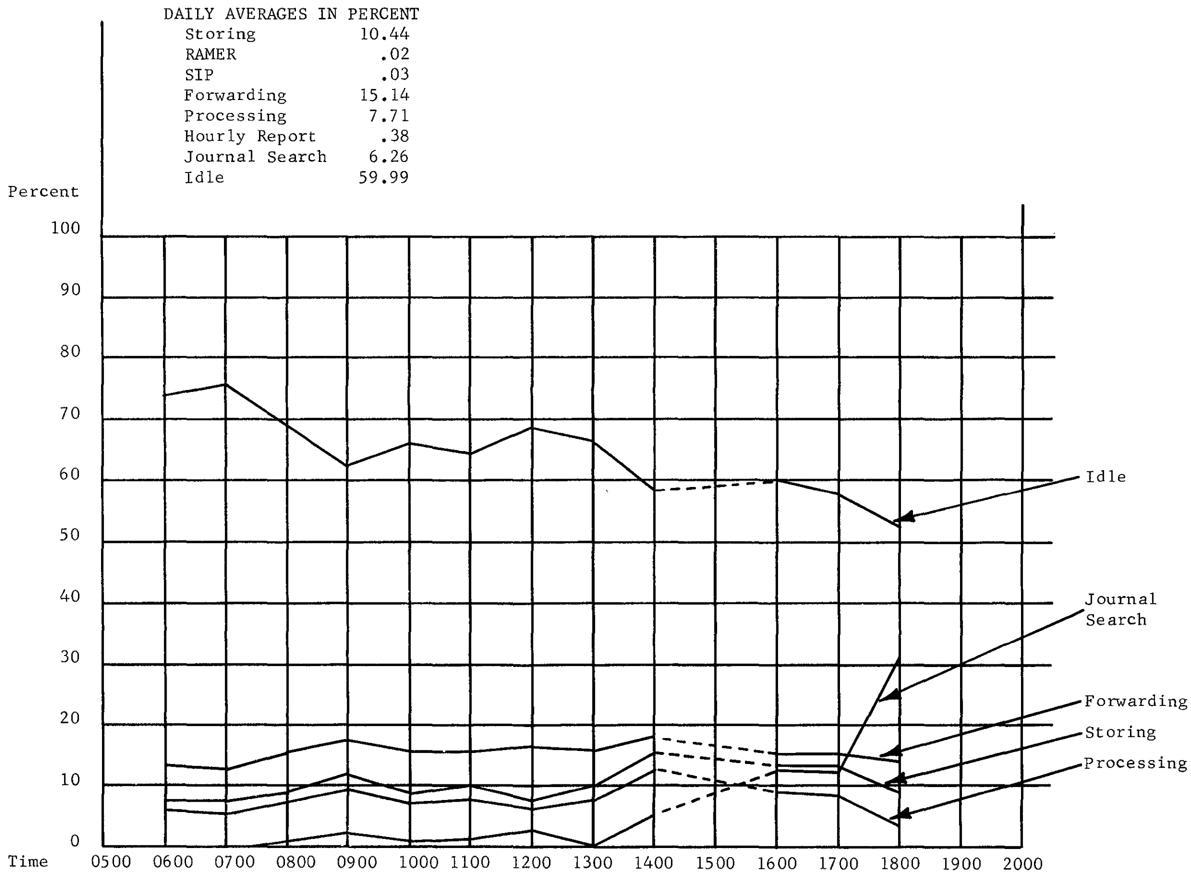


Figure 16. Timing Chart, May 19

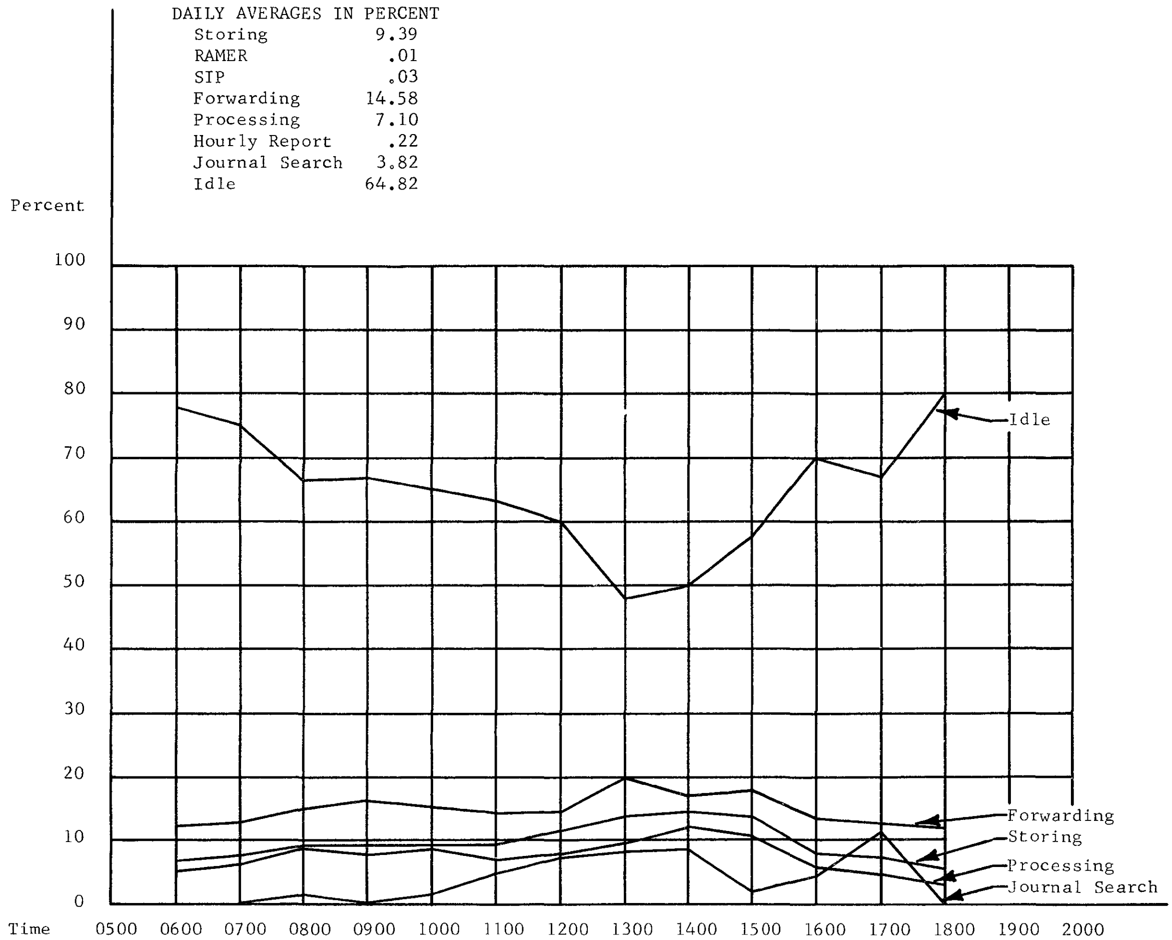


Figure 17. Timing Chart, May 20

9. MESSAGES IN QUEUE REPORTS

The switching center operates for twelve hours a day and the messages in queue reports for a day, May 13, are presented in Figures 18 through 22. There are thirteen reports presented because the last one is necessary to show the end-of-day status of the queues. The reports show the number of messages that were in the normal queues (Q) and the intercept queues (I) at the start of the hour, at the end of the hour and the maximum that occurred during the hour. The hour shown on each report is the beginning of the hour. As an example, the 0600 queue report is for the hour from 0600 to 0700. Queues are not created by the DATANET-30 but rather by line loading and station outage. As an example, if a high volume station is on intercept, a high number of messages in queue can be expected. When interpreting these queue reports, it should be remembered that this is a half-duplex system and that a circuit does not have simultaneous two-way transmission.

The 0600 queue report was the first for the day and the report shows that only three lines had any traffic switched to them during that hour. If a line did not have any messages in queue during the hour, then that line was deleted from the report. The report also shows that messages were not stored on the DSU from the previous day, because the start of the intercept queue was zero, blank.

The queue report for the next hour shows increased activity on the system because more stations have started to transmit. Note that the end of the normal queues and the intercept queues for 0600 are the start of the normal queues and the intercept queues for 0700.

