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AN EVALUATION OF DATA INFORMATION TRANSFER REQUIREMENTS FOR THE--ETC(U)
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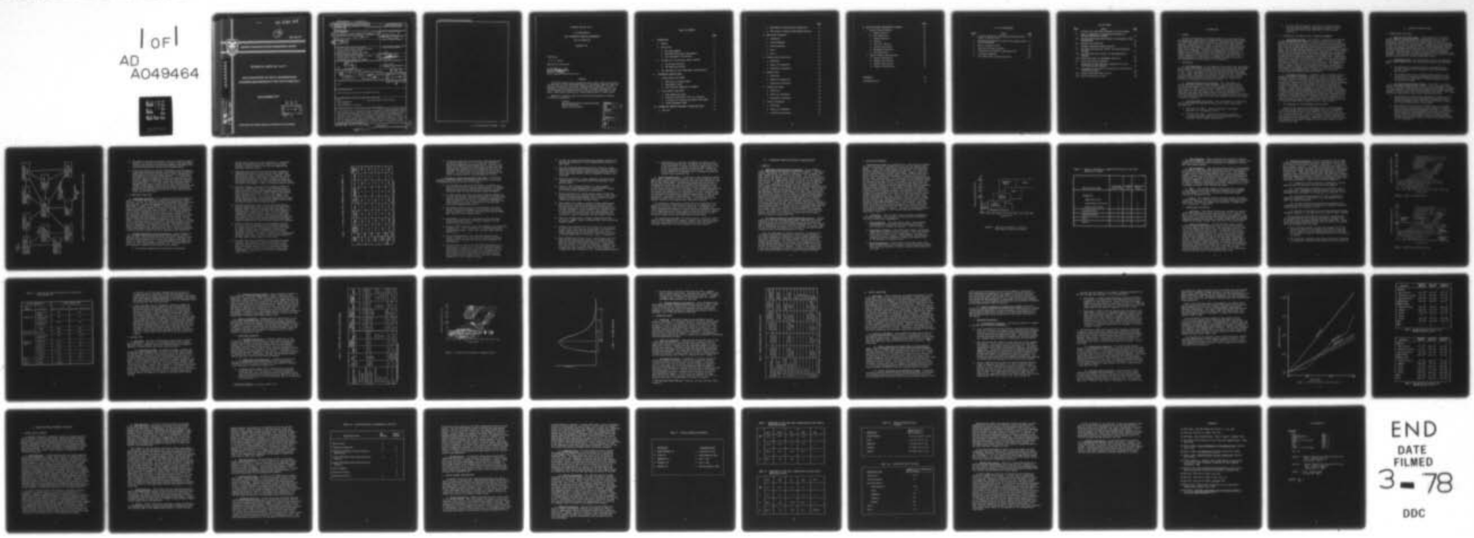

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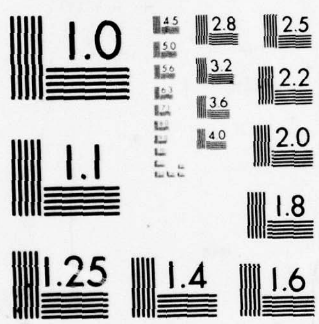

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DEFENSE COMMUNICATIONS ENGINEERING CENTER

TECHNICAL NOTE NO. 24-77

AN EVALUATION OF DATA INFORMATION TRANSFER REQUIREMENTS FOR THE FUTURE DCS

NOVEMBER 1977

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To perform telecommunications design effectively, a data base of user requirements for ADP generated information transfer must be developed. There is little commonality of data transfer characteristics among many existing ADP systems that use telecommunications transfer of data. Therefore, the problems of telecommunication of data are numerous, and a growing need for additional capability is foreseen. To provide this telecommunications capability, existing and future data transfer needs must be identified and characterized, and this report is intended to provide insight into the problem.

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FOR THE FUTURE DCS

NOVEMBER 1977

Prepared by:

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Approved for Publication:

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FOREWORD

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Reston, Virginia 22090

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I. INTRODUCTION

1. PURPOSE

The Military Departments and Defense Agencies are currently planning and implementing a wide variety of automatic data processing (ADP) systems to increase the effectiveness with which they accomplish their assigned missions. The purpose of this report is to take a preliminary look at these evolving ADP systems as a point of departure for a continuing effort within DCEC to evaluate the potential impact of DoD information transfer needs on the future DCS. The functional and statistical aspects of the common unit of information transfer, the TRANSACTION, are discussed, together with the relative distributions which may be anticipated for the various categories of transactions. A projection of the traffic that could be imposed on the DCS during the 1980-86 time frame as a result of the implementation of these systems is also addressed.

2. DEFINITIONS

a. User Requirements. For the purpose of this report, user requirements are defined as those teleprocessing needs which reflect the basic ADP system design objectives, and are formulated from the ADP system designers' point of view. "User" requirements are held distinct from "system" requirements in that "system" requirements are generally derived from "user" requirements and are primarily concerned with the network aspects of sizing, switch placement, and other matters pertaining to satisfactory communications service, and are normally not visible to the user.

b. Functional/Statistical Requirements. User requirements are further specified in terms of their functional and statistical aspects. Functional requirements are not specifically parameter related, but are descriptive of a generic class or type of capability such as the need for speed conversion, mail box service, etc. Statistical requrements, on the other hand, are those requirements which can only be accurately and completely described by the specification of a parameter value or distribution. It is the statistical aspect of the user requirements with which this report is primarily concerned.

c. User Requirement Time Periods. User requirements are divided into the following three time periods to reflect more clearly time-related considerations:

- Near Term (1977-1980) - specific "Validated" requirements expressed in a high degree of detail.

- Mid Term (1981-1986) - projected requirements beyond the validation phase that need a relatively high degree of detail to support current network design efforts.

- Far Term (1987 and beyond) - qualitative requirement identification and gross quantity projections in support of transition and other broad issues concerned with future program direction.

3. THE NATURE OF THE EVOLVING "DATA" TRANSFER ENVIRONMENT

a. The Current Situation. Past studies, in particular the "DoD ADP Systems and the DCS" (1), Volumes I and III of the DCS Plan FY 76/86 and the DoD "Data Internet Study" (3), have indicated the rapidly growing need for a DCS switched communications service that is more responsive than the present DCS switched networks to ADP and ADP related communications needs. Over 150 ADP systems throughout the DoD with implementation schedules between now and 1980 have been identified in these studies. Initial review of the associated communications requirements indicates that the needs of only 56 can be fully satisfied by the current AUTODIN network (AUTODIN I). An additional 78 systems were identified as candidates for a "common user" type service, but could not be effectively supported by the current network because of limitations in three principal aspects: (1) speed of service, (2) transfer protocols, and (3) unit transfer lengths. The communications needs of these systems are currently being addressed in the AUTODIN II, Phase 1 program. The DCS role in supporting the communications needs of the balance of the systems identified has not yet been fully evaluated and is being investigated by DCEC in support of the current DTACCS directed Integrated AUTODIN System (IAS) Program.

b. The Emerging Situation. In addition to the traditional areas of command and control, intelligence gathering, logistics, and personnel management, emerging information processing systems are finding application in a wide variety of situations requiring the rapid assimilation and/or processing of information affecting many other aspects of defense management. As technology changes, so do the concepts by which we understand the content of information and the need for its transfer from one point to another. For many systems, computer and terminal facilities are being located at widely dispersed geographic points, and therefore large volumes of information must be transferred between these facilities. In addition, a need is rapidly emerging in response to the evolving complexities of our operations to exchange information between traditionally isolated systems on a more or less routine basis. That these evolving information processing systems will have a considerable impact upon the nature and extent of future DoD communications network design is clearly evident.

4. THE IMPORTANCE OF USER REQUIREMENT IDENTIFICATION

Because of the foregoing considerations, DCEC is currently engaged in various programs, particularly the AUTODIN II and IAS, intended to meet the data transfer needs of the identified future users of the DCS in a cost-effective manner. The most essential of these planning efforts, and the most difficult to perform, is the identification of the specific user needs which the communications network will be called upon to support. The remainder of this report attempts to provide some insight into the nature of these needs.

II. INFORMATION TRANSFER NEEDS

1. PRESENT NEEDS (1977-1980)

a. Definition of Present Needs. For the purpose of this report, present needs are represented by the validated subscriber listing submitted by the Military Departments for the AUTODIN II program, the requirements exhibited by the current AUTODIN community, and the findings derived from the previous study by DCEO(1). Questionnaires were developed to obtain the specific information from the Military Departments required to analyze the communications requirements of each validated ADP system. Detailed information about each system, such as equipment, geographic locations, projected traffic volumes, and transaction classifications, was requested. This information was then augmented by personal contact with ADP personnel associated with the ADP systems under review.

b. Requirement Trends. Two related trends found to be developing within the DoD community will have considerable impact on the near-term DCS:

- The advantages of consolidating ADP and telecommunications planning is gaining wider recognition within the DoD management structure.

- The economies which can be achieved through automation in the various areas of traditional management functions are giving new impetus to the development of complex management information processing systems.

c. The Increasing Complexity of Demand. While there is a trend toward consolidated "teleprocessing" planning, the vastly greater accumulations of information made possible by the available technology is creating a current demand for a more sophisticated communications network than that presently available within the "store-and-forward" environment. This sophistication of communications demand arises from several factors:

- ADP systems are no longer being implemented in isolation of one another but are being consolidated and interconnected within a complex arrangement such as that partially depicted in Figure 1 for currently identified Air Force Systems.

- Rapid response times nornally associated with priority matters affecting the national security are now required on a regular basis for matters affecting management efficiency. In particular, the philosophy of the new management information systems is to record information into computer format for electrical transmission at the information source, thereby avoiding duplication in effort and time lags inherent in the more conventional acquisition of information.

