# THE NAVAL COMMUNICATIONS PROCESSING AND ROUTING SYSTEM: ANALYSIS OF AN AUTOMATED SYSTEM

Beth Marie Hintz

# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS

THE NAVAL COMMUNICATIONS PROCESSING AND ROUTING SYSTEM:

ANALYSIS OF AN AUTOMATED SYSTEM

by

Beth Marie Hintz

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Thesis Co-Advisor: N. F. Schneidewind
Thesis Co-Advisor: S. H. Parry

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This thesis is designed to present a detailed description and analysis of the Naval Communications Processing and Routing System (NAVCOMPARS). Discussed are the objectives and principles of the Naval Telecommunications Automation Program (NTAP), with emphasis placed on delineating the shore components, particularily NAVCOMPARS. The capabilities of NAVCOMPARS are identified by describing the patterns of message flow through the automated system. Also considered are the manpower and training characteristics and

the projected link with the Information Exchange Subsystem (IXS). A model of the central processing unit is presented in order to highlight the sequence of procedures employed by an automated message processing system. The underlying intent of this thesis is to provide a compact document which could be used as introductory material to acquaint non-computer specialists with the characteristics, requirements and potential of the Naval Communications Processing and Routing system.

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ANALYSIS OF AN AUTOMATED SYSTEM

by

Beth Marie Hintz
Lieutenant, United States Navy
B. S., University of Illinois, 1967

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# ABSTRACT

This thesis is designed to present a detailed description and analysis of the Naval Communications Processing and Routing System (NAVCOMPARS). Discussed are the objectives and principles of the Naval Telecommunications Automation Program (NTAP), with emphasis placed on delineating the shore components, particuiarily NAVCOMPARS. The capabilities of NAVCOMPARS are identified by describing the patterns of message flow through the automated system. Also considered are the manpower and training characteristics and the projected link with the Information Exchange Subsystem (IXS). A model of the central processing unit is presented in order to highlight the sequence of procedures employed by an automated message processing system. The underlying intent of this thesis is to provide a compact document which could be used as introductory material to acquaint non-computer specialists with the characteristics, requirements and potential of the Naval Communications Processing and Routing System.

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| | | |
|---|---|---|
| ACP | - | Allied Communications Publication |
| ACS | - | Autodin Control Subsystem |
| AIG | - | Address Indicating Group |
| AIS | - | Autodin Interface Subsystem |
| ASCII | - | American Standard Code for Information Interchange |
| ASC | - | Autodin Switching Center |
| AUTODIN | - | Automatic Digitial Network |
| CAI | - | Command Action Indicator |
| CCM | - | Multi-channel Communications Controller |
| CCS | - | Communication Control Subsystem |
| COBOL | - | Common Business Oriented Language |
| CPU | - | Central Processing Unit |
| CSRF | - | Common Source Routing File |
| CUDIXS | - | Common User Information Exchange Subsystem |
| DADS | - | Direct Access Disk Storage |
| DTG | - | Date time group |

| | | |
|---|---|---|
| EBCDIC | - | Extended Binary Coded Decimal Interchange Code |
| ECS | - | Executive Control Subsystem |
| EOM | - | End of Message |
| FLTSATCOM | - | Fleet Satellite Communications Program |
| JANAP | - | Joint Army/Navy/Air Force Publication |
| LDMX | - | Local Digital Message Exchange |
| LMF | - | Language and Media Format |
| MAGFL | - | Multiple Addressee Guard File |
| MARFL | - | Multiple Addressee Routing File |
| MPDISK | - | Message Processing Disk |
| MPFC | - | ACP 126 Routing and Format Conversion Module |
| MPJA | - | Common JANAP 128 Heading Analysis Module |
| MPS | - | Message Processing Subsystem |
| NAVCOSSACT | - | Naval Command Systems Support Activity |
| NAVMACS | - | Naval Modular Automated Communications System |
| NECOS | - | Network Control Station |

| | | |
|---|---|---|
| NTAP | - | Naval Telecommunications Automation Plan |
| NTP | - | Naval Telecommunications Publication |
| OCR | - | Optical Character Reader |
| OTC | - | Over the counter |
| PLA | - | Plain Language Address |
| PLAD | - | Plain Language Address Directory |
| RCS | - | Receive Control Subsystem |
| RCDSK | - | Recovery disk |
| RCFX | - | Receive Control Format Exchange Module |
| RCIO | - | Receive Control Input/Output Module |
| RI | - | Routing Indicator |
| RIXT | - | Remote Information Exchange Terminal |
| ROUTFL | - | Routing File Directory |
| SMN | - | Subscriber Message Number |
| SSIC | - | Standard subject identification code |
| SSN | - | Station serial number |
| TCLP | - | Transmission Control Line Program |
| TCS | - | Transmission Control Subsystem |

| | | |
|---|---|---|
| TPS | - | Transmission Processing Subsystem |
| TPMJ | - | Transmission Processing Message Journal Module |
| TPQH | - | Transmission Processing Queue Handler |
| TOF | - | Time of File |
| TOR | - | Time of Receipt |
| VDT | - | Video Data Terminal |

# I. INTRODUCTION

The mission of naval telecommunications is to supply accurate, secure, reliable and rapid communications to naval forces and commands around the world. The Naval Telecommunications System (NTS) also has responsibilities as an integral part of the Defense Communications System Automatic Digital Network (AUTODIN), which provides a connection to the National Command Authority and the other military services.

The prime element in judging the effectiveness of the NTS is the determination as to whether the system can transfer required information accurately and reliably from originator to addressee in an interval timely enough to be useful to the recipient. In the late 1960s, serious questions were raised concerning the ability of the NTS to meet the requirements imposed upon it. Delays which severly downgraded service below acceptable levels were occurring during message processing at originating and terminating communications centers, as well as in the points of interface between fleet and shore systems. In order to alleviate the delays which resulted through the inefficient and error prone procedures involved in manual processing of messages, emphasis was placed on developing and implementing automated message processing systems which would meet all the Navy's requirements for information transfer. This paper will examine the objectives of the Naval Telecommunications Automation Program (NTAP) and will describe the innovations in automated message handling procedures which have occurred in shore communications.

Detailed attention will be focused on the characteristics of the Naval Communications Processing and Routing System (NAVCOMPARS).

# II. DISCUSSION OF NTAP

Adoption of the Naval Telecommunications Automation Plan in 1971 established guidelines for the evolution of the NTS into an automated system which would satisfy the demands placed upon communication centers ashore and afloat.

## A. OBJECTIVES

The specific objectives of the NTAP are as follows [Refs. 15 and 18]:

a. Improve originator to addressee delivery times to meet designated standards.

b. Obtain a timely exchange of information critical to the command and control of forces afloat through the automation of message processing functions.

c. Provide a capability to effect consolidation of telecommunication facilities and functions to allow significant manpower and equipment savings.

d. Eliminate current slow manual operations to reduce error rates and to allow more efficient utilization of personnel.

e. Make maximum use of high speed data links (satellites) and provide more efficient operation during crises situations.

## B. PLANNING PRINCIPLES

Several principles were delineated to govern the implementation of the NTAP. Due to the urgent nature of the requirements for automated processing systems and the

availability of commercial hardware, maximum use would be made of off-the-shelf hardware in order to decrease developmental cost and to permit the most cost-effective installation of the system. Hardware and software would be modular in design in order to ensure flexibility in the system, and procurement practices would be oriented toward maintaining compatibility between subsystems. Consideration was to be given to utilizing, where possible, relatively simple input-output terminals which would operate under the control of a more sophisticated host processor. Additionally, systems would be 'user transparent' to provide maximum usability with minimum training. Due to space limitations prevalent on a large number of ships, the NTAP stressed the requirement that the maximum number of communications functions would be performed ashore, thereby minimizing the equipment inventories needed on board ships.

## C. COMPONENTS OF THE SHORE ESTABLISHMENT

The NTAP encompasses automation projects in shore communications, fleet communications and the interface between the two, which is basically the Fleet Satellite Communications (FLTSATCOM) Program. Present planning calls for a shore subsystem to be composed of seventeen Local Digital Message Exchanges (LDMX) for major telecommunication centers, five NAVCOMPARS for Naval Communication Stations (NAVCOMMSTA), and ninety-five Remote Information Exchange Terminals (RIXT) for small telecommunications centers in the immediate area of an LDMX/NAVCOMPARS. Each of these systems is designed to eliminate to the greatest extent possible manual intervention in the processing of messages. RIXT is being devised to utilize an LDMX/NAVCOMPARS computer as a host for processing functions including message entry, logging, routing, formatting, file and retrieval. RIXT

installations at telecommunication centers will generally replace presently existing Autodin terminals. In order to comply with the planning principles of the NTAP, NAVCOMPARS software will be used on future LDMX systems, and presently operating LDMX sites will be transitioned to it. The LDMX at San Diego is currently operating with modified NAVCOMPARS software.

# III. NAVCOMPARS SYSTEM DESCRIPTION

A real-time system devoted exclusively to naval telecommunication applications, NAVCOMPARS is a tactical system designed primarily to provide an automated fleet broadcast and an automated entry into Autodin. When FLTSATCOM is completely operational, NAVCOMPARS, in conjunction with Autodin, will enable ships to have the capability for high speed point-to-point transmissions. NAVCOMPARS also provides administrative and service functions to over-the-counter (OTC) users.

## A. EQUIPMENT

Due to the critical nature of its command and control function as a link to the operating forces, NAVCOMPARS requires an extraordinary degree of system reliability. To provide for this key factor, NAVCOMPARS consists of a duplexed Univac series 70/45 system. Under this duplexed configuration, one central processing unit and associated equipment are on-line, while the second CPU is maintained in the back-up mode. A multiplexor is an integral part of the CPU and is capable of accomodating 256 devices in a wide variety of configurations. Each CPU has communications capabilities when equipped with appropriate communications equipment. The communications module is composed of two multi-channel communications controllers, up to 82 teletype devices, two Dataspeed readers, an Optical Character Reader (OCR) and 10 Video Data Terminals (VDT). The Multi-channel Communications Controller (CCM) is a communications

coordination device which provides a capability to accomodate up to 48 half-duplex channels and provides the computer systems interface for the VDTs, dedicated channels, teletypewriter logs, medium speed readers, OCR, satellite and broadcast channels. [Refs. 15 and 16] A memory protection feature, which allows up to sixteen levels of memory separation, maintains memory and program integrity in a multi-programming environment. The internal logic for elementary operations is contained in read-only memory.

Software has been developed by Naval Command Systems Support Activity to accomodate the requirements of various actual and proposed locations; therefore, identical software has been installed at all operating sites. Standardization of software has been rigidly maintained, and system modifications are implemented only as directed by program changes from NAVCOSSACT. Flexibility has been built into the system through incorporation of a modular design, which for example will accept the program additions necessary for satellite communications. Each subsystem must fit properly within the total system, but the various subsystems were initially developed as separate sections of software. A dual file concept is utilized to provide a fall back capability. This is significant because it allows the back-up set of routing files to be used for the daily update action while the on-line system is operating.

## B. MESSAGE FLOW ANALYSIS

NAVCOMPARS automates message processing activities in three areas of a NAVCOMMSTA: Fleet Center, Computer Center and Message/Service Center. In addition to the major function of automatically keying on-line the fleet broadcast, procedures managed by NAVCOMPARS include

preparation, routing, formatting, code conversion, validation, editing, transmission, filing, recalling, re-addressal and retransmission. The system also distributes OTC traffic, handles data traffic, generates statistics and maintains a real-time fleet locator. Using Figure 1 as a reference source, this paper will detail the procedures involved in processing narrative traffic through the subsystems of a NAVCOMPARS.

1. Message Entry

Messages are entered in NAVCOMPARS through Autodin Switching Centers (ASC), over-the-counter procedures (primarily OCR for narrative traffic), on-line dedicated/full period channels and off-line full period channels.

a. Autodin

Autodin messages in JANAP 128 format are received via the Autodin Interface Subsystem (AIS) which is resident in two Univac 70/1600 Autodin Communication Controllers. This digital stored program processor, which supplies the connection between the ASC and NAVCOMPARS maintains synchronization with the ASC, strips control characters from incoming line blocks and checks block/character parity. Under the dual homing concept, simultaneous interfaces will be maintained with two different ASCs.