Line 14 on the 0800 queue report shows the start of a very high number of messages backed up in queue during the next several hours for that line. That line had only one station, an RO, that received all of the bakery orders from the remote stations. During the morning, the remote stations transmitted a high volume of bakery orders to be processed in the afternoon by the GE-225. The high number of orders in queue during the morning was acceptable because all of the morning bakery orders would be received on the an RO by 1200. The 1100 queue report shows that at the start of the hour there were 22 messages in normal queue for line 14, but at the end of the hour the queue was empty.

The 1000 queue report has 11 messages in intercept queue at the end of the hour for Line 23. A station on that line had trouble with the ASR and was on intercept for maintenance. (The Monitor RO had previously logged when the station was put on intercept.) The end of intercept queue on the 1100 queue report for Line 23 shows that seven more messages were put into intercept queue. During the hour of 1200 to 1300, the station was taken off intercept and the messages were put into the normal queue and delivered to the station. (The Monitor RO logged when the station was removed from intercept.) The high maximum normal queue was due to the transfer of messages from the intercept queue to the normal queue when the station was removed from intercept during that hour. By the end of the hour, only two messages remained in the normal queue and the intercept queue was empty. The two messages were delivered during the next hour.

MESSAGES IN QUEUE REPORT

Hour 0600 Date 5/13

Line	Start Q	Start I	End Q	End I	Max Q	Max I
15				1		1
22			1		1	
23			1	1	1	1

MESSAGES IN QUEUE REPORT

Hour 0700 Date 5/13

Line	Start Q	Start I	End Q	End I	Max Q	Max I
1					1	
2					2	
7					1	
13			1		3	
14			3		4	
15		1			1	1
20					1	
21					2	
22	1		2		2	
23	1	1		1	2	2
25					2	

MESSAGES IN QUEUE REPORT

Hour 0800 Date 5/13

Line	Start Q	Start I	End Q	End I	Max Q	Max I
2					3	
10					1	
13	1				4	
14	3		27		29	
15					1	
20					2	1
21					2	
22	2				3	
23		1	1		2	1
24					2	
25					2	

Figure 18. Messages in Queue Reports for May 13.

MESSAGES IN QUEUE REPORT
Hour 0900 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					1	
2					3	
7					1	
10					2	
11					1	
12					1	
13					4	1
14	27		36		38	
15					1	
20					3	
21					2	
22					1	1
23	1			4	5	4
24			4		4	
25					6	

MESSAGES IN QUEUE REPORT
Hour 1000 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					1	
2					2	
10			1		2	
11					1	
13					3	
14	36		22		37	
15					1	
20					2	
21					3	
22					1	
23		4		11	3	11
24	4				8	
25					1	

MESSAGES IN QUEUE REPORT
Hour 1100 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					1	
2					1	
7					1	
9					1	
10	1				1	
11					1	
13					3	
14	22				24	
15					2	
20					2	
21					2	1
22					1	
23		11		18	3	18
24			2		3	
25					3	

Figure 19. Messages in Queue Reports for May 13

Starting at 1400 the order traffic generated by the GE-225 was being entered into the system. Lines 20 through 25 were the six nationwide circuits and the queues for these lines show the effect of the order traffic. Because the orders were long messages, the normal short administrative messages were backed up on the normal queues. Also, several of the remote stations were on intercept during the midafternoon and this also backed up the intercept queues. The high maximum normal queues at 1500 was due to the transfer of the intercept queues to the normal queues during the hour.

The 1700 queue report shows all of the normal queues empty, with the exception of line 24 which was the circuit to the West coast and naturally, would be busier at this time of the day because of the time zones. The 1800 queue report shows that all of the messages in normal queue had been delivered, but that line 25 had three messages in intercept queue. The three messages were to a station that was on intercept because the stations had transmitted an SGN. These messages were delivered the next day.

