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ADMINISTRATIVE (ZYB) MESSAGE PROCESSING:
A SIMULATION
AND ANALYSIS OF IMPLEMENTATION STRATEGIES

by

Paul Anthony G. Cruz

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In July 1985, the Chief of Naval Operations (CNO) in response to increasing message traffic on the Fleet Broadcast System mandated the creation of the *Administrative Message* designation and the capability to remove or intercept such messages from the Fleet Broadcast should queue conditions warrant. In June 1986, the Commander, Naval Telecommunications Command (CNTC), promulgated guidance concerning the activation of an administrative message intercept. The CNTC guidance on activation of an intercept was based on output queue level of the congested Fleet Broadcast channel. Based on results generated from a GPSS V simulation of a single Fleet Broadcast output channel and the message responses of the affected Naval Communications Area Master Stations (NAVCAMS) to the CNTC guidance, a more comprehensive framework, consisting of two phases, policy and guidance development and on-station decision making, is proposed for use in decision making on the activation of an administrative intercept. The implementation of the recommended strategy would ensure a decision making process that is sensitive to both the priorities of the policy makers and the variables present in the communication environment.

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March 1988

ABSTRACT

In July 1985, the Chief of Naval Operations (CNO) in response to increasing message traffic on the Fleet Broadcast System mandated the creation of the *Administrative Message* designation and the capability to remove or intercept such messages from the Fleet Broadcast should queue conditions warrant. In June 1986, the Commander, Naval Telecommunications Command (CNTC), promulgated guidance concerning the activation of an administrative message intercept. The CNTC guidance on activation of an intercept was based on output queue level of the congested Fleet Broadcast channel. Based on results generated from a GPSS V simulation of a single Fleet Broadcast output channel and the message responses of the affected Naval Communications Area Master Stations (NAVCAMS) to the CNTC guidance, a more comprehensive framework, consisting of two phases, policy and guidance development and on-station decision making, is proposed for use in decision making on the activation of an administrative intercept. The implementation of the recommended strategy would ensure a decision making process that is sensitive to both the priorities of the policy makers and the variables present in the communication environment.

TABLE OF CONTENTS

I. INTRODUCTION . . . 1
A. BACKGROUND . . . 1
B. OBJECTIVES AND RESEARCH QUESTIONS . . . 1
C. SCOPE . . . 1
D. ORGANIZATION OF STUDY . . . 2

II. NAVCOMPARS - ADMINISTRATIVE TRAFFIC INTERCEPT MODE . . . 3
A. INTRODUCTION . . . 3
B. FLEET MULTICHANNEL BROADCAST SYSTEM . . . 3
1. Fleet Satellite Broadcast (FSB) System . . . 3
2. High Frequency Broadcast (HFB) System . . . 5
C. ADMINISTRATIVE TRAFFIC INTERCEPT . . . 5
D. ADMINISTRATIVE TRAFFIC INTERCEPT MODES . . . 7
1. ZYB Altroute Mode - AM Command . . . 7
2. ZYB Redirect Mode - ADM Command . . . 8
3. Combination AM/ADM Command Usage . . . 9
E. MESSAGE REENTRY MODES . . . 10
1. VDT Initiated Message Reentry . . . 10
2. Message Reentry Tape . . . 10
3. Reentry Altroutes . . . 10

III. ADMINISTRATIVE MESSAGE INTERCEPT IMPLEMENTATION STRATEGIES . . . 12
A. INTRODUCTION . . . 12
B. EXTERNAL FACTORS . . . 12
1. Time . . . 12
2. Types of Users . . . 13
3. Exercise Conditions . . . 13
4. World Events . . . 13
C. INTERNAL FACTORS . . . 13
D. TRANSMISSION CONSIDERATIONS . . . 14

E. PROPOSED STRATEGIES . . . 15
1. NAVCOMMSTA Stockton CA . . . 16
2. NAVCAMS EASTERN PACIFIC Honolulu HI . . . 16
3. NAVCAMS ATLANTIC Norfolk VA . . . 16
4. NAVCAMS WESTERN PACIFIC Guam . . . 18
5. NAVCAMS MEDITERRANEAN Naples Italy . . . 18
6. Naval Telecommunications Systems Integration Center . . . 18
7. Response Summary . . . 19

IV. COMPUTER SIMULATION METHODOLOGY . . . 21
A. INTRODUCTION . . . 21
B. AN OVERVIEW TO SIMULATION . . . 21
C. GENERAL PURPOSE SIMULATION SYSTEM (GPSS) V . . . 22
D. SIMULATION MODEL DESIGN . . . 25
1. Simulation Model Foundation . . . 25
2. Simulation Model Limitations . . . 25
3. ADM Model Design . . . 26

V. SIMULATION RESULTS AND ANALYSIS . . . 28
A. INTRODUCTION . . . 28
B. SIMULATION MODEL TEST VARIABLES . . . 28
1. Model Variables . . . 28
2. Simulation Test Run Coding . . . 29
3. Simulation Test Run Results . . . 30
C. SIMULATION MODEL TEST RESULTS AND DISCUSSION . . . 32
1. Message Precedence Distribution Variation . . . 32
2. Message Length Variation . . . 35
3. Message Type Variation . . . 39
4. Message Arrival Rate Variation . . . 46
a. Arrival Rate Variation . . . 46
b. Variation about the Mean Interarrival Time . . . 46
5. Administrative Intercept Command Variation . . . 50
a. Administrative Intercept Command Activation . . . 50
b. Administrative Intercept Precedence Variation . . . 54

6. Summary 54

VI. ADMINISTRATIVE INTERCEPT CONSIDERATIONS 59
A. INTRODUCTION 59
B. THE DEVELOPMENT OF GUIDANCE AND POLICY 59
C. ON-STATION DECISION MAKING 60

VII. CONCLUSIONS AND RECOMMENDATIONS 64
A. FINDINGS 64
B. POSSIBLE FUTURE TOPICS 66

APPENDIX A. NAVCOMPARS - AN OVERVIEW 67
A. FUNCTIONAL INTERFACE AREAS 67
1. Message Center (MSGCEN) 67
2. Service Center (SVCEN) 68
3. Fleet Center (FLTCEN) 68
4. Computer Center (COMPCEN) 68
5. Technical Control (TECHCTL) 68
6. Receiver Site (RECSITE) 69
7. Top Secret (TS) Control 69
8. Operations Office (OPSOFF) 69
B. NAVCOMPARS SUBSYSTEMS 69
1. AUTODIN Interface Subsystem (AIS) 71
2. Executive Control Subsystem (ECS) 71
3. AUTODIN Control Subsystem (ACS) 71
4. Communication Control Subsystem (CCS) 71
5. Receive Control Subsystem (RCS) 71
6. Message Processing Subsystem (MPS) 71
7. Transmission Processing Subsystem (TPS) 72
8. Transmission Control Subsystem (TCS) 72
9. Support Program Subsytem (SPS) 72
10. System Service Subsystem 72

APPENDIX B. SIMULATION MODEL SPECIFICATIONS 73

A. SIMULATION MODEL PROGRAM 73
1. Model GPSS Code 73
2. Model Functions 74
B. SIMULATION MODEL FLOW CHART 74

APPENDIX C. DECISION MAKING AMONG MULTIPLE OBJECTIVES .. 78
A. MULTIATTRIBUTE UTILITY ANALYSIS 78
B. THE ANALYTICAL HIERARCHY PROCESS (AHP) 78

APPENDIX D. GLOSSARY OF ACRONYMS 80

LIST OF REFERENCES 83

INITIAL DISTRIBUTION LIST 86

LIST OF TABLES

Table 1. COMNAVTELCOM PROPOSED IMPLEMENTATION STRATEGIES 16
Table 2. HIGH FREQUENCY ENVIRONMENT THRESHOLDS - NAVCAMS EASTPAC 17
Table 3. SATELLITE ENVIRONMENT THRESHOLDS - NAVCAMS EASTPAC 17
Table 4. HIGH FREQUENCY ENVIRONMENT THRESHOLDS - NAVCAMS WESTPAC 19
Table 5. SATELLITE ENVIRONMENT THRESHOLDS - NAVCAMS WESTPAC 19

LIST OF FIGURES

Figure 1. Fleet Multichannel Broadcast Transmission 6
Figure 2. AM Command - NAVCOMPARS Release 11.0 and 12.0 8
Figure 3. ADM Command - NAVCOMPARS Release 11.0 and 12.0 9
Figure 4. Three Phases of System Simulation 23
Figure 5. Generic GPSS Simulation Model (Single Server Queue Model) 24
Figure 6. Fleet Broadcast - Simplified Single Server Model 26
Figure 7. Simulation Test Run Coding Scheme 30
Figure 8. Test Graph Legend 31
Figure 9. Message Precedence Distribution Variation 33
Figure 10. Precedences Transmitted - Tests #29, #27, #28 34
Figure 11. Message Length Variation 36
Figure 12. Precedences Transmitted - Test #30, #6, #31 37
Figure 13. Message Types Transmitted - Test #30, #6, #31 38
Figure 14. Message Type Variation (a) 40
Figure 15. Message Type Variation (b) 41
Figure 16. Precedences Transmitted - Test #4, #5, #6 42
Figure 17. Precedences Transmitted - Test #7, #8, #9 43
Figure 18. Message Types Transmitted - Test #4, #5, #6 44
Figure 19. Message Types Transmitted - Test #7, #8, #9 45
Figure 20. Message Interarrival Time Variation 47
Figure 21. Message Interarrival Time Spread Modifier Variation (a) 48
Figure 22. Message Interarrival Time Spread Modifier Variation (b) 49
Figure 23. Intercept Activation Level Variation 51
Figure 24. Precedences Transmitted - Test #1, #2, #3 52
Figure 25. Message Types Transmitted - Test #1, #2, #3 53
Figure 26. Intercept Precedence Level Variation 55
Figure 27. Precedences Transmitted - Test #10, #11, #12 56
Figure 28. Message Types Transmitted - Test #10, #11, #12 57
Figure 29. Hierarchy of Attributes 60
Figure 30. Considerations for Implementing an Administrative Intercept 62
Figure 31. Decision Making Process for Administrative Intercept 63

Figure 32. NAVCOMPARS Subsystem Organization 70
Figure 33. Simulation Model General Flow Chart 75
Figure 34. Simulation Model Block Diagram (a) 76
Figure 35. Simulation Model Block Diagram (b) 77

I. INTRODUCTION

A. BACKGROUND

In July 1985, the Chief of Naval Operations (CNO) promulgated a procedure to all naval commands which required the originators of all narrative messages to determine if a message is administrative or operational in nature. The annotation of the message type on the message would permit the Fleet Commander-in-Chief (FLTCINC), through the Naval Communication Area Master Station (NAVCAMS), to remove administrative messages from the Fleet Broadcast channels should message traffic loading warrant.

In June 1986, Commander, Naval Telecommunications Command (CNTC), issued management guidelines for the administrative message intercept capability. CNTC also requested comments and/or recommendations from the NAVCAMS concerning the guidelines. The responses from the NAVCAMS was generally negative and dealt with key issues. One key issue was the failure of the CNTC guidance to consider the operating environments and the special needs required when operating in these environments. Another issue dealt with infringement on the NAVCAMS' control of traffic management; the issuance of a set policy/guideline on the implementation of administrative intercepts restricts the NAVCAMS from fully utilizing all local expertise and resources available. Finally, the effectiveness and efficiency of the administrative intercept was questioned; specifically, questions were raised on the value of the intercept in its present form.

B. OBJECTIVES AND RESEARCH QUESTIONS

This thesis has multiple objectives; the first objective is to present the concept of the administrative message intercept and to examine the capabilities of the intercept. Additionally, the responses from the NAVCAMS will be examined to consider the validity of their claims. This study will also, through the use of a computer simulation system, investigate the effects of different traffic characteristics on the effectiveness of the intercept. From this simulation it is hoped to present a more complete set of considerations for activating an intercept.

C. SCOPE

The research conducted in this thesis focuses upon the Fleet Broadcast sections of the Naval Communications Processing and Routing System (NAVCOMPARS). Using the General Purpose Simulation System V, a simple model of a single output channel of the Fleet Broadcast is simulated. Due to the lack of historical data and/or actual NAVCOMPARS operation time, the model did not receive full validation via comparison. However, it is felt that the model does portray similar behavior, in terms of output, to provide beneficial data for analysis. It is further felt that this model and its results can serve as a foundation for future study in this particular area of Naval Communications.

D. ORGANIZATION OF STUDY

The first chapter of this research provides a brief introduction into the issues concerning the implementation of an administrative message intercept. This chapter also points out the objectives and research questions emphasized. The second chapter examines both the concept and mechanics of the administrative message intercept. The third chapter presents a review of factors to be considered when forming a decision on activating an intercept; the chapter also provides a summary of CNTC's guidance and the responses submitted by the individual NAVCAMS. Chapter IV details the General Purpose Simulation System V and presents the model of the Fleet Broadcast output channel used. Chapter V is a presentation and discussion of simulation results. Chapter VI is a proposed decision making process for both the policy maker and the operator/manager. The final chapter concludes with recommendations and suggested future topics of research.

II. NAVCOMPARS - ADMINISTRATIVE TRAFFIC INTERCEPT MODE

A. INTRODUCTION

Within the Naval Communications Processing and Routing System (NAVCOMPARS),[1] intercept of administrative message traffic is only one of many traffic control methods available to the system operator. In this chapter the following topics will be discussed:

1. Fleet Multichannel Broadcast System
2. Administrative Traffic Intercept
3. Administrative Traffic Intercept Modes
4. Message Reentry Modes

B. FLEET MULTICHANNEL BROADCAST SYSTEM

The Fleet Multichannel Broadcast System (MULCAST) serves as the United States Navy's primary method of sending general service (genser) message traffic between forces afloat and the Naval Telecommunications System (NTS). The Multichannel Broadcast is a non-termination[2] system capable of being received by properly equipped and frequency aligned units.

The Multichannel Broadcast is primarily operated through two transmission systems:

1. Fleet Satellite Broadcast (FSB) System
2. High Frequency Broadcast (HFB) System

1. Fleet Satellite Broadcast (FSB) System

The Fleet Satellite Broadcast serves as the primary method of transmitting the Multichannel Broadcast. The FSB's normal configuration requires a one channel assignment for uplink and downlink from one of the U.S. Navy's satellite communication systems (i.e. Fleet Satellite Communications System (FLTSATCOM), Gapfiller System, Leased Satellite System (LEASAT)). Using multiplexing technology, sixteen individual

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[1] For a detailed summary of NAVCOMPARS see Appendix A.

[2] A termination is a special full-time dedicated circuit between a fleet unit and the NTS. Terminations are usually required because of high traffic flow due to major exercises/operations, special operations, or command requirements.

channels comprising the Multichannel Broadcast are combined into a single 1200 Baud FSB channel for uplink to the system satellite. The sixteen channels include:

- 11 - 75 Baud general service teletype (TTY) channels
- 2 - 75 Baud special intelligence channels
- 2 - 75 Baud meteorological channels
- 1 - frame synchronization channel

The fleet units, receiving the satellite downlink, demultiplex the single 1200 Baud signal back into the original sixteen individual 75 Baud TTY channels. User communication requirements and equipment availability then determine which of the sixteen channels are actually decrypted and utilized. It should be noted that equipment availability is usually the most significant factor in determining channel utilization. The amount of equipment on hand to decrypt and utilize a channel is dependent on the class of ship and it's mission.

Of the eleven genser TTY channels available at a Communication Station eight comprise the Fleet Broadcast. Normal configuration is six channels controlled directly from the Fleet Center while the remaining two channels are controlled in other spaces. Three of the six channels are run continuously as common or type channels while the remaining three are run as either overload, rerun, or contingency channels. [Ref. 1: pp. 68-69; Ref. 2: pp.39-40]

Common channels generally contain messages for all fleet units in the Communication Area (COMMAREA); type channels carry messages which are designated for ships of a particular warfare type (i.e. amphibious, destroyer).

Overload channels are used as a means of expanding system output capacity. When an overload is activated, traffic which was designated for a primary channel is then split between that primary channel and the overload. This, in effect, doubles the output capacity of the transmitting station. The activation of the overload also requires that the receiving fleet units allocate additional decryption and processing equipment to the overload.

Rerun channels are used for ensuring that units receive all traffic designated for them. In principle, a rerun channel rebroadcasts message traffic which was originally broadcast on a primary channel some time period before. For example, a rerun channel will transmit message traffic one hour after the initial message broadcast over a common or type channel. This enables the receiving units to recopy any message which it may have missed on the initial broadcast.

2. High Frequency Broadcast (HFB) System

High Frequency multichannel communication serves as the secondary transmission medium for the Fleet Broadcast. Because of the system's versatility and survivability, and the growing vulnerability of satellite communications systems, HF communications have received increased emphasis to meet present and future needs. The Chief of Naval Operations (CNO) has mandated that, at a minimum, a complete 16 channel HF broadcast capability be maintained in each of the major communications areas [Ref. 3: p. VIII-1].

Multichannel HF communications are similar in concept to the satellite communications mentioned above except that the transmission medium is HF vice satellite (SHF, UHF). Additionally, the capability exists to simultaneously key on other frequency bands any message being transmitted on HF. This process of "simo-keying" further improves the probability of success on these non-satellite communication systems. The effects of using HF as a transmission medium will be expanded upon in later chapters. See Figure 1 on page 6.

C. ADMINISTRATIVE TRAFFIC INTERCEPT

Message interception is used as a means of demand management; selected messages are removed from the system thereby lessening the total number of messages actively being processed. The purpose of an administrative traffic intercept is to

> . . . allow the Broadcast Keying Station (BKS) to remove from and/or suspend queueing to the broadcast (during extreme traffic loading periods) ZYB marked messages [Ref. 4: p.1].

Administrative traffic are messages which have been deemed by the message originator to be non-operational in nature. The originator identifies this traffic by inserting *ADMIN* in the Message Handling Instruction (MHI) block of the message form.

Within NAVCOMPARS, after input via an Optical Character Reader (OCR) or some other system input device, the message is marked with the Operating Signal (OPSIG) ZYB by the resident software. The operating signal ZYB then serves to identify a message as administrative to the NAVCOMPARS. Once converted to ZYB, the administrative message is flagged for possible interception should traffic conditions warrant.

Additional processing will assign a message, whether operational or administrative, a Routing Indicator (RI) based on the addressee (final destination). The RI assigned

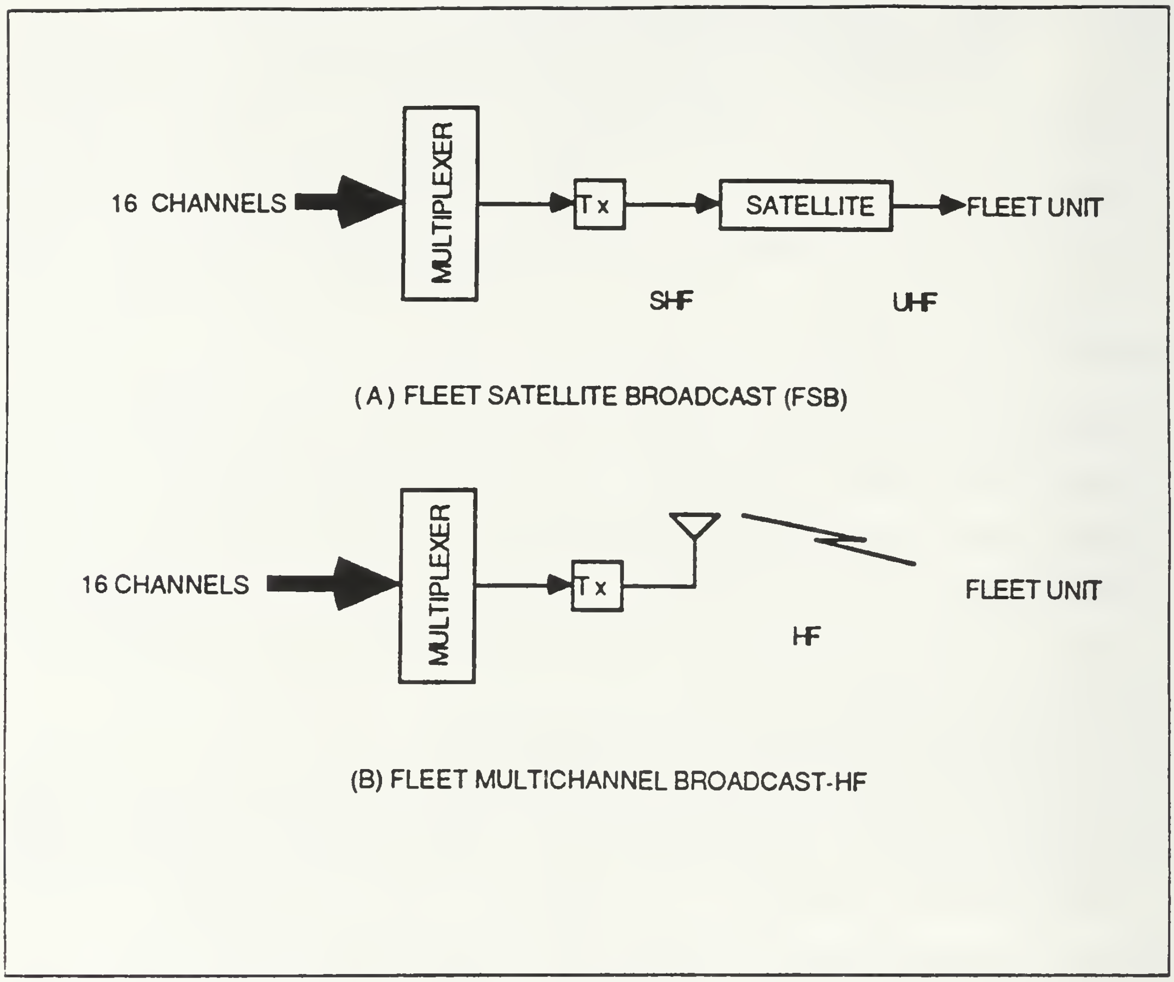

Figure 1. Fleet Multichannel Broadcast Transmission

will then be matched with a Logical Reference Number (LRN) which designates the output path required for message delivery.

At this point in processing, a specific message is either in queue awaiting transmission, or enroute to a LRN's queue. As mentioned above, it is possible for broadcast queues to become congested due to high traffic loading; in this situation the broadcast LRN becomes a likely candidate for some sort of demand management action (i.e. an intercept).

If the system manager invokes an administrative intercept all messages flagged with ZYB OPSIGs will be intercepted either from the LRN queue or enroute to the queue. These intercepted messages are then sent to the Screening Board printer LRN for printing.[3] Messages sent to the Screening Board are then individually examined by members of the board to determine further action. Further actions may include: [Ref. 5: p.35]

- delivery by other means (i.e. courier, mail)
- immediate reentry in NAVCOMPARS for broadcast
- holding for reentry when queue conditions warrant

A more detailed explanation of ZYB intercept modes and message reentry options is provided in the following sections.

D. ADMINISTRATIVE TRAFFIC INTERCEPT MODES

Removal of administrative traffic from NAVCOMPARS is performed by two different methods; an alternate routing (altroute) or a redirect.

An altroute command is used to remove messages which are already queued on a LRN awaiting transmission. A redirect command is used to divert messages from a LRN which may be backlogged or non-operational due to equipment malfunctions or outages. [Ref. 5: p.28,p.35]

1. ZYB Altroute Mode - AM Command

The AM altroute is designed to remove existing administrative traffic from a specified LRN queue. In NAVCOMPARS Release 11.0 the specified LRN must be a broadcast type; in the upcoming Release 12.0 the LRN can be broadcast, full period, dedicated or CUDIXS.[4] See Figure 2 on page 8. [Ref. 4: p.3; Ref. 6]

The AM command is applicable for Immediate precedence messages and below. For example, an altroute of Immediate administrative traffic will also result in the altrouting of Priority and Routine traffic.

Upon completion of the LRN purge the AM command will automatically delete.

---

[3] The Screening Board LRN is also the final destination for a Screening Board altroute and redirect function. The Screening Board functions are similar to an Administrative Screen except that all messages, whether operational or administrative in nature, are affected.

[4] CUDIXS, the Common User Digital Information Exchange System, is a communications link between a shore communication element and fleet units, using UHF satellites. CUDIXS can serve up to sixty properly equipped units using a polling scheme for transmission and reception order.