The message then is received by the Autodin Control Subsystem (ACS), which is resident in the 70/45 processor. ACS accepts message input from AIS and then utilizes the Communications Control Subsystem (CCS) to

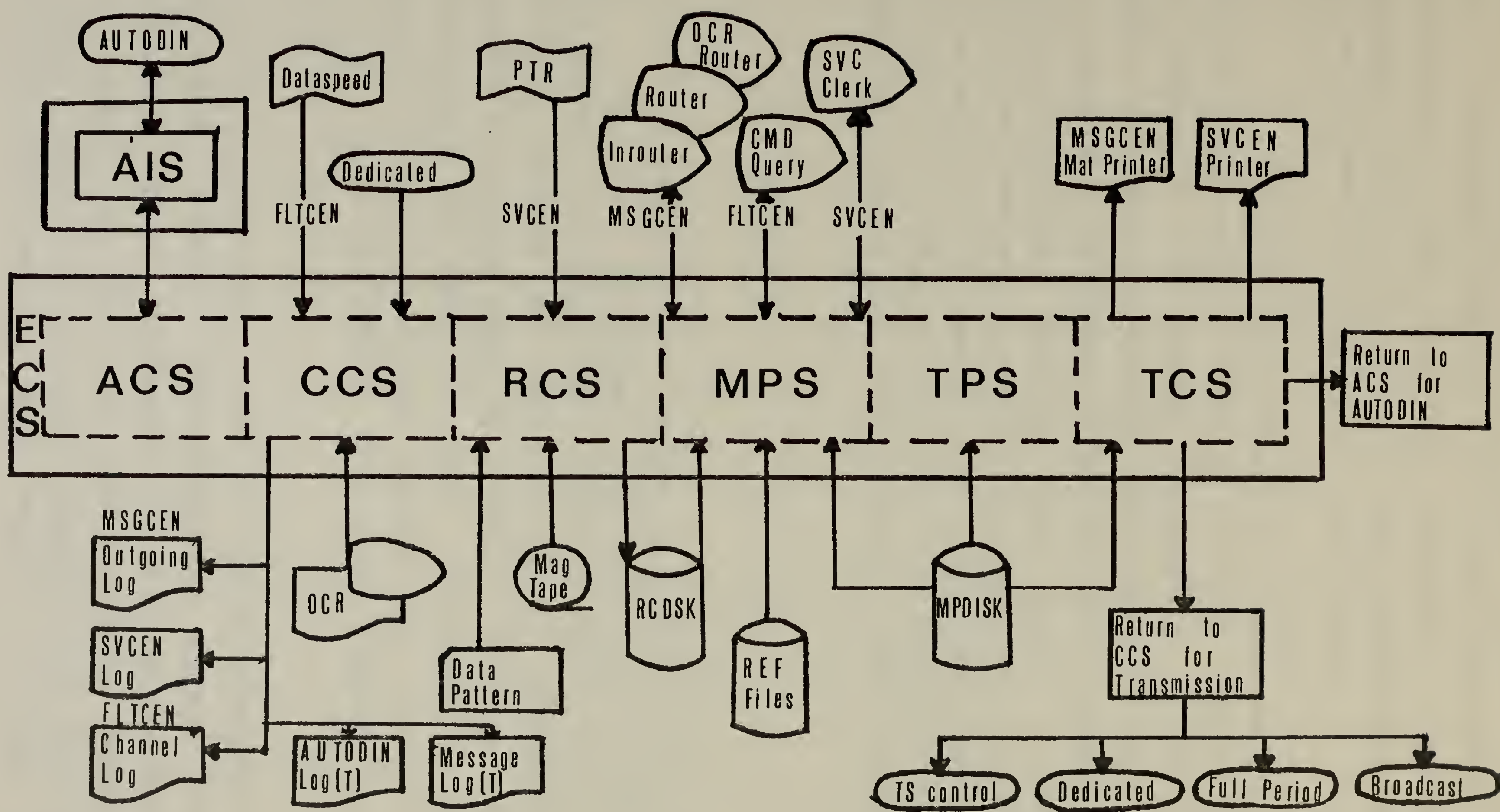



Figure 1 - FLOW OF MESSAGE INFORMATION (Ref. 15, p. 81)

notify the Receive Control Subsystem (RCS) of receipt of data. ACS acknowledges to AIS for each line block received; additionally, when an entire message is processed and accounted for by RCS, ACS will send an end of message (EOM) acknowledgement to the Autodin Controller.

The RCS is an interrupt driven subsystem capable of interfacing with all sources of input concurrently. It is responsible for channel coordination to ensure that all traffic received is correctly identified and that any errors in sequence of messages or SOM-EOM will be detected. After translating Autodin messages from ASCII to EBCDIC, RCS assigns each message a processing precedence and then queues the message for the Message Processing Subsystem (MPS). RCS records each message received on two separate on-line disk files for recovery purposes in case of system failure.

b. On-line

Messages are entered into NAVCOMPARS on-line via OCR, on-line dedicated channels and full period terminations. On-line dedicated/full period channels can be landline channels to ships in port, electronic courier circuits to on-base users or landline quality full period terminations to ships at sea. Satellite channels are expected to be of landline quality and will be on-line directly into NAVCOMPARS for both incoming and outgoing traffic.

The entry point for on-line traffic is via the CCS, which queues communications device interrupts, distributes these interrupts to the appropriate subsystem and checks for errors on communication devices. This subsystem supervises the logs generated by the teleprinter (channel log, service log, outgoing log and temporary

Autodin log) and interfaces with the OCR, Dataspeed reader, VDT and on-line teletype. OCR messages are converted by RCS to modified ACP 126 format. The ASCII code used by the OCR is translated into EBCDIC. RCS then performs input processing corresponding to that performed on Autodin traffic on all the above categories of messages.

c. Off-line

Off-line channels are high frequency radio channels which are not of suitable quality for direct interface into the system. Torn tape procedures are utilized for the interface with NAVCOMPARS. Upon receipt, each message is visually screened. If the message is acceptable, it is entered into the system via medium speed paper tape readers which interface with CCS. Messages are then passed to RCS for input processing and conversion of five level baudot code to EBCDIC. All narrative messages will be converted to one of two basic formats, JANAP 128 or modified ACP 126. Use of basic formats and a common data code, EBCDIC, allows for minimization of the number of message analysis routines needed in processing.

2. Message Processing

Control of messages passes from RCS to the Message Processing Subsystem (MPS). NAVCOMPARS processes three forms of traffic: narrative, data pattern and readdressals. Readdressals are previously transmitted messages which are designated for transmission by one of the original recipients to a command not on the initial distribution. These messages require the generation of a new message header upon subsequent transmission. MPS is responsible for message analysis and functions such as format conversion

from modified ACP 126 to JANAP 128, header validation, routing indicator assignment, susdupe processing to eliminate duplicate messages, broadcast guard list processing, generation of broadcast recap messages and determination of OTC and broadcast delivery requirements. Messages can be recalled on-line for up to ten days and MPS will build and append headers for readdressal. The only processing done to the text of the message, other than classification and special handling checks, is the insertion of the proper paging and sectioning information. MPS will display error conditions or specifically requested information to the VDT operator in order to perform functions involved with message recalls, routing and distribution, file displays, channel status and control, message entry, broadcast screens and message editing. Changes in routing files can be entered on-line by the VDT operator in order to effect immediate shift in guard list responsibilities. NAVCOMPARS possesses traffic management features which permit the operators to closely monitor traffic queues and to establish alternative transmission paths to eliminate backlog conditions. Using a VDT, supervisory personnel can visually inspect the queues existing on a specific channel and can activate rerouting procedures via VDT entered command. Separate queue reports can be displayed to show queue status for the total system with a breakdown by processing step and precedence as well as the number of messages by precedence being queued for each outgoing channel.

The Transmission Processing Subsystem (TPS) receives message information from MPS, utilizing the delivery instructions generated by MPS to determine the destination queues to which the message will be linked. Prior to assigning a message to a transmission channel queue, TPS ensures that the security classification of the channel matches that of the message. If a security mismatch exists,

the message is automatically delivered to either the Service Center or Top Secret Control for alternate routing determination or off-line encryption. TPS coordinates the creation of journal entries after all destinations have received the message.

### 3. Message Delivery

Responsibility for the delivery of messages to a communications channel or terminal device is lodged in the Transmission Control Subsystem (TCS). This subsystem interfaces with the Service Center line printer, Message Center mat printer, paper tape punch, card punch, Top Secret courier, electronic courier circuits, broadcast channels, full period channels, dedicated channels and Autodin. TCS provides for format and code conversion for the outgoing line, editing, routing line segregation and broadcast reruns. NAVCOMPARS processes messages by precedence on a first-in first-out basis. Provisions have been established for interruption by Emergency Command and FLASH messages. These messages will be retransmitted immediately after their original transmission and again fifteen minutes later. The message interrupted for higher precedence traffic is repositioned at the head of its respective queue and is retransmitted under a new number.

#### a. Autodin/OTC

Under the dual homing concept of operations, simultaneous interfaces are maintained with two separate Autodin Switching Centers, and messages are automatically assigned to the appropriate channel. TCS interfaces with the Autodin Communications Controller through AIS. ACS generates Autodin log entries upon receiving acknowledgement

from the ASC for SOM, EOM or cancellation. The NAVCOMMSTA Message Center retains responsibility for reproduction and distribution of traffic to OTC users. NAVCOMPARS can automatically distribute a specified number of copies to applicable commands according to several arguments including standard subject identification code (SSIC) and flagwords, or it can perform internal command distribution by office codes for designated users. When a message is printed at the mat printer, the system displays delivery lines, copy counts and internal distribution at the bottom of the first page of the message. At this point, the message is at the end of the automated process and probably has not been seen by anyone at the receiving communications center. One of the new billet descriptions for NAVCOMPARS calls for an editor who will examine each message prior to reproduction in order to detect errors, such as garbles within the text, which would not have been identified by software processing.

b. Fleet Broadcast

NAVCOMPARS has the capability to automatically key up to seventeen channels of the fleet broadcast with both single and multi-channel circuits being keyed. Traffic on the broadcast will be in modified ACP 126 format; messages will be edited to delete format lines 1, 2, 3, 4, 15, and all paging information. (See Figure 5 for an explanation of modified ACP 126 format.) The system is structured so an operator can exercise control over the broadcast by VDT command to either hold traffic due to an outage or to initiate altroute procedures to relieve overloaded queues. A delayed rerun channel will normally be assigned for each first run traffic channel of a multi-channel broadcast with activation being accomplished by VDT command. An additional feature provides for automatic message rerun when no queue of first run traffic

exists.

c. On-line/Off-line Channels

All outgoing messages sent to channels of dedicated landline quality will be transmitted on-line by the system. Messages addressed to ships terminated off-line will be delivered to a low speed paper tape punch associated with each full period termination. An operator will manually perform the send operation, repeating transmission until the addressee acknowledges receipt of a legible copy. Prescribed format for both on-line and off-line channels is JANAP 128 with non-pertinent routing indicators being automatically deleted.

## 4. Reports and Statistics

The various subsystems within the central processor are all under the control of the Executive Control Subsystem (ECS). The ECS monitors the multi-programming environment and controls the exchange of information between subsystems and user programs. ECS includes functional areas involved with console control whereby the programming is affected by the computer operator; input/output control which allocates peripheral devices to programming modules and subsystems; program control which allocates the CPU to various subsystems on a priority basis; and interrupt control. The CPU is allocated in the following descending order: executive, highest communications I/O functions, communications processing functions and support. The Support Program Subsystem (SPS) supervises report generation and file maintenance. The dual nature of the files allows updating to be accomplished off-line. Statistical analysis reports are generated daily summarizing key message

processing and traffic statistics

Message files are maintained both on-line and off-line. A six months file of messages for retrieval purposes is stored on magnetic tape, while separate on-line files are designed to be kept for either ten or thirty days. The ten day file is on direct access storage and is utilized for broadcast channel reruns, broadcast screen, susdupe and service actions. The thirty day file is to support on-base users for readdressal, reference routing and redistribution requirements.

## C. MANPOWER REQUIREMENTS

In accordance with the NTAP goal to reduce manpower levels, automated systems are to perform the routine message handling chores, thereby releasing personnel for more creative tasks in management and supervisory areas. Actual manpower reductions are expected to vary from station to station depending on the degree of automation and the volume and type of traffic. The design intent was to create a "user transparent" system. For some operating positions this has been accomplished, and personnel familiar with manual techniques can transition over to working competently with the automated system after a month or less of on-the-job training. Other positions require new skills, and personel assigned these jobs routinely need approximately three months of intensive on-the-job training to acquire proficiency. Consequently, personnel familiar with manual techniques can be expected to transition over to operation of the automated system with minimal training.