The messages in queue report is a valuable managerial tool because it gives the exact queue status of each line in real-time and guesswork or estimates are no longer necessary. As an example, one day the RO on line 14 became inoperative and the messages in queue report immediately reflected this condition. A change routing tables (CRT) Service Message was entered and this traffic was rerouted to a low volume station. Another example, line 13 was the queue for the four RO's to receive the Minneapolis administrative traffic. As many as 500 messages could be received by these RO's. Not once during May 13 did the maximum normal queue show more than four messages during an hour. It was decided that two RO's could adequately receive this traffic. It was only because accurate traffic data was not available during initial system design that four RO's were originally specified. Eliminating two RO's saved about $100 a month. No doubt, additional savings can be made after more detailed analysis is made of the messages in queue reports in conjunction with the traffic reports.

MESSAGES IN QUEUE REPORT
Hour 1200 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
2			1		2	
7					1	
11					1	
13					3	
14			4		4	
15					1	
20					2	
21					1	
22					2	
23		18	2		20	19
24	2				2	
25			1		1	

MESSAGES IN QUEUE REPORT
Hour 1300 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					1	
2	1			3		3
14	4					
20				3	2	3
21				1	1	1
22				1	1	1
23	2					
25	1					

MESSAGES IN QUEUE REPORT
Hour 1400 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					2	
2		3				
20		3		19	3	19
21		1		9	5	9
22		1		6	4	6
23				11	3	11
24				32	2	32
25				20	2	20

Figure 20. Messages in Queue Reports for May 13

MESSAGES IN QUEUE REPORT
Hour 1500 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
2					6	2
7					1	
10					1	
11					3	1
12					2	
13					2	
14					1	
15			3		4	2
20		19	10		24	19
21		9			13	9
22		6			10	6
23		11	15	2	19	11
24		32	24	1	37	32
25		20	7		24	20

MESSAGES IN QUEUE REPORT
Hour 1600 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
1					1	
2					3	
7					2	
9					1	
11					2	
12					2	
13					2	
14					1	
15	3				5	
20	10		15		16	
21					1	
22					1	
23	15	2	20		22	15
24	24	1	33		33	2
25	7			1	8	1

Figure 21. Messages in Queue Reports for May 13

MESSAGES IN QUEUE REPORT
Hour 1700 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
2					2	
7					2	
9					2	
10					1	
12					1	
13					1	
14					1	
20	15				15	
21					1	
22					1	
23	20				24	
24	33		18		41	
25		1		3	2	3

MESSAGES IN QUEUE REPORT
Hour 1800 Date 5/13

Line	Start Q	Start I	End Q	End I	Max. Q	Max. I
24	18				18	
25		3				3

Figure 22. Messages in Queue Report for May 13

10. INTRA-LINE AND SIMULTANEOUS MESSAGE DELIVERY

When the 83B2 line control system was initially designed by AT&T, one of the major considerations was to allow one station on a circuit to transmit to any other station or stations on that circuit without requiring that the message go through the switching center. This type of message is called intra-line. Messages being switched from one line to another are called interline.

Intra-line messages were not allowed in this system for two reasons. The first was that this type of message can not be controlled or directed by the DATANET-30. This control is necessary to insure a successful and operating system at that point in time. Control would be lost on incoming and outgoing sequence number checks and in header verification. The second reason is that intra-line message traffic load on the system is not heavy enough to necessitate designing the system with this function. By requiring all messages to go through the center, the intra-line messages appear twice on that line. Therefore, if there were a high percentage of these messages, the line could be forced into an overload condition.

Undoubtedly, some of the future DATANET-30 switching systems with 83B2 terminal equipment will be required to allow intra-line message delivery. As an example, companies that have their headquarters on the East coast and have one circuit to the West coast with San Francisco and Los Angeles on the circuit, normally will have a high volume of traffic between these two cities. If the volume is over 50 percent of the line load, the line will be overloaded if all messages are required to go through the center before delivery. The addition of another long line would be an added expense. Therefore, the DATANET-30 system must allow intra-line delivery and either lose some of the system control or use more sophisticated control techniques.

Another feature of the 83B2 system not allowed in this system is that of simultaneous delivery of the same message from the DATANET-30 to two or more stations on the same circuit. The reason for not allowing this is because the volume of multiple address messages delivered to two or more stations on the same line is insignificant and does not justify the programming effort to properly provide this function with the proper message control. Again, this feature may be required on future DATANET-30 switching systems because of the line loading factor.