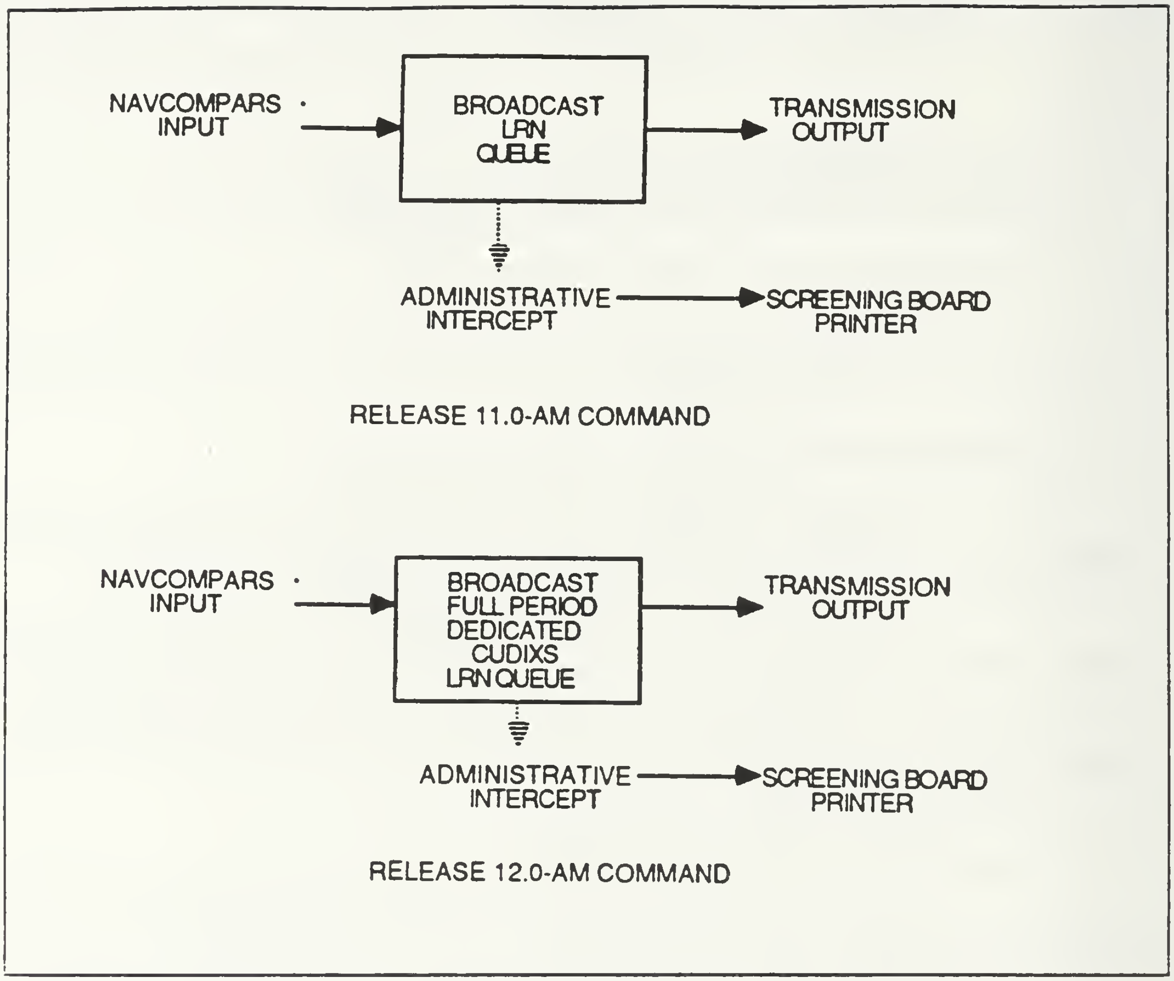

Figure 2. AM Command - NAVCOMPARS Release 11.0 and 12.0

2. ZYB Redirect Mode - ADM Command

The ADM command is used by the system operator to prevent delivery of ZYB designated messages to a specified LRN. Initiation of the command will direct qualifying messages from the original LRN to the Screening Board printer.[5] See Figure 3 on page 9. The precedence rules mentioned above for the AM command are also applicable for the ADM command.

Unlike the AM command the ADM command must be manually terminated by the system operator. [Ref. 4: p.2]

---

[5] The Screening Board printer is the only allowed destination LRN currently used with NAVCOMPARS Release 11.0. Release 12.0 will incorporate additional destination LRN's when installed.

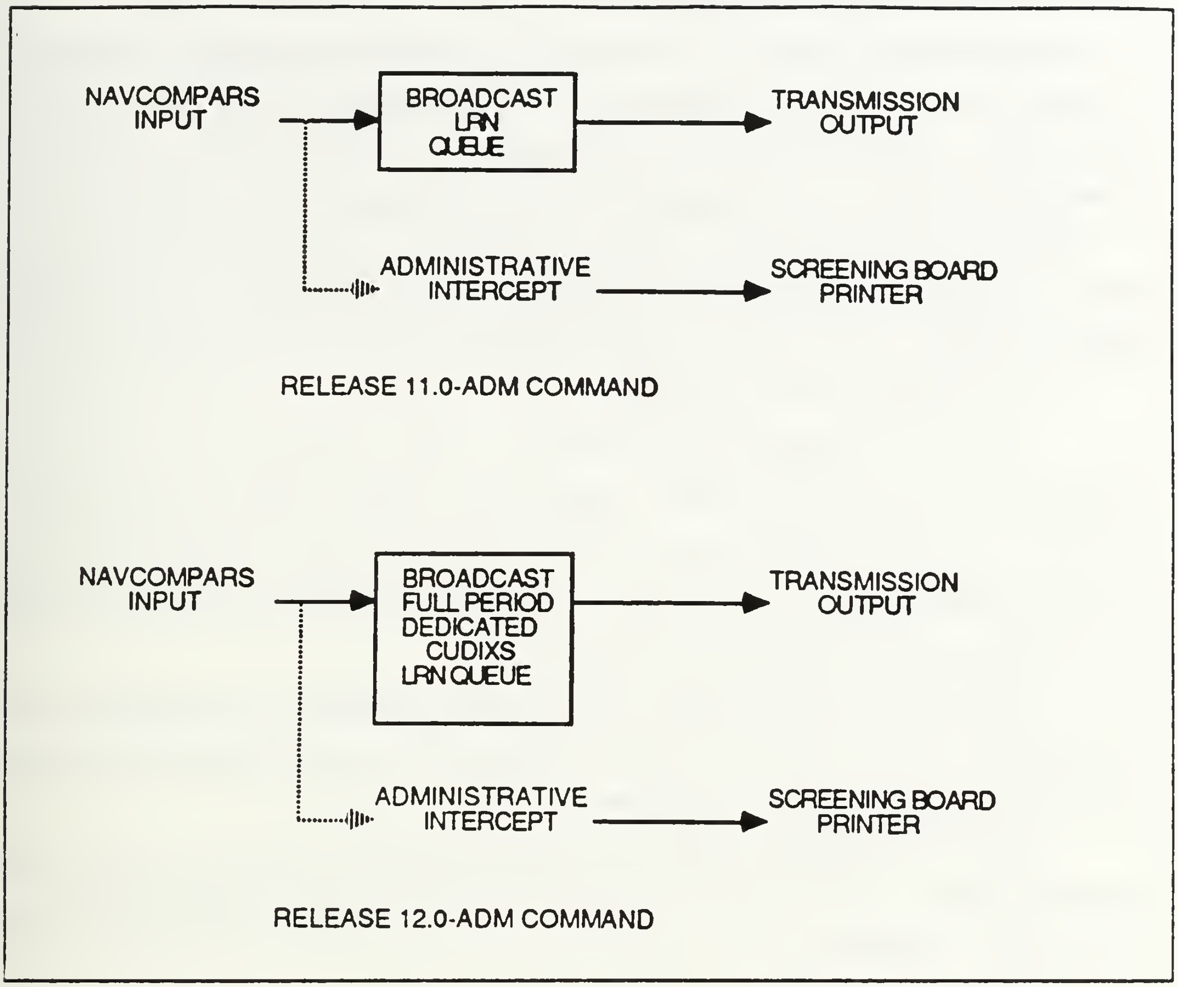

Figure 3. ADM Command - NAVCOMPARS Release 11.0 and 12.0

3. Combination AM/ADM Command Usage

In addition to being used separately the AM and ADM commands can be used simultaneously on the same source LRN. Operating in this mode the ADM command will direct newly arriving traffic to the Screening Board LRN while the AM command clears the specified source LRN queue of existing administrative messages. As mentioned above, the AM command will automatically delete when the source LRN is purged of qualifying messages. The ADM command will require operator action for command removal.

E. MESSAGE REENTRY MODES

Messages that have been altrouted or redirected to the Screening Board printer as a result of an administrative intercept must be screened to determine the next step in processing. At this point the individual message can either be delivered by other means or reentered into the system immediately or later, depending on queue conditions.

Reentry of intercepted messages into the system can be achieved either through the intervention of a system operator at a Command Video Data Terminal (VDT), the creation of a reentry tape, or the use of reentry altroutes. [Ref. 7: pp.71-72; Ref. 4: p.4]

1. VDT Initiated Message Reentry

Within NAVCOMPARS, the Message Processing Subsystem (MPS) performs message analysis and VDT interface. The software module used for VDT interface is MPSVC. By using MPSVC and a VDT, it is possible to reenter intercepted administrative messages using SVC commands. Two SVC commands are used for reentering intercepted messages: SBR and SBO [Ref. 8: p.71].

The use of the SBR command will requeue the message to the original LRN for transmission. In the event that another administrative altroute is performed these requeued messages will again be intercepted.

The SBO command is similar to the SBR command except that it will override any administrative altroute which takes place while the requeued message awaits transmission. [Ref. 9: p.164]

2. Message Reentry Tape

An alternate method of reentry is accomplished through the creation of a reentry tape using an off-line program. This program will extract identified administrative messages from the journal tape, reformat the messages appropriately, and then write them to a reentry tape. The system operator can then input the messages back into NAVCOMPARS using the reentry tape.

3. Reentry Altroutes

Intercepted messages can also be reentered from the Screening Board using reentry altroutes. The reentry altroutes include:

- channel reentry
- short title reentry
- routing indicator reentry
- count reentry

Reentry altroutes return intercepted messages to the system if the specified precedence range and subject parameter requirements are met. Channel reentry returns to the source LRN messages which meet the precedence and destination channel requirements. Short title and routing indicator reentry commands are similar to the channel reentry, with the message short title and routing indicator being the second specified parameter. Count reentry differs slightly; the parameters specified by this command are the precedence range and number of messages to be reentered. Any message meeting the criteria of the selected reentry altroute will be requeued for transmission by the system. [Ref. 7: pp.45-47]

III. ADMINISTRATIVE MESSAGE INTERCEPT IMPLEMENTATION STRATEGIES

A. INTRODUCTION

The use of an administrative message intercept to alleviate a broadcast queue buildup is only one of many traffic management options available to the NAVCOMPARS manager. The decision to invoke an intercept command should take into account many factors and considerations. Among these factors are the current operational situation (external factors), NAVCOMPARS system status (internal factors), and the transmission medium in use. In this chapter the following factors will be addressed:

1. External Factors
2. Internal Factors
3. Transmission Considerations
4. Proposed Strategies

B. EXTERNAL FACTORS

When forming decisions on traffic management options the systems manager must take into account factors external to the NAVCOMPARS. These factors may have some bearing on what option the manager chooses to pursue. Factors to consider include:

1. Time
2. Types of Users
3. Exercise Conditions
4. World Events

1. Time

Time factors to be considered include the time of day and the day of the week. The message releasing rates of users within a NAVCAMS's COMMAREA may show some sort of pattern over a period of twenty-four hours. For example, given that most messages are written during a normal working day, it may develop that these messages will enter NAVCOMPARS late afternoon or early evening local time, creating a higher traffic arrival rate. This proposed scenario combined with an already congested

NAVCOMPARS suggests imminent difficulties for system managers and operators. Trends such as these requires an operator's attention.

The day of the week has also shown cyclic traffic patterns. Comparing traffic conditions shows that Wednesday through Friday are generally the heaviest load days, concurrent with the end of the workweek. Considering these cycles may aid a decision maker in forecasting a possible drop or increase in traffic arrival rates. [Ref. 5: p.37]

2. Types of Users

Each Naval Communication Area Master Station (NAVCAMS) is responsible for communications within a geographical area [Ref. 3: p.IV-1]. A systems manager should know both the number and type of users within its Communication Area (COMMAREA); using this information enables the manager to better judge the potential for traffic loading. For example, the arrival of multiple Carrier Battle Groups (CVBG) into a COMMAREA presents many factors to be considered. The increase in the total number of fleet units will undoubtedly increase message traffic arrival. An alert NAVCAMS should have overload circuits ready or arranged for to handle expected increases. Additionally, the commands controlling these units will generate additional high precedence traffic. Again, this may warrant additional overloads. [Ref. 5: p.37]

3. Exercise Conditions

The operational schedule of users within a COMMAREA should also be considered. The conducting of exercises will increase message traffic arrival rates as coordination takes place. This increase will continue during the actual exercise and will probably not lessen until the exercise is well over.

4. World Events

World events can usually be expected to affect message traffic loading also. The outbreak of conflict in a NAVCAMS's COMMAREA, whether directly or indirectly involving U.S. forces, will increase communication activity as reports and observations are sent to command and control centers. Few such outbreaks occur instantaneously; the system manager should be aware of potential areas and the possible effects on traffic.

C. INTERNAL FACTORS

In addition to external factors a NAVCOMPARS operator must closely monitor the equipment and assets available to him or her. Keeping an overall picture of the system's parameters should enable the watch teams to forecast any inhouse problems short of catastrophic equipment failure.

Inherent in NAVCOMPARS are system status displays which are printable in hard copy form. These reports are:

- Input Queue Summary Report
- Output Queue Summary Report
- Data Pattern Directory Report
- CUDIXS Output Summary Report
- Intercept File Queue Report
- System Queue Summary Report

Timely usage of the above reports[6] should enable the operator to identify trends, potential backlog situations, or any unusual problems.

In addition to the hard copy reports, queue status can also be obtained from:

- Computer Operator console typeouts, both unsolicited and initiated
- VDT Display
- Teletype Logs

Console typeouts appear as the result of computer detected conditions; typeouts are also the result of operator initiated requests. Example typeouts include reached queue limits, queue overflow, input/output errors, or imminent storage wraparound. Command VDT status displays can also achieve similar results as the hard copy reports mentioned above. Teletype logs are LRN-oriented; typeouts of this type indicate computer detected conditions at specific channel logs.

Additional system status indicators are the Output Queue Profile Reports: NCQPROS and NCQPROT. These background programs available on 90/60 computer-equipped systems provide profile data for each message on a selected LRN output queue. NCQPROS provides printed output data in ascending order by originator short title. NCQPROT provides profile data on a queue by message. [Ref. 5: pp.13-25]

D. TRANSMISSION CONSIDERATIONS

In addition to NAVCOMPARS' internal system status reports and the external considerations, the system manager must consider the transmission medium being used. As stated in Chapter two, the Fleet Broadcast is primarily carried via satellite on one of the Fleet Satellite Broadcast systems, or it is carried using High Frequency radio

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6 For a more detailed explanation of the above listed reports see NAVTASC Document No. 15X7001 OM-02C, NAVCOMPARS Computer Operation Manual.

communications. When operating in either transmission mode, the operator must understand the nuances of each of the individual systems.

The primary difference between HF and satellite communication is the frequencies used. Satellite communications typically operate in Ultra High Frequency (UHF) (300 Mhz-3Ghz), Super High Frequency (SHF) (3Ghz-30Ghz), or in a combination of UHF and SHF (i.e. SHF uplink, UHF downlink). The particular satellite constellation in use by the NAVCAMS will determine the applicable frequency range. HF systems operate in the 3 Mhz - 30 Mhz frequency range. [Ref. 1: p.56]

The chief disadvantage of HF communications is the susceptibility of radio wave in this range to attenuation and atmospheric disturbances. Maximum Useable Frequency (MUF) and Lowest Useable Frequency (LUF) are concepts used in understanding ionization effects on HF propagation. The time of day, placement of the moon, season of the year, latitude of the transmission, presence of sunspots, or meteor showers, individually or in combination, all affect the probability of successful HF communication. The above factors are all contributors to atmospheric ionization; this ionization can lead to HF attenuation by absorption. To ensure satisfactory HF communications both the sender and the receiver of an HF signal will have to display a fair amount of frequency agility to stay below MUF and above LUF. [Ref. 10: pp.11-1 - 11-11]

Because of HF attenuation problems, prudent practice may require the activation of additional rerun channels on the Fleet Broadcast. These channels, run in combination with common or type channels, would increase the probability of receiving all messages on the fleet unit should a message or messages be unreadable due to atmospheric conditions.

E. PROPOSED STRATEGIES

As mentioned in Chapter One, Commander, Naval Telecommunications Systems Command (CNTC) promulgated proposed thresholds for the implementation of an administrative message intercept. These thresholds were to be recommended to the Fleet Commander in Chiefs (FLTCINCs) [Ref. 11]. See Table 1 on page 16 for a listing of the proposed thresholds.

COMNAVTELCOM also solicited comments and/or recommendations concerning the proposed thresholds. In this section the responses from each of the message addressees will be presented.

Table 1. COMNAVTELCOM PROPOSED IMPLEMENTATION STRATEGIES

QUEUE BACKLOG	ACTION
70	Analyze to determine if specific units can be brought up on special CUDIXS to clear single addee messages.
175	Implement admin message intercept for affected broadcast channels.
50	Commence reentering diverted messages.

1. NAVCOMMSTA Stockton CA

The comments from NAVCOMMSTA Stockton were generally negative concerning the proposed threshold limits. The primary comment was that a *standard* traffic threshold would restrict effective broadcast management by not allowing the operators onhand to exercise real-time decision making. The need to consider operational tempo and requirements was also emphasized. [Ref. 12]

2. NAVCAMS EASTERN PACIFIC Honolulu HI

The response from NAVCAMS EASTPAC generally paralleled NAVCOMMSTA Stockton's response. The response again emphasized that the uniqueness of each situation, in terms of operational requirements and the operating environment, required flexibility which would be reduced with the promulgation of *standard* thresholds.

The message from NAVCAMS EASTPAC provided two alternatives, one for a satellite environment and one for operating in a HF environment. The threshold limits are provided in Table 2 on page 17 and Table 3 on page 17.

The reasoning behind the different thresholds is that operating in HF differs from operating by satellite. The quality of a HF signal, as mentioned in previous sections, is heavily dependent on the environment and usually requires the activation of rerun channels to ensure greater probability of message reception. By activating an administrative intercept first, the requirement for fleet units to secure rerun channels in order to receive newly activated overload channels is delayed as long as possible. [Ref. 13]

3. NAVCAMS ATLANTIC Norfolk VA

NAVCAMS LANT's response to the CNTC request was also negative towards the use of administrative intercepts. NAVCAMS LANT suggests the following system,

Table 2. HIGH FREQUENCY ENVIRONMENT THRESHOLDS - NAVCAMS EASTPAC

QUEUE BACKLOG	ACTION
75	Analyze Queue profiles to determine specific reasons for backlog. Try to reduce backlog with various management options, less overload activation or admin intercept.
100	Invoke administrative intercept to the precedence level necessary to promote timely delivery of operational traffic.
175	Activate Broadcast overload channel(s).
20	Reenter intercepted messages. When all the messages have been reentered, revoke the intercept(s).

Table 3. SATELLITE ENVIRONMENT THRESHOLDS - NAVCAMS EASTPAC

QUEUE BACKLOG	ACTION
75	Analyze queue profiles to determine specific reasons for backlog. Try to reduce backlog with various management options, less overload activation or admin intercept.
175	Invoke administrative intercept to the precedence level necessary to promote timely delivery of operational traffic.
100	Activate Broadcast overload channel(s).
20	Reenter intercepted messages. When all the messages have been reentered, revoke the intercept(s).

when combined with active evaluation of the broadcast backlog and real world operational conditions, to be more effective than the CNTC proposed thresholds:

- Prompt activation of overload channels, if not in HF environment.
- Review queue profiles on various channels and reduce broadcast queue by sending single addressee messages to special CUDIXS termination.[7]

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7 Using Queue Profiles allows the NAVCOMPARS manager to review messages held in queue for an output channel. By inspecting the profile the manager may identify a fleet unit which has a high number of messages slated for delivery. With this information the manager can altroute those messages through alternate delivery means (i.e. CUDIXS).

- Activate RCS overflow for high speed input lines. This removes lower precedence traffic onto an overflow tape for later reentry using controlled automatic methods.
- Final alternative, activate TPS intercept for routine messages.

NAVCAMS LANT also addresses the manpower efficiency of administrative intercepts as well as the need for a magnetic tape store and recall feature. These issues will be addressed in following sections. [Ref. 14]

4. NAVCAMS WESTERN PACIFIC Guam

The response from NAVCAMS WESTPAC was similar to that of NAVCAMS EASTPAC. Similar points concerning the lack of flexibility from a *standard* threshold and the need for real-time comprehensive situational analysis were raised.

NAVCAMS WESTPAC also highlighted the requirement for a *standard* which addressed HF and satellite communications individually. The reasoning again centered on the fact that the success of HF communications is heavily dependent on the current environmental conditions; because of this dependency, fleet units must configure to receive rerun channels, in addition to their common and type channels, to ensure highest probability of receiving all messages. See Table 4 on page 19 and Table 5 on page 19 for proposed thresholds. [Ref. 15]

5. NAVCAMS MEDITERRANEAN Naples Italy

NAVCAMS MED generally concurred with the responses mentioned above. Again, the need to fully utilize the talents and experience of on-scene personnel was emphasized. A comment was also made that the imposition of *standard* thresholds would reduce flexibility and stifle initiative of the Broadcast Control Authority (BCA).

There were no proposed threshold limits but it was mentioned that NAVCAMS MED procedures called for activating overload channels when broadcast queues reached 60 to 70 messages. There was no mention of differences between operating in a HF or satellite environment. [Ref. 16]

6. Naval Telecommunications Systems Integration Center

The Naval Telecommunications Systems Integration Center (NAVTELSYSIC) was also solicited for comments and/or recommendations concerning the proposed thresholds; NAVTELSYSIC currently serves as the NAVY's telecommunication certification facility [Ref. 3: p.III-2].

The comments submitted by NAVTELSYSIC stated that the thresholds proposed conflicted with the numbers listed in REF. 3 with respect to the activation of

Table 4. **HIGH FREQUENCY ENVIRONMENT THRESHOLDS - NAVCAMS WESTPAC**

QUEUE BACKLOG	ACTION
70	Analyze. Implement special management actions (activate HF RFCS Termination).
100	Implement admin intercepts.
150	Commence overload activation process if conditions allow.
50	Reenter intercepted admin messages.

Table 5. **SATELLITE ENVIRONMENT THRESHOLDS - NAVCAMS WESTPAC**

70	Analyze. Implement special management actions (Special CUDIXS termination).
150	Implement admin intercepts.
100	Commence overload activation process.
50	Reenter intercepted admin messages

overload channels. The Current FOTP instruction calls for the activation of overloads at a queue backlog of 150 messages.

NAVTELSYSYIC also recommended that the individual NAVCAMS be allowed to establish their own implementation thresholds for administrative intercepts. [Ref. 17]

7. Response Summary

The responses generated by CNTC's request for comments and/or recommendations had many common points. Areas in common dealt with the effect of *standard* guidance on organizational relationships and decision making, the need for more environment oriented considerations, and the perceived design deficiencies of the administrative message intercept. Another common thread that ran through the solicited responses was that queue levels through NAVCOMPARS are used as the most basic indicator of the current system status. Although the actual numbers varied, the general rule to success was to keep a queue level below a selected level.

Many comments were made concerning the effect of *standard* thresholds on the organizational relationships between the FLTCINCs and the individual NAVCAMS.

The FLTCINCs, as operational commanders, exercise authoritative control over the communication assets within their geographical area of control [Ref. 3: p.V-2]. The issuance of CNTC guidance is perceived as an erosion of this operational authority.

Decision making issues were also raised; specifically, that the guidance failed to take into account the dynamic nature of the operating environment. Additional comments were that the experience and talents of on-scene personnel were not fully utilized when operating under such guidance. It was felt that operators on station could more adequately address an increasing queue problem by working with all resources available at the NAVCAMs, rather then by invoking a static set of procedures.

The need for HF and satellite environment considerations was also highlighted. The guidance failed to consider the differences when operating with either HF or satellite.

The effectiveness and efficiency of administrative message intercepts were also questioned. The comment was made that the intercept was manpower intensive due to the reentry procedures; this is critical with the current and future state of Naval manning. The need for a magnetic tape store and recall feature was mentioned; this would enable the operators to reenter intercepted messages by automatic means when queue levels permit.

As mentioned above, queue levels are seen by both CNTC and the NAVCAMSs, as serving as a solid measure of system status. Since this appears to be the case throughout the Naval Telecommunications System (NTS), this research will also utilize queue levels as a status indicator on the simulation model.

IV. COMPUTER SIMULATION METHODOLOGY

A. INTRODUCTION

In this chapter, an overview of simulation will be presented, followed by an introduction to General Purpose Simulation System (GPSS) V. The final sections will pertain to the actual model of simulation used for this research.

B. AN OVERVIEW TO SIMULATION

> It often turns out that it is not possible to develop analytical models for queueing systems. This can be due to the characteristics of the input or service mechanisms, the complexity of system design, the nature of the queue discipline, or combinations of the above [Ref. 18: p.455].

The above quotation by Gross and Harris lists the possible reasons or combinations of reasons why simulation might serve as an adequate representation of an actual queueing system. Emphasis is placed on *adequate*. However, simulation is experimenting through the use of changing parameters; because of this, simulation can be subject to the same limitations of any experimentation. Limitations may include the validity of any inferences or assumptions made; this idea must be kept in mind throughout the simulation process.

The execution of a simulation model can be divided into three phases:

- Data Generation
- Bookkeeping
- Output Analysis

Data generation is the creation of *customers*, the subject of the transaction. The creation of *customers* can be multiphased; the first phase is the actual generation of the subject *customer*. The second phase is the assignment of attributes to the *customer*; this is conditional on the particular simulation model in use since a *customer* may have many attributes or none at all.

Bookkeeping is the gathering of measurements as the simulation model is run. Measurements may include the arrival and departure of each *customer*, the times involved in each significant part of the simulation, and the number of *customers* utilizing these significant sections of the simulation.