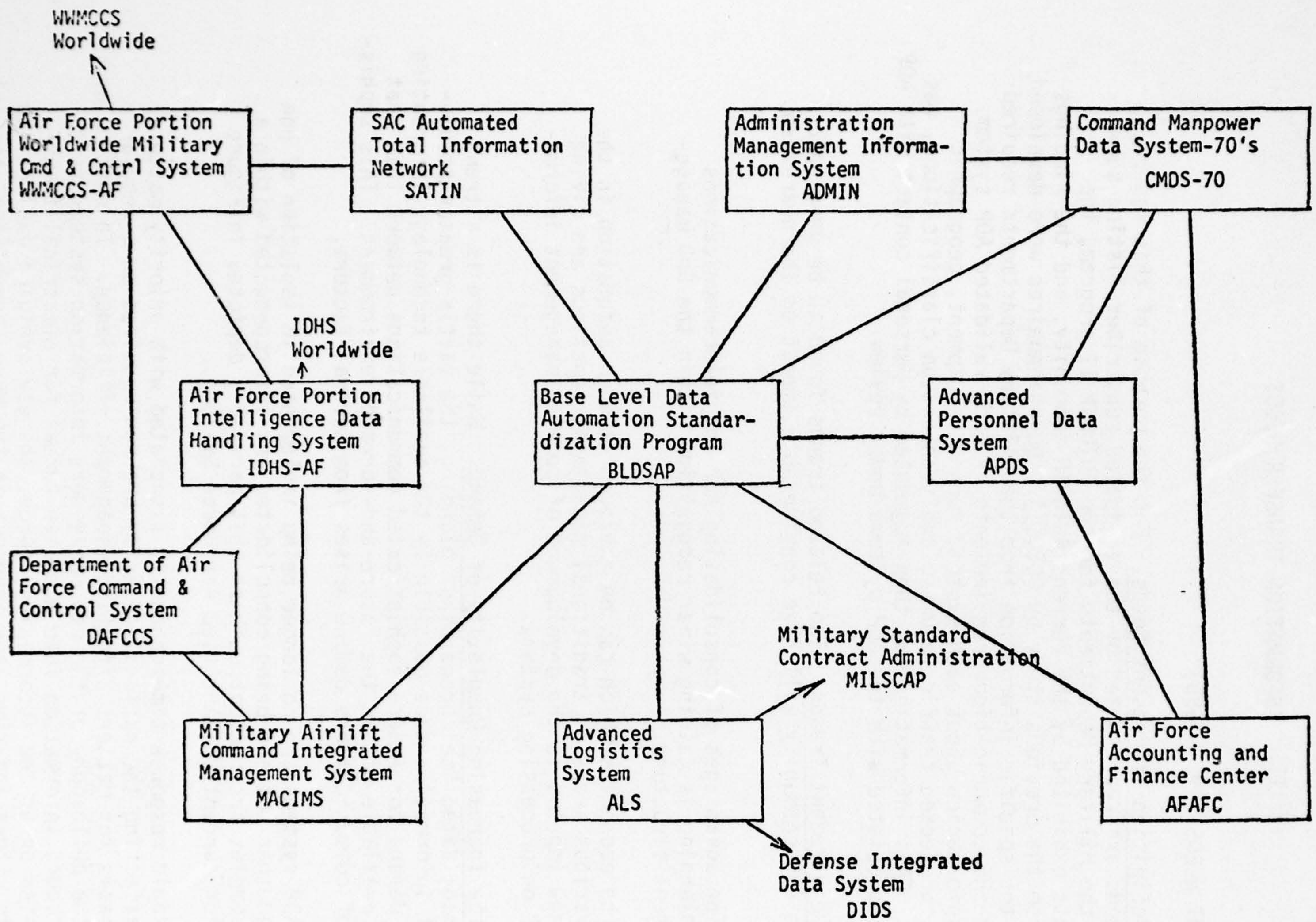

Figure 1. A Partial Depiction of ADP System Functional Interaction in the Air Force

- The extent of the problems related to the new information handling systems is resulting in a substantial increase in the requirement for bulk data transfer with associated handling efficiencies which cannot be achieved within the existing switched networks.

- Various DoD elements are currently implementing both time sharing systems and data sharing systems, such as the Air Force CREATE and LITE systems, which tend to create large central information depositories for use by widely dispersed users. It is anticipated that these types of systems will continue to spread and will constitute a substantial percentage of the future DoD data communications requirement. To this end, several ADP systems were identified during the course of recent surveys (Data Internet Study, AUTODIN II Requirements review, etc.) for which no current data communications requirements were identified but which nevertheless appear to have potential as time sharing or data sharing systems within the very near future.

2. FUTURE NEEDS (1981-1990)

a. Requirement Evaluation. In an attempt to forecast data transfer needs for the post-1980 time frame, several previous sources, notably reference [2] and [3], together with ARPA and AUTODIN traffic statistics, were evaluated. Information subsequently obtained from the Military Departments in support of the AUTODIN II effort was also considered, but found to be primarily addressed to existing ADP systems or those in an advanced planning stage with funds allocated. The available information did not address requirements which are still on the "drawing board" or have not as yet filtered down to the "communications" community. Thus, the information obtained provides a fairly accurate overview of the near-term (1976-80) data requirements but provides little insight into the specific nature of data requirements beyond this time period. For this reason, a thorough search of the available literature was made in the hope of acquiring a more definitive insight into where data transfer requirements may be heading in the 1981-86 time period. The balance of this report is addressed to the findings of this search, and to a discussion of how these findings have been incorporated into a statistical characterization of the data transfer needs to be supported by the 1981-86 DCS.

b. Pertinent Observations From the Literature. Several sources provide a valuable insight into the direction that information transfer needs may take in the 1981-1986 time frame and beyond. Notable of these are ESD's "Mission Analysis on Air Force Base Communications-1985" [4], and two of James Martin's books - "Future Developments in Telecommunications" [5] , and "The Computerized Society" [6]. From these works and the literature in general, seven important points emerge:

- The present communications network does not completely satisfy today's needs to transfer information. Accordingly, the way the communications user conducts his day-to-day business is heavily biased by the existing communications facilities available to him.

- Teleprocessing acquisitions and programs have responded to identified deficiencies in specific user areas rather than addressing the total information creation, transfer, storage and retrieval problem. Accordingly, a detailed listing of user identified deficiencies, with associated validated communications requirements, is not a sufficient basis from which to evaluate the adequacy of today's information transfer systems.

- The normal tendancy on the part of the network designer to push for a "standardized" family of user terminal devices in order to minimize network design problems may offset the less obvious but equally important economic benefits and technological innovations which will accrue to the customer in an "open" terminal market. This is not to say, however, that certain operating features or interface characteristics should not be standardized when standardization clearly benefits both the ADP and communications systems designers.

- Available information, such as the Air Force Base Mission Analysis summarized in Table I, indicates that current "data network" traffic (electrical message, data, and graphics) now supports less than 6% of the total Air Force information transfer need. Providing users with a totally responsive, integrated information transfer network will set the stage for a sudden, massive spread in data communications usage into functional areas which have traditionally been accomplished either by nonelectrical transfer or less efficiently by telephone.

- With the increasing complexity of DoD management decisions, as well as those of government and the business community as a whole, the need for collecting vast quantities of data to support complex resource management allocations and decisions is becoming more and more essential to orderly government operation. Accordingly, there will be a considerable increase in the volume as well as type of traffic handled by the data communications networks of the future.

- In projecting future requirements, overconservatism usually prevails. The literature is replete with examples of insufficient imagination resulting in a failure to foresee major applications and has led to the under-design of many systems. Although examples to the contrary, such as the "picturephone," are recognized, these are the exceptions rather than the rule.

TABLE I. A TYPICAL AIR FORCE BASE INFORMATION TRANSFER SUMMARY [4]

USER GROUP SIZE (POP)	TOTAL BASE COMM MISSION UNITS *	DIAL PHONE	HOT LINES & INTERCOM	RADIO	MAIL & COURIER	ELECTRICAL MESSAGE	DATA	GRAPHICS	FACE TO FACE & CCTV
SUPPORT (1820)	23199	8687	1297	715	3757	75	7066	73	1529
HOSPITAL (220)	2894	686	1243	21	441	2	87	29	385
MAJOR MISSION (2100)	14565	5226	1570	831	2277	21	120	4	4512
FLYING TENANT MISSION (500)	2392	1100	330	230	110	20	34	7	561
REPRESENTATIVE BASE TOTALS (4640)	43,050	15,699	4440	1797	6585	122	7307	113	6987

* NORMALIZED UNIT OF MEASUREMENT FOR ALL TYPE INFORMATION TRANSFER ACTIONS.

- It has been found that newly developed technology generally precedes implementation by 5 to 10 years due primarily to application engineering and program inertia. Therefore, the impact of currently emerging technological advances upon the communications networks will not be generally felt until the post-1986 time period and will not impact the interim data networks. For this reason, the user needs forecasted in this report are based solely on the technology now in being.

c. A Forecast of Teleprocessing Needs (1981-1990). The following discussion highlights some of the changes which will most likely occur to teleprocessing during the next 10 to 15 years:

- The requirement to move more information in a shorter time span will be reflected in greatly enhanced efforts to automate source data entry at the communications terminal with direct voice/data input offering the greatest system improvement.

- To reduce access line costs, the primary interface between the user and the long-haul communications network at least for major military installations, will be a large base concentrator(s). These concentrators will provide a significant improvement over those currently available in providing true "user-to-user," multi-media communications service.

- The separate functional areas of communications, data automation, and resource management will be merged into one area treating information creation, processing, and resource management transfer as an integrated whole.

- Developments in large scale integrated circuits and plasma display technologies offer considerable potential for new teleprocessing applications.

- Routine clerical functions such as file updating, text correcting, dictation, etc., will be performed on a routine basis by the teleprocessing system - often from a location remote from the Central File.

- The fact that personnel costs constitute the bulk of the annual increment of life cycle costs for administrative type services will be the major driving force for conversion to ADP operation.

- Multiple copies of manuals and other bulky documentation will be reduced to a single control file with electrical access and peripheral reproduction capability. The transfer of the large volumes of data associated with this concept will be facilitated by the increased bandwidth available for bulk data transfer and the application of "slow scan" techniques together with "cheap" terminal storage.

- In order to increase both employee and management productivity, more and more personnel will have communications terminals at their desks.

- With the increasing deterioration of mail service as volume grows and transportation and handling costs increase, facsimile "mail" will likely become a much more attractive alternative to current operations and will place a substantial demand on the future DCS.

- With the availability of larger bandwidths, facsimile may be coupled directly to the office copiers and operated at compatible speeds.

