State Criminal Justice Telecommunications (STACOM) Final Report

Volume II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network

Law Enforcement Assistance Administration
U. S. Department of Justice

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FOREWORD

The State Criminal Justice Telecommunications, (STACOM), Project consists of two major study tasks. The first entails a study of criminal justice telecommunication system user requirements and system traffic requirements through the year 1985. The second investigates least cost network alternatives to meet these specified traffic requirements.

Major documentation of the STACOM Project is organized in four volumes as follows:

Title	Document No.
State Criminal Justice Telecommunications (STACOM) Final Report - Volume I: Executive Summary	77-53 Vol. I
State Criminal Justice Telecommunications (STACOM) Final Report - Volume II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network	77-53 Vol. II
State Criminal Justice Telecommunications (STACOM) Final Report - Volume III: Requirements Analysis and Design of Texas Criminal Justice Telecommunications Network	77-53 Vol. III
State Criminal Justice Telecommunications (STACOM) Final Report - Volume IV: Network Design Software Users Guide	77-53 Vol. IV

The above material is also organized in an additional four volumes which provide a slightly different reader orientation as follows:

Title	Document No.
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Ohio	5030-43*
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Texas	5030-61*
State Criminal Justice Telecommunications (STACOM) User Requirements Analysis	5030-80*
State Criminal Justice Telecommunications (STACOM) Network Design and Performance Analysis Techniques	5030-99*

*Jet Propulsion Laboratory internal document

This document, No. 77-53, Vol. II, entitled "State Criminal Justice Telecommunications (STACOM) Final Report -- Vol II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network," describes methodologies developed for user requirements studies and for the analysis and design of communication network configurations. It then illustrates the applications of these methodologies in the State of Ohio.

This document presents the results of one phase of research carried out jointly by the Jet Propulsion Laboratory, California Institute of Technology, and the States of Texas and Ohio. The work at the Jet Propulsion Laboratory was performed by the Systems Division, Telecommunications Science and Engineering Division, and Information Systems Division under the cognizance of the STACOM Project. The project is sponsored by the Law Enforcement Assistance Administration, Department of Justice, through the National Aeronautics and Space Administration (Contract NAS7-100).

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

APB	All points bulletin
BCII	Ohio Bureau of Criminal Identification and Investigation
BMV	Ohio Bureau of Motor Vehicles
bps	Bits per second
CCH	Computerized Criminal Histories
CDS	Comprehensive Data System
CJIS	Criminal Justice Information System
CLEAR	Hamilton County, Ohio (Cincinnati) County Law Enforcement Applied Regionally
CRT	Cathode ray tube
DEA	United States Drug Enforcement Agency
DHS	Ohio Department of Highway Safety
FINDER	Calspan Technology Products, Inc., registered trademark for Fingerprint Detector Readers
FBI	Federal Bureau of Investigation
LEAA	Law Enforcement Assistance Administration
LEADS	Ohio Law Enforcement Automated Data System
MDT	Mobile Digital Terminal
NALECOM	National Law Enforcement Telecommunications
NCIC	National Crime Information Center
NCJISS	National Criminal Justice Information and Statistics Service
NILECJ	National Institute of Law Enforcement and Criminal Justice
NLETS	National Law Enforcement Telecommunications System
NORIS	Lucas County, Ohio (Toledo) Northwest Ohio Regional Information System
OBSCIS	Offender Based State Corrections Information System

OBTS	Offender Based Transaction Statistics
OCCA	Omnibus Crime Control Act of 1968
OCH	Ohio Criminal History
ODRC	Ohio Department of Rehabilitation and Corrections
OSP	Ohio State Patrol
PD	Police Department
RCC	Regional Computing Center
RCIC	Regional Crime Information Center
RSC	Regional Switching Center
SEARCH	System for Electronic Analysis and Retrieval of Criminal Histories
SGI	Search Group, Inc.
SIFTER	System for Identification of Fingerprints by Technical Search of Encoded Records
SJIS	State Judicial Information System
SO	Sheriff Office
SPA	State Planning Agency
STACOM	State Criminal Justice Communications
UCR	Uniform Crime Reports

ABSTRACT

Requirements analysis and design for the Ohio Criminal Justice Telecommunications Network is provided in Volume II of the Final Report of a State Criminal Justice Telecommunications (STACOM) project sponsored by the Law Enforcement Assistance Administration (LEAA).

The project has developed techniques for identifying user requirements and network designs for criminal justice networks on a state wide basis. Techniques developed for user requirements analysis involve methods for determining data required, data collection, (surveys), and data organization procedures, and methods for forecasting network traffic volumes. Developed network design techniques center around a computerized topology program which enables the user to generate least cost network topologies that satisfy network traffic requirements, response time requirements and other specified functional requirements.

The developed techniques were applied in the state of Ohio, and results of these studies are presented.

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SECTION 1

SUMMARY

1.1 OBJECTIVES OF STACOM

The State Criminal Justice Communications (STACOM) user requirements study was performed to support the primary STACOM project objective of providing states with the tools needed for designing and evaluating intrastate communications networks. The STACOM project goals are:

(1) Develop and document techniques for intrastate traffic measurement, analysis of measured data, and prediction of traffic growth

(2) Develop and document techniques for intrastate network design, performance analysis, modeling and simulation

(3) Illustrate applications of network design and analysis techniques on typical existing network configurations and new or improved configurations

(4) Develop and illustrate a methodology for establishing priorities for cost effective expenditures to improve capabilities in deficient areas.

To support these overall project goals, and specifically the first, a user requirements task was undertaken to develop and use tools for predicting future criminal justice communications traffic. These tools include techniques of statistical analysis for extrapolating past trends into future traffic predictions, and survey and interviewing techniques for estimating traffic in data types that do not yet exist. The user requirements study was therefore divided into two phases: a study of past trends in existing data types to project future trends in communications traffic for these data types; and a study of new data types that do not yet exist, but which are anticipated, to estimate their future traffic volume.

Network designers then use these estimates of existing and new data types to suggest future intrastate network designs that minimize cost and still satisfy performance requirements. Knowing estimated traffic volumes over a decade, network designers can suggest the best times to upgrade computers or communications lines to keep the performance within the required limits and assure minimum costs.

1.2 TRAFFIC PROJECTION METHODOLOGY AND RESULTS

1.2.1 Existing Data Types

Existing data types contain information primarily used by law enforcement agencies which have been in use typically for several years. These data bases contain files on:

(1) Stolen articles including automobiles, license plates, and other property

(2) Wanted persons

(3) Drivers license information, including driving record and description of driver

(4) Vehicle registration information.

Law enforcement agencies in most states have had access to centralized state data bases containing these file types since the early 1970s. This allows the establishment of historical communication traffic growth patterns and the use of these patterns to project future growth. In the past users have accessed these data files over low-speed communication lines which are defined as 300 bps lines or slower. Many states are now upgrading to high-speed lines which are defined as 1200 bps or faster.

Two causes of past growth of communication traffic into existing data bases have been identified: growth due to communication system improvements, and baseline growth. Communication system improvements that occurred in the two model states were:

(1) Addition of new data bases

(2) Conversion of low-speed communication lines to high-speed lines and new terminal equipment

(3) Addition of new user agencies

(4) Establishment of regional information systems

(5) The use of mobile digital terminals by large municipal police departments.

Baseline growth is the increase in communications traffic that would occur even if there were no communication system improvements and is generally related to:

(1) Increased utilization of existing services

(2) Population and personnel increases

(3) Training.

The first step in our traffic projection methodology was to establish the historical total system traffic growth pattern and to record all past communication system improvements. The second involved the determination of the component of traffic growth caused by past system improvements. This was done by measuring traffic from impacted user agencies or data bases immediately before and immediately after system improvements were made. These increases were short term in nature and were not projected into the future. Baseline growth was calculated in the third step by using the equation:

$$\begin{pmatrix}\text{Baseline Traffic}\\ \text{Growth}\end{pmatrix} = \begin{pmatrix}\text{Total Traffic}\\ \text{Growth}\end{pmatrix} - \begin{pmatrix}\text{Communication System}\\ \text{Improvement Growth}\end{pmatrix}$$

A key assumption of the forecasting technique was that baseline growth in the future will continue as it has in the past. Thus, the fourth step involved using the baseline growth curve established in step three to project future baseline growth. Finally, it is recognized that over the next decade there will be further communication system improvements. The fifth step, therefore, was to identify future expected communication system improvements, their implementation schedule, and their impact on future traffic. The sixth and final step was to combine future baseline growth and growth due to system improvements to obtain future traffic levels into existing data files.

In Ohio, system traffic in early 1972 averaged 32,000 messages per day and increased to 125,000 messages per day by 1976. Of this increase 48,000 messages per day was due to baseline growth and 45,000 messages per day was growth due to communication system improvements. Figure 1-1 shows the Ohio existing data type traffic projections. It is projected that by 1985 traffic into existing data files will be approximately 280,000 messages per day.

1.2.2 New Data Types

New data types consist of those information files which are not now in common use but which are being seriously considered for future implementation. They include:

(1) Law enforcement agency use of a computerized criminal history (CCH) and offender based transaction statistics (OBTS) file, where "law enforcement agency" includes police, sheriff, state police, federal agencies, prosecutors, county jails, and local probation offices

(2) Court use of the CCH/OBTS file for both felony and misdemeanor court processing in the large metropolitan areas of each state

(3) Corrections use of the CCH/OBTS file from the corrections department headquarters and from the penal institutions throughout each state

(4) Use of the CCH/OBTS files by the agencies in each state that administer parole from state institutions, if it is reasonable for that parole agency to participate in the communications network

(5) A state judicial information system (SJIS) for reporting court statistics from the civil and criminal cases of the courts that handle felonies and misdemeanors in the large metropolitan areas

(6) An offender based state corrections information system (OBSCIS) which is a system of files at the headquarters of each state's correctional agency containing information on all inmates in all the state's penal institutions. Portions of these files might be accessible to terminals in the institutions and in the parole agency

(7) Juvenile agency records, if it is reasonable for the juvenile detention agency to participate in the communications network

(8) An automated fingerprint encoding, classification, and transmission system for the large metropolitan areas

(9) Traffic from the states' identification and investigation bureaus for converting manual files on offenders into computerized files, and for entering new offender records that are received manually at the state center.

This traffic in new data types is added to projections of traffic from existing data types to obtain total criminal justice system traffic for the next decade. Network design techniques are then applied to this total traffic volume to design a minimum cost criminal justice information system that meets the performance requirements.

New data type traffic forecasts were made using a combination of estimates from operators and users of the present criminal justice communications systems in each of the states, and using extrapolations based on recent history. The new data types were divided into three basic types for purposes of projecting future traffic: (1) Arrest-dependent traffic such as transactions with the CCH/OBTS files which originate at law enforcement agencies, courts, correctional institutions, probation and parole agencies, prosecutors, and federal offices, and including automated fingerprint traffic; (2) Offender-related traffic such as that associated with an OBSCIS system in adult correctional institutions or with juvenile agency traffic; (3) Traffic whose volume is determined by other factors, such as that in an SJIS system which would be determined by court activity, or traffic from a state data center devoted to converting manual records to automated files.

Arrest dependent traffic was estimated by determining the number of offenders through each step of the states' criminal procedures and then projecting the number and types of messages that would be generated at each step of the procedure. Summing these information needs over the procedural steps carried out by a particular agency then yielded the total message volume generated by that agency as a function of the number of arrestees through the process. The approach of assigning information needs to the several steps of a state criminal procedure

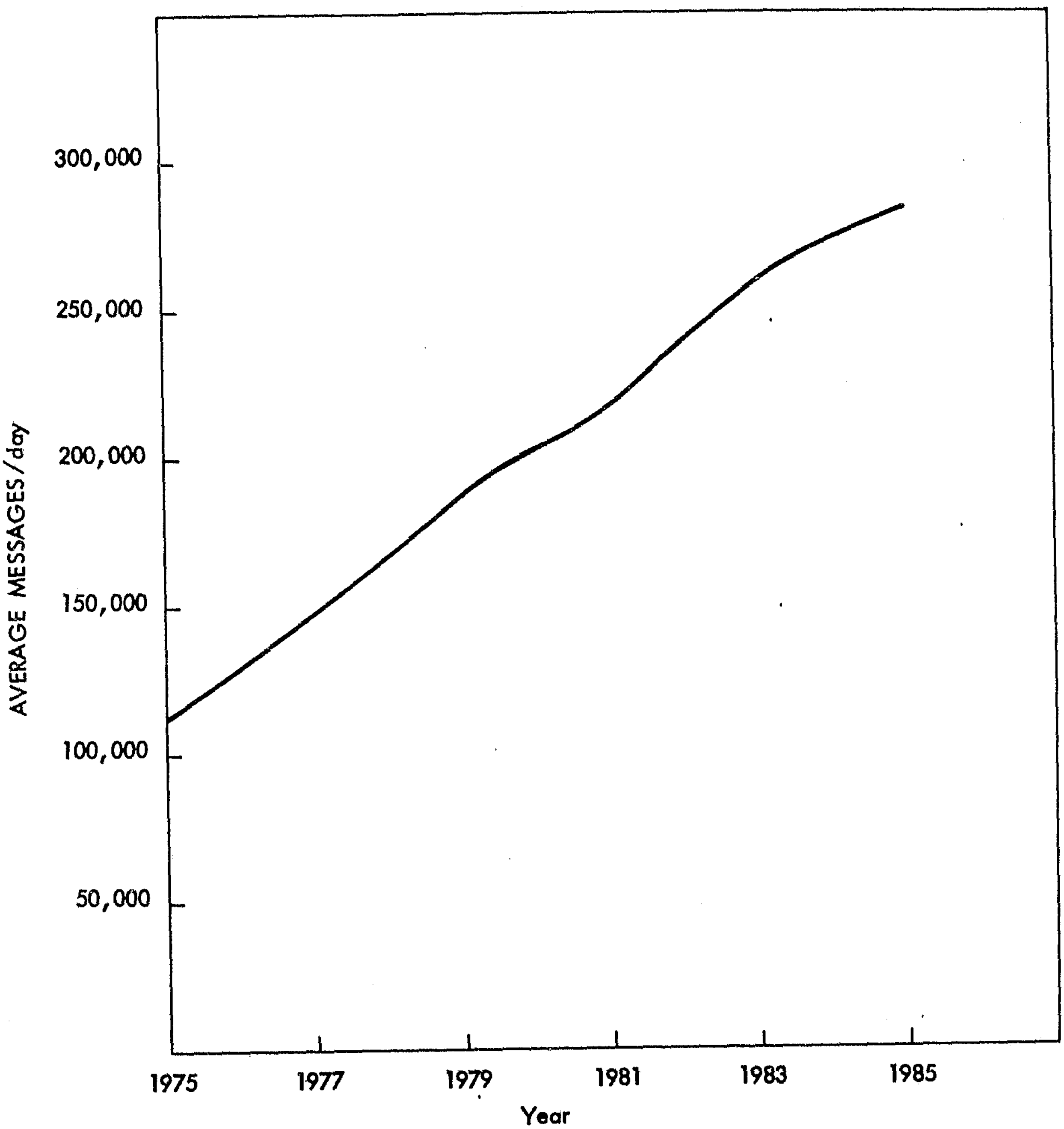

Figure 1-1. Ohio Projected Existing Data Type Traffic Growth

was first suggested for this project by Bill Griffith of the Ohio Department of Computer Services. This technique was applied to both CCH/OBTS traffic from all criminal justice agencies and to automated fingerprint traffic from law enforcement agencies. CCH/OBTS traffic was allocated to user terminals according to the total FBI index crime in each law enforcement jurisdiction. Court usage was prorated according to the population or court activity in the largest metropolitan areas. Correction usage was distributed according to the number of inmates in the several institutions, and only the headquarters of the parole agency was allocated traffic if that office was a user of the CCH/OBTS files. Automated fingerprint traffic was distributed to the large metropolitan areas according to the population of each city or according to the total FBI index crime in each metropolitan area.

Offender-dependent traffic includes an OBSCIS system for each state's correctional institutions and, if anticipated by the states, a youth agency data system. Traffic was computed by assuming that an inquiry and a file update were generated for every inmate or student in the state institutions every few weeks, and that, if the parole agency had access to an appropriate part of the system, it would also generate inquiries on a regular basis. The estimate of transaction frequency was derived from conversations with correctional institution information system officials who described past experience and provided future estimates of traffic volumes. Traffic was distributed between the institutions according to the number of inmates or students in each facility.