The third and final phase is output analysis. Using the data provided by the bookkeeping phase, measurements are generated for analysis. Typical measurements and results may include average queue size, average time in queue, idle time, or average waiting time. [Ref. 18: pp.456-469]

Figure 4 on page 23 provides a diagram showing the three phases of simulation. Note the recursive feature between the Data Generation phase and the Bookkeeping phase; this represents the repetitive runs with compilation of data for the Output Analysis phase.

C. GENERAL PURPOSE SIMULATION SYSTEM (GPSS) V

GPSS is a block diagrammatic simulation language which uses command operations to define a system structure [Ref. 18: p.471]. The fundamental element in GPSS is the entity; entities are designed to perform a variety of functions relative to the type of entity that it is. The most frequently used entities are [Ref. 19: p.7]:

- transactions
- blocks
- facilities
- storage
- queue
- logical switches
- boolean variables

Transactions are the principal items of movement within a simulated model; they can be created or destroyed dependent upon the model requirements. Transactions can also be assigned up to 1020 attributes; through the use of these attributes, it is possible to make each individual transaction somewhat unique.

Blocks are used to perform command operations which were described when a system was analyzed. Blocks may perform four basic events:

- creation and destruction of a transaction
- alteration of an entity's numerical attribute
- transaction delay consistent with simulated action
- model flow alteration

Facilities are used to represent equipment; a facility may be used to simulate the process of a cashier operating a grocery check-out stand or any process in a model which

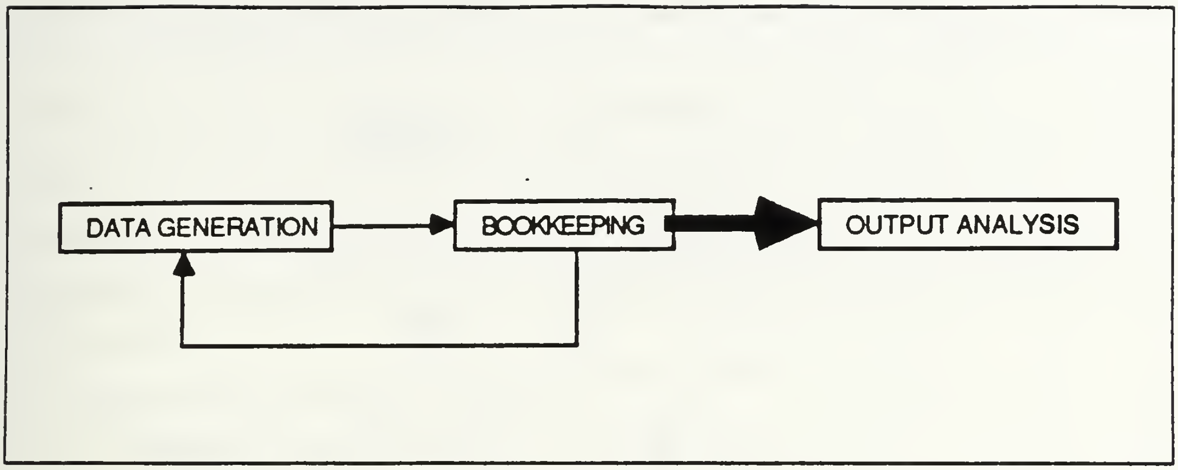

Figure 4. Three Phases of System Simulation

acts as a server. It should be noted that only one transaction may occupy a facility at a given time.

Parallel processing equipment is represented using storages. Storages can be used to represent the maximum capacity of a room or the maximum storage available on a magnetic tape unit.

Since facilities emulate single servers and storages have some set maximum capacity, transactions may be delayed awaiting a facility's process or a storage's availability. In this event, a transaction is held in queue; these transactions will be held until the facility or storage become available.

Logical switches are used to block or divert traffic dependent on the value of the switch. Transactions can also be utilized to set, reset, or invert a switch.

Boolean variables can be used to make decisions based on numerous values; for example, any specific attribute of a transaction can be used as a basis for a decision using some sort of operator. Example operators include conditional, boolean, and logical attributes. [Ref. 19: pp.5-7]

To aid in the generation of output most of the above mentioned entities create and maintain their own statistics. The queue entity, for example, gathers queue length, average time in queue, total number of entries, average time per transaction spent in queue, and more. For a more detailed explanation of each entity and it's statistics, the reader must refer to Ref. 19 or Ref. 20.

See Figure 5 on page 24 for an illustration of a GPSS block diagram for a single server queue model. In this single server simulation a transaction is created in the

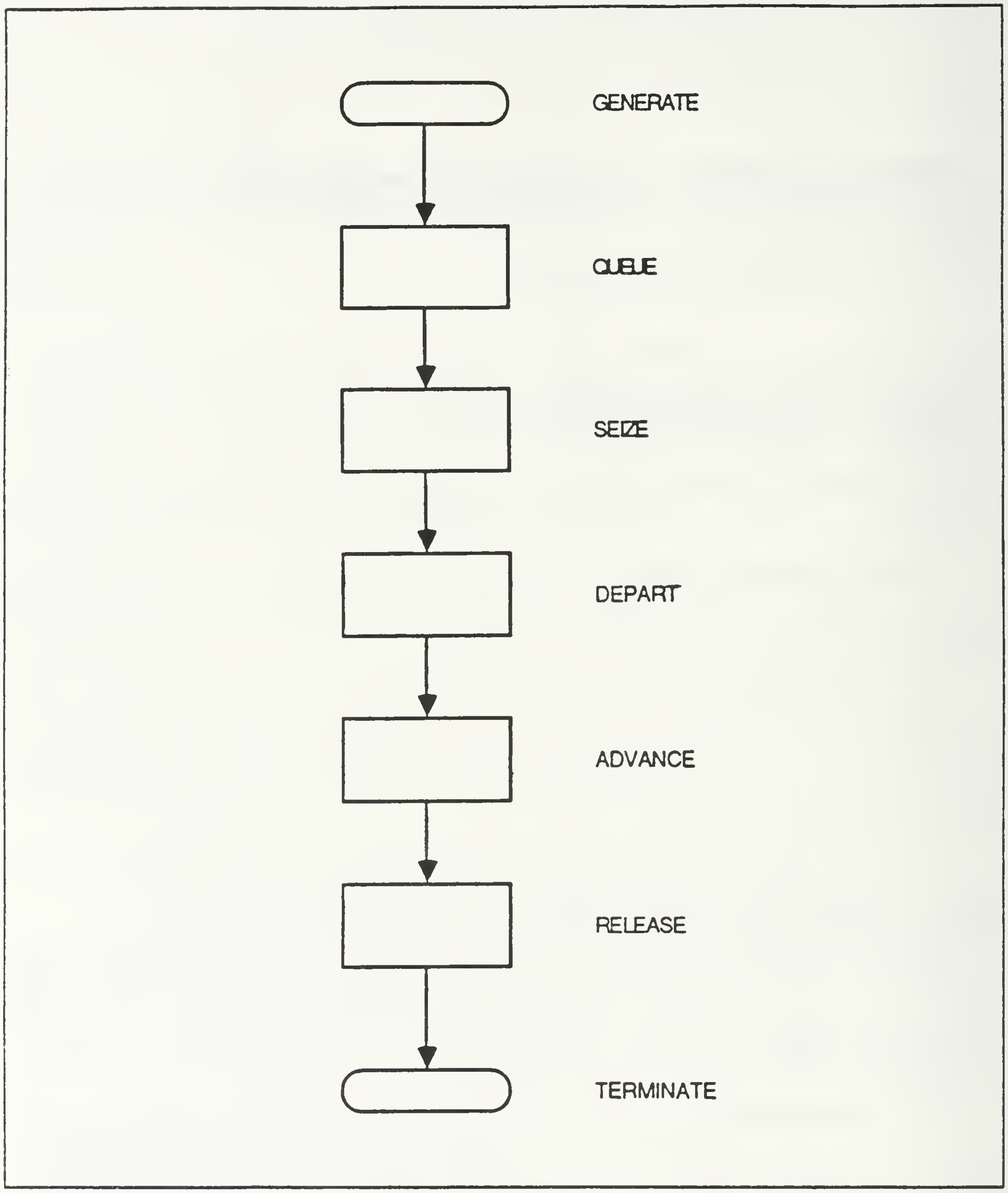

Figure 5. Generic GPSS Simulation Model (Single Server Queue Model)

generate entity. Following generation the transaction enters a *queue* block with subsequent entry into a *seize* block. The *queue* block is entered to simulate a line of transactions awaiting the use of the following facility; the use of the queue also generates valuable statistics, as mentioned above. The *seize* block engages a specified facility to simulate some action taking place; once the facility is seized the transaction is allowed to leave the queue via the *depart* block. To generate a service time for the transaction GPSS uses the *advance* block; the *advance* block generates a delay time comparable to a service time. Upon completion of the delay time the transaction is released for further processing. The final block is the *terminate* block; it is in this block that the transaction is destroyed.

D. SIMULATION MODEL DESIGN

1. Simulation Model Foundation

In Glenn's research on administrative message schemes he states the following regarding the Fleet Broadcast:

> . . . Broadcast can be looked upon as 15 parallel, nonidentical M/M/1 transmission facilities. Each channel has unique message arrival and service rates and is assumed to be a single service supplying its subscribers with the message traffic it transmits [Ref. 21: p.43].

Glenn later states,

> . . . final and most detailed model definition can be viewed as approximately seven parallel nonidentical facilities which would correspond with the number of first run channels, regular and overload, that are used [Ref. 21: p.43].

For the purpose of simulation it will be assumed that Glenn's proposals are valid. With this in mind, the idea that each output channel is a single server will serve as the basis for this research's model.

See Figure 6 on page 26 for an illustration of the system model.

2. Simulation Model Limitations

As explained in Chapter Two, the activation of an administrative intercept results in either the altrouting of messages in queue on the output channel, or the redirecting of newly arriving messages from the selected channel. The action performed is dependent on the mode chosen by the system manager. In modeling the AM command feature the simulation package would be required to screen messages already held in queue to identify ZYB flagged messages for removal. Unfortunately, this capability does not exist with GPSS and prevents the author from modeling the AM intercept or the combination AM/ADM intercept. The decision to continue using GPSS was based on two reasons; one, GPSS's ease of use, and two, that the modeling of the ADM feature

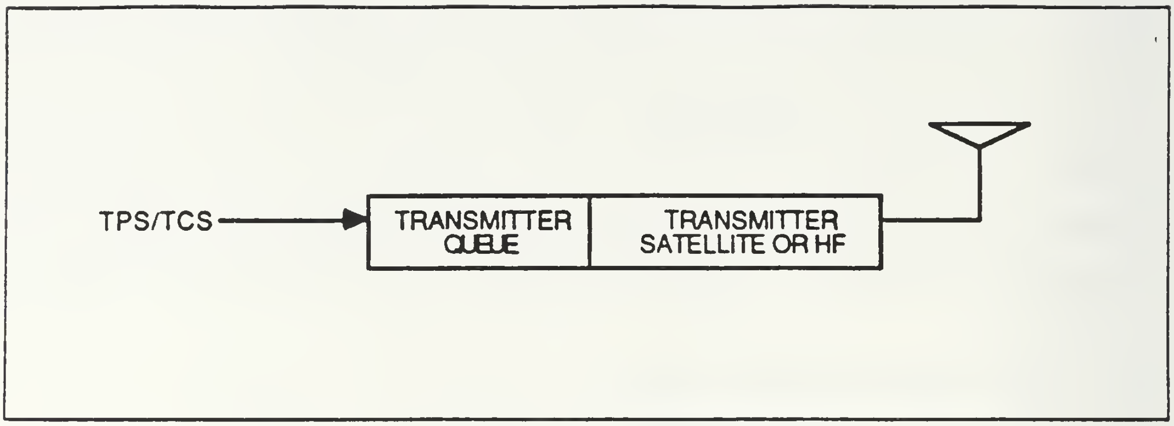

Figure 6. Fleet Broadcast - Simplified Single Server Model

would qualitatively show the intercept effects that the author considered pertinent to the research.

The author also wishes to reemphasize that the results given are qualitative in nature. To validate the quantitative results of the simulation model would require resources not available at the time of the research (i.e. historical analytical data, actual NAVCOMPARS operation time under experimental conditions).

3. ADM Model Design

The single server model proposed in Ref. 21 is based on a standard teletype transmission circuit operating at seventy-five baud. To simulate this model using GPSS will require the following features:

- transaction generation and termination
- queue entrance and departure
- simulation of transmission time
- ADM intercept capability

Transaction generation and termination is easily accomplished using the GPSS commands *generate* and *terminate*. The *generate* command will simulate message arrival at a desired rate; this is the first phase of generation mentioned above. The second phase, the assignment of attributes, is accomplished using three *assign* commands. The three attributes to be used are message precedence (routine, priority, immediate), administrative operational designation, and message length in characters. Note that both the simulated message arrival rates and attributes can be varied to simulate desired conditions; these options will be used to demonstrate the model features.

Queue entrance and departure is simulated through use of the *queue* and *depart* commands. Use of the *queue* command produces useful statistics mentioned above.

Simulation of transmission time is done using the *advance* command. Using eight bits per character,[8] multiplied by the individual message length gives the message length in bits. Dividing this value by the capacity of the transmission circuit gives transmission time; the transmission capacity used was seventy-five baud. [Ref. 22: pp.343-345]

The simulation of an ADM command is done using multiple *test* commands. The first *test* command is used as a trigger that simulates a redirect when the queue level reaches a certain level. Once a redirect is started the second and third *test* commands check for message type (administrative or operational) and precedence respectively. See Appendix B, Simulation Model Specifications, for the actual GPSS code and an accompanying flow chart showing diagrammatic model flow.

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8 Actual bits per message character is 7.42 for Baudot code TTY's [Ref. 22: p.342]. This is rounded up to eight bits due to GPSS requirement for *advance* block values to be intergers [Ref. 19: p.26].

V. SIMULATION RESULTS AND ANALYSIS

A. INTRODUCTION

The purpose of a simulation model is to allow via experimentation understanding of the influence of different parameters and variables on system behavior. By varying these parameters it is hoped that the researcher can develop causal relationships which might prove helpful in understanding the simulated system as a whole. In this chapter the following sections are included:

1. Simulation Model Test Variables
2. Simulation Model Test Results and Discussion

B. SIMULATION MODEL TEST VARIABLES

As mentioned in the previous chapter, the simulation model used in this research is a representation of a single output channel on the Fleet Broadcast with the capability of activating an ADM altroute. Within this representation of the Fleet Broadcast channel, there are several parameters which can be manipulated to test the model under varying conditions.

1. Model Variables

In this simulation model there are two types of variables which can be controlled; the first variable types are the attributes assigned each individual message on generation by the *generate/assign* block sequence. These variables are:

- Message Precedence
  There are four message precedence levels in use in the NAVY: Routine, Priority, Immediate, and Flash (in increasing priority). Of these four, only three , Routine, Priority, and Immediate, can be categorized as administrative messages [Ref. 23: p.4-2]. To reflect this, message precedence is granted through the *assign* block using the relative distributions and a random number generator. The user has the ability to vary the distribution of each message precedence to reflect the precedence characteristics of any simulation test run.

- Message Length
  Through the use of the second *assign* block it is possible to dictate the range of total characters per message. In this simulation model, character assignment is given by a continuous function with a user determined low end and high end number of characters per message. In Ref. 24 , CNTC's Semi-Annual Summary of Naval Telecommunications Performance, the approximate average message length was 1962 characters; this figure was used as a rough indicator on where to start length variation.

- Ratio of Administrative to Operational Messages
  The designation of whether a message is administrative or operational is determined in the third and final *assign* block. By varying the percentage of administrative message traffic , the researcher can affect the ratio of administrative to operational traffic to determine if there are any effects on the measured outputs.

The second variable type is external to the actual messages; these are related to the message mean arrival rates and the activation of the administrative intercept command.

- Message Arrival
  Message arrival can be manipulated in two manners; the first is by the setting of the mean time between message generation. This, in effect, is the controlling of the message mean arrival rate to the system. The second modification is accomplished by specifying a spread modifier about the mean time between message generation. Using this feature makes the arrival rate less constant and more realistic.

- Administrative Intercept Command
  The activation of the administrative intercept command can also be modified in two ways. First, the model can be executed with the intercept command being invoked at any specified queue level; in the actual GPSS code, the intercept command is set to activate when the output queue equals a user determined level. The second modification to the intercept command is precedence oriented; the user can set the model to intercept administrative messages at different precedence levels using *test* blocks.

2. Simulation Test Run Coding

To identify the various simulation test runs, it was necessary to develop a means of differentiating between the runs. The coding scheme is illustrated in Figure 7 on page 30. Test Run Designation is the identification number for the simulation run. Total Message Arrivals for 24 Hour Period is the cumulative total of messages to be generated by the simulation system. Message Interarrival Time Modifier (%) is the control of variance about the message mean interarrival time; message mean interarrival time is total seconds per day (86400) divided by the total messages per day. Administrative Messages (%) in Total Traffic indicates the percentage of total arriving messages that are administrative in nature. Queue Level at which Intercept is Activated is set by the user; Precedence of Administrative Messages Affected is also selected by the user. Two factors are not included in the coding scheme; these are the message precedence distribution and message character ranges. It will be assumed that the message precedence distribution is 0.33 Routine, 0.33 Priority, and 0.33 Immediate, unless otherwise specified; similarly, the message character range will be assumed to be 100-2500. The message character range is continuous and message character values assigned are distributed

Test #AA/BBBB/CC/DD/EEEZ

Parameters:

AA - Test Run Number Designation

BBBB - Total Message Arrival for 24 Hour Period

CC - Message Mean Interarrival Time Modifier (%)

DD - Administrative Messages (%) in Total Traffic

EEE - Queue Level at which Intercept is Activated

Z - Precedence of Administrative Messages Affected
(includes selected precedence and lower)

Figure 7. Simulation Test Run Coding Scheme

uniformly over the indicated range. Should test parameters for precedence distribution or message character range require alteration the new values will be indicated in the applicable section and on the resulting graphs.

3. Simulation Test Run Results

As mentioned in the previous chapter, the result of the simulation runs will be used for comparative analysis using graphs of the following factors:

- Total Message Throughput
- Output Channel Queue Level (noncumulative)
- Total Administrative Messages Intercepted

Additional graphs will also be used to further examine output characteristics. Precedence distribution of messages transmitted (throughput) will be provided with the individual cumulative precedence levels over the test period. The breakdown of administrative versus operational messages transmitted will also be provided. See Figure 8 on page 31 for an explanation of test graph terminology.

TEST GRAPH LEGEND**

A. THROUGHPUT GRAPH

1) THROUGHPUT - Messages transmitted (cumulative)
2) QUEUE - Messages in queue (noncumulative)
3) ADMIN - Administrative messages intercepted (cumulative)

B. MESSAGE PRECEDENCE GRAPH

1) ROUTINE - Routine messages transmitted (cumulative)
2) PRIORITY - Priority messages transmitted (cumulative)
3) IMMEDIATE - Immediate messages transmitted (cumulative)

C. MESSAGE TYPE GRAPH

1) ADMIN-XMIT - Administrative messages transmitted (cumulative)
2) OPS-XMIT - Operational messages transmitted (cumulative)

**-all graphs are based on a 24 hour run time with data generated every 2 hours.

Figure 8. Test Graph Legend

C. SIMULATION MODEL TEST RESULTS AND DISCUSSION

In this section the results of simulation test runs will be presented graphically.

1. Message Precedence Distribution Variation

In this set of simulation tests all parameters were held constant with the exception of the precedence distributions. Three tests were conducted using the following precedence distributions:

- #29 - 0.45 Routine, 0.40 Priority, 0.15 Immediate
- #27 - 0.15 Routine, 0.40 Priority, 0.45 Immediate
- #28 - 0.05 Routine, 0.40 Priority, 0.55 Immediate

Average utilization for the system test runs, using average message arrival rate, divided by the average message service rate, is [Ref. 20: p.288]:

- #29 - 1.31
- #27 - 1.31
- #28 - 1.32

The results are presented in Figure 9 on page 33.

From inspection of the results there appears to be no appreciable differences when using throughput, queue level, and intercepted administrative messages as measures of performance. This is not completely surprising given that only the precedence distribution was altered. Keeping in mind that this is a preemptive system with higher precedence messages receiving first servicing, it can be hypothesized that the sequence of individual messages being processed changed when the distribution was altered. For example, in Test #28 with fifty-five percent Immediate and forty percent Priority messages, it is hypothesized that the majority of Routine traffic is either in queue or has been intercepted if an administrative message altroute had been in effect. This hypothesis appears valid by examining the precedences of messages transmitted in Figure 10 on page 34. The Routine messages in Test #28 are never transmitted due to their low priority. In Test #29 with only fifteen percent Immediate messages, there are more Routine messages processed through the system without preemption; this is illustrated in Figure 10 on page 34.

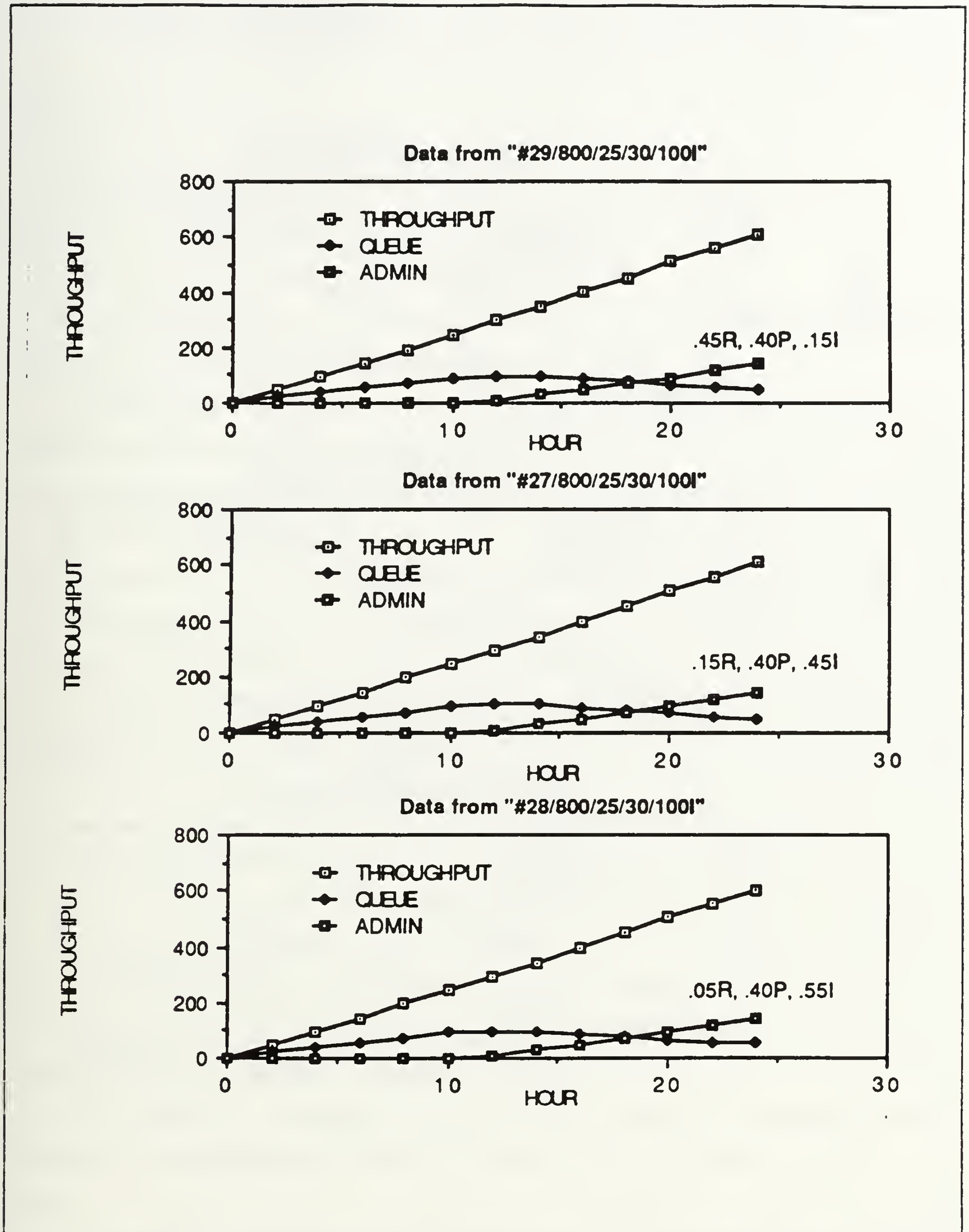

Figure 9. Message Precedence Distribution Variation

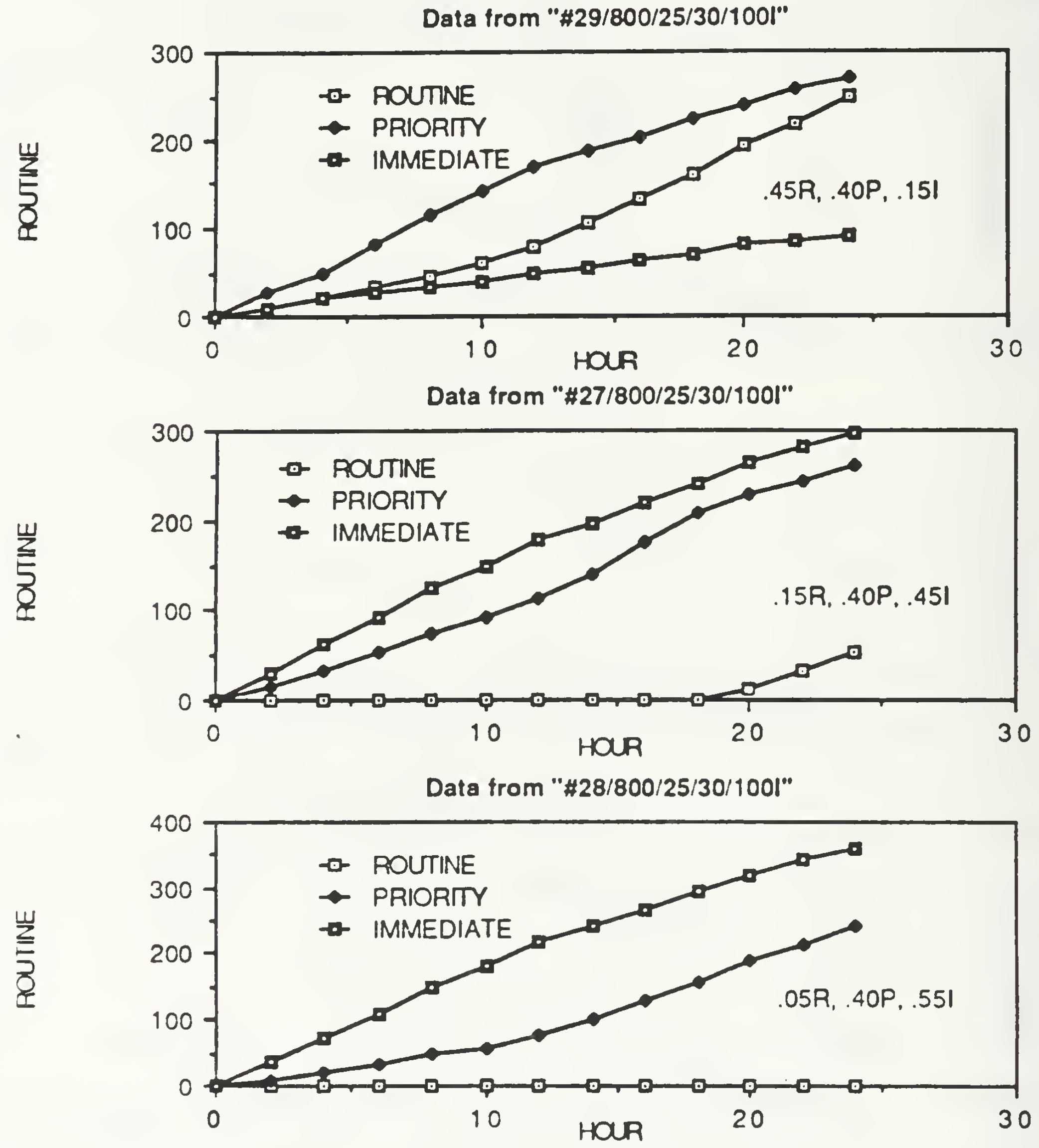

Figure 10. Precedences Transmitted - Tests #29, #27, #28

2. Message Length Variation

The number of characters present in a message directly determines the transmission time required on the output channel assigned. In this test set, three runs were conducted using the following ranges:

- #30 - 100-1500 characters per message
- #6 - 100-2500 characters per message
- #31 - 100-3500 characters per message

The reader is again reminded that the character values assigned are uniformly distributed over the indicated continuous character range.