- The use of the Touchtone telephone as a cheap computer terminal with voice answerback or a coupled digital display, will greatly expand teleprocessing applications.

- Optical processors will greatly enhance pattern recognition, associative processing, and other areas in which a very large number of different data elements must be correlated, again creating new applications for data transfer.

- Work patterns will change as screen-to-screen communications proves to be an attractive alternative to business travel. This application will be greatly enhanced by the addition of facsimile peripherals for the transmission of permanent copies of notes, sketches, or other "briefing" type material, and, in particular, preliminary drafts of planning documents at a much earlier stage of development then now thought practical.

- There will be many areas of software standardization that will have a snowball effect as programs used in one installation spread to others.

- Extremely large computer files (data banks) will be available in which every item stored can be retrieved in a fraction of a second. Banks of data on many subjects will grow to the extent that computers will be used as "librarians" for aiding in the worldwide search for particular items of information.

- Data transmission will drop in cost. Long distance costs will drop much more than short-distance costs, thereby having an effect on the organizational structure of the various departments and agencies of the Federal Government. Computers will also drop in costs at a faster rate than communications lines. To some extent this trend will counter the trend towards increased use of data transmission (i.e., greater decentralization).

- The processing of "tactical" information in support of real-time mission objectives will be removed from the forward area of the battlefield to reflect the growing complexities of fire control and target assignment systems and their integration across organizational and joint service lines. This may well involve the DCS as a necessary link in the normal tactical-to-tactical data information flow.

d. System Management Needs. In addition to user information transfer needs, there is also a continuing need by both the ADP system and the communications network managers to know how effectively the information transfer has been accomplished. Teleprocessing systems have evolved from a conglomeration of terminal types and communications subsystems carrying all manner of traffic including teletype, high and low speed data, facsimile, analog and digital voice, and video. To be effective and efficient at this level of complexity, all functional entities at all echelons of the network configuration must be considered as a single interacting body for the purpose of transferring information between users to their mutual satisfaction. Successful accomplishment of this mission can only be measured in terms related to the total body -- not merely according to how well any particular communications subsystem may operate.

In contemporary teleprocessing systems the first indication of malfunction or failure is often *the user's inability to communicate*, even though the failure may have occurred much earlier. The managers of future teleprocessing systems will require continuous automatic monitoring of all communications facilities along the lines currently being planned for the DCA System Control and Management Information System, so that corrective actions can be taken before major failure occurs.

The teleprocessing managers will require specific statistical information from the communications network, together with a system to process, interpret, and evaluate this information, and to relay the findings to the proper authorities for system management and system control.

III. INFORMATION TRANSFER REQUIREMENT CHARACTERIZATION

1. OVERVIEW

a. Requirement Characterization Perspective. In our present record communications environment as typified by AUTODIN I, information transfer requirements are generally reported in terms of average "message" lengths and busy hour load on the network. For the most part, these figures are obtained on a "circuit" basis rather than for a particular user or ADP system, except where the user has his own terminal and does not rely on a communications center for input into the communications network. Lacking any significant insight into what forces this traffic, user requirement projections have not adequately foreseen major changes in the traffic demands resulting from contingency operations or from major changes in the way the user does business. This picture is now changing as the major percentage of total data traffic swings from the traditional narrative/record category to traffic generated within a well-defined ADP system, for which records are generally maintained on a transaction-by-transaction basis in response to ADP system management needs and as a byproduct of the ADP system capability. As yet very little information of this nature has been made available to DCEC, except for the more "traditional" data networks identified for AUTODIN II. To overcome these deficiencies, DCEC is currently developing a definitive user requirement model for the DCS which will incorporate newly emerging transactional statistics, together with the relationships which may exist between these statistics and certain definable force parameters such as troop population, number of aircraft, mission objectives, etc. However, this effort is not expected to produce definitive results until the middle of calendar year 1978.

b. The Current Information Transfer Requirement Baseline. Pending completion of the DCS User Requirement Model, guidelines are required concerning future user requirement demand on the DCS to support the ongoing planning efforts within DCEC and Headquarters DCA. This interim need is addressed by using the traditional "average" or "typical" transactional attributes, but adding as much insight as currently available information and a few educated guesses will allow.

First, the requirement to transfer information is separated into five general application categories for ease of further discussion. The relative frequency of transactions in each category together with the primary transactional attributes-response time and transaction length-are investigated. The results of this investigation are then coupled with an estimate of total network traffic demand envisioned for the 1981-86 time frame to derive daily and busy hour traffic projections for each application category. Finally, a few observations on the user's requirement to transfer information are presented where trends indicate the possible need to change traditional thinking.

2. APPLICATION CATEGORIES

Teleprocessing systems are established for a wide variety of purposes and differ according to the demand they place upon the communications network. To facilitate system design, the wide variety of applications should be ordered into as few categories as possible, still retaining the basic attributes of the service requirement. Ideally, these categories would be uniquely defined, both in terms of ADP function and in terms of the basic transaction parameters of response time and transaction length. Unfortunately, it is found that the relationships between function, response time, and transaction length are not consistent across the spectrum of data applications. Accordingly, each application category is defined primarily by its most descriptive attribute, with the other attributes assigned appropriate boundary values which may sometimes overlap adjacent categories. As an example, the BULK 1 application category is defined primarily in terms of its function of transmitting entire data files or computer programs, and secondarily in terms of a response time requirement of less than 1 hour and by transaction lengths normally not exceeding 10^6 bits. However, certain BULK 1 type transactions (requiring response times less than 1 hour) can be of a length greater than 10^6 bits - thereby impinging on the BULK 2 domain; or they may have response time requirements of less than 5 minutes - thereby impinging on the INQUIRY/RESPONSE domain. For reference, these categories are defined in the following subsections in terms of their functional attributes and graphically depicted in terms of their primary transactional parameters in Figure 2. The order of importance placed on the transaction attributes in defining each application category is summarized in Table II.

a. Interactive. These are applications requiring an immediate or "real time" response. This category is further divided functionally into the following three subcategories:

- Human Interaction. Those applications where a human-computer or human-human dialogue takes place and responses must be quick enough not to impede the operator's train of thought.

- Alarm/Status Indicators. Those applications where a transmitted remote alarm or status indication requires a "real-time" response either from a machine or from a human operator. For ease of classification, this category is differentiated from monitoring/telemetry by defining transaction length to not exceed 10 bits or one character of information text.

- Monitoring/Telemetry. These are applications where remote telemetry or other monitoring information is transmitted which requires "real time" data reduction or graphic display at some central control point.

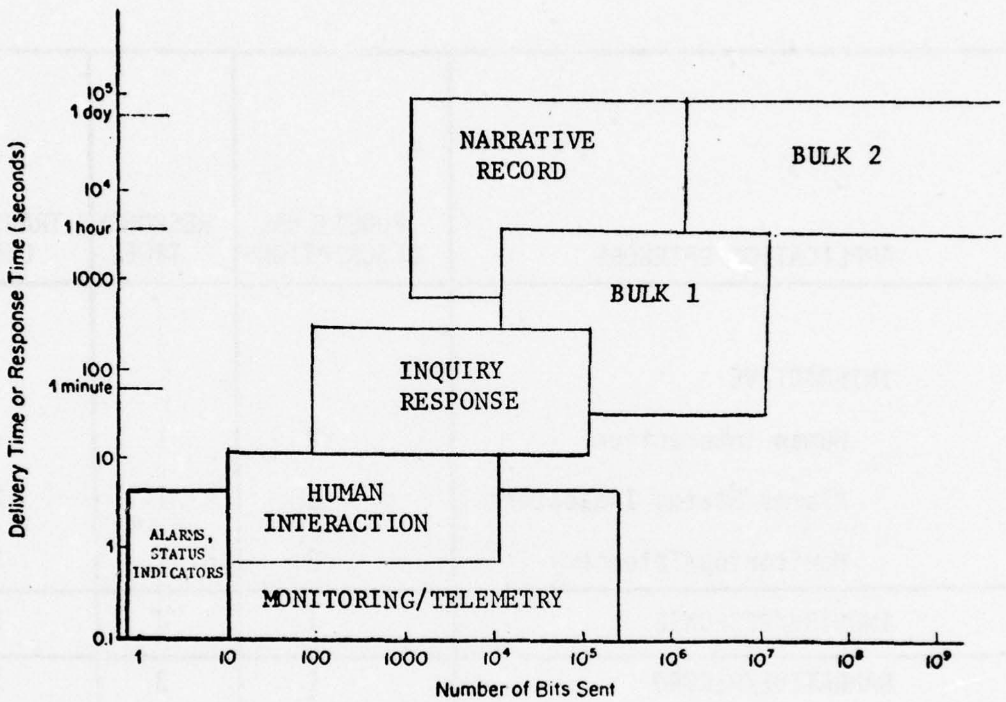

Figure 2. Application Categories in Terms of the Primary Transaction Parameters

TABLE II. ORDER OF IMPORTANCE OF TRANSACTION ATTRIBUTES IN DEFINING APPLICATION CATEGORY.

APPLICATION CATEGORY	FUNCTIONAL DESCRIPTIONS	RESPONSE TIME	TRANSACTION LENGTH
INTERACTIVE			
Human Interaction	2	1	-
Alarms/Status Indicators	2	1	2
Monitoring/Telemetry	2	1	3
INQUIRY/RESPONSE	1	2	3
NARRATIVE/RECORD	1	3	3
BULK 1	1	2	3
BULK 2	3	1	2

b. Inquiry/Response. These are applications where short requests or inquiries are made of a central data bank, and responses of from 5 to 10 minutes do not cause sufficient inconvenience to economically justify a more rapid system response.

c. Narrative/Record. These are applications relating to the delivery of messages or other record type transactions which are considered to be "one way" from a communications network point-of-view. This category is characterized by the teletype message traffic currently processed by AUTODIN. However, with the potential for mail service deterioration as volume grows, it seems likely that facsimile transmission will place a substantial demand on the future DCS. Accordingly, the narrative/record transaction category is subdivided into "message" type traffic as we know it today, and facsimile applications which are considered to be a valid requirement of the DCS in the 1981-86 time frame.

d. BULK 1. This category comprises entire data files, programs, or other data processing results which are characterized by response time requirements of less than 1 hour and by transaction lengths normally not exceeding 10^6 bits.

e. BULK 2. This category comprises extremely lengthy information (normally in excess of 10^6 bits), such as an entire data base or certain sensor data, for which the response time requirement is commensurate with "non-busy hour" transmission.