Other types of traffic include an SJIS system, which would produce traffic dependent upon the level of court activity, and data conversion traffic from the state data center, which would depend on the number of employees in such a center and on the volume of records requiring conversion and updating. SJIS traffic was estimated by assuming that only statistical information would be transmitted on state networks and that one message would be generated for each criminal or civil disposition in the courts of the largest metropolitan areas. SJIS traffic was distributed according to the population of metropolitan areas, or according to the volume of dispositions, whichever provided the best statistics. Although an assumption was made throughout the study that criminal activity and communication traffic will increase each year, data conversion traffic was kept constant because it was also assumed that inquiries and file updates will gradually come from remote user terminals rather than from a central state investigative agency.

This analysis suggests that new data traffic in Ohio will increase from an early 1977 value of about 14,000 messages per day to 170,000 messages per day in 1985. The large increase in Ohio traffic is based on the assumption that recent legislative bills requiring state reporting of both felony and misdemeanor arrests will be enacted, and that traffic will be much higher than if only felony arrests were reported. Local agencies are understood to be opposed to this legislative request because of the increased workload it would impose, but its passage was assumed so that the system was conservatively designed to handle this increased traffic if it should appear on the network. New data traffic growth for Ohio is shown in Figure 1-2.

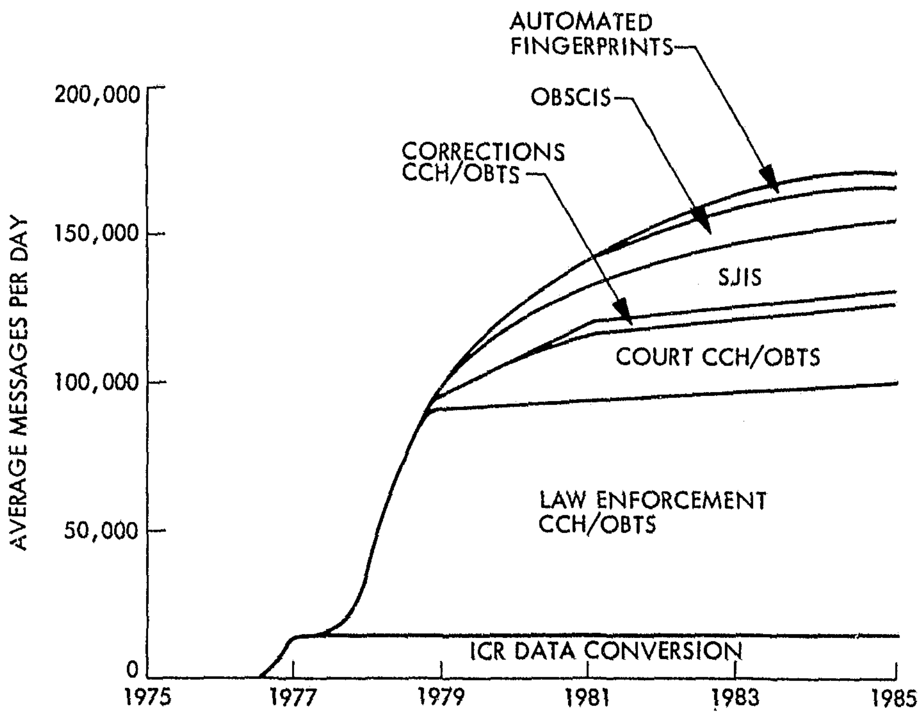

Figure 1-2. Ohio New Data Traffic Growth

1.2.3 Existing and New Data Type Traffic Projections

The existing data type traffic volume of Section 1.2.1 and the new data type traffic volume of Section 1.2.2 were added to obtain the total estimated traffic volume for the study period as shown in Table 1-1 and in Figure 1-3. The derivation of these total traffic volumes is described in Section 5. For the purposes of this summary, it is sufficient to note that, in addition to merely adding the traffic volumes of new and existing data types, the total system traffic was modified to account for a slowing of traffic growth whenever the volume reached a level close to the system's computer capacity, and for a similar brief period of slow growth followed by an accelerated growth period immediately after a computer upgrade. Note that, although existing data type traffic exceeds new data traffic volume throughout the period of this study when measured in units of average messages per day, new data volume far exceeds existing data traffic toward the end of the study period if volume is converted to peak characters per minute. This dominance is caused by the longer message lengths of the expected new data types. Note also that between 1977 and 1985 this study projects about a threefold increase in Ohio's traffic measured in average messages per day, and a fivefold increase in demand in terms of peak characters per minute. If existing data traffic continues to increase as it has in the past, and if new data types are implemented at the rate state planners hope they will be, state communication system operators and data system planners should prepare for a continuing program of upgrades to terminals, lines, switchers, and central processors. The necessity of such a program is apparent in Ohio and it is likely that many other states are in a similar growth situation.

1.3 SUMMARY OF NETWORK DESIGN GENERAL METHODOLOGY

Six major activities were carried out in the network design phase of the study. These activities are summarized in the following paragraphs:

1.3.1 Definition of Analysis and Modeling Techniques

A task was undertaken to define and develop specific analysis and modeling tools for general use in intrastate systems. The principal tool developed is the STACOM Network Topology Program. This program, written in FORTRAN V and implemented on a UNIVAC 1108 computer under the EXEC-8 operating system, enables a user to find least cost multidropped statewide networks as a function of traffic level demands and other functional performance requirements.

The major inputs to the program are:

(1) Traffic levels at each system termination on the network

(2) Desired response time at network system terminations

(3) Line tariff structures

(4) Locations of system terminations using Bell System Vertical-Horizontal (V-H), coordinates

(5) The number of desired regional switching center, (RSC), facilities. RSCs serve system terminations in their defined regions and are interconnected to form total networks.

Table 1-1. Total Statewide Criminal Justice Information System Traffic in Ohio

Traffic Summary: Average Messages per Day.

Year	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	147,200	14,300	161,500
1979	188,800	99,500	288,300
1981	213,500	142,300	355,800
1983	255,800	163,500	419,300
1985	281,200	170,300	451,500

Traffic Summary: Peak Characters Per Minute.

Year	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	23,720	10,960	34,680
1979	30,420	69,240	99,660
1981	34,400	103,560	137,960
1983	41,200	121,720	162,920
1985	45,300	127,250	172,550

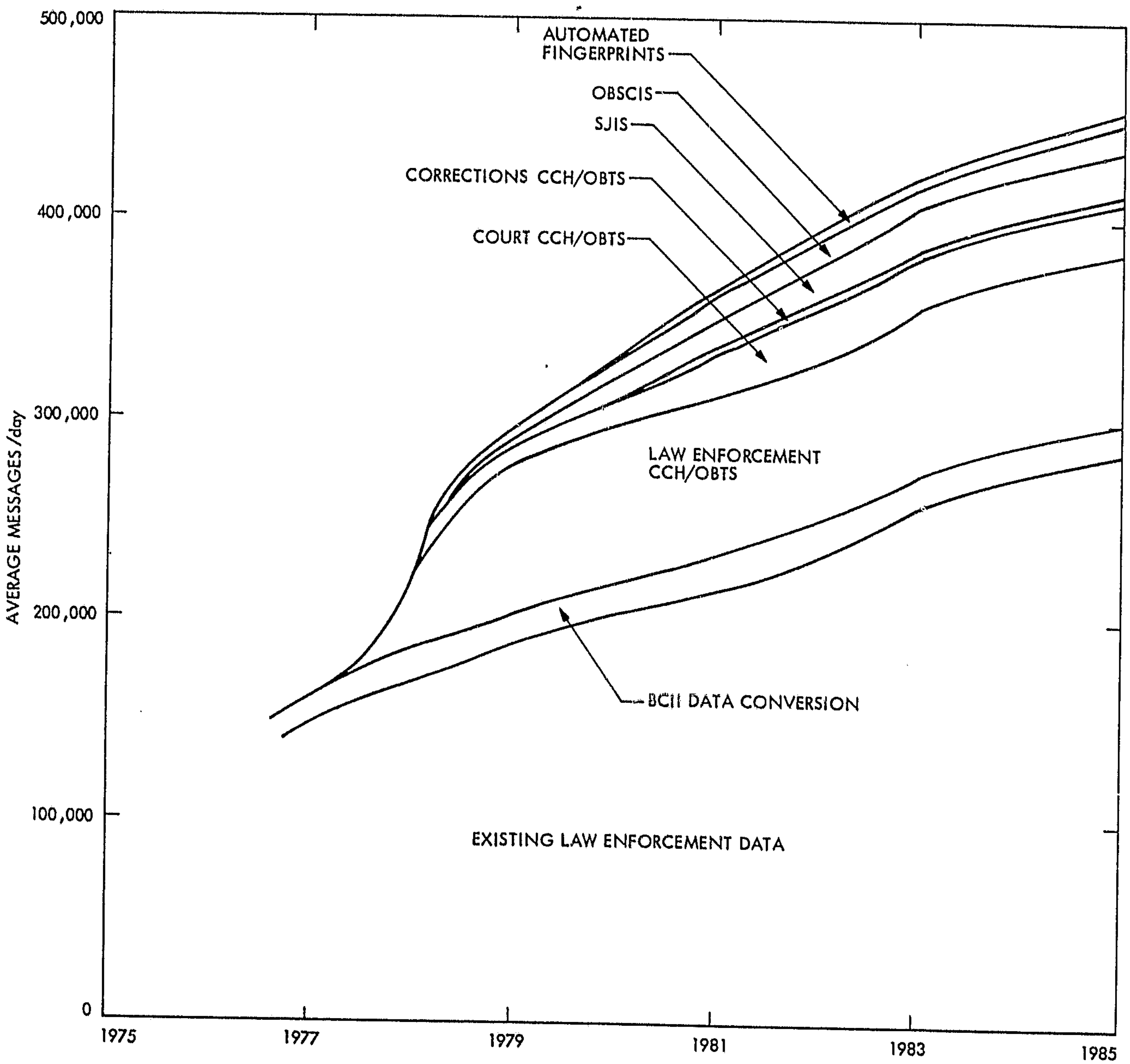

Figure 1-3. Ohio Statewide Criminal Justice Information System Traffic Projection in Average Messages per Day

Principal outputs of the topology program are:

(1) Line capacities and layouts servicing system terminations

(2) Fixed and annual recurring costs for lines, modems, service terminals, etc. RSCs are priced separately.

(3) Line performance characteristics such as line utilizations and mean response times

A second major analysis technique enables network designers to determine the reliability and availability of network configurations produced by the topology program.

Finally, a network response time model used in the topology program, is also useful in understanding present and future performance requirements for switching and/or data base computers in the network. This is true because the response time model involves a queueing analysis which includes queueing times encountered at computer facilities.

Descriptions of these design and analysis tools are presented in more detail in Section 7 of this report.

1.3.2 Network Functional Design Requirements

At the completion of state system surveys, and after sufficient interaction with state planning personnel, and prior to any specific network design activity, a document was produced specifying Network Functional Design Requirements. This document provides network performance criteria which are to be met in subsequent designs. The Functional Requirements specify what the network must do, and do not address at this level the specifics of how requirements are to be met.

The network Functional Requirements for Ohio are presented in Section 10.

1.3.3 Analysis of Existing Networks

This task employed developed design and analysis tools to determine the extent to which existing statewide networks conform to State Network Functional Requirements. Areas of discrepancy are noted and discussed. Results for Ohio are summarized later in this Section. A detailed discussion is presented in Section 11.

1.3.4 Generation of New or Improved Networks

After specific studies of interest were identified with state personnel, STACOM design and analysis techniques were employed to study statewide network configuration alternatives, (options), and additional cost impact studies of interest.

In the State of Ohio, four basic network options were considered for the LEADS system. These involved determining cost and performance measures under the Multi-Schedule Private Line, (MPL), tariff for LEADS configurations employing from zero to three RSCs in addition to the switcher/data base facility in Columbus. The four options were:

Option 1 - switcher/data base located in Columbus (one region).

Option 2 - switcher/data base located in Columbus plus an RSC in Cleveland (two regions).

Option 3 - switcher/data base located in Columbus plus RSCs located in Cleveland and Cincinnati, (three regions).

Option 4 - switcher/data base located in Columbus plus RSCs located in Cleveland, Cincinnati and Toledo, (four regions).

Four more network options were studied in Ohio involving the possible integration of BMV and New Data Networks with the LEADS Network. These options were:

Option 5 - costs for maintaining separate LEADS and BMV networks.

Option 6 - costs for integrating the LEADS and BMV networks into a single network.

Option 7 - costs for maintaining separate LEADS and New Data networks.

Option 8 - costs for integrating the LEADS and New Data networks into a single network.

Two additional network performance studies carried out in Ohio included consideration of LEADS network cost increases as terminal response time requirements are reduced, and an inquiry into the impact on network cost and performance due to adding digitized classified fingerprints as a traffic type to the LEADS system.

1.3.5 Software Documentation

A final task carried out was the documentation of the STACOM Network Topology Program in the form of a users guide. This document, No. 77-53, Vol. IV, is entitled, "State Criminal Justice Telecommunications (STACOM) Final Report - Volume IV: Network Design Software Users' Guide."

1.4 SUMMARY OF NETWORK DESIGN STUDY RESULTS

The study results itemized below are discussed in more detail in Section 13 in this report. The following summary lists the principal findings of interest for each of the studies carried out.

Ohio Study Outcome

- The least cost LEADS Network is a single region configuration with a switcher/data base facility located in Columbus. The line savings due to the use of one, two or three additional regional switchers do not offset increased costs for regional switcher hardware, sites, personnel, interregion lines and increased engineering costs.

- The STACOM optimized single region LEADS network is less costly than continuation of the present LEADS system over a period of eight years by approximately $2,850,000. This cost differential considers user terminal and line costs only. Columbus switcher/data base costs are not included. The new network also meets all STACOM/OHIO Functional Requirements.

- Response time goals listed in the STACOM/OHIO Functional Requirements are not met in the existing system on low speed lines, and on high speed lines during periods of network peak loading.

- There are no meaningful network cost savings to be realized through the integration of the LEADS and BMV systems if the integrated network is priced with the MPL interstate tariff. A meaningful cost savings can be realized if the integrated network is priced under an intrastate tariff.

- There are no significant cost savings to be realized through the integration of New Data Types into the LEADS network over maintaining separate networks.

- Digitized classified fingerprint data can be added to the LEADS network as specified in this report without compromising performance of the STACOM/OHIO LEADS System.

- LEADS network response time requirements for the STACOM/OHIO single region case can be reduced from 9 to 7 seconds before additional costs are incurred. Reduction to 6 seconds increases annual line costs approximately 2%. Reduction to 5 seconds increases annual line costs approximately 13%.

- The mean service time per transaction in the Columbus switcher/data base computer should be immediately reduced to 470 ms. In 1981 the required mean service time per transaction is 425 ms and in 1985 340 ms is required in order to meet functional requirements for traffic growth. A 4 x 4 processor (4 central processing units) configuration is called for in 1981.

SECTION 2

SYSTEM DESCRIPTION

2.1 GENERAL

Many states already have sophisticated criminal justice communications systems and are continually working to upgrade them. This upgrade process includes modifications to anticipate increased traffic and the addition of new files to make the systems more useful to criminal justice agencies. Ohio is doing exactly this; it already has several data systems for law enforcement and criminal justice agencies with steadily increasing traffic, and it is considering system improvements to user terminals, line speed, and central computers. State planners keep informed and look forward to the day when some of the new data types suggested in this report may be included in the files of their state's system.

In this report, the central state files of existing data types were assumed to include such items as:

- Wanted persons
- Outstanding warrants
- Stolen vehicles
- Stolen license plates
- Drivers licenses
- Vehicle registrations

New data types that might be added during the period of the study included:

(1) Law enforcement use of state CCH/OBTS files

(2) Court use of CCH/OBTS files

(3) Corrections use of CCH/OBTS files

(4) Parole agency use of CCH/OBTS files

(5) A state judicial information system

(6) An offender-based state corrections information system

(7) An automated fingerprint encoding, classification and transmission system

(8) State investigation bureau data conversion traffic

Most of these files were assumed to be located at a central state data center, although it is up to each state to organize the control of its files. In some states, for instance, it might be desirable to keep control of corrections agency files within correctional organizations rather than maintaining them with other state data bases. States will also vary in the distribution of terminals, lines, computers, and switchers. A schematic representation of a state communication system is shown in Figure 2-1, and a diagram of the facilities making up such a system is shown in Figure 2-2. These figures will assist in clarifying the description of the Ohio data bases, facilities, users, and functions in the remaining portions of this section.