### 1. NAVCCMPARS Billets

A NAVCOMPARS requires the creation of 58 billets which are unique to the operation of this automated system. Of these new billets, 56 are identified for the Radioman (RM) rating and two are for Data Processing Technicians (DP). Experience at operational installations has demonstrated that the average radioman can handle computer operations; therefore, RMs are being assigned to positions such as computer operator, router, OCR operator and Fleet Center command VDT operator. The billet for the Programmer/Systems Analyst is for a Chief Data Processing Technician, while a First Class Data Processing Technician fills the Assistant Programmer billet. As part of their duties, the DPs will assist in the installation of succeeding versions of the system and will update the current system in accordance with program changes from NAVCOSSACT. Additionally, they are responsible for on-site software maintenance and problem documentation. A new Navy Enlisted Classification Code (NEC), DP-2746, has been established for LDMX/NAVCOMPARS' programmer/system analysts. Source ratings are DP and RM. The above billet requirements concern only those positions necessary for the NAVCOMPARS installation; many existing billets required for a manual system will be transferred unchanged to an automated one. Personnel will still be needed to fill administrative and supervisory positions such as communications watch officers and section supervisors. Since message reproduction and distribution has not been automated, these functions must still be performed manually. Despite the creation of new billets, substantial personnel savings can be realized with an automated system. Major reductions for a NAVCOMMSTA will occur in the Fleet Center and the Message Center. The largest saving in the Fleet Center is a result of NAVCOMPARS keying the fleet broadcast on-line. Eliminated are such jobs as broadcast operator, recap operator and broadcast traffic checker. Reductions have been made also in the

number of personnel required as torn tape operators for the broadcast and full period terminations. Cuts in the Message Center have occurred through the elimination of manual look-up of routing indicators, assignment of OTC distribution and tape cutting operations.

2. Statistics from NAVCOMMSTA Norfolk

A study of personnel requirements of NAVCOMMSTA Norfolk before and after installation of a NAVCOMPARS highlights the areas where personnel reductions are most prominent. The following summary, taken from Reference 28, emphasizes the impact that automation has had on the Fleet Center and Message Center.

| NAVCOMMSTA NORVA | NAVCOMPARS | BEFORE NAVCOMPARS | INCR/DECR |
|---|---|---|---|
| Management Group | 007 | 009 | -02 |
| Watch Officers | 008 | 008 | |
| Fleet Center | 041 | 097 | -56 |
| Computer Center | 019 | 024 | -05 |
| Message Center | 050 | 089 | -39 |
| Service Center | 012 | 012 | |
| Data Base Maintenance | 013 | 000 | +13 |
| TOTAL | 150 | 239 | -89 |

These above reductions were realized even though NAVCOMMSTA Norfolk had been automated previously to a limited degree. NAVCOMPARS replaced an Autodin IBM 360/20 installation. As noted above, the total number of personnel needed for operation of the computer center decreased because the IBM 360/20 required extra operators to handle

manual message entry and removal from terminal equipment. The NAVCOMPARS computer center is not involved in message input/output procedures. Since the present NAVCOMPARS installations are on maintenance contracts, requirements for Navy maintenance personnel are also reduced; however, the cost of maintenance contracts would negate any actual monetary savings. The above figures are representative only of NAVCOMMSTA Norfolk and can not be projected unconditionally to the other NAVCOMPARS sites, but the potential for personnel reduction and improved message processing through automation clearly exists. The realization of these personnel reductions requires the full support of the cognizant command. All too often, a command will not give up billets whose functions have been eliminated due to automation. Stations have used these released manpower assets to augment shortages perceived in other areas; thus the only effect of communications automation has been the shift of personnel resources within a command, with no total manpower reduction resulting.

### 3. Training

One design objective of the LDMX/NAVCOMPARS system was that additional schooling should not be required prior to assignment of personnel to NAVCOMPARS sites. Consequently, the formal training program for NAVCOMPARS operating personnel is rather limited. No training course is taught at any military school, and the major responsibility for training has been inherited by NAVCOSSACT. NAVCOSSACT, assisted by Univac instructors, conducts four weeks of training for computer programmers/system analysts. On site training, also conducted by NAVCOSSACT and consisting of classroom presentations and on-the-job training, is concentrated in the seven weeks prior to test and acceptance of a system at

each individual location. This is a one-time effort, and the indoctrination of subsequent replacements has been been left to the individual command, although NAVCOMMSTA Norfolk is currently preparing video-tapes and programmed lessons for use as instructional material by all NAVCOMPARS sites. Experience at Norfolk has demonstated that individuals can become proficient as routers and service clerks in four weeks and six weeks respectively. The training period for the Fleet Center Command VDT operator normally takes longer-about three months-because the major responsibilites such as queue status control and channel management are essentially new functions unrelated to any prior communications experience [Ref. 26]. In order to gain the maximum benefit from the training and experience that is developing among the personnel currently assigned to automated stations, the Bureau of Naval Personnel must adopt a policy of rotating experienced personnel from one automated site to another. This presently is not being done, and any knowledge acquired from one tour is not being utilized in subsequent assignments. Additionally, the NAVCOMPARS sites are having to accept personnel with no background in automation and indoctrinate them with the basics before they can be used effectively.

## D. NAVCOMPARS/IXS INTERFACE

The satellite Information Exchange Subsystem (IXS) consists of three components: Common User Digital Information Exchange Subsystem (CUDIXS), Submarine Satellite Information Exchange Subsystem (SSIXS) and Tactical Data Information Exchange Subsystem (TADIXS). Programs for the development of the NAVCOMPARS system and the satellite Information Exchange Subsystem (IXS) originally proceeded concurrently but independently. One of the objectives of

CUDIXS is that it have an on-line connection into the Autodin network. With the successful implementation of NAVCOMPARS, adherence to the principles of the NTAP dictated that NAVCOMPARS and CUDIXS be interconnected, thereby eliminating software and hardware redundancy and reducing requirements for operating personnel. Currently, neither TADIXS nor SSIXS has the requirement for an on-line entry into Autodin; however, the procedures developed for the NAVCOMPARS/CUDIXS link could be utilized in the future with SSIXS.

1. CUDIXS

CUDIXS, a store and forward system using a communications satellite to relay message traffic, is being implemented as an alternative to present high frequency ship-shore-ship communications. The shore component is a Network Control Station (NECOS) which organizes its subscriber ships into a functional net. The NECOS, in conjunction with the satellite terminal equipment and the satellite, will provide teletype message capability to a group of sixty ships. Of this total, fifty will be smaller ships which will be equipped with shipboard terminals which will allow them to transmit, but not receive, message traffic via satellite on the CUDIXS channels. These ships will receive all message traffic addressed to them by means of the fleet broadcast. The fleet broadcast uses a separate satellite channel, and the transmissions will go directly from NAVCOMPARS to the satellite terminal equipment. (See Figure 2). The remaining ten ships, designated "Special Subscribers," are high volume users which will have both the send and receive capability. (See Figure 3). Employing round-robin network discipline to maintain control of its

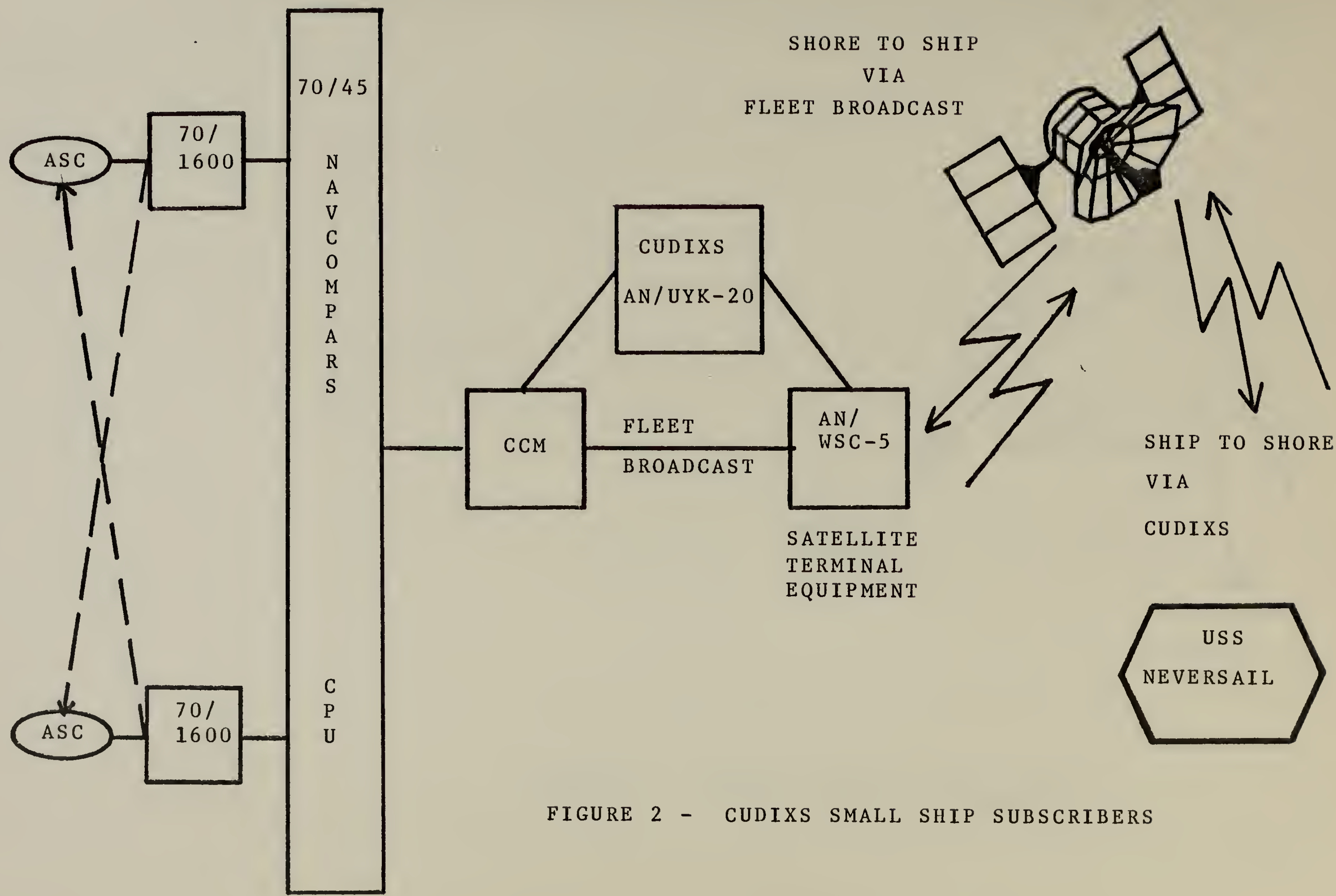



FIGURE 2 - CUDIXS SMALL SHIP SUBSCRIBERS

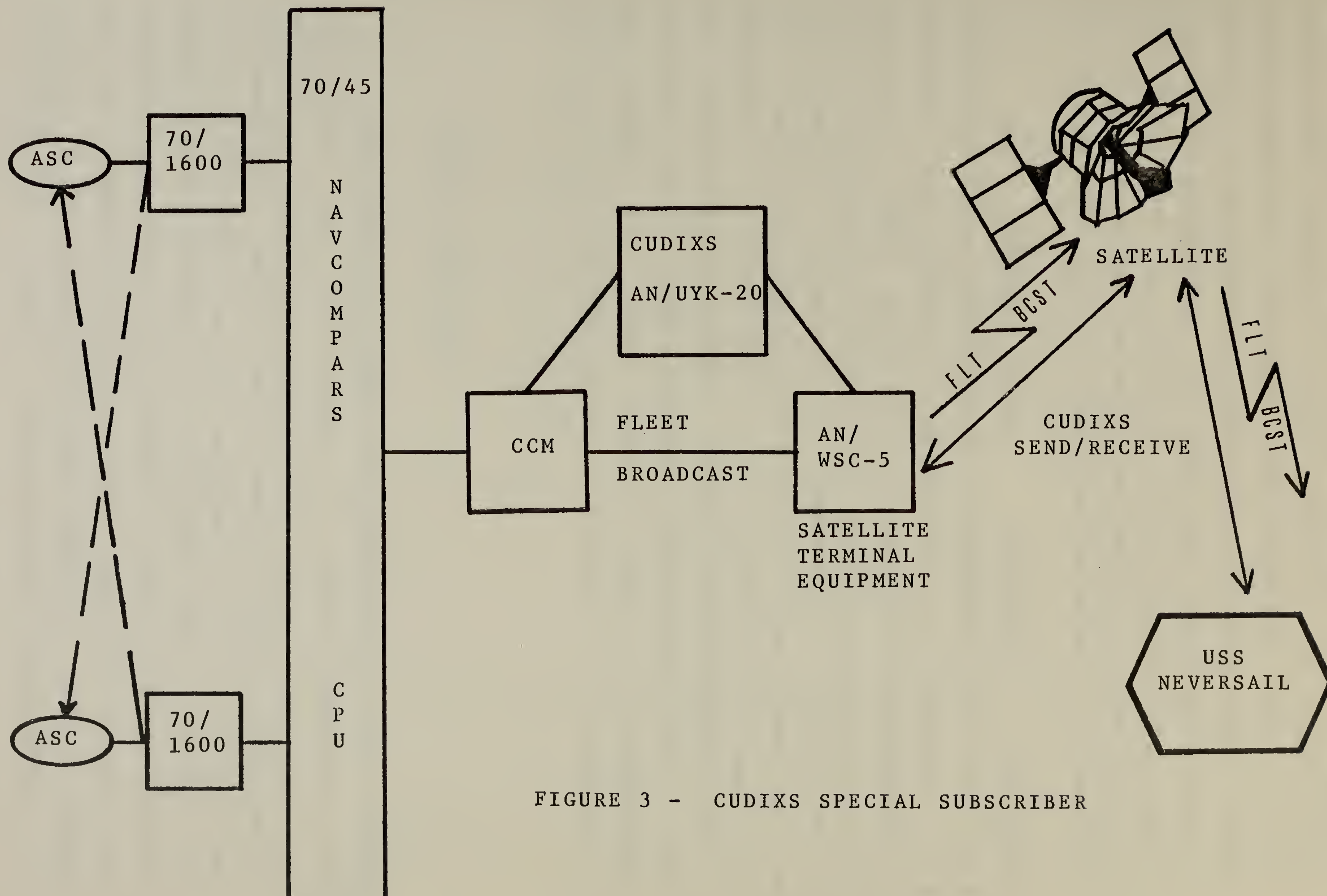



FIGURE 3 - CUDIXS SPECIAL SUBSCRIBER

net of ships. The shore station sends out a subscriber transmission sequence which specifies the order in which subscribers are to transmit. Each scheduled network cycle includes a transmission phase and a reception phase to/from each active subscriber. The NECOS will check the status of each subscriber to transmit or receive messages prior to each operating cycle; by means of intercept processing, it can hold traffic until a subscriber is capable of receiving.

