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COMPARATIVE ANALYSIS OF THE EFFECTS OF SYSTEM STRUCTURE AND INFORMATION INPUT CHARACTERISTICS ON THE SYSTEM'S RESPONSE OF A MILITARY INTELLIGENCE HANDLING SYSTEM

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COMPARATIVE ANALYSIS OF THE EFFECTS OF SYSTEM STRUCTURE AND INFORMATION INPUT CHARACTERISTICS ON THE SYSTEM'S RESPONSE OF A MILITARY INTELLIGENCE HANDLING SYSTEM

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SUMMARY

The United States Army is currently engaged in extensive research in the field of information collection sensors and intelligence handling systems. One area of research effort is directed toward evaluating the performance of a specific intelligence system, the Battlefield Information Control Center (BICC) system, under different tactical environments. The BICC system is an information handling and intelligence production system which provides direct support to the intelligence staff officer at all of the major maneuver and fire support echelons in a division force.

This research is directed toward determining, through model simulation, the effects of various manning levels and information input volumes on the timeliness of information flow in a BICC system supporting a brigade size force.

The model was constructed based on observations of a brigade BICC system operating in a field test environment, and programmed for the Univac 1108 digital computer system using General Purpose System Simulator II (GPSS-II), a special purpose programming language.

The model was exercised with various intelligence analyst manning levels and army estimated message input volumes corresponding to low, mid, and high intensity combat situations.

It was found that, for low intensity environments, intelligence analyst authorization could be reduced from those now authorized with only minor degradations in the two lowest priorities of information transit timeliness; however, the addition or reallocation of analysts or communication facilities does not yield significantly improved timeliness of information flow. It was also found that the present BICC system is saturated by mid and high intensity message volumes. The mid intensity problem may be partially alleviated by the addition of intelligence analysts, but no practical solution was found for the high intensity case. The results are depicted in a number of figures and tables showing the results of comparing various inputs and model configurations.

CHAPTER I

INTRODUCTION

Background

One important aspect of military operations throughout history has been the performance of the intelligence function. Information about the enemy is, along with the friendly forces' assessment of their relative mobility and firepower capabilities, a critical input to the commander's options concerning mobility and firepower (1, p. 313). However, the intelligence gathering and processing organizations currently found in the U. S. Army remain substantially unchanged since the Korean War. While there have been information collection hardware improvements, the continued existence of an "intelligence gap" is recognized by the Army (1, p. 313). An effort to close this gap commenced in 1965 when the U. S. Army Combat Developments Command (USACDC) initiated a major study entitled Tactical Reconnaissance and Surveillance, 1975 (TARS-75). The purpose of this study was to determine the combination of sensor hardware and organization which would best fulfill the field forces' need for tactical intelligence in the 1970-1975 time frame. TARS-75 examined via computer simulations ten families or mixes of hardware and organizational concepts. None of the ten mixes satisfied the selection criteria. Therefore, additional analysis of the simulation data was performed with the intent to identify the weak areas of the simulated alternatives so that an eleventh system could synthesized which would potentially overcome the known weaknesses. This synthesis, finished in 1967, produced what is now known as the Battlefield Information Control Center (BICC) concept. This new concept was not at that time simulated and has not since been.

The BICC concept provides a separate battalion sized force to each division to collect and process information and to disseminate intelligence. This battalion is structured to provide a team of specialized intelligence personnel to each of the division's combat echelons from company through division headquarters. At company level the provided support consists of either or both an Attendant Ground Sensor team or an Unattended Ground Sensor team. The Attended Ground Sensor team operates radar, night observation devices, and performs visual surveillance. The Unattended Ground Sensor team monitors seismic, acoustic, and magnetic sensors which are placed in the supported company's area of operations and interest. These teams are a basic entry point of information into the overall BICC system. At battalion and higher echelons the supporting team is termed either a Battlefield Information Control Center (BICC) or Battlefield Information Center (BIC). At maneuver battalion, brigade, and division headquarters the team is a BICC, while at field artillery units and armored cavalry squadron headquarters it is a BIC. The difference lies in the authority given to a BICC which enables it to actually direct the collection effort. A BIC has no directing authority and serves primarily as an information interface point. In the performance of its mission the BICC prepares, based on guidance from the S2/G2,* the informa-

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*The designation of the intelligence staff officer found on all staffs within the division. At division level it is G2 while at all lower echelons it is S2.

tion collection plans, disseminates the collection directives and Standing Requests for Information (SRI), controls and coordinates the collection effort, receives the information gathered and processes it into intelligence, and disseminates both information and intelligence as necessary (2, p. 1-3). With minor exceptions the communications required to accomplish these tasks are passed over nets belonging to the BICC system, a significant departure from past concepts. A schematic of the BICC system which supports a brigade, approximately a third of the entire division BICC system, is shown in Figure 1. The internal operations and the information flow paths found in the BICC are shown in Figure 2.

With only minor differences from the concept discussed in preceding paragraphs, a test battalion was organized in Vietnam (1968) to exercise this new concept and to provide a vehicle for testing new sensors. This author was the operations officer (S3) of that unit during its formation and testing. The concept functioned as envisioned and was considered a success. The concept's success was, however, in a rather restricted low intensity[*] environment which left open the question of its performance in the more demanding mid and high intensity[**] environments.

This open question and the increased availability of sensor hardware since the Vietnam test were important factors in the initiation of the U. S. Army's Project MASSTER (Mobile Army Sensor Systems Test Education and Review) at Fort Hood, Texas. Project MASSTER has the general

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[*]Low intensity environments are essentially counter-insurgency conflicts.

[**]Mid and high intensity refer, respectively, to mobile conventional warfare and nuclear warfare.

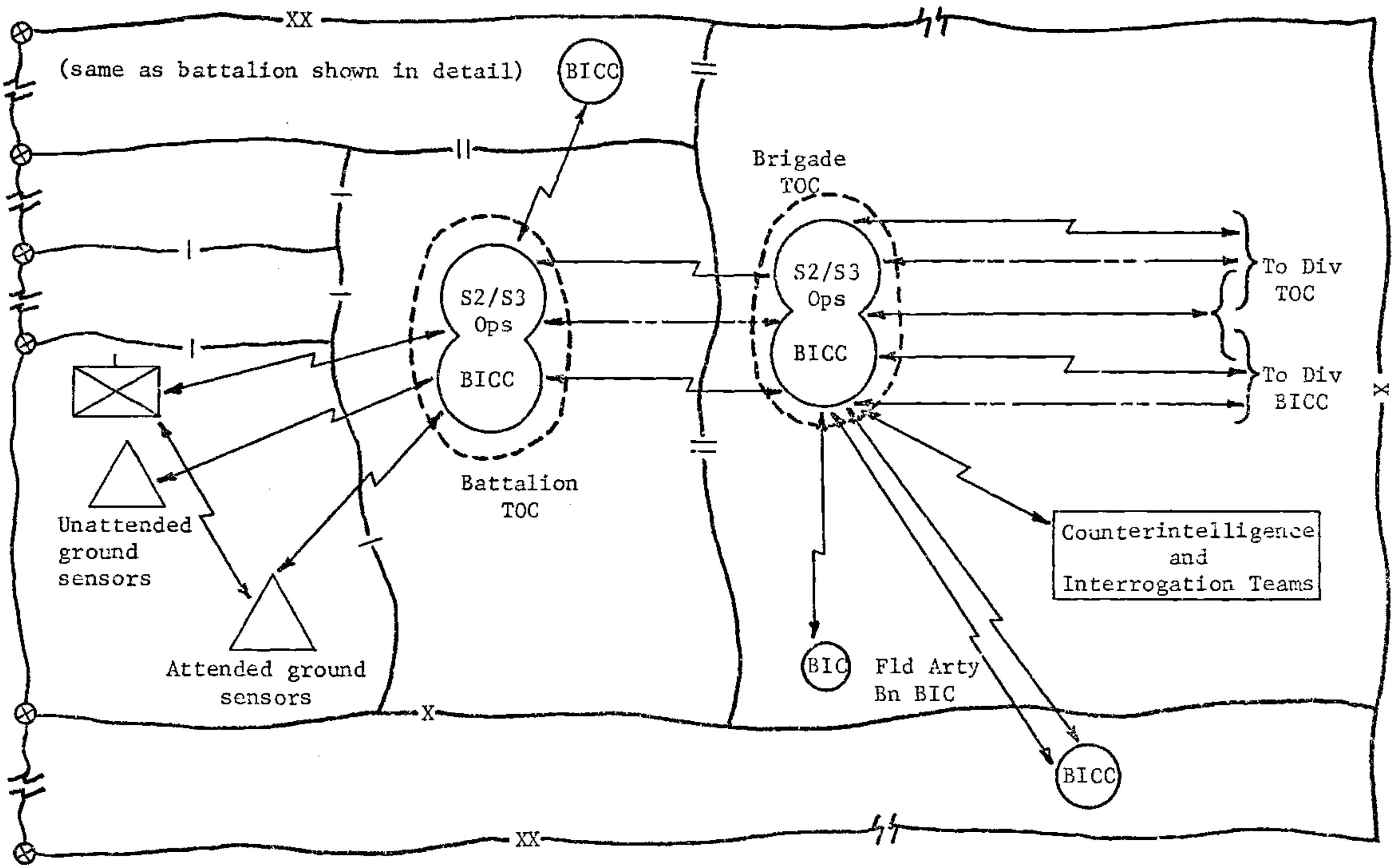
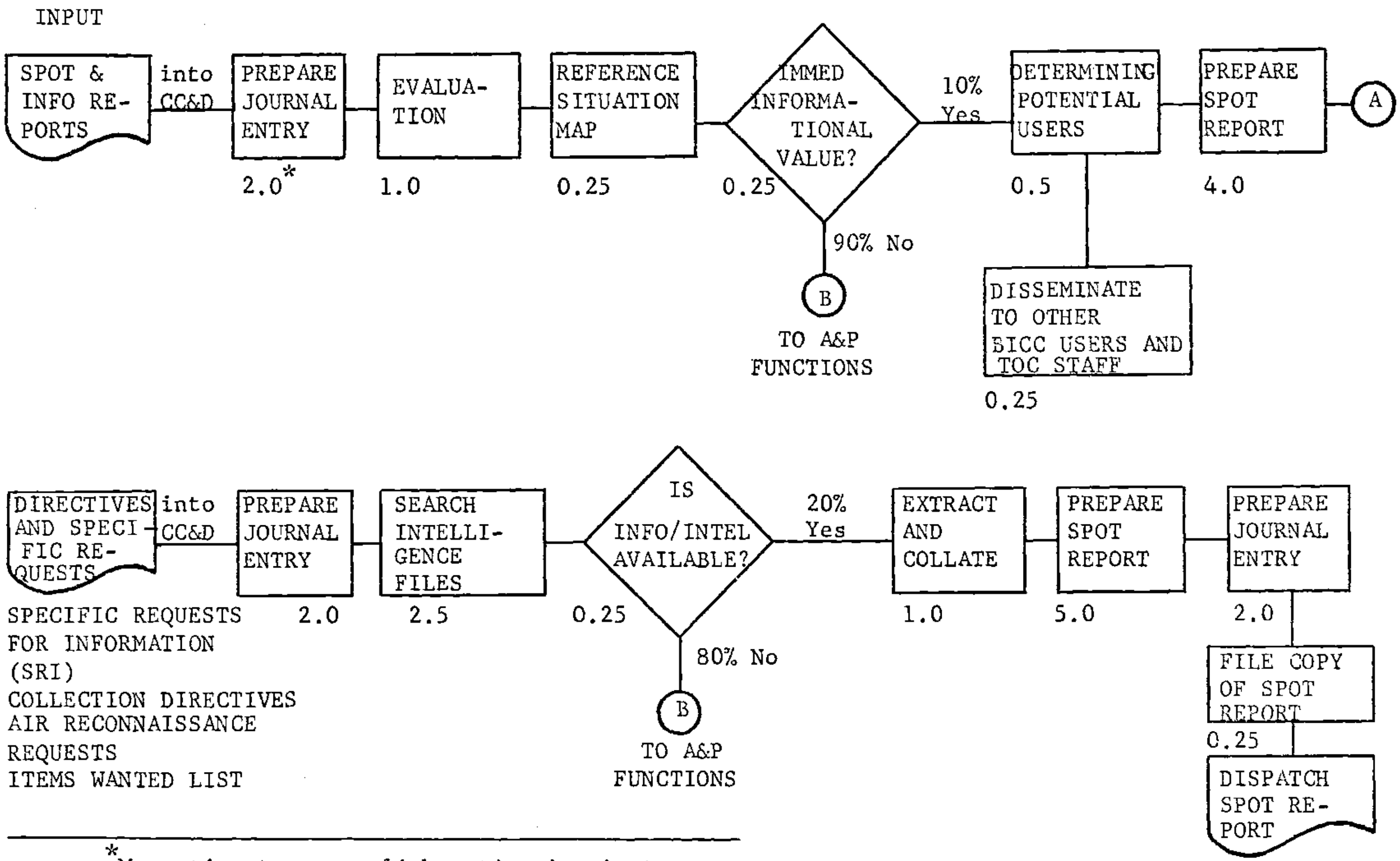
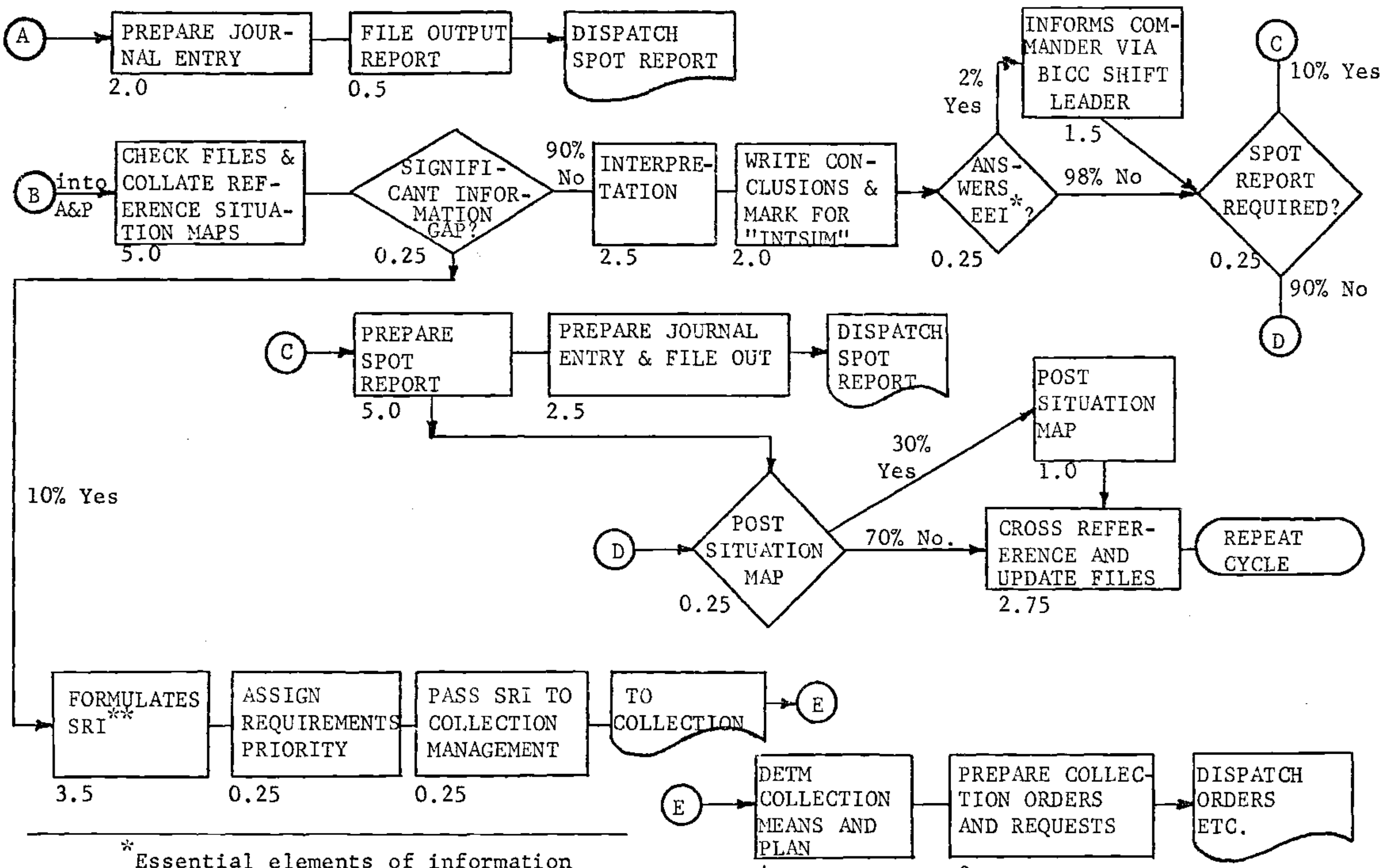


Figure 1. Typical Brigade Organization Supported by BICC System and Interconnecting Communication Links



*Mean time to accomplish action in minutes. Distribution assumed to be exponential.

Figure 2. Initial (Hypothesized) BICC Internal Operations and Information Flow Channels



*Essential elements of information

**Standing request for information

Figure 2. Continued

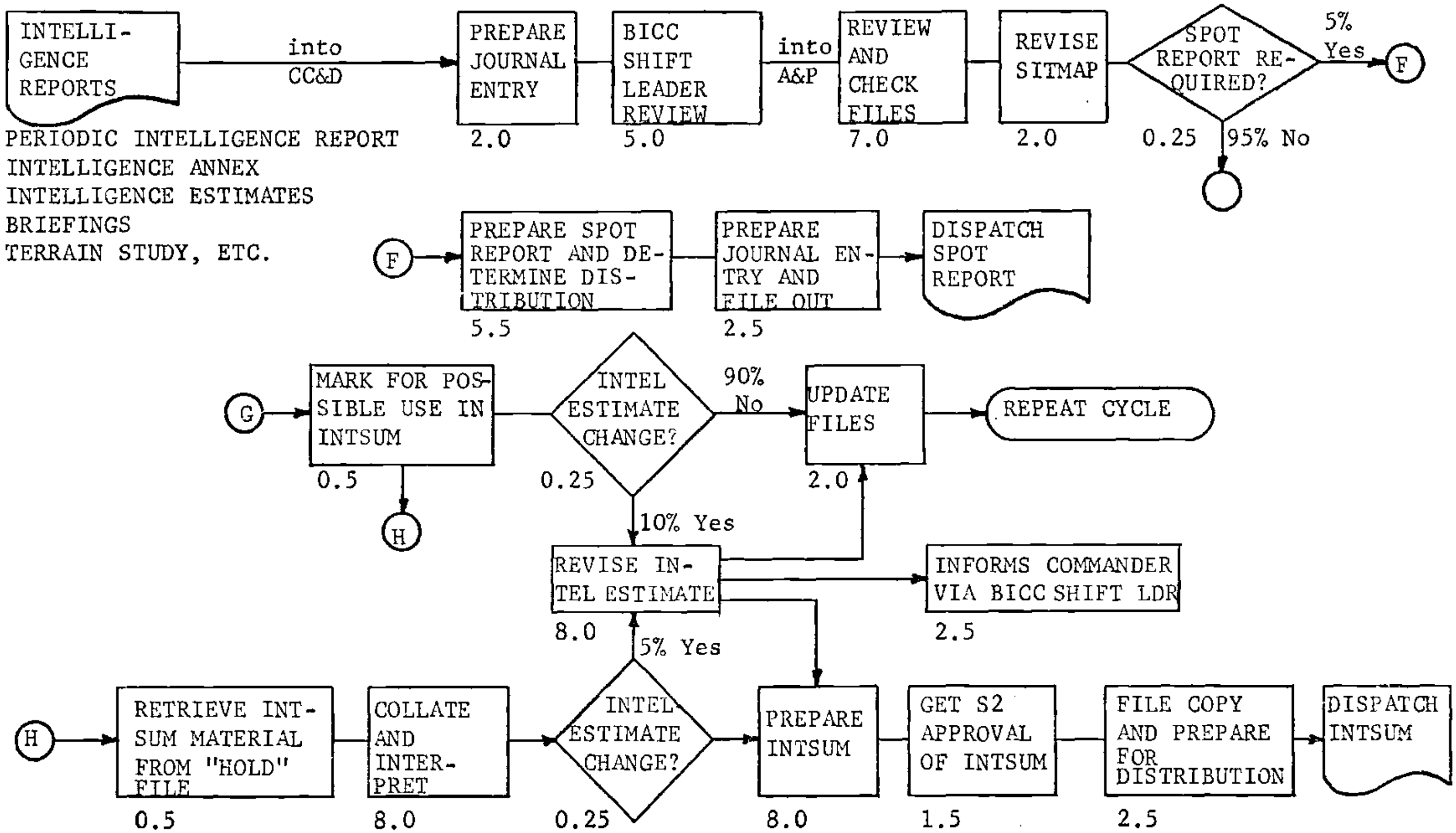


Figure 2. Concluded

mission to plan and conduct tests and evaluations of surveillance, target acquisition and night observation systems and material in order to improve the Army's combat intelligence capability (1, p. 315). While MASSTER will eventually test in the mid intensity environments, all testing to date has been in low intensity type environments with the major effort directed toward evaluating sensor hardware and sensor employment methods. That aspect of the testing which has been directed toward organizational and operational concepts for the BICC system has relied upon subjective evaluations rather than "hard data" objective analysis of the system. Considering this and the fact that expense precludes live testing of all the possible alternative organizational structure of the BICC system, it would be cost and time advantageous to be able to narrow the spectrum of alternatives down to those which, a priori, appear to offer the better chances for successful system operation in the environment specified for the live test.

Purpose

Thus, the purpose of this research is to both construct a model of the information flow and intelligence processing function of a brigade force operating with the BICC system and to conduct experimentation on that model. Following model construction, specific objectives are to:

1. Validate the model using data generated in the Project MASSTER field experiments.

2. To determine, through experimentation of the model, the BICC system's performance profile in terms of queue lengths, delays, and information transit times as a function of system's parameters such as,

a. Message volume input

b. Number, type, and capacity of communications links between echelons

c. Personnel manning levels and internal information staffing procedures at each echelon.

3. To determine if the system's performance profile for low intensity environments can be significantly improved by a reallocation of personnel manning levels or not significantly degraded by a selected reduction in personnel manning levels.

4. To determine the BICC system's operating characteristics where subjected to information input volumes hypothesized for mid and high intensity environments (3, p. B-II-2).

With these objectives formulated, research into literature pertinent to this problem is required in order to determine the precise procedures to be followed. The results of that research are found in Chapter II.

CHAPTER II

LITERATURE

Combat Intelligence

Military intelligence is the knowledge of an actual or possible enemy and the natural characteristics of the areas where military operations are to be conducted. It is essential to the planning and execution of military operations and encompasses, along with other categories of intelligence, combat intelligence (4, p. 5). Combat intelligence is that knowledge of the enemy and the area required by a commander planning and conducting tactical operations. It is derived from the processing of information concerning the enemy, the weather, and the terrain (4, p. 5). Processing is the step whereby information becomes intelligence. This is accomplished in three operations: recording, evaluation, and interpretation (4, p. 6).

> 1. Recording. The reduction of information to writing or some other form of graphical representation and the arranging of this information into groups of related items.
> 2. Evaluation. The determination of the pertinence, reliability, and accuracy of the information.
> 3. Interpretation. The determination of the significance of the information in relationship to information and intelligence already known and the drawing of conclusions as to the probable meaning of the evaluated information.

The general procedures and sequences of information flow for combat intelligence processing are outlined in FM 30-5, Combat Intelligence (4). More detailed information of this type is available in Functional

Area Description -- Enemy Situation (3). Examination of these two documents reveals that information flow involves the arrival of information at various points in the processing system and the subsequent performance of service on that information by both men and machines.

Such a description readily fits into the broad category of queuing problems (5, p. 4). Queuing problems have received wide interest and much effort has been devoted to developing general solutions to queuing models; however, many of the solutions which exist relate Laplace transforms of the distributions of waiting and queuing time to the Laplace transforms of the inter-arrival time and service-time distributions. Since, except for the simplest forms of inter-arrival and service-time distributions, the Laplace transform cannot be precisely inverted, many solutions in the academic sense are not solutions in the practical sense (5, p. 22; 6, p. 66). This is normally the case where inter-arrival and service-times are not exponentially distributed (5, p. 86).