2.2 SYSTEM DESCRIPTION

For the purposes of this study, the Ohio criminal justice telecommunications system includes the present LEADS system with all its data bases and existing terminals, any new terminals that might be added to the LEADS system, terminals in courts to support the CCH/OBTS and SJIS functions, terminals in the Ohio Department of Rehabilitation and Corrections (ODRC) for the ODRC's use of the CCH/OBTS files and for an OBSCIS system, and several terminals in the offices of the Ohio Bureau of Criminal Identification and Investigation (BCII) for converting manual records to computer input. One of the options studied for network optimization purposes also includes all the terminals in the Ohio Bureau of Motor Vehicles (BMV) throughout the state.

The system does not include terminals connected to local computers which contain strictly local data bases. For instance, in the Lucas County Northwest Ohio Regional Information System (NORIS) surrounding Toledo, law enforcement agencies and courts have terminals tied into a local computer, but the individual terminals are not included in the state system, as defined in this study, since the state-level termination is taken to be the local computer. The many local terminals have access to the state files through the local computer, but for purposes of traffic distribution on the state network, the termination is taken as the local computer. Similarly, the County Law Enforcement Applied Regionally (CLEAR) system in Hamilton County surrounding Cincinnati, is another regional system with many terminals tied to it, but the local terminals are invisible to the state system since the termination for state traffic projections is the local CLEAR computer.

2.2.1 Data Bases

All of the data bases in the state criminal justice telecommunication system are located in Columbus. The present Ohio criminal justice data center contains records on wanted persons, stolen vehicles, and stolen license plates. It also will contain a large CCH file in the near future, which is treated as a new data type because it has not yet been made available to the users of the LEADS system, and because in the future it might become the nucleus of an expanded CCH/OBTS system with many more data elements.

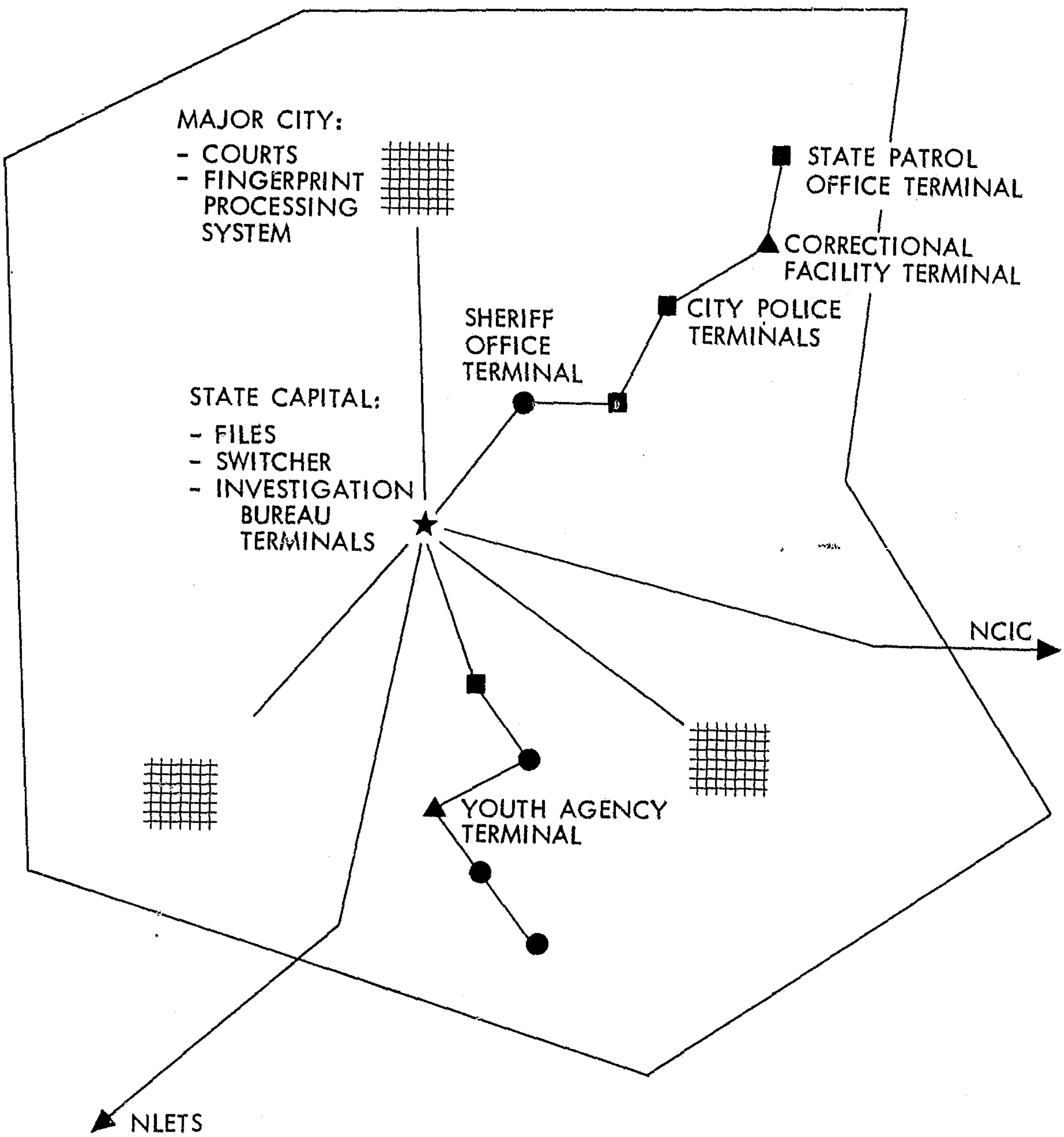

Figure 2-1. State Communication System Schematic

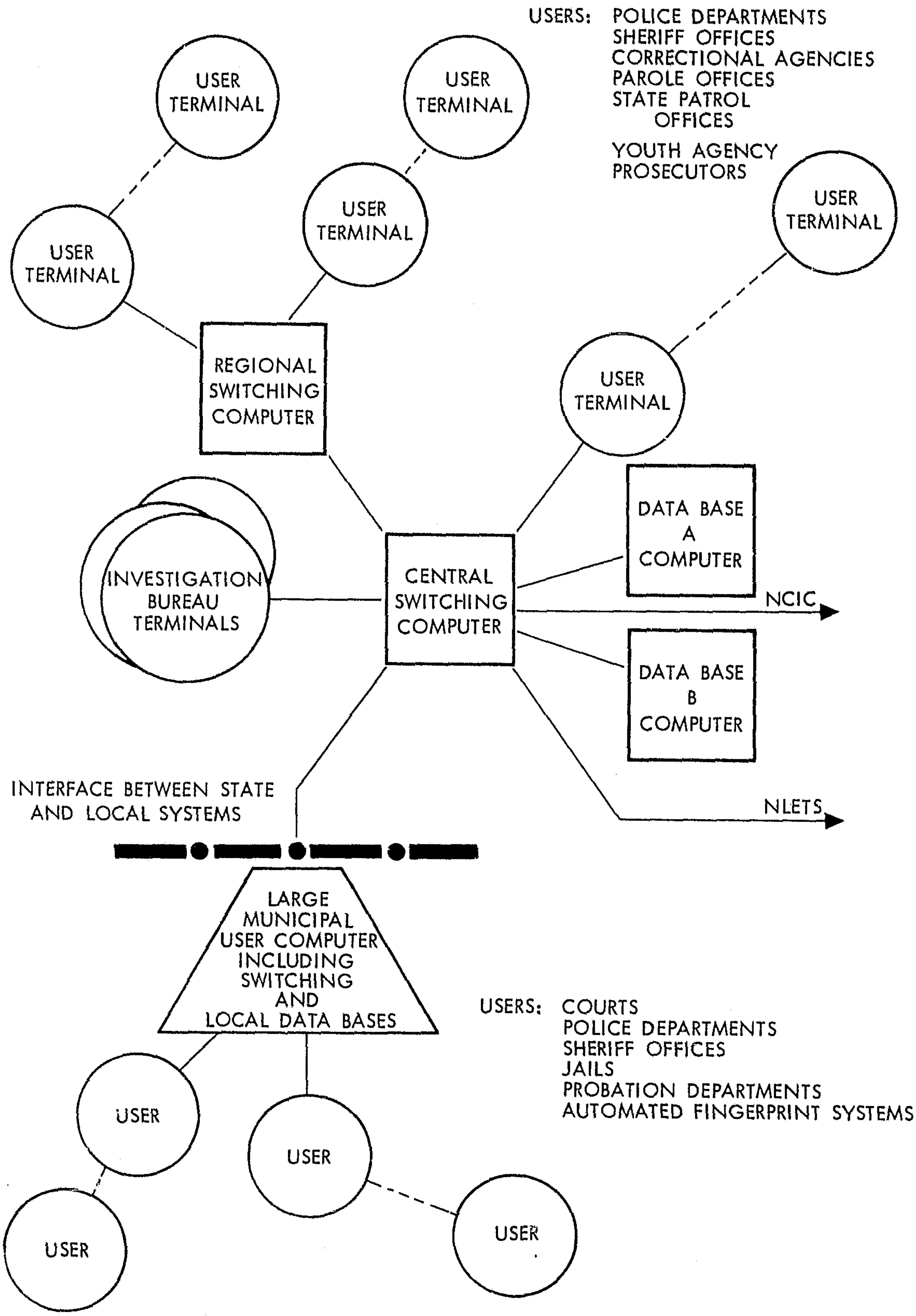

Figure 2-2. State Communication System Facilities

Also located in the data center are files of the BMV which contain records on all licensed drivers and motor vehicles in the state.

New data types include, in addition to the BCII CCH file, data bases required for the systems summarized in Section 2.1. These are:

(1) Statistical data kept by the Administrative Director of Courts in the Ohio Supreme Court for the SJIS system. If an on-line system connecting the large metropolitan courts to the Supreme Court data base were established, the files would likely be kept in Columbus.

(2) The files maintained by the Ohio Department of Rehabilitation and Corrections (ODRC) at its headquarters which would make up the OBSCIS system.

(3) New automated fingerprint files kept by the BCII in Columbus. These automatic files would be kept in a file separate from, but similar to, the manual fingerprint file presently maintained by the BCII.

2.2.2 Users

The users proposed for the Ohio criminal justice information system include all of the present users of the LEADS system, any expansion of that system to counties or agencies which would like to participate, and other criminal justice institutions which have, up to now, not had computerized information systems available to them or which had their own dedicated machines, but which were not tied into a statewide system. These additional users are listed in Section 2.1 but are summarized below for completeness.

(1) The law enforcement users of the LEADS system are primarily the local police departments and sheriff offices throughout the state. In addition, Ohio State Patrol (OSP) offices are tied in, as are several federal law enforcement, military, and investigatory agencies. In the larger cities such as Cleveland, Cincinnati, and Toledo, the user is a large computer installation provided by the city or county, with individual terminals in the local offices connected to the central local computer. To the statewide network, the terminal appears as a very large single user, when it really is up to several hundred users on the other side of a single computer.

(2) The proposed statewide system would include the courts in the appellate judicial districts surrounding the six largest metropolitan areas. These users would include both courts of general and limited jurisdiction and would apply to both criminal and civil court activity. The statewide network would allow the courts to inquire into or update the CCH/OBTS files, and it would allow

the courts to send their statistics automatically to the Supreme Court for inclusion in the SJIS system. The complete SJIS system would provide the calendar management and court records functions at the local level within the largest appellate judicial districts but on a statewide level it would only provide a court statistics capability.

(3) The ODRC would be connected to the statewide criminal justice information system under this proposal, to allow the eight ODRC institutions to obtain information and update state records in the CCH/OBTS files and to communicate with the ODRC files in Columbus to obtain information on inmates from the OBSCIS system.

(4) Law enforcement agencies in the largest metropolitan areas would already be users of the statewide system, but the new automated fingerprint data would be added to their traffic in future years. This use would consist of both fingerprint cards that had been automatically encoded and classified, and latent prints for search and matching during an investigation.

2.2.3 Facilities

The facilities of a statewide Ohio criminal justice information system which would include both existing and new data types would be an expanded version of the present LEADS system. The LEADS system includes the criminal justice data base in Columbus, lines and modems to communicate with the users, and terminals in the user agencies. The BMV network includes a separate system of lines, modems and terminals in BMV offices with users having access to the drivers license and vehicle registration files of the criminal justice data base. Computer installations are located at the data bases and in the large cities and counties where they serve as the termination of the statewide system and as a central switcher and data base for hundreds of local terminals which can access the state system through this local computer.

An expanded statewide system including new data types would have more individual terminals as local agencies come to depend on the speed and utility of the state system. The detailed design of a statewide system, including cost trade-offs to minimize network and computer costs, is described in the network design and performance analysis phase of this report. The SJIS systems run by the courts in the appellate judicial districts surrounding the six largest metropolitan areas would each likely require a computer with terminals in the individual courts, since it is anticipated that the SJIS systems would be local court record keeping installations with only statistics sent on to the Supreme Court in Columbus. Additional lines and modems would be required for connecting these local SJIS installations into the statewide system.

Similarly, the ODRC would require a computer in Columbus with terminals in the eight remote institutions to operate an OBSCIS system.

This computer could be a portion of the LEADS system with a separate data base, or it could be an entirely separate machine with its own data base which is dedicated to the ODRC. ODRC headquarters already has a LEADS terminal, and it will likely only be a short time before ODRC has access to the state CCH files. Terminals in the institutions are several years away, and it would take this development before a true OBSCIS system could be established. The Ohio parole system is under the jurisdiction of the ODRC so parole records are available to the parole agency management. It is not likely that terminals will be placed in local parole offices since parole officers would likely be able to use a nearby police or court terminal for an inquiry or update that was required.

2.2.4 Functions

The statewide Ohio criminal justice information system discussed in this report serves a multitude of functions by providing all criminal justice agencies with easily and rapidly accessible data in a wide variety of categories. Data files maintained in the state criminal justice data base contain information on:

- Wanted persons
- Auto alert files
    - Stolen vehicles
    - Vehicles involved in felonies
    - Stolen license plates
- Drivers licenses
- Vehicle registrations
- CCH files

In addition to these files, users can access a national data base located in Washington, D.C., via the state system. This National Crime Information Center (NCIC) is operated by the FBI. NCIC files are:

- Stolen vehicles
- Stolen articles
- Wanted persons
- Stolen securities
- Stolen guns
- Stolen boats.

Finally, users can send and receive messages to and from other states over the National Law Enforcement Telecommunications System (NLETS) which consists of only communication lines and a switcher. NLETS has no data base. Messages to other states first travel via the state system to Columbus where they are switched onto the NLETS system.

This report suggests that in the coming decade the existing CCH files in the BCII will be expanded to include a complete CCH/OBTS system so that offenders are tracked throughout their criminal careers by all criminal justice agencies. For purposes of estimating traffic over such a system, it is assumed that this expanded CCH/OBTS file will be made available to a larger group of users, including more local city and county police agencies, the courts in the large appellate judicial districts, and the ODRC and its institutions throughout the state. The functions to be performed by this system are really limited only by the imagination of the individual user agency and the local terminal operators. Data on a wide variety of topics are made available to users in a matter of seconds, and user resourcefulness is the limiting factor in determining the functions to be performed.

Besides assuming a continuation of the existing files, and an expanded CCH/OBTS data base with more users, this report estimates future traffic on the assumption that several more new data types will be added to the system in the next decade, along with the appropriate users. These new data types and users are described in the sections above, and the functions performed by the system are again limited primarily by the imagination of the user and the operating agency.

For instance it is assumed that the SJIS system, which is estimated to be started on an experimental basis in a single judicial district, but which is not projected to be in use throughout the state until the 1980s, will be used on a local level for court management, case tracking, and calendar scheduling in both criminal and civil cases. None of this business would appear on state lines, however, since state reporting would be confined largely to statistical record keeping.

The Ohio Department of Rehabilitation and Corrections does not presently have access to the BCII CCH files, nor is there an on-line OBSCIS system operating. However, within the next decade it is projected that both of these functions will be provided in the Ohio criminal justice communication system.

Gradually, as automated fingerprint systems become standardized, less experimental, and less costly, it is expected that Ohio will begin to implement such systems, at least in the large metropolitan areas where fingerprint volumes justify the expense of the equipment. The statewide telecommunications system would function to transmit both encoded and classified 10-print cards and encoded latent prints found in an investigation. Fingerprint card information would then be filed, and the files could be searched automatically for prints to match latents.