The results from this set of tests, illustrated in Figure 11 on page 36, show distinct differences in all three quantities measured. Precedences transmitted and message types transmitted are illustrated in Figure 12 on page 37 and Figure 13 on page 38. At the lowest range, in Test #30, throughput was maximized with few messages held in queue; because of this, it was not necessary to activate an administrative message intercept. Precedences transmitted in Test #30 showed corresponding increases at all levels. There was also an appreciable number of administrative messages transmitted. Widening the range to 100-2500 characters in Test #6 shows a drop in throughput with a buildup in queue level. Messages of Routine precedence were not transmitted until hour ten; this is the approximate point where the intercept was activated. The activation reduced message arrival into the queue allowing Routine messages in queue the opportunity to be transmitted. It should also be noted that the administrative message intercept in this character range aided in lowering the queue level when activated. Test #31, at 100-3500 characters, illustrates an appreciable drop in throughput with increases in both queue level and intercepted administrative messages. Lower priority Routine messages had little possibility of being transmitted; correspondingly, both administrative and operational messages transmitted decreased. In this run the activation of the intercept showed little effect in lowering queue level. With the increase in message characters it is felt that the benefits of the intercept are reduced by the slowdown in message processing.

Results of these tests show that the number of characters in arriving messages affects the message throughput and lessens the effectiveness of the adminstrative intercept in reducing queue level as the number of average message characters increases.

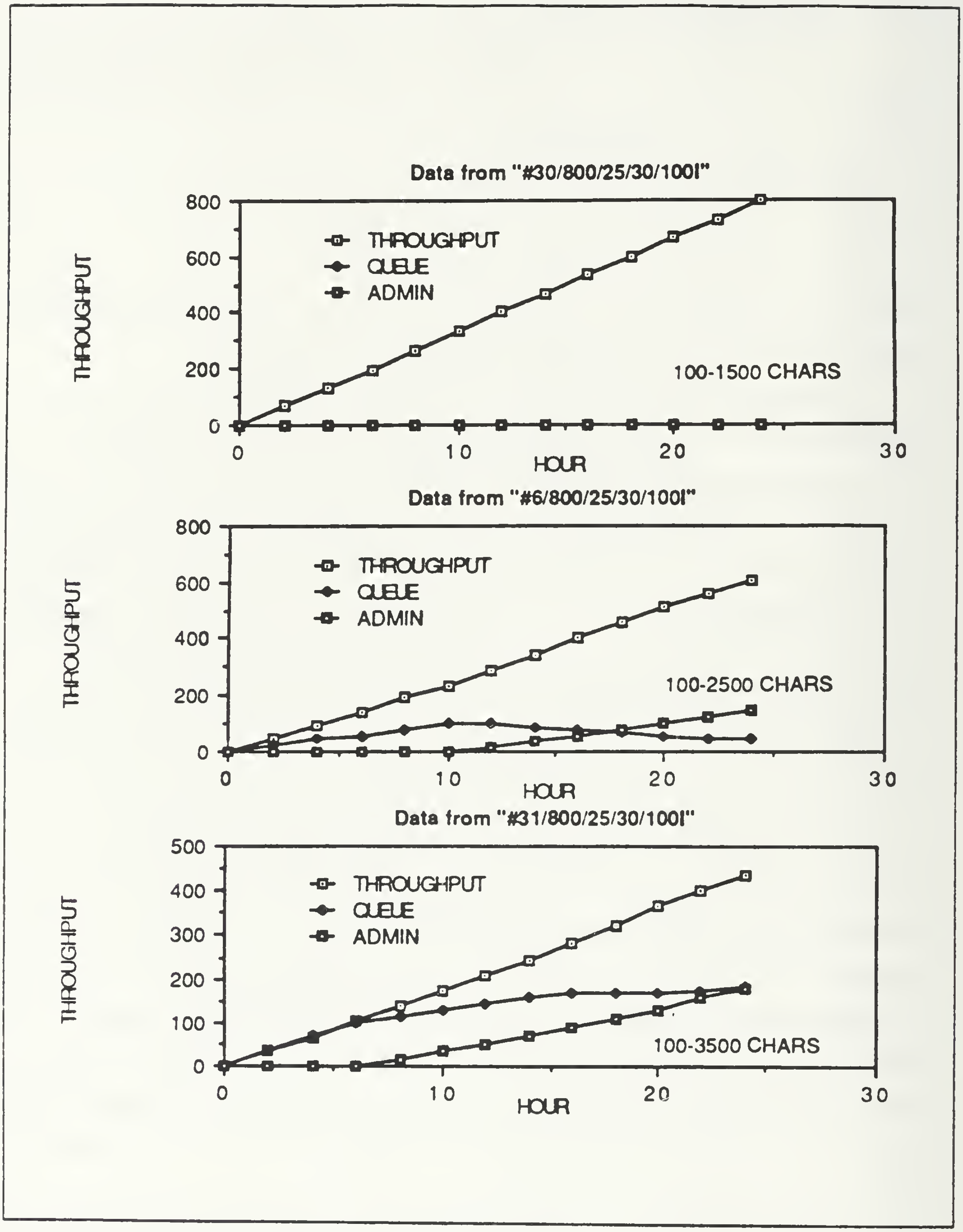

Figure 11. Message Length Variation

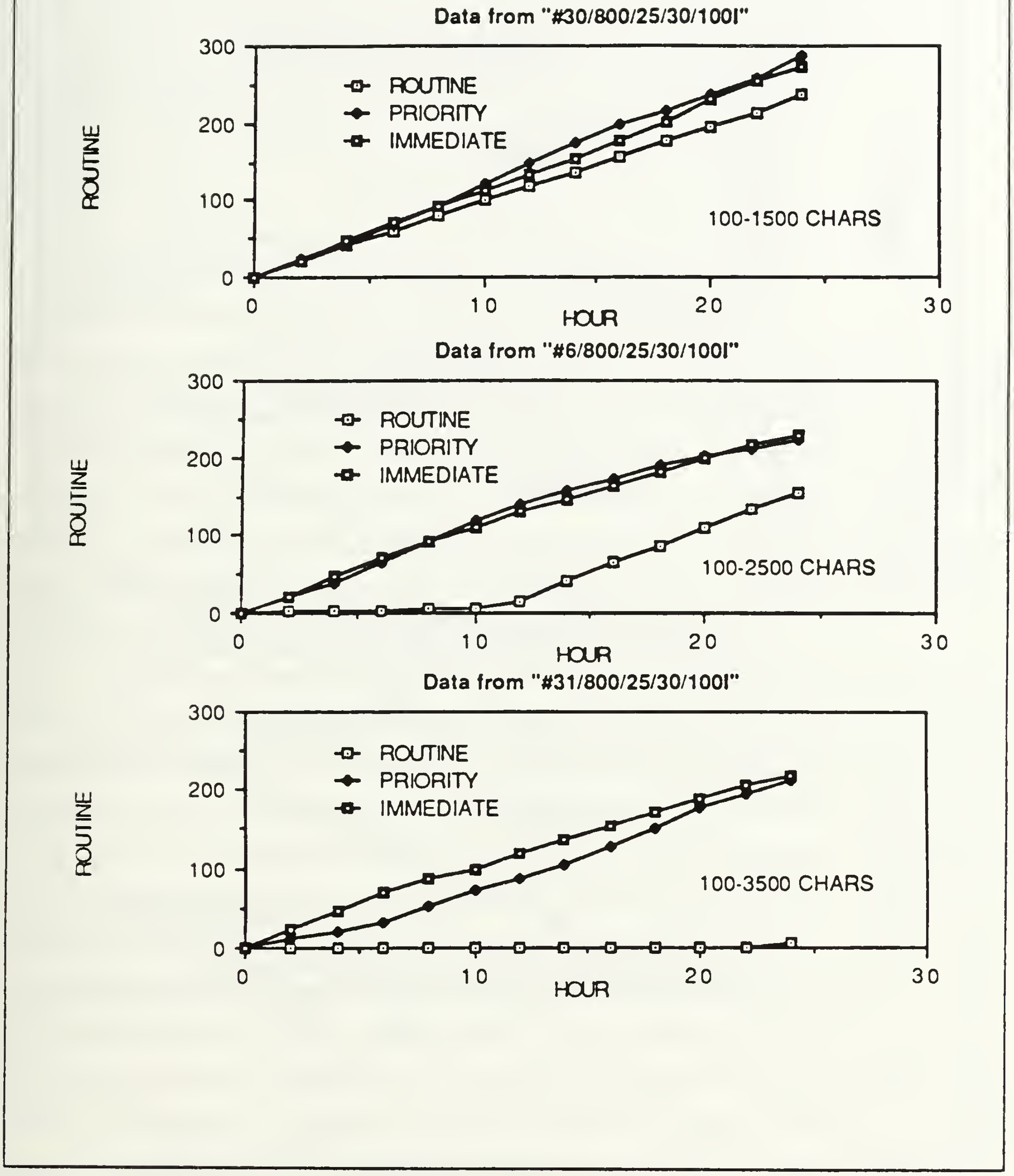

Figure 12. Precedences Transmitted - Test #30, #6, #31

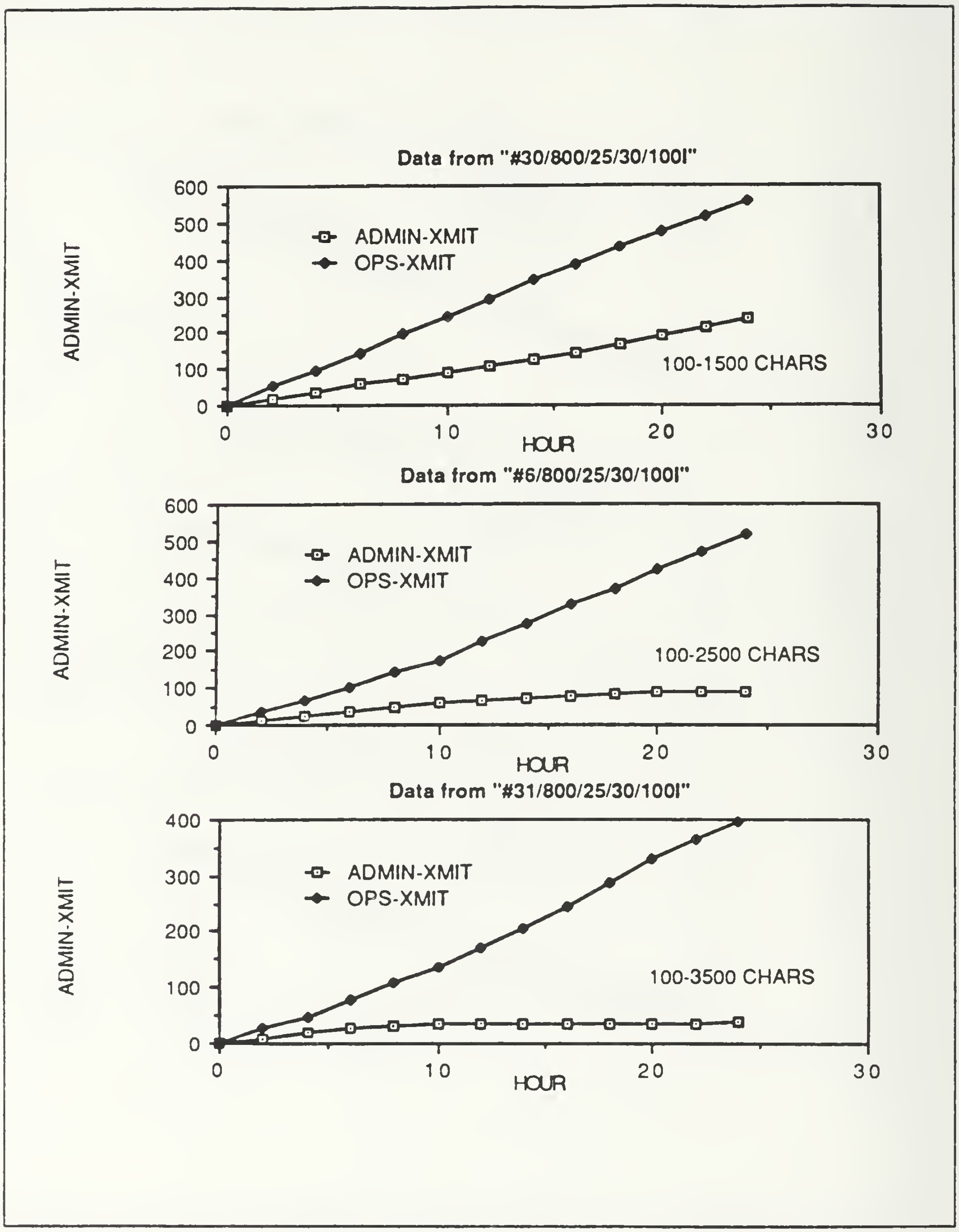

Figure 13. Message Types Transmitted - Test #30, #6, #31

3. Message Type Variation

The effectiveness of an administrative message intercept is directly related to the percentage of administrative messages in the arriving traffic. This effect was demonstrated using the following variations in percentage administrative traffic:

- #4 - 20%
- #5 - 25%
- #6 - 30%
- #7 - 35%
- #8 - 40%
- #9 - 45%

The results of these test runs are illustrated in Figure 14 on page 40 and Figure 15 on page 41. Precedences transmitted during these tests are illustrated in Figure 16 on page 42 and Figure 17 on page 43. Message types transmitted are illustrated in Figure 18 on page 44 and Figure 19 on page 45. From observation, it is apparent that as percentage administrative traffic increased so does the effectiveness of the intercept in reducing queue level. Additionally, this effectiveness leads to higher amounts of intercepted messages at the Screening Board printer.

Precedences transmitted show decreasing numbers of Priority and Immediate traffic with increasing Routine messages being transmitted as the percentage administrative traffic increases. The cause of this behavior is that an intercept of administrative messages while at a high percentage of administrative traffic, will remove all administrative Priority and Immediate traffic. This decrease in higher precedence messages leads to the transmission of lower precedence traffic already held in queue. Administrative messages transmitted also show an increase in the Message Types Transmitted graph with operational messages decreasing. This is the result of the sheer increase of percentage administrative traffic in each test run. Note, however, that once an intercept is activated the amount of administrative transmitted drops until finally no administrative traffic is transmitted. This would allow the possibility of higher throughput for operational traffic; this is shown by the increased rate of operational messages transmitted.

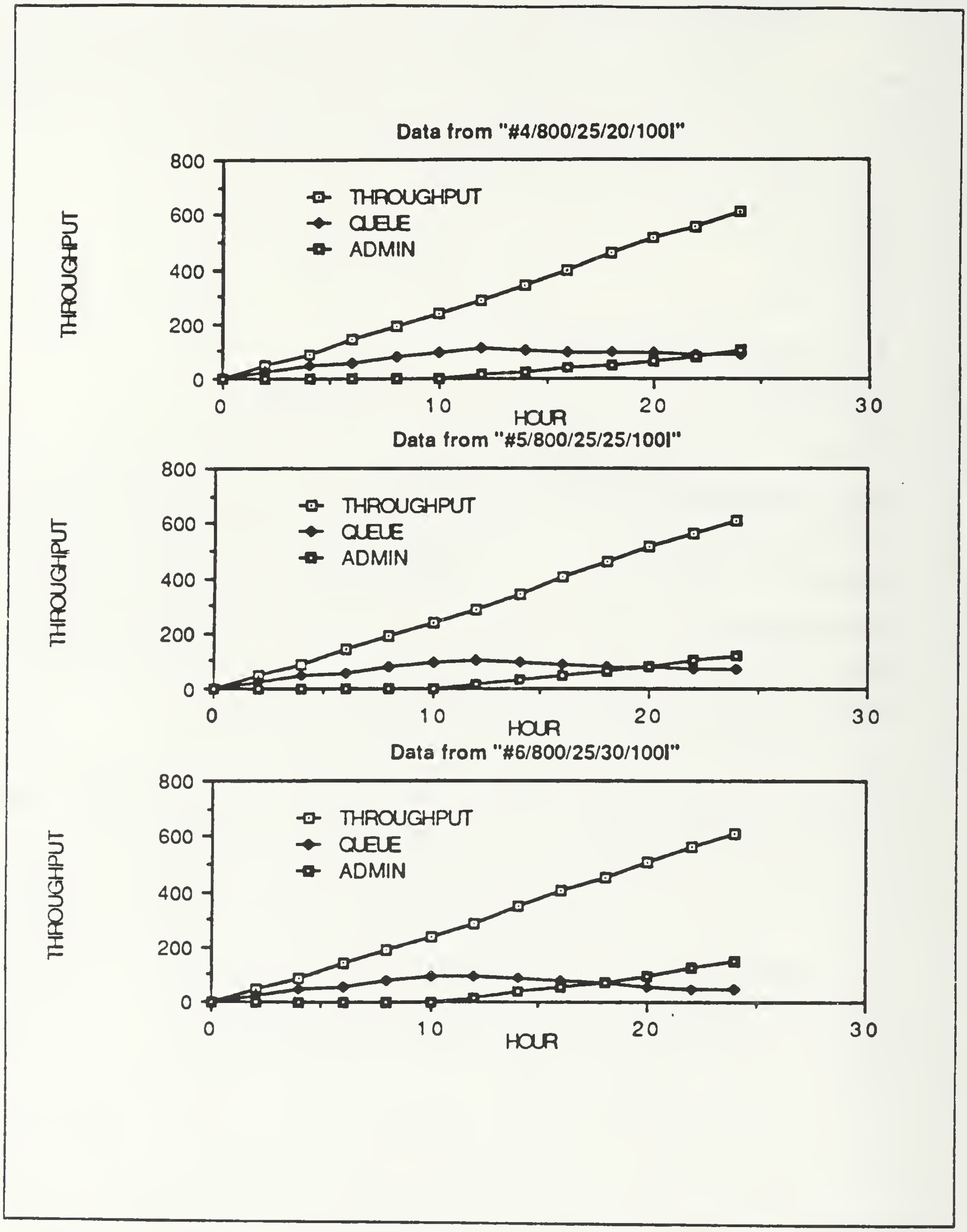

Figure 14. Message Type Variation (a)

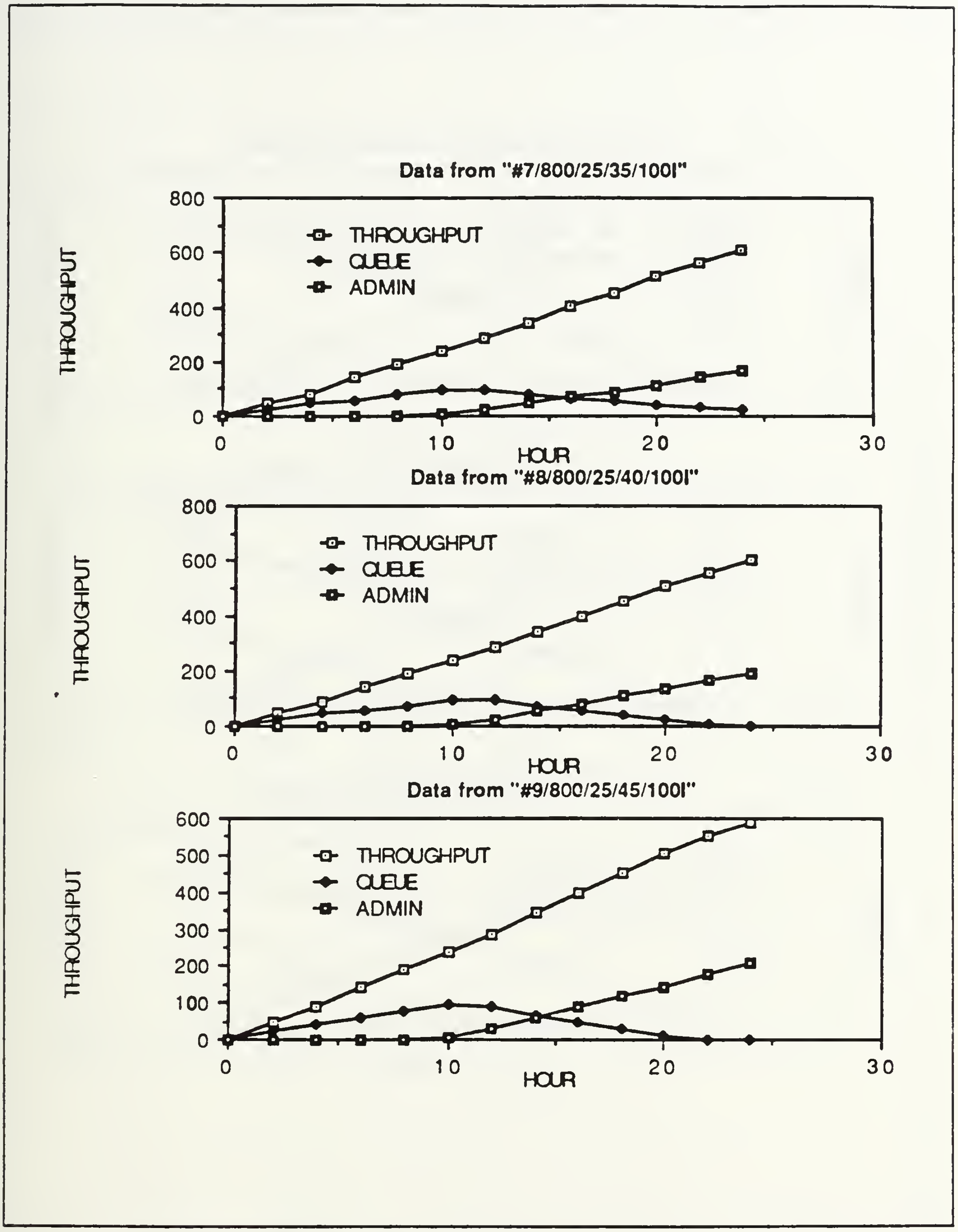

Figure 15. Message Type Variation (b)