This author's observation of the information handling and processing system under study reveals that service-time distributions are not exponential, thereby requiring that some other method of analysis be employed. In those queuing systems where mathematical complexities make practical applications difficult, the technique of Monte Carlo simulation is recommended (5, p. 82; 6, p. 86).

Simulation

The term "simulation" is widely used, meaning many different things in different contexts with the result that there is no mutually agreeable definition (7, p. 92; 10, p. 2). From the range of choices, there is one definition which best fits this research. This choice defines simulation to be the action of performing experiments on a model of a given system, where system is considered to be a collection of entities which act and interact together toward the accomplishment of some logical end (8, p. 4).

Systems may be represented by one of several common model forms: iconic, analog, or symbolic. Iconic is essentially a scale version of the real system while analog implies only that specified characteristics of the model under study adequately portray the same characteristics of the real system. Of primary interest in this research is the symbolic model which requires that the properties of the system being modeled are capable of being represented symbolically, i.e., equations, letters, signs, and marks (9, p. 1).

There is a wide variety of literature available discussing various aspects of conducting simulations of symbolic models on a digital computer. Unfortunately, much of this literature usually consists of introductory expositions or of descriptions of the solution of a particular problem (7, p. 92). Happily, there are exceptions (7,8,10,11,12,13) which provide insight into the problems of model formulation, validation, and experimental design.

Based on the known complexities of the information system to be examined and the desirable characteristics of digital computer simulation, it was decided to formulate a symbolic model of the real system and to experiment upon that model using digital computer simulations. The next decision, what computer language is best suited for the particular problem at hand, required examination into the characteristics of various languages.

This examination was narrowed to special simulation languages because they consume less time in programming and allow commensurate increases in the time available for planning the experimental design and analyzing the results (11, p. 49). Of the special simulation languages available, one, General Purpose Systems Simulator (GPSS)-II, was selected because its orientation, logic, and method of formulation closely parallel the physical system to be modeled. GPSS's orientation is one of transactions moving in time through a system composed essentially of facilities, storages, and queues (10, p. 219), which is precisely the orientation of the information system depicted previously (2,3).

GPSS is a two-part program. The first part is an assembly program that converts the user's description of the system to be simulated into suitable input for the second. The second portion of the program actually performs the desired simulation runs of the computer (10, p. 219). GPSS-II is simple to use and easy to learn. All of the information needed to develop a GPSS-II program is found in Univac's GPSS-II Reference Manual (14).

The details of how GPSS-II will be used in the model building will be discussed in the following chapters.

Combat Intelligence and Simulation

The extent of the use of simulations to study combat intelligence is difficult to determine since very little literature is available on the subject. The TARS-75 study (15), discussed in Chapter I, employed simulation; however, the thrust was directed toward sensor hardware and employment analysis. There was no modeling of the information processing function as the results of sensor simulations were fed directly into a team of military officers which manually performed the processing function. In this regard, TARS-75 was a hybrid simulation and manual war game.

This author's review of a recent comprehensive bibliography of military related simulation studies (16) found none which deal with the modeling or simulation of combat intelligence flow or processing. Additionally, reviews of many abstracting and indexing services (17,18,19, 20,21,22) yielded negative results. While not dealing directly with the subject of this research, two documents were found which are of some assistance. The first, an equipment and terrain oriented communications simulation (23), provides some basic input data to the communications aspect of this research. The second (24) discusses the impact of modern information technology on the structure of intelligence organizations at the tactical level. Of primary interest in this latter work are estimates of the volume of intelligence messages which flow between selected echelons of a division force.

CHAPTER III

PROCEDURE

Introduction

The procedure used in conducting this research is separable into two phases. The initial phase is the translation of the information system into a representative model and the validation of that model. This phase is also broken into two subphases. This subdivision occurs since initial model formulation depends entirely upon written doctrine and operating procedures. A model representative of the concept as published in (2,3) is developed and exercised. Following this a model representative of the system as it actually operates is constructed. This actual system model is developed based on the author's observation of the system as it operates under live troop test conditions. Following validation of the actual system model, the second major phase of the research begins. This second phase involves experimentation with the model to determine its response to various inputs.

Construction of the Initial Model: Phase Ia

Prior to the actual fielding and troop test of the system under study, the only firm bases for model construction and operation were contained in two previously referenced documents (2,3). These documents specify the organization and communications links shown in Figure 1, the Battlefield Information Control Center (BICC) personnel manning strengths shown in Table 1, the BICC internal operations and information flow channels shown in Figure 2, and the volume of messages, by type, entering the battalion and brigade BICC daily, shown in Table 2. Detailed descriptions of the processing actions shown in Figure 2 are found in Functional Area Description - Enemy Situation (3, p. B-II-2). Personnel duties of the BICC operators are discussed in Training Text 30-7 (2). With these data available and making several assumptions, it is possible to translate the BICC system into a computer model using GPSS-II. The method and procedure to perform this translation is straightforward and will not be discussed as it is described in great detail in the GPSS-II user's manual (14). The assumptions made in this phase are necessary primarily due to the lack of data. These assumptions are that:

1. Personnel performing the manual information processing functions operate at a constant efficiency which is independent of time and state of system.

2. All processing functions and their associated service times are not affected by personal trait and characteristic dissimilarities between different analysts which perform the same function, and BICC section capability is a constant slope linear function of the number of analysts.

3. All queues have the capacity of containing an infinite number of messages.

4. Service times of the processing functions shown in Figure 2 are exponentially distributed with the mean service time shown under the left hand corner of each appropriate block.

Table 1. Initial Battlefield Information Control Center (BICC) Specified Manning Strengths (2, pp. 4-7, pp. 4-20)

Brigade BICC	
Collection, Control, and Dissemination Section (CC & D)	
Officer in Charge	1
Section Sergeant	1
Intelligence Analyst	6
Radio/Telephone Operator, Vehicle Driver	2
Analysis and Production Section (A & P)	
Intelligence Analyst	3
Total	13*
Battalion BICC	
Officer in Charge	1
Section Sergeant	1
Intelligence Analyst	5
Radio/Telephone Operator, Vehicle Driver	1
Total	8

*Does not include the supporting communication team of three personnel which operates the teletype equipment.

Table 2. Estimated Daily Message Volumes (3, p. B-II-2)

Echelon		ACTIVITY 1	2	3	4	5
Brigade	L*	606	455	10	2	32
	M*	895	675	15	4	44
	H*	1021	765	15	4	55
Battalion	L	282	212	10		8
	M	444	333	15		30
	H	504	378	15		30

Activity:
1. Initial review and dissemination of incoming information by the Collection, Control, and Dissemination (CC & D) Section.
2. Evaluation and analysis of information and dissemination and filing of intelligence by the Analysis & Production (A & P) Section.
3. Review, extracting, and filing of intelligence by A & P Section.
4. Intelligence Summary (INTSUM) production by S2 and A & P Section.
5. Processing of requests for information and collection directives by CC & D Section.

*L - Low Intensity, M - Mid Intensity, H - High Intensity

5. Message interarrival times are exponentially distributed with a mean calculated to yield the message volume flow shown in Table 2.

With these assumptions and the system structure information provided (2,3), a GPSS-II computer model was constructed. The only option for validation of this initial model is a careful construction process and a thorough check of the logic used to insure that the information flow matched that shown in Figure 2 (25, p. 296).

This something-less-than-desirable validation process was necessary due to the absolute lack of objective system performance data at that time. The sole purpose of this phase is to test the author's subjective hypothesis about the system's ability to operate. This hypothesis, based on previous experience with a similar system, states that a combination of both the mean service times for each processing action shown in Figure 2 and the input message volumes shown in Table 2 will result in the system's failure to function with reasonable timeliness of information flow. To test this hypothesis, the model was subjected to the message inputs specified for low intensity environments (Table 2). Four runs, representing 12, 24, 36, 48 hours of system's operation, were performed. The results of these runs were examined to determine the existence and location of critical queues within the system. Two types of such queues were identified. These are:

1. Queues of messages waiting for detail analysis, evaluation, and interpretation at the battalion (Bn) BICC, i.e., waiting for the performance of the analysis and production (A & P) function. This queue is labeled Queue 16 in all models.

2. The queue of messages waiting for detail analysis, evaluation, and interpretation at the brigade (Bde) BICC, i.e., the queue waiting for processing by the Bde BICC A & P Section. This is labeled Queue 34 in all models.

Pertinent statistics gathered during these runs included hourly queue histories in terms of the mean waiting time of all messages which had been processed from each queue at the time of each sampling. These statistics reveal that mean waiting time is a non decreasing function which in essence indicates that the information arrival rate is greater than the system service rate resulting in a system which will not stabilize. This is best illustrated by Figure 3 which shows the 48 hour run results. As can be observed, the mean wait for Bn A & P processing increases from 21 minutes after the first hour's operation to 14.1 hours wait after 48 hours of operation, while the Bde A & P mean queuing time increased from 12 minutes to 12.6 hours. These results satisfied the author's hypothesis and gave added impetus to the second task in Phase I, i.e., more precise definitions of both the system and its associated service time distributions and the determination of realistic low intensity information input volumes.

Modification of the Model and Validation: Phase Ib

To accomplish this second subphase of model construction and validation, it was necessary to observe the brigade BICC system in operation. This was done during a Project MASSTER test period (5-9 April 1971) when experiments in a low intensity environment were being conducted. This author personally observed all phases of the system's operation and with

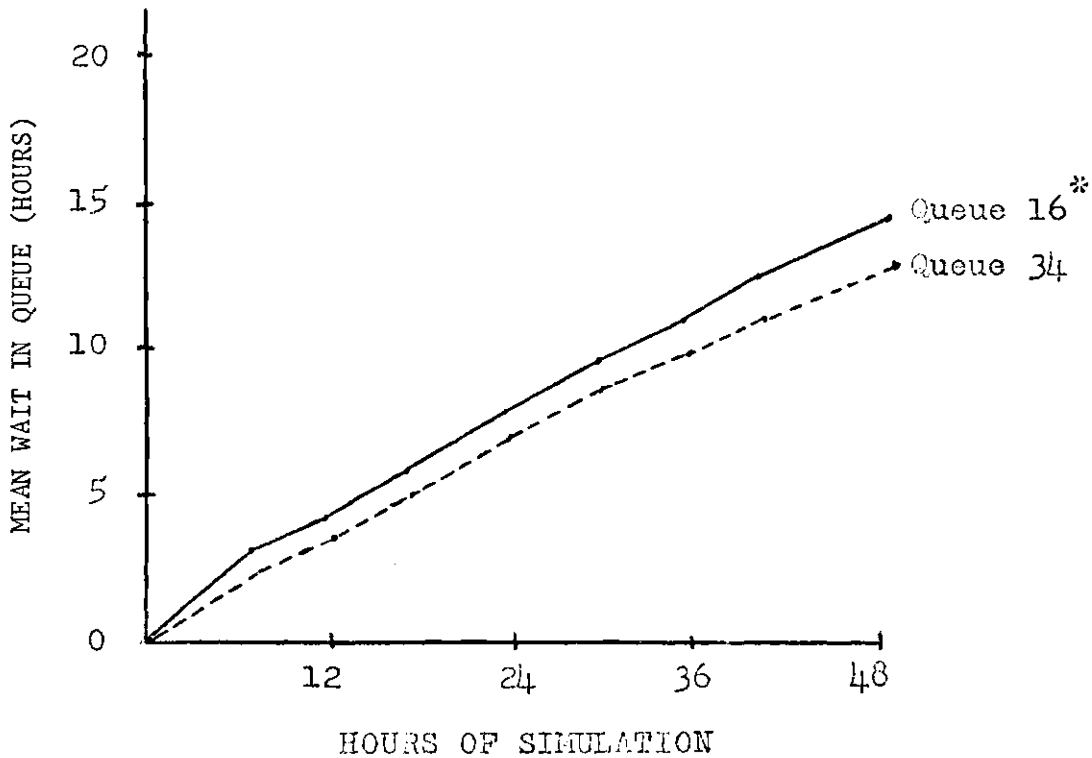


Figure 3. Initial(Hypothesized) System Critical Queue Histories

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* Queue 16--Bn BICC A&P
Queue 34--Bde BICC A&P

some assistance from Project MASSTER data collectors, determined the system's essential operating characteristics in terms of information input volumes, information routing, operating procedures, and time distributions associated with the handling and processing of information.

Personnel manning levels, shown in Table 3, were found to vary from those shown in Table 1; however, general operating procedures were substantially those described in doctrinal literature (2,3). In addition to the differences in manning strength other major variations between the system as described in Figures 1 and 2 and the system as it actually operates concern volume of information to be handled, information routing patterns, and service time distributions for various processing functions.

Table 2 indicates that the estimated daily load of messages for low intensity is 282 and 606 for Bn and Bde BICCs, respectively. This is obtained by examining Activity Column 1, which gives the total volume entering the BICC. All other columns reflect the internal routing and do not indicate a separate input to the BICC. The message volumes observed flowing during the Fort Hood experimentation were 96 and 171 for the Bn and Bde BICCs, respectively. The other two major variations, routing and service times, are better understood after a more detailed description of the observed system and its model.

The Observed System and Its Schematic Model

The operations which occur in the BICC system, and consequently those which are modeled, are the entry of an information bearing message of a specific type and priority into the system at various points in the flow channel from company to brigade echelon. The message is then trans-

Table 3. Observed Manning Levels

Brigade		
Collection, Control, and Dissemination (CC & D) Section		
Officer in charge	1 (1st Shift Ldr)	
Section Sergeant	1 (2nd Shift Ldr)	
Intelligence Analyst	6 (3 per Shift)	
Radio/Telephone Operator, Vehicle Driver	2 (1 per Shift)	
Analysis and Production (A & P) Section		
Intelligence Analyst	4	
Total	14*	
Battalion BICC		
Collection, Control, and Dissemination Section		
Officer in charge	1 (1st Shift Ldr)	
Section Sergeant	1 (2nd Shift Ldr)	
Intelligence Analyst	4 (2 per Shift)	
Radio/Intelligence Operator	2 (1 per Shift)	
Analysis and Production (A & P) Section		
Intelligence Analyst	2 (1 per Shift)	
Total	10	

*Does not include the supporting communication team of three personnel which operate the teletype equipment.

mitted through communication facilities until it reaches the first processing facility, i.e., a BICC. Prior to more discussion, it should be mentioned that, for clarity of relating this narrative to a later system, schematic percentages of messages which receive specified routing are given at appropriate points in the discussion. The percentages are based on the author's observation of the system during five days of operation. At the BICC the message is received by the radio/telephone operator (RTO) and, depending upon its priority, routed in one of two ways. If the priority is category 4 (20 percent), the highest category, the message is routed to the BICC shift leader who interrupts whatever else he is doing to review the message contents. If the contents are, in the judgment of the shift leader, of immediate operational significance to either adjacent units or the next higher echelon, the message is immediately retransmitted to the appropriate BICC and a copy of the message is routed through the other elements of the BICC for normal processing. At Bn BICC 87 percent are considered urgent, while at Bde BICC only 12 percent are judged urgent. If the contents are not of immediate operational significance to other BICCs, the message is released for normal processing. Messages of less than priority 4 (80 percent) are routed to normal processing. Normal processing commences in the Collection, Control, and Dissemination (CC & D) Section of the BICC. In this section one of a number, two per shift at Bn and three per shift at Bde, of intelligence analysts receives the message, records its arrival in the BICC journal, reviews its contents, and gives the contained information a preliminary evaluation. This initial evaluation is made without reference to intelligence files and consists of determining the pertinence of the information, considering the reliability of the source and collecting agency, and judging the probable truth or accuracy of the information in comparison with the tactical and enemy situation as known to the analyst. Next, based on knowledge of the enemy situation, the analyst determines if the report contains obviously significant information. This decision is made after the analyst reviews the enemy situation as depicted on the BICC situation map (SITMAP). If the newly arrived information is considered significant (33 percent at Bn and 24 percent at Bde), the analyst informs the shift leader, determines other necessary recipients of the information, prepares a spot report (SR) message of the information, logs the message out in the BICC journal, and passes it to the RTO for transmission to the addressees. The analyst is then free to receive and process another message. In the event that the information is not of obvious significance (67 percent at Bn and 76 percent at Bde), the analyst passes the information to the analysis and production (A & P) section of the BICC and is again available for the processing of another message.

In the A & P section, manned by one and two intelligence analysts per shift at Bn and Bde, respectively, the incoming information is subjected to detailed analysis in order to determine its contribution to the intelligence picture. In this process the analyst searches the A & P information and intelligence files for data related to the just arrived information. These data are then collated with the new information and the analyst re-evaluates the new information based on his knowledge of the source and collection agency, other related data on file, credibility of the information, and either confirms or changes the preliminary evaluation given by the CC & D analyst. It is at this point that the A & P analyst may recognize the existence of an intelligence gap, that is, the new information is of some significance to previous data on file but does not contain either enough information to complete the picture or its reliability evaluation is so low as to require confirmation before it can be seriously considered. The existence of an intelligence gap requires that an additional collection effort be made to gather the required information. This is the case with 11 percent of the reports handled by the Bn A & P section and 12 percent handled by the Bde A & P section. When this occurs the A & P analyst passes a request for information to the collection planning and control element of the BICC. At Bn this collection control function is performed by the BICC shift leader, while at Bde it is accomplished by an analyst in the CC & D section. At either echelon, the new information request is integrated into the current collection plan and, if modifications in sensor coverage are required, the necessary changes in collection directives and requests are disseminated over the BICC communications system to the appropriate collection agency.

If no intelligence gap exists, the A & P analyst interprets the information by analyzing and integrating it with the collated data. In this process, the analyst formulates his conclusions as to the worth and meaning of the information and determines the urgency of the conclusions. If the conclusions are not urgent, the analyst annotates them for possible later inclusion in periodic intelligence reports, primarily the Intelligence Summary (INTSUM) which is produced at Bde level every 12 hours.

If the conclusions are urgent (7 percent at Bn, 13 percent at Bde), the analyst informs the BICC shift leader and prepares a spot report which is passed to the BICC RTO for dispatch to the designated addressees. After making the necessary updating changes in the intelligence files, the analyst is free to receive another information message or action from the CC & D section and start the process again.

In order to simulate this system, it is necessary to know the time distributions associated with the processing actions previously described. This was accomplished by observation of the functions as they were performed and a review of operating records as kept by the BICC. The author was assisted in this effort by Project MASSTER data collectors who were assigned to full time observation of the major aspects of the BICC operation. The only activity which occurred at insufficient frequency to get a reasonable sample size was the Intelligence Summary production function at the Bde BICC. Thus the mean time (one hour) and a time spread (plus or minus 15 minutes) to accomplish this activity were determined based on the interview of eight analysts at two Bde BICCs who prepare the Intelligence Summary.

The raw data from the observations are in the form of service times to accomplish a specific part of the processing. Initially it was planned to use a Weibull process generator (8, p. 270) to produce simulation service times; therefore, the observed data were fitted to the Weibull distribution function using graphical procedures (26). Later investigation indicated that computer run time could be saved by constructing a cumulative distribution function from the empirical data and using the empirical distribution as a direct input to the GPSS-II program. This is a straightforward procedure and is discussed in detail in the GPSS-II user's manual (14, p. 2-4). In the system schematic, Figure 4, the GPSS-II function number and mean service time (T_s) in minutes are shown by appropriate blocks. Appendix A contains figures graphically showing the empirical distribution functions corresponding to each GPSS-II function number and gives the corresponding Weibull density function.

The system schematic shown in Figure 4 serves to illustrate the system's operation and was used as the starting flow diagram for model conversion into GPSS-II. The GPSS-II coded model and an example run of the computer program are provided in Appendix B. The system and computer model as shown in the schematic diagram and Appendix B are representative of the observed system and are henceforth referred to as the Base Model.

Validation

While there is no consensus on the best method to validate a model (25, p. 23), there are some techniques which offer reasonable confidence that the model portrays the real system. Naturally the most desirable validation procedure would be to prove that statistics and operating history of the model exactly duplicate those of the real system; however, the myriad of possible areas of comparison makes this strategy unattractive from the data collection standpoint. A validation strategy which offers something less than maximum confidence but which is more realistic in scope is discussed by Meirer, et al. (25, p. 274). This is a two step procedure which initially requires that the model be examined to determine if it is internally correct in a logical sense. The second step requires

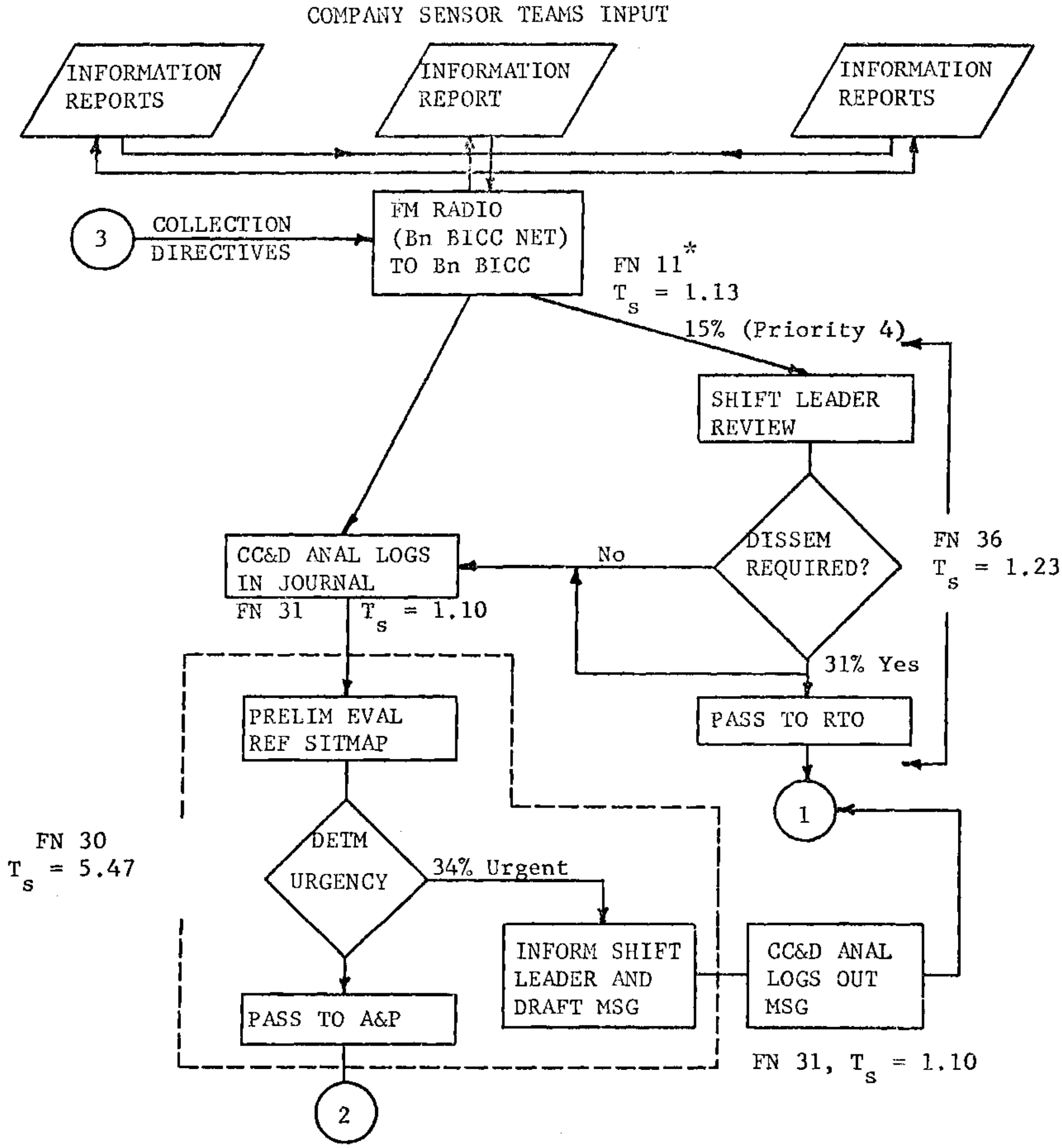

Figure 4. The Observed Brigade BICC System Schematic

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*Transmission or service time per message computed by GPSS-II FUNCTION (FN) number.