In addition to providing access to a centralized data base, the state criminal justice system allows transmission of messages between users. Administrative messages can be sent from one user agency to another or an "all points bulletin" message can be sent from one agency to many other agencies. These messages are free form in format and do not require data base searches.

SECTION 3

TRAFFIC GROWTH MODELING - EXISTING DATA TYPES

3.1 APPROACH

Determining future communication traffic levels is of primary importance in assessing the users' needs of a state criminal justice telecommunication system. Future communication traffic levels into existing data files were estimated by examining available past growth trends, and projecting these trends forward. There were two components to past traffic growth: growth due to communication system improvements, and growth due to increased user demand. It was assumed that growth due to increased user demand would continue into the future as it has in the past. Growth due to communication system improvements can be characterized as short term rapid increases and thus it would be inappropriate to project these increases forward. We have instead predicted implementations of future communication system improvements and their impact on traffic levels. Our estimates of these two components of traffic growth are combined to form the prediction of total future communication traffic levels into existing data types.

Once total communication traffic levels are known we must determine the distribution of traffic across all locations in the state. This involves the identification of the paths of general traffic flow as well as a quantification of the number of messages to and from each system user. Models were developed that correlated current traffic levels with user characteristics. These models were then used to determine future traffic distributions.

3.2 DATA GATHERING TECHNIQUES AND RESULTS

In order to perform this analysis, information is needed from the model states concerning current and past network configurations, record types, traffic volumes, message lengths, traffic distributions, operating procedures, user agency characteristics, and planned upgrades. Five years of past data were collected.

Two survey forms were developed to obtain this information. A state level questionnaire was written and given to the communication system planner in the state planning agency. This survey form is shown in Appendix A. The survey was directed to the proper persons in the Ohio state government. We obtained answers to our questionnaire from the Ohio State Patrol and the Law Enforcement and Programming Division of the Department of Computer Services.

As seen in Appendix A we began by asking state planners to provide one diagram showing principal components used in information interchange between all criminal justice user agencies. Principal components were defined as:

Data bases

Switchers/concentrators

Terminals

Communication lines

Data bases only included those computers containing records that could be accessed by communication lines considered part of the state information system. We also asked for communication line sizes in bauds which measures the rate that information can be loaded on and taken off communication lines. Finally we asked state planners to identify changes to the above diagram and indicate when these changes were made. Answers to these questions provided a knowledge of current and past network configurations. In general, this information was available.

The second question on the state survey asked for more specific information concerning data bases. We asked for the type and number of records available to system users from 1971 - 1976. A minimum of five years of past traffic statistics were needed to establish past growth trends. Again, Ohio provided us with answers to this question.

The third question asked for traffic volume data. We requested monthly communication traffic volumes in units of average messages per day by user agency and message type. The time period was again January 1971 - 1976. Ohio had complete statistics back to 1971; however, due to inconsistencies between IBM and UNIVAC statistical packages there were discrepancies in the definition of a message before and after the Spring of 1975.

The fourth question asked state planners to provide average message lengths by message type. As a check of these numbers, we also asked to see format details for all message types transmitted over the state criminal justice telecommunications system. Ohio responded to this question by providing us with a copy of their operating manuals which presented formats required to obtain access to the files. Combining knowledge of message formats with a knowledge of the message type volume distribution allowed us to calculate an average message length.

Question five asked for an origin and destination matrix showing yearly message volume from each user agency to each other user agency in the state. Ohio could not provide this information.

The sixth question asked about operating policies that affect traffic volumes. Specifically we asked whether queries into one data file automatically generate queries into other data files and whether there were record update requirements. No answers were obtained to the second question; however, information was provided on automatically generated messages.

Finally we asked state planners to inform us of any planned upgrade that would affect traffic against current law enforcement files. We listed examples such as:

(1) An increase in the number of records in a file

(2) A reduction in response time

(3) An increase in the number of user agencies.

Ohio provided a complete response to this last question.

The second form designed for the collection of information was the User Agency Questionnaire. (See Appendix B.) This questionnaire was intended to obtain information on user characteristics, on current and desired response time and to obtain from the users an estimate of their current traffic levels. This last item was intended to be a check of similar data requested from the state. User survey forms were sent to all user agencies in Ohio. Many, but not all, agencies completed the survey and returned it to us.

As seen in Appendix B user agencies were asked to supply traffic data in the form of the average number of messages sent per day on the state system, the average number of messages received per day on the state system, and the number of messages sent during a peak hour on the state system. Responses were generally consistent with state statistics which were most likely the data source used by the respondents.

Users were next asked for current average response times and acceptable response times. Almost all agencies answered these questions with acceptable response times slightly lower than actual response times.

Finally, user agencies were asked to supply data on the crime rate per capita in their area and the number of personnel requiring information over the state criminal justice telecommunications system. Five years of this information was requested; most agencies supplied it for the current year but did not give historical data.

Because a number of agencies did not respond to the user surveys, other sources of data were identified that could fill information gaps. Uniform crime report data were obtained for Ohio. This report presented population and crime statistics for all law enforcement agencies in the state. We also used the national Uniform Crime Reports issued annually by the FBI (Crime in the United States) to obtain information on the number of personnel employed by each agency.

In addition to survey forms and statistical tables, we conducted personal interviews to collect data necessary for predicting future traffic levels into existing data files. Interviews were conducted with data processing personnel in the larger metropolitan police departments and with persons representing regional information centers. Personal interviews were conducted with these representatives because of the large volume of traffic originating from metropolitan police departments and regional information systems. We asked questions concerning present methods for accessing state data files, future communication plans that would impact communication traffic into the state system, accessibility of information contained in regional data bases to other users of the state system, data types maintained on regional systems, and operating procedures that automatically generate messages from regional data bases into the state data base. We found that on-site interviews were required in some instances; however, we were able to interview a number of these agencies by telephone. Both the large police departments and regional information centers were cooperative and provided the required information.

All the above data were used in our traffic growth and distribution models which will be discussed in following sections.

3.3 ANALYSIS METHODOLOGIES APPLIED TO TRAFFIC STATISTICS

3.3.1 Definitions

Traffic statistics were obtained primarily from the operating agencies of the existing state criminal justice telecommunication systems. The form of the data used to project future growth was monthly message volumes broken out by system users. In examining the data, care had to be taken in interpreting the numbers given and in defining carefully the parameters to be measured.

There are two measures of system traffic that will affect final system design. The first is the number of communication messages transmitted over the system. A communication message is defined as the transmission of information between a sender and a final receiver. For example, when a user is attempting to obtain a record contained in a data base, the sender is considered to be the user and the final receiver is considered to be the data base. Independent of the path of the message, the transmission of the data base query between the user and the data base constitutes one communication message. Once the computer's files have been searched and a response prepared, the transmission of the response from the data base back to the user constitutes a second communication message.

The second measure of traffic affecting system design is the number of transactions handled by the computer. A transaction is defined as the processing by the computer of a request for service. Requests for service include data base searches and preparation of response, data base record modifications, and switching of messages. It is possible for one message into the computer to generate more than one transaction. For example, if a query into the state wants/warrants file automatically generates a message to the national wants/warrants file then two transactions occur: the state wants/warrants data base search and the switching of the inquiry to the national file.

From the definitions above, it is apparent that communication messages demand communication line services while transactions demand computer services. Methods of estimating these parameters from available statistics will be discussed next.

3.3.2 Interpretation of Communication Traffic Statistics

In examining available traffic statistics, the analyst must first determine whether traffic is a measure of communication messages or transactions. If it is established that communication messages are being counted, then a knowledge of computer message handling procedures allows the calculation of computer transactions. Likewise, if it is established that transactions are being measured, then a knowledge of computer message handling procedures will generally allow the calculation of communication message volumes. When it is not clear whether transactions or messages are being counted the analyst must test both hypotheses. Generally by looking for internal consistency or by checking with other independent traffic statistics, it is possible to determine if transactions or messages are being measured.

It is common for statistics gathering routines to record the number of communication messages sent and received from every component of the communication system. Thus a message sent from a user terminal to a data base is recorded as being sent from the user terminal and received by the data base. When total system messages are calculated by summations of messages over all components, this leads to a double counting of messages. Dividing by a factor of two leads to the true message count.

Determination of the number of messages sent from the state system to national communication systems must be handled with care. There are currently two national communication systems, the National Crime Information Center (NCIC) and the National Law Enforcement Telecommunication System (NLETS). The NCIC services data base queries and updates but has no message switching capability. The data base is located in Washington, D.C. NLETS provides message switching capabilities tying together state data bases, but it maintains no data base of its own.

Messages sent from state telecommunication users to the NCIC data base can be generated in two ways. The first involves a direct message between the user and NCIC where the state user utilizes required NCIC formats. The second, and by far the most common, results from a user sending a message into the state computer which then automatically forwards it to the NCIC stolen article file.

Messages into the NCIC data base must travel from the user to the state switching center and from the state switching center to the NCIC data base. Responses then retrace this path back to the user. Communication messages to and from the NCIC should be counted in the following way (see Figure 3-1):

(1) The initial transmission from the user to the state switching center should be counted as a separate NCIC communication message only if it is a direct message between the user and NCIC.

(2) All transmissions of the data base queries and updates between the state switching center and NCIC should be counted as communication messages.

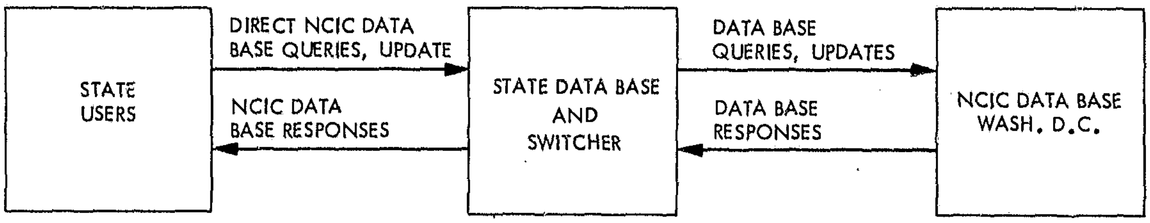

Figure 3-1. NCIC Traffic Flow

(3) All transmissions of responses to data base queries and updates between NCIC and the state switching center should be counted as communication messages.

(4) The final transmission of the response to the NCIC data base query or update from the state switching center to the user should be counted as a communication message.

Transactions should be counted as follows:

(1) The switching or automatic generation of a message by the state data base computer into NCIC should be counted as a transaction.

(2) The switching of the NCIC response by the state data base computer to the appropriate user terminal should be counted as a transaction.

If the states' traffic statistics do not follow these conventions, adjustments should be made.

Communication traffic traveling from the state system to the NLETS system is measured in the same way as NCIC traffic with the following exceptions. First, all communication messages sent from state system users to other states via NLETS must be sent directly, i.e., there is no automatic generation of messages to other states. Second, other states can originate data base queries into the state data base.

Communication messages to and from NLETS should be counted as follows (see Figure 3-2):

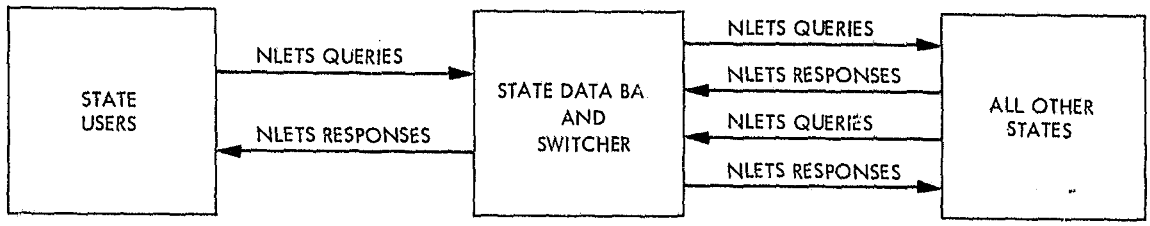

Figure 3-2. NLETS Traffic Flow

(1) All initial NLETS queries from state users to the state data base should be counted.

(2) All queries from the state data base to other states via NLETS should be counted.

(3) All responses from other states to the state data base via NLETS should be counted.

(4) All transmissions of the NLETS response from the state data base should be counted.

(5) All NLETS queries from other states to the state data base should be counted.

(6) All NLETS responses from the state data base to other states should be counted.

Rules for counting NLETS transactions are:

(1) The switching of an NLETS query by the state data base to other states should be counted.

(2) The switching of NLETS responses by the state data base to state users should be counted.

(3) The file search and response preparation done by the state data base in responding to an NLETS inquiry from another state should be counted.

Again, care must be taken in examining states' procedures for measuring NLETS traffic levels. If the measuring procedures do not follow the above rules, adjustments must be made.

Once the traffic statistics have been analyzed and a good measure of the number of communication messages has been obtained, it is necessary to convert traffic from units of messages per day to characters per day. Our procedure for this conversion is presented in the next section.

3.3.3 Message Length

For the purpose of designing a network of communication lines, communication planners must know in addition to the number of messages, the length of the messages so they can determine the number of characters that are to be flowing on communication lines.

Determination of average message length begins by identifying message types and message functions. Message types are the state data base file types, administrative messages, NCIC messages, NLETS data base messages and NLETS administrative messages. Message functions apply only to data base message types and can be grouped into two categories: data base queries and data base modifications.

Lengths of data base message types by message function were determined by examining specified formats in users operating manuals. Response formats were also shown in these manuals. However, there are two possible responses to the query message function. The first is a short response indicating that no record matching the input identifiers could be found. The second, a positive response, is a longer message transmitting the entire record requested. Therefore, it is necessary to know the positive response rate in order to calculate average message length of responses to inquiries.

Average administrative message lengths were estimated by examining example administrative message formats, by discussions with state personnel and by examining available statistics kept by NLETS on administrative message lengths. Since the format of an administrative message is left to the discretion of the user, message length could not be determined by studying format specifications. However, good agreement was obtained from the three sources listed above, increasing confidence in the administrative message length estimates.

Message lengths for NCIC and NLETS messages were obtained from a previous JPL report (National Criminal Justice Telecommunications Requirements). These numbers were slightly modified to reflect changes since the JPL report was released.

A simple example of the method for calculating overall average message length will be presented and then the methodology will be generalized to cover our more complex case.

Suppose there are only two message types and the average length of message type 1 is L_1 and the average length of message type 2 is L_2. Also suppose F_1 is the fraction of total messages that are type 1 and F_2 is the fraction of total messages that are type 2. Overall average message length can be calculated as follows:

$$\text{Overall Average Message Length} = F_1 \times L_1 + F_2 \times L_2$$

To continue the example by assigning values. let:

L_1 = 100 characters/message

L_2 = 150 characters/message

F_1 = 0.30

F_2 = 0.70

Then:

$$\begin{matrix}\text{Overall Average} \\ \text{Message Length}\end{matrix} = 0.3 \times 100 + 0.7 \times 150 = 135 \text{ char/msg}$$

In our case we have more than two message types and there are also different message functions within message types. We do however know the average message length and the fraction of total traffic of each message function within each message type. We can thus apply the methodology presented above by taking the summation of the products of average message lengths and fraction of total traffic over all message functions and message types. An example is shown below where there are m message types and n message functions within each message type. The fraction of total messages and the average message length is shown for each message function and the calculation of overall average message length is shown at the bottom.

Overall average message lengths in the model states were calculated using the above methodology.

3.3.4 Peak/Average Ratios

In determining needed communication capacity to satisfy performance requirements, we would like to use a measure of demand that reflects the load on the system during the busiest hours. Proper network design requires that service objectives be met during the busiest times as well as the average situation. All previous traffic statistics have given message volumes averaged over a day. To derive the desired traffic measurement we establish the ratio of traffic volume during the busiest hour and average traffic volume and designate it the peak to average ratio. Average traffic volumes are then multiplied by this ratio to give peak traffic volumes.