3. TRANSACTIONAL DISTRIBUTION

a. Definition. Transactional distribution represents the percentage of total transactions, taken either on a daily or on a "busy hour" basis, for each of the previously defined application categories. This distribution, in conjunction with the transaction parameters of average length and response time, provides a valuable insight into the required communications network transfer rates and traffic load distributions.

b. Source of Information. The only definitive source of data relating to application distribution found in the current literature is the work done by James Martin [7]. The importance of Martin's work lies in the insight into future traffic distribution which is provided by his "relative popularity poll." In this poll, Martin asked approximately 50 systems analysts, all highly experienced in diverse areas, what they thought would be the relative future popularity of different data transmission response time requirements and message lengths. Their estimates differed over a wide range; however, Martin was able to prepare a composite diagram, as discussed in more detail below, depicting the relative popularity of different data transmission applications from which he concluded that "given good line facilities, the data transmission industry will grow in many new directions, including some that are barely anticipated today." This report draws heavily on Martin's work in the discussions that follow.

c. <u>Statistical Evaluation</u>. Martin's "popularity" chart as given in Figure 3 has been divided into regions corresponding to the transaction application categories defined in subsection 2. The resulting plot is shown in Figure 4. The numbers lying within each region, representing the relative popularity of that combination of response time and transaction length, were then added and normalized as a percentage of their total. These percentages were then interpreted as the percentage of total transactions falling within that application category. These percentages are tabulated in Table III on both a daily and a busy hour basis. Conversion of daily transaction percentages to busy hour transaction percentages is based on the following assumptions:

(1) Telemetry and status indication is essentially a 24 hour operation with no single hour receiving particular emphasis.

(2) "Over-the-counter" operations such as FAX Mail, and to some extent BULK 1 transmission, overlap the normal duty day and are considered to be represented in the busy hour in a ratio of 1 in 12.

(3) Routine narrative/record and all BULK 2 transactions, handled in the network as load permits, are not considered to be a "busy" hour design requirement.

(4) All other transaction categories are considered to be accomplished during the normal duty day and are therefore represented in the busy hour in a ratio of 1 to 7.5.

(5) FAX Mail is considered to be apportioned among the various precedence categories in the same portion as currently found in AUTODIN.

The fact that the numbers derived from Martin's popularity poll can be manipulated in this fashion was confirmed by telephone with Mr. Martin at the IBM Systems Research Institute in New York. However, three observations concerning the application of Martin's work to the DCS user environment should be noted:

- Due to differing economic considerations between the military and private sectors of the economy, particularly in the area of air transport, the trend towards facsimile mail within DoD may not occur as rapidly as envisioned by Martin for the country as a whole.

- The significant requirement identified by Martin for two classes of transactions, characterized by average transaction lengths of

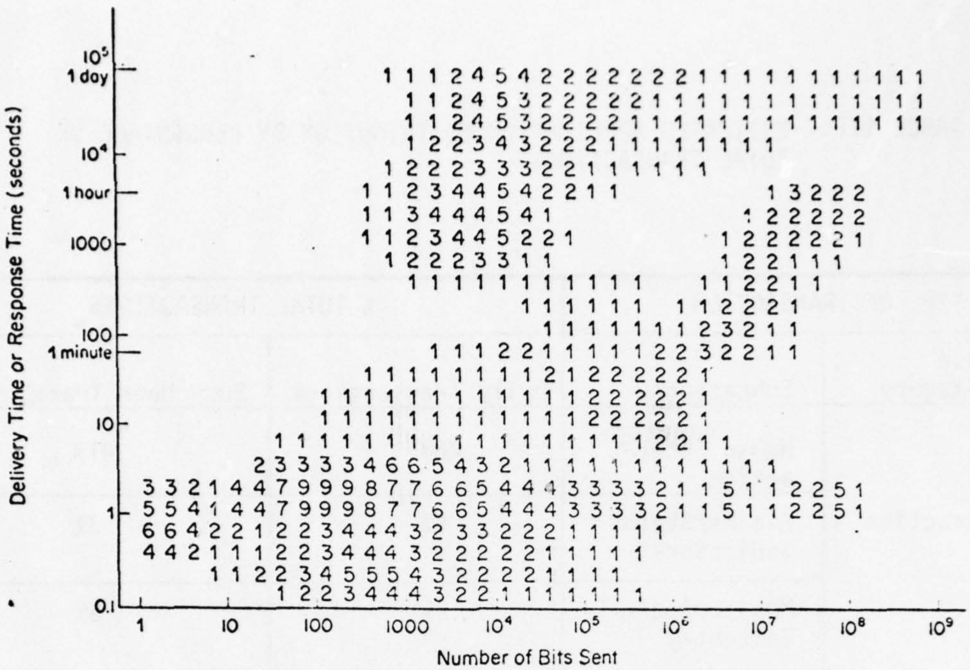

Figure 3. Martin's Popularity Poll

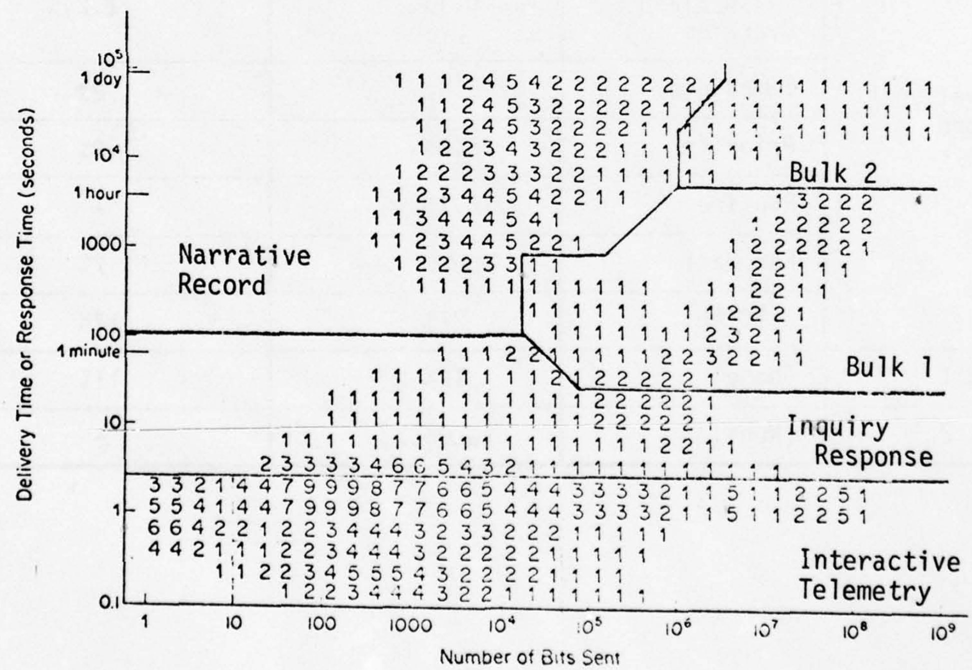

Figure 4. Application Category Overlay

TABLE III. ESTIMATED APPLICATION DISTRIBUTION BY PERCENTAGE OF TOTAL TRANSACTIONS

TYPE OF TRANSACTION		% TOTAL TRANSACTIONS	
Main Category	Subcategory	Daily Transactions	Busy Hour Transactions
Interactive	Human Interaction	28%	41%
	Alarms/Status Indicators	6%	3%
	Monitoring/ Telemetry	12%	6%
	TOTAL:	46%	50%
Inquiry/Response	(None)	15%	22%
Narrative/ Record	Flash/Flash Override	0.1%	(.2)%
	Immediate	1.4%	2%
	Priority	5.0%	8%
	Routine	6.1%	-
	Fax Mail	14.4%	7%
	TOTAL:	27%	17%
BULK 1	(None)	12%	11%
BULK 2	(None)	(0.05)%	-

4×10^6 and 7×10^7 bits with a response time on the order of 1 second, appears to correlate with possible requirements for "battlefield" TV and other large volume critical sensor requirements. These requirements, although recognized, are considered to be beyond the scope of the DCS switched data network for the foreseeable future and were deleted from the calculations.

- It was found that, due to a substantial difference between the average transaction length assumed for BULK 2 transactions and the average transaction lengths assumed for the remaining categories, a change of a single percentage point for the relative distribution of BULK 2 transactions had a considerable impact on the projected network loading. Since Martin did not intend his "poll" to be viewed with this degree of accuracy, the initial value of 3% computed for BULK 2 distribution from Martin's chart has been replaced with the value of 0.05%, based on an engineering judgment which would indicate that each computer, on the average, will not generate more than two BULK 2 category transactions per day during the interim (1980-86) time period. Due to the importance of this estimate to the relative balance between "busy hour" and "non-busy hour" traffic applications, the subject of BULK 2 transaction rates will receive special consideration during the upcoming IAS studies.

4. RESPONSE TIME

a. Definition. The time a teleprocessing system takes to respond to a given input is referred to as the response time for that system. More specifically, response time can be considered from two viewpoints, depending on the particular application being considered.

(1) Interactive Systems. For operation between a computer and a remote terminal, response time is defined as the time interval between the operator pressing the last key (or enter key) of the input message and the terminal's indication of the first character of the reply. It is similarly defined for other kinds of interactive information transfer systems as the interval between an event and the system's response to that event. Strictly speaking, receipt of the first complete "thought" rather than the first character of the reply is the major concern to most interactive terminal users. However, the difference in time between the receipt of the first character and the first "thought" is a function of terminal speed, which should have been properly selected by the user for the application at hand. Accordingly, the fine point of "thought" receipt versus character receipt can generally be ignored by the commications network designer.