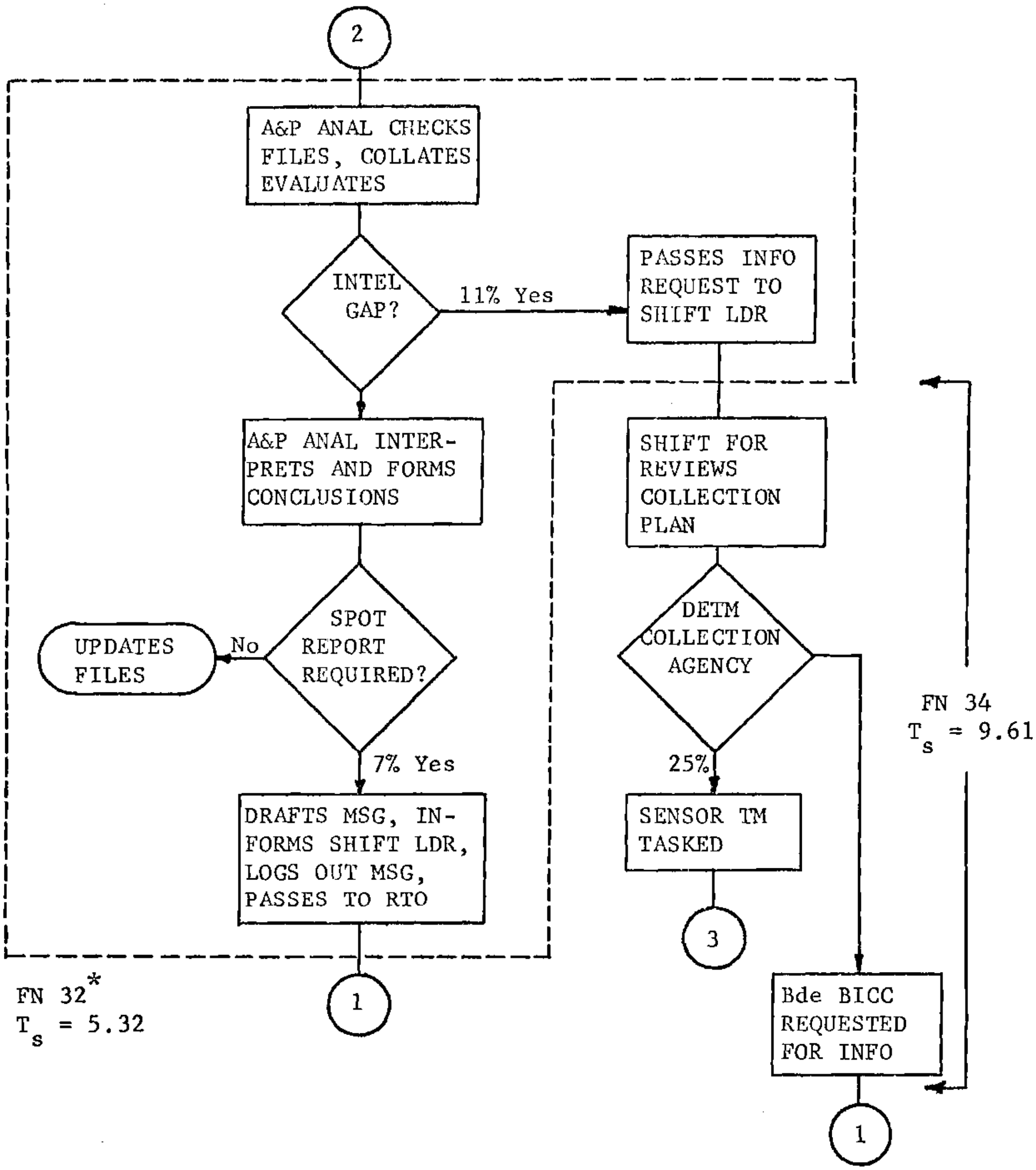

Figure 4. Continued

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*All activities within enclosed area included.

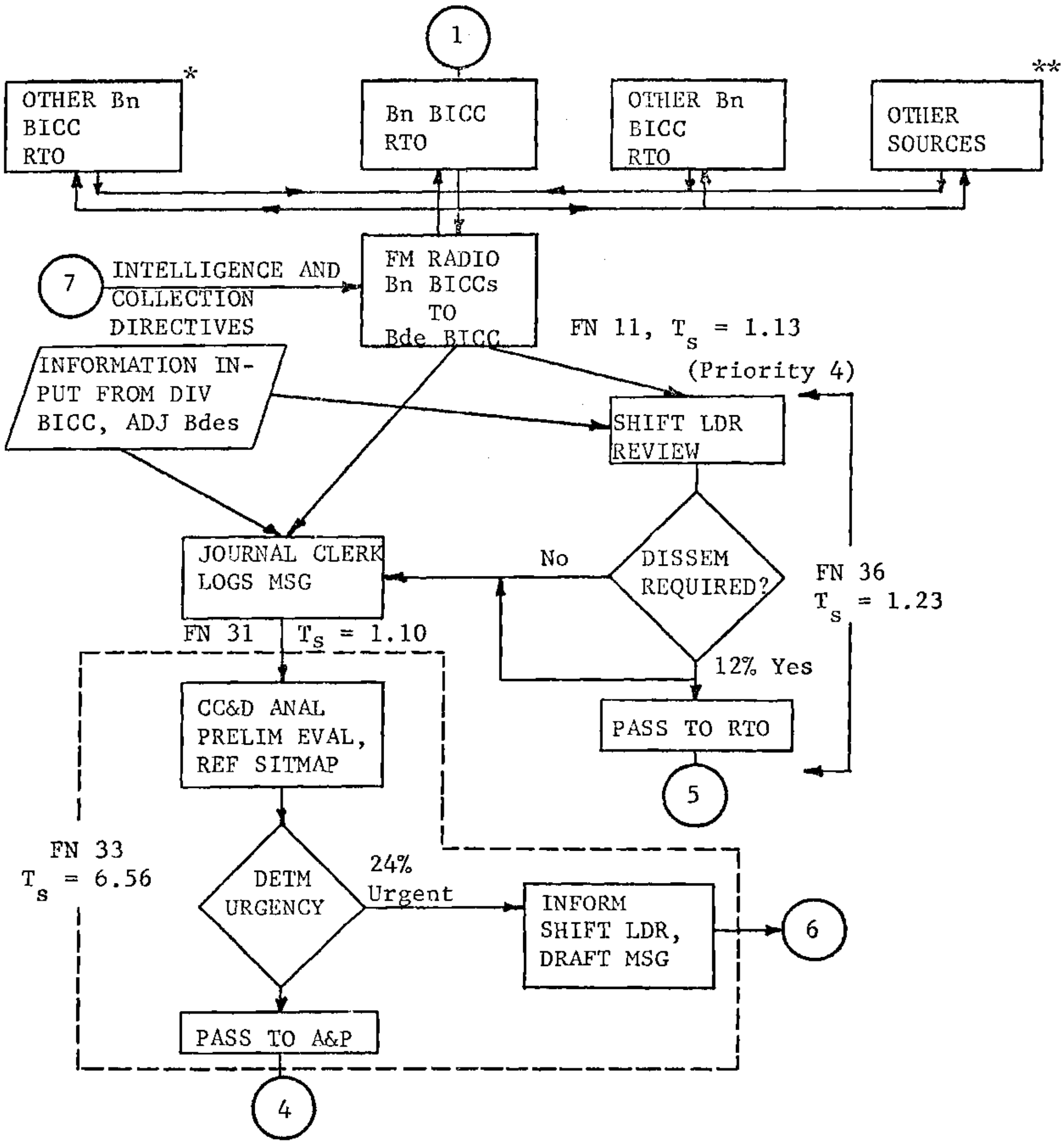

Figure 4. Continued

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*Other Bn BICC's function as the one Bn BICC shown in detail.

**At Bde level other sources available consist of the Field Artillary BIC and a counterintelligence team. These elements do not analyze information and for low intensity environments their volume input is negligible.

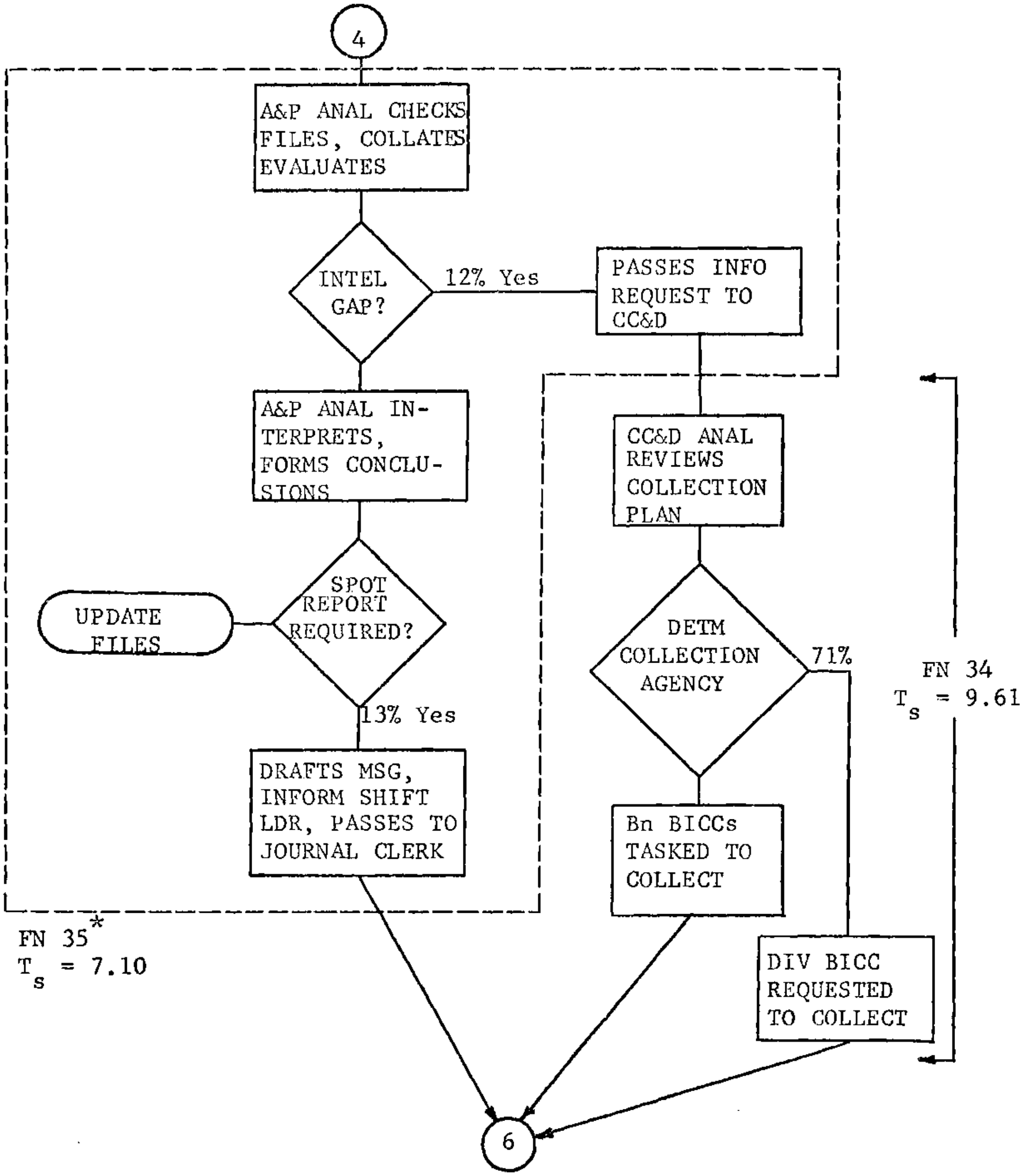

Figure 4. Continued

*All activities within enclosed area included.

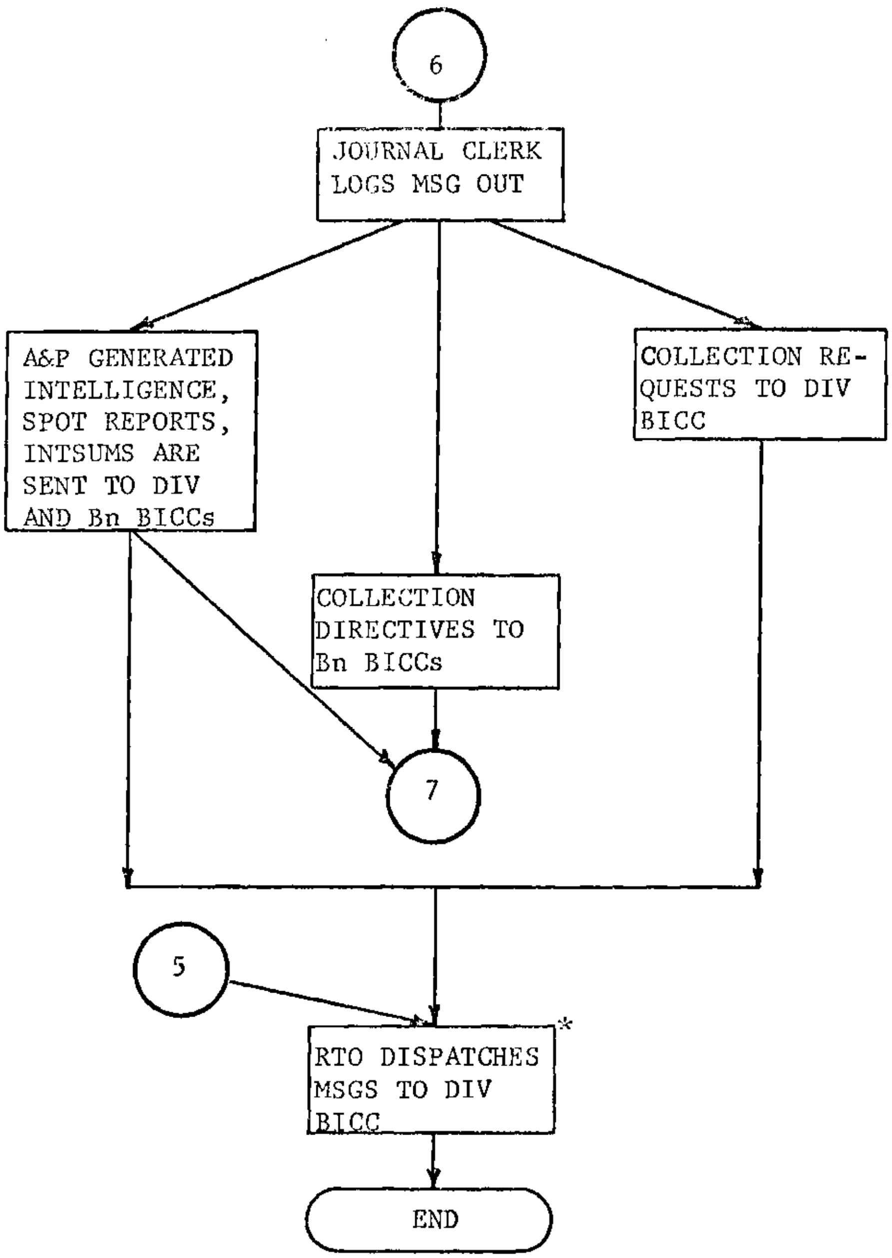

Figure 4. Concluded

*Nineteen percent transmitted by FM radio, 81 percent by sole user teletype. Bde BICC responsibility ends after message transmission.

that certain key statistics be selected to determine whether the model represents the phenomena it is supposed to represent. The results of these two determinations are then relied upon to form some kind of judgment as to the overall validity of the model. This procedure was used in validating the BICC system model. GPSS-II has two characteristics which make the first part of the procedure simple. These are the straightforward block arrangement used in GPSS to exercise logical control of the program and the automatically gathered transaction data from a run of the model. With the transaction data, it is possible to verify that the proper flow is being achieved and that the percentage routing is correct. For the second portion of the validating procedure, the key statistics selected for comparison were mean queue lengths of the critical queues and a subjective assessment of "slack" in the system. This author's observation of the Fort Hood test indicated that the system capacity was not being taxed by the low intensity inputs, which is in fact reflected by the BICC utilization factors in the validating runs. Queues observed during the test had insignificant mean lengths (less than 1) which is again matched by the Base Model validating runs. These aspects of the system's operation and a subjective analysis of the model performance based on the author's experience (three years) with the concept yield the conclusion that the model is sufficiently valid for the type of experimentation to be conducted.

Experimentation

Since after validation (Objective 1) the second objective, as stated in Chapter II, is fulfilled by the GPSS-II program automatically providing the necessary output statistics for any combination of input and parameter arrangement the primary thrust of the experimentation is directed toward Objectives Three and Four, that is, firstly, can the system performance be improved significantly by reallocation of intelligence analyst personnel and what degradation of system performance results from selected reductions in manning strengths. Second, what are the BICC systems' performance characteristics when subjected to the mid and high intensity inputs as hypothesized in Army literature (3, p. B-II-2).

Since timeliness is a critical aspect of intelligence operations, the measure of effectiveness selected to assist in answering the questions posed is the timeliness of information flow. Specifically, the timeliness of each separate priority of traffic and a combination of all priorities is examined from the time of initial message entry at the company/sensor team echelon until the information has completed processing at the Bde BICC and is ready for transmission to the division BICC.

In order to make reasonable comparisons between the system's performance with various manning configurations, it is necessary to insure that the start-up or transient effect on the pertinent statistics is discounted. To accomplish this requires that runs of different time lengths be made in order to determine, by examination of queue histories, when a system steady state has been achieved. Computer runs simulating 24, 36, and 48 hours were employed in this effort. For those configurations which did stabilize, 24 hours of system operation was sufficient to allow the system to reach steady state. Those configurations which did not achieve steady state within 48 hours are specifically discussed in Chapter IV (Results of Experimentation). Following the 24 hours stabilization period, 48 hours of simulated system operations were used for statistical purposes.

Experiment 1

The first experiment conducted was to test the effects on information transit timeliness of varying the intelligence analyst manning strengths at the Bn and Bde BICC operating with low intensity inputs. In this endeavor, six models were employed. These models are designated Base (the system as observed at Fort Hood) and numbers two through six. The configurations of models two through six were determined incrementally by examining the results of the previous runs in terms of personnel utilization factors. Generally, personnel utilization factors of the intelligence analysts at Bn and Bde BICC were examined for each configuration to determine those factors which might serve as an identifier of functions where strength alterations could influence the system's timeliness performance. Additionally, communications facility and communications personnel (radio/telephone operators) utilization factors were examined for each model configuration; however, as discussed in Chapter IV, these aspects were found not to be critical to the system's operation. For each configuration ten replications, each with a different random number seed, are run in order to use the central limit theorem's power and thereby perform the necessary tests assuming normal distribution of the mean time of each priority classification for each model configuration.

Experiment 2

This experiment concerns the system operation when the volume inputs are those specified for mid-intensity environments (Table 2). Initially the Base model is analyzed and depending upon its performance and utilization factors modifications in personnel manning strengths are made using the same rationale as discussed for Experiment 1. All model configurations examined with mid-intensity inputs are run only once after insuring that the system reaches a steady state. Each run employed the same random number seed in order to allow a comparison of results without the extensive computer time required for replications. This strategy was selected because the computer time and effort required to generate the necessary data for rigorous statistical comparisons did not seem appropriate in light of the author's belief that the mid-intensity input volumes are over estimated.

Experiment 3

This experiment is identical to Experiment 2 except that high-intensity inputs (Table 2) are used.

CHAPTER IV

RESULTS

Experiment 1

Following ten replications of the Base Model, personnel utilization, communications facility utilization, and the information transit time for each priority were averaged and examined. These data are shown in Table 5 (Personnel Utilization Factors), Table 6 (Communications Utilization Factors), and Table 7 (Low Intensity Information Transit and Processing Timeliness). For ready reference all model manning levels are shown in Table 4. As can be seen in Table 5 for the Base Model, the Bn BICC personnel utilization factors were less than the Bde factors. This prompted the removal of one intelligence analyst from each Bn BICC. This configuration was entitled Model 2 and ten replications run. As displayed (Model 2 column, Table 5), the expected increase in personnel utilization factors was achieved at the Bn level without apparently significant changes at the Bde level. The effects on the measures of effectiveness show (Table 7), for all except the highest priority category, a statistically significant difference at the five percent level. The hypotheses tested in Table 7 were equality of means assuming unknown and not necessarily equal variances. The recommended procedures for these conditions call for using the "modified t" test (27, p. 173). Statistically significant differences are indicated by asterisk. At this point it is appropri-

Table 4. Experiment 1 Manning Levels per Shift by Model

	Bn BICC		Bde BICC	
Model	CC&D	A&P	CC&D	A&P
Base	2	1	3	2
2	1	1	3	2
3*	1	1	3	2
4	2	1	2	2
5	1	1	2	2
6	3	1	4	2

Table 5. Low Intensity Intelligence Analyst Utilization Factors (Percent)

	Base	2	3	4	5	6
Bn BICC						
CC&D	19.85	41.45	34.02	20.05	38.33	12.68
A&P	16.34	19.13	17.60	18.54	17.58	16.97
Bde BICC						
CC&D	29.57	29.34	29.78	42.46	42.87	20.78
A&P	32.42	32.71	32.30	31.47	33.76	31.77

* Model 3 employs a decision rule such that the A&P analyst performs CC&D functions when the queue waiting for CC&D service is greater than two messages.

Table 6. Communications Utilization Factors (Percent)

Net	Intensity: Low	Mid	High
Bn BICC Net (FM Radio Link from Company/Sensor Team to Bn BICC)	6.83	29.08	47.49
Bde BICC Net (FM Radio Link from Bn BICCs to Bde BICC)	8.35	32.54	52.05
Division BICC Net (FM Radio Link from Bde BICC to Division BICC)	8.31	24.48	39.15
Division BICC Teletype Net (Sole User Teletype from Bde BICC to Division BICC)	3.21	8.27	12.59

Table 7. Low Intensity Information Transit and Processing Times (Minutes)

Transit Times by Priority

Model	4	3	2	1	ALL
Base	12.60	26.80	35.57	40.60	30.60
2	14.60	32.23*	41.92*	56.27*	35.35*
3	12.35	29.70	41.28*	50.23*	34.33*
4	13.22	34.20*	42.34*	67.54*	39.42*
5	15.38*	36.00*	44.51*	71.21*	41.90*
6	12.21	25.61	33.80	39.32	30.52

Processing Times by Section**

Model	Bn CC&D	Bn A&P	Bde CC&D	Bde A&P
Base	13.1	13.9	15.1	23.2
2	23.8*	26.3*	14.5	22.3
3	14.3	14.8	15.2	24.1
4	13.1	14.8	24.4*	30.1*
5	24.4*	23.8*	20.9*	29.1*
6	13.4	13.6	14.7	23.8

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* Test statistic significant at $\alpha = .05$. Hypotheses tested Base Model mean and indicated mean for equality.

** Mean time for processing information by section including time spent in queues.

ate to stress that any differences indicated as a result of hypothesis testing are based on statistical significance and not on operational significance. While it is desirable to make clear cut statements about differences in the operational significance of different mean times, this is impossible for security reasons. Even though the Army has established timeliness criteria for information flow, these data, known as CSTAIN (Commander's Surveillance and Target Acquisition Information Needs), are classified and cannot be cited in this research. Any statements made concerning the operational implication of a particular configuration are based solely on the author's opinion.

Next, it was decided to examine a slight variation of Model 2. This variation, Model 3, specifies the same number of intelligence analysts at Bn BICC as Model 2 (one each in CC & D and A & P), but employs an arbitrary decision rule which specifies that, when the CC & D queue (Queue 14) is greater than two messages, the A & P analyst, upon completion of his current task, assumes CC & D type duty until the queue is reduced to less than two. The physical arrangement of the Bn BICC and the skill levels of the analysts make this a viable strategy at Bn level, but the operating arrangement of the Bde BICC precludes such an option. The effect of this strategy is that the timeliness of both the two highest priorities of traffic are not significantly different from the Base model (Table 6) while the other categories are significantly decreased.

The next configuration tested (Model 4) restores the Bn BICC to normal strength (Table 3) but removes one analyst from the Bde CC & D section. The effect on CC & D utilization is to increase it 12 percent

(Table 5), while the effect on information timeliness is to significantly decrease all priority categories except Priority 4, the highest priority (Table 7).

The next configuration (Model 5) was selected to study the effects of raising both Bn and Bde personnel utilization factors simultaneously by deleting one analyst at each Bn BICC and Bde BICC. As can be seen in Table 7, the effects were to significantly decrease the timeliness of all priority categories.