Peak to average ratios can be associated with different components of the communication system. At the first level we examine peak/average ratio of the number of messages sent from a user agency. The second level involves demand for communication circuits. In some instances, where there is only one user agency on a circuit, this cor-

	Fraction of Total Messages	Average Message Length
Message Type 1		
Msg Func 1	F_{11}	L_{11}
Msg Func 2	F_{12}	L_{12}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{1n}	L_{1n}
Message Type 2		
Msg Func 1	F_{21}	L_{21}
Msg Func 2	F_{22}	L_{22}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{2n}	L_{2n}
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
Message Type m		
Msg Func 1	F_{m1}	L_{m1}
Msg Func 2	F_{m2}	L_{m2}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{mn}	L_{mn}
	--- 1	

Overall Average Message Length $= \sum_{\begin{pmatrix}\text{Message}\\ \text{Type}\\ i\end{pmatrix}=1}^{m} \; \sum_{\begin{pmatrix}\text{Message}\\ \text{Func}\\ j\end{pmatrix}=1}^{n} (F_{ij} \times L_{ij})$

responds to the first level. However, for those circuits serving more than one user agency, a separate peak/average ratio can be computed. This circuit ratio is dependent on communication line configuration and therefore changes as new configurations are proposed. To avert this complication we have assumed one constant peak-to-average ratio for the entire communication system. This one value is taken to be the peak-to-average ratio of traffic to the computer. We justify using this as the peak/average ratio for user agencies and communication circuits for the following reasons:

(1) Historically, the utilization level of the computer has been significantly higher than the utilization levels of communication circuits. Therefore it is more important to establish demands for computer service than for communication lines and user agency terminals.

(2) It is likely that the peak/average ratio for communication circuits and for the computer are not greatly different.

(3) There is a possibility that particular user agencies will have peak/average ratios somewhat higher than the computer's ratio. However, it is unlikely that this higher than predicted number of messages would have any impact on network system design since communication circuit utilization is low.

To determine this ratio we examine in detail one month of total system traffic data. The number of transactions occurring each hour in the month is determined. We search for the busiest hour and determine the ratio of transaction volume during this busiest hour to the average hourly transaction volume during the month. This ratio becomes the peak/average traffic ratio.

Predictions of average traffic levels are then multiplied by the peak-to-average ratio to describe traffic levels during the busiest hour.

3.3.5 Output of Analysis of Traffic Statistics

The outputs of the traffic analysis task are:

(1) Historical traffic statistics: 1971 - 1976

(a) Number of average total monthly communication messages

(b) Number of average total monthly transactions

(c) Number of average monthly communication messages by system user

   (d) Number of average monthly communication messages by message type.

(2) Current traffic statistics

   (a) Average message length by message type

   (b) Total average message length

   (c) Peak/average ratio.

This information on past and current traffic statistics serves as input into the traffic growth and distribution modeling tasks to be discussed in the next two sections.

3.4 TRAFFIC GROWTH MODELING

3.4.1 Introduction

Before we present our forecasting techniques a note of caution is in order; forecasting is a hazardous occupation. As Martino has said (Technological Forecasting for Decision Making) "The forecaster is never absolutely certain that he has prepared the most useful possible forecast with the data he had available and the resources he employed." Martino continues to describe what forecasting does and does not do. "A forecast does not tell us anything about the future. Instead, it tells only of the implications of available information about the past. These implications are connected with the future through a logical framework. Hence, the utility of a forecast for decision making purposes depends on the validity of the logical framework it uses, and the extent to which it extracts all the implications which are contained in the body of available information." We have attempted to identify the body of available information and develop a logical framework allowing us to use the information to predict future growth of criminal justice telecommunications traffic.

Our basic forecasting framework postulates that past traffic growth is caused by two factors. The first is an increased demand by the users and the second is communication system improvements. We assume that growth in traffic due to the first factor will continue in the future as it has in the past. However, growth in traffic due to communication system improvements will depend on the rate of future system improvements. Our estimates of these two components of traffic growth are combined to form the prediction of total future communication traffic levels into existing data types.

3.4.2 Input Data

Data describing past operations of the state criminal justice telecommunications system included past traffic statistics, past network configurations and past operational procedures. Recall that traffic statistics obtained from Ohio were used to determine the total number of communication messages each month and total transactions each month during the years 1971 - 1976. In addition, these aggregate monthly traffic figures were broken out by message type and wherever possible by user agency.

Data on past network configurations included location, content, and size of data files; communication line configurations and capacities; and lists of all user agencies and their means of access to the state telecommunication system. An operational procedure affecting traffic was the policy regarding the automatic generation of messages from the state computer to the National Crime Information Center maintained in Washington, D.C.

3.4.3 Data Analysis

Historic traffic statistics were used to establish the past growth pattern of communications traffic. Growth in traffic in Ohio, shown in Figure 3-3, was characterized by periods of fairly stable growth rates; however, there were erratic periods where large increases or decreases in traffic occurred. The decreases which occurred were explained by the obsolescence of vehicle registration files each spring. The sudden increases in traffic were caused by improvements to the communication system. The following improvements were identified:

(1) Addition of new users

(2) Addition of new data files

(3) The substitution of high-speed communication lines for low-speed lines and new terminal equipment

(4) Changes in operating procedures that provide the user with additional information per query

(5) Mobile Digital Terminals (MDTs).

Since these increases in traffic could be tied to specific communication system improvements and were short term in nature, it would be inappropriate to project such increases into the future. It thus becomes necessary to factor out the impacts on traffic of these improvements to the communication system. The remaining growth component is categorized as baseline growth and we see it as being principally caused by:

(1) Increased utilization of existing services

(2) Population and personnel increases

(3) Training.

Baseline growth, shown in Figure 3-4, is assumed to continue in the future as it has in the past.

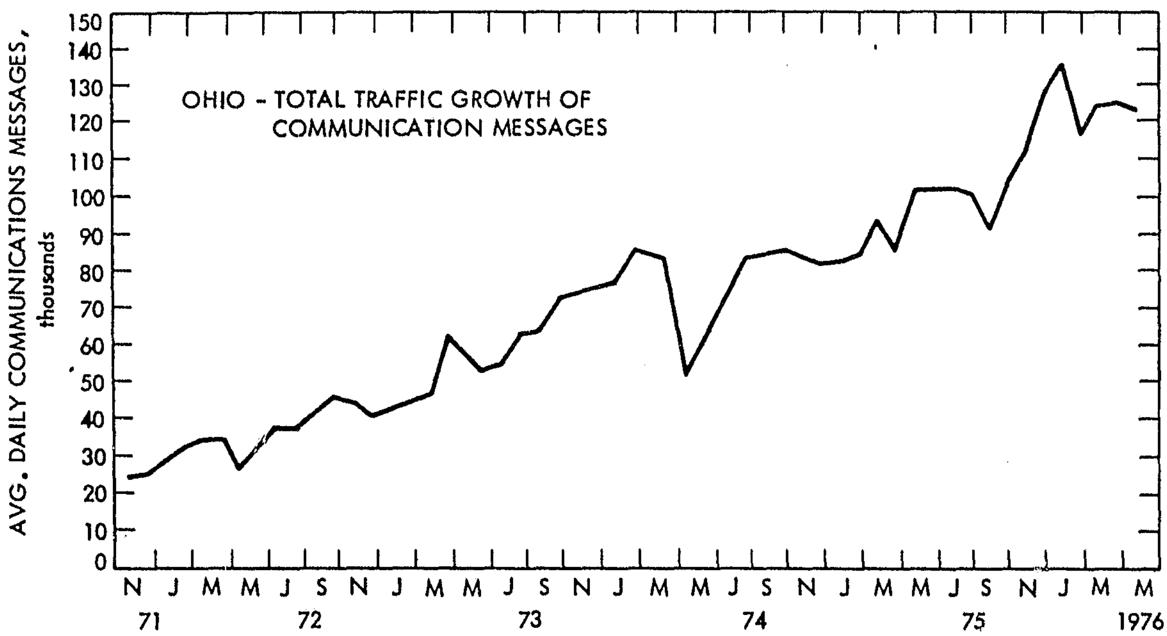

Figure 3-3. Ohio Past Communication Traffic Growth

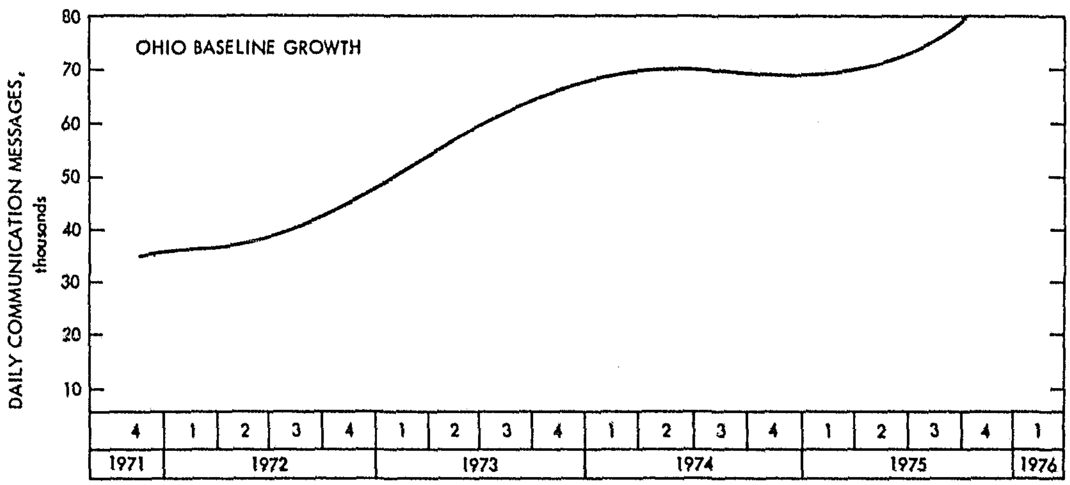

Figure 3-4. Ohio Baseline Traffic Growth

3.4.3.1 Past System Improvements. To obtain baseline growth statistics, we had to establish a procedure for quantifying the impacts on traffic of communication system improvements. Our procedure assumed that the traffic impacts of system improvements were independent of one another. We recognized that in the real world this is not the case, but were confident that the errors caused by non-independence would be small. As an example assume that two system improvements occurred simultaneously and were the conversion of low-speed lines to high-speed lines and the addition of a new data base. To determine the increase in traffic from a particular user caused by the high-speed line upgrade we look at the user's traffic just before and just after the increase. The increase is taken to be caused by the line upgrade. However, a portion of the increase is due to traffic into the new data file. However, during all periods the portion caused by the secondary effect was sufficiently small that it could be ignored. So errors resulting from our assumption of independence are small. Procedures for determining the impacts of each system improvement are now discussed.

Ohio has added new user agencies to its communication system over the last few years, and we collected a list of all new agencies added within each three month period from 1971 - present. The increase in traffic caused by the addition of a new terminal was obtained by measuring traffic levels from the terminal in the three-month period after it had been added. The average of traffic over this three-month period was considered to be the traffic increase. In Ohio, for the period September 1971 - April 1976 approximately 14,600 of the new messages per day could be attributed to the addition of new user agencies.

When a new data file is added, there is generally a period of two or three months of rapid growth of traffic into the files followed by a stabilization in traffic volume. It is this sudden increase in traffic that we consider the impact of the implementation of a new data base. An example of traffic volumes into a new data files is shown in Figure 3-5. Traffic increases into the new Wants-Warrants file occur rapidly during the first month of operation and stabilize into a normal growth pattern after this first month.

Ohio originally designed its state criminal justice telecommunication system with low-speed teletype lines but has since upgraded a portion of these lines to high-speed 1200 or 2400 baud lines. We define low-speed lines to be 300 baud or slower. Terminals serving low-speed lines are either older teletype terminals or hard copy printing terminals. High-speed lines are 1200 baud or faster and are served by CRT terminals. Ohio does not use lines of between 150 and 1200 baud.

The impact of past conversions to high-speed lines is measured by taking the difference in traffic the month before the upgrade and the month after the upgrade for each affected agency. These increases range from 12% to 200%. In Ohio a 50% average increase was observed after conversion to high-speed lines.

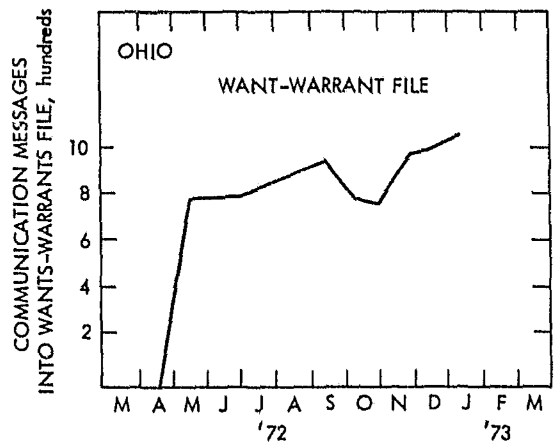

Figure 3-5. Example of New File Traffic Growth

A change in operating procedures that affected traffic levels occurred in Ohio. During the summer of 1973 the Ohio state computer began passing all queries into the state vehicle registration file on to the national stolen vehicle files. This procedural change was reflected in the traffic statistics as the number of messages per day to and from NCIC increased from 6,500 to 18,000. This procedural change is regarded as a system improvement because it provided more information to the user with no extra work required on his part.

The final past system improvement was the implementation of mobile digital terminals. These are computer terminals that are placed in patrol cars and allow faster access to information contained in the state data bases. Between March 1975 and April 1976, one hundred Cleveland patrol cars were equipped with mobile digital terminals. The increase in traffic due to these in-car terminals was 3,600 messages per day.

The effects of all the above system improvements in Ohio are summarized in Figure 3-6. Slightly more than half the growth could be attributed to baseline growth, and the addition of new users and the policy of forwarding messages into the national data file were the major system improvements.

3.4.3.2 Past Baseline Growth. Calculation of baseline growth began by using as input the total monthly historic communication message levels. These statistics were then averaged over three-month periods giving average message volumes for the four quarters of each calendar year. We then determined the component of each of these quarterly message volumes that could be attributed to the communication system improvements discussed above. Traffic caused by system improvements was subtracted from total traffic. The remaining traffic for each quarter was then plotted (see Figure 3-4) and served as a measure of baseline growth.

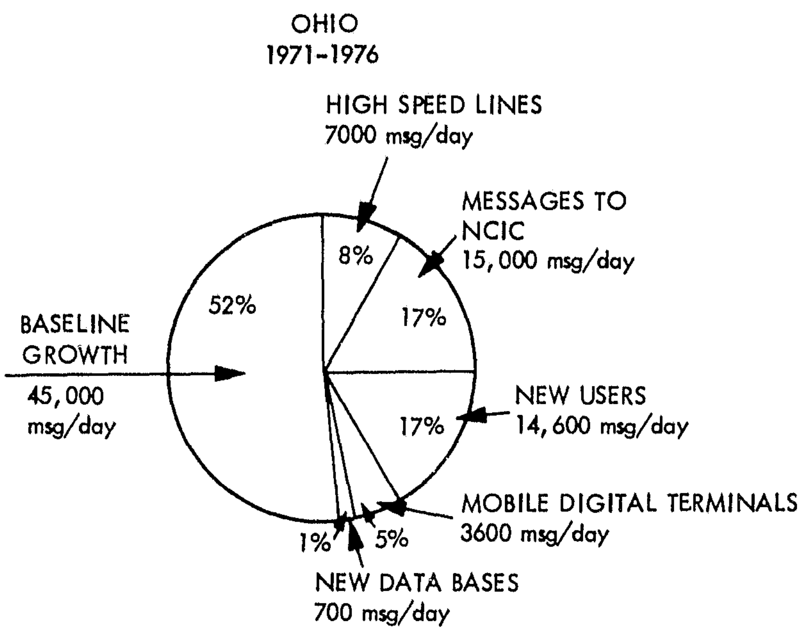

Figure 3-6. Distribution of Traffic Growth Sources

3.4.4 Traffic Projections

The previous section dealt with establishing past growth patterns and our attempt to relate portions of the past growth to communication system improvements. We will now use the knowledge gained about the past to predict future traffic levels.

3.4.4.1 Future Baseline Growth. Recall our basic assumption that baseline growth will continue into the future as it has in the past. Past baseline growth curves exhibited the following characteristics:

(1) A long-term increase in traffic

(2) Seasonal effects due primarily to procedures or customs

(3) Periods of relatively slow growth.

Using these characteristics we construct the following baseline growth model. The long-term increase in traffic will continue into the future. Seasonal effects may continue into the future but will have no impact on system design because although these effects have been to cause exceptionally low traffic levels during some months, the system must be designed to handle the loads during peak traffic months. We will thus not include seasonal effects in our future traffic model.

We explain periods of slow baseline growth as being caused by one of two factors. First, growth may be slow because the communication system is near saturation. Users experience deterioration in the level of service with the primary effect being an increase in the waiting time for a reply to an inquiry. Second, growth may be slow immediately following an upgrade because of sub-standard system performance while the inevitable problems of a new system are corrected, and reduced agency utilization while users familiarize themselves with new operating procedures.