(2) Information Delivery Systems. Where information transfer is not interactive, it is more appropriate to specify a "delivery time" rather than a response time. Within this context, delivery time refers to situations in which information is considered, from a communications viewpoint to be flowing only in one direction, and can be defined as that time interval between the start of transmission at the sending location and the completion of reception at the receiving station. This definition differs from that of "Response Time" because in most "Delivery Time" applications, the communications service is considered to be "over-the-counter" from the customer's viewpoint (i.e., the customer does not provide the terminals). Accordingly, selection of the proper terminal device is in this case more appropriately a communications network design issue.

b. Source of Information. Although based for the most part on very limited data, the response time and delivery time criteria reported by previous DCEC studies and extracted from MilDep requirement submissions, are summarized in Table IV together with the applicable AUTODIN statistics. In addition, valuable insight gained from the work done by Martin is also reflected in the table, both in terms of application boundary values and in expected values derived from Martin's "Popularity Poll" by contour plotting as depicted in Figure 5.

c. Statistical Evaluation

(1) The Gamma Distribution. In Martin's report [7], a rule of thumb for response time calculations is given which concludes that response time follows a gamma distribution where the 95 percentile of response time is close to the mean response time plus two standard deviations, and the minimum response time is close to the mean minus one standard deviation. This rule of thumb, hereafter referred to as the Gamma Assumption, is shown graphically in Figure 6. The benefit to be derived from the Gamma Assumption is that only two of the three attributes of response time (i.e., the minimum, the mean, and the maximum values) need be specified, since the third can be calculated.

(2) Human Factors Considerations. In addition to purely statistical considerations, the following human factor considerations reported by Miller [8], Martin and others [7]* are especially important to any discussion of interactive response time:

- In general, delays greater than 15 seconds rule out conversational dialogue. As Miller puts it, "if delays of more than 15 seconds will occur, the system had better be designed to free the user from physical and mental activity so that he can turn to other activities and get his displayed answer when it is convenient for him to do so."

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* Additional references are given in Martin [7].

TABLE IV. RESPONSE TIME STATISTICS (USER-TO-USER)

Transaction Category	SEF Study	SPP 2-74	Available Requirements Documentation			Martin's Transaction Categories		Martin's Popularity Poll	Recommended Estimate*		
			MIN	MEAN	MAX	MIN	MAX	MODE	MIN	MEAN	MAX
Interactive	0.3 to 4 sec	1 sec	< 1 sec	1 sec	7 sec						
Human Interaction						1 sec	10 sec	1-2 sec	0.75 sec	1 sec	2 sec
Alarm, Status Indicators						0.1 sec	3 sec	0.8 sec	0.3 sec	1 sec	3 sec
Telemetry/Monitoring						0.1 sec	1 sec	0.3 sec	0.1 sec	0.3 sec	1 sec
Inquiry/Response	4 to 40 sec	secs/min	15 sec	30 sec	2 1/2 min	3 sec	100 sec	30 sec	7.5 sec	36 sec	2 min
Narrative/Record	1 min	secs/min				15 min	24 hrs	20m to 2hrs			
Flash/Flash Override					10 min				1 min	3 min	10 min
Immediate					30 min				10 min	15 min	30 min
Priority					3 hr				30 min	1h 15m	3h
Routine					6 hr				1 hr	2h 30m	6h
Fax Mail						2 hrs	24 hrs	5 1/2-24 hrs		12 hrs	24 hrs
Bulk 1	1 min	10s of secs-10s of mins	20 sec	30 min	4 hr	30 sec	1 hr	1-2 min	30 sec	5	20 min
Bulk 2	1 hr	10s of mins-hrs	1 hr	12 hrs	24 hrs	1 hr	24 hrs	2 hrs	1 hr	4 hrs	12 hrs

* Times are given for one-way transmission through the network

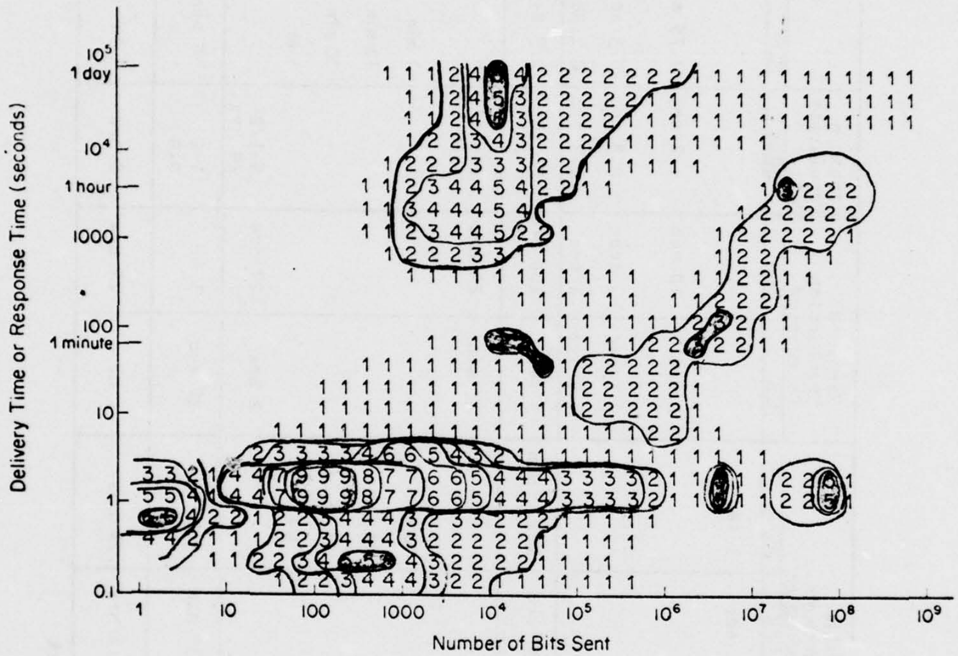

Figure 5. A Contour Plot of Martin's "Popularity Poll"

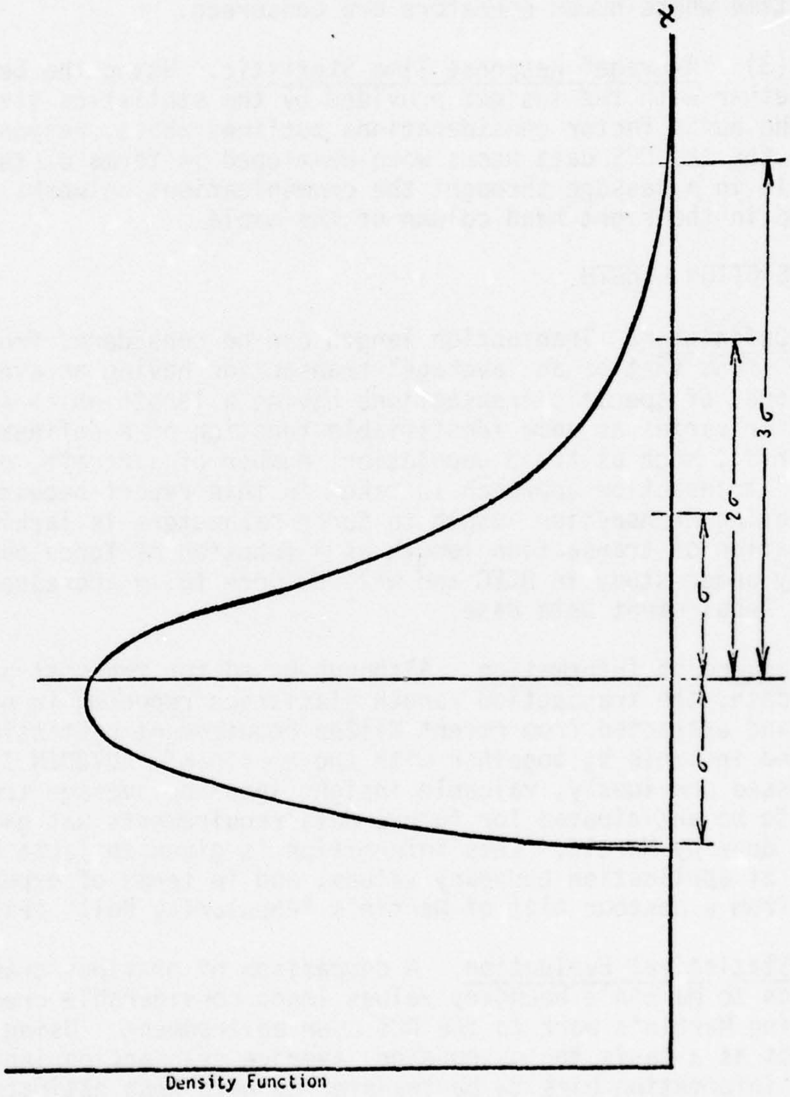

FIGURE 6. THE GAMMA ASSUMPTION

- In some cases it has been claimed that too short a response time is psychologically bad. Subconsciously, the operator feels coerced into an attempt to keep up with the machine. In general, it appears that 1.5 seconds is the minimum value for response time where human operators are concerned.

(3) "Average" Response Time Statistic. Using the Gamma Assumption together with the insight provided by the statistics given in Tabel IV and the human factor considerations outlined above, response time criteria for the DCS data users were developed in terms of the delay acceptable in a passage throught the communications network; these are tabulated in the right hand column of the table.

5. TRANSACTION LENGTH

a. Definition. Transaction length can be considered from two aspects: from that of an "average" transaction having an average length, or from that of specific transactions having a length which is either constant or varies as some identifiable function of a defineable force parameter(s), such as troop population, number of aircraft, etc. The "average" transaction approach is taken in this report because current data relating transaction length to force parameters is lacking. The specification of transaction length as a function of force parameter is currently under study in DCEC and will be more fully addressed in developing the User Requirement Data Base.

b. Source of Information. Although based for the most part on very limited data, the transaction length statistics reported in previous studies and extracted from recent MilDep requirement submissions are summarized in Table V, together with the applicable AUTODIN I statistics. As discussed previously, valuable insight into the average transaction lengths to be anticipated for future data requirements was gained from the work done by Martin. This information is given in Table V, both in terms of application boundary values, and in terms of expected values derived from a contour plot of Martin's "Popularity Poll" (Figure 5).

c. Statistical Evaluation. A comparison of previous transaction statistics to Martin's boundary values lends considerable credence to applying Martin's work to the DCS user environment. Using these statistics as a basis for discussion, average transaction lengths in terms of information bits to be transferred have been estimated for the purpose of establishing a baseline statistic and are tabulated in the right-hand column of Table V. Figures associated with a slash denote Inquiry/Response transaction lengths* and are assumed to be found in the communications network in the ratio of two responses for every three inquiries to reflect data base update transactions for which no response other than an acknowledgment of receipt is required.