The sixth configuration (Model 6) was exercised to provide possible answers to two questions. The first question concerns the implications of reallocating intelligence personnel, that is, can significant improvements in overall timeliness be achieved by deleting strength at one echelon and increasing the manning level at another echelon by the same total amount. In order for this reallocation to be profitable, the increased processing time at the reduced strength echelon must be compensated by an equal or greater reduction in processing time at the increased strength echelon. The second question, a natural complement to the question concerning the reduced strength models already discussed, is whether increasing the number of analysts at Bn and Bde simultaneously will yield significant improvements in timeliness over the Base model.

To answer these questions one additional analyst is added to the Base model Bn and Bde BICC strengths and ten replications of this model (Model 6) are run. The answer to the first question is provided by examining the Intermediate Processing Times portion of Table 7. As can be seen there is no significant difference in intermediate processing times at either Bn or Bde when Model 6 is compared with the Base model. There is, however, a significant increase in processing times when a one analyst reduction is made at either Bn (Model 2) or Bde (Model 4). These results indicate that there is nothing to be gained in the way of timeliness by reallocation of personnel.

The second question is answered by examining the transit time portion of Table 7. As indicated the transit times achieved by Model 6 are not significant improvements over the times achieved by the Base model; therefore, the addition of personnel is not warranted.

With the mean transit times for six models available and no apparent significance between several of the means, it was decided to determine if the variances associated with transit timeliness would assist in distinguishing between models which have the same mean times. To determine the relationship among the variances for each model and priority category, five hypotheses are tested. These hypotheses are that within a priority category the variance of transit times for each model are equal. The procedure used is Cochran's Test for the Homogeneity of Variances (27, p. 198). The tests, performed at the five percent level, result in failure to reject the hypotheses; therefore, there exists no significant difference in variances which could be used to discriminate among alternatives with equal means.

The homogeneity of variances makes it possible to perform Duncan's Multiple Range Test (28, p. 31) and subsequently to graphically portray the relation between all means for a specific priority category (Figure 5). In addition, a plot of mean transit time versus priority category for all

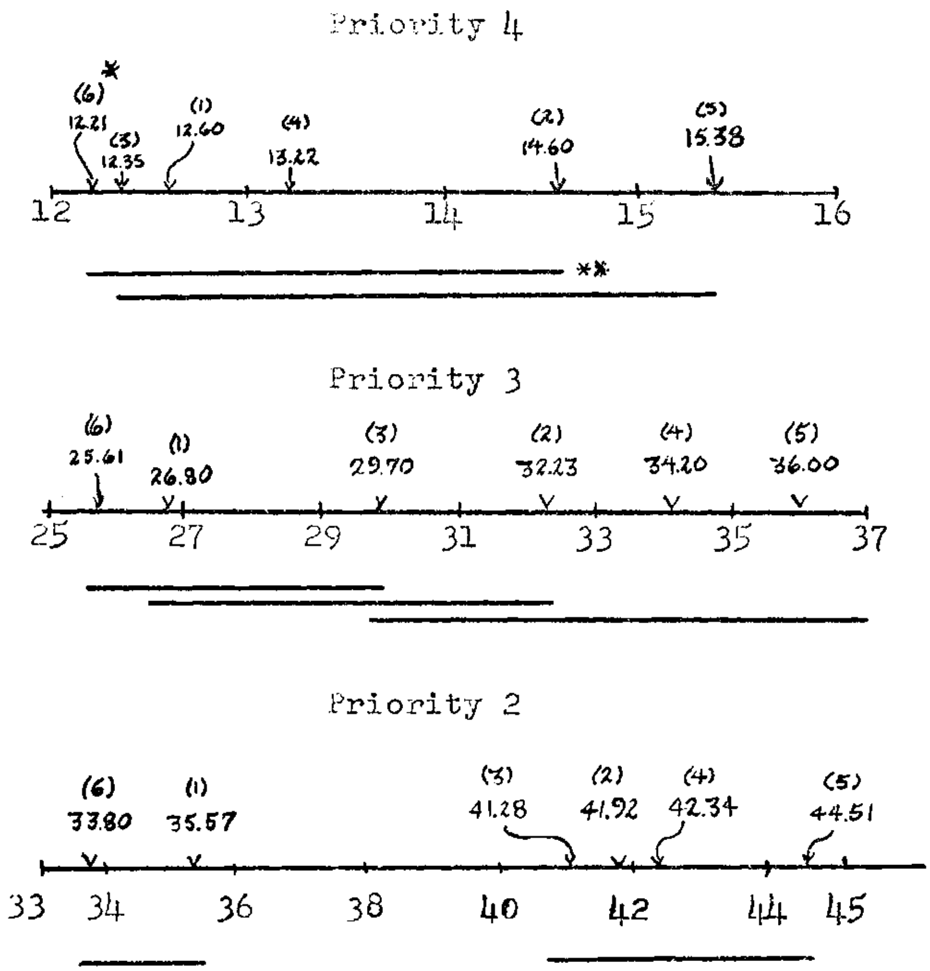

Figure 5. Results of Duncan's Multiple Range Test on Total System Transit Time by Priority

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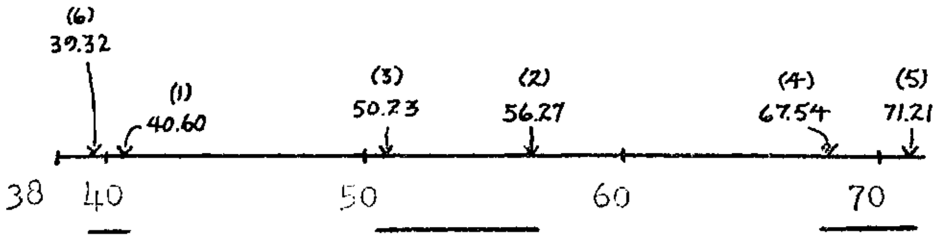
* Number in parenthesis is the model yielding the mean time in minutes shown below. Model 1 is the Base Model.

** Means underscored by the same line are not significantly different at the five percent level.

Priority 1



Priority- All Combined

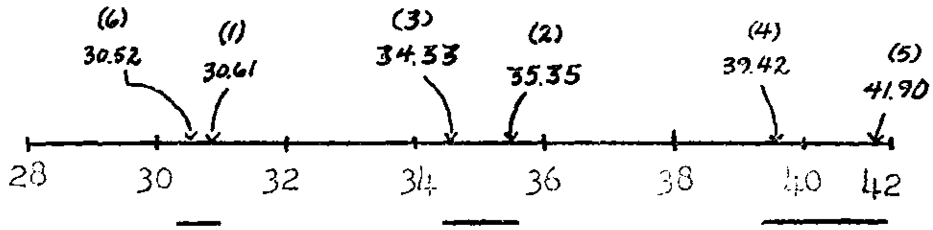


Figure 5. Results of Duncan's Multiple Range Test on Total System Transit Time by Priority(Continued)

six low intensity models is shown in Figure 6.

Figure 5 indicates that only Model 5 yields a statistically significant reduction in Priority 4 transit timeliness when compared to Model 6. This is an apparent contradiction of the data presented in Table 7 until one remembers that Table 7 used the "modified t" test which is not as precise as Duncan's Multiple Range test used in Figure 5. When evaluating the various model effects on Priority 3 transit timeliness, it is evident from Figure 5 that neither Model 2 nor Model 3 has significant degrading effects when compared to the Base model, shown as Model 1. For lower priorities, however, the issue is more clear cut. Any reduction in manning levels produces significant reductions in Priorities 2 and 1, and the "all combined" category of transit timeliness.

In the event that the BICC system manning levels were under review for possible strength reduction, it would be worthwhile to consider two cases. Case 1: If approximately eleven and six minute reductions in Priorities 1 and 2 timeliness were operationally acceptable, then Models 2 and 3 are equally attractive and would result in the saving of one analyst at each Bn BICC for a total of three in each brigade.* Case 2: If the Case 1 reductions are acceptable and an approximately three minute reduction in Priority 3 timeliness and an additional eleven minute reduction in Priority 1 timeliness are operationally acceptable, then it is possible to implement the Model 5 strength levels and save four analysts per brigade, one in each Bn BICC and one in the Bde BICC.

*Brigades normally control three battalions.

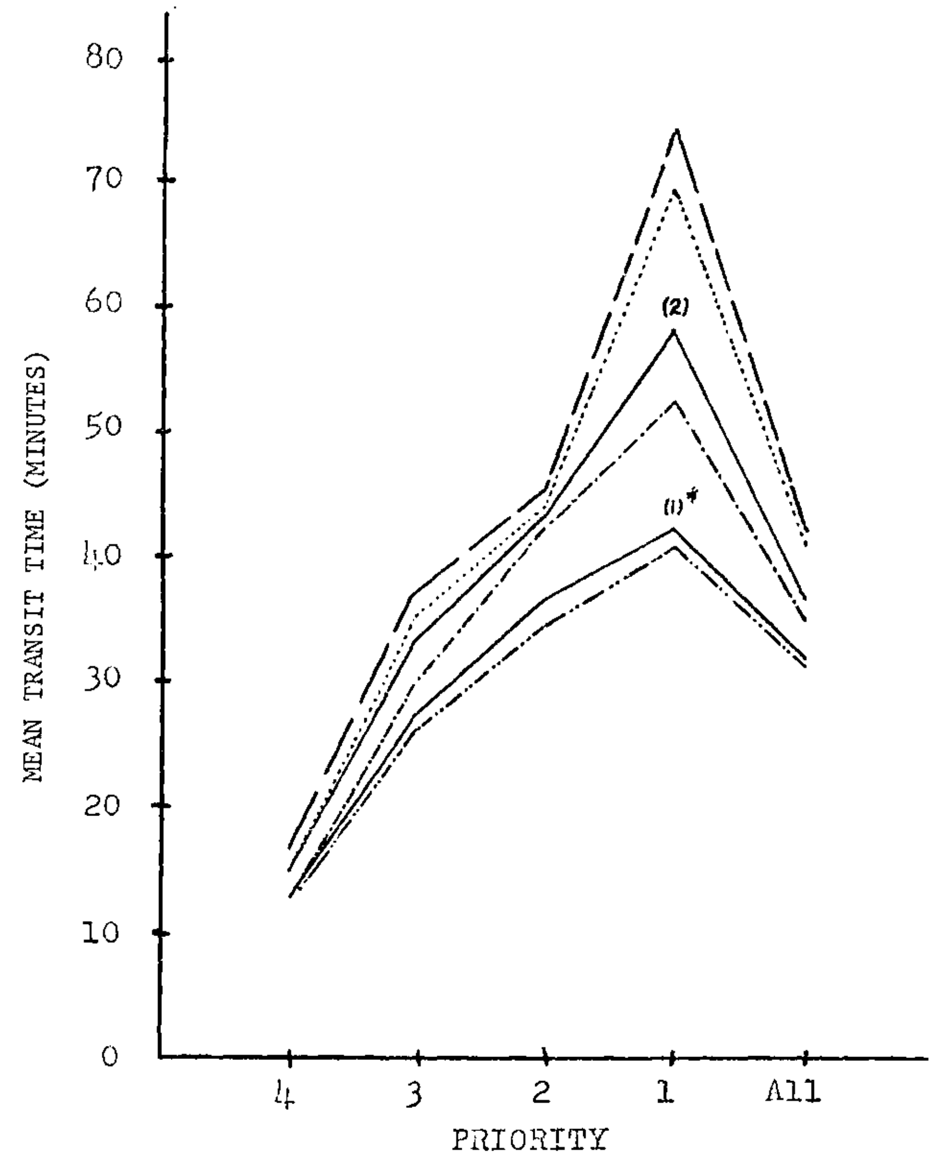


Figure 6. Total System Information Transit Times for Low Intensity Message Input

*Model: 1(Base) and 2 —————— 5 — — —
3 —·—·—·— 6 ··—··—··—
4 ··············

Of equal importance is the result that transit timeliness cannot be significantly improved by the addition of analyst personnel. In this case the author's opinion indicates that any small improvement shown by the means in Figure 5 is also not operationally significant.

While a great deal of attention has been given to personnel utilization, the communications aspects have not been ignored. In all models the communications utilization factors were examined; however, in no model were they of such magnitude as to indicate that delays in timeliness were resulting from waits to "get on the net." This observation was borne out by examining the queuing statistics for each communications facility. In all cases the mean number of messages in the queue approached zero. The first column in Table 6 shows the communications utilization factors meaned over all low intensity models. Reductions in communications nets were not contemplated since either the net has no alternative or an alternative net was specified for redundancy purposes based on tactical operational considerations. In summary, Table 6 indicates that the communications nets are not taxed by the low intensity message flows and that a considerable excess capability exists.

Experiment 2

The initial portion of this experiment concerns determining the Base model system performance when loaded with the estimated mid-intensity message flows (Table 2). The appropriate message volumes are generated and the model run for a simulated 48 hour period to determine if and when the system reaches steady state. The results of this effort are shown in

Figure 7. As can be seen by the slightly positive slope of mean time histories for Queues 31 and 34 (Bde CC & D and A & P queues), this system has not stabilized. It is difficult to tell from Figure 7, but in fact both Bn BICC queues have stabilized. While it cannot be absolutely stated that the system will not stabilize at some future time, there is no reason to believe that the slopes will ever become negative for a prolonged period. Accepting this implies that, even if the system did stabilize at some future time, the mean wait for service at the Bde CC & D and A & P sections would be equal to or greater than 1.4 and 1.2 hours, respectively. This fact makes such a system operationally unacceptable. The high personnel utilization factors for the Bde BICC shown in Table 8 correlate readily with the system's saturation. For ready reference, Table 9 shows Experiment 2 manning levels by model.

In an attempt to reduce the utilization factors and the mean queue time in order to achieve a stable system, the addition of one analyst was made to both the Bde CC & D and A & P sections. This model (Model 7) was exercised with the result that the previously unstable queues reached stability within 24 hours. A 48 hour data run was then made after a 24 hour stabilization period. This yielded the utilization factors and timeliness shown in Table 8 and Figure 8. Even though Model 7 stabilized, the long transit times for Priority 1 traffic prompted the addition of an analyst to the Bn CC & D to determine if Priority 1 transit timeliness could be significantly improved. This addition resulted in Model 8 which stabilized within 24 hours. A 48 hour run after stabilization was made which yielded the utilization factors and transit times shown in Table 8

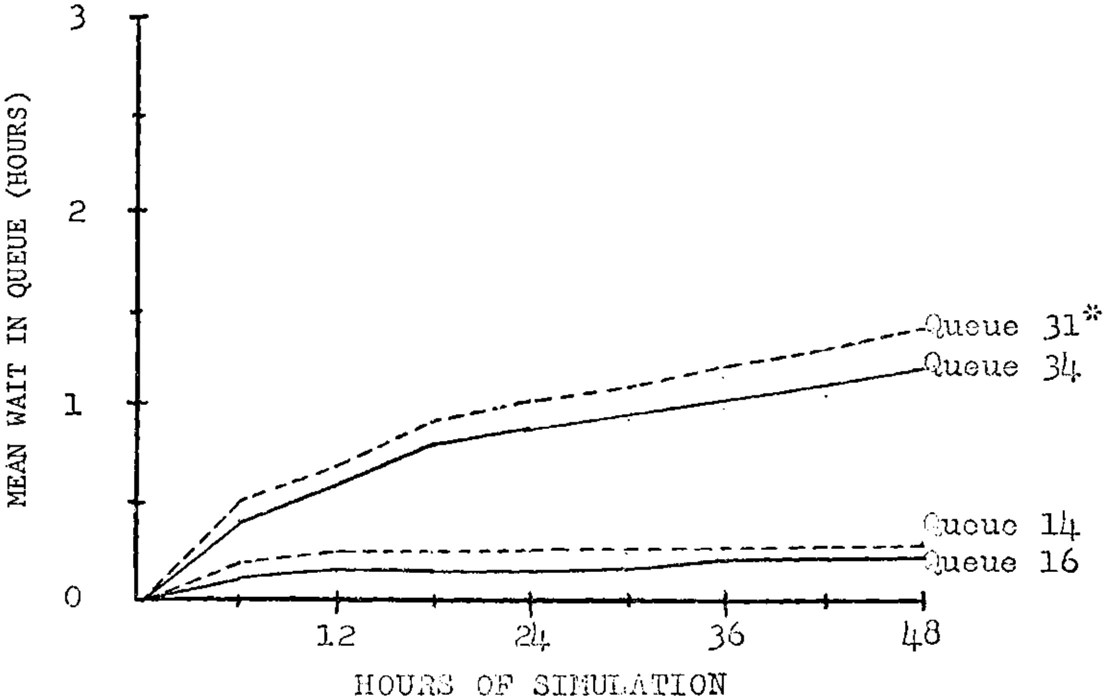


Figure 7. Mid Intensity Base Model Critical Queue Histories

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* Queue 31--Bde BICC CC&D
Queue 34--Bde BICC A&P

Queue 14--Bn BICC CC&D
Queue 16--Bn BICC A&P

Table 8. Mid Intensity Intelligence Analyst Utilization Factors (Percent)

Bn BICC	Base	7	8	9
CC&D	85.69	81.38	58.26	61.67
A&P	79.77	79.61	81.50	42.25
Bde BICC				
CC&D	1.000	82.78	84.83	92.13
A&P	1.000	77.60	74.87	83.75

Table 9. Experiment 2 Manning Levels per Shift by Model

	Bn BICC		Bde BICC	
Model	CC&D	A&P	CC&D	A&P
Base	2	1	3	2
7	2	1	4	3
8	3	1	4	3
9	3	2	4	3

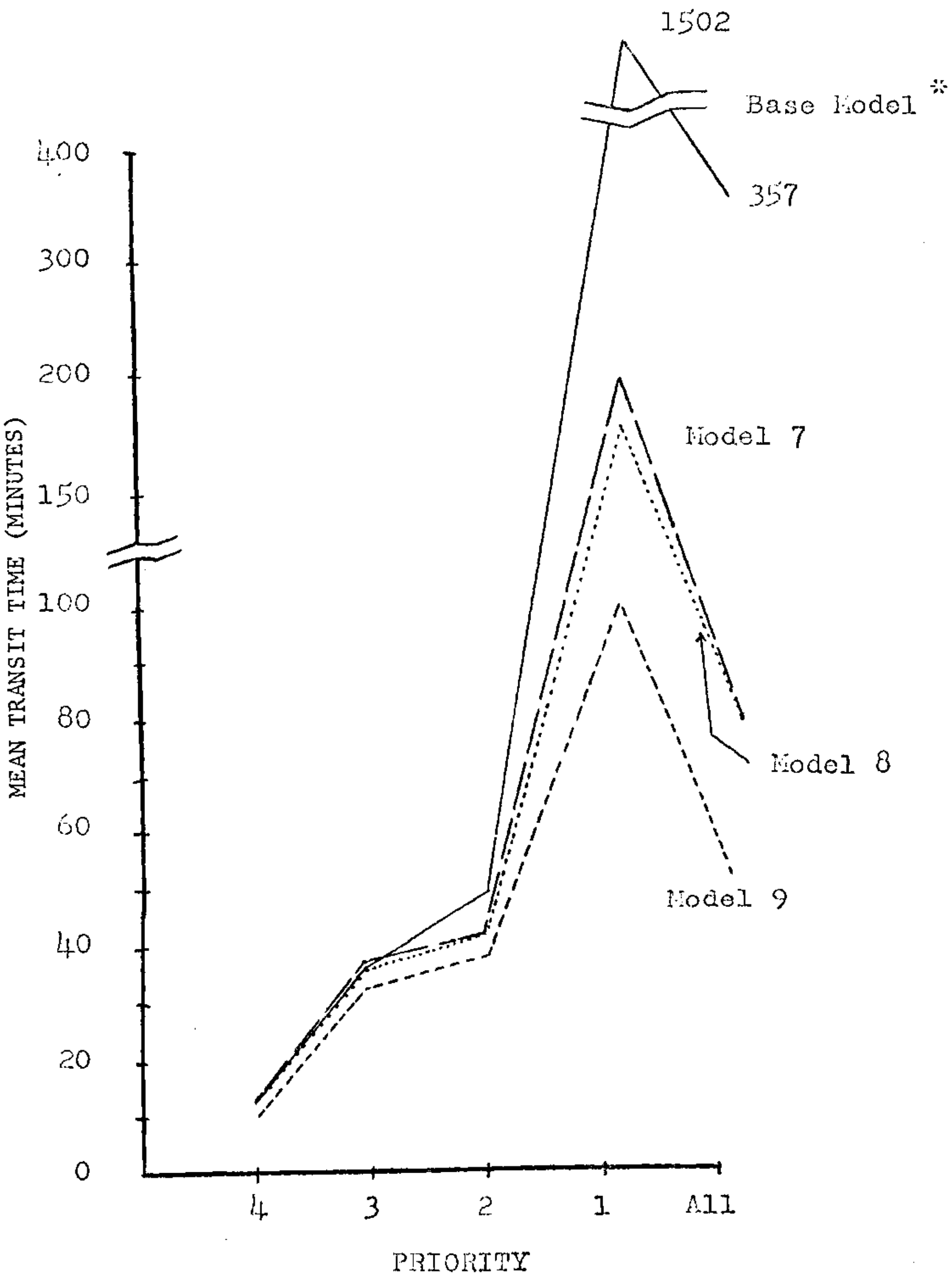

Figure 8. Total System Information Transit Times for Mid Intensity Message Input

* Model did not stabilize within 48 hours.

and Figure 8. As can be seen in Figure 8, the timeliness improvements over Model 7 are not apparently significant.

One other model (Model 9) was exercised with mid-intensity inputs. This model, formed from Model 8 by the addition of an analyst to the Bn A & P Section, represents the maximum manning level that can be used per shift in the Bn BICC and Bde CC & D Section due to the physical limitation of the work area. The Model 9 transit time results in Figure 8 show that there was a slight improvement in timeliness of Priorities 4, 3, and 2 and an apparent significant improvement in timeliness for Priority 1 and the "all combined" category.

The absence of replications of the models precludes any meaningful rigorous statistical comparisons of the mid-intensity results. However, what is evident from this experiment is the fact that the estimated mid-intensity inputs overload the system as described by the Base model. Additionally, it is apparent from a comparison of timeliness between Figures 6 and 8 that all of the mid-intensity models which stabilize yield substantially the same transit timeliness as the low-intensity models for the three highest priorities of traffic; however, even the most timely mid-intensity model (Model 9) is significantly slower than all of the low-intensity models in Priority 1 and the "all combined" category.

From Table 6 it is noticed that communications utilization factors increased substantially from the low-intensity environment; however, examination of the waiting times to get on the net reveal that losses in transit timeliness due to net crowding are not significant and would not warrant additional communications facilities. For example, the greatest time lost waiting for net usage occurs at the Bn BICC where only 39.2 percent of the traffic routed to the Bde BICC finds the net busy. In the event that a message arrives and finds the net busy, the mean wait for service is only 32 seconds. All other nets either have a zero wait or a wait time less than 32 seconds.

Experiment 3

This experiment is conducted substantially as Experiment 2. Table 10 gives the strength configurations studied in this experiment. Initially, the Base model is exercised with the high-intensity inputs (Table 2) for a simulated 48 hour period. Examination of the results reveals extremely high personnel utilization factors (Table 11), and a plot of the critical queue histories (Figure 9) indicates the system's failure to stabilize within the 48 hour period.