In Ohio, major system upgrades occurred in October 1971 and March 1975. Examining baseline growth (see Figure 3-4) we note that the slow growth periods are the fourth quarter of 1971 through the second quarter of 1972 and the third quarter of 1974 through the third quarter of 1975. In the first case we observed slow growth through three quarters after an upgrade and in the second case we observe slow growth three quarters before an upgrade and two quarters after the upgrade. Unfortunately there are no response time statistics available in Ohio during periods of slow growth prior to the March 1975 upgrade. Thus we cannot document our contention that slow growth was caused by increased response times. We do know that the upgrade involved the replacement of an IBM computer with a UNIVAC system. According to Ohio system planners it was a difficult transition with considerable deterioration in service as the problems of a new system were corrected.

In Ohio, the state criminal justice telecommunications system is centralized with all files maintained and all switching services performed by one computer. The demands for service are such that the utilization of all other system components including communication lines and terminals are low. Response time deterioration caused by excessive demands for service thus are governed by response time performance of the central computer. Figure 3-7 shows a general case of this response time performance. Notice that response times stay relatively constant as transaction volumes build until a critical point is reached (about the 80% utilization point). Response times then degrade rapidly. The response time profile just described is consistent with baseline traffic growth observed in Ohio.

We will now use these past traffic baseline growth characteristics to predict future traffic volumes.

We have developed a growth projection model that predicts average daily traffic volume for each of the next 20 six-month periods. The model assumes that growth will be caused by three factors. They are: baseline growth, improved communication technology, and new users and data bases.

We assume baseline growth will continue into the future as it has in the past. In Ohio past baseline growth displayed an S-shaped curve with growth being slow before and after system upgrades and linear between these periods. Since baseline traffic growth appears to be dependent on available system capacity it becomes necessary for us to make assumptions regarding actions to be taken by the state when system saturation is reached. Possible actions are:

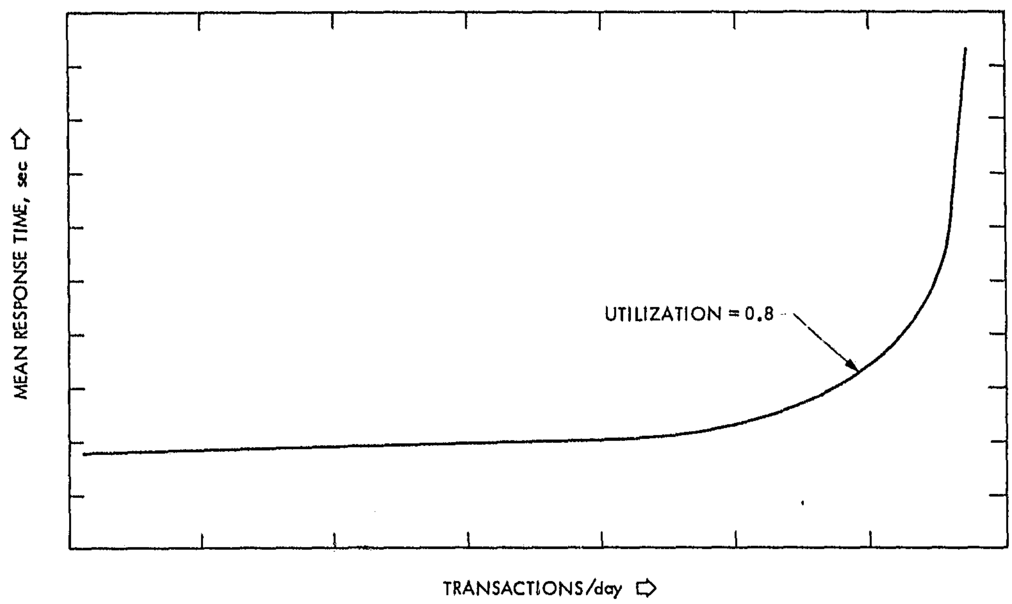

Figure 3-7. Typical Communication System Response Time as Function of Traffic Volume

(1) To increase capacity before saturation is reached to avoid inconvenience to users and allow unconstrained growth

(2) To wait for the first signs of saturation and then increase capacity

(3) To delay for a substantial period any upgrade even after saturation is reached

(4) To fix a limit to growth and not upgrade at all.

In talking with planners in Ohio, the second action seemed the most likely. Ohio planners believed that it was not possible to increase capacity before system capacity was reached but did indicate that funding necessary for increasing capacity could be obtained quickly when deterioration in response times was noticed. Thus the shape of the future baseline growth curve was assumed to be basically linear with a slowing of traffic before and after system upgrades.

Our assumption concerning possible actions regarding system upgrades is a critical one. If the state decides to delay upgrades for a substantial period or to fix a limit to growth, then our traffic predictions will be substantially high. However, if a state decides to increase capacity before saturation is reached, errors in our prediction will not be as large because decreased traffic growth periods have been assumed to be short term.

To project future baseline growth we fit past baseline growth statistics with regression lines and minimize the least square errors. A slow growth line and a fast growth line are developed.

Then, using our knowledge of present system capacity and assumptions on delay before capacity increase and magnitude of capacity increase, we can project these baseline traffic growth lines forward. Figure 3-8 shows our baseline growth projections.

3.4.4.2 Future System Improvements. In addition to increases in traffic volumes caused by baseline growth, there will be increases caused by communication system improvements. The future implementations of the following communication system improvements and their impacts on traffic were considered.

(1) The substitution of high-speed communication lines to low-speed lines and new terminal equipment

(2) The implementation of Mobile Digital Terminals (MDTs)

Information concerning implementation plans was obtained from state planning personnel and there is considerable uncertainty in their future scenarios. However, we did attempt to talk with as many people as possible to gain the most complete understanding of the state's plans.

Ohio has plans for converting all remaining low-speed communication lines to high-speed lines. We have estimated the effect of this conversion by assuming that traffic increases in the future will be similar to traffic increases resulting from past line upgrades. Recall that there was a 50% increase in traffic in Ohio when lines were converted from low- to high-speed.

This conversion process is assumed to begin in late 1977 and to be completed by early 1978. We have estimated an additional 18,000 msg/day resulting from low- to high-speed line conversion in Ohio.

In conversations with municipal police departments we learned that there is considerable interest in mobile digital terminals. Radio dispatchers currently serve as the link between officers in their patrol cars and the states' law enforcement data bases. Officers must gain the attention of the dispatcher and verbally relay the information necessary for a transaction into the data files. Responses must again be verbally transmitted between dispatcher and officer. Terminals are available that can be installed in patrol cars allowing the officer to enter and receive information directly from data bases. The officer utilizes a keyboard to enter information that is then transmitted digitally from patrol car to dispatcher station and then forwarded automatically into the data base. The response is again automatically forwarded from dispatcher station to patrol car and displayed on a read-out device in the patrol car. Mobile digital terminals thus relieve dispatchers

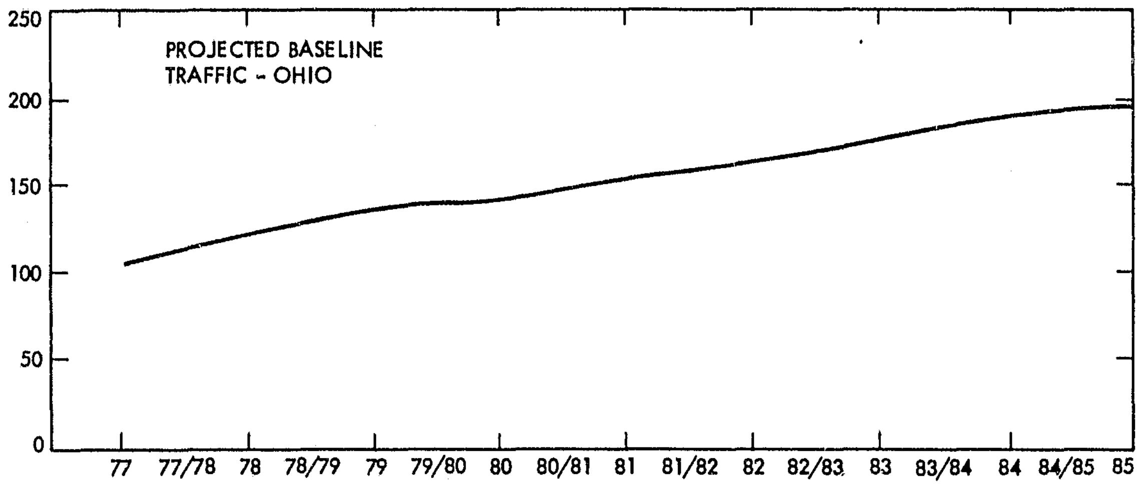

Figure 3-8. Projected Ohio Baseline Traffic Growth (Average Messages/Day, thousands)

of a portion of their workload, ease communication channel congestion, and facilitate easier access to, and faster responses from, central data bases. It is thus expected that communication message volume will increase when mobile digital terminals are added to police vehicles.

In spite of the advantages mentioned above, the spread of mobile digital terminals has not occurred as rapidly as expected three or four years ago. The primary reason is cost. These in-car terminals cost between $3,000 and $5,000 per unit and municipal police departments find it hard to generate needed funds. In the past, significant funding for mobile digital terminals (there are currently approximately 1,000 operational units throughout the United States) came from the Law Enforcement Assistance Administration (LEAA) which funded these units as a part of an innovative project. It is unlikely that LEAA will continue to provide funds at the previous level for further mobile digital terminals. Thus municipal police departments must evaluate the performance of existing in-car terminals and determine whether mobile digital terminal benefits outweigh their costs.

Clearly the future of MDTs is an uncertain one. To aid us in forecasting future implementation we spoke with state planners, municipal police department planners and mobile digital terminal vendors. These sources agreed that the large municipal police departments would ultimately decide that MDTs were cost effective and equip their patrol cars with them. However, we assumed that only cities with populations of 500,000 or larger would purchase MDTs by 1985.

In Ohio this meant that Cleveland, Cincinnati and Columbus police departments would be adding mobile digital terminals. Cleveland is one of the cities that currently does equip a portion of its patrol fleet with in-car terminals. It was found in Cleveland that traffic between patrol cars and the state data base approximately doubled as a result of the addition of mobile digital terminals. We will use this rate of increase as a measure of the impact on traffic of the addition of in-car terminals. We assume implementation of MDTs will begin in 1980 and will be completed by 1984 and that 25,000 new msg/day will come as a result of mobile digital terminals.

It is apparent by the size of the increase predicted and the uncertainty in the future of MDTs that this is a possible area of substantial error in our traffic forecast. If in the future it is determined that growth in MDTs is slower or faster than we predicted, adjustments should be made to the traffic forecasts.

Table 3-1 summarizes the predicted increases in traffic caused by communication system improvements over the next 20 six-month periods. Designation 77 represents the middle six months of 1977, April-October, while 77/78 represents the last three months of 1977 and the first three months of 1978. The traffic increase numbers are given in units of messages per day and show the expected increase in traffic resulting from each system improvement that occurs in each six-month period.

These techniques used for projecting traffic growth forward can be applied in other states besides Ohio. The basic steps are:

Table 3-1. Future Traffic Increases due to Communication System Improvements (Units are Average Communication Messages per day.)

Time Period	High-Speed Lines	Mobile Digital Terminals
77	6,000	0
77/78	6,000	0
78	6,000	0
78/79	0	0
79	0	0
79/80	0	2,400
80	0	2,400
80/81	0	2,400
81	0	2,400
81/82	0	2,400
82	0	2,400
82/83	0	2,400
83	0	2,400
83/84	0	2,400
84	0	2,400
84/85	0	0
85	0	0
	18,000	24,000

(1) Analysis of past traffic statistics to determine the historical pattern of total system traffic growth

(2) Determination of past system improvements that would impact traffic growth

(3) Determination of the magnitude and the timing of past increases in traffic caused by system improvements

(4) Determination of the historical baseline growth curve by subtracting traffic increases due to system improvements from total traffic increases

(5) Determination of future baseline growth by projecting the baseline growth line or curve forward. Assumptions concerning future system capacity are factored in here.

(6) Determination of future system improvements and their impact on future traffic. Both the magnitude of the traffic increase and the implementation schedule must be predicted.

(7) The last step involves adding together future baseline traffic and traffic due to future system improvements to obtain the forecast for total future traffic into existing data files.

Recall that there is a third growth component which is growth due to the addition of new data types. Section 4 will discuss new data type traffic and in Section 5 we will delineate the method used in combining all three growth components to generate a total future traffic level forecast.

3.5 TRAFFIC DISTRIBUTION MODELING

3.5.1 Approach

Once total communication message volumes are known, we must determine the distribution of traffic among system users. Ideally, we would like to know the amount of traffic sent from every user to every other user. However, this is not possible simply because of the large number of system users. In Ohio where there are 364 system users, a matrix with 132,496 entries is required to describe traffic volumes sent from every terminal to every other terminal.

To avert this problem, we begin the traffic distribution task by identifying the major direction of traffic flow on the network. We can then eliminate all the user pairs for which there is very little traffic. Our next step is to determine the number of messages into and out of each user agency. This is accomplished by determining relationships between user agency characteristics and the amount of communications traffic sent and received by the agency. Once these relationships are developed, the final step involves using these relationships to predict future traffic distributions.

3.5.2 Input Data

Data required for the traffic distribution task included, for each current system user:

(1) Number of communication messages sent and received

(2) User characteristics

(a) Population served

(b) Number of personnel

(c) Crime rate

(d) Agency type

(e) Type of communication line.

Communication message volumes were obtained from automatically generated statistics describing system performance in Ohio. The latest available three months of message volumes were averaged to reduce the effects of abnormalities in one month.

Information concerning user characteristics was generally available. Sources included user surveys, Uniform Crime Reports, the state survey, and state almanacs. We had the most difficulty obtaining data on the number of personnel. The complicating factor was that often an agency with a terminal into the state criminal justice telecommunication system will provide service to adjacent agencies that do not have their own terminals. Thus the user survey asked respondents to report the number of personnel requiring information available over the state criminal justice telecommunications system through the responding agency. Not all user agencies in Ohio responded to our survey but for those agencies not responding we were able to obtain data on the number of personnel employed from the Uniform Crime Reports. However, for these non-responding agencies, we were unsuccessful in determining which agencies with terminals were serving agencies without terminals. Thus for those agencies not responding to our survey, there may be errors in the number of personnel statistics.

Additional data were required concerning changes in user characteristics that would affect future traffic distributions. We assumed that population, number of personnel, and crime rate would be distributed in the future as they are now. However, we did account for future changes in communication line types. All low-speed lines were assumed to be converted to high-speed lines by 1979.

3.5.3 Data Analysis

3.5.3.1 General Traffic Flow. Traffic flows can be determined by examining the functions of the state criminal justice telecommunications system. They are:

(1) To provide access to information contained in state data files

(2) To allow for general distribution messages to be sent to law enforcement agencies in the state

(3) To allow for communication between two law enforcement agencies.

Approximately 90% of all messages in Ohio were data base related. Thus the major traffic flow involves messages from users to data bases and the subsequent response. In Ohio there is only one data base located in Columbus so all data base messages flow through it.

A general distribution message is issued when an agency needs to pass on information to many other agencies. Generally states establish sectors and allow users to send a message to all user agencies in the appropriate sector or sectors. A general distribution message sent to all system users and called an "all points bulletin" message generates a large volume of traffic so operators of the state telecommunication system review the message before it is distributed. In Ohio this means the APB message comes from a user agency into Columbus for review. If approved, the message is then sent out to all user agencies. Thus APB messages follow similar paths of flow as do data base related messages.

Administrative messages are free form messages sent between one user agency and another. Currently in Ohio these messages must go to Columbus for switching out to the appropriate agency.

The only way to completely describe traffic flows on the state network is to identify the amount of traffic going from every terminal to every other terminal. Recall, however, that this becomes impractical because of the large number of system users. Using our knowledge of traffic functions and major traffic flows, we can reduce the size of the traffic distribution matrix.

In describing traffic flow we must insure that our distribution matrix presents traffic statistics that can be used by the design team to test the major design parameters which are:

(1) The number of switchers

(2) The switcher locations

(3) The communication line sizes

(4) The communication line configuration.

Thus, we should not attempt to describe traffic between users and a particular switcher because our design team may examine options where that switcher does not exist. The location of data bases is not a design parameter so we can assume data base locations remain unchanged. Also, we will assume that there will be switching capacity located at the state capitol. Keeping these design parameters in mind we now discuss methods for describing data base messages, general distribution messages, and administrative messages.