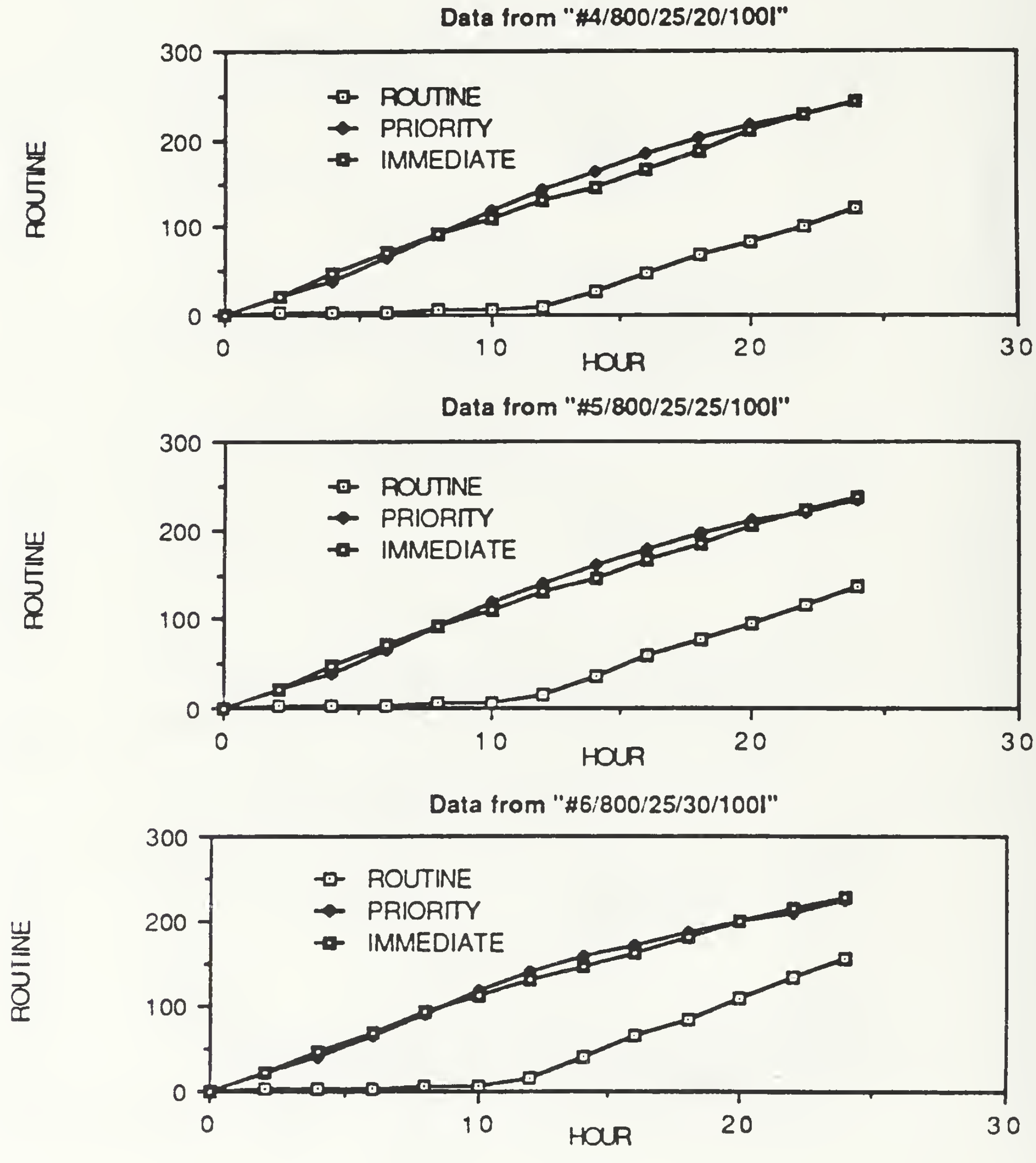

Figure 16. Precedences Transmitted - Test #4, #5, #6

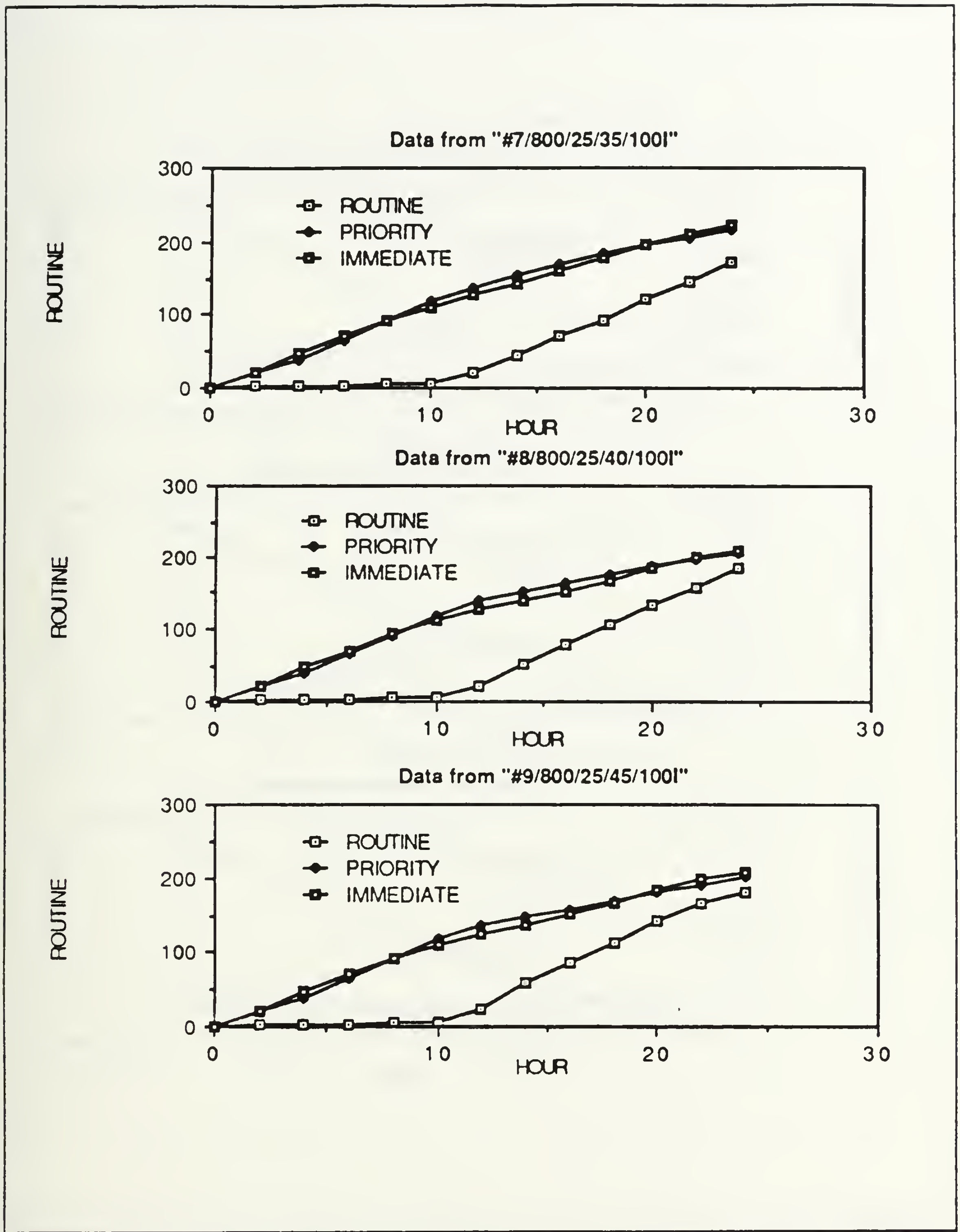

Figure 17. Precedences Transmitted - Test #7, #8, #9

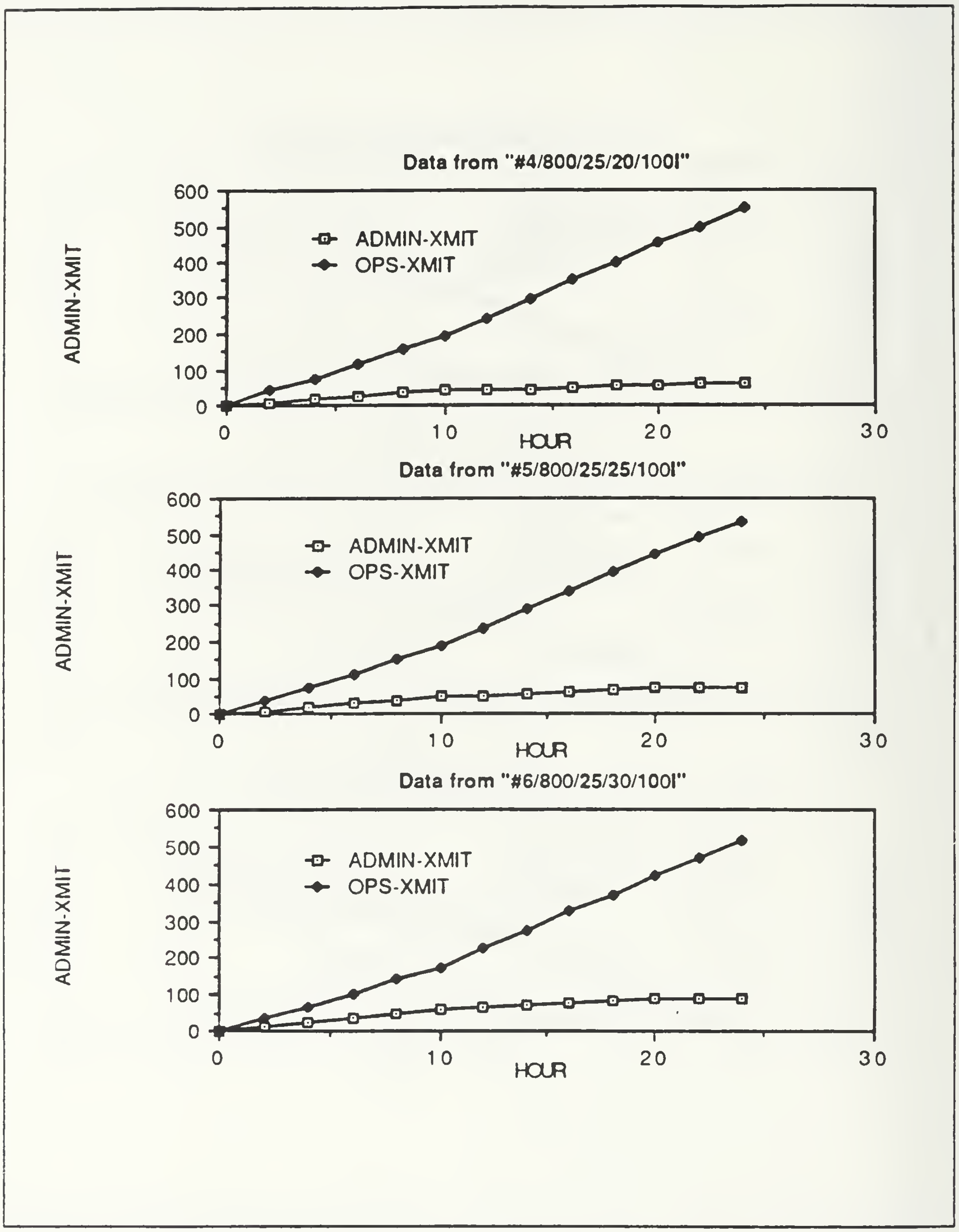

Figure 18. Message Types Transmitted - Test #4, #5, #6

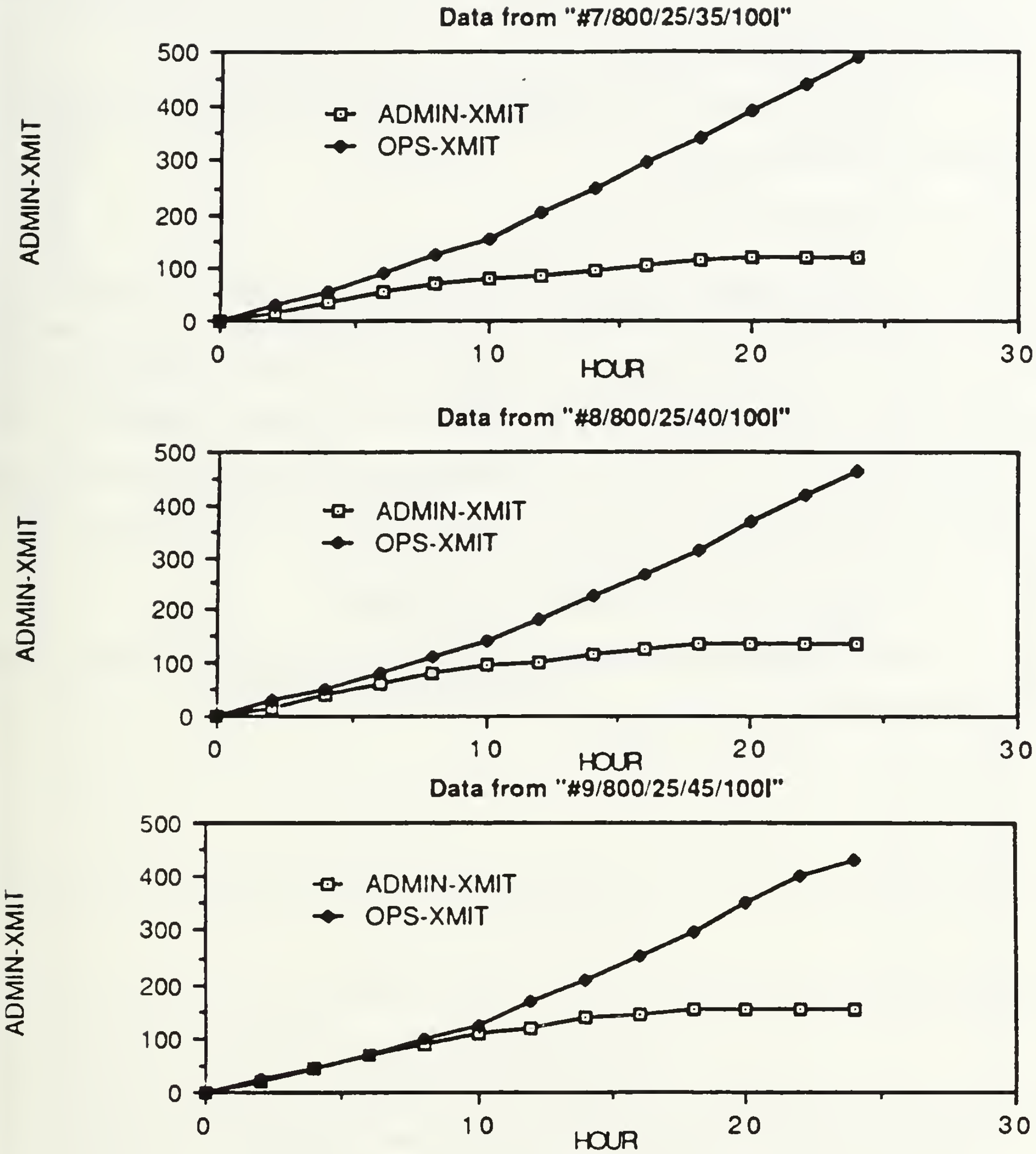

Figure 19. Message Types Transmitted - Test #7, #8, #9

4. Message Arrival Rate Variation

In this phase of testing, simulations were conducted in two parts; the first part included variation of total messages arrived over a twenty-four hour period. The second part involved variations in the spread modifier about the mean interarrival time.

a. Arrival Rate Variation

This test sequence was conducted at the following daily arrival rates:

- #6 - 800 messages per day
- #1 - 1000 messages per day

The results of the two runs are in Figure 20 on page 47. The results indicate two differences. The first difference is that the administrative message intercept requires an earlier activation; in this case, activation at six hours for 1000 messages per day and activation at ten hours for 800 messages per day. The second difference is that the higher arrival rate of Test #1 reduces the effectiveness of the intercept; the number of messages altrouted will not be sufficient enough to reduce the queue level. At the lower arrival rate, the intercept does aid in queue level reduction.

b. Variation about the Mean Interarrival Time

The testing in this set was conducted at the following percent variation about the mean interarrival time:

- #15 - 10%
- #16 - 20%
- #17 - 25%
- #18 - 30%
- #19 - 40%
- #20 - 50%

From observation of Figure 21 on page 48 and Figure 22 on page 49, there is no appreciable difference. Inspection of the data from the Precedences Transmitted and the Message Types Transmitted also indicate no appreciable difference. The data shows minor variation of one or two messages at any given point during the run. This phenomena may be explained by the Law of Large Numbers which states that in a large sample, the probability is high that the sample mean is close to the mean of the parent population [Ref. 25: p.284]. In other words, given a parent population mean message interarrival time with a large sample size, the amount of variance (or in this case, spread modification) will have little effect in producing a sample mean interarrival time much

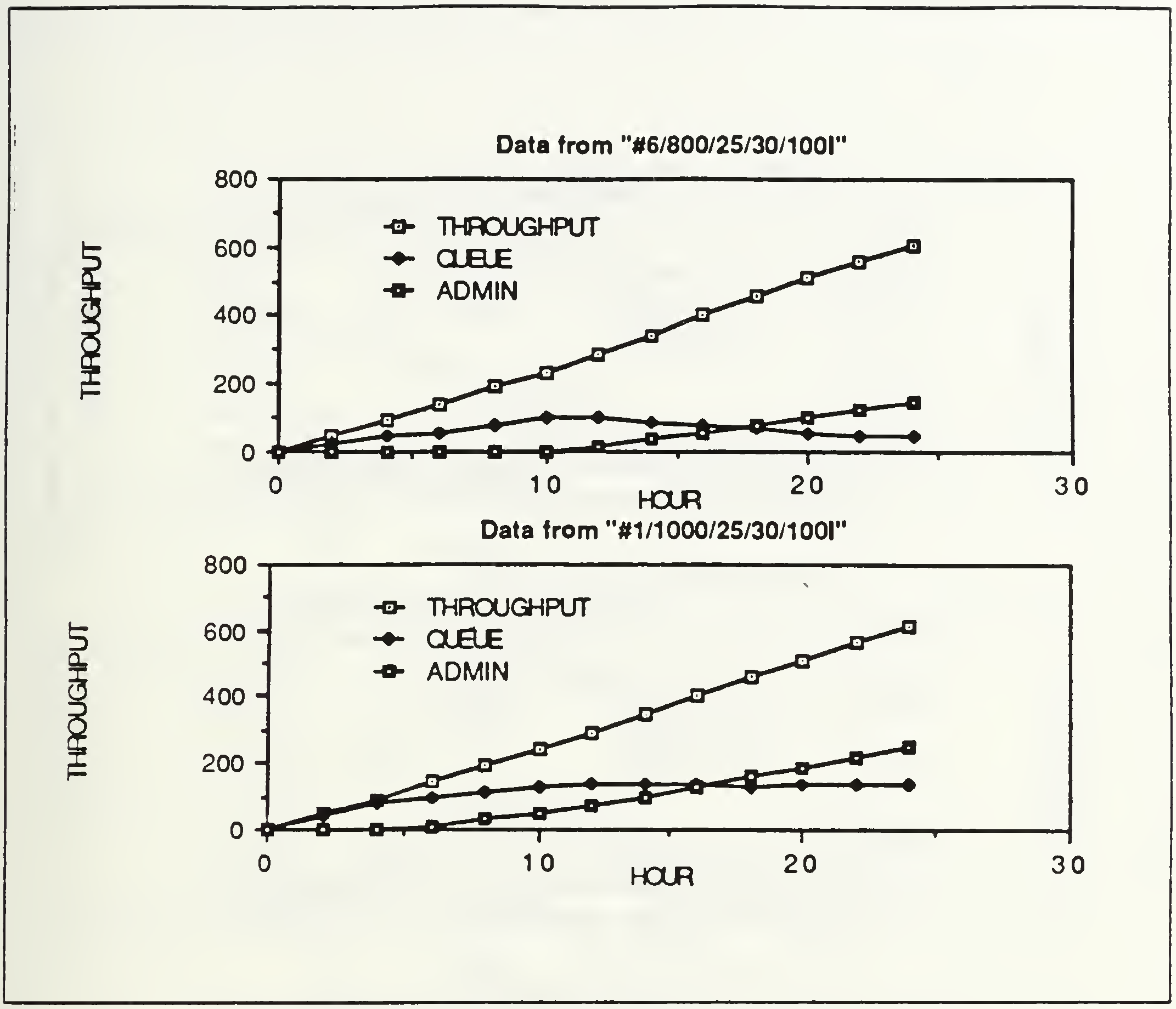

Figure 20. Message Interarrival Time Variation

different from the parent population mean. This would explain why each graph appears almost identical regardless of the spread modification.

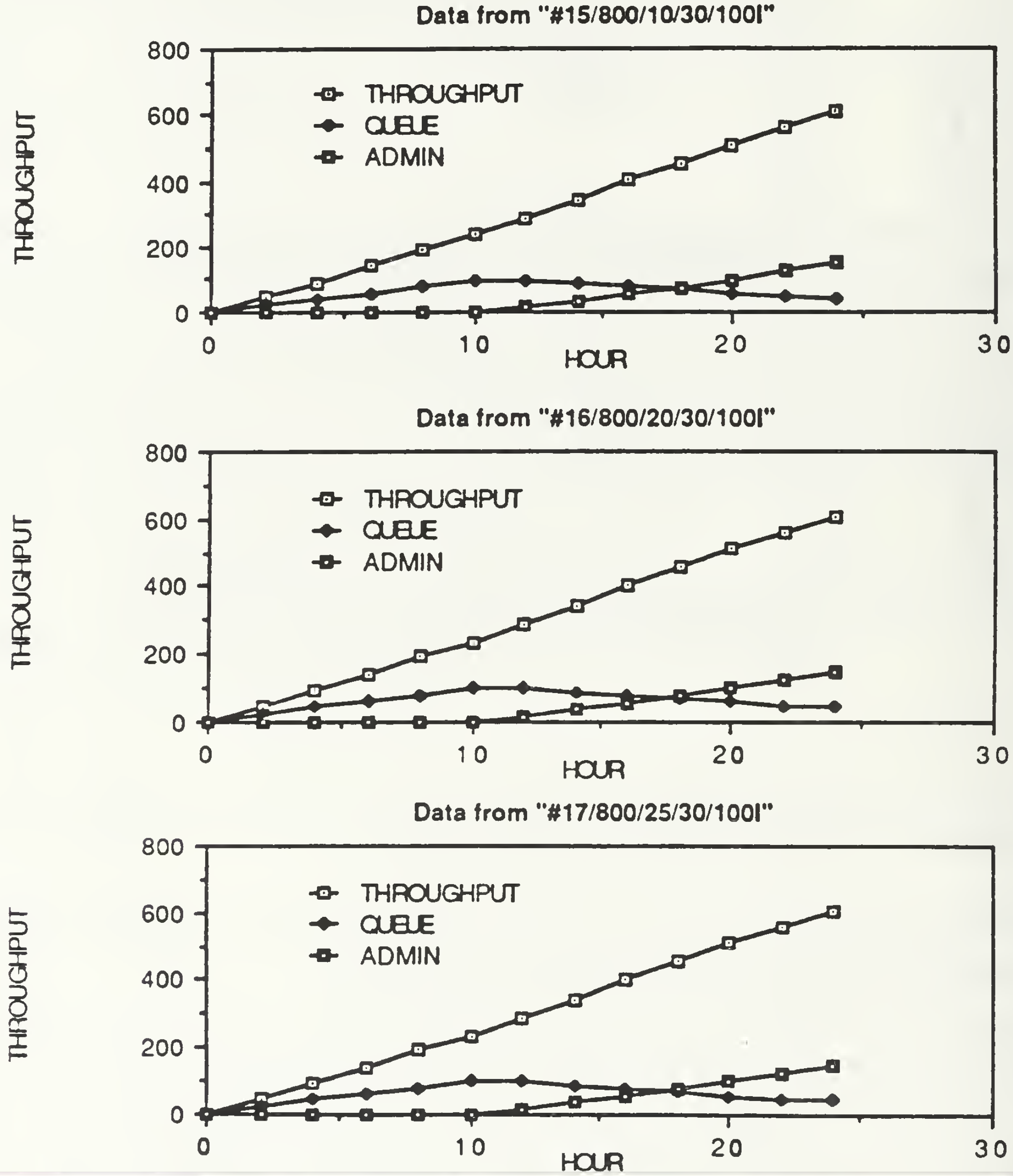

Figure 21. Message Interarrival Time Spread Modifier Variation (a)

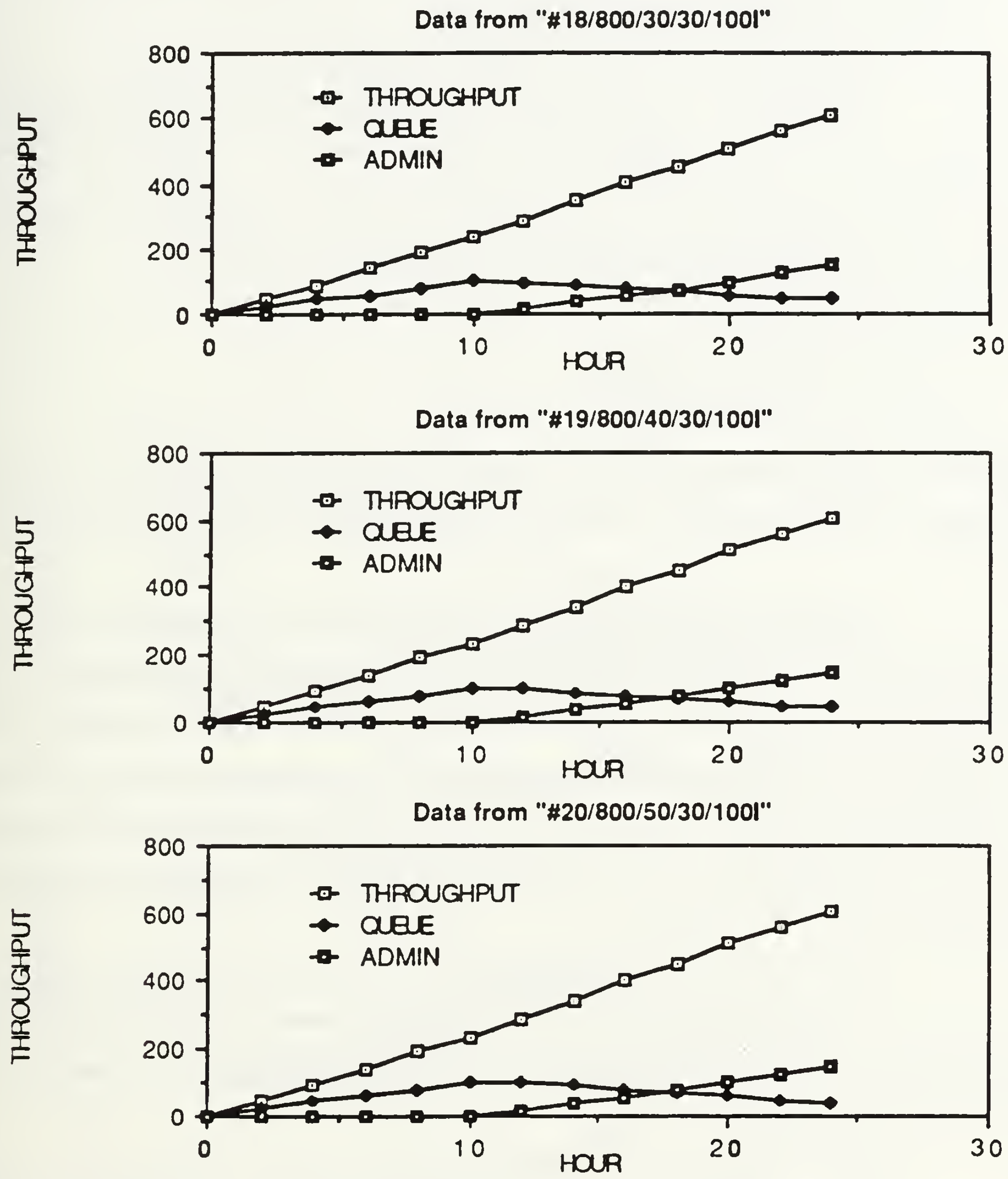

Figure 22. Message Interarrival Time Spread Modifier Variation (b)

5. Administrative Intercept Command Variation

The administrative intercept command can be altered in two ways; the first method involves the timing of intercept activation. The second method involves the precedence level selected for the intercept.

a. Administrative Intercept Command Activation

The decision of when to activate an administrative altroute is dependent on what the system manager's definition of a congested queue is. In this set of simulations the message arrival rate was set at 1000 messages per day to rapidly congest the queue. For testing purposes, the following activation points were selected:

- #1 - 100 messages in queue
- #2 - 150 messages in queue
- #3 - 200 messages in queue

Note that the above tests were run at Immediate precedence and below. See Figure 23 on page 51 for the test results. Precedences transmitted is shown in Figure 24 on page 52.