The CUDIXS shore equipment, designated AN/USQ-64(V)2, is located in the NAVCOMMSTA Fleet Center and utilizes the AN-UYK-20 mini-computer to accomplish its functions. NECOS will queue traffic for transmission by message precedence, automatically synchronize modulation and cryptographic equipment for transmission and perform all data transfers on the satellite link. After transmission is completed, the shore station will coordinate the passing of the proper acknowledgements. Several short messages may be forwarded to a ship during one transmission cycle, or one long message may require several cycles for completion. Untransmitted message portions are stored in the buffers of the NECOS until the next cycle.

2. Systems Interface

The linking of these two systems will allow CUDIXS subscribers to have access to those functions which NAVCOMPARS currently provides to OTC, broadcast and dedicated/full period users, such as format validation and correction, utilization of modified ACP 126 format and direct on-line access to two different ASCs. Equipment and operator savings will be realized in that the NECOS does not need to maintain a separate Mode I terminal for entry into Autodin. A more direct altroute capability exists because NAVCOMPARS can reroute messages automatically from a poor

quality satellite link to a broadcast or full period channel. CUDIXS subscribers will be able to recall messages from NAVCOMPARS files for up to ten days on-line and six months via magnetic tape. NAVCOMPARS will maintain a subscriber message number (SMN) directory which will accomodate a 24-hour file of messages transmitted to each subscriber. This file allows subscribers to request message reruns using the SMN as a reference. Utilization of the file capacity of NAVCOMPARS eliminates the requirement for separate message storage by the NECOS, thereby generating further equipment savings. NAVCOMPARS prepares the necessary statistics and reports for both systems. The NECOS will control all data transmission via the satellite link, and the interconnect between the two systems will not impose any additional timing restrictions on the NECOS. A CUDIXS shore station has been installed at NAVCOMMSTA Norfolk, but it is still undergoing testing and evaluation. The interface between NAVCOMPARS and CUDIXS has functioned satisfactorily, but problems have been encountered in the shipboard terminal. [Ref. 28]

a. Shore-Ship Message Flow

A message routed to a CUDIXS "Special Subscriber" could enter the NAVCOMPARS from any source. After internal processing by the NAVCOMPARS, the message, preceded by a header identifying the subscribers who are to receive the message, is queued by precedence to CUDIXS. Upon successful delivery of the message to all addees, the NECOS will return a control record to the NAVCOMPARS which identifies the subscriber's SMN, and the NAVCOMPARS will journal the message.

b. Ship-Shore Message Flow

Modified ACP 126 narrative messages are to be transmitted from subscribers to the NECOS, where the traffic is queued by precedence to the NAVCOMPARS. After the EOM indicator has been accepted by the NAVCOMPARS, the NECOS will generate a one line acknowledgement message to the subscriber. The NAVCOMPARS will validate/correct the message and route the message as appropriate.

## E. DATA BASE MAINTENANCE

The NAVCOMPARS data base is composed of the library file of processed messages, the local station internal distribution files and those files used to route messages. Due to the staggered installation dates of the various NAVCOMPARS sites, each location was initially responsible for development and maintenance of its data base. Of primary concern in the development of the data base was the accuracy of the routing files, and this section will discuss only this particular aspect of the NAVCOMPARS data base.

### 1. History of the Common Source Routing File

One of the key characteristics of NAVCOMPARS as a tactical communications system was that it would possess the capability to provide routing instructions for all traffic originated by ships, thereby alleviating individual ships of the continuing task of maintaining an updated edition of ACP-117, the world-wide routing indicator (RI) list. Due to the strict compliance with the requirement for

standardization of hardware and software at all NAVCOMPARS sites, the capability existed for the various NAVCOMPARS to assume traffic handling functions for each other during periods of downtime; however, for this procedure to work effectively, the previously individualized data bases also needed to be standardized. Initial responsibility for data base maintenance was assigned to NAVCOMMSTA Norfolk, and this station began to update the data bases of all NAVCOMPARS sites in September 1974 by means of a Common Source Routing File (CSRF). All routing indicator changes were transmitted to Norfolk, and that station prepared the necessary computer inputs to make the required additions and deletions. These inputs were then forwarded via card traffic on a daily basis to all other NAVCOMPARS stations for file update action. Since June 1975, NAVCOMMSTA Honolulu has acted as the CSRF Update Facility for the Western Hemisphere, and Norfolk has retained responsibility for the Atlantic and Mediterranean areas. Norfolk and Honolulu receive identical update information with which they unilaterally prepare the input for the CSRF. Prior to further dispersal of this information, the above stations compare their data via point-to-point orderwire, and any conflicts are researched and immediately resolved. After all necessary corrections have been made, the daily update information is forwarded to the other CSRF subscribers. The actual udating of the CSRF is done on the off-line file system, and the complete procedure takes approximately four hours; the new files go on-line at 0001Z of every new radio day. On-line VDT changes can be made for immediate update, and an average of five of this type are accomplished each day.

NAVCOMMSTA Norfolk has thirteen billets authorized for data base maintenance, and NAVCOMMSTA Honolulu operates its CSRF facility with approximately the same number. Not only does this procedure ensure a world-wide

standard routing file, but it also saves manpower resources because the above two stations are managing this vital function for the whole network. These savings will be increasingly significant as additional LDMX stations are outfitted with NAVCOMPARS software and become part of the CSRF.

### 2. Composition of Common Source Routing File

The CSRF has five component parts: ACP Routing Indicator File, Ships/Station Guard Source File, Task and Type Organization File, Multiple Address Routing Source File and the Alternate Spelling Source File. The ACP Routing Indicator File contains the preferred spelling of a command's short title as specified in NTP-3 and up to four RIs which can be used for delivery via electrical means. This file, which is basically the information contained in ACP-117, is continually updated via card input of additions and deletions. As of September 1975, there were more than 21,900 entries in the ACP file. The Ship/Station Guard Source File contains a list of commands or units by short title which are guarded for by a host ship or station. In this way an embarked commander is related to his host ship for broadcast screening action. The composition of Navy task and type force organizations are delineated in the Task and Type Organization File. Task force designations may be used to address single or multiple addressees. That is, any task force, group, unit or element commander may be individually addressed, but a message addressed to a task organization will be automatically delivered to all components of the specified organization. The Multiple Addressee Routing Source File is composed of every Navy and Coast Guard collective and Address Indicating Group (AIG), as well as many collectives and AIGs of the other services. The only file prepared by the individual stations is the

Alternative Spelling Source File. This consists of common abbreviations or misspellings of primary short titles in the ACP file, and its function is to relate the misspelled short title to the correct routing indicator. The last four files are maintained on magnetic tape with the daily update being accomplished via card changes being processed simultaneously with the running of the old tape to produce an entirely new tape.

### 3. Problems of the Common Source Routing File

The main difficulties encountered by NAVCOMMSTA Honolulu in managing the CSRF are in obtaining timely and accurate change information from applicable commands. Improper submission of data has resulted in confusion in maintaining a complete Task and Type Organization File. Lower eschelon commands have requested that they be added or removed from an organization listing without proper authorization from the cognizant commander. The situation has left the CSRF facility with the burden of resolving the conflicting data in order that its files will be accurate. NAVCOMMSTA Honolulu has engaged the support of CINCPACFLT in this matter, and two messages addressed to all pacific fleet commands have been issued which specify that the task or type force commander has the responsibility to provide the CSRF facility with the breakdown of its components. Any contradictory information will be referred back to the applicable commander for resolution. [Ref. 22]

Another problem involves the necessity for periodic and complete validation of the composition of collectives and AIGs. Disestablished commands are still carried in certain AIGs and collectives simply because the cognizant authority has neglected to remove the outdated information. The CSRF facility can not cancel an AIG or delete data, even

if it knows such information is erroneous. The cognizant authority must do its job responsibly in purging the system of extraneous and incorrect information.

One minor problem area at present which could cause major difficulties in the future is the inclusion of other service short titles in the NAVCOMPARS data base. Army and Air Force AIGs and collectives with even one Navy, Marine Corps or Coast Guard addee must be included in their entirety. The Navy has expended a great amount of effort in the past several years in order to standardize short titles in preparation for communications automation. The Army and Air Force have done little to document and distribute preferred short titles for their commands; consequently, the individual command may itself use several alternate spellings for its command designator. Any variation in short title which is not anticipated with an entry in the Alternate Spelling Source File will require manual intervention, thereby negating a major portion of the advantage of automation. Unless the initiative is taken by the Army and Air Force to develop standardized short titles, extending NAVCOMPARS capabilities to other military users could result in degradation of the system.

# IV. MODEL OF CENTRAL PROCESSING UNIT

The section on traffic flow pattern of the NAVCOMPARS in the previous chapter described the functions of the NAVCOMPARS subsystems in general terms; this chapter will emphasize those major program modules within each subsystem which most directly affect message processing. Modules which direct error routines or handle special situations are, for the most part, neglected in order to give a comprehensive and straightforward description of routine message processing. The individual user retains a substantial amount of control over system performance through his compliance, or lack thereof, with prescribed format requirements. The objective of this chapter is to create a model of the message processing sequence within the NAVCOMPARS CPU in sufficient detail to establish an awareness of and an appreciation for the format precision which is necessary for an automated system to operate at its full potential.

The means utilized by this thesis to accomplish the above objective will be to follow a typical message through the NAVCOMPARS; a flowchart model with narrative comments will trace the progress of one message through the message processing sequence. In order to demonstrate the full tactical potential of the system, the following scenario has been selected: A ship at sea transmits a routine message in modified ACP 126 format via HF radio to the nearest NAVCOMMSTA for entry into Autodin and forwarding to a command in the Washington D. C. area. [Step 1, Figure 6] Figure 4 presents the sample message, and Figure 5 explains the function and structure of each format line.

```
F/L 1          VZCZCABC127
F/L 2          RTTUZYUW RUEBABCØØ34 35Ø171Ø--RUHPSUU.
F/L 3
F/L 4          ZNR UUUUU
F/L 5          R161710ØZ DEC 75
F/L 6          FM USS NEVERSAIL
F/L 7          TO CHNAVPERS WASHINGTON DC
F/L 8          INFO CINCLANTFLT NORFOLK VA
F/L 9
F/L 10
F/L 11         BT
F/L 12         UNCLAS

               TEXT

F/L 13         BT
F/L 14
F/L 15         #ØØ34
F/L 16         NNNN
```