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* The left hand figure represents "Inquiry," and the right hand figure "Response."

TABLE V. AVERAGE TRANSACTION LENGTH STATISTICS (IN BITS)

Transaction Category	SEF Study[1]	SSPP 2-74[1]	Available Statistics[1]	Martin's Transaction Categories	Martin's Popularity Poll	Recommended Estimate[1]
INTERACTIVE	1800/18,000	600/6,000	600/6,000			
Human Interaction				$70-3x10^4$	70-240	600/6,000
Alarm, Status Indicators				1-10	2	2
Telemetry/Monitoring				$10-10^3$	200-900	600
INQUIRY/RESPONSE	1440/19,200	600/6,000	600/6,000	10^2-10^5	$4x10^4$	600/6,000
NARRATIVE/RECORD	$2.88x10^5$	----	$2x10^4$	$300-10^6$	10^4	
Flash/Flash Override						$9x10^3$
Immediate						$1.4x10^4$
Priority						$2.1x10^4$
Routine						$2.2x10^4$
Fax Mail				$300-10^6$	10^4	$4x10^4$
BULK 1	$2.88x10^5$	10^4-10^6	$4x10^5$	10^4-3x10^6	$(2to5)x10^6$	$5x10^5$
BULK 2	$17.3x10^6$	$>10^6$	$5x10^7$	10^5-10^9	$3x10^7$	$3x10^7$

1 - 600/6,000 represents the inquiry and response transaction lengths respectively.

6. TRAFFIC PROJECTIONS

a. Definition. Traffic projections are generally developed in either of two ways. The first way is from the "bottom-up," wherein detailed traffic statistics and community of interest information are gathered or postulated for each user element in the population being evaluated, and then added to arrive at a comprehensive traffic matrix depicting the interaction between the various elements of the population. The second way is from the "top-down," by first projecting a value for total traffic demand based on some generalized model of the subscriber community, and then apportioning this total among the various user elements. Apportioning schemes can be based on computer core densities, base population, or some other estimator relating traffic to geographic area of location. The bottom-up method can provide a much more accurate picture of requirement demand, but to achieve this accuracy requires considerable insight into the activity of and interrelationships between the various users in the community. This insight is available for only a few specialized communities at present, but is being expanded by current DCEC efforts. However, sufficient data on which to base a comprehensive DoD wide projection of user demand will not be available before the fall of 1977. Accordingly, the top-down approach was used in developing the requirement projections presented in this report.

b. Source of Information. Many attempts have been made in the past to project a value for total data traffic to be supported by the DCS in the 1980-1985 time period. Broadly speaking, these efforts can be divided into three somewhat similar approaches, each of which arrives at approximately the same total value of $3x10^{11}$ bits per day in the mid -- 1980 time period.

(1) Traffic Projection for the DCS Plans FY 72/82 Through FY 75/85. Several projected values for total future data traffic based on the work done at the DCA System Engineering Facility during 1971-1972 [9] have been reported in past DCA Long Range Plans [10], [11], [12]. These projections are based on an assumed rate of growth for user terminals to be supported by the DCS at some particular time in the future, and on certain assumptions concerning relative distribution of terminal data rates, terminal utilization factors, and the percentage of terminal traffic expected to transit the DCS. The traffic values thus derived are added to figures similarly developed for computer-to-computer application, and for local Digital Message Exchange (LDMX) and non-LDMX narrative/record traffic derived from AUTODIN Statistics and Base Population figures.

(2) Traffic Projection for the AUTODIN II Program. A projection technique similar to that utilized for the Long Range Plans was developed by the Defense Communications Engineering Office during 1973-1974 [13]. This projection utilized terminal growth rates and computer/terminal inter-

action patterns developed during the initial AUTODIN II study effort. This information was augmented by the transaction statistics derived in part from the work done by Martin and others, as previously discussed. This effort went beyond previous efforts in that the total traffic value once derived was then geographically apportioned within the DoD community on the basis of relative computer core densities as projected by the General Service Administration (GSA) for DoD [14].

(3) Traffic Projection for the DCS Plan FY 76/86. The traffic projection techniques employed in the DCS Plan FY 76/86 essentially combined the two previous approaches, refining considerably the estimates for computer/terminal growth and the spread of future ADP system applications. The near and mid-term traffic projections for this report are taken from this source.

c. Statistical Evaluation

(1) A Conservative Projection. The traffic projection in support of the DCS Plan FY 76/86 was developed by:

- First, characterizing existing military installations in terms of their size, function, and automatic data processing (ADP) equipment. From this, profiles of military locations were developed in terms of their ADP and data communications needs. These resulting base profiles postulated the number of computers and terminals required for a typical base or location of a particular size and function.

- Next, postulating the volume of traffic generated at each computer and terminal. The user modes were identified as data terminals (low speed and high speed), computer, and narrative - with nominal transmission rates of 450 b/s and 3600 b/s, 4800 b/s, and 300 b/s respectively. The nominal time per user transaction and the nominal number of transactions in the busy hour were then estimated using military ADP systems, the professional literature, Volume III of the DCS Plan 75/85, and engineering judgment as guidelines. By multiplying these quantities, the average information bits generated in the busy hour were obtained for each class of user terminal.

- Finally, combining the base profiles, which represented the total number of computers and terminals in 1986, with the estimated volume of traffic generated per computer and terminal. This computation resulted in a total daily traffic volume of 3.34×10^{11} bits per day, approximately 10% greater than estimated in the DCS plan FY 75/85. If a lower bound of 2,000 or an upper bound of 3,000 on-line computers is used, daily traffic volume will vary from approximately 2.61×10^{11} bits to 3.91×10^{11} bits per day.

The upper and lower bounds to the number of computers expected to be "on-line" by 1985 were developed in the following manner:

- Lower Bound - A review of DoD ADP systems currently installed or approved for installation by 1978 indicated a total of 2,374 computers for that time period. Eighty five percent of these computers were considered as likely to be on-line in the 1986 time frame. Accordingly, the figure of 2,000 was taken as a reasonable lower bound for the number of computers "on-line" in 1986.

- Upper Bound - Adding to the ADP system assets considered in the lower bound calculation all shipboard computers, scientific computers at non-military locations, and other DoD computer assets identified in the GSA Inventory of Automatic Data Processing Equipment [14], a total figure of 3,500 was established for computers which could exist in 1978. Applying the same 85% figure as used in the lower bound calculations, a figure of 3,000 was proposed as a reasonable upper bound for the number of computers "on-line" in 1986.

The DCS Plan FY 76/86 traffic projection is based on a postulated increase in interaction between computer assets essentially in-being in 1978-1979, and does not consider the more revolutionary developments which may occur in data transfer applications such as Fax-Mail, central document respositories, or the possible proliferation of "cheap" data terminals at each "desk." Accordingly, this traffic projection is considered to be overly conservative when applied to the post - 1980/82 time frame.

(2) <u>An Optimistic Projection</u>. In considering the potential impact of new and innovative applications for data transfer as discussed earlier in this report, it is not unreasonable to expect a traffic volume in the mid-1980's of one to two orders of magnitude above that projected by the more conservative on-line computer projection approach. This higher order projection is given additional weight by the literature which is replete with examples of gross underestimation of future requirements. Accordingly 132×10^{11} bits per day, as a compromise between one and two orders of magnitude above the conservative estimate of 3.34×10^{11} bits, is considered an optimistic upper bound to the traffic volume expected in the 1986 time frame.

(3) <u>The "Most Likely" Projection</u>. Noting that the current communications networks are constrained, at least in terms of speed of service and transfer protocols, and the fact that new applications for data transfer generally emerge only when a clear economic or other specific advantage is perceived by the potential user, it is expected that actual "validated" data transfer requirements will lag behind even

the conservative traffic projection until around 1980, when the enhanced capabilities of AUTODIN II become available. During this period, the annual budget pinch together with the probability that requirements do not emerge as rapidly as the "forecasters" projected, will lead top management to take a "wait and see" approach concerning additional communications program expansion.

Early in the 1980 time period, with AUTODIN II and cheaper "smart" terminal designs available, data transfer requirements will reflect the pent-up demand resulting from an increasing economic advantage for electronic transmission. This rate of requirement growth should exceed the conservative projection by 1982 or 1983, and continue until the application design limits of the AUTODIN II network are reached, most likely in 1985 or 1986.

With the rapidly increasing demand for data transfer clearly visible by 1982, together with an enhanced requirement forecasting posture within the DoD community, top management will recognize the long prophesied "Information Age" as an emerging reality and will approve new and innovative communications system programs in keeping with the pace and direction of the expanding data revolution. The fact that implementation generally lags planning from 5 to 7 years will tend to damp actual data transfer growth until the full third-generation system capability becomes available around 1988 or 1989.

The conservative and optimistic traffic growth projections together with the expected path of traffic demand are shown in Figure 7. The 1986 busy hour and daily traffic totals expected for the five application categories are shown in Tables VI and VII respectively for each of the three traffic projections.