The first noticeable effect is that the earlier the command activation the lower the resultant queue size. While there is no reduction in queue size the intercept activation prevents the queue size from expanding further. In the previous section on message arrival rate, it was pointed out that at 1000 messages per day the activation of an intercept did not reduce a queue size but only helped control it. At a lower message arrival rate, the promptness of the intercept activation will determine the effectiveness of queue reduction.

The Precedence Transmitted graph illustrates that the earlier activation of an intercept quickens the transmission of Routine messages already held in queue. These Routine messages would otherwise remain in queue while higher precedence messages get transmitted.

The Message Type Transmitted graphs, shown in Figure 25 on page 53, show minor differences in adminstrative messages transmitted. The differences are due to the varying amounts of administrative messages allowed in queue prior to activation. For example, Test #3 with a late activation at 200 messages in queue, will accumulate more administrative traffic in queue prior to intercept activation. These messages are later transmitted after activation of the intercept.

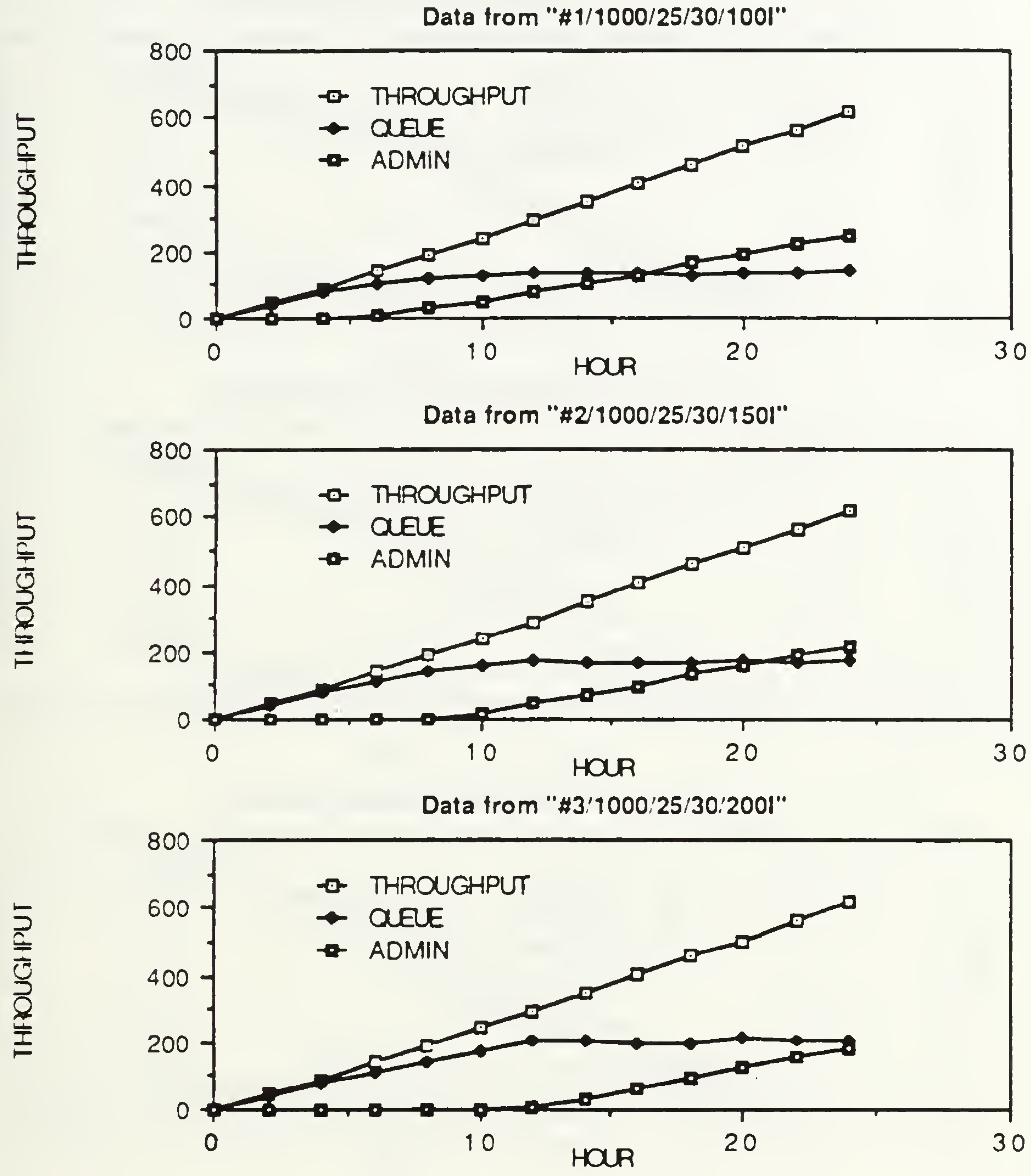

Figure 23. Intercept Activation Level Variation

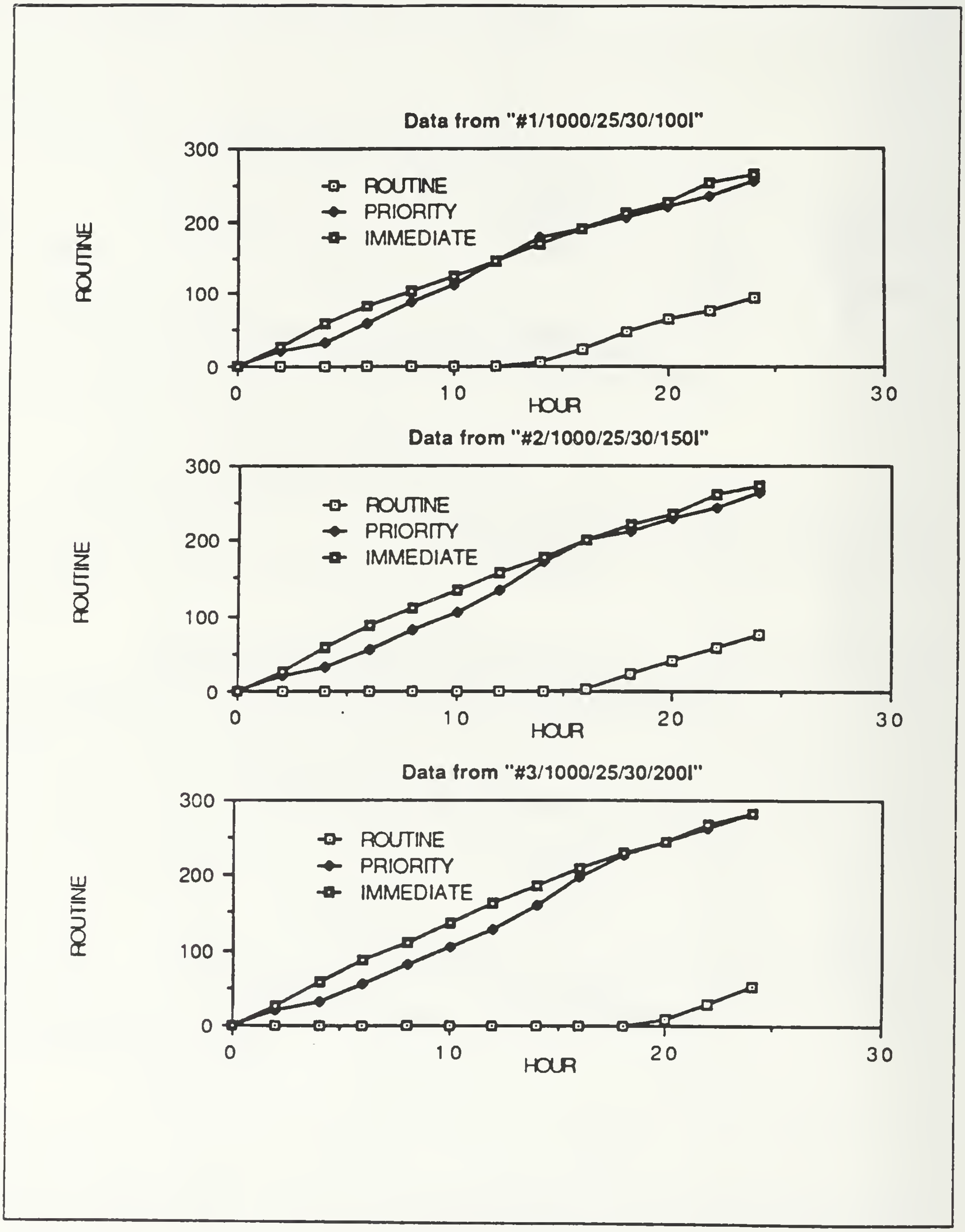

Figure 24. Precedences Transmitted - Test #1, #2, #3

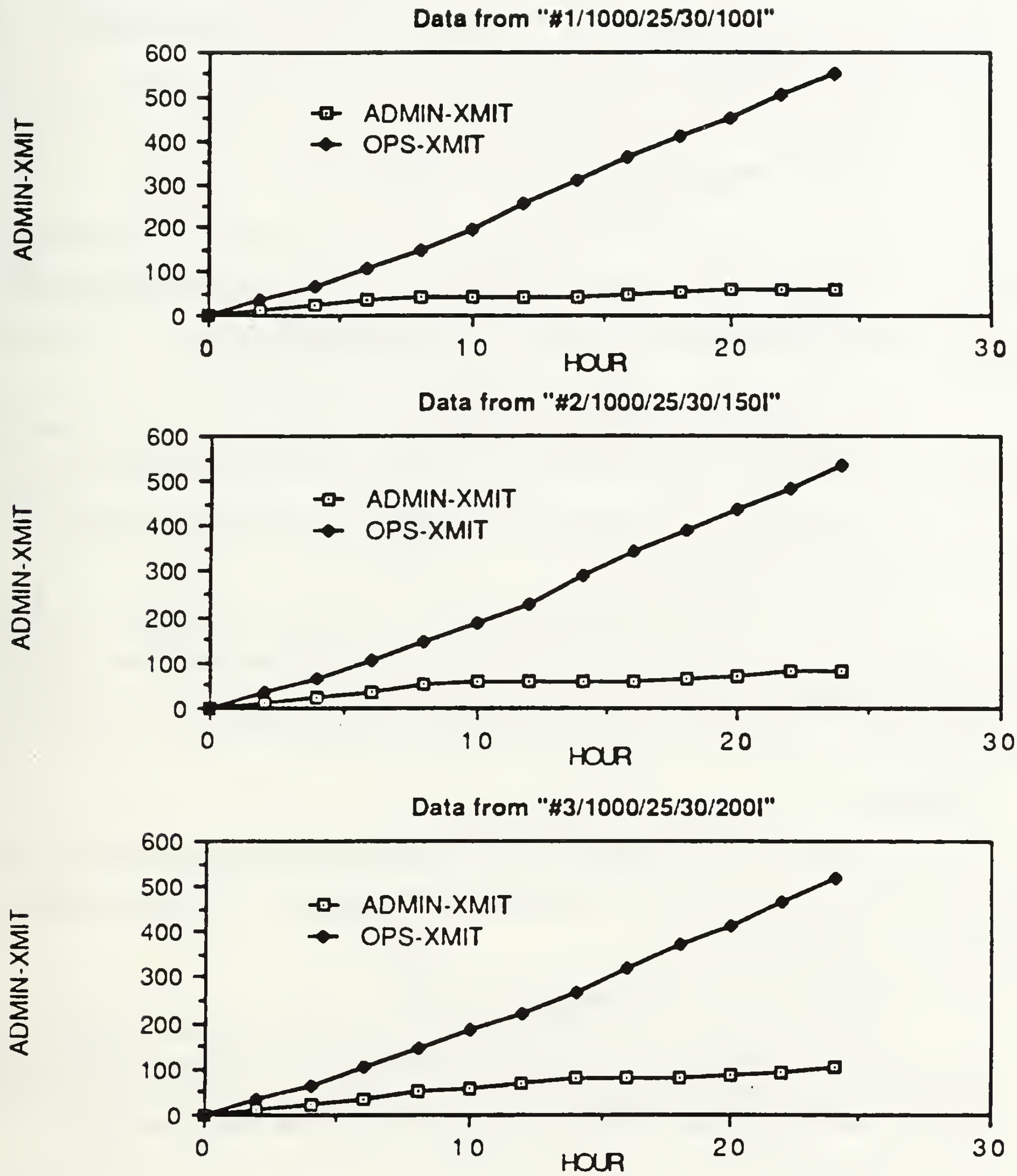

Figure 25. Message Types Transmitted - Test #1, #2, #3

b. Administrative Intercept Precedence Variation

This set of tests was conducted using a 0.33 Routine, 0.33 Priority, 0.33 Immediate precedence distribution at 800 messages per day mean arrival rate, with intercept activation at a queue level of 100 messages. The test parameters are:

- #10 - Routine precedence
- #11 - Priority precedence and below
- #12 - Immediate precedence and below

The results, illustrated in Figure 26 on page 55 demonstrate that the precedence level selected for the intercept will directly determine the effectiveness of the intercept. A low precedence selection will decrease the effectiveness of the intercept; conversely, a high precedence will increase intercept effectiveness.

The Precedences Transmitted graph in Figure 27 on page 56 shows that an intercept set at a higher precedence frees more lower precedence traffic from the queue. In essence, the operator is trading higher precedence administrative traffic for lower precedence operational traffic.

Message Types Transmitted shown in Figure 28 on page 57 indicates a higher administrative transmission total at the low precedence intercept. In this case, the higher precedence administrative messages are blocking the lower precedence operational traffic.

6. Summary

The results of the simulation tests demonstrate that the effectiveness of an administrative intercept is related to the specific characteristics of arriving messages. The specific characteristics include:

- Precedence Distribution of Arriving Messages
  The distribution across the various precedence catagories affects the effectiveness of the intercept based upon the precedence level chosen for the altroute. For example, an administrative intercept of routine messages will have minimal effect if the arriving traffic is primarily Priority or Immediate precedence.

- Message Length
  The transmission time required for a message is directly related to the number of characters in the individual messages; traffic composed of messages with high average number of characters will move slower than traffic with a low average number of characters. Similarly, the longer transmission times will lead to higher queue levels. The advantage of an administrative intercept will be less apparent in traffic with a a higher average character count; the intercept may slow queue build-up, but most likely will not decrease the backlog. The average message length will also affect the precedence levels transmitted; at a high average character count the possibility of transmitting low precedence traffic drops.

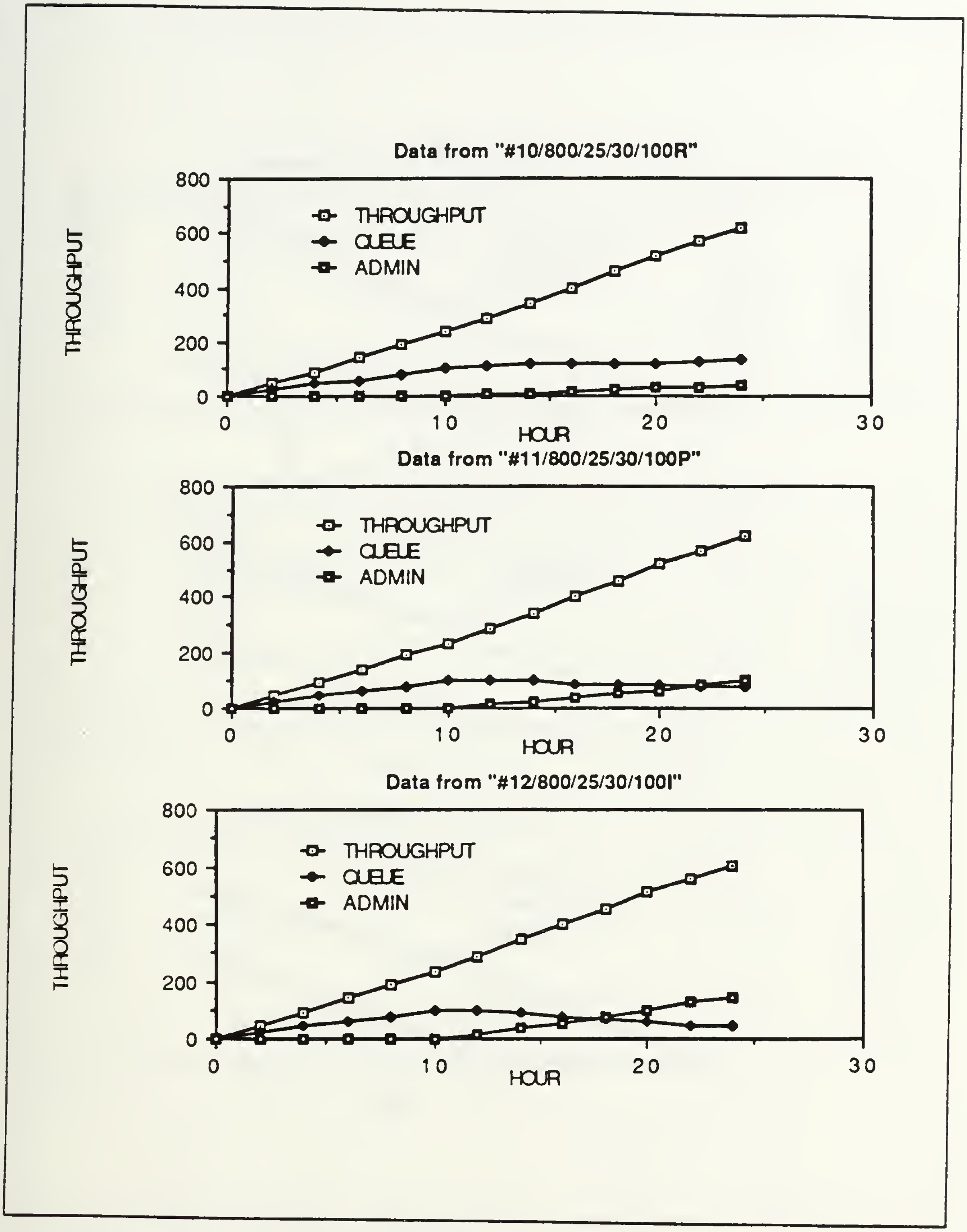

Figure 26. Intercept Precedence Level Variation

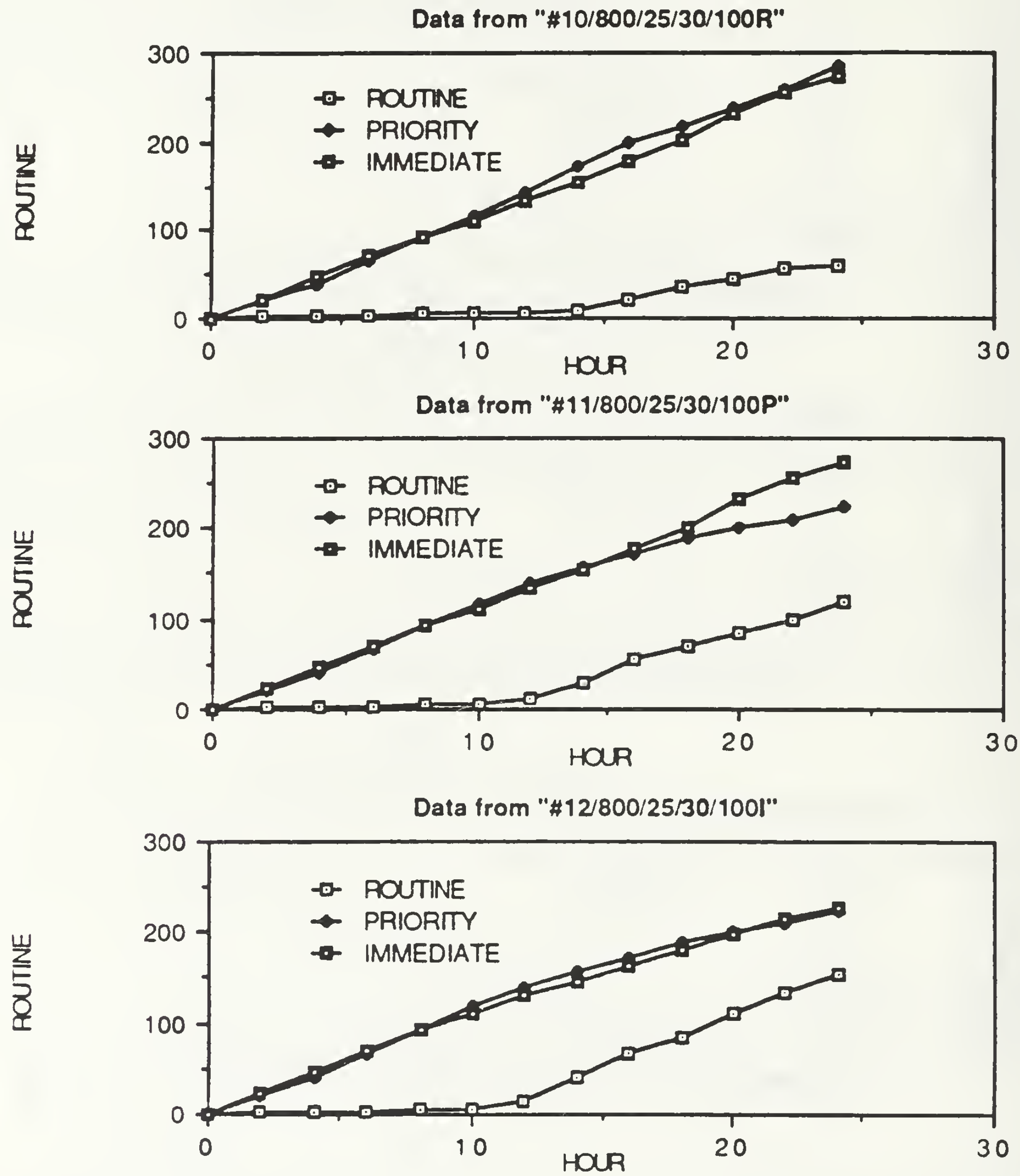

Figure 27. Precedences Transmitted - Test #10, #11, #12

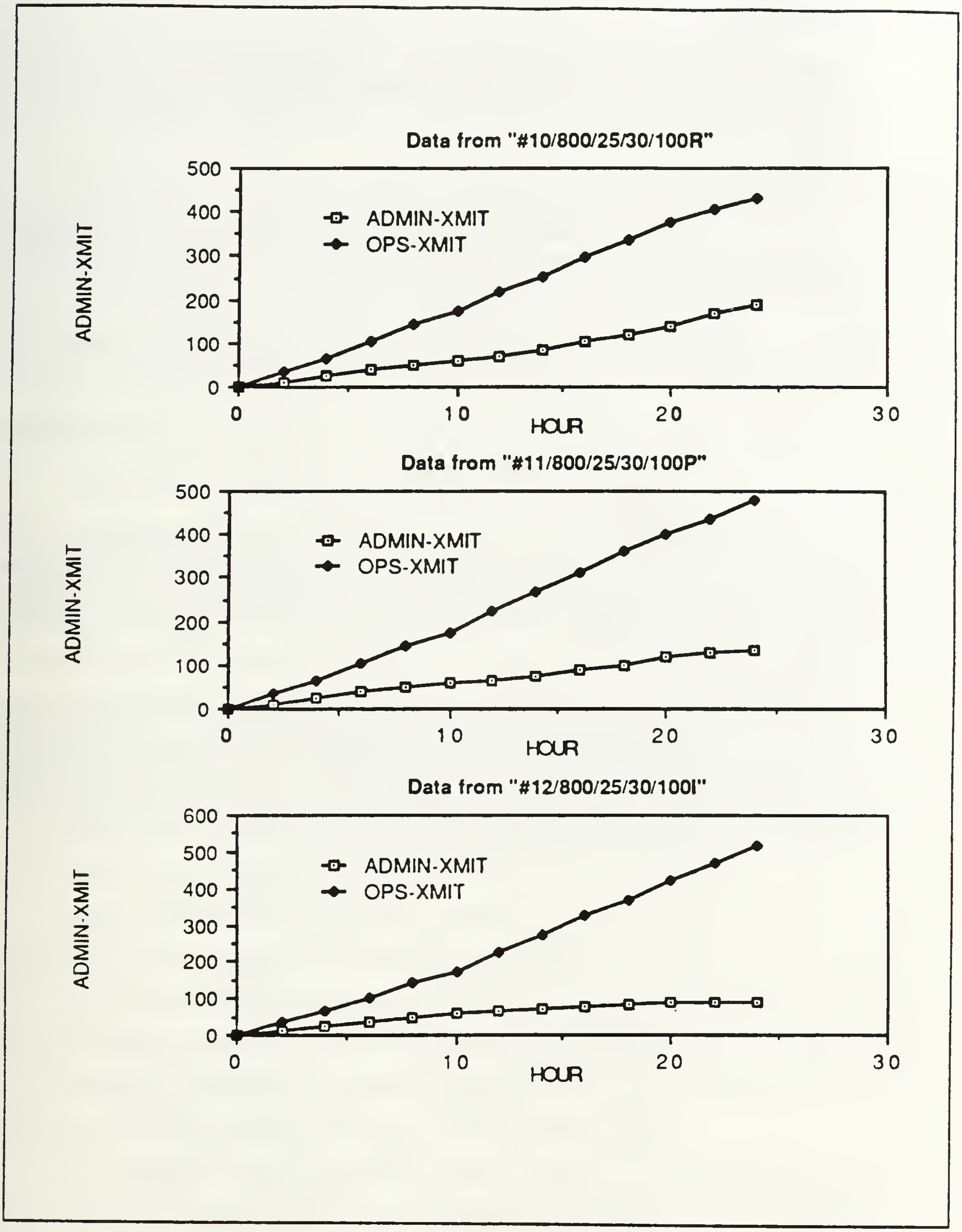

Figure 28. Message Types Transmitted - Test #10, #11, #12

- Message Type

  The percentage of administrative messages in arriving traffic directly determines the effectiveness of any intercept. The activation of an intercept in a scenario with a high percentage of administrative messages will have marked effects on the queue levels while the activation in traffic with low percentage leads to a lessened effectiveness.