As a possible remedy, Model 10 was formed by adding, simultaneously, one analyst to each of the Bn CC & D Sections and to the Bde CC & D and A & P Sections. This model also failed to stabilize; therefore, Models 11, 12, and 13 were sequentially formed with the manning levels shown in Table 10 with the hope that one configuration would achieve stability. Unfortunately, this was not the case and, even though Model 13 manning levels are in excess of practical strength limits, it was decided to continue strength additions until at least a stabilizing model was found. Fortunately, this occurred with Model 14, which has exactly twice the analyst strength as the Base model. The transit timeliness results for all models are shown in Figure 10. Comparing Figures 8 and 10 for these

Table 10. Experiment 3 Manning Levels per Shift by Model

	Bn BICC		Bde BICC	
Model	CC&D	A&P	CC&D	A&P
Base	2	1	3	2
10	3	1	4	3
11	3	2	4	3
12	3	2	5	3
13	3	2	6	4
14	4	2	6	4

Table 11. High Intensity Intelligence Analyst Utilization Factors (Percent)

	Model					
Bn BICC	Base	10	11	12	13	14
CC&D	99.88	95.79	96.04	94.49	98.98	73.06
A&P	89.73	98.84	64.83	65.03	71.92	62.80
Bde BICC						
CC&D	99.58	99.48	99.58	98.62	96.73	97.95
A&P	97.02	94.70	86.49	99.32	97.00	75.70

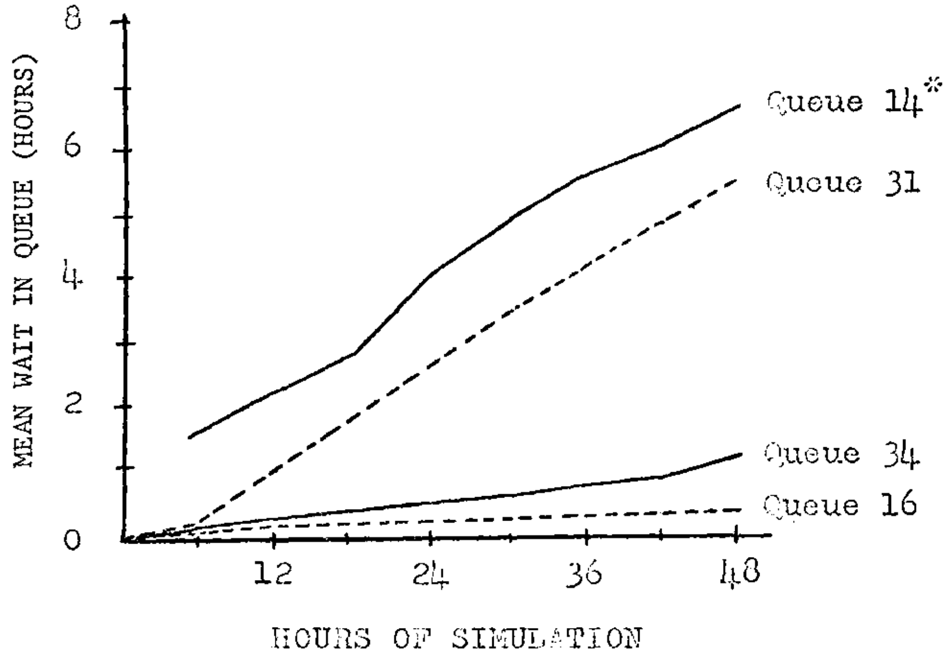

Figure 9. High Intensity Base Model Critical Queue Histories

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* Queue 14-- Bn BICC CC&D
Queue 16-- Bn BICC A&P
Queue 31-- Bde BICC CC&D
Queue 34-- Bde BICC A&P

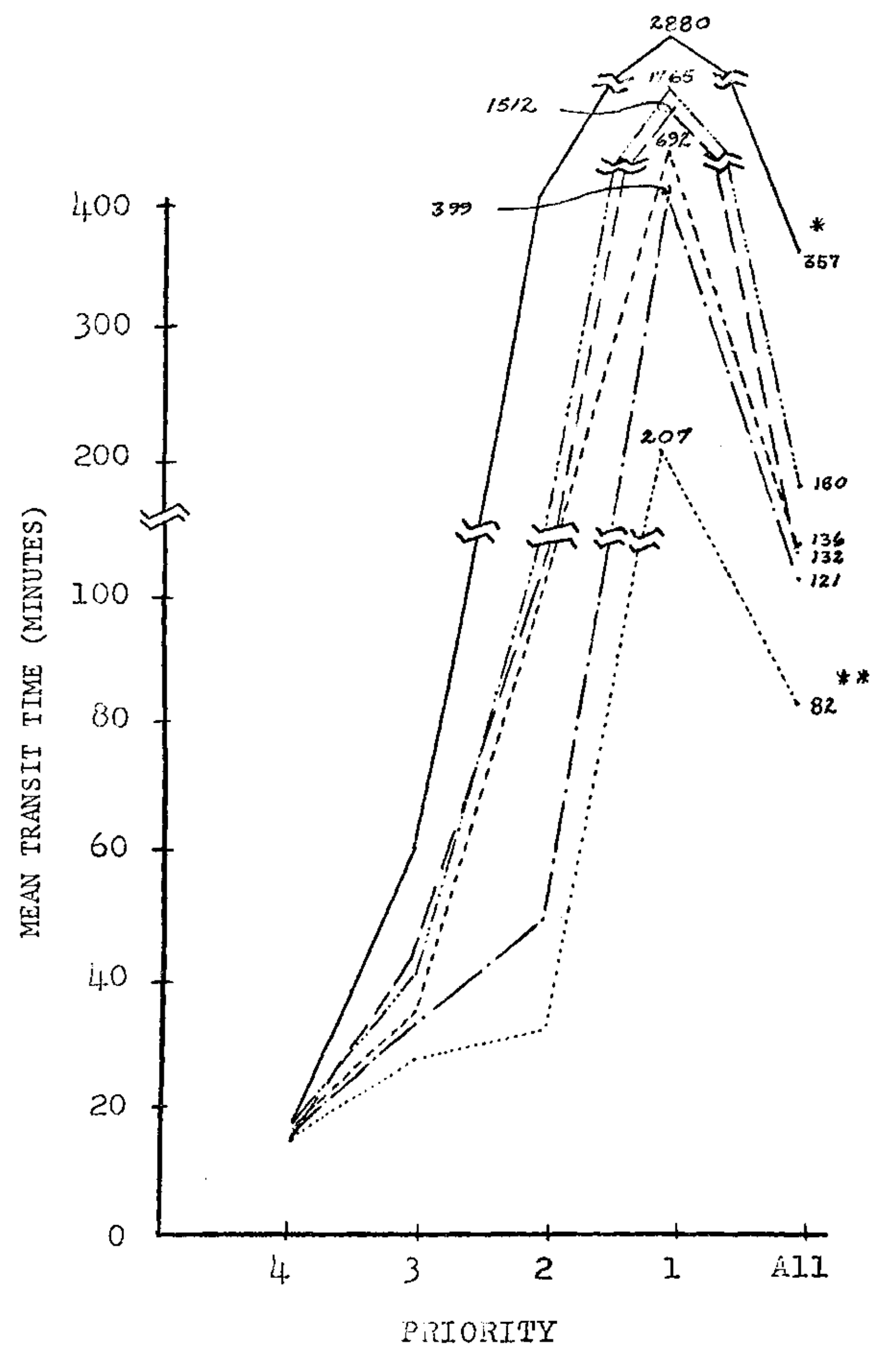

Figure 10. Total System Information Transit Times for High Intensity Message Inputs

*Model: Base, 10, 11, 12, 13, 14

** The only model that stabilized within 48 hours.

models which did stabilize shows that there is very little difference in transit timeliness for the three highest priorities of traffic but that the Priority 1 and "all combined" category transit times do respond significantly differently to the mid and high intensity inputs.

Communication utilization factors (Table 6) increased as expected; however, examination of queue data relative to communications usage shows no significant degradation of overall timeliness is attributable to overloaded nets. As in the mid-intensity environment, the minor waiting which occurs in the system takes place in the Bn BICC. Here 66 percent of the traffic bound for the Bde BICC finds the FM net busy; however, the mean wait is less than 90 seconds.

The high-intensity results indicate that the Base model system is incapable of effective and timely operation in that environment. Additionally, the number of analysts which must be added in order to even stabilize the system is in excess of practical limits based on physical facility limitations.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

General Comments

While the system described by the Base model is believed to be an accurate representation of the real world system for low intensity environments, it should be remembered that results and conclusions reached from exercising this model with mid and high intensity inputs are less reliable than the low intensity results. This comment is prompted by the author's experience concerning the propensity of analysts to disseminate information in low volume flow situations (low-intensity environments) which might not be disseminated if a greater volume of higher quality data was available. This phenomenon is incorporated in the observed model in the form of the percentage flow routing shown in Figure 4. It is highly probable that analysts would be more discriminating in mid and high intensity environments, that is, the percentage of information determined significant enough for immediate dissemination could be lower which would affect the communications utilization factors and the traffic load on echelons above battalion.

Additionally, the volume flows used in the mid and high intensity experiments are Army estimates and significant alterations of these volumes could substantially affect the conclusions concerning the mid and high intensity environments.

Conclusions

1. The simulation model constructed for this research is flexible and with care in determining the input data and essential system parameters could be used to study a wide variety of intelligence system configurations.

2. GPSS-II is an appropriate language for a simulation study of this type in that it minimizes programming time and permits the majority of the effort to be devoted to data collection and to the study of the system through experimentation.

3. A system model incorporating the hypothesized internal operations of the BICC and their associated processing times, as shown in Figure 2, will not successfully accommodate the estimated information flow (Table 2) for any of the listed environments.

4. The observed system, as represented by the Base model, can be reconfigurated for low intensity operations with an analyst strength savings of three personnel per brigade, if minor degradations in the two lowest priorities of information timeliness are operationally acceptable.

5. No significant improvements in timeliness of information can be achieved by either increasing analyst strengths or communications facilities in low intensity environments.

6. Mid-intensity volume flow overloads the base system processing capability but does not tax communications facilities. Increasing analyst strength partially alleviates the problem; however, even with the maximum practical manning level at Bn BICC, the system fails to produce Priority 1 transit timeliness comparable to the Base model operating with

low-intensity inputs.

7. High-intensity inputs to the Base model system saturate the system's processing capability but do not overload available communications. Increasing analyst strengths, within practical limits, does not produce acceptable system operation.

8. For those system's configurations which stabilize, the transit timeliness for the highest two priorities is not significantly different regardless of intensity of the environment. Priority 1 (lowest priority) shows the greatest sensitivity to input and configuration changes and could be used as a rough estimator of a system's performance in intelligence systems design projects.

Recommendations

1. As stated in an earlier assumption, personnel changes were made assuming equal incremental changes in the altered sections' processing capability. Research into the overall capability of the BICC section as a function of manning strength should be conducted to determine the relationship between manning level and incremental capability changes so that relationship could be incorporated into the model.

2. In this research, personnel utilization factors were examined from the aspect of identifiers for activities where either slack capability or inadequate capability existed. It is expected that utilization factors are more important than this sole use indicates. It is known that human performance and efficiency in information handling tasks are fairly stable within a given work range, but there is evidence that there

is a sharp performance decline at a saturation point rather than a gradual decline when quantity of information is increased by a higher rate of presentation (29, p. 1117). The implication of this phenomenon for the BICC system requires that research be conducted to determine the correlation between the expected saturation point for the general population of analysts and utilization factors so that some realistic upper bound on utilization factors can be established for use in intelligence systems design.

3. More research effort should be directed toward identifying adequate computer systems to assist in low echelon (Bn and Bde) processing functions. This is particularly important since computer or machine aggregation is most beneficial in circumstances which produce large volumes of low quality data (30), the exact situation resulting from the recent trend in sensor systems, particularly the unattended ground sensors.

4. An attempt should be made to verify mid and high intensity information inputs so that more confidence could be placed in results of experimentation with the BICC model.

5. This study should be extended to cover the entire division BICC system.

APPENDIX A

FUNCTIONS USED IN THE GPSS-II PROGRAM*

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*FUNCTION 1 is not shown as it is a common exponential distribution which can be used with any mean time to produce time lengths that are exponentially distributed about the specified mean.

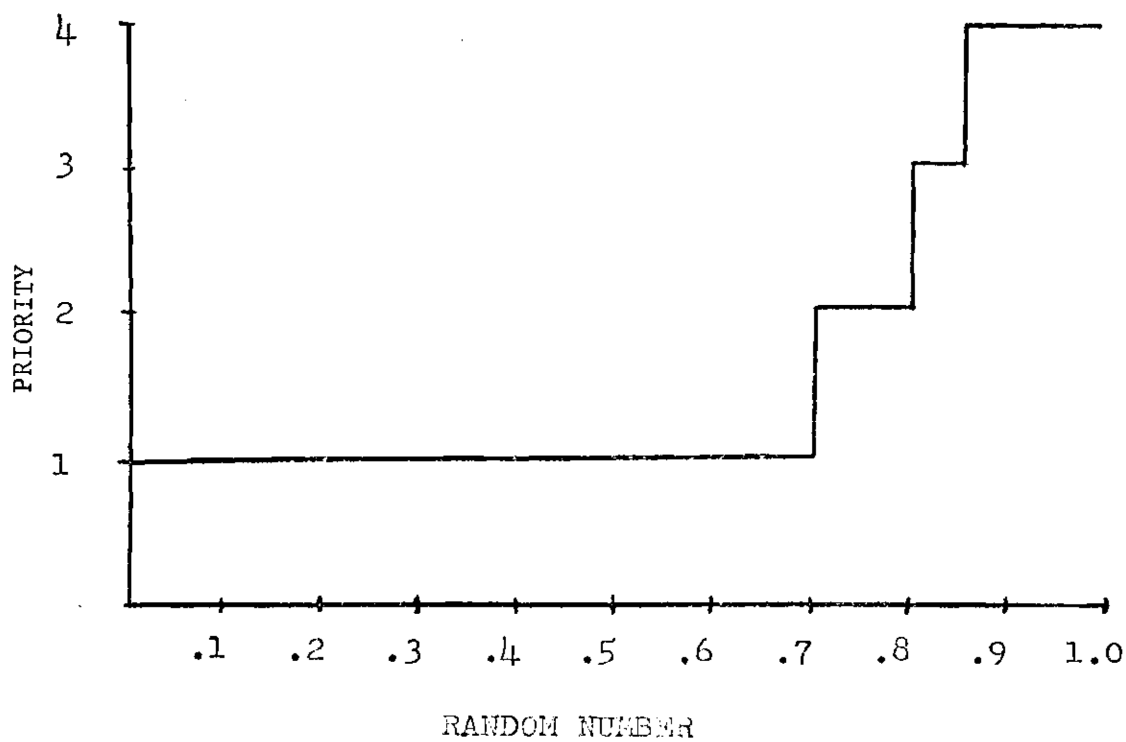

Figure 11. FUNCTION 3-- Priority Assignment

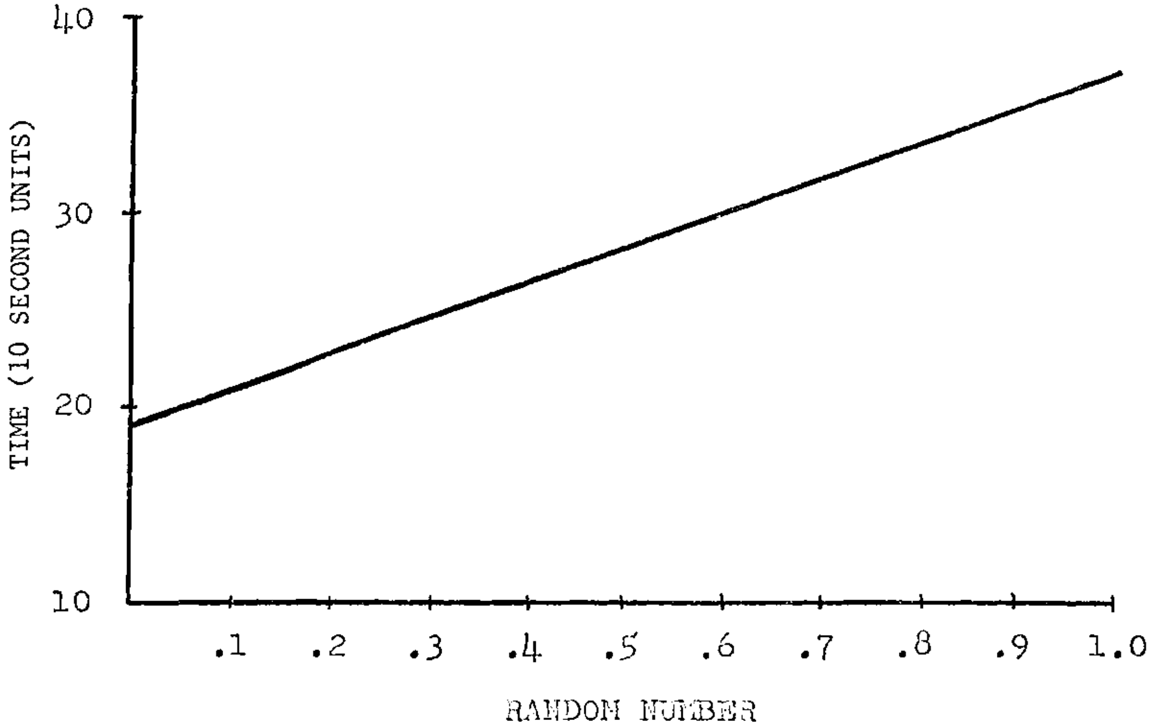

Figure 12. FUNCTION 8 -- Teletype Tapo Preperation Times (23)

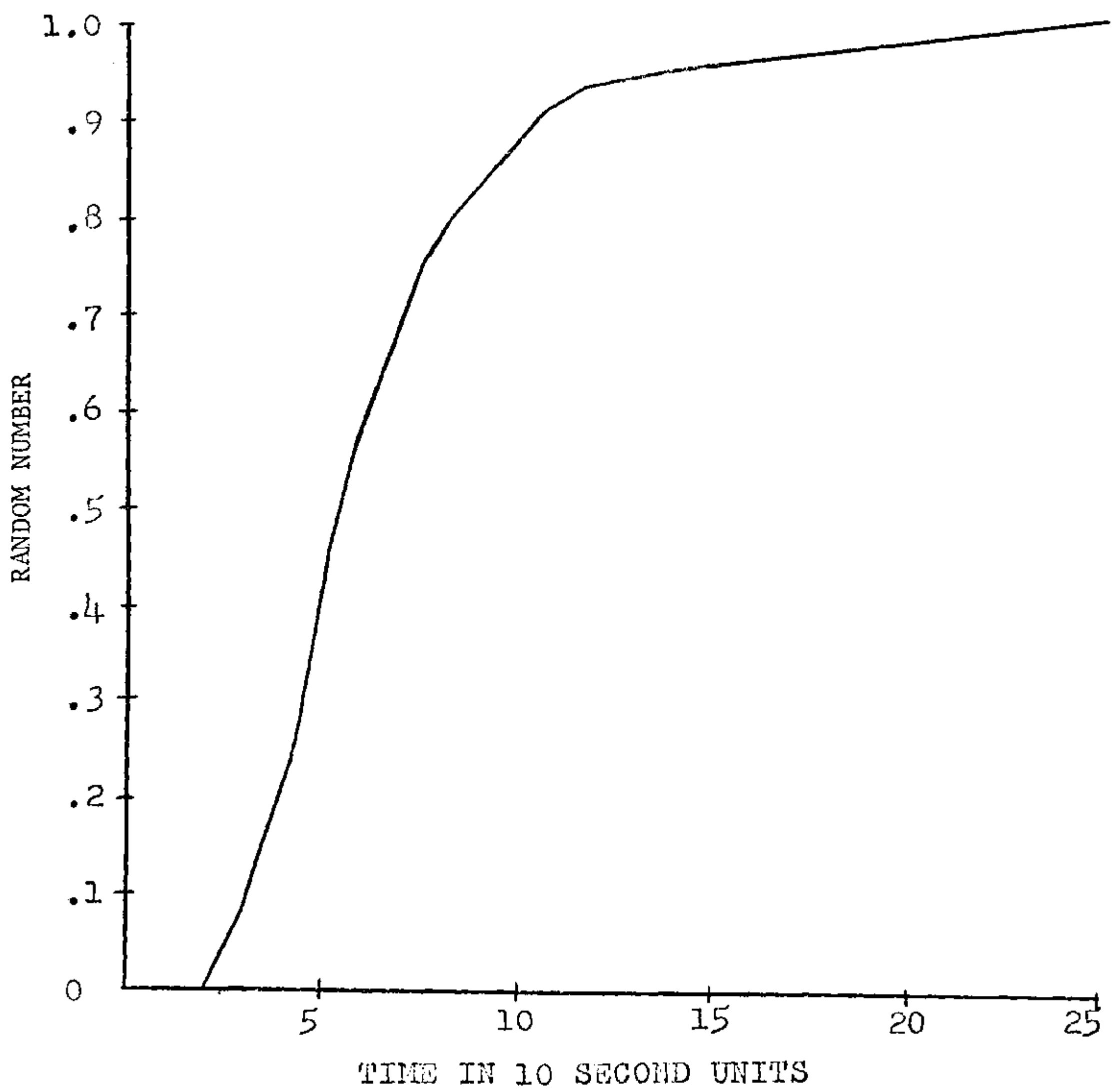

Figure 13. FUNCTION 11-- Cumulative Distribution of FM Radio Transmission Times *

---

*Weibull distribution is $F(t) = 1 - \exp^{-\frac{(t-2)^{1.1}}{3.67}}$

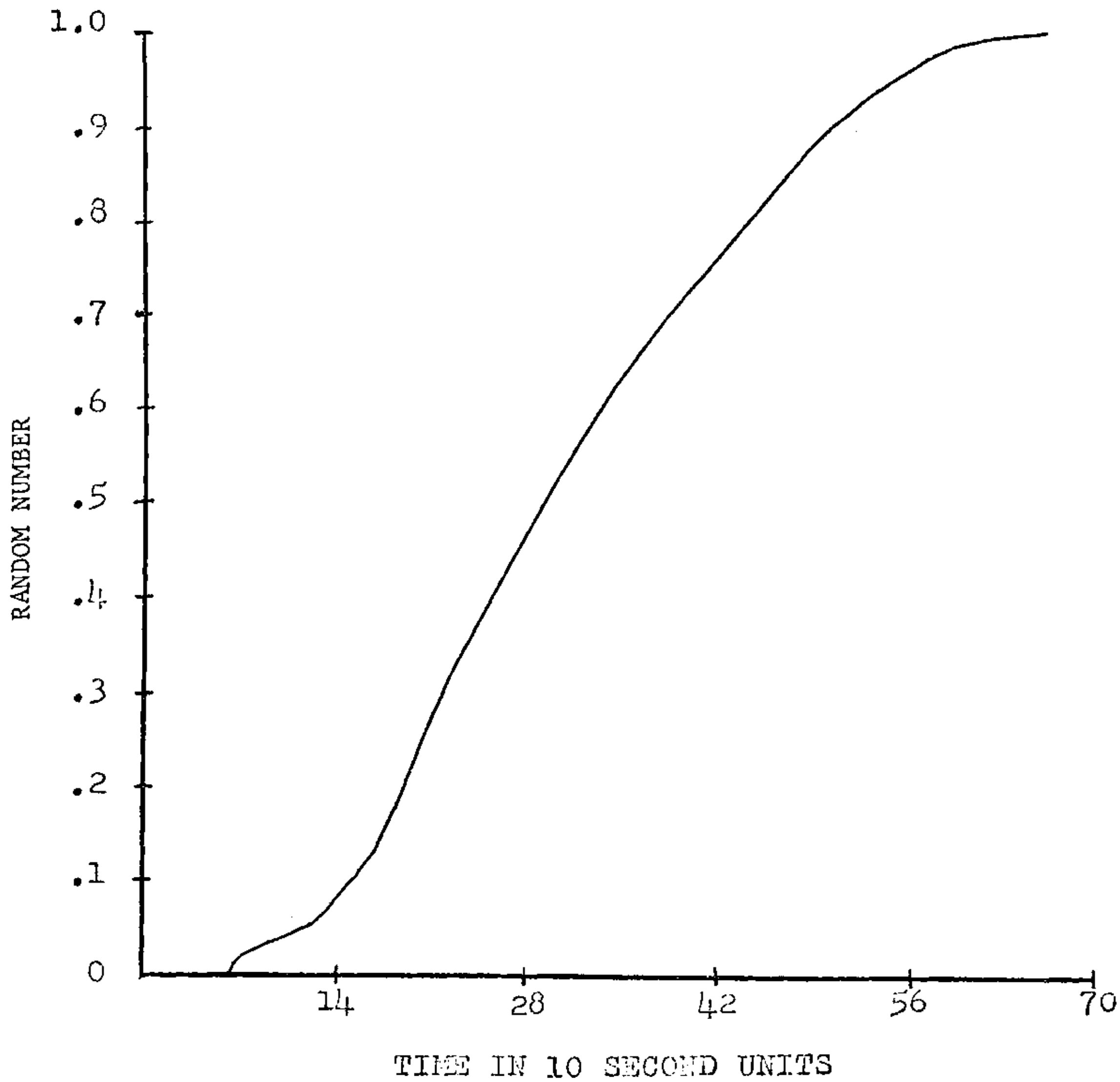

Figure 14. FUNCTION 30-- Cumulative Distribution of Bn BICC CC&D Service Times *

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*Weibull distribution is $F(t) = 1 - \exp^{-\frac{(t-3)^{2.3}}{240.6}}$