Since data base location is not a design criterion the number and location of data bases is fixed. We can thus describe the number of messages between each user agency and each data base. Thus, currently in Ohio where there is one data base located in Columbus and 364 user agencies, a 364 X 1 matrix is required.

Messages into the NCIC and NLETS national systems have flow characteristics similar to messages into the central data base. Recall these messages originate from a user agency, flow into the state capitol, are switched to the national system, return from the national system to the state capitol, and finally are switched back to the original user agency. National traffic between users and the state capitol and between the state capitol and the national systems is treated as traffic between users and the central data base. Thus NCIC and NLETS are considered to be system users.

General distribution traffic and administrative traffic are both dependent on the location and the number of switchers. To describe accurately these message flows we need to know the exact communication system configuration. In addition, since these are messages between agencies we would require the complete origin - destination traffic matrix to describe traffic distribution. In order to avoid the need for this information we assume:

(1) General distribution and administrative messages flow as do data base queries to the state capitol

(2) Each user agency sends the equivalent number of administrative messages that it receives

(3) The ratio of general distribution messages sent and received is the same for all user agencies and is equal to the system-wide average.

These assumptions obviate the need to separate administrative and APB message types from data base message types. We need only report the amount of communication traffic between each system user and each data base. Administrative and general distribution messages are included in the count of messages between user agencies and the central data base. These assumptions, of course, lead to errors in the description of traffic flows.

Figure 3-9 shows a user agency that communicates with the state capitol via a regional switcher. An administrative or general distribution message would travel from the user to the regional switcher and then be sent out to the appropriate recipient(s). We assume, however, that the message is sent from the regional switcher to the state capitol

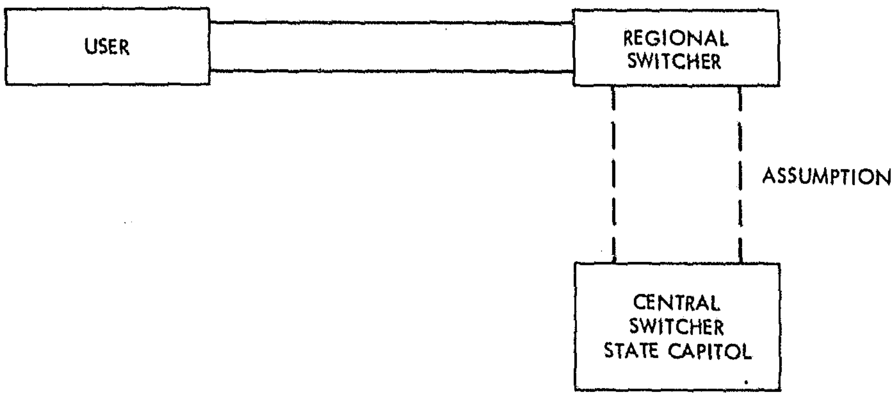

Figure 3-9. Communication System Configuration with Regional Switcher

and distributed from there. This leads to an overestimation of traffic on the communication line between the regional switcher and the state capitol. An example of the magnitude of this overestimation can be obtained by examining traffic on the existing Texas system (the other model state in the STACOM study). Actual traffic on the line between the Dallas and Austin switchers is 36,000 msg/day; while using the above assumption we would estimate traffic to be 40,000 msg/day, an 11% error. We feel this error is acceptable because:

(1) Overestimates of traffic will occur only on lines between regional switchers and the state capitol.

(2) There is a low probability that overestimates will affect communication system design.

(3) If there are design errors they will be in the direction of excess communication capacity.

We should mention that the above error could be alleviated if in reporting traffic from each agency, administrative and general distribution messages were reported separately. For any proposed system configuration, a closest switcher could be identified for each user agency and traffic could be described as flowing from the user agency to this closest switcher. An unattractive feature of this approach is that the design program would be required to describe traffic between each terminal and a variable number of locations which would be dependent on the number of switchers. It was our opinion that the errors associated with the assumptions were sufficiently small so that the added work required for a more accurate description was unnecessary.

Figure 3-10 shows existing major traffic flows in Ohio. NCIC and NLETS have been shown as separate user agencies because of their high traffic volume. The number of data base messages and administrative and general distribution messages between all user agencies and the central data base(s) are shown.

3.5.3.2 User Characteristics. In order to design the communication line configuration and the line sizes, we must describe traffic in more detail than is shown in Figure 3-10. The amount of traffic between each user agency and data base must be specified. Recall that these statistics are available for the present systems and that we attempt to establish relationships between user agency characteristics and these traffic statistics so that future traffic distributions can be estimated. User characteristics are agency type, communication line type, population served, number of personnel and crime rate.

Agency types are police, sheriff, state patrol and all others. The category "other" includes such agencies as university police departments, bureaus of criminal identification and federal agencies such as the Federal Bureau of Investigation, the Drug Enforcement Agency, the Internal Revenue Service, etc. Distributions of user agencies for Ohio are shown in Table 3-2.

Line types currently in use in Ohio are 150 bit/sec lines and 2400 bit/sec lines. Designating line types of 300 bit/sec or less as low-speed lines and line types of 1200 bit/sec or greater as high-speed lines, Table 3-3 shows the current line type distribution for Ohio. Ohio plans to replace all low-speed lines with high-speed lines.

Table 3-4 shows statistics describing the three remaining agency characteristics.

Table 3-2. Distribution of Ohio Users by Agency Type

Agency Type	Number of Users
Police Terminals	214
Sheriff Terminals	68
State Patrol Terminals	60
Other Terminals	22
Total	364

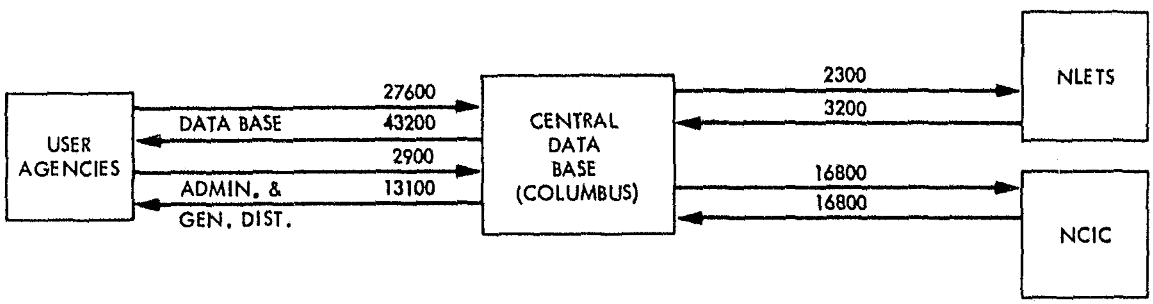

Figure 3-10. Existing Ohio Traffic Flow, Average Messages per Day

Table 3-3. Distribution of Ohio Users by Line Speed

Line Type	Number of Lines
Low-Speed	268
High-Speed	96
Total	364

There is considerable variation in the characteristics of the agencies served by these communication systems, especially in population served and number of personnel as these characteristics have standard deviations considerably larger than their mean. To further investigate variations in user characteristics, frequency tables were constructed showing the number of agencies falling within population and personnel categories. (See Tables 3-5 and 3-6).

A large percentage of users are small agencies with 45% of all Ohio terminals being located in agencies serving 20,000 or fewer people.

User characteristics clearly demonstrate the tremendous diversity existing between agencies served by the state telecommunication system. The methodology used in distributing traffic to these diverse agencies is covered in the next section.

Table 3-4. Ohio User Statistics: Population, Number of Personnel, Crime Rate

Agency Characteristic	Number of Agencies Reporting	Average Value	Standard Deviation
Population	346	55,362	120,520
Personnel	292	54	174
Crime Rate	324	3,560	2,240

Table 3-5. Population Distribution of Ohio User Agencies

Population Category	Frequency	% of Total
Less than 5,000	34	10
5,000 - 10,000	39	11
10,000 - 20,000	82	24
20,000 - 30,000	52	15
30,000 - 50,000	61	18
50,000 -100,000	43	12
100,000 - 200,000	17	5
200,000 - 500,000	10	3
500,000+	8	2
Total	346	100

Table 3-6. Number of Personnel Distribution of Ohio User Agencies

Personnel Categories	Frequency	% of Total
Less than 10	16	6
10 - 20	79	27
20 - 30	94	32
30 - 40	45	16
40 - 50	18	6
50 - 100	23	8
100 - 200	7	2
200 - 500	6	2
500+	4	1
Total	292	100

3.5.4 Traffic Distribution

3.5.4.1 Regression Techniques. Regression analysis is a technique that identifies potential functional relationships between independent and dependent variables. In our case we attempt to develop a relationship between the dependent variable of the number of communication messages and independent variables consisting of different forms of the parameters:

Population - POP

Personnel - PERS

Agency Type - AT

Communication Line Type - LT

Crime Rate - CR

We considered the following forms of the above parameters in attempting to explain the number of communication messages between each user and the data bases.

POP	$(POP)^2$	$(POP)^{1/2}$	POP • PERS	PERS • AT	AT • LT	LT • CR
PERS	$(PERS)^2$	$(PERS)^{1/2}$	POP • AT	PERS • LT	AT • CR	
AT	$(AT)^2$	$(AT)^{1/2}$	POP • LT	PERS • CR		
LT	$(LT)^2$	$(LT)^{1/2}$	POP • CR			
CR	$(CR)^2$	$(CR)^{1/2}$				

The variable selection procedure of stepwise regression was applied to these independent variables. Stepwise regression selects, from our total set of independent variables, those that are most highly correlated with the number of communication messages. It then utilizes the standard least squares technique to develop a functional relationship between communication message volumes and the chosen independent variables. The usual procedures were followed in determining the best coefficients for the model relations. (See Draper and Smith.)

3.5.4.2 Results. Like user characteristics, communication traffic levels vary greatly between system users. This increases the difficulty of the modeling task because even though we may be able to explain a substantial percentage of the variance, the standard error of our estimate may be high with respect to the mean.

In order to alleviate this problem, we have chosen to divide the user agencies into more homogenous groups in terms of information needs. In Ohio the following groups were formed:

(1) Police Departments (PDs) and Sheriff Offices (SOs) serving fewer than 20,000 people

(2) Police Departments and Sheriff Offices serving between 20,000 and 100,000 people

(3) Police Departments and Sheriff Offices serving more than 100,000 people

(4) All offices of the Department of Public Safety

(5) All other.

Police departments and sheriff offices were combined because they perform similar law enforcement functions and thus have similar information needs. State patrols on the other hand concentrate their law enforcement activities on traffic enforcement only. Other terminal groupings were tried such as combining terminals by agency and line type and by line type only. However, regression models developed for these groupings had larger standard errors and explained a smaller percentage of the variance than our final classification procedures.

Values used for line type and agency type were:

Line or Agency Type	Independent Variable Values
150 bits/sec	1
2400 bits/sec	2
Police Depts	1
Sheriff Office	2

Crime rate is a measure of the incidence per 100,000 population of the seven major index crimes (murder and nonnegligent manslaughter, forcible rape, robbery, aggravated assault, burglary, larceny, and auto theft).

Personnel is a measure of the number of employees whose information needs are being served by the computer terminals. Population is the size of populace served by the agency.

Table 3-7 shows the expressions which best describe the relationship between user characteristics and communication message volumes. These are complex expressions that in many cases contain different forms of the same variable. In some groups there appear to be terms that would intuitively be erroneous. For example, examining Ohio's first P.D. and S.O. group, $-43.7 + 50.7\ (\text{PERS})^{1/2} - 0.000116\ (\text{POP})(\text{PERS})$, the last term affixes a negative coefficient to the product of population and personnel. This appears to be saying that agencies serving large populations and more personnel transmit fewer communication messages. However, the second term

Table 3-7. Regression Results - Ohio Communications Message Volumes (Messages per Day)

P.D. and S.O. < 20,000 People

$$-43.7 + 50.7\ (PERS)^{1/2} - 0.000116\ (POP)(PERS)$$

P.D. and S.O. 20,000 - 100,000 People

$$-356 + 541\ (LT)^{2} + 0.0000176\ (POP)(PERS)$$

P.D. and S.O. > 100,000 People

$$693 - 5.47\ (PERS) + 0.00223\ (PERS)^{2} + 2.45\ (PERS)(LT)$$

Ohio State Patrol (O.S.P.)

$$400 + 13.2\ (PERS) - 8.73\ (CR) + 276\ (LOG\ (POP) - 3)$$

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in the expression has a large positive coefficient attached to the variable personnel. In addition, there is a positive correlation between population and personnel so in general larger populations generally mean more personnel. Thus as population and personnel increase, the third term does become more negative but the second term becomes more positive. The net result is that the total expression becomes larger.

Personnel number is an important variable in determining the number of communication messages as it appears in all four expressions. As the number of personnel increases, the number of communication messages increases. The rate of increase of communication messages as personnel increases slows down for smaller agencies, and in general, stays constant for other groups.

Population appears in three of the four expressions. Since population and personnel are positively correlated, and since personnel is more highly correlated with communication message volume, population may be excluded from the regression equations. In those expressions containing population, the coefficient is sufficiently small such that the magnitude of the term containing population is small compared to the magnitude of the total expression.

Line type is important in determining communication traffic volume. The only places where it does not appear are those groups in which all agencies have the same line types. In all groups where a fraction of the agencies have low-speed lines and a fraction have high-speed lines, the high-speed line agencies display significantly higher message volumes.

Agency type does not enter into any of the expressions and crime rate appears in only one and is not highly correlated with communication traffic levels.

These expressions yield information useful to all states in determining traffic distributions. Conclusions are:

(1) Personnel and line type are important in determining traffic levels.

(2) Crime rate does not affect traffic levels.

(3) Personnel and population to a large extent measure the same thing, i.e., the size of the agency. Since personnel is entered in the above expressions, there is no need for population to play a significant role.

(4) Police departments and sheriff offices should be treated separately from state patrol offices.

(5) Sheriff offices and police departments may or may not have different traffic levels.

The expressions developed cannot be applied per se to any other states. However, the data collection and analysis procedures leading to the development of similar expressions is the same for all states. The steps of the procedure are:

(1) Determine general traffic flow. If a large percentage of messages are data base messages, describe message flow between each system user and data bases.

(2) Compile a user agency data base. Information on number of personnel, size of population served, size of communication line, agency type and any other parameter that may impact traffic volume should be collected for each user agency.

(3) Determine the number of messages sent and received from each terminal over a recent three month period.

(4) Develop relationships between traffic volume and user characteristics. Develop one relationship for each of the following groups.

  (a) Police Departments and Sheriff Offices serving less than 20,000 people

  (b) Police Departments and Sheriff Offices serving between 20,000 and 100,000 people

  (c) Police Departments and Sheriff Offices serving more than 100,000 people

  (d) State patrol.

(5) Use these relationships to predict future traffic distributions.

3.5.4.3 Accuracy of Results. The expressions developed in the previous section attempt to describe the number of communication messages originating from each user agency as a function of user agency characteristics. After the expressions are developed, we must assess their accuracy. Table 3-8 presents statistics describing the effectiveness of the regression equations.

Standard error is a measure of the differences in the actual communication traffic levels, and the levels calculated using the regression expressions. If:

y_i = Actual values of the dependent variable

$\hat{y}_i$ = Predicted values of the dependent variable

n = Number of observations

Table 3-8. Accuracy of Regression

Ohio	Standard Error	R^2	Mean Traffic	F-Ratio	SE/Mean
P.D. and S.O. < 20,000	58	0.25	154	19	0.38
P.D. and S.O. 20,000 - 100,000	86	0.60	262	72	0.33
P.D. and S.O. > 100,000	355	0.99	1,651	301	0.22
Ohio State Patrol	229	0.68	733	15	0.31

Then the standard error is:

$$\left\{ \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right\}^{1/2}$$

If the standard error (SE) is small, we can be assured that our regression equations yield communication traffic volume close to the actual values. In our case, the standard error values are significant. However, the standard error should always be evaluated in relation to the mean value. If the standard error is small with respect to the mean, then our regression equations help us in assessing the amount of traffic originating from each user agency. The ratio SE/Mean is shown in Table 3-8. These ratios lead to fairly large error terms around predicted values, but the predictions are sufficiently accurate for our network design purposes.

The statistic R^2 is a measure of the amount of variation in the dependent variable explained by the regression equations. An R^2 value of 1.0 would mean a perfect fit between observed and calculated values. The closer R^2 is to 1.0, the larger the proportion of total variation about the mean is explained by the regression equations. In small police and sheriff agencies in Ohio the regression equations explain very little of the variation.