Both intra-line and simultaneous message delivery can be provided with more sophisticated techniques. These techniques are now being developed because the basic problem of switching traffic has been solved. The successful solution is possible by gradually stepping into the message switching application and not trying to do everything at one time when it is neither required nor justified.

The following is a brief description of a method to allow Intra-line and simultaneous message delivery. This is not a complete solution and should not be used as such.

Figure 23 illustrates the operation of this 83B2 system under DATANET-30 control. The example in Figure 23 shows the DATANET-30 polling station E by transmitting the transmitter start code (TSC) for station E. If station E does not have a message to transmit, a "V" answerback is sent to the DATANET-30 by station E. Upon receiving the "V" answerback, the DATANET-30 polls the next station in the polling pattern.

However, if station E has a message to be transmitted, a call directing code (CDC) and a LTRS character are transmitted. This is the CDC of the transmitting station and will set it's receiving unit in a print condition in order to have a copy of the message printed as the message is transmitted. The receiving unit sends a "V" answerback to the transmitting unit and the "V" causes two more characters and a LTRS to be transmitted.

In the example, these two characters are the CDC for station B on the same line. This CDC will set the receiving unit for station B in a print condition. Station B now sends a "V" answerback to station E, and two more characters and a LTRS are transmitted.

These characters are not another CDC, but the end of directing code, a carriage return (CR), line feed (LF), and letters (LTRS). The message is now transmitted. Station E receives a page copy, and station B receives a page copy. The DATANET-30 is monitoring the entire procedure and also receives the message.

The end of transmission code, FIGS H LTRS, puts all receiving units in a nonprint condition. The DATANET-30 senses the FIGS H LTRS, and now creates the trailer. The trailer always has the transmitting station mnemonic, sequence number and date. Because this message has been delivered on this line, this trailer will also have the receiving station mnemonic and sequence number. The DATANET-30 now transmits the CDC for the transmitting station, receives a "V" answerback, transmits the CDC for the receiving station on that line, receives "V" answerback and then transmits the trailer. The trailer gives the ability to assign a sequence number to all messages in the system. The DATANET-30 assigns all sequence numbers and thus relieves the operator of this task.

The DATANET-30 monitors the line and stores the message on the DSU for further processing. If the message is not to be delivered on another line, the message will be only entered into the journal. If it is going to be switched, it will be entered into the journal and into the proper outgoing queue or queues.

Figure 24 illustrates the input header format. Line 1 consists of the CDC's for the transmitting station and for receiving stations on that line. The CR LF LTRS is the end of the directing code. Line 2 consists of the station mnemonics of messages that are to be switched. The DATANET-30 will route and queue these messages to other lines. Line 3 is the text which may be any length. Line 4 is the end of transmission code.

Figure 25 is the trailer format. A limit of four stations for intra-line messages will allow a Trailer to be created in 30 words or less. This is necessary to reduce the memory requirements because trailers must be created in separate areas. If a separate trailer area is not used and the trailers are treated in the message buffer areas, a time lag between the end of transmission of the messages and the transmission of the trailer is introduced because the message buffer areas must first be emptied before the trailers can be created. The trailer must also be attached to the message on the DSU to identify the message when it is delivered to stations on other lines. Line 1 of Figure 25 is taken from the input header and is composed of the CDC of the transmitting station and CDC's of receiving stations on that line for intra-line traffic. The end of directing code signal also is taken from the input message header. Line 2 consists of the transmitting station mnemonic, the transmitting station sequence number and the date. Lines 3-6 consist of the receiving station mnemonics for intra-line traffic and the receiving station sequence numbers. Line 7 is the end of transmission code.

The output header format for messages switched by the DATANET-30 has the CDC of the receiving station, or the CDC's of the receiving stations in case of simultaneous message delivery, and the end of Directing Code. The text of the message includes the input header, the text, and the Trailer from the incoming line. Another Trailer to include the outgoing sequence number or numbers must be created.

All stations broadcast messages are sent simultaneously to all stations on a line. A special Trailer is used along with a special sequence number. This is possible because a unique CDC for an all stations broadcast is part of the 83B2 line operation.