- Message Interarrival Time

  The arrival rate of messages is directly related to the effectiveness of an administrative intercept. The effectiveness will run from high in a low message arrival rate to low in a high traffic arrival rate. Additionally, higher traffic rates will require prompt action from operators/managers since the queue build-up is more rapid.

  Variations about the mean interarrival time demonstrated no appreciable effects on throughput; as mentioned above, this can be explained by the Law of Large Numbers.

The effectiveness of administrative intercepts is also related to the timeliness and scope of the activation command. These considerations are:

- Command Activation

  The timeliness of activation may not increase the actual effectiveness of the intercept, but it may determine whether or not the queue reaches a critical saturation point. Earlier activation may aid a manager in controlling a potential backlog problem. Earlier activation may also help in freeing lower precedence operational traffic in queue.

- Precedence Level

  The precedence level selected for use by the manager will control the scope of the intercept command. At higher precedence levels the command becomes much more inclusive. This can be consider a sensitivity adjustment of the intercept; this would allow the manager to more effectively tailor the intercept to the traffic situation. The key concept is that using administrative intercepts at higher precedence levels frees the lower precedence operational traffic.

VI. ADMINISTRATIVE INTERCEPT CONSIDERATIONS

A. INTRODUCTION

The decision to activate an administrative intercept is a complicated one; it requires much more forethought than the simple observation of the queue level of an output channel on the Fleet Broadcast. It is proposed by the author that the decision on when activate an intercept is composed of two distinct phases; the first is the guidance and policy development phase. The second phase is the actual on-station decision making using the guidance and policy promulgated. These phases will be discussed in the following sections.

B. THE DEVELOPMENT OF GUIDANCE AND POLICY

The decisions on how to utilize a tool like the administrative intercept are very complicated. In Glenn's research on methodology for evaluating the effectiveness of an administrative intercept he states that there are multiple performance attributes to be evaluated [Ref. 21: p.50]. He proposes that the decision process for actuating an intercept is composed of the attributes listed in Figure 29 on page 60 [Ref.21: p.52].
Note that the hierarchy of attributes Glenn suggests is applicable to the development and implementation of a new traffic management option. For a feature already installed in the fleet, like administrative intercept, the applicable attributes would be system effectiveness, Navy acceptance, and cost to employ (not including initial costs).

Utilizing these attributes the policy makers can, using Multiattribute Utility Analysis [Ref. 26] or the Analytical Hierarchy Process[9] [Ref. 27 and Ref. 28], assign a preference value by weighting the attributes individually. In this process the policy makers can directly influence the decision making process, emphasizing the factors deemed critical. For example, by weighting system effectiveness heavily, a policy can be generated which is tailored to ensure system effectiveness over the other choices.

Upon completion of the attribute analysis, a policy with proposed thresholds and procedures can be promulgated to the operators and managers at the NAVCAMS.

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9 See Appendix C for a brief explanation of the concepts behind Multiattribute Utility Analysis and the Analytical Hierarchy Process.

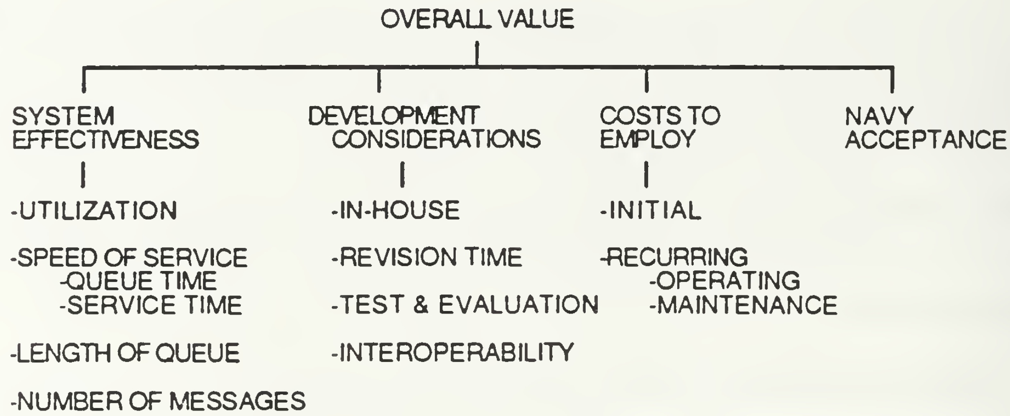

Figure 29. Hierarchy of Attributes

C. ON-STATION DECISION MAKING

Once a policy is promulgated it is the responsibility of the operators and managers to ensure that it is carried out. However, the perfect conditions under which the policy was generated may not exist at the user level; it is for this reason that the author recommends that any policy regarding administrative intercept be advisory. The issuance of an advisory guidance vice a firm set of rules allows the operators to work effectively in even the most unpredictable set of circumstances.

At the user level, any good decision making process must include all information available. The external factors and internal NAVCOMPARS factors mentioned in Chapter III must be included. The transmission system in use also will be a factor in the process. The characteristics of the arriving message traffic was shown in the previous chapter to be extremely influencial in determining the relative effectiveness of an intercept action. All the above factors combined with the various intercept command variations (different activation levels, varied precedence levels) will impact heavily upon the decision making process. The relationship emphasizing the interdependence of all these factors, is highlighted in Figure 30 on page 62.

Using the above listed information, it is possible for the managers and operators, working within the guidance of CNTC, to reach a decision on intercept activation which would be both responsive and effective at the local level. See Figure 31 on page 63 for an illustration of the proposed process. The policy development is comprised of the several steps; the first step is the determination of applicable criteria or attributes. Using either Multiattribute Utility Analysis, the Analytical Hierarchy Process, or any applicable analysis process, the criteria can then be evaluated with the end result being the generation of criterion for policy. It is then recommended that an advisory guidance, based on those criterion, be promulgated. The NAVCAMSs, using the advisory guidance, can then take into account all information held on-station and forge an activation decision which is influenced by both upper echelon policy and local communication conditions.

It should be noted that this decision process can be readily adapted to other traffic management decisions. The factors to be considered, both at the policy making level and on-station, may require modification depending on the particular decision to be evaluated.

E - Effectiveness of an administrative intercept

E = F(AA,BB,CC,DD,EE,XX,YY,ZZ)

AA - Precedence Distribution

BB - Message Length (avg) of Arriving Traffic

CC - Percent Administrative Message

DD - Message Arrival Rate

EE - Intercept Command

1) Queue level selected

2) Precedence level selected

XX - External Factors (Chapter III)

YY - NAVCOMPARS Internal Factors (Chapter III)

ZZ - Transmission Considerations (HF vs SAT)

Figure 30. Considerations for Implementing an Administrative Intercept

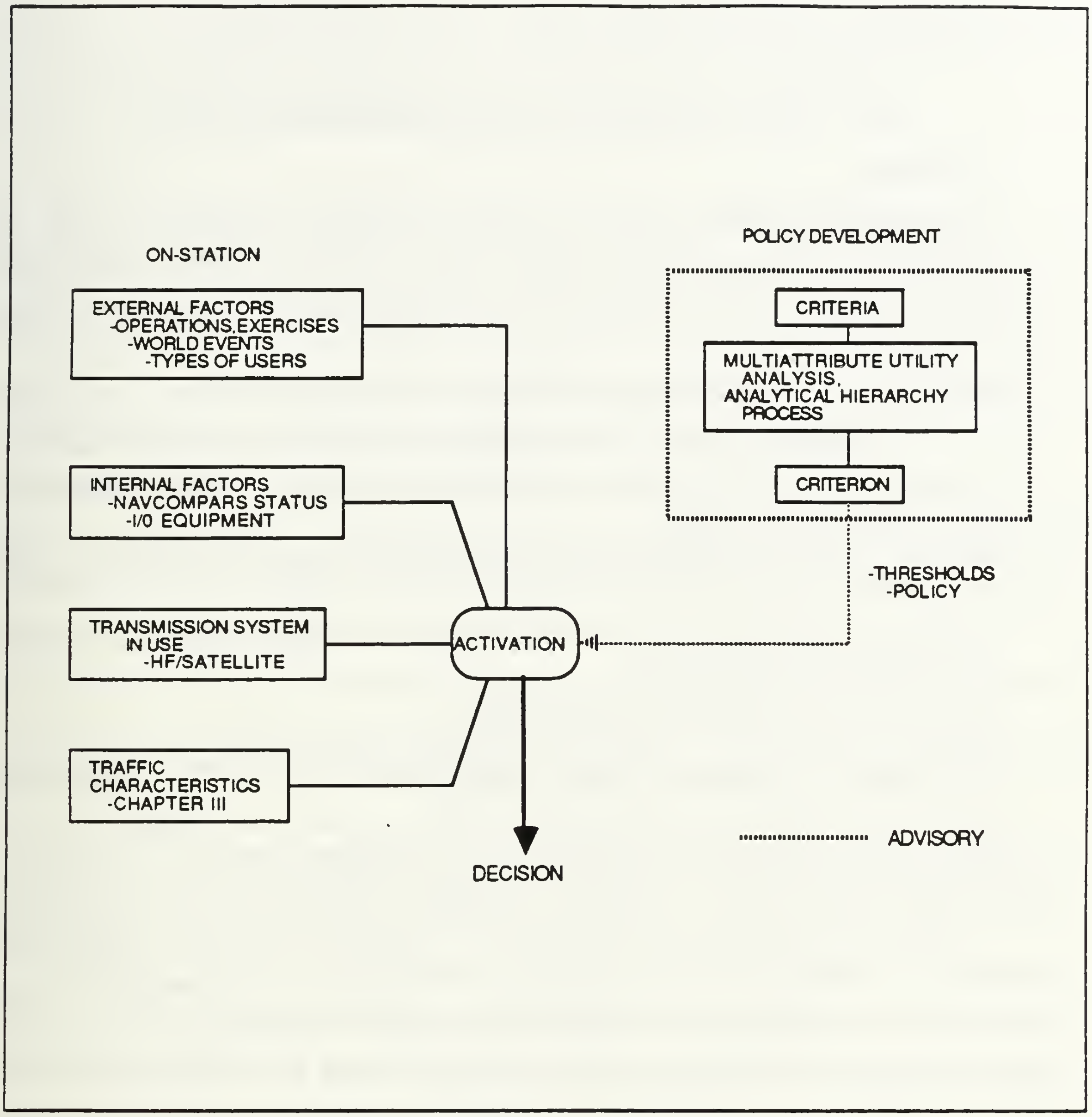

Figure 31. Decision Making Process for Administrative Intercept

VII. CONCLUSIONS AND RECOMMENDATIONS

A. FINDINGS

The guidance promulgated by CNTC in Ref. 11 presents an activation scheme for an administrative message intercept based on Fleet Broadcast output channel queue backlog. Subsequent message reentry of intercepted message is also based on queue backlog level.

The solicited responses from the individual NAVCAMS summarized in Chapter III, were for the most part negative. Frequent comment was made on the following issues:

- the need for thresholds oriented with the particular Fleet Broadcast transmission means in use (HF/Satellite)
- the effectiveness and efficiency of the administrative message intercept as a traffic management device in its present form
- perceived erosion of traffic management decision making at the FLTCINCs/NAVCAMS level
- disregard for on-station watchteam expertise
- the failure of the CNTC threshold to take into account the special requirements and causes of each traffic congestion problem

Based on the NAVCAMS's responses and the conducted research of this thesis it appears that the NAVCAMS's comments are generally well founded. Due to differences in HF and Satellite operation requirements it is imperative that there be specialized thresholds for working in each environment. It may also be necessary to develop thresholds for each individual NAVCAMS based on the local propagation conditions. The individual tailored thresholds should take into account the differing sequence on intercept activation steps (HF-intercept/overload versus Satellite-overload/intercept).

The second item listed above questioned the most current configuration of the administrative intercept. As mentioned in Chapter II, the activation of an intercept results in the altrouting of qualifying messages to the Screening Board printer for further screening. This process would appear to be both equipment and manpower internsive. The intercept results in additional printer requirements as well as the personnel required to review the messages by hand. Reentry requirements are also manpower intensive since it requires that the Service Clerk key individual messages for reentry into the NAVCOMPARS. One recommendation by NAVCAMS LANT, was that alternate routing to a magnetic tape storage unit be used in place of the Screening Board printer

[Ref. 14]. This recommendation fails to address message screening. Altrouting directly to a storage medium (i.e. magnetic tape or disk) without screening fails to remove messages from the system; this type of altroute would only postpone reentry until queue levels permit.

One improvement on the horizon is the Automatic Message Screening Subsystem (AMSS) scheduled for NAVCOMPARS Release 13.0 software [Ref. 6]. AMSS should improve the current Screening Board procedure by electronically allowing message screening by video terminals with the capability of on-line reentry of messages if desired [Ref. 29]. Additionally, AMSS will reduce the requirement for message printing and sorting, and Service Clerk reentry procedures for intercepted messages.

The final three points can be addressed as a group. The imposition of a firm threshold guidance by CNTC was felt, by the NAVCAMS, to reduce traffic management options. By virtue of being *on-station* it was felt that the watchteams would have a more complete "big picture" of the traffic situation in their individual COMMAREAs. The watchteams would also have more information on equipment resources and/or limitations, and be in direct communication with the end users, the fleet units. The watchteams would also, through the traffic monitoring capabilities of the NAVCOMPARS, be appraised on the characteristics of the arriving traffic. The characteristics listed in Figure 30 on page 62 of Chapter VI were shown, individually or in combination, to affect the effectiveness of an activated administrative intercept.

Given this information on traffic characteristics, equipment resources, and the needs of the fleet units it appears that the NAVCAMS's watchteams, using their combined expertise and experience, would be better suited to judge when to activate an administrative message intercept at the user level.

This in a sense is a shift from an upper echelon controlled activation to a user controlled activation scheme. In Chapter VI, it is suggested that a two phase decision process be utilized. Using the two recommended phases would allow CNTC to emphasize its priorities, but at the same time allow the users, the NAVCAMS's, a certain amount of flexibility to deal with a dynamic environment. It is the conclusion of this thesis that such a process would be beneficial to all parties concerned. Through the use of this proposed scheme it is hoped the fleet units, the end users, can be assured timely delivery of vital message traffic.

B. POSSIBLE FUTURE TOPICS

From the simulation test runs it was apparent that message characteristics can affect message throughput. One characteristic, the percentage of administrative messages in arriving traffic, showed strong influence on the effectiveness of an administrative message intercept. In his research, Glenn states that fifty percent of all arriving traffic may be administrative in nature [Ref. 21: p.57]. If this were indeed the case it would appear that the effectiveness of an intercept is being held artificially low by the incorrect classification of messages. CNTC is in the process of developing an policy where message originators will be required to classify a message as administrative or operational [Ref. 30]. The current policy assumes that all messages are operational unless marked as administrative. Although the marking of both administrative and operational messages has no real effect in terms of message handling procedures, it is hoped that the originators will be forced to more closely screen their messages before marking one as operational. One possible research topic is to compare user's perceptions of what constitutes an administrative message or an operational message. Using this data and data from CNTC it may be possible to develop criteria to use in defining message categories.

Another traffic characteristic which affected throughput was message length. By reducing message lengths throughput and speed of service should improve. Is there a way of decreasing average message length? Several recurring Navy messages have a set format which seems to reduce message length. Examples are Casualty Reports (CASREP) used for reporting equipment casualties or degradation and the NEURS (Navy Energy Usage Reporting System) report used for reporting fuel consumption and accounting. Both reports are format oriented and would seem to reduce message lengths. The possibility of increasing use of format messages and the potential gains in terms of throughput and speed of service should be investigated.

With the increased use of Decision Support Systems (DSS) it may be possible to commence implementation in the Naval Telecommunications System. One possibility is the use of DSS with the AMSS; this would further decrease the need for manpower since the proposed AMSS requires experienced personnel to man the video terminals.

The final proposed topic is related to the user level decision making criteria shown in Chapter VI. Given this wide set of variables, it may be possible to develop a detailed flowchart which can lead a user step-by-step to a valid activation decision or provide a foundation for DSS implementation.

APPENDIX A. NAVCOMPARS - AN OVERVIEW

The Naval Communications Processing and Routing System (NAVCOMPARS) is an automated system which serves as an interface between the Naval Telecommunication System (NTS) and the Defense Communication System (DCS). In this appendix, the following areas will be addressed:

1. Functional Interface Areas
2. NAVCOMPARS Subsystems

A. FUNCTIONAL INTERFACE AREAS

The NAVCOMPARS is comprised of eight functional interface areas which interact with the system processing actions. These areas include:

1. Message Center (MSGCEN)
2. Service Center (SVCEN)
3. Fleet Center (FLTCEN)
4. Computer Center (COMPCEN)
5. Technical Control (TECHCTL)
6. Receiver Site (RECSITE)
7. Top Secret (TS) Control
8. Operations Office (OPSOFF)

1. Message Center (MSGCEN)

The primary purpose of the MSGCEN is serving as the delivery and acceptance source for over-the-counter traffic. These services are provided for local users; local users may include tenant commands and/or fleet units (when under "guard" or "protect" coverage by the NAVCAMS).[10] The MSGCEN interfaces with the NAVCOMPARS using optical character readers (OCR), video data terminals (VDT), teletype (TTY), and medium-speed line printers. [Ref. 8: pp.3-8]

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10 "Guard" and "Protect" are different levels of coverage provided by the NAVCAMS for the local users. "Protect" coverage means that the NAVCAMS only receives traffic for the local users; "guard" is similar to "protect", but includes routing (extra copies and internal distribution) for the users.

2. Service Center (SVCEN)

The SVCEN's main purpose is to service and/or correct messages which are rejected by the system. The SVCEN also processes Broadcast Service Requests (BSR) for units requiring retransmission of missed or garbled messages. NAVCOMPARS interfaces are through VDTs, line printers, teleprinters, and paper tape readers/punches. [Ref. 8: pp.8-11]

3. Fleet Center (FLTCEN)

The FLTCEN serves as the major terminal area for low speed communication channels; this responsibility entails monitoring and operating of active channels. Active channels include off-line and on-line quality terminations; off-line quality channels are not landline quality and require operator interaction to provide interface between the user and NAVCOMPARS. Typical operator interaction is visually proofing the message for mistakes and correct format, and then entering the message into the NAVCOMPARS using a paper tape reader. On-line channels are landline quality[11] and interface directly with NAVCOMPARS; there is no operator interaction required.

Additional FLTCEN duties include controlling and monitoring Fleet Broadcast channels. This control includes common, type, overload, and rerun channels.

Hardware in the FLTCEN includes VDTs, teleprinters, 100 word per minute (WPM) channels, and paper tape readers. [Ref. 8: pp.11-16]

4. Computer Center (COMPCEN)

The COMPCEN is the location for most of all the automatic data processing equipment comprising the NAVCOMPARS; it also serves as the interface between the NAVCOMPARS and DCS' Automatic Digital Information Network (AUTODIN). Responsibilities include actual NAVCOMPARS operation, data base maintenance, and report generation.

Hardware includes computer consoles to control and monitor the entire system, medium-speed line printers, card readers, card punches, magnetic tape stations, and AUTODIN interface units. [Ref. 8: pp.20-23]

5. Technical Control (TECHCTL)

TECHCTL is the master switchboard and monitoring station for the NAVCOMPARS. TECHCTL uses landline or radiolinks with remotely located

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11 Landline quality is defined as a state where a transmission means is of high enough quality to equal the performance received on a land system which is hardwired.

transmitting and receiving stations to support the communication mission. Note that TECHCTL has no message entry or delivery capabilities. [Ref. 8: pp.18-20]

6. Receiver Site (RECSITE)

The RECSITE serves as the primary and secondary ship/shore channel terminal area, using on-line channels from FLTCEN. Hardware is similar to that of the FLTCEN, but also includes 100 WPM TTY on-line channels. [Ref. 8: pp.11-18]

7. Top Secret (TS) Control

TS Control is the NAVCOMPARS area for receipt and delivery of Top Secret/Special Category (SPECAT) traffic. Using on-line and off-line processing, TS Control provides encryption, decryption, and delivery services. Note that TS Control may be a SVCEN function. [Ref. 8: pp.23-24]

8. Operations Office (OPSOFF)

The OPSOFF is the central management and control point for functions external to the actual NAVCOMPARS; there are no hardware interfaces. Primary functions include report analysis (statistical/historical), traffic checks, and file maintenance. [Ref. 8: pp.23-24]

B. NAVCOMPARS SUBSYSTEMS

When the NAVCOMPARS software was originally designed it was done with the concept of seperating system function into various subsystems. This concept of modularity meant that each subsystem was seperate with only uniform interface requirements for intrasubsystem communication. The NAVCOMPARS subsystems are: [Ref. 8: p.65]

1. AUTODIN Interface Subsystem (AIS)
2. Executive Control Subsystem (ECS)
3. AUTODIN Control Subsystem (ACS)
4. Communication Control Subsystem (CCS)
5. Receive Control Subsystem (RCS)
6. Message Processing Subsystem (MPS)
7. Transmission Processing Subsystem (TPS)
8. Transmission Control Subsystem (TCS)
9. Support Program Subsystem (SPS)
10. System Service Subsystem

See Figure 32 on page 70 for an illustration of NAVCOMPARS Subsystem organization [Ref. 8: p.68].