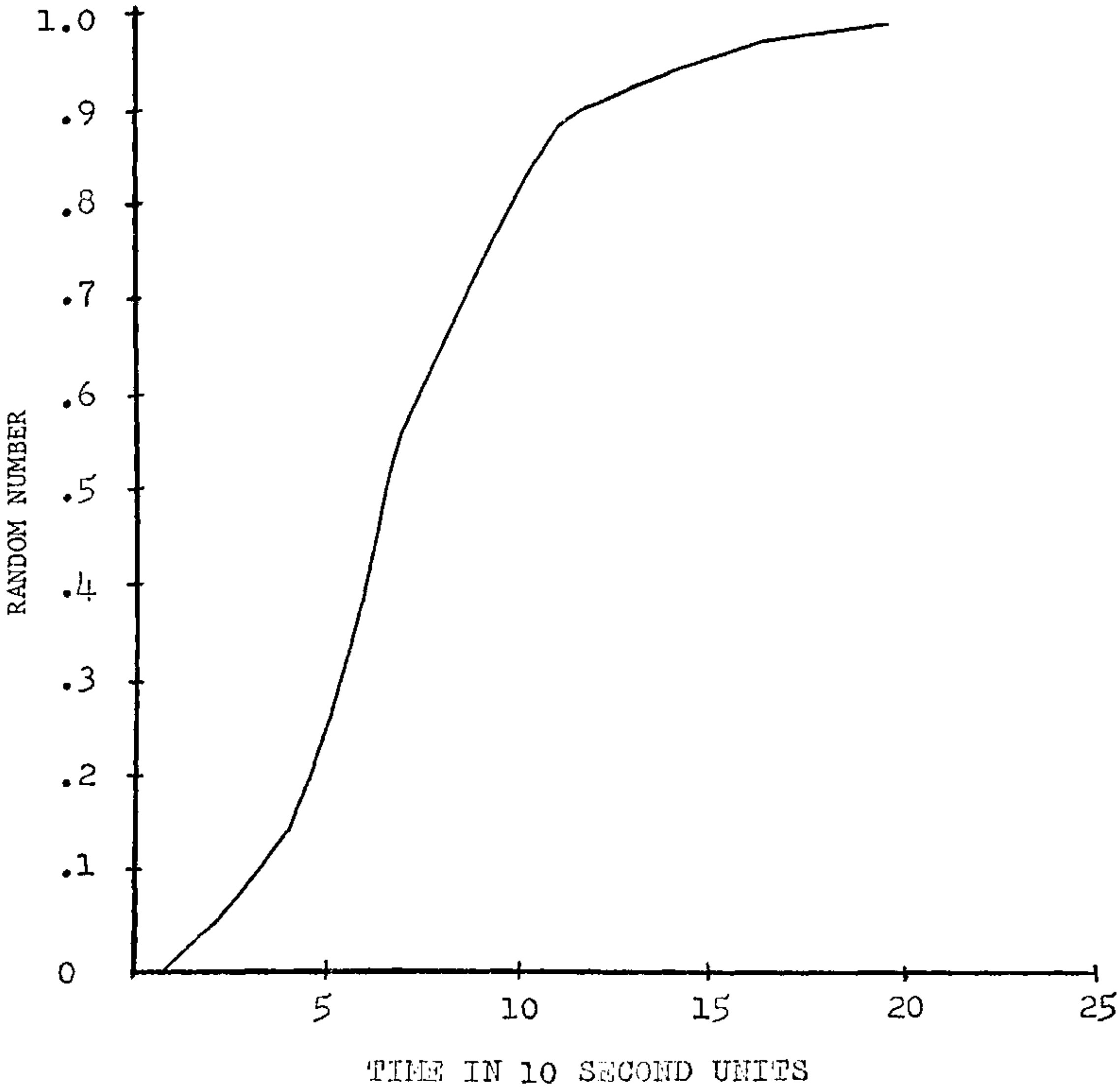

Figure 15. FUNCTION 31-- Cumulative Distribution of Journal Entry Service Times *

---

* Weibull distribution is $F(t) = 1 - \exp^{-\frac{(t-.5)^{1.9}}{54.59}}$

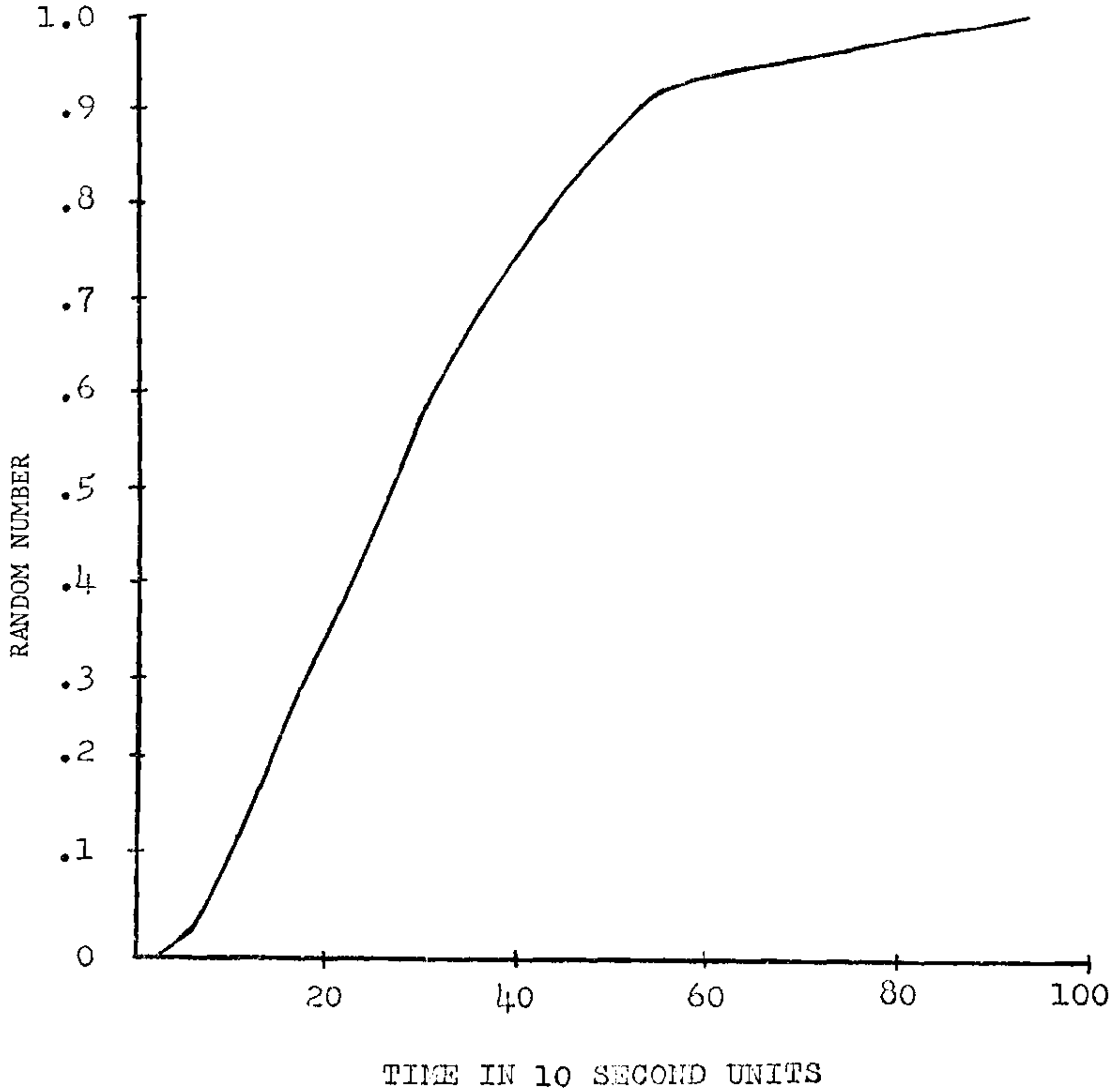

Figure 16. FUNCTION 32-- Cumulative Distribution of Bn BICC A&P Service Times*

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*Weibull distribution is $F(t)= 1\text{-}\exp^{-\frac{(t-.5)^{1.68}}{14.87}}$

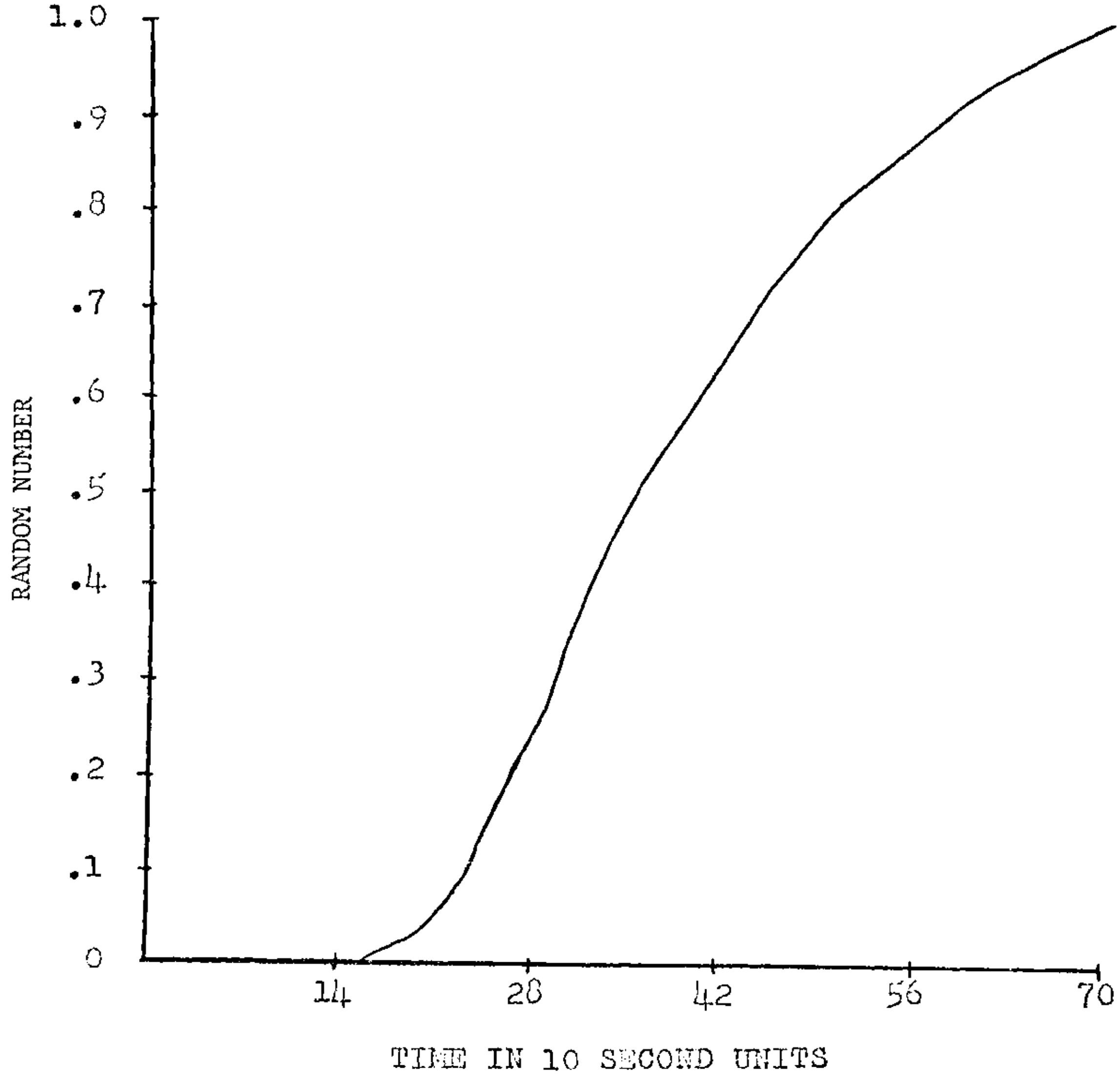

Figure 17. FUNCTION 33-- Cumulative Distribution of Bde BICC CC&D Service Times *

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*Weibull distribution is $F(t)=1-\exp^{-\frac{(t-16.5)^{1.62}}{2.46}}$

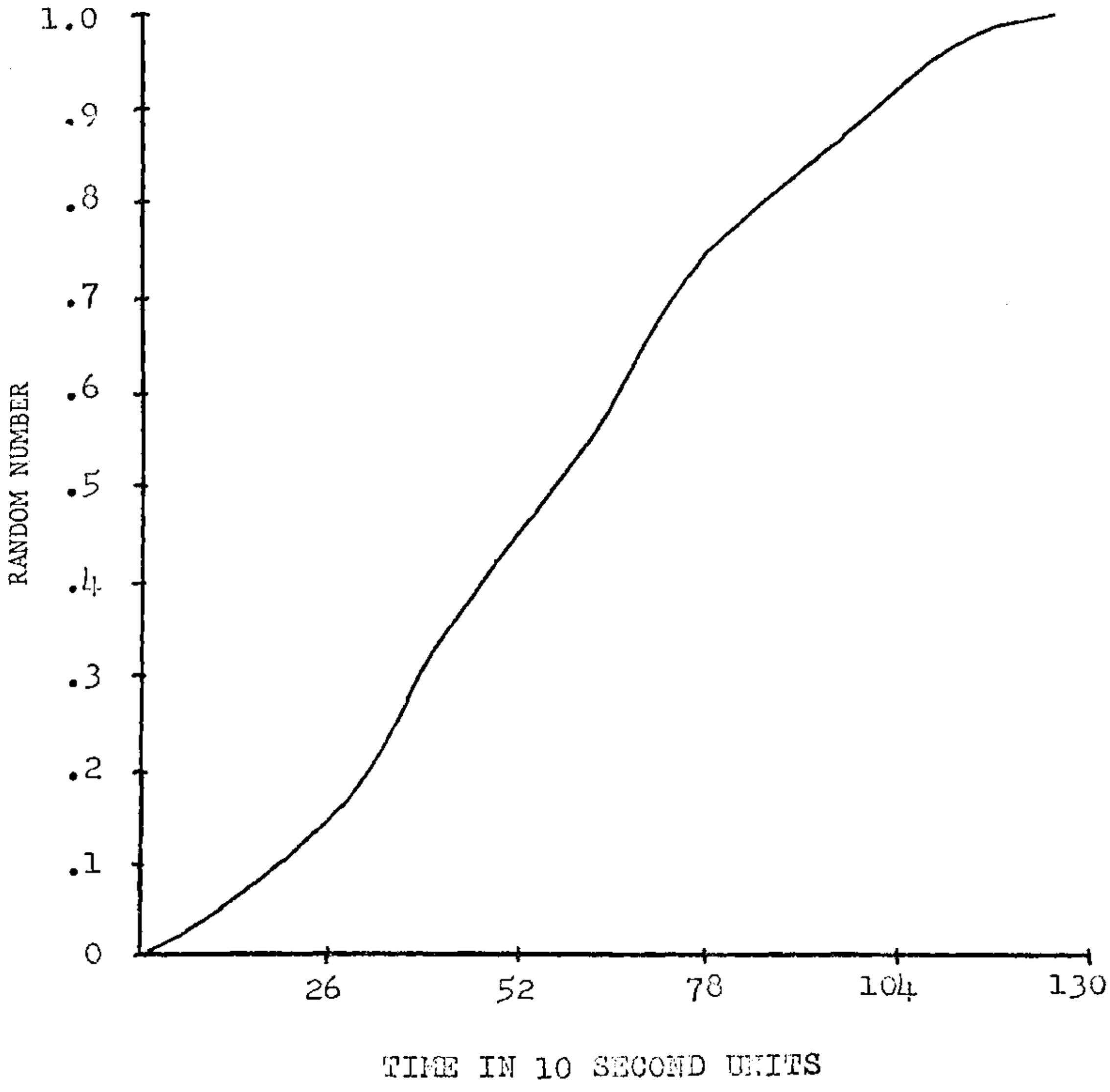

Figure 18. FUNCTION 34-- Cumulative Distribution of Collection Management Service Times*

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*Weibull distribution is $F(t) = 1 - \exp - \frac{(t)^{1.96}}{109.94}$

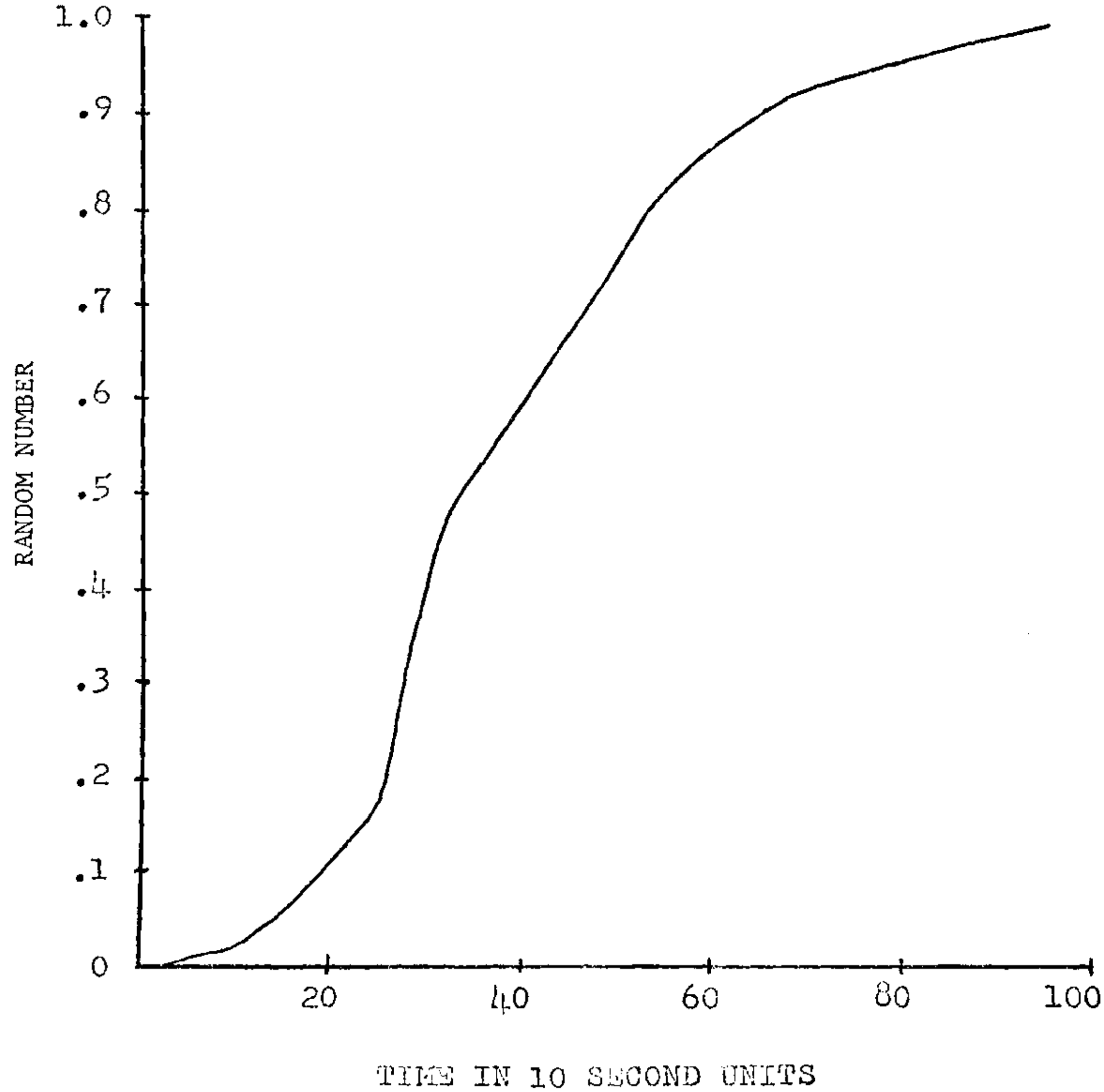

Figure 19. FUNCTION 35-- Cumulative Distribution of Bde BICC A&P Service Times *

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*Weibull distribution is $F(t) = 1 - \exp^{-\frac{(t-3)^{2.4}}{99.48}}$

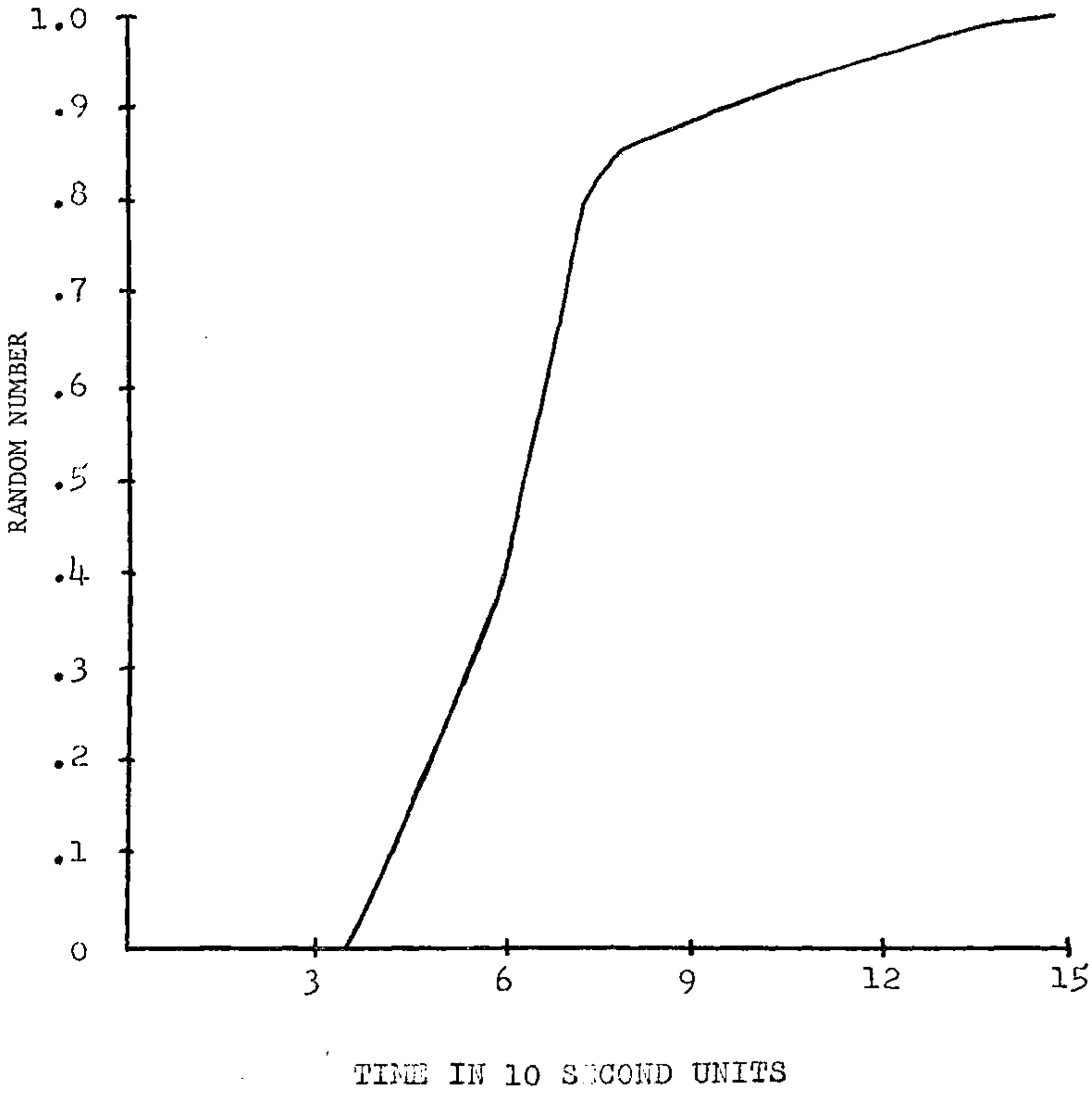

Figure 20. FUNCTION 36-- Cumulative Distribution of Shift Leader's Initial Review Service Times *

---

*Weibull distribution is $F(t)= 1-\exp^{-\frac{(t-4)^{1.05}}{2.22}}$

Figure 21. FUNCTION 40-- Bde BICC Collection Request Routing Control *

---

* Twenty one percent of Bde BICC generated collection requests are directed to the Bn BICCs and the remaining 79 percent are forwarded to the Division BICC.