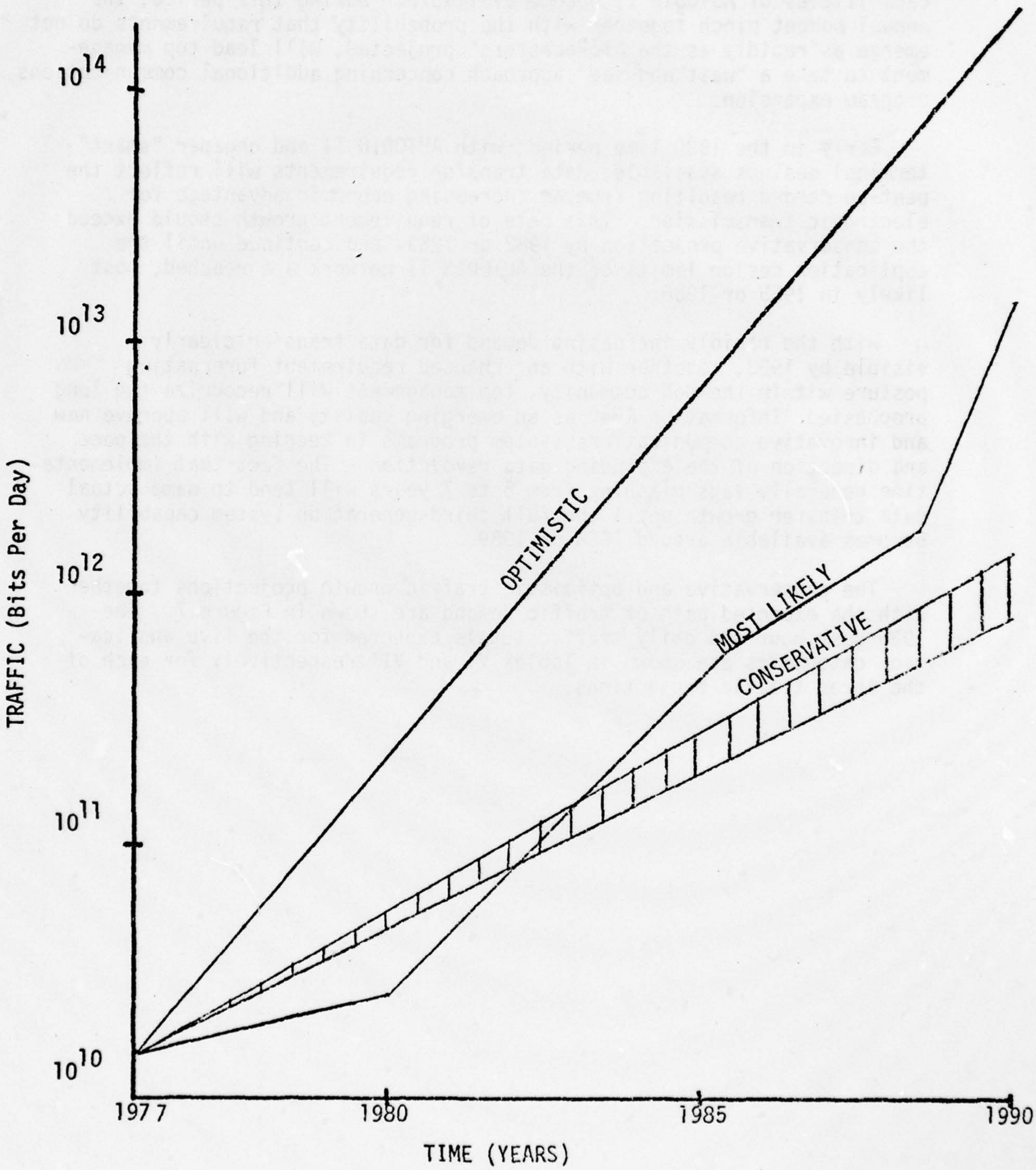

Figure 7. 1977-1990 Traffic Growth Projections

APPLICATION	OPTIMISTIC PROJECTION	MOST LIKELY PROJECTION	CONSERVATIVE PROJECTION
INTERACTIVE			
Human Interaction	1.61×10^{10}	8.77×10^{8}	4.01×10^{8}
Alarms/Status Indicators	6.50×10^{5}	3.55×10^{4}	1.62×10^{4}
Monitoring/Telemetry	4.67×10^{8}	2.55×10^{7}	1.17×10^{7}
INQUIRY/RESPONSE	8.61×10^{9}	4.69×10^{8}	2.15×10^{8}
NARRATIVE RECORD			
Flash/Flash Override	1.87×10^{8}	1.02×10^{7}	4.68×10^{6}
Immediate	4.08×10^{9}	2.23×10^{8}	1.02×10^{8}
Priority	2.19×10^{10}	1.19×10^{9}	5.45×10^{8}
Routine	- - -	- - - -	- - - -
Fax Mail	3.60×10^{10}	1.96×10^{9}	9.00×10^{8}
BULK 1	7.8×10^{11}	4.26×10^{10}	1.95×10^{10}
BULK 2	- - - -	- - - -	- - - -

TABLE VI. THE 1986 TOTAL BUSY HOUR TRAFFIC FOR EACH APPLICATION CATEGORY (IN BITS)

APPLICATION	OPTIMISTIC PROJECTION	MOST LIKELY PROJECTION	CONSERVATIVE PROJECTION
INTERACTIVE			
Human Interaction	1.21×10^{11}	6.58×10^{9}	3.01×10^{9}
Alarms/Status Indicators	1.56×10^{7}	8.51×10^{5}	3.90×10^{5}
Monitoring/Telemetry	1.12×10^{10}	6.13×10^{8}	2.81×10^{8}
INQUIRY/RESPONSE	6.46×10^{10}	3.52×10^{9}	1.61×10^{9}
NARRATIVE RECORD			
Flash/Flash Override	1.40×10^{9}	7.66×10^{7}	3.51×10^{7}
Immediate	3.06×10^{10}	1.67×10^{9}	7.64×10^{8}
Priority	1.64×10^{11}	8.93×10^{9}	4.09×10^{9}
Routine	2.09×10^{11}	1.14×10^{10}	5.23×10^{9}
Fax Mail	8.99×10^{11}	4.90×10^{10}	2.25×10^{10}
BULK 1	9.36×10^{12}	5.11×10^{11}	2.34×10^{11}
BULK 2	2.34×10^{12}	1.28×10^{11}	5.85×10^{10}

TABLE VII. THE 1986 TOTAL DAILY TRAFFIC FOR EACH APPLICATION CATEGORY (IN BITS)

IV. MAJOR FUNCTIONAL REQUIREMENT ATTRIBUTES

1. SPECIAL SERVICE FEATURES

In addition to the basic information transfer requirement characterization discussed in the previous section, additional service features may be desired. Certain of these special features may place an added demand on the communications network design, while others, more appropriately considered a function of the automatic data processing system, may only indirectly affect traffic volume or the requirement for specialized terminal design. To clarify the extent of communications system design responsibility, both of these categories are addressed in the following discussions.

a. Speed Conversion. A teleprocessing system has three components that may be incompatible in speed: the computer, the terminal, and the communications network interlinking them. Normally, this problem is resolved by the use of buffers located within the ADP system or the communications network, or within both. For narrative/record traffic, speed conversion is principally achieved within the communications network via the buffering action of the store-and-forware switch, although, to a much lesser extent, the continued use of paper tape at some low speed terminals is considered to be a form of terminal buffering. For computer-to-computer and terminal-to-terminal interaction, the buffers are generally located within the host computer complex, although a small but growing population of so called "smart" terminals is being developed to do editing, error control, and other logic functions at the terminal in addition to speed conversion. Except for the relatively few "smart" terminals, this solution is generally limited to a single ADP system, and does not provide the capability for direct communications between terminals operating at different speeds, or between terminals of one ADP system and the terminals and/or computers of another ADP system which are not speed compatible.

The cost of buffering within the terminals, once high, has fallen substantially in recent years as a result of the advances in LSI technology. However, a preponderance of unbuffered terminals is still projected through the 1976/80 time period. Therefore, economic considerations, as well as the need for flexible interchange between dissimilar ADP systems, dictate a continuing need for speed conversion as a service feature of the communications network. By the 1980/85 time period, however, it is conceivable that large base concentrators may prevail as the interface between the user and the long haul DCS. The remaining terminals requiring direct access to the long haul DCS will most likely be of the "smart" variety in order to benefit from a more efficient utilization of the access line, thus reducing or eliminating entirely the need for speed conversion at the switching nodes of the communications network.

b. Code Conversion. A variety of data text codes are presently in use within the various ADP systems in response to differing data structure considerations. Although ASCII is being stressed as the standard code for information interchange and has been adopted as the standard for narrative/record traffic passing through AUTODIN, it does not appear that a single data text code will be acceptable to all ADP users anytime in the near future. Since it is desirable for devices that use different codes to be able to communicate, some form of code conversion is required, either within the ADP system or as a service provided by the communications network. Which alternative should be selected in a particular case depends on economic and, in some cases, response time considerations.

With respect to code conversion, information transfer requirements can be placed in one of three categories. The first addresses narrative/record type transactions for which a standardized teleprocessing code (ASCII) has been adopted and appears satisfactory as a continuing solution for subscriber needs. The second category involves computer-to-computer information transfer or terminal-to-computer interaction between ADP systems wherein such interactions are considered a common occurrence for at least one of the systems. In this case, code conversion, if required, can usually be provided most cost-effectively by the central computer of one of the ADP systems, most likely the system for which interaction is the most common occurrence. The last category involves terminal-to-terminal or terminal-to-computer interaction between ADP systems wherein such interaction is uncommon for either system. In this case it would appear that code conversion, if required, would be more economically provided as a service feature of the communications network -- at least until the present, relatively unintelligent terminals are replaced by "smart" terminals, as discussed previously in subparagraph a. In any case, the communications network should provide transparency to the user's transaction or data text code, ensuring that there are no restrictions as a result of the communications control code adopted for network processing.

c. Format Conversion. Data formats used for information transfer within the communications network can differ widely for seemingly similar ADP systems. The format structure, other than for transfer protocols, involves the very nature of the data being interchanged and as such is not amenable to manipulation within the communications network. Network transfer protocols, of necessity, will continue to be dictated by communications network design considerations.

d. Editing. Editing collectively represents a number of administrative functions that logic circuitry located within the terminal, within the switching nodes of the communications network, or within the host computer complex, can perform as an additional service for the teleprocessing user. These functions can take the form of simple text editing, printout/display formating, routing table lookup and address formating, "header" and "trailer" generation, etc. The value of addressing these services, whether within the ADP or communications system design, is again a matter of economics. In regard to editing, it would appear that those services associated with the information text itself, or the special communications feature which cannot be abbreviated and vary from transmission to transmission, are more appropriately addressed in the terminal design (although certain services such as text editing may continue to be performed manually or provided by a distant host computer for those applications where an "intelligent" terminal is not considered cost effective). It is generally more economical to provide routine services, such as routing table lookup, within the switching nodes of the communications network by the assignment of appropriate class·marks or other logic features.

e. <u>"Mail Box" Service</u>. Narrative/record traffic, and to some extent inquiry/response traffic, may be submitted to the communications network for delivery at a time not convenient to the addressee, either because of a busy terminal condition or because delivery is attempted outside of normal duty hours. With respect to this problem, a "Mail Box" service such as presently offered in the ARPA network, or to a more limited extent by the AUTODIN store-and-forward message service, is a continuing requirement for the communications network.