Figure 4 - SAMPLE MODIFIED ACP 126 MESSAGE

| FORMAT LINE | ELEMENTS | EXPLANATION OF SAMPLE MESSAGE CHARACTERS |
|---|---|---|
| F/L 1 | Handling instructions | V-Ensures subsequent intelligence not garbled |
| | | ZCZC-Start of message indicator |
| | | ABC-Station/channel designator (CID) |
| | | 127-Channel sequence number (CSN) |
| F/L 2 | Header | R-Precedence: ROUTINE |
| | | TT-Language and Media Format (LMF): TELETYPE |
| | | U-Classification: UNCLASSIFIED |
| | | ZYUW- Communication Action Identifier (CAI): THIS IS A NARRATIVE MESSAGE |
| | | RUEBABC-Originating Station Routing Indicator (OSRI) |
| | | ØØ34-Station serial number (SSN) |
| | | 35Ø-Julian date |
| | | 171Ø-Time of file (TOF) |
| | | UUUU-Classification redundancy |
| | | RUHPSUU-Destination routing indicator: SPECIAL NAVCOMPARS RI ENDING IN SUU |
| | | Period-End of routing symbol |
| F/L 3 | Calling Station and filing time | NOT USED |
| F/L 4 | Transmission Instructions | ZNR-Security prosign |
| | | UUUUU-Classification designation: UNCLASSIFIED |
| F/L 5 | Precedence | R-Precedence: ROUTINE |
| | & DTG | 16171ØZ DEC 75-Date time group (DTG) |
| F/L 6 | Originator | USS NEVERSAIL |
| F/L 7 | Action Addressee | CHNAVPERS |
| F/L 8 | Information Addressee | CINCLANTFLT |
| F/L 9 | Exempted Addressee | NOT USED |
| F/L 10 | Accounting Information | NOT USED |
| F/L 11 | Separation | BT-Separates heading from text |
| F/L 12 | Text | UNCLAS-Classification |
| F/L 13 | Separation | BT-Separates text from end of message |
| F/L 14 | NOT USED IN TAPE RELAY PROCEDURES | |
| F/L 15 | EOM Validation | #ØØ34-Station serial number |
| F/L 16 | EOM Function | NNNN-Proceeded by 2 carriage returns and eight line feeds |

Figure 5 - EXPLANATION OF MODIFIED ACP 126 FORMAT

## A. INITIAL PROCESSING

Upon receipt by the NAVCOMMSTA Fleet Center, the message is visually screened by operating personnel to ensure that the message is of sufficient quality (no garbles in heading or text) for entry into the NAVCOMPARS. [Step 2, Figure 6] The paper tape copy is then manually run through a paper tape reader which introduces the message directly into the system. [Step 3, Figure 6] The Communications Control Subsystem (CCS) is a software package which provides the necessary support functions to coordinate the system's peripheral equipment to the message processing subsystems. In this specific instance, CCS allows the paper tape reader to generate input to the Receive Control Subsystem so that the sample message is queued for the Receive Control Format Exchange Module (RCFX). [Step 4, Figure 6]

### 1. Receive Control Format Exchange Module (RCFX)

The primary functions of RCFX are to convert the narrative character codes of the various message input devices into a common character code and then to divide the input stream into proper length file segments for recording on the recovery disks. For the sample message, the five-level baudot code used by the paper tape reader is translated into EBCDIC to facilitate processing within the CPU. The shift characters of the teletype are set to null characters, and carriage returns and line feeds are deleted. RCFX identifies format lines 1, 2, 11, 13, 15 and 16 of every message. Line analysis is accomplished by a series of subroutines, each of which analyzes a specific line. Entry to the appropriate subroutine is gained by using an

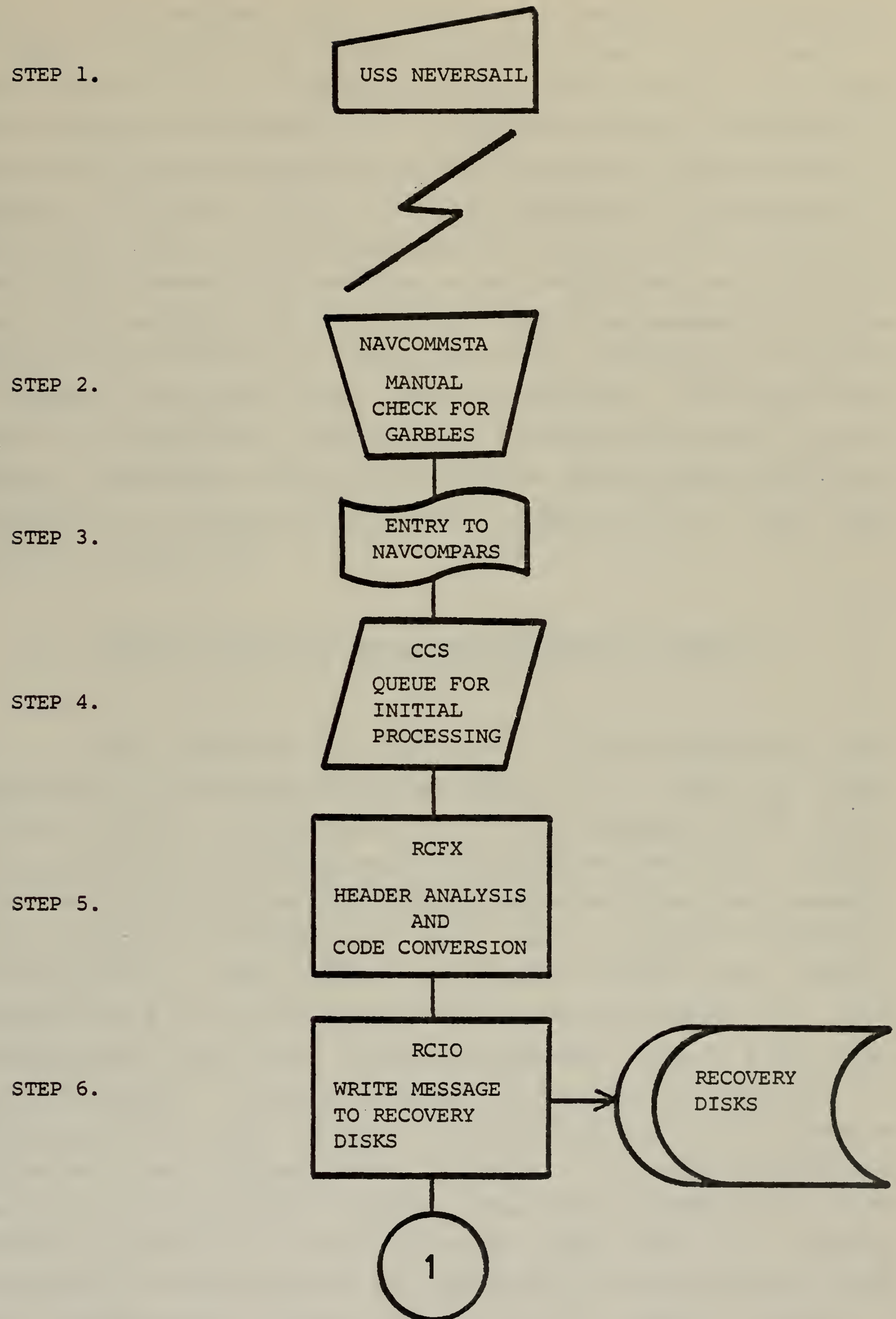



Figure 6 - MESSAGE INPUT AND INITIAL PROCESSING

index to an address table of all line analysis subroutines. For this message, the index is set to format line one; as each format line is identified, the index is set to the next line analysis processor, but the index will not be bumped to the next subroutine until the line currently being sought is found. If format line two is not validated, the message is rejected, and a rejection notice is built. The format of the sample message is assumed to be validated as correct, and the message is assembled into file segments for the Recovery Disk (RCDSK). RCFX begins the process of building a Summary Data Area (SDA) for each message. As each format line is identified, applicable information such as the CDCSN, precedence code, input device symbol, OSRI, SSN, and numerics of straggler check are transferred to the SDA. [Step 5, Figure 6]

2. Receive Control Input/Output Module (RCIO)

The function of RCIO is to accomplish the dual recording of message information on the Recovery Disks (RCDSK) which are resident on on-line magnetic disk packs. The information recorded on each RCDSK consists of certain line defining information, actual material from the message, data linking instructions and some message handling information. The inputs to RCIO include the message segments and SDA generated in RCFX, and processing of this information falls in three categories: start, middle and end of message. Start of message processing is designed to initiate the disk address linkages for the entire message prior to the writing of the RCDSK. Middle processing handles continuation linkages for the message and then writes the message on both Recovery Disks. End of message processing incorporates the SDA into the final section and adds finalization linkages as necessary. [Step 6, Figure 6]

## B. MESSAGE PROCESSING SUBSYSTEM

The RCS/MPS Interface Table is core-resident in the Common Data Area, and it is used as a means of communication between the two subsystems. After the RCDSKs have been written and RCS has a message queue entry to pass to MPS, RCS will place the RCDSK pointer, message type and message priority in the interface table and will set an indicator requesting transfer to MPS. [Step 7, Figure 7] MPS periodically checks the indicator, and when it is set, MPS will enter the message in its input queue and set an acknowledgement indicator for RCS in the interface table as to the action taken. Processing for the sample message begins with the Common JANAP 128 Heading Analysis Module.

### 1. Common JANAP 128 Heading Analysis Module (MPJA)

MPJA operates on non-data pattern JANAP 128 and modified ACP 126 messages with its major function being the analysis of the heading up to and including format line five. The processing includes format line analysis, routing indicator isolation, end-of-message checks and straggler checks. A straggler is a message which, because of an incorrect end-of-message function, either trails or is attached to the preceding message. Throughout the identification process, all vital elements of information are preserved in the MPS SDA for subsequent processing. The MPS SDA is a core resident buffer which provides an area where processing programs can maintain and obtain transient data (such as line counts) or provide pertinent data (such as the station serial number assigned by MPJA) to fulfill other program's tasks; it is used by all modules in the MPS environment, with each module updating specific fields as the message processing analysis functions are performed.

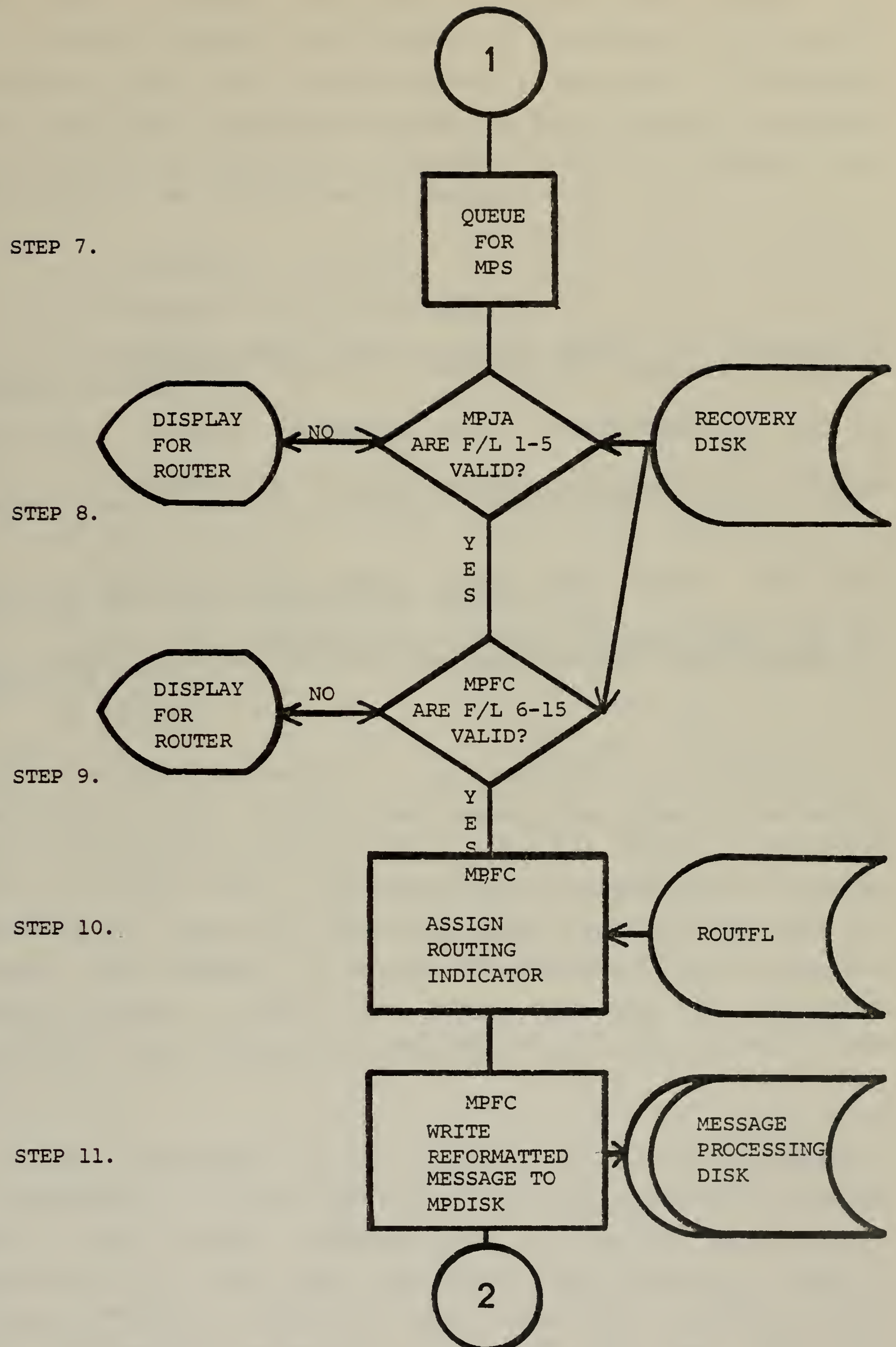



Figure 7 - MESSAGE PROCESSING SEQUENCE

MPJA begins processing analysis by fetching the first line of a message segment and testing it for format line one; if validated, this line is transferred to the SDA. Processing then continues as MPJA fetches the next line and validates it element by element. Format line two elements are interrogated in the following order:

a. Precedence character

b. Language and Media Format

c. Classification (The security level is temporarily saved for redundant security test with the security field in columns 30-33.)

d. Channel Identification Code/Command Action Identifier

e. Originating Station Routing Indicator and Station Serial Number (Used for straggler check with F/L 15)

f. Time of File

g. Security Field (This field must agree with the security character saved from column 4.)

h. Test for modified ACP 126 type message (The RI in the format line is compared for the special NAVCOMMSTA RI ending in SUU.)

i. Period

If any element is unable to be validated, a display is built for the VDT operator indicating the error. The screen will be annotated with an error notation reading "INVALID F/L X" which will be followed by ten addditional lines of the message. The VDT router can either correct the line or reject the message to either the Service Clerk or the Top Secret Courier. Since the sample message is correctly formated, each element is validated and then stored in the SDA.