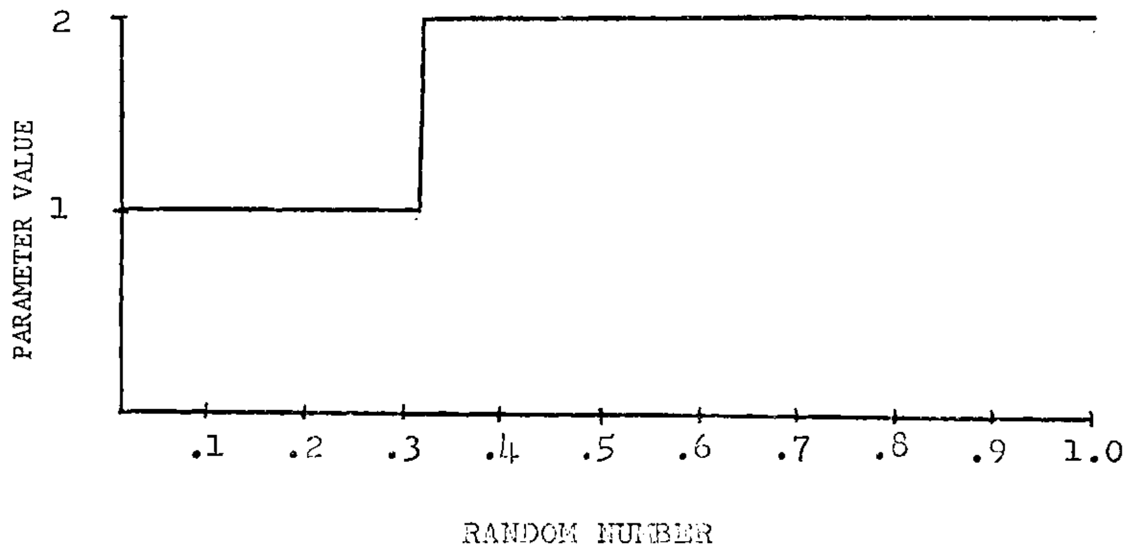

Figure 22. FUNCTION 41-- Controls Bn BICC RTO Utilization *

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* This function insures that the Bn BICC RTO utilization factor reflects the proper proportion of Bde BICC to Bn BICC message traffic.

APPENDIX B

GPSS-II COMPUTER PROGRAM AND EXAMPLE RUN RESULTS

```
LOC  NAME        X     Y     Z     SEL   NBA   NBB   MEAN  MOD   REMARKS   F


     JOB         265101624025
 1   FUNCTION    RN1   C24   EXPONENTIAL DISTRIBUTION
 0   0     .1    .104  .2    .222  .3    .355  .4    .509  .5    .69
.6   .915  .7    1.2   .75   1.38  .8    1.6   .84   1.83  .88   2.12
.9   2.3   .92   2.52  .94   2.81  .95   2.99  .96   3.2   .97   3.5
.98  3.9   .99   4.6   .995  5.3   .998  6.2   .999  7     .9997 8
 3   FUNCTION    RN1   D4                                    PRIORITY ASSGN
.25  1     .70   2     .80   3     1.00  4
 8   FUNCTION    RN1   C3                                    TAPE CUT DIST
.00  18    .50   60    1.0   18
 11  FUNCTION    RN1   C16
.00  2     .086  3     .241  4     .442  5     .563  6     .666  7
.781 7     .844  9     .890  10    .913  11    .942  12    .959  14
.971 15    .976  17    .994  23    .999  24
 20  FUNCTION    RN1   C24    EXPONENTIAL DISTRIBUTION
 0   0     .1    .104  .2    .222  .3    .355  .4    .509  .5    .69
.6   .915  .7    1.2   .75   1.38  .8    1.6   .84   1.83  .88   2.12
.9   2.3   .92   2.52  .94   2.81  .95   2.99  .96   3.2   .97   3.5
.98  3.9   .99   4.6   .995  5.3   .998  6.2   .999  7     .9997 8
 21  FUNCTION    C1    D4                                    PERS LEVEL
4680 1     8640  1     10440 1     17280 1
 30  FUNCTION    RN1   C14                                   BN CC&D SVC TM
.010 6     .017  8     .053  13    .178  18    .303  23    .464  28
.589 33    .696  38    .767  43    .857  48    .928  53    .982  58
.999 61    1.00  65
 31  FUNCTION    RN1   C17                                    JOUR ENTY TM
.00  1     .039  2     .093  3     .156  4     .249  5     .367  6
.546 7     .679  8     .773  9     .812  10    .882  11    .914  12
.953 14    .968  15    .992  16    .99918      1.00  19
 32  FUNCTION    RN1   C16                                   BN A&P SVC TM
.00  0     .031  6     .158  12    .284  18    .431  24    .597  30
.683 36    .800  42    .863  48    .916  54    .937  60    .946  66
.957 72    .973  80    .988  86    1.00  92
 33  FUNCTION    RN1   C30                                   BDE CC&D SV TM
.00  16    .011  17    .022  18    .033  19    .043  21    .054  22
.087 23    .109  24    .142  25    .164  26    .230  27    .252  28
.265 29    .317  30    .339  31    .372  32    .416  33    .438  34
.515 37    .559  40    .646  43    .690  45    .734  47    .767  50
.811 52    .854  55    .887  57    .931  61    .964  67    1.00  71
 34  FUNCTION    RN1   C18   COLLECTION MGMT SVC TM DISTRIBUTION
.00  6     .032  12    .128  24    .161  30    .225  36    .322  42
.386 48    .483  54    .548  60    .580  66    .676  72    .741  78
.774 84    .806  90    .870  96    .934  108   .992  120   1.00  126
 35  FUNCTION    RN1   C16                                   BDE A&P SVC TM
.00  0     .025  12    .063  18    .178  24    .332  30    .498  36
.639 42    .690  48    .805  54    .869  60    .920  66    .934  72
.958 78    .971  84    .984  90    1.00  96
 36  FUNCTION    RN1   C9     PRIORITY MSG SVC TM DISTRIBUTION
.00  0     .091  4     .363  6     .773  7     .864  8     .909  11
.954 12    .998  14    1.00  15
 40  FUNCTION    RN1   D2                                    INFO NEED SORT
.71  2     1.00  3
 41  FUNCTION    RN1   D2                                    BN RTO UTILIZ
```

```
.333  1     1.00  2
 3    VARIABLE     FN11*K1
 183  GENERATE                           BOTH   185     780     1
 185  COMPARE      N186    L       K1           186
 186  ADVANCE                                   187             4680           USED WITH  185
 187  ADVANCE                                   186             3960           USED WIT8   85
 15   ORIGINATE                          BOTH   16      105     374     FN1    NORMAL TRAFFIC
 16   COMPARE      W186    E       K1           32
 20   ORIGINATE                          BOTH   21      105     374     FN1    NIGHT TRAFFIC
 21   COMPARE      W187    GE      K1           32
 32   ASSIGN       4       FN3                  34                             PRIORITY ASSGN
 34   ASSIGN       3       V3                   36                             TRANS TIME FM
 36   PRIORITY     *4      BUFFER               38
 38   ASSIGN       6       K1                   40                             DATA ENTRY PT
 40   ASSIGN       2       K2                   42                             MSG TYPE CLASS
 42   ASSIGN       5       K12                  44                             MSG EVAL ASSGN
 44   QUEUE        2                            46                             CODEING QUEUE
 46   HOLD         2                            48              1              MSG INIT PREP
 48   SPLIT                                     50      56                     VOLUME MULT
 50   SPLIT                                     52      54                     VOLUME MULT
 52   QUEUE        6                            100                            FM RADIO QUEUE
 54   QUEUE        8                            100             1       1      FM RADIO QUEUE
 56   QUEUE        10                           100             1       1      FM RADIO QUEUE
 64   PRIORITY     4       BUFFER               68                             PRIORITY /SSGN
 80   ORIGINATE                                 82              180     FN1    BN-SEN TRAF
 82   PRIORITY     1       BUFFER               90
 90   ASSIGN       3       V3                   92                             TRANS TIME FM
 92   ASSIGN       1       K1                   94                             TYPE TRAFFIC
 94   ASSIGN       2       K1                   96                             BN-CO MSG TYPE
 96   QUEUE        12                           100                            BN-CO TRAF QUE
 100  SEIZE        6                     BOTH   110     111
 110  COMPARE      P2      E       K1           101             *3             TRAFFIC SORT
 101  RELEASE      6                     BOTH   102     103                    NETFREEANDSORT
 102  COMPARE      P1      E       K1           105                            TRAFFIC SORT
 103  TABULATE     1                            105                            TRANS TIME TAB
 111  SEIZE        7                            112             *3             BN BICC RT6
 112  RELEASE      6                            113                            FREES FM NET
 113  MARK         8                            114                            START BN PROC
 114  TABULATE     2                            115                            TAB TRAN TIME
 115  RELEASE      7                            116                            FREES RTO
 116  ADVANCE                            BOTH   120     124                    SORTS PRI TRAF
 120  COMPARE      PR1     L       K4           128
 124  INTERRUPT    13                           126                     FN36   SHIFT LDR SCAN
 126  SPLIT                                     128     134                    SIMUL ACTION
 134  ADVANCE                            .870   105     136                    87% MSG FWD
 136  ASSIGN       1       K4                   188                            ID FOR SORT
 128  ADVANCE                            BOTH   130     132                    SHIFT CONTROL
 130  COMPARE      Q14     L       K2           138                            NORMAL OPS
 132  ASSIGN       1       K1                   140                            BUSY OPS SHIFT
 138  ASSIGN       1       K1                   140                            NORM OPS SHI6T
 140  QUEUE        14                           145                            CC&D QUEUE
 145  ENTER        14      P1                   148                            ENTER CC&D
 14   CAPACITY     2
 148  ADVANCE                                   150                     FN31   ENTER JOURNAL
 150  ADVANCE                            .660   152     160             FN30   CC&D ANALE&CTN
 152  ADVANCE                                   154                            WRITE OUT MSG
 154  ADVANCE                                   156                     FN31   FILE&JOUR ENTY
```

156	LEAVE	14	P1			188				FREE ANALYST
160	LEAVE	14	P1			162				FREE ANALYST
162	QUEUE	16				174				A&P NORMAL QUE
164	COMPARE	Q14	GE	K3		166				CC&D BUSY TIME
166	QUEUE	17				168				BUSY TIME QUE
168	COMPARE	Q14	L	K2		174				QUEUE CONTROL
174	ENTER	16				176				
16	CAPACITY	1								
176	ADVANCE					178			FN32	A&P ANALYSIS
178	LEAVE	16			.110	180	184			11% NEED INFO
180	ADVANCE				.070	106	182			7% NEW SR
182	ASSIGN	1	K3			188				IO FOR A&P SR
184	HOLD	13			.75	90	188		FN34	SHIFT LOR SCAN
188	ADVANCE				BOTH	200	201			MSG SORT
200	COMPARE	P2	E	K4		105				DSTRY AIR MSGS
201	ADVANCE				ALL	202	204			TRAFFIC SORT
202	COMPARE	P1	E	K3		206				FULL ANAL SR
203	COMPARE	P1	E	K4		205				PRI 6 SPOT RPT
204	TABULATE	40				210				OTHER SPOT RPT
205	TABULATE	42				209				TAB PRI 6
206	TABULATE	41				207				TABS DETAIL SR
207	TABULATE	43			BOTH	208	212			FULL ANAL TM
209	TABULATE	44			BOTH	208	212			CC&D INTEM TM
210	TABULATE	45			BOTH	208	212			CO-BN TRAN TM
208	COMPARE	PR1	GE	K3		220				TRAF SORT
220	SPLIT					224	232			VOL EXPANSION
212	ADVANCE					220				
232	SPLIT					234	236			VOL EXPANSION
234	QUEUE	19				240				
236	QUEUE	21				240				
224	ASSIGN	7	K1			225				
225	QUEUE	20				228				OUTBOUND QUE
240	SEIZE	20			BOTH	241	243			
228	GATE	NU7				240				RTO CAN TRANMT
241	COMPARE	P7	E	K1		242				
242	INTERRUPT	7				244		*3		RTO USE
243	ADVANCE					244		*3		NO RTO USE
244	RELEASE	20			BOTH	245	250			
245	COMPARE	P2	E	K4	.333	246	106			
246	ADVANCE					116				
250	TABULATE	50				254				COMB TRAN TIME
254	MARK	8			BOTH	256	268			TABS START TM
256	COMPARE	PR1	GE	K4		258				HIGH PRI TRAF
258	INTERRUPT	14				260			FN36	SHIFT LOR SCAN
260	SPLIT					262	268			SIMULT ACTION
262	ADVANCE				.12	107	264			12% FORWARDED
264	ASSIGN	1	K6			375				IO FOR STAT
268	QUEUE	29				270				JOUR CLERK QUE
270	HOLD	29			ALL	273	275	1	FN31	JOUR CLERK
273	COMPARE	P1	E	K11		328				SRI&INFO REQST
274	COMPARE	P1	L	K6		288				INCOMING TRAF
275	ADVANCE				BOTH	276	280			OUTGOING TRAF
276	COMPARE	P1	E	K12		278				OUTBOUND INTSM
278	SPLIT					285	393			INTSUM DISSEM
280	ADVANCE				ALL	281	283			OUTBOUND SORT
281	COMPARE	P7	E	K3		285				BDE-BN SPT RPT
282	COMPARE	P1	E	K8		284				DUAL DISSEM SR

284	SPLIT					285	375			SR SPLIT
283	ADVANCE					375				DIV INFO RQRMT
285	ASSIGN	7	FN41			286				BN RTO LOAD ID
286	ASSIGN	2	K4			240				ID FOR BN PROC
288	QUEUE	31				290				CC&D QUEUE
290	ENTER	31			BOTH	291	292			START CC&D
31	CAPACITY	3								
291	COMPARE	P1	E	K9		294				ID FOR COLL FN
294	ADVANCE					320			FN34	COLL PLANNING
320	ASSIGN	7	FN40			322				COLL DIR SORT
322	ASSIGN	1	K10			324				OUTBOUND MSG
324	LEAVE	31				268				FREES ANALYST
326	ASSIGN	1	K9			288				COLLECTION ID
292	ADVANCE				.76	293	295		FN33	CC&D REVIEW
293	ADVANCE					296				SR MSG PREP
296	LEAVE	31				298				FREES ANALYST
298	ASSIGN	1	K7			268				OUTBOUND MSG
295	LEAVE	31				302				FREES ANALYST
302	ASSIGN	5	K1			304				ID FOR CONTROL
304	QUEUE	34				306				A&P QUEUE
306	ENTER	32			BOTH	309	310			START A&P
32	CAPACITY	2								
309	COMPARE	P5	E	K1		311				REG TRAF SORT
311	ADVANCE				.88	313	314		FN35	FULL ANALYSIS
313	LEAVE	32				326				FREE ANALYST
314	LEAVE	32			.13	105	315			13&NEW SPT RPT
315	ASSIGN	1	K8			268				OUTBOUND MSG
310	ADVANCE					316		360	90	INTSUM PRODUCT
316	LEAVE	32				319				FREES ANALYST
319	ASSIGN	1	K12			268				INTSUM ID
300	ORIGINATE			2		254		860	FN1	COLL DIRECTIVE
330	ASSIGN	1	K11			268				COLLECTION ID
308	ORIGINATE	1440		2		304		4320		INTSUM REQMNT
328	HOLD	14				302			FN36	SHIFT LDR SCAN
375	TABULATE	57			ALL	376	379			COMM SORT
376	COMPARE	P1	E	K6		380				PASSES TOP PRI
377	COMPARE	P1	E	K7		381				PASS CC&D ANAL
378	COMPARE	P1	E	K8		382				PASS A&P ANAL
379	ADVANCE				ALL	383	386			PRI SORT
380	TABULATE	51				379				TAB PRI 6 TOTM
381	TABULATE	52				379				TAB CC&D PROC
382	TABULATE	53				379				TAB A&P PROC
383	COMPARE	PR1	GE	K4		390				FLASH TO RADIO
384	COMPARE	PR1	E	K3		387				PRI 3 PASSES
387	TABULATE	54			.81	390	393			TABS TOT PRI 3
385	COMPARE	PR1	E	K2		388				PASSES PRI 2
388	TABULATE	55			.81	390	393			TABS TOT PRI 2
386	TABULATE	56			.50	393	394			TABS TOT PRI 1
390	QUEUE	35				395				FM RADIO QUE
395	STORE	33				108			FN11	FM RADIO
33	CAPACITY	1								
393	QUEUE	36				396				PRE TAPE CUT
396	STORE	34				397		1	FN8	TAPE CUTTING
34	CAPACITY	2								
397	QUEUE	37				398				PRE SEND
398	STORE	35				107				LL TELTYPE
35	CAPACITY	1								

```
394  ADVANCE                                  107                  MSG
105  TERMINATE
106  TERMINATE
107  TERMINATE
108  TERMINATE
700  GENERATE          1                      701                  PRINT ROUTINE
701  ASSIGN     1      K10                    702                  HISTORY OF
702  SAVEX      *1     QT16          BOTH     703    704           QUEUE16 EVERY
703  COMPARE    P1     E       K58            705                  HOUR FOR THE
704  ASSIGN     1+     K1                     702          360     SIMULATION
705  PRINT      10     58                     701          360
706  GENERATE          1                      707
707  ASSIGN     1      K60                    708
708  SAVEX      *1     QT17          BOTH     709    710
709  COMPARE    P1     E       K108           711
710  ASSIGN     1+     K1                     708          360
711  PRINT      60     108                    707          360     Q17 HISTORY
720  GENERATE          1                      721
721  ASSIGN     1      K110                   722
722  SAVEX      *1     QT14          BOTH     723    724
723  COMPARE    P1     E       K158           725
724  ASSIGN     1+     K1                     722          360
725  PRINT      110    158                    721          360     Q14 HISTORY
730  GENERATE          1                      731
731  ASSIGN     1      K160                   732
732  SAVEX      *1     QT34          BOTH     733    734
733  COMPARE    P1     E       K208           735
734  ASSIGN     1+     K1                     732          360
735  PRINT      160    208                    731          360     Q34 HISTORY
740  GENERATE          1                      741                  PRINT ROUTINE
741  ASSIGN     1      K210                   742                  HISTORY OF
742  SAVEX      *1     QT31          BOTH     743    744           QUEUE31 EVERY
743  COMPARE    P1     E       K258           745                  HOUR FOR THE
744  ASSIGN     1+     K1                     742          360     SIMULATION
745  PRINT      210    258                    741          360
498  ORIGINATE                                499          298  FN1  DIV&BDE INPUT
499  ASSIGN     4      K2                     500
500  PRIORITY   *4     BUFFER                 501
501  ADVANCE                         .81      502    503           TT-TEL USE
502  STORE      33                            254          9    FN1  USE FM RADIO
503  STORE      35                            254          4    FN1   USE TT
780  TERMINATE
2    TABLE      M1     0       6     60   TABS CO-BN INTEL TRAFFIC
40   TABLE      MP8    18      6     30   BN BICC CC&D PROCESSING TIMES
41   TABLE      M1     72      6     20   TOTAL TRAN TM CO - BN A&P PROCESSING
42   TABLE      M1     0       6     20   PRIORITY 4 TOT TRAN TM CO THRU BN BICC
43   TABLE      MP8    72      6     40   BN BICC A&P PROCESSING TIMES
44   TABLE      MP8    0       3     40   PRIORITY 4 BN BICC PROCESSING TIMES
45   TABLE      M1     24      6     40   TOT TRAN TM CO-BN CC&D PROCASSING
50   TABLE      M1     12      12    60   TRANSIT TIME INTO BDE FOR ALL PRIORITY
51   TABLE      M1     28      6     20   PRIORITY 4 TOTAL SYSTEM TRAN TIME
52   TABLE      MP8    0       12    20   BDE BICC CC&D PROCESSING TIME
53   TABLE      MP8    36      18    20   BDE BICC A&P PROCESSING TIMES
54   TABLE      M1     72      36    40   PRIORITY 2 TOTAL SYS TRAN TIME
55   TABLE      M1     72      36    40   PRIORITY 3 TOTAL SYS TRAN TIMES
56   TABLE      M1     120     36    40   PRIORITY 1 TOTAL SYS TRAN TIMES
57   TABLE      M1     36      12    60   TRANSIT TIME THRU BDE FOR ALL PRIOR9TY
```

START 17280

SAVEX

NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
10	0	11	1	12	4	13	4	14	3
15	3	16	2	17	2	18	4	19	4
20	3	21	3	22	3	23	3	24	4
25	4	26	4	27	4	28	4	29	4
30	4	31	4	32	4	33	4	34	4
35	4	36	4	37	4	38	3	39	3
40	3	41	3	42	3	43	5	44	6
45	6	46	6	47	5	48	5	49	5
50	5	51	5	52	5	53	5	54	5
55	5	56	5	57	5	58	6	59	0

SAVEX NR........VALUE NR........VALUE NR........VALUE NR........VALUE NR........VALUE

ALL SAVEX VALUES REFERENCED BY PRINT BLOCK 711 ARE ZERO.