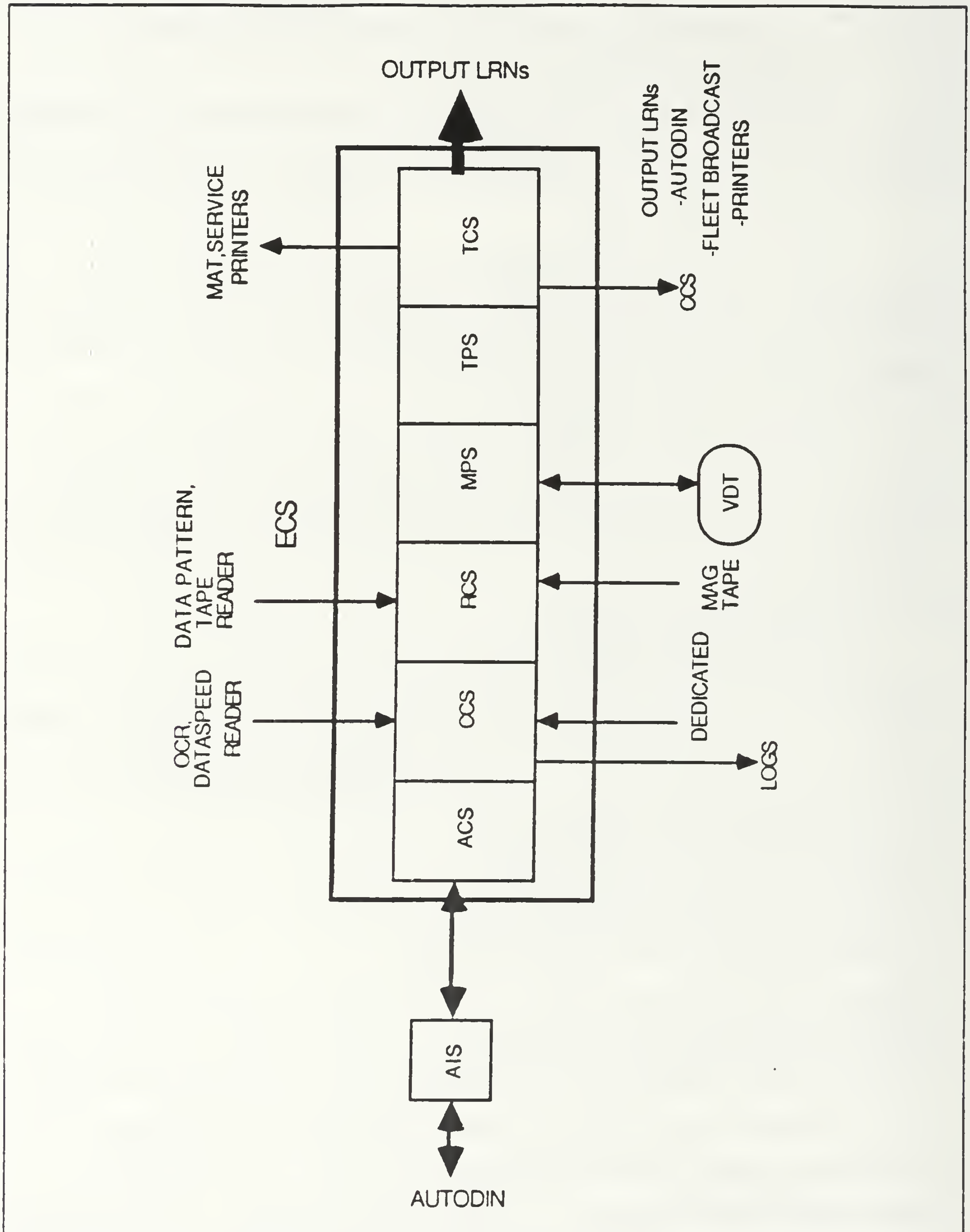

Figure 32. NAVCOMPARS Subsystem Organization

1. AUTODIN Interface Subsystem (AIS)

The AIS serves as the interface between the NAVCOMPARS and the AUTODIN Switching Center (ASC). Primary duties are synchronization and error checking of incoming data from the ASC. [Ref. 8: p.65]

2. Executive Control Subsystem (ECS)

The ECS is the foundation for the NAVCOMPARS; ECS serves as the hardware/software interface for the subsystems. ECS can be divided into four functional areas: console control, input/output (I/O) control, porgram control, and interrupt control. [Ref. 8: pp.65-66]

3. AUTODIN Control Subsystem (ACS)

The ACS serves as the interface for receipt and transmission of messages over AUTODIN. The interfacing is done between the RCS and TCS respectively. The type of interfacing by the ACS is channel initialization and message acknowledgement. [Ref. 8: p.70]

4. Communication Control Subsystem (CCS)

The CCS, working with the ECS, provides both data flow control and logkeeping. The CCS controls flow by queueing communication device interrupts; additionally, the CCS provides recordkeeping for various input devices. [Ref. 8: p.70]

5. Receive Control Subsystem (RCS)

The RCS's primary duties include channel coordination, input buffering, and message format exchange. Channel coordination includes message sequence checking and error checking. The RCS also controls input buffers for incoming data; incoming data is later sent to seperate disk files for processing. The RCS additionally converts all incoming messages into a common code (EBCDIC) and format for processing. [Ref. 8: p.71]

6. Message Processing Subsystem (MPS)

The MPS performs the majority of message processing; processing includes message analysis, format conversion, routing indicator (RI) assignment, distribution assignment, recalls and header processing. The MPS also acts as an interface for the system VDTs; types of actions include message recall requests, broadcast screens, and message editing and entry. [Ref. 8: pp.71-72]

7. Transmission Processing Subsystem (TPS)

Altrouting, message journaling, channel scheduling, and transmission is performed by the TPS. The TPS also interfaces with the MPS to give queue status; the TPS also initiates and terminates message transmission with the TCS. [Ref. 8: pp.72-73]

8. Transmission Control Subsystem (TCS)

The TCS's purpose is to transmit messages to an output device, whether it is communication channel or terminal channel. The TCS also performs any format conversion necessary to utilize the output device. The broadcast rerun function is also performed by the TCS. [Ref. 8: p.73]

9. Support Program Subsytem (SPS)

Report generation, file maintenance, and distribution assignment is performed by the SPS. Reports include historical data on message processing, routing files, and distribution files. [Ref. 8: pp.73-74]

10. System Service Subsystem

The System Service Subsystem serves primarily as a utility program; it is responsible for creating and maintaining the storage environment required by the NAVCOMPARS. [Ref. 8: p.74]

APPENDIX B. SIMULATION MODEL SPECIFICATIONS

A. SIMULATION MODEL PROGRAM

1. Model GPSS Code

The following GPSS code is similar to the code used to run the simulations for this research.

Test run - **#AA/800/25/30/100I**

```
        REALLOCATE COM,250000,XAC,5000
        SIMULATE
        INITIAL    XF1,0
*
*  DEFINE FUNCTIONS
*
 MPREC FUNCTION   RN1,D3
.33,1.0/.66,2.0/1.0,3.0
 MLEN  FUNCTION   RN1,C2
.000,100/1.0,2500
 MZYB  FUNCTION   RN1,D2
.30,0.0/1.0,1.0
*
*  DEFINE VARIABLES
*
 PREC  VARIABLE   FN$MPREC         PRECEDENCE CODE
 ADMIN VARIABLE   FN$MZYB          ADMIN/OPERATIONAL CODE
 MSGL  VARIABLE   FN$MLEN          MESSAGE LENGTH (CHARACTER)
 TTIM  VARIABLE   (PF3*8)/75       TRANSMISSION TIME (SECONDS)
 PPR   VARIABLE   PF1-1
*
*  SIMULATION PROGRAM
*
       GENERATE   108,27,,,,3PF     TRANSACTION  GENERATION
       ASSIGN     1,V$PREC,PF      PRECEDENCE ASSIGNMENT
       ASSIGN     2,V$ADMIN,PF     ADMIN/OPERATIONAL CODE ASSIGNMENT
       ASSIGN     3,V$MSGL,PF      MSG LENGTH ASSIGNMENT
       PRIORITY   V$PPR            PRECEDENCE ASSIGNMENT
       TEST GE    XF1,100,RTN      INTERCEPT TRIGGER
       TEST E     PF2,1,ADMIN      ADMIN MESSAGE CHECK
 RTN   QUEUE      QUE,1
       PREEMPT    OCHNL,PR         FACILITY OCHNL SEIZED W/ PREEMPTION
       ADVANCE    V$TTIM           TRANSMISSION TIME
       RETURN     OCHNL
       DEPART     QUE,1
       TABULATE   TPREC
 TPREC TABLE      PF1,0,1,5
       TABULATE   TADMN
```

```
TADMN TABLE      PF2,0,1,4
      SAVEVALUE  1,QM1,XF
      TRANSFER   ,ENDD
ADMIN TEST LE    V$PPR,2,RTN      ADMIN MESSAGE PRECEDENCE CHECK
      QUEUE      RMAD,1           QUEUE FOR INTERCEPTED MESSAGES
      DEPART     RMAD,1
      TRANSFER   ,ENDD
ENDD  TERMINATE                   TRANSACTION TERMINATION
      GENERATE   3600
      TERMINATE  1
      START      24,,2
```

2. Model Functions

1. MPREC - Message Precedence Assignment
   -code: 1.0 - Routine
   2.0 - Priority
   3.0 - Immediate
   -assignment by random number generation

2. MLEN - Message Length Assignment (in characters)
   -continuous with low and high end ranges
   -assignment by random number generation

3. MZYB - Message Type Assignment
   -code: 0.0 - administrative
   1.0 - operational
   -assignment by random number generation

B. SIMULATION MODEL FLOW CHART

In Figure 33 on page 75, the single output channel of the Fleet Broadcast is conceptualized as single server queue model into a general flow chart. Using this flow chart, the general flowchart is further decomposed into GPSS block diagrams in Figure 34 on page 76 and Figure 35 on page 77.

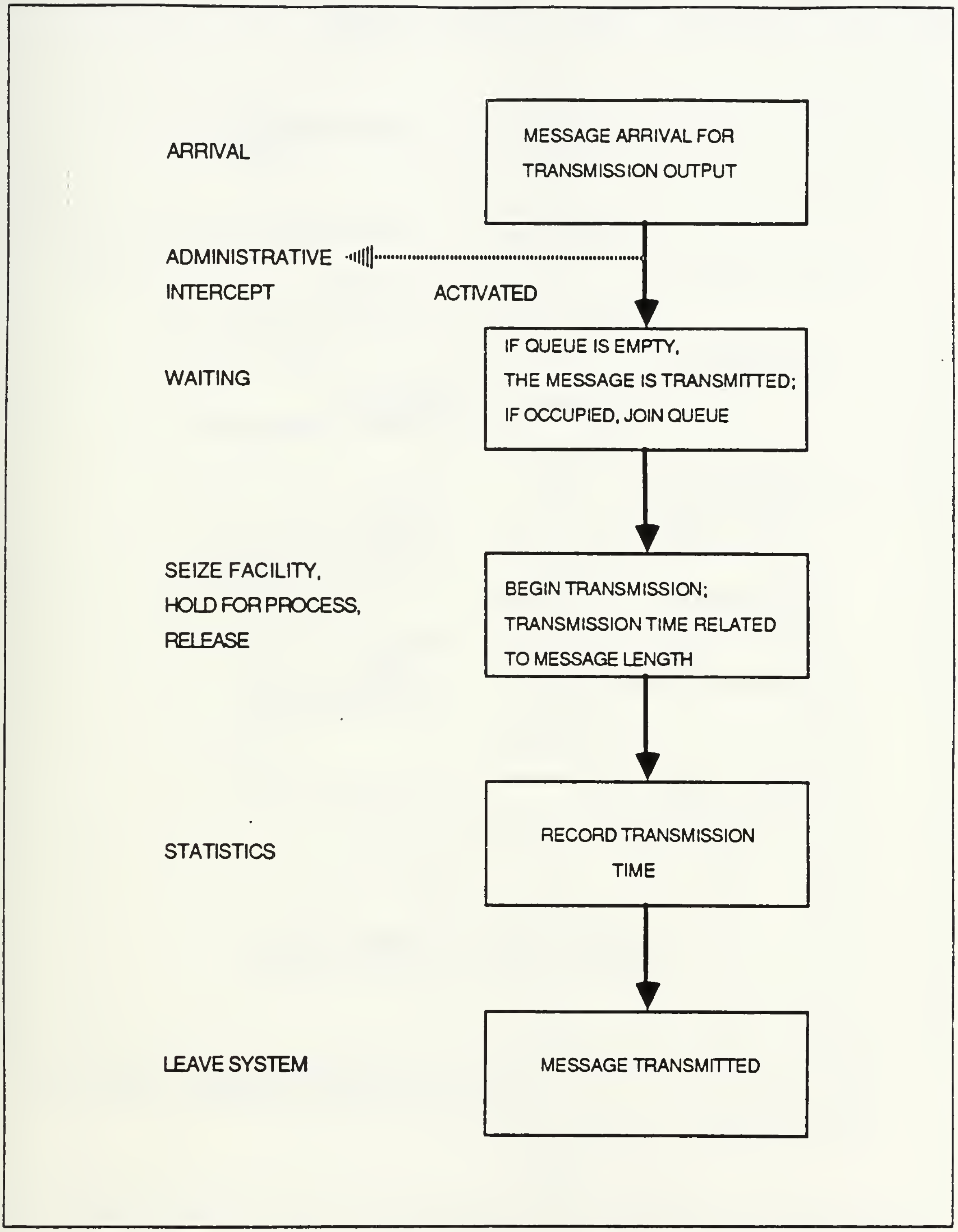

Figure 33. Simulation Model General Flow Chart

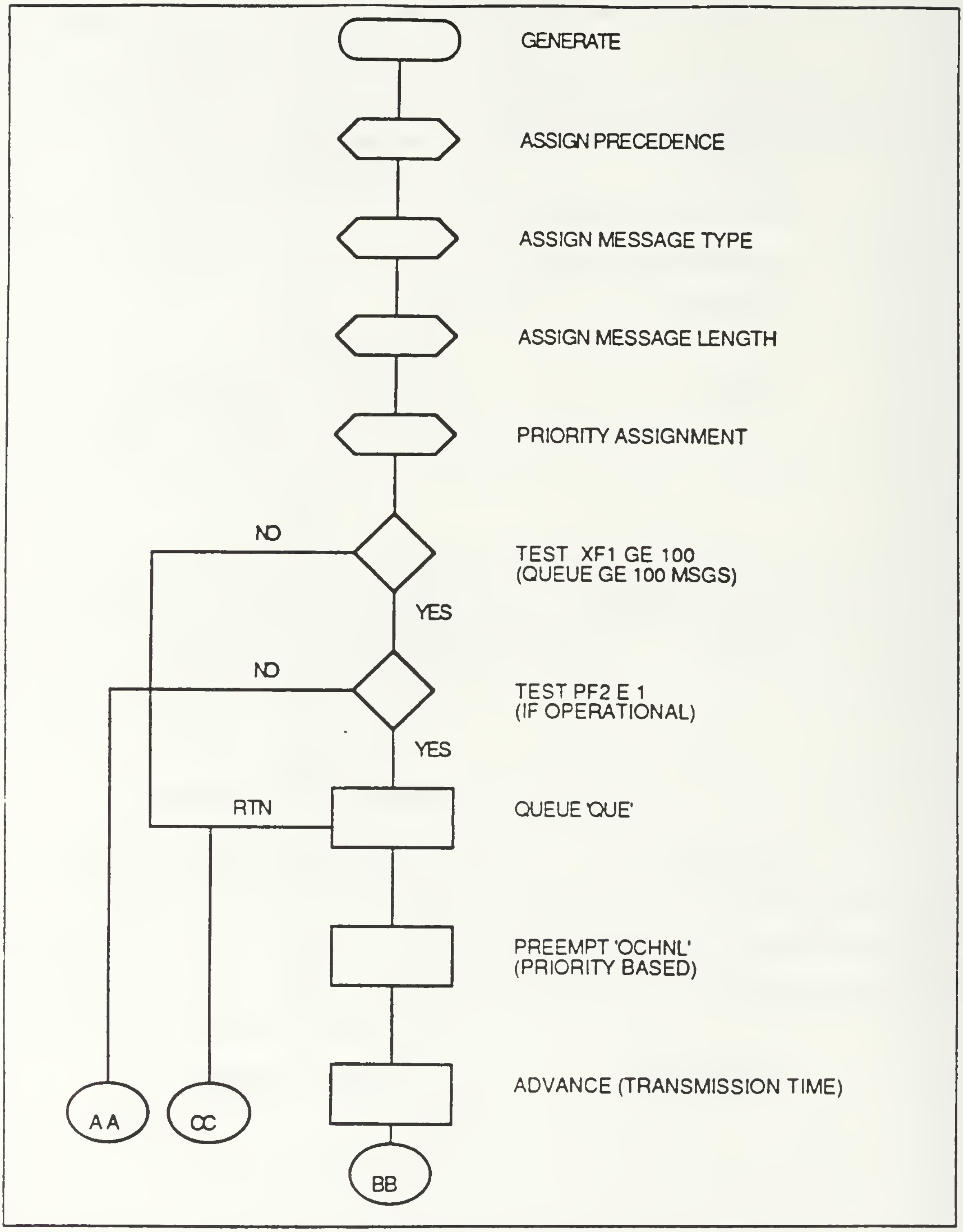

Figure 34. Simulation Model Block Diagram (a)

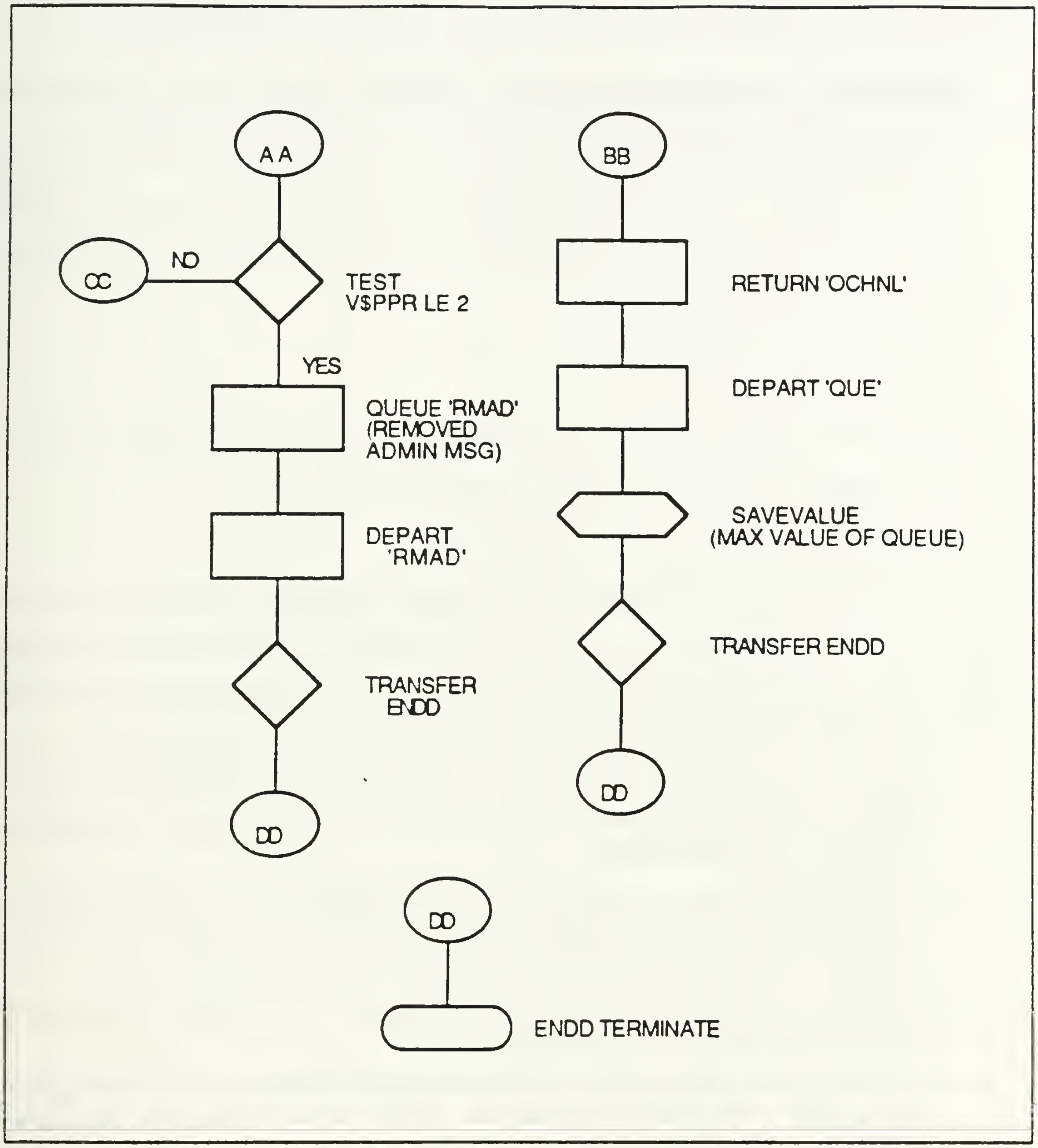

Figure 35. Simulation Model Block Diagram (b)

APPENDIX C. DECISION MAKING AMONG MULTIPLE OBJECTIVES

Many policy decisions today are very complex with extensive interaction among factors. To deal with these complex, unstructured situations has required the development of analytical processes to reach a decision taking into account all these interactive factors. Two such processes are:

1. Multiattribute Utility Analysis
2. The Analytical Hierarchy Process

The following sections provide a brief description of each of the processes. For a detailed description the reader must refer to Ref. 26 and 27.

A. MULTIATTRIBUTE UTILITY ANALYSIS

Multiattribute Utility Analysis was developed as a means of allowing decision makers to balance multiple objectives while at the same time incorporating personal judgements. By allowing personal judgements the process allows the inclusion of intangibles and preferences; this feature was lacking in earlier decision making processes.

The analysis process is composed of the following four steps [Ref. 26: pp.136-139]:

1. Defining attributes of value - These attributes are used to highlight the differences between the possible choices.
2. Assessing performance of choices on each attributes - It is at this point where perference is assessed. Using a set scale of measure, for example, 0-100 for economy, choices are ranked in each attribute.
3. Determining tradeoffs across attributes - Using a set of weights, decision makers determine tradeoff across attributes.
4. Calculating an overall average - Using a weighted average, a score is calculated for each choice. The resultant overall value is the choice's measure of attractiveness compared to the other choices.

B. THE ANALYTICAL HIERARCHY PROCESS (AHP)

AHP is based on three principles which are key to logical analysis: the principle of constructing hierarchies, the principle of establishing priorities, and the principle of logical consistency. AHP consists of the following steps:

1. Using a hierarchal concept, complex systems are broken down into constituent parts according to their essential relationships [Ref. 27: p.33].

2. Step two requires the establishing of priorities. Using matrices, pairwise comparison is performed in an effort to find which elements dominate with respect to criterion on higher levels of the hierarchy.

3. Step two is performed on all levels and clusters of the hierarchy. The end result is an overall priority vector for the lowest levels of the hierarchy [Ref. 27: p.94].

APPENDIX D. GLOSSARY OF ACRONYMS

ADM	Message Redirect Command
AHP	Analytical Hierarchy Process
ACS	AUTODIN Control Subsystem
AIS	AUTODIN Interface Subsystem
ALTROUTE	Alternate Route
AM	Message Alternate Route Command
AMSS	Automatic Message Screening Subsystem
ASC	AUTODIN Switching Center
AUTODIN	Automatic Digital Information Network
BKS	Broadcast Keying Station
BSR	Broadcast Service Request
CCS	Communication Control Subsystem
CNO	Chief of Naval Operations
CNTC	Commander, Naval Telecommunications Command
COMMAREA	Communications Area
COMPCEN	Computer Center
CUDIXS	Common User Digital Information Exchange System
CVBG	Carrier Battle Group
DCS	Defense Communications System
EASTPAC	Eastern Pacific
ECS	Executive Control Subsystem
FIFO	First in, First out
FLTCEN	Fleet Center
FLTCINC	Fleet Commander in Chief
FLTSATCOM	Fleet Satellite Communications System
FOTP	Fleet Operational Telecommunications Program
FSB	Fleet Satellite Broadcast
GENSER	General Service
GHZ	Gigahertz

GPSS	General Purpose Simulation System V
HF	High Frequency
HFB	High Frequency Broadcast
LANT	Atlantic
LEASAT	Leased Satellite System
LRN	Logical Reference Number
LUF	Lowest Useable Frequency
MED	Mediterranean
MHI	Message Handling Instruction
MHZ	Megahertz
MPS	Message Processing Subsystem
MPSVC	Message Processing Subsystem Software Module - Service Clerk Support
MSGCEN	Message Center
MUF	Maximum Useable Frequency
MULCAST	Multichannel Broadcast
NAVCAMS	Naval Communications Area Master Station
NAVCOMMSTA	Naval Communications Station
NAVCOMPARS	Naval Communications Processing and Routing System
NAVTELSYSIC	Naval Telecommunications Systems Integration Center
NCQPROS	Output Queue Profile Report
NCQPROT	Output Queue Profile Report
NTS	Naval Telecommunications System
OCR	Optical Character Reader
OPSIG	Operating Signal
OPSOFF	Operations Office
RCS	Receive Control Subsystem
RECSITE	Receiver Site
RI	Routing Indicator
SBO	MPSVC SVC Reentry Command
SBR	MPSVC SVC Reentry Command
SHF	Super High Frequency

SPECAT	Special Category
SPS	Support Program Subsystem
SVC	MPSVC Command
SVCEN	Service Center
TECHCTL	Technical Control
TCS	Transmission Control Subsystem
TPS	Transmission Processing Subsystem
TS	Top Secret
TTY	Teletype
UHF	Ultra High Frequency
VDT	Video Data Terminal
WESTPAC	Western Pacific
WPM	Words Per Minute
ZYB	Operating Signal for Administrative Message Designation

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