MPJA continues to fetch each line in turn, validating it depending on the characteristic of that particular format line. The sample message has no format line three; therefore, it will next encounter the security prosign (either "ZNR" or "ZNY") in format line four. "ZNR" is used with unclassified messages, while "ZNY" is used with all

classified messages including those designated UNCLAS EFTO (Encrypted for Transmission Only). After validating the prosign, MPJA will next access the security redundancy symbols. Since the sample message has the prosign "ZNR", the only acceptable designation is the characters "UUUUU" representing an unclassified message. Having validated this as correct, the routine compares format line four security to that found in format line two; if these don't agree, a mismatch has occurred, and a display is built for the router, who can either correct the line or reject the message. In scanning format line four, MPJA also searches for precedence, and it enters format line five processing when it finds arguments which meet these search criteria. In all cases where a dual precedence exists, format line five will be validated if the format line two precedence matches either the ACTION or INFO character. MPJA then searches for the date-time-group, and, when found, the module moves the entire line to the proper field in the MPS SDA in order to effect the Originator Date-time-group File update. If the DTG can not be delimited, MPJA causes a display of the message to the router who can assign or correct the ODTG or reject the message to the service clerk. Once the entire line has been processed, it is moved to the SDA. In addition to format line validation, MPJA performs a check for Suspected Duplicate (SUSDUPE) messages. The arguments for the OSRI SSN search are extracted from the proper fields in the SDA and are used for comparison against the system's Originating Station Routing Indicator file. If the message is a SUSDUPE, it is rejected to the service clerk and further processing is terminated. The processing serial numbers of up to seven previous duplicates are extracted from the file and are appended as a service line in order to facilitate action by the service clerk. MPJA waives the SUSDUPE check for all Flash and Emergency Command messages. Once format line five has been entirely validated, MPJA has completed its processing on modified ACP

126 type messages, and it relinquishes control. [Step 8, Figure 7] The next module is MPFC.

2. Message Processing Subsystem ACP 126 Routing and Format Conversion (MPFC)

MPJA has up to this point constructed a model of certain portions of the JANAP 128 header; MPFC continues format line analysis with line six and completes the conversion from modified ACP 126 to JANAP 128 format. It also does paging, sectioning and maintenance of continuity for sectioned messages. Errors and illogical conditions that arise during processing are referred to a VDT operator for resolution. The RCDSK segment which contains format line six will already be core resident, but MPFC will access RCDSK as many times as necessary to read all segments associated with the message. [Step 9, Figure 7] This module begins processing by reading the first three characters of the line and testing them for the argument "FM". If this configuration is not identified, MPFC causes a display to the router who can correct the line. If the first three characters are correct, MPFC accesses the short title and validates it.

The message header is then scanned for one of the following arguments which are positional: "TO" or "INFO". When neither is found, an error is diagnosed and a display is built for the router. If "TO" is found, MPFC goes into format line seven processing in order to validate short titles and assign routing indicators. The routine will determine if a short title is valid by comparing it with the information in the Routing File Directory (ROUTFL), which is a consolidation of all the on-line message processing files. If a short title can't be found in the ROUTFL, a display will be built for the router indicating this fact. When the

short title is validated, the routine then proceeds to determine the routing indicator. The ROUTFL itself will contain one primary RI. If the RI thus obtained is not cleared for the classification of the message or if a collective routing is indicated, the processing routine will extract a pointer from the ROUTFL for the ACPFIL entry for that short title and the necessary routing indicator will be accessed from that entry. [Step 10, Figure 7]

Once the format line seven processing has been accomplished, MPFC initiates a program scan for the next processing event. If "INFO" is encountered, the routine utilizes format line eight processing which is identical to F/L 7. When "XMT" is detected, MPFC takes action to remove the exempted addressee from any collective routing indicators. The sample message has no format line ten, so the next event validated by MPFC will be the "BT" in format line eleven. After the "BT" has been framed and moved, the programming module begins text processing with format line twelve. MPFC will examine the security narrative in this line and will determine if it matches the security warning found in both format lines two and four. If the security narrative does not agree, a mismatch has occurred, and MPFC will build a display to the router for the resolution of this error condition. Any special handling instructions are identified and validated. After the security and special handling criteria have been processed, MPFC tests the message line count to determine if this will be a sectioned message. Messages are sectioned only if they exceed five pages or 100 lines of text from format line twelve. In order to ascertain the number of sections for long messages which meet the above criteria, MPFC substracts the number of lines found from F/L 2 to F/L 11 from the total message line count. The result is divided by twenty to determine the number of pages; this figure is then divided by five to arrive at the number of sections.

During text processing, reference lines and paragraph lines are searched for and identified for any necessary subsequent processing. After the textual portion of the message has been processed, MPFC completes the JANAP 128 header in the SDA by attaching the routing indicators for format line two. MPFC sorts these indicators in binary ascending order and then moves them to the MPS SDA. Duplicate RIs are not moved and are thus eliminated from inclusion in the header. After the header and routing information have been supplied and all necessary linkages between text segments and these elements have been effected, the message is redundantly written on the Message Processing Disk (MPDISK); the data contained on this disk is the output image of the message. [Step 11, Figure 7] MPFC then causes the message to be queued to the Transmission Processing Subsystem (TPS), thus completing an input transaction. [Step 12, Figure 10] Figure 8 is the output version of the sample message in JANAP 128 format. Pertinent characteristics of this format have been explained in Figure 9.

## C. TRANSMISSION PROCESSING

The remaining NAVCOMPARS subsystems handle the message transmission and journaling functions. The modules of the Transmission Processing Subsystem (TPS) deal with the message queuing functions, while the modules of the Transmission Control Subsystem (TCS) supervise channel activation and message delivery. As the sample message will be relayed to its ultimate destination via the Autodin system, the Autodin Control Subsystem (ACS) is the final subsystem thru which the message must traverse.

```
F/L 1     VZCZCXYZØ66
F/L 2     RTTUZYUW RUHRSVCØ321 35Ø171Ø-UUUU--RUWMFDA RUCLBEA.
F/L 3
F/L 4     ZNR UUUUU
F/L 5     R16171ØZ DEC 75
F/L 6     FM USS NEVERSAIL
F/L 7     TO RUWMFDA/CHNAVPERS WASHINGTON DC
F/L 8     INFO RUCLBEA/CINCLANTFLT NORFOLK VA
F/L 9
F/L 10
F/L 11    BT
F/L 12    UNCLAS

          TEXT

F/L 13    BT
F/L 14
F/L 15    #Ø321
F/L 16    NNNN
```

Figure 8 - SAMPLE OF JANAP 128 MESSAGE

| FORMAT LINE | ELEMENTS | EXPLANATION OF SAMPLE MESSAGE CHARACTERS |
|---|---|---|
| F/L 1 | Handling Instructions | V-Ensures subsequent intelligence not garbled |
| | | ZCZC-Start of message indicator |
| | | XYZ-Station/channel designator (CID) |
| | | Ø66-Channel sequence number of NAVCOMMSTA |
| F/L 2 | Header | R-Precedence: ROUTINE |
| | | TT-Language and Media Format: TELETYPE (Repeats LMF of original modified ACP 126 message) |
| | | U-Classification: UNCLASSIFIED |
| | | ZYUW-Communication Action Identifier: THIS IS A NARRATIVE MESSAGE |
| | | RUHRSVC-Origination Station Routing Indicator: ROUTING INDICATOR FOR THE NAVCOMMSTA SERVICE CENTER IS USED AS THE OUTGOING RI ON NAVCOMPARS MESSAGES |
| | | Ø321-Station Serial Number: SUPPLIED BY NAVCOMPARS |
| | | 35Ø-Julian date |
| | | 171Ø-Time of file |
| | | UUUU-Classification redundancy |
| | | RUWMFDA-Destination routing indicator |
| | | RUCLBEA-Destination routing indicator |
| | | Period-End of routing symbol |
| F/L 3 | | NOT USED |
| F/L 4 | Transmission Instructions | ZNR-Security prosign |
| | | UUUUU-Classification designation: UNCLASSIFIED |
| F/L 5 | Precedence | R-Precedence: ROUTINE |
| | & DTG | 16171ØZ DEC 75-Date time group |
| F/L 6 | Originator | USS NEVERSAIL |
| F/L 7 | Destination RI & Action Addressee | RUWMFDA/CHNAVPERS |
| F/L 8 | Destination RI & Information Addressee | RUCLBEA/CINCLANTFLT |
| F/L 9 | Exempted Addressee | NOT USED |
| F/L 10 | Accounting Information | NOT USED |
| F/L 11 | Separation | BT-Separates heading from text |
| F/L 12 | Text | UNCLAS-Classification |
| F/L 13 | Separation | BT-Separates text from end of message |
| F/L 14 | | NOT USED |
| F/L 15 | EOM Validation | #Ø321-NAVCOMPARS Station serial number |
| F/L 16 | EOM Function | NNNN-Proceeded by 2 carriage returns and eight line feeds |

Figure 9 - EXPLANATION OF JANAP 128 FORMAT

Once the message has been processed by ACS, the sample message has completed the NAVCOMPARS cycle.

When the sample message comes under the responsibility of TPS, the initial module which assumes control is the Transmission Processing Queue Handler.

### 1. Transmission Processing Queue Handler (TPQH)

TPQH is the module which manages all queuing functions, as well as other related tasks such as checking for message/line security mismatches and the generation of queuing statistics. In order to fully understand the procedures utilized by TPQH, several terms must be identified and defined. A bit map is included in the SDA for each message; the intended destinations of each message are indicated by whether predetermined bits are placed in an "on" condition. Initially, two maps are created. The original remains intact, but the duplicate is modified and updated as each individual delivery is made. Files labelled Destination Control Blocks (DCB) are maintained in core memory for each outgoing channel and electronic courier circuit. TPQH is structured to utilize two separate queues for each message. A message queue, designated Q1, contains an entry for each individual message processed by the system. The information contained in the Q1 entry includes the following: a transmission count giving the number of destinations for the message, a pointer to the location of the message on the RCDSK, a pointer to the location of the message on the MPDISK, the code for message type, and the processing priority assigned to the message. A pointer is a link between one record and another in that a field in the first record indicates the location on the storage devices of the second record. The other queue is the transmission queue, known as Q2, which functions as a storage area