The method described has several immediate problems to be solved before it can be implemented. One is that the trailer must be created in real-time and the program to do this must always be in memory. Another is that processing must do a sort on the station mnemonics to determine if two or more are on the same line to create only one header in case of simultaneous message delivery. Another problem (if simultaneous message delivery is desired) is the requeueing of messages if one or more of the stations does not respond to a CDC or if the stations are on intercept. Still another problem is that journal search must be performed on sequence numbers that are now on the end of the message and not in the header.

There are solutions to the above problems, but they do create a more sophisticated system than the one presented here, which in itself is a complex system.

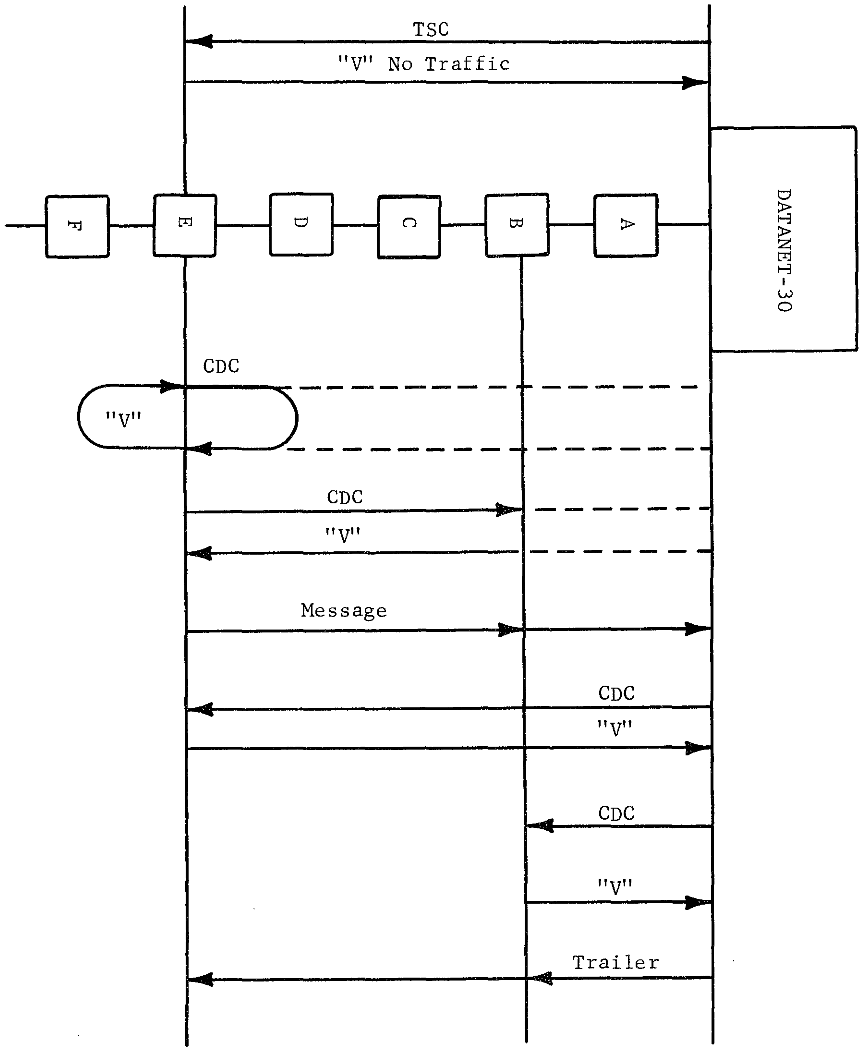


Figure 23. DATANET-30 Control of 83B2 (Intra-line)

1. EE LTRS, AA LTRS, BB LTRS, CC LTRS, DD LTRS, CR LF LTRS
2. XX LTRS, YY LTRS, CR LF LTRS
3. TEXT
4. FIGS H LTRS LTRS

Figure 24. Input Header Format

1.	TT LTRS AA LTRS BB LTRS CC LTRS DD LTRS CR LF LTRS	6
2.	TT FIGS SP SE QN SP DD/ DD/ DD SP CR LF LTRS	7
3.	AA FIGS SP SE QN SP	4
4.	BB FIGS SP SE QN SP	4
5.	CC	4
6.	DD	4
7.	FIGS H LTRS	1
	Words Maximum	30

Figure 25. Trailer Format

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