f. <u>Security and Privacy</u>. The users of the communications network may transfer information which is classified or which contains information about private individuals or other proprietary subjects that must be kept confidential. Keeping such information out of unauthorized hands is an extremely important requirement placed on the communications network. Equally important is the need to prevent unauthorized access to the ADP systems served by the communications network for the purpose of changing data files or otherwise tampering with the ADP system structure. Denying such access is essential to preclude fraud, sabotage, or other unauthorized operation, and is a requirement to be shared equally by the ADP system, the terminal, and the communications network design.

g. <u>Management Statistics.</u> In order to monitor ADP system operation effectively or otherwise manage their teleprocessing resources, both the user and the communications network manager will require certain statistical information from the communications network in addition to that normally maintained by the terminal operator. The information envisioned as being required can be grouped into the eight interrelated prime factors shown in Table VIII, and is seen to be little different from that now required for communications network management. The first two factors relate to the cost of service and provide the measure necessary for the ADP system manager to weigh alternative solutions to his teleprocessing needs. The next three factors contribute to the same general functions of monitoring

TABLE VIII. APPLICATION AREAS FOR MANAGEMENT STATISTICS

Application Areas	ADP Manager	Network Manager
Service Costs	X	
Transaction Statistics	X	X
Equipment Performance Status Monitoring and Analysis	X	X
Circuit Performance Status Monitoring and Analysis	X	X
System Performance Status Monitoring and Analysis		X
Fault Isolation		X
Decision Selection		X
Maintenance Control	X	X

and analysis and are applied to the three teleprocessing levels of major concern. The last three factors relate to maintaining communications continuity and are of primary interest to the communications network manager. In this regard, full time and/or rapid sequential scanning of selected parameters should be computer controlled, then analyzed and compared against preselected thresholds. Trouble or impending difficulty should be reported both to the user facility and to a central system control point for equipment and circuit related problems, and to the central system control for other network related problems. Reporting should be by exception so that even with continual sampling and storage of status information, only those items varying from predetermined norms would be automatically reported. One should be able to extract periodic reports on demand by selecting only that data relevant to the analysis at hand. It should also be possible to dump historic data for in-depth analysis when appropriate.

h. Off-Hook Service. In those ADP systems wherein the terminal communicates only with a single location or computer, off-hook service could be an essential requirement of the communications network. Other ADP systems may require programmed altroute service as a method for switch bypass should normal communications service be disrupted. In this manner interswitch trunk assets would be assigned to certain high priority subscribers in the event of switch failure, giving the advantages of both the switched network and today's special purpose networks at a much more reasonable cost.

2. SPECIAL NETWORK CONSIDERATIONS.

In addition to the basic user requirement attributes and special service features discussed above, inherent communications network design characteristics heavily impact the alternatives available to the user. A thorough insight into this area is required of both the ADP system and the communications network designers in order to optimize the various design tradeoffs jointly available to them. In this report, this aspect of user requirement definition is referred to as Special Network Considerations, and includes network availability, network survivability, network error control, and external network access.

a. Network Availability. Network availability from a user's point of view has two aspects: The first concerns the degree of certainty of obtaining initial access to the communications network, while the second concerns the continuity of service once intial access is achieved. These two aspects of availability may or may not be couched in the same terms. In some systems, such as command and control, it is necessary to have both a high degree of certainty of obtaining access to the communications network and a high degree of certainty that information transfer will not be interrupted once intiated. In other applications, such as the monthly transfer of large volumes of payroll data, a wait of hours for network access can be tolerated, while a high degree of certainty that information transfer will not be interrupted once initiated is needed to preclude costly and inefficient retransmission. Other user requirements range between these two extremes, as measured by an appropriate traffic processing priority derived from the user's mission criticality, and his type of data transfer application, as shown in Table IX. As an aid to network design, the estimated percentage of total transactions for each of the traffic processing categories is given in Table X for the busy-hour, and in Table XI for total daily traffic. These percentages are based on the projected transactional distributions presented in Table III and the current distribution of AUTODIN traffic by message precedence.

(1) Connection Delay. The time between the user's request for communications network access and the receipt of an appropriate acknowledgement that network access has been achieved is defined as connection delay. The connection delay which can be tolerated will vary from user to user, depending on type of application and impact on the user's mission. Although insufficient data have been received from potential users concerning what connection delay can be tolerated, the criteria specified in Table XII are considered to be fully responsive to the large majority, if not all, of the data transfer requirements envisioned for the DCS through the 1981-1986 time frame. In reference to this table, connection delays for each category should not exceed the time T for more than the specified percent of the time.

(2) Service Interruption. This condition applies to those situations wherein the data transfer has been initiated but aborted completely for some reason beyond the control of the user, and retransmission must be initiated. Again, little information is available concerning what level of service interruption is acceptable to the user. However, any experience with today's AUTOVON network should convince the skeptic that that level has been exceeded as far as the non-command and control Analog FAX or Bulk II data user is concerned. Currently, the importance placed on continuity of service in both the AUTOVON and AUTODIN networks is based on a message or call precedence scheme assigned on the basis of assumed impact on national security. In order to be responsive to the future data user, this area must be expanded to include economic considerations, such as work processing efficiencies, as well. Accordingly, the criteria specified in Table XIII for each data transfer application category are deemed essential to achieving an acceptable level of service by the communications network.

b. Network Survivability. Survivability from the viewpoint of the user covers a multitude of concerns, but probably the least of these is communications network survivability other that in terms of availability. However, due to the wording of the current DCS planning factor for network survivability in terms of "user" survivability, this subject merits separate consideration under the definition of user requirements.

TABLE IX. TRAFFIC PROCESSING CATEGORIES

CRITICALITY	APPLICATION TYPE
A. FLASH OVERRIDE (O)	1. Interactive (I/A)
B. FLASH (F)	2. Query/Response (Q/R)
C. IMMEDIATE (I)	3. Bulk 1 (B1)
D. PRIORITY (P)	4. Bulk 2 (B2)
E. ROUTINE (R)	5. Narrative/Record (N/R)

TABLE X. PERCENTAGE OF TOTAL BUSY HOUR TRANSACTIONS FOR EACH TRAFFIC PROCESSING CATEGORY

	I/A	Q/R	B1	N/R	B2
O&F	0.5	0.1	0.1	0.2	---
I	5.9	2.0	1.5	3.4	---
P	20.9	6.9	5.5	12.3	---
R	25.7	8.3	6.7	---	---

TABLE XI. PERCENTAGE OF TOTAL DAILY TRANSACTIONS FOR EACH TRAFFIC PROCESSING CATEGORY

	I/A	Q/R	B1	N/R	B2
O&F	0.4	0.1	0.1	0.2	---
I	5.1	1.7	1.3	3.0	---
P	18.2	6.0	4.8	10.7	---
R	22.3	7.2	5.8	13.1	(0.05)

TABLE XII. NETWORK CONNECTION DELAY CRITERIA

CRITICALITY	CONNECTION DELAY NOT TO EXCEED:
FLASH OVERRIDE	$T < 1$ sec 99.99% of time
FLASH	$T \leq 1$ sec 99% of time
IMMEDIATE	$T < 5$sec 99% of time
PRIORITY	$T < 10$sec 95% of time
ROUTINE	$T < 30$sec 90% of time

TABLE XIII. SERVICE CONTINUITY CRITERIA

APPLICATION TYPE	PROBABILITY OF INTERRUPTION NOT TO EXCEED:
Interactive	0.1%
Inquiry/Response	1%
Narrative/Record	
FLASH OVERRIDE	0.1%
FLASH	.1%
IMMEDIATE	1%
PRIORITY	5%
ROUTINE	10%
Bulk 1	1%
Bulk 2	1%

Communications network survivability concerns the degree to which communications services can be retained or rapidly restored after disruption by natural calamity or by deliberate "enemy" action. The current DCS objective for network survivability is to design communications facilities to be survivable to the same extent as the user. This planning factor is couched in terms of "service" or "no service" and does not reflect the incremental nature of service acceptable to the user during varying periods of emergencies. Although considerable work has been done in identifying critical command and control communications needs and flows during crisis situations and a prioritization scheme developed for selective restoral of the communications network on a circuit-by-circuit basis, the need still exists to expand this work to the other subscriber categories as well.

In the future development of the DCS user requirement data base, a meaningful measure of "essentiality" relating user needs to particular emergency situations will be developed by DCEC and applied to each user requirement. This will greatly facilitate communications network design in terms of the communications assets requiring restoral during the various categories of emergency operations.

c. Network Error Control. Errors in a typical ADP system can be generated at many places between data source and final disposition, but this report is concerned primarily with the errors generated within the communications network, and the relationship between communications error control and ADP system error control design.

A certain number of errors can be expected in data transmitted through the communications network. For most types of transmission facilities, statistics are available giving the distribution of errors to be expected. Depending on the nature of the information transfer requirement and the type of facilities available, the errors contributed by the network may either be insignificant or dominant with respect to ADP system generated errors. Accordingly, a major design tradeoff concerns whether error control should be addressed within the communications network design, within the ADP system design, or within both. A discussion of this question is clearly beyond the scope of this report. However, it can be said that the decision is extremely complex and is best served, at least within today's environment of limited dialogue between ADP system and communications network planners, by establishing a single error rate objective for the communications network as low as is commensurate with an economical network design while meeting the minimum threshold required to satisfy the majority of potential users. With a specific communications network objective established, it is then left to the ADP system designer to address those cases where communications network error control is not adequate for his teleprocessing requirements.

Current information is not sufficient to make any meaningful judgment as to what error rate objective will satisfy the majority of potential users in the 1980-1985 time frame. Accordingly, this issue will receive special attention in the upcoming IAS studies. It is evident, however, that the minimum allowable error threshold will have to be established at a figure significantly greater than the current DCS system planning factor specified as "not to exceed one error in 10^6 bits for more than one percent of the time."

d. External System Access. Present ADP systems are generally self-contained due to code and software limitations. However, in the future ADP systems will require ever increasing access to other ADP systems, culminating eventually in what well may be a national computer utility. The communications network design must be flexible to the shifts in both traffic pattern and traffic volume which may result from the associated, dynamically changing communities of interest.

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