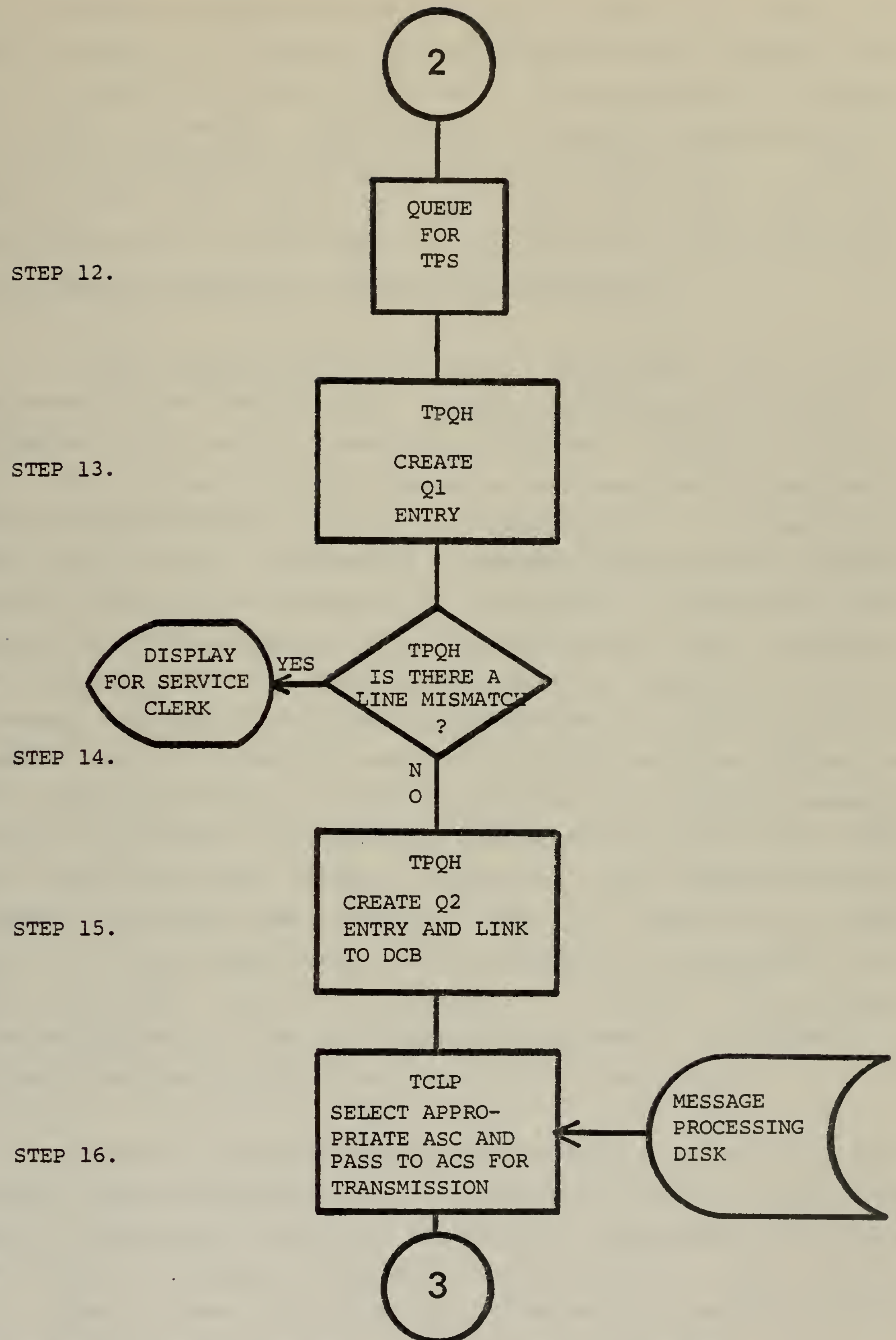



Figure 10 - TRANSMISSION PROCESSING

for pointers to message entries in Q1. Each Q1 entry has corresponding Q2 entries for each Destination Control Block to be utilized to effect delivery. The information included in each Q2 entry consists of a pointer referencing the relative position of the applicable Q1 entry and a pointer linking the Q2 entry to the next Q2 entry for this particular DCB. Within Q2, all entries for a particular DCB are linked together by processing precedence.

The sequence of events involving the above components is begun when message information from MPS is enqueued to Q1 and a Q1 entry is created. [Step 13, Figure 10] The bit maps of this message are examined to determine all the destinations. Once a destination is identified, TPQH will match the security classification of the message against that of the destination channel. If a mismatch has occurred, the message will be diverted to the Top Secret courier and a service message delineating the error will be created. [Step 14, Figure 10] Otherwise, Q2 pointers and Q2 entries will be created, and the Q2 entry will be linked to the appropriate DCB. [Step 15, Figure 10] When the message reaches the head of the queue, the Q2 pointer will be used to access the Q2 entry, which in turn provides the Q1 pointer to access the Q1 entry. The Q1 entry then leads back to the output image of the message on the MPDISK, and this is read for transmission. After transmission acknowledgement, the Q2 entry is dequeued. Subsequent to message journalization, the Q1 entry is dequeued.

Other functions performed by TPQH are involved with overall queue management and recording of statistics. The module maintains queuing counts by precedence for each destination channel or courier circuit, and it will notify the Fleet Center VDT operator by means of a service notice whenever pre-established thresholds are exceeded.

Additionally, TPQH totals queue statistics for each radio day.

2. Transmission Control Line Program (TCLP)

TCLP is a module of the Transmission Control Subsystem, and its main functions are to monitor the status of individual channels and to begin message transmission when channels are activated. TCLP will access the DCB to receive the next queue entry from TPQH. Another check will be run by TCLP to validate that the line security level is equal to or greater than the message classification. Messages will be rejected to the Top Secret courier if this test is failed. Upon completion of delivery, TCLP will instruct TPS of this fact and will provide the applicable channel sequence number.

Because the sample message will be entered into the Autodin network, additional processing steps are required. Determination must be made as to which Autodin Switching Center will receive the message; the message will be sent to the primary switch if it is available and otherwise to the secondary switch. The primary switch is the one designated to handle the greater number of routing indicators. TCLP will access the MPDISK to obtain the message data for transmission, but any previously recorded format line one will be deleted. The programming routine adds the necessary upshifts, downshifts, carriage returns and line feeds, and then converts the message into ASCII code for the outgoing Autodin line. The message data is then placed in the Autodin Transmit buffer for transfer to the Autodin Control Subsystem. [Step 16, Figure 10]

3. <u>Autodin Control Module (ACS)</u>

This module links the Series 70/45 processor to the two 70/1600 Autodin terminals, one for each Autodin Switching Center. TCS will notify ACS when an outgoing message has been stored in the Autodin Transmit buffer, and ACS will retreive the message segments and transmit them to the appropriately designated 1600 processor. ACS receives acknowledgement of message receipt from the 1600 processor and passes this acknowledgement back to TCS. [Step 17, Figure 11]

4. <u>Transmission Processing Message Journal Module (TPMJ)</u>

TPMJ accomplishes the journal entries for every message that is processed by NAVCOMPARS. All messages are written on the Journal Tape File; this file is stored on magnetic tape, and each message is kept for six months. Additionally, a journal file of all over-the-counter traffic is maintained on disk for approximately thirty days. TPMJ does journalizing action on a timed interval of every three minutes or whenever ten messages are waiting in the journal queue. [Step 18, Figure 11]

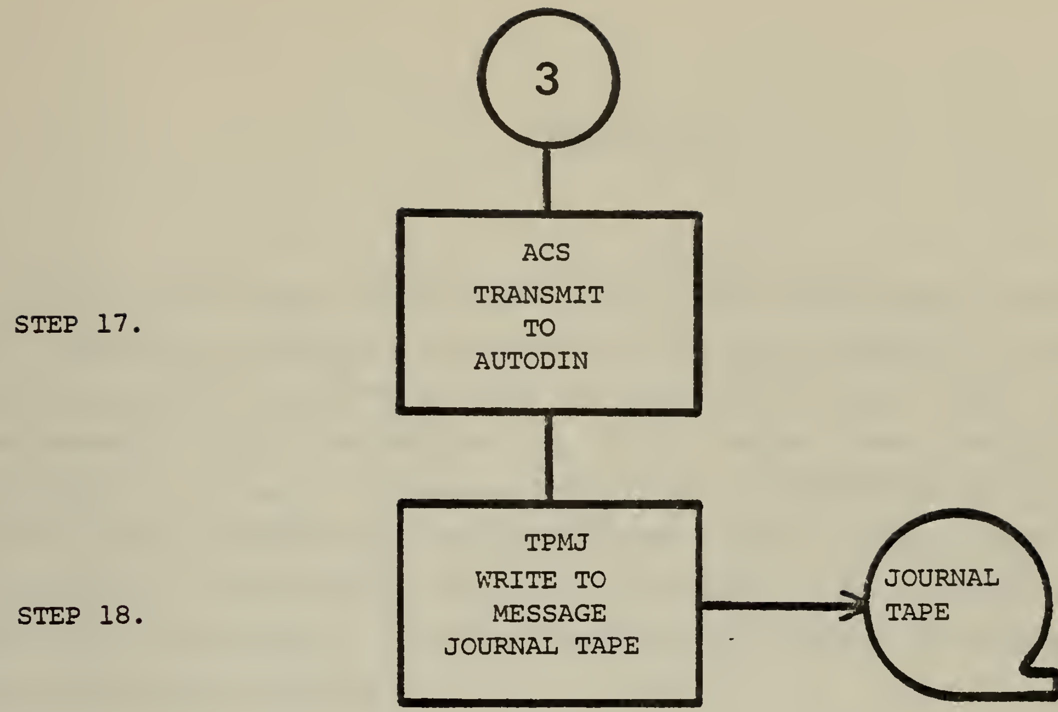



Figure 11 - MESSAGE JOURNALIZATION

# V. CONCLUSION

This thesis has delineated the major procedures involved in processing messages traffic, as well as examined various related system aspects such as training and data base management. The emphasis of this paper has focused on providing a basic understanding of NAVCOMPARS and its associated procedures as they exist today. The intent was to produce a document which could be used as an orientation text for personnel upon initial contact with an automated communications system.

The manager in a communications environment must be involved with the total system-with both human and non-human elements. Because NAVCOMPARS is currently operational, the equipment and the prescribed message procedures are fixed in the short-run. Therefore, immediate improvements in message handling efficiency can only be obtained by gaining the support and dedication of the personnel utilizing the system and stimulating them to better performance. In the long run, equipment and procedures can be modified in an effort to upgrade the system. The concluding section of this thesis will discuss some background which affected system development and will present projected modifications of NAVCOMPARS.

## A. HARDWARE

The heart of NAVCOMPARS is the UNIVAC Series 70/45 (formerly RCS Spectra 70/45) central processing unit. This

computer was procured through competitive formally advertised procedures and was selected as the CPU which met the technical specifications and which was most cost effective. [Ref. 24] RCA brought out the Spectra 70 series of computers at the end of 1964 as a competitor to the newly introduced IBM 360 family. Even though the Spectra 70s were estimated to be priced at 40% of the cost of the comparable IBM 360s, they did not make a significant impact on IBM's market. In 1970 the RCA computer division chief re-introduced the Spectra 70 series and cut prices further to attract business. As a result of inefficient management within its computer division, RCA left the computer industry in 1971 and sold its base of customers to the UNIVAC division of Sperry Rand. [Ref. 3] Since 1 January 1972 the Navy has received service on its Series 70/45s from UNIVAC. The NAVCOMPARS/LDMX computer equipment was leased up until August 1975 when the decision was made to buy the existing installations. [Ref. 21] Difficulty has been encountered in that the Series 70/45 has reached the limit of core memory that the system can handle. The original core memory consisted of 252,144 (8 bit) bytes. [Ref. 28] This capacity has been doubled through the addition of boxes of core memory. The implementation of additional functions on the NAVCOMPARS will have to be delayed pending the acquisition of the follow-on CPU with its expanded core memory. The decision has been reached to procure the UNIVAC 90/60 as the follow-on to the Series 70/45. The 90/60 system will have a maximum of 1,048,000 bytes of core memory and will be able to support planned system enhancements such as the consolidation of special intelligence and general service traffic within a single processor. The 90/60 processor will be installed at NAVCOMPARS sites, while the Navy-owned 70/45s will be split apart and used to back fit projected LDMX locations. As an LDMX utilizes only one CPU, each upgraded NAVCOMPARS can provide a 70/45 for two LMDX sites.

Another hardware problem has revolved around the peripherial equipment utilized for file storage. The original equipment configuration included a Mass Storage Unit which recorded data on magnetic cards and could contain up to 45 days worth of message traffic. This unit proved to be mechanically unreliable, and its access time was relatively slow. In order to alleviate these conditions, the Mass Storage Units are being replaced by a Direct Access Disk Storage (DADS) system which will be faster and more reliable. The message file capacity will be reduced to approximately twenty-five days worth, which will be employed for reference routing for over-the-counter traffic. [Refs. 21 and 24] The installation of the DADS in Honolulu has provided an excellent illustration of the necessity of evaluating the total situation. The maintenance of a constant physical environment, especially in regard to temperature, is a critical factor in the operation of a computer system. When the DADS was installed, the result was a modification of the heat load in the computer area. This heat imbalance began to cause problems in performance of the system's perpherial equipment, such as disk drive heads. In order to rectify the difficulty, the computer room air conditioning was re-ducted at the cost of $10,000. A computer system is a delicately balanced entity, and all aspects of its operation and maintenance must be carefully examined and evaluated prior to the implementation of changes. Adequate preplanning can prevent problems and outages.

## B. CODE TRANSLATION

Code translation is the term used to describe the process whereby the code used by terminal devices is converted into the code utilized by the central processor.

The extensive use of this process could be considered a source of major inefficiency of the current structure of NAVCOMPARS. In its effort to compete with IBM, RCA designed its Spectra 70 series to employ the same instructions, formats and character codes as the IBM 360. [Ref. 3] The result of this is that the 70/45 CPU utilizes EBCDIC as its internal processing code. In contrast, the major communications code employed by the federal government on its lines is ASCII.