SAVEX

NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
110	0	111	10	112	8	113	8	114	7
115	6	116	6	117	6	118	7	119	6
120	6	121	6	122	6	123	6	124	11
125	11	126	11	127	10	128	10	129	9
130	9	131	9	132	9	133	9	134	9
135	9	136	9	137	9	138	9	139	9
140	9	141	9	142	9	143	10	144	10
145	9	146	9	147	9	148	9	149	9
150	9	151	9	152	9	153	9	154	9
155	9	156	9	157	9	158	9	159	0

SAVEX

NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
160	0	161	0	162	20	163	17	164	16
165	15	166	13	167	13	168	12	169	11
170	11	171	10	172	10	173	9	174	9
175	9	176	8	177	16	178	15	179	14
180	13	181	13	182	12	183	12	184	11
185	11	186	11	187	11	188	10	189	11
190	11	191	11	192	11	193	10	194	10
195	10	196	10	197	10	198	9	199	9
200	11	201	11	202	11	203	11	204	11
205	14	206	14	207	14	208	13	209	0

SAVEX

NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE	NR	VALUE
210	0	211	2	212	3	213	3	214	3
215	3	216	2	217	2	218	2	219	2
220	3	221	3	222	3	223	3	224	2
225	2	226	2	227	2	228	2	229	2
230	2	231	2	232	2	233	2	234	2
235	2	236	3	237	3	238	3	239	3
240	3	241	3	242	3	243	3	244	3
245	2	246	2	247	2	248	2	249	2
250	4	251	4	252	4	253	4	254	5
255	6	256	6	257	6	258	7	259	0

CLOCK TIME REL 17280 ABS 17280

TRANS COUNTS

BLOCK	TRANS, TOTAL		BLOCK	TRANS, TOTAL		BLOCK	TRANS, TOTAL		BLOCK	TRANS, TOTAL		BLOCK	TRANS, TOTAL	
11	0,	0	12	0,	0	13	0,	0	14	0,	0	15	0,	38

16	0,	18	17	0,	0	18	0,	0	19	0,	0	20	0,	45
21	0,	19	22	0,	0	23	0,	0	24	0,	0	25	0,	0
31	0,	0	32	0,	37	33	0,	0	34	0,	37	35	0,	0
36	0,	37	37	0,	0	38	0,	37	39	0,	0	40	0,	37
41	0,	0	42	0,	37	43	0,	0	44	0,	37	45	0,	0
46	0,	37	47	0,	0	48	0,	37	49	0,	0	50	0,	37
51	0,	0	52	0,	37	53	0,	0	54	0,	37	55	0,	0
56	0,	37	57	0,	0	58	0,	0	59	0,	0	60	0,	0
76	0,	0	77	0,	0	78	0,	0	79	0,	0	80	0,	108
81	0,	0	82	0,	108	83	0,	0	84	0,	0	85	0,	0
86	0,	0	87	0,	0	88	0,	0	89	0,	0	90	0,	111
91	0,	0	92	0,	111	93	0,	0	94	0,	111	95	0,	0
96	0,	111	97	0,	0	98	0,	0	99	0,	0	100	0,	222
101	0,	111	102	0,	111	103	0,	0	104	0,	0	105	0,	333
106	0,	84	107	0,	115	108	0,	43	109	0,	0	110	0,	111
111	0,	111	112	0,	111	113	0,	111	114	0,	111	115	0,	111
116	0,	138	117	0,	0	118	0,	0	119	0,	0	120	0,	115
121	0,	0	122	0,	0	123	0,	0	124	0,	23	125	0,	0
126	0,	23	127	0,	0	128	0,	138	129	0,	0	130	0,	132
131	0,	0	132	0,	6	133	0,	0	134	0,	23	135	0,	0
136	0,	20	137	0,	0	138	0,	132	139	0,	0	140	1,	138
141	0,	0	142	0,	0	143	0,	0	144	0,	0	145	0,	137
146	0,	0	147	0,	0	148	1,	137	149	0,	0	150	1,	136
151	0,	0	152	0,	48	153	0,	0	154	0,	48	155	0,	0
156	0,	48	157	0,	0	158	0,	0	159	0,	0	160	0,	87
161	0,	0	162	0,	87	163	0,	0	164	0,	0	165	0,	0
171	0,	0	172	0,	0	173	0,	0	174	0,	87	175	0,	0
176	1,	87	177	0,	0	178	0,	86	179	0,	0	180	0,	81
181	0,	0	182	0,	5	183	0,	17280	184	0,	5	185	0,	1
186	0,	2	187	1,	2	188	0,	75	189	0,	0	190	0,	0
196	0,	0	197	0,	0	198	0,	0	199	0,	0	200	0,	16
201	0,	59	202	0,	4	203	0,	15	204	0,	40	205	0,	15
206	0,	4	207	0,	4	208	0,	30	209	0,	15	210	0,	40
211	0,	0	212	0,	29	213	0,	0	214	0,	0	215	0,	0
216	0,	0	217	0,	0	218	0,	0	219	0,	0	220	0,	59
221	0,	0	222	0,	0	223	0,	0	224	0,	59	225	0,	59
226	0,	0	227	0,	0	228	0,	59	229	0,	0	230	0,	0
231	0,	0	232	0,	59	233	0,	0	234	0,	59	235	0,	0
236	0,	59	237	0,	0	238	0,	0	239	0,	0	240	0,	212
241	0,	70	242	0,	70	243	0,	142	244	0,	212	245	0,	35
246	0,	27	247	0,	0	248	0,	0	249	0,	0	250	0,	177
251	0,	0	252	0,	0	253	0,	0	254	0,	258	255	0,	0
256	0,	69	257	0,	0	258	0,	69	259	0,	0	260	0,	69
261	0,	0	262	0,	69	263	0,	0	264	0,	7	265	0,	0
266	0,	0	267	0,	0	268	0,	356	269	0,	0	270	0,	356
271	0,	0	272	0,	0	273	0,	0	274	0,	258	275	0,	98
276	0,	4	277	0,	0	278	0,	4	279	0,	0	280	0,	94
281	0,	9	282	0,	22	283	0,	63	284	0,	22	285	0,	35
286	0,	35	287	0,	0	288	2,	281	289	0,	0	290	0,	279
291	0,	23	292	3,	256	293	0,	49	294	0,	23	295	0,	204
296	0,	49	297	0,	0	298	0,	49	299	0,	0	300	0,	16
301	0,	0	302	0,	204	303	0,	0	304	0,	208	305	0,	0
306	0,	208	307	0,	0	308	0,	4	309	0,	204	310	0,	4
311	2,	204	312	0,	0	313	0,	23	314	0,	179	315	0,	22
316	0,	4	317	0,	0	318	0,	0	319	0,	4	320	0,	23
321	0,	0	322	0,	23	323	0,	0	324	0,	23	325	0,	0
326	0,	23	327	0,	0	328	0,	0	329	0,	0	330	0,	0

371	0,	0	372	0,	0	373	0,	0	374	0,	0	375	0,	92
376	0,	7	377	0,	49	378	0,	22	379	0,	92	380	0,	7
381	0,	49	382	0,	22	383	0,	28	384	0,	6	385	0,	54
386	0,	4	387	0,	6	388	0,	54	389	0,	0	390	0,	43
391	0,	0	392	0,	0	393	0,	51	394	0,	2	395	0,	43
396	0,	51	397	0,	51	398	0,	51	399	0,	0	400	0,	0
496	0,	0	497	0,	0	498	0,	65	499	0,	65	500	0,	65
501	0,	65	502	0,	9	503	0,	56	504	0,	0	505	0,	0
696	0,	0	697	0,	0	698	0,	0	699	0,	0	700	0,	1
701	0,	1	702	0,	49	703	0,	1	704	0,	48	705	1,	1
706	0,	1	707	0,	1	708	0,	49	709	0,	1	710	0,	48
711	1,	1	712	0,	0	713	0,	0	714	0,	0	715	0,	0
716	0,	0	717	0,	0	718	0,	0	719	0,	0	720	0,	1
721	0,	1	722	0,	49	723	0,	1	724	0,	48	725	1,	1
726	0,	0	727	0,	0	728	0,	0	729	0,	0	730	0,	1
731	0,	1	732	0,	49	733	0,	1	734	0,	48	735	1,	1
736	0,	0	737	0,	0	738	0,	0	739	0,	0	740	0,	1
741	0,	1	742	0,	49	743	0,	1	744	0,	48	745	1,	1
776	0,	0	777	0,	0	778	0,	0	779	0,	0	780	0,17279	

SAVEX	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE	NR........	VALUE
	11	1	12	4	13	4	14	3	15	3
	16	2	17	2	18	4	19	4	20	3
	21	3	22	3	23	3	24	4	25	4
	26	4	27	4	28	4	29	4	30	4
	31	4	32	4	33	4	34	4	35	4
	36	4	37	4	38	3	39	3	40	3
	41	3	42	3	43	5	44	6	45	6
	46	6	47	5	48	5	49	5	50	5
	51	5	52	5	53	5	54	5	55	5
	56	5	57	5	58	6	59	0	60	0
	111	10	112	8	113	8	114	7	115	6
	116	6	117	6	118	7	119	6	120	6
	121	6	122	6	123	6	124	11	125	11
	126	11	127	10	128	10	129	9	130	9
	131	9	132	9	133	9	134	9	135	9
	136	9	137	9	138	9	139	9	140	9
	141	9	142	9	143	10	144	10	145	9
	146	9	147	9	148	9	149	9	150	9
	151	9	152	9	153	9	154	9	155	9
	156	9	157	9	158	9	159	0	160	0
	161	0	162	20	163	17	164	16	165	15
	166	13	167	13	168	12	169	11	170	11
	171	10	172	10	173	9	174	9	175	9
	176	8	177	16	178	15	179	14	180	13
	181	13	182	12	183	12	184	11	185	11
	186	11	187	11	188	10	189	11	190	11
	191	11	192	11	193	10	194	10	195	10
	196	10	197	10	198	9	199	9	200	11
	201	11	202	11	203	11	204	11	205	14
	206	14	207	14	208	13	209	0	210	0
	211	2	212	3	213	3	214	3	215	3
	216	2	217	2	218	2	219	2	220	3
	221	3	222	3	223	3	224	2	225	2
	226	2	227	2	228	2	229	2	230	2
	231	2	232	2	233	2	234	2	235	2
	236	3	237	3	238	3	239	3	240	3

241	3	242	3	243	3	244	3	245	2
246	2	247	2	248	2	249	2	250	4
251	4	252	4	253	4	254	5	255	6
256	6	257	6	258	7	259	0	260	0

FACILITY NR	AVERAGE UTILIZATION	NUMBER ENTRIES	AVERAGE TIME/TRANS	TRANS	$TRANS
2	.0021	37	1.00	0	0
6	.0787	222	6.13	0	0
7	.0629	181	6.01	0	0
13	.0337	28	20.82	0	0
14	.0240	69	6.00	0	0
20	.0659	212	5.37	0	0
29	.1354	356	6.57	0	0

STORAGE NR	MAXIMUM CONTENTS	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	TOTAL ENTRIES	TOTAL TRANS	AVERAGE ENT/TRAN	AVERAGE TIME/ENTRY	CURRENT CONTENTS
14	2	2	.31	.1560	137	137	1.00	39.35	2
16	1	1	.15	.1531	87	87	1.00	30.40	1
31	3	3	.65	.2158	279	279	1.00	40.10	3
32	2	2	.55	.2736	208	208	1.00	45.45	2
33	1	1	.02	.0166	52	52	1.00	5.52	0
34	2	2	.12	.0594	51	51	1.00	40.25	0
35	1	1	.01	.0094	107	107	1.00	1.51	0

QUEUE NR	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	ZEROS PERCENT	AVERAGE TIME/ENTRIES ALL ENT	NON ZERO ENT	TABLE NUMBER	CURRENT CONTENTS
2	1	.00	37	37	100.00	.00	.00	0	0
6	1	.00	37	34	91.89	.22	2.67	0	0
8	2	.02	37	0	.00	11.16	11.16	0	0
10	1	.02	37	1	2.70	8.57	8.81	0	0
12	2	.01	111	104	93.69	1.07	17.00	0	0
14	4	.08	138	90	65.22	9.54	27.42	0	1
16	2	.03	87	60	68.97	6.46	20.81	0	0
19	2	.03	59	4	6.78	7.53	8.07	0	0
20	2	.00	59	51	86.44	.81	6.00	0	0
21	2	.05	59	0	.00	13.36	13.36	0	0
29	6	.07	356	235	66.01	3.17	9.34	0	0
31	7	.11	281	197	70.11	7.02	23.49	0	2
34	5	.17	208	132	63.46	13.75	37.62	0	0
35	1	.00	43	42	97.67	.02	1.00	0	0
36	1	.00	51	50	98.04	.06	3.00	0	0
37	1	.00	51	51	100.00	.00	.00	0	0

TABLE NUMBER 2

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
111	14.081	12.063	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	.000	-1.167
6	25	22.52	22.5	77.5	.426	-.670
12	39	35.14	57.7	42.3	.852	-.173
18	21	18.92	76.6	23.4	1.278	.325

24	13	11.71	88.3	11.7	1.704	.822
30	4	3.60	91.9	8.1	2.131	1.320
36	1	.90	92.8	7.2	2.557	1.817
42	3	2.70	95.5	4.5	2.983	2.314
48	2	1.80	97.3	2.7	3.409	2.812
54	0	.00	97.3	2.7	3.835	3.309
60	1	.90	98.2	1.8	4.261	3.807
66	1	.90	99.1	.9	4.687	4.304
72	1	.90	100.0	.0	5.113	4.801

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 40

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
40	60.075	35.153	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
18	1	2.50	2.5	97.5	.300	-1.197
24	1	2.50	5.0	95.0	.400	-1.026
30	2	5.00	10.0	90.0	.499	-.856
36	4	10.00	20.0	80.0	.599	-.685
42	6	15.00	35.0	65.0	.699	-.514
48	3	7.50	42.5	57.5	.799	-.344
54	4	10.00	52.5	47.5	.899	-.173
60	2	5.00	57.5	42.5	.999	-.002
66	4	10.00	67.5	32.5	1.099	.169
72	1	2.50	70.0	30.0	1.199	.339
78	2	5.00	75.0	25.0	1.298	.510
84	5	12.50	87.5	12.5	1.398	.681
90	3	7.50	95.0	5.0	1.498	.851
96	0	.00	95.0	5.0	1.598	1.022
102	0	.00	95.0	5.0	1.698	1.193
108	0	.00	95.0	5.0	1.798	1.363
114	0	.00	95.0	5.0	1.898	1.534
120	1	2.50	97.5	2.5	1.998	1.705
126	0	.00	97.5	2.5	2.097	1.875
132	0	.00	97.5	2.5	2.197	2.046
138	0	.00	97.5	2.5	2.297	2.217
144	0	.00	97.5	2.5	2.397	2.387
150	0	.00	97.5	2.5	2.497	2.558
156	0	.00	97.5	2.5	2.597	2.729
162	0	.00	97.5	2.5	2.697	2.899
168	0	.00	97.5	2.5	2.797	3.070
174	0	.00	97.5	2.5	2.896	3.241
180	0	.00	97.5	2.5	2.996	3.412
186	0	.00	97.5	2.5	3.096	3.582
OVERFLOW	1	2.50	100.0	.0		

TABLE NUMBER 41

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
4	119.250	41.318	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
72	0	.00	.0	100.0	.604	-1.144
78	0	.00	.0	100.0	.654	-.998
84	1	25.00	25.0	75.0	.704	-.853
90	0	.00	25.0	75.0	.755	-.708
96	0	.00	25.0	75.0	.805	-.563
102	1	25.00	50.0	50.0	.855	-.417
108	1	25.00	75.0	25.0	.906	-.272
114	0	.00	75.0	25.0	.956	-.127
120	0	.00	75.0	25.0	1.006	.018
126	0	.00	75.0	25.0	1.057	.163
132	0	.00	75.0	25.0	1.107	.309
138	0	.00	75.0	25.0	1.157	.454
144	0	.00	75.0	25.0	1.208	.599
150	0	.00	75.0	25.0	1.258	.744
156	0	.00	75.0	25.0	1.308	.889
162	0	.00	75.0	25.0	1.358	1.035
168	0	.00	75.0	25.0	1.409	1.180
174	0	.00	75.0	25.0	1.459	1.325
180	0	.00	75.0	25.0	1.509	1.470
OVERFLOW	1	25.00	100.0	.0		

TABLE NUMBER 42

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
15	20.800	8.968	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	.000	-2.319
6	0	.00	.0	100.0	.288	-1.650
12	2	13.33	13.3	86.7	.577	-.981
18	5	33.33	46.7	53.3	.865	-.312
24	4	26.67	73.3	26.7	1.154	.357
30	2	13.33	86.7	13.3	1.442	1.026
36	1	6.67	93.3	6.7	1.731	1.695
42	0	.00	93.3	6.7	2.019	2.364
48	1	6.67	100.0	.0	2.308	3.033

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 43

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
4	108.000	40.181	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
72	0	.00	.0	100.0	.667	-.896
78	1	25.00	25.0	75.0	.722	-.747
84	1	25.00	50.0	50.0	.778	-.597
90	0	.00	50.0	50.0	.833	-.448
96	0	.00	50.0	50.0	.889	-.299

102	1	25.00	75.0	25.0	.944	-.149
108	0	.00	75.0	25.0	1.000	.000
114	0	.00	75.0	25.0	1.056	.149
120	0	.00	75.0	25.0	1.111	.299
126	0	.00	75.0	25.0	1.167	.448
132	0	.00	75.0	25.0	1.222	.597
138	0	.00	75.0	25.0	1.278	.747
144	0	.00	75.0	25.0	1.333	.896
150	0	.00	75.0	25.0	1.389	1.045
156	0	.00	75.0	25.0	1.444	1.195
162	0	.00	75.0	25.0	1.500	1.344
168	0	.00	75.0	25.0	1.556	1.493
174	0	.00	75.0	25.0	1.611	1.643
180	1	25.00	100.0	.0	1.667	1.792

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 44

ENTRIES IN TABLE 15 MEAN ARGUMENT 7.533 STANDARD DEVIATION 3.284 NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	.000	-2.294
3	0	.00	.0	100.0	.398	-1.381
6	9	60.00	60.0	40.0	.796	-.467
9	3	20.00	80.0	20.0	1.195	.447
12	1	6.67	86.7	13.3	1.593	1.360
15	1	6.67	93.3	6.7	1.991	2.274
18	1	6.67	100.0	.0	2.389	3.188

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 45

ENTRIES IN TABLE 40 MEAN ARGUMENT 72.625 STANDARD DEVIATION 38.201 NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
24	1	2.50	2.5	97.5	.330	-1.273
30	2	5.00	7.5	92.5	.413	-1.116
36	2	5.00	12.5	87.5	.496	-.959
42	3	7.50	20.0	80.0	.578	-.802
48	5	12.50	32.5	67.5	.661	-.645
54	3	7.50	40.0	60.0	.744	-.488
60	2	5.00	45.0	55.0	.826	-.330
66	0	.00	45.0	55.0	.909	-.173
72	3	7.50	52.5	47.5	.991	-.016
78	3	7.50	60.0	40.0	1.074	.141
84	0	.00	60.0	40.0	1.157	.298
90	4	10.00	70.0	30.0	1.239	.455
96	3	7.50	77.5	22.5	1.322	.612
102	5	12.50	90.0	10.0	1.404	.769

108	2	5.00	95.0	5.0	1.487	.926
114	0	.00	95.0	5.0	1.570	1.083
120	0	.00	95.0	5.0	1.652	1.240
126	0	.00	95.0	5.0	1.735	1.397
132	0	.00	95.0	5.0	1.818	1.554
138	1	2.50	97.5	2.5	1.900	1.711
144	0	.00	97.5	2.5	1.983	1.868
150	0	.00	97.5	2.5	2.065	2.025
156	0	.00	97.5	2.5	2.148	2.183
162	0	.00	97.5	2.5	2.231	2.340
168	0	.00	97.5	2.5	2.313	2.497
174	0	.00	97.5	2.5	2.396	2.654
180	0	.00	97.5	2.5	2.478	2.811
186	0	.00	97.5	2.5	2.561	2.968
192	0	.00	97.5	2.5	2.644	3.125
198	0	.00	97.5	2.5	2.726	3.282
204	0	.00	97.5	2.5	2.809	3.439
210	0	.00	97.5	2.5	2.892	3.596
216	0	.00	97.5	2.5	2.974	3.753
222	0	.00	97.5	2.5	3.057	3.910
228	0	.00	97.5	2.5	3.139	4.067
234	0	.00	97.5	2.5	3.222	4.224
240	0	.00	97.5	2.5	3.305	4.381
246	1	2.50	100.0	.0	3.387	4.539

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 50

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
177	77.559	45.673	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
12	1	.56	.6	99.4	.155	-1.435
24	14	7.91	8.5	91.5	.309	-1.173
36	19	10.73	19.2	80.8	.464	-.910
48	17	9.60	28.8	71.2	.619	-.647
60	30	16.95	45.8	54.2	.774	-.384
72	8	4.52	50.3	49.7	.928	-.122
84	15	8.47	58.8	41.2	1.083	.141
96	19	10.73	69.5	30.5	1.238	.404
108	18	10.17	79.7	20.3	1.392	.666
120	15	8.47	88.1	11.9	1.547	.929
132	5	2.82	91.0	9.0	1.702	1.192
144	4	2.26	93.2	6.8	1.857	1.455
156	4	2.26	95.5	4.5	2.011	1.717
168	1	.56	96.0	4.0	2.166	1.980
180	1	.56	96.6	3.4	2.321	2.243
192	0	.00	96.6	3.4	2.476	2.506
204	3	1.69	98.3	1.7	2.630	2.768
216	0	.00	98.3	1.7	2.785	3.031
228	0	.00	98.3	1.7	2.940	3.294
240	0	.00	98.3	1.7	3.094	3.557
252	2	1.13	99.4	.6	3.249	3.819
264	1	.56	100.0	.0	3.404	4.082

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 51

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
7	64.143	18.497	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
28	0	.00	.0	100.0	.437	-1.954
34	0	.00	.0	100.0	.530	-1.630
40	1	14.29	14.3	85.7	.624	-1.305
46	1	14.29	28.6	71.4	.717	-.981
52	0	.00	28.6	71.4	.811	-.656
58	1	14.29	42.9	57.1	.904	-.332
64	1	14.29	57.1	42.9	.998	-.008
70	1	14.29	71.4	28.6	1.091	.317
76	0	.00	71.4	28.6	1.185	.641
82	0	.00	71.4	28.6	1.278	.965
88	1	14.29	85.7	14.3	1.372	1.290
94	1	14.29	100.0	.0	1.465	1.614

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 52

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
49	65.306	26.249	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	.000	-2.488
12	0	.00	.0	100.0	.184	-2.031
24	0	.00	.0	100.0	.368	-1.574
36	4	8.16	8.2	91.8	.551	-1.116
48	9	18.37	26.5	73.5	.735	-.659
60	11	22.45	49.0	51.0	.919	-.202
72	9	18.37	67.3	32.7	1.103	.255
84	8	16.33	83.7	16.3	1.286	.712
96	3	6.12	89.8	10.2	1.470	1.169
108	3	6.12	95.9	4.1	1.654	1.626
120	0	.00	95.9	4.1	1.838	2.084
132	0	.00	95.9	4.1	2.021	2.541
144	1	2.04	98.0	2.0	2.205	2.998
156	0	.00	98.0	2.0	2.389	3.455
168	1	2.04	100.0	.0	2.573	3.912

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 53

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
22	125.591	45.697	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
36	0	.00	.0	100.0	.287	-1.961
54	0	.00	.0	100.0	.430	-1.567
72	1	4.55	4.5	95.5	.573	-1.173
90	4	18.18	22.7	77.3	.717	-.779
108	6	27.27	50.0	50.0	.860	-.385
126	3	13.64	63.6	36.4	1.003	.009
144	1	4.55	68.2	31.8	1.147	.403
162	2	9.09	77.3	22.7	1.290	.797
180	1	4.55	81.8	18.2	1.433	1.191
198	1	4.55	86.4	13.6	1.577	1.585
216	2	9.09	95.5	4.5	1.720	1.978
234	1	4.55	100.0	.0	1.863	2.372

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 54

ENTRIES IN TABLE 6 | MEAN ARGUMENT 182.000 | STANDARD DEVIATION 80.306 | NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
72	0	.00	.0	100.0	.396	-1.370
108	1	16.67	16.7	83.3	.593	-.921
144	2	33.33	50.0	50.0	.791	-.473
180	1	16.67	66.7	33.3	.989	-.025
216	0	.00	66.7	33.3	1.187	.423
252	0	.00	66.7	33.3	1.385	.872
288	1	16.67	83.3	16.7	1.582	1.320
324	1	16.67	100.0	.0	1.780	1.768

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 55

ENTRIES IN TABLE 54 | MEAN ARGUMENT 134.481 | STANDARD DEVIATION 69.014 | NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
72	12	22.22	22.2	77.8	.535	-.905
108	12	22.22	44.4	55.6	.803	-.384
144	4	7.41	51.9	48.1	1.071	.138
180	13	24.07	75.9	24.1	1.338	.660
216	8	14.81	90.7	9.3	1.606	1.181
252	2	3.70	94.4	5.6	1.874	1.703
288	1	1.85	96.3	3.7	2.142	2.224
324	2	3.70	100.0	.0	2.409	2.746

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 56

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
4	170.750	27.444	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
120	0	.00	.0	100.0	.703	-1.849
156	1	25.00	25.0	75.0	.914	-.537
192	2	50.00	75.0	25.0	1.124	.774
228	1	25.00	100.0	.0	1.335	2.086

REMAINING FREQUENCIES ARE ALL ZERO

TABLE NUMBER 57

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	
92	148.685	79.054	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
36	1	1.09	1.1	98.9	.242	-1.425
48	8	8.70	9.8	90.2	.323	-1.274
60	4	4.35	14.1	85.9	.404	-1.122
72	4	4.35	18.5	81.5	.484	-.970
84	4	4.35	22.8	77.2	.565	-.818
96	5	5.43	28.3	71.7	.646	-.666
108	9	9.78	38.0	62.0	.726	-.515
120	5	5.43	43.5	56.5	.807	-.363
132	4	4.35	47.8	52.2	.888	-.211
144	1	1.09	48.9	51.1	.968	-.059
156	3	3.26	52.2	47.8	1.049	.093
168	11	11.96	64.1	35.9	1.130	.244
180	5	5.43	69.6	30.4	1.211	.396
192	1	1.09	70.7	29.3	1.291	.548
204	4	4.35	75.0	25.0	1.372	.700
216	7	7.61	82.6	17.4	1.453	.852
228	5	5.43	88.0	12.0	1.533	1.003
240	1	1.09	89.1	10.9	1.614	1.155
252	1	1.09	90.2	9.8	1.695	1.307
264	2	2.17	92.4	7.6	1.776	1.459
276	2	2.17	94.6	5.4	1.856	1.610
288	0	.00	94.6	5.4	1.937	1.762
300	0	.00	94.6	5.4	2.018	1.914
312	2	2.17	96.7	3.3	2.098	2.066
324	2	2.17	98.9	1.1	2.179	2.218
336	0	.00	98.9	1.1	2.260	2.369
348	0	.00	98.9	1.1	2.341	2.521
360	0	.00	98.9	1.1	2.421	2.673
372	0	.00	98.9	1.1	2.502	2.825
384	0	.00	98.9	1.1	2.583	2.977
396	0	.00	98.9	1.1	2.663	3.128
408	0	.00	98.9	1.1	2.744	3.280
420	0	.00	98.9	1.1	2.825	3.432
432	0	.00	98.9	1.1	2.905	3.584
444	0	.00	98.9	1.1	2.986	3.736
456	0	.00	98.9	1.1	3.067	3.887
468	1	1.09	100.0	.0	3.148	4.039

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