Between 1959 and 1962, the 7-level code designated ASCII was developed in order to provide some means of standardized coding capability between products of various computer manufacturers. IBM, realizing that standardization between processors might cut into its dominant position, voted against the adoption of ASCII as a standard. Instead, it developed an 8-level code, EBCDIC, which it utilized for the IBM 360 series. This code was adopted by other manufacturers, including RCA for its Spectra 70 series. The federal government was a major supporter of the movement to designate ASCII as an official standard; to give impetus to this development, President Johnson in 1968 released a memorandum establishing ASCII as a federal standard. All computers brought into the government inventory after 1 July 1969 were required to have the capability to use ASCII. In an effort to prevent ASCII from becoming the only standard, IBM endeavored to limit ASCII to being recognized only as a communications standard. In 1969 the strict position of President Johnson was modified, and the government directed that ASCII was required only for communications. The mandatory use of ASCII as an internal processing code could be waived by an agency head if efficiency could be improved by not using ASCII; however, a translator must be provided which would convert the internal code used to ASCII for transmission over the communications lines. This decision has resulted in performance degradation because code

translation is wasteful of the resources of the CPU. [Ref. 3]

NAVCOMPARS is especially hindered by this process of code translation. Not only must it contend with the ASCII code used in the Autodin system, but it also must handle code conversion of the five level baudot of the high frequency links. In that these requirements for code conversion are relatively locked in due to the prevailing equipment inventories and other governmental requirements, the problem is to accomplish code conversion in the least wasteful manner. As currently configured, the Receive Control Subsystem manages code conversicn for incoming messages and the Transmission Control Subsystem performs this function on outgoing messages. Both these subsystems are core-resident, thereby utilizing the limited and expensive core memory for a standardized function performed twice for every message.

As previously stated, additional programs are contemplated for NAVCOMPARS which would increase demands on the limited amount of core available. The UNIVAC 90/60 processor currently has the option to use either EBCDIC or ASCII. [Ref. 5] Because of the established use of ASCII in the Autodin network, it is strongly advocated that the 90/60 be configured so that ASCII is the internal processing code. Furthermore, the rapid development of mini-computers and the corresponding decrease in their cost present an alternative possibility which should be seriously explored. Concentrators which are mini-computers have been created which could handle the code translation function on a more economical basis, thereby freeing the CPU for more essential and less routinized work. [Ref. 6] Applicable cost analysis is beyond the scope of this paper, but it is recommended that action be taken to investigate the potential of using a mini-computer with a code conversion capabilbity in

conjunction with the UNIVAC series 70/45 and 90/60 processors.

## C. SOFTWARE

The operating system for the NAVCOMPARS was supplied by the manufacturer, whereas the programs dealing with the unique communications functions were written by NAVCOSSACT. The Navy experiences a distinct advantage by having software programs individually tailored to its functions and applicable hardware. Software designed for specific activities results in much faster response time, although the investment in software programs is much higher than if standardized off-the-shelf software is used. The maintenance of uniform software at all NAVCOMPARS sites not only increases interconnectivity, but it also is the most cost effective method of developing the extensive programs needed for a major system like NAVCOMPARS. The software currently operating on the Series 70/45 is compatible with the requirements for the Series 90/60 processor; therefore, staying with a UNIVAC follow-on computer will minimize software transition costs.

The programming for this system was done in two different computer languages. Assembly language code is employed for those programs which are used for message processing within the core. The advantage of assembly language is that it allows for faster response time and provides for conservation of core; its main disadvantage is that it is difficult to code. Most of the NAVCOMPARS support programs are done in the Common Oriented Business Language (COBOL) because these programs are the ones with which the on-site operators are directly involved. COBOL was designed to be easy to use and it is well adapted to an

external environment like a NAVCOMMSTA where the majority of users are not computer experts. COBOL is not an ideal communications language in that it is a verbose language which should not be used where speed and compactness of code are salient features. [Ref. 7] NAVCOMPARS has a mix of 80% assembly language and 20% COBOL programming. This mix roughly reflects the division between operating and support programs.

## D. HUMAN FACTORS

In accordance with the proposition that a communications manager must treat with the whole environment in order to gain maximum performance from an automated system, attention will now be focused on the human element. This is extremely important in an automated system which depends upon a myriad of sources for input. A well constructed system design is essential to create a viable package, but the human factor can be a critical feature. An automated network places additional requirements on operators as to degrees of precision needed for efficient thruput. Consequently, these requirements must be identified and publicized.

Humans are flexible and adaptable, and they can supply corrections to plain text mistakes easily and quickly; by contrast, computers have rigid specifications and are very unforgiving of even minor errors. NAVCOMPARS was designed to compensate as much as possible for human mistakes, as well as for transmission errors and garbles. As delineated in Chapter Four, the programs have been written so that the computer processing immediately refers any error or unaccountable situation to the VDT operator for manual resolution. This prevents messages from being sent back to the originator, but it also slows down processing. The

queue for the VDT operators is one point of congestion which can be readily identified. Errors which require manual intervention can be the result of improper format used by the originator, equipment malfunction (particularily the OCRs) or poor quality high frequency transmission path. [Ref. 25]

One of the input principles delineated in Reference 19 is that the volume of data to be produced by humans should be reduced. In contradiction to this idea, NAVCOMPARS is a system in which all input is produced by human operators of varied training and talent. To compound this situation is the problem that absolute determination can not be made as to the cause of the errors. 70% of all errors occur in those format lines (6, 7 and 8) which use the standardized Plain Language Address (PLA) for command short titles. [Ref. 25] Some portion of the above error total can be blamed upon commands not following the prescribed short titles delineated in the Plain Language Address Directory (PLAD) contained in NTP 3. Some degree of flexibility has been built into the system through the inclusion of the Alternate Spelling File, which incorporates common short title mistakes and connects these with the correct routing indicator. Improvements in compliance with the PLAD and general format conformity can only be achieved through the efforts of each individual command. Not only communications personnel, but also message drafters and releasors must be made aware of the consequences of careless performance. Performance from an individual point of view strongly depends upon the individual's perception of the importance of the work being accomplished and of his particular role within the whole. [Ref. 19] The average radioman onboard a ship or small command is unable to visualize how his daily work fits into the rather remote goal of "improving Naval communications through automation." Communications officers have a responsibility for ensuring that their personnel

understand their contribution toward improving their command's communications record. The division level is the logical place to start because this is where the work is actually performed. The average radioman must perceive that he is a vital link in the Navy's communications network and that his adherence to prescribed procedures is beneficial to himself and his ship. The NAVCOMMSTA has the function of supplying all available performance feedback and orientation on automated procedures and requirements. NAVCOMMSTA Honolulu has personnel who are available to indoctrinate its subscribers in the methods and procedures prescribed for the input into the NAVCOMPARS. This approach should be instituted at all NAVCOMPARS sites. The area of performance motivation affects every facet of the Navy today, but it is a subject which is easier to discuss than to isolate solutions. However, the human element should not be neglected; if personnel can be motivated to fulfil their role, communications automation can benefit from improvements which depend not at all on increased expenditures or more exotic equipment. [Refs. 8 and 14]

## E. SUMMATION

The initial NAVCOMPARS site at NAVCOMMSTA Norfolk became operational in June 1973; since then additional systems have become operational at NAVCOMMSTAs Honolulu, Guam and Naples, Italy. The fifth and final NAVCOMPARS is slated for installation at NAVCOMMSTA San Francisco in 1977. The NAVCOMPARS has evolved into a successful system which has accomplished its stated objectives of providing faster processing times and of shifting the majority of time consuming message handling tasks from fleet units to shore based communications stations. NAVCOMPARS is not a perfect system: software bugs are still being uncovered and

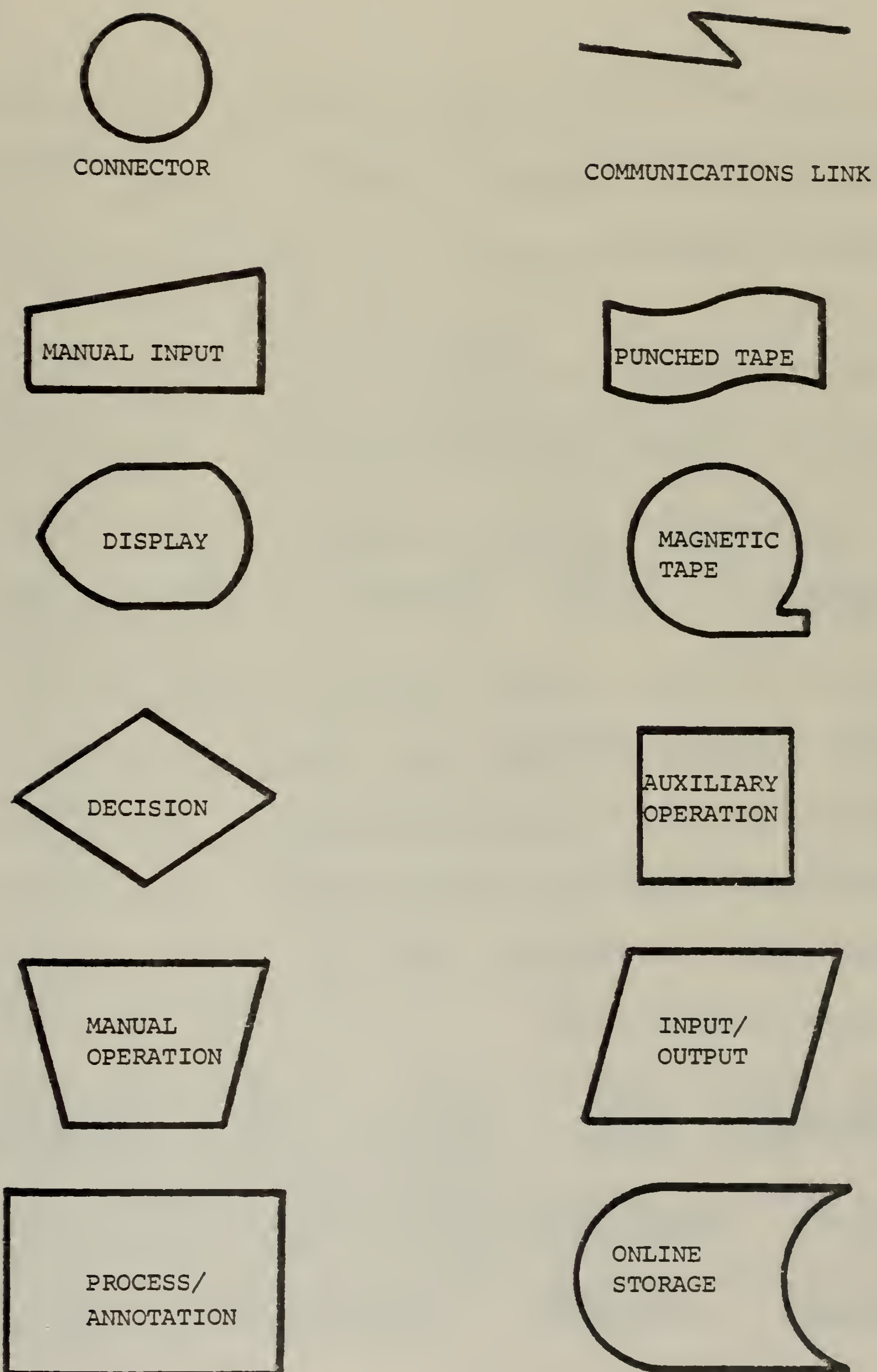
hardware modifications have already taken place. However, the system has recorded a hardware/software reliability of 98%, and it has achieved an error rate of less than 1% of all messages processed. [Ref. 21] It is a dynamic system which is continuing to grow and to assume new capabilities. Projected enhancements include the consolidation of special intelligence and general service traffic, the installation of the RIXT terminals and full implementation of the IXS program.

This thesis has constructed a flowchart model of the message handling procedures which could be used as an instructional tool to introduce communications personnel to the characteristics, capabilities and limitations of communications automation. Specific recommendations have been made throughout the body of the text and will not be repeated here. Perhaps the most important aspect of this thesis is the delineation of the limitations of automation. Continued benefits for naval telecommunications through system automation will ensue only if system requirements are understood and supported by all users. The following NAVTELCOM statement issued in 1973 is still valid today [Ref. 4]:

> "Success depends upon strict adherence to prescribed procedures and formats, most of which are currently effective. Failure to comply will negate the advantage of automation."

APPENDIX A

EXPLANATION OF FLOWCHART SYMBOLS



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4401 Mass. Avenue
Washington, D. C. 20390

7. LT Beth M. Hintz, USN 1
Naval Communications Station
Norfolk, Virginia 23511

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