After the regression is performed, statisticians always consider the possibility that their entire approach was wrong. They ask themselves whether or not any of the independent variables should be included in the regression equation. This is equivalent to testing the hypothesis that all coefficients are zero. The F-ratio allows them to test this hypothesis. The larger the F-ratio, the more confident statisticians are in rejecting this zero coefficients hypothesis. In all cases, our F-ratios are sufficiently high such that we can reject the hypothesis with a high degree of confidence.

3.5.4.4 Future Traffic Distribution. Once these expressions for distributing traffic have been developed, they must be applied to the future traffic projections. The expressions are used to determine, at each future point in time, the percentage of total communication messages from and to each user agency. We have developed distributed traffic projections for years 1977, 1979, 1981, 1983 and 1985. A new user characteristic data base is used for each of these future time periods so that expected changes in line type, population and personnel can be reflected in future traffic levels.

Also, in the future there will be improvements to the communication system for a small number of user agencies that will cause their message volumes to increase. These increases will not be due to any factors contained in the regression expressions but will be caused by implementation of Mobil Digital Terminals. For these few user agencies, the percentage of total traffic will be increased to account for the above system improvements.

The last step in the traffic projection process is the conversion of traffic volume units from average messages per day to peak characters per minute. Messages are converted to characters as follows:

If

T_m = Average Traffic in Units of Messages/Day

L = Average Message Length in Characters

T_c = Average Traffic in Units of Characters/Day

then:

$$T_c = L \times T_m$$

This is then converted to peak characters per minute.

If:

P = Peak-to-Average Ratio (See Section 3.3.4)

T_p = Peak Trafic in Units of Characters/Minute

then:

$$T_p = T_c \times P \times \frac{1 \text{ day}}{1440 \text{ min}}$$

We are thus able to specify the traffic to and from each user terminal in units of peak characters per minute.

SECTION 4

TRAFFIC MODELING AND GROWTH PROJECTIONS: NEW DATA TYPES

4.1 DATA DESCRIPTIONS

New data types whose volumes are projected into the future in this section are summarized below. They are:

(1) Law enforcement use of state CCH/OBTS files

(2) Court use of CCH/OBTS files

(3) Corrections use of CCH/OBTS files

(4) Parole agency use of CCH/OBTS files if the agency is distinct and if the parole officers would not use law enforcement terminals in their areas

(5) A state judicial information system

(6) An offender-based state corrections information system

(7) A juvenile records system if the model state believes that it is feasible to include these data on a statewide criminal justice information system

(8) An automated fingerprint encoding, classification and transmission system

(9) State investigation bureau data conversion traffic.

The growth in traffic from these data types is shown in Figure 1-2. Descriptions of the files, users, hardware, facilities, and functions are provided in Section 2. This section outlines the methodology used to forecast traffic in these data types for the next decade. Other data types were considered, such as boat registrations and state parks department files, but were rejected because it is likely they would be used infrequently compared to those included in the study and would contribute an insignificant amount of traffic to the system. These minor data sources would therefore not alter the state network significantly, nor would they change the network performance.

4.2 SECURITY AND PRIVACY CONSIDERATIONS

To comply with Section 524(b) of the Omnibus Crime Control and Safe Streets Act, the National Criminal Justice Information and Statistics Service (NCJISS) of the Department of Justice's Law Enforcement Assistance Administration (LEAA) has published regulations in the Federal Register (40 FR 49789 of October 24, 1975, as amended by 41 FR 11714 of March 19, 1976) designed to assure the privacy of information on individuals contained in state criminal files and to assure the security of the files and means of access to them. The regulations seek to maintain the integrity of state criminal justice files by focusing on five major concerns:

(1) Assuring the completeness and accuracy of the information kept in the files

(2) Limiting the dissemination of information in criminal files to criminal justice and other lawful purposes

(3) Auditing the state agencies to assure compliance with the LEAA regulations

(4) Protecting the physical security of state criminal files from destruction and unauthorized access

(5) Allowing individuals whose records are contained in state criminal files to review and correct any erroneous information contained in them.

All states are required to submit plans for assuring the proper handling and operation of state criminal files. Ohio is in the process of complying with these regulations, and it is expected that all local criminal justice agencies in the state will likewise be required to comply, since the regulations apply to all state and local agencies that have received LEAA funds after July 1, 1973 for criminal records systems.

These LEAA regulations are expected to have very little effect on traffic through an Ohio criminal justice telecommunications system, since many of each state's criminal justice agencies already have their own individual security policies, and all users will be asked to comply with user agreements designed to assure compliance with LEAA requirements. For purposes of the traffic projections in this study, it has been assumed that the Ohio state plan for assuring the integrity of criminal records will be accepted by LEAA and that agencies responsible for the records, and user agencies, will comply with the approved state plans. It appears that none of the information transfers that have been identified as generating new data type traffic will be inhibited by security and privacy regulations. Traffic is therefore assumed to be unconstrained by security and privacy regulations. It is likely that other states will also comply with the federal guidelines and that their criminal justice communication system traffic will be similarly unconstrained. Such compliance will allow states to obtain maximum utility from the system.

4.3 DATA GATHERING TECHNIQUES AND RESULTS

4.3.1 Traffic Volume

Information on what future traffic levels in new data types might be was gathered primarily from state officials who have been administering criminal justice information systems in Ohio for the last several years, and from officials (often the same people) who are planning for the future of these systems. Responses from these data system administrators and planners were gathered in the form of written answers to formal written inquiries, by informal personal conversations, and by formal personal presentations to large groups of state officials who were invited to criticize the assumptions and analyses used in projecting future traffic in new data types.

In addition to talking with administrators and planners at the state level, data on the future of the state criminal justice information system were also obtained from speaking with local users in city police departments, and other local agencies such as county courts and sheriff offices. The following list summarizes the types of agencies visited in each model state:

State criminal justice information system operators

State criminal justice information system planners

Law enforcement users of the state and local criminal justice information systems such as city police departments and county sheriff offices

State judicial system planners and administrators of state judicial system statistics services

Operators and planners of local judicial information systems for general jurisdiction courts

Administrators and planners of state corrections information systems

Operators of state youth agency information systems

Administrators and planners of state parole information systems.

The following list summarizes the types of vehicles used to obtain estimates of future new data traffic volume from these several agencies:

(1) Formal written questionnaires (see Appendix A) were sent to the state criminal justice information system operators asking their judgment on what new data types they expected to see on their network in the next decade. These questions were part of the formal written questionnaire that asked for detailed traffic statistics on existing data types and for past historical trends in data volume. If the state operators of the criminal justice information system indicated there would likely be another type of data added, this statement was followed up by a phone call or visit to the agency which would provide the expected data in order to obtain better estimates of when the data might appear on a state system and what its volume would be over a period of time.

CONTINUED

1 OF 4

(2) Formal meetings were held with operators, administrators and planners of the criminal justice information systems in each state to present the STACOM team's assumptions and forecasts for the future of the traffic volume. These "advisory committee" meetings consisted of presentations by the team members concerning the team's assessment of what future traffic in new and existing data types would be, and how this would affect the design of the state information system over the next decade. After the formal presentations, participants from all agencies were invited to discuss the material presented and offer suggestions on how the traffic projections could be made more accurate. These discussions also usually led to further individual discussions with present or potential users to obtain more accurate projections of how each agency thought its traffic level would change over the years.

(3) Individual discussions were held, often several discussions, with all of the agencies listed above. Visits were made to the state offices of all agencies involved in criminal justice and to several representative local agencies that either use or administer automatic data processing facilities. A single visit was usually insufficient to obtain all the information required to gather realistic data traffic volume projections, so several telephone calls were generally made to clarify the estimated future traffic and to obtain user response to assumptions and projections that the STACOM team had made based on earlier formal discussions or written responses.

It should be emphasized that future traffic volume estimates were usually obtained from individuals within the criminal justice community who were advocates of the effectiveness of automatic data processing, or at least convinced that it was a benefit to their agency. Criticism of the existing systems was heard from several individuals, but it was usually accompanied by suggestions for improvements that are already planned or that are likely to be made. There was no opposition to the basic idea that automatic data processing use would become more extensive in criminal justice or that it was a significant benefit to the record keeping and rapid communication required of law enforcement, court and corrections institutions.

Discussions with state agencies and with users of the state criminal justice information system were held in the context of trying to determine what <u>could</u> happen to traffic volume on the system over the next decade, not what <u>should</u> happen or what <u>will</u> happen. It was therefore important to get the best judgment of state officials concerning present state policies and budgets and their ideas about what future policies and budgets might be. Whenever these projections left room for scenarios that would lead to low or high traffic volumes, or to the addition of a new data type or not adding it, it was usually decided to assume the higher traffic volume so that communication lines and computers would be adequate to handle the higher load. Except for CCH/OBTS estimates, a low or high estimate for traffic in a single data type made little difference in the statewide network design or in the size of the required computing facility since these data types are projected to account for a small fraction of the total traffic volume. Thus, large variations in the estimates of traffic for these new data types have very little effect on the design of the statewide system.

In the discussions with both operators of the state systems and with the individual user agencies, questions were always asked concerning the functions of both the agency itself and of the data which were being transmitted on the statewide system. From the answers to these questions, it was possible to estimate two of the factors which are used in the following sections to forecast future traffic volumes. By obtaining a qualitative estimate of the implementation schedule for a new data type, a "technology penetration factor" was estimated which is used to specify the fraction of the total statewide potential use of the specific data type. By discussing the functions of the agency and its information needs, it is possible to estimate the number of transactions the terminals assigned to the agency will have with the state information system per arrest or per inmate per day or per court case disposition or per whatever measure is used for the agency's activity level.

User discussions also brought out whether the data used by the agencies are needed in real time or whether a slower means of transmission is acceptable. For instance, in the case of judicial statistics, it is likely that these need not be transmitted to a state judicial statistics center in near real time, but it was decided that, since large information systems are available at both the courts and at the state data center, it would be wise to connect them and avoid the cost and manual processing of the statistics by including this type of data on the state system. On the other hand, in some cases it was decided not to include certain data types on the state system because of the high cost involved for only marginal convenience or benefit. An example of this is the decision to assume that only the four or five largest cities in the state would have fingerprint volumes high enough to justify the great cost of automatic fingerprint processing equipment. Cities with smaller arrest and fingerprint volumes would therefore have to rely on facsimile transmission or communication by mail.

In Ohio user and operator discussions were useful in trading off regional data bases versus a central state file and in estimating the effects this would have on the traffic over a statewide network. It was decided, for example, that court information systems that kept track of offender processing to the detail of court calendar control would best be handled on a local or regional level as it already is in several jurisdictions, and that only court statistics would be transmitted on the statewide networks.

The techniques of written survey, individual discussions with operators, planners and users of the criminal justice information system, and presentations to advisory groups of criminal justice information system experts from the model states can, of course, be used on any state and with any potential user agency in the state. Ohio cooperated fully with these methods of determining its information processing needs and we believe that the projections are therefore as realistic as it is possible to be when dealing with the uncertain future.

4.3.2 Traffic Distribution

The techniques used for obtaining estimates of future statewide traffic volume were also used to project the distribution of that total data volume between the users throughout the state. As discussions were held with both state officials and data system users, comments were solicited concerning how much data traffic would flow to each of the offices of an agency. In some cases simple mechanical estimates were made such as prorating the total traffic to the correctional agency between the several institutions according to the number of inmates in each facility. In other cases the uniform proration according to arrests or offender volume was tempered by past experience to arrive at estimates that suggested, for instance, that certain facilities such as reception centers for correctional agencies generated far more information than those with no offender processing function. Thus, at the same interviews and presentations, data were obtained which allowed projections of both total statewide criminal justice information system traffic volume and the distribution of that traffic throughout the state.

4.3.3 Results

Questionnaire responses, discussions with state officials, and presentations to the Ohio advisory committee suggested that the following types of new data should be included in the STACOM projections for the next decade:

- Law enforcement use of a CCH/OBTS file
- Court use of the CCH/OBTS file
- Use of the CCH/OBTS file by state correctional institutions
- Local or regional SJIS files connected to a state system for the purpose of transmitting court statistics
- An OBSCIS system for the state correctional facilities
- A network for transmitting automatically processed fingerprints from the state's largest cities to central state files
- A traffic component associated with the conversion of present manual CCH/OBTS files to computerized files and with the maintenance of those automatic files.

During the time of the Ohio STACOM study, it was unclear whether Ohio intended to implement a statewide criminal history system that would include reports on both felonies and misdemeanors, and would include all the data elements of a computerized criminal history and those of an offender based transaction statistics system. There was a bill pending in the state legislature that would require all local jurisdictions to report both felonies and misdemeanors to state data bases, but some state officials anticipated strong opposition to this bill from local law enforcement agencies because many of the agencies had insufficient manpower to fingerprint and process all misdemeanants to the same level of formality as felons, which would be required if these reports were to be included in state files. Other state officials, however, felt that, independent of the concerns of the local police officials, the bill requiring reporting on all offenders would pass and a state criminal information system should account for this eventuality. It was also uncertain as to the number of data elements that would be included in the Ohio criminal history system - whether it would encompass a more limited set of CCH data elements, or whether a lengthier OBTS format would be used. In both cases - the question of whether both misdemeanants and felons would be included in the system, and that of how extensive the data files would be - the judgment of the state officials was used, tempered by the philosophy that this project did not want the STACOM system to be undersized, so if a lower or higher traffic estimate could be made, the higher volume was chosen. In Ohio, this meant that all offenses, both felonies and misdemeanors, were included in the traffic volume, and the size of the messages was that estimated by the officials who operate the present LEADS system in the state -- usually on the order of a 960-character page for entries. The basis of the law enforcement CCH/OBTS network was taken as the present LEADS network since state officials indicate that it is a relatively minor software and hardware modification to allow present LEADS users access to the existing CCH files. For this reason, future traffic projections for Ohio new data types show a very rapid growth in law enforcement CCH/OBTS traffic volume and suggest that the system will be fully utilized by about 1979.

The STACOM study also included court use of the proposed CCH/OBTS files in Ohio, based on discussions with local and state officials and on observation of similar local systems in two of the large metropolitan areas. In Cincinnati, the CLEAR system includes court tracking data elements, and in Toledo, the offender based system in Lucas County includes similar elements. In planning the STACOM network, therefore, these observations and discussions led the team to include court use of the state files, but only from the major metropolitan areas. It was assumed that if state files were made available for court access, one of the appellate judicial districts surrounding a large city that already had a local system operating would be the first to connect. In this case, Cincinnati and its CLEAR system were projected to be the first district to use the state system. Thereafter, the courts in the appellate judicial districts surrounding Cleveland, Columbus, Toledo, Dayton, and Akron were added to the system. However, since it was also assumed that, as these cities connected to the state system they also developed their own local SJIS system for calendar management and court record keeping, these court systems are included as single large terminals in the major cities rather than individual terminals in each of the courts. It is likely that the state system would interface with a court computer in each of the major appellate judicial districts or major metropolitan areas rather than directly with the individual courtroom terminals.

Conversations with data processing officials in Ohio's correctional institutions revealed that their connection to the state CCH/OBTS files would not likely occur for some years. The Ohio Department of Rehabilitation and Corrections had once operated an on-line data processing system but it was taken out a few years ago in the interests of economy. The Department presently has a system that is operated in a batch mode and this will likely remain the technique for inmate tracking for the next few years. However, to be complete in the STACOM study, it was decided to show the inclusion of the corrections institutions in the state network about midpoint in the decade being studied. At that time the headquarters office and several facilities throughout the state are assumed to be able both to inquire and to update the state CCH/OBTS files.

It has been pointed out that systems like an SJIS system are already operating in a few of the large Ohio cities - at least these systems have elements like an SJIS system in that they assist in the efficient operation of the courts of Hamilton or Lucas Counties, for instance. After discussing this topic with Ohio officials, it was decided to include an SJIS system in the STACOM network, but only on the level of transmitting judicial statistics to the Supreme Court Administrative Director. Discussions with the STACOM staff and Ohio officials suggested that, to be as realistic as possible, the SJIS functions of court management and record keeping would likely be retained at the local level during the period of the STACOM study, since some of them are already operating in that mode at the present time, but that a need did exist for statistics to be sent to the state that could be made more efficient by automatic data processing, especially since large computer installations would likely exist at each end of the transmission path anyway. It was estimated that cities like Cincinnati or Toledo would likely be the first to connect to and use such a system, and that only the appellate judicial districts surrounding the six largest cities would be included in the network by the end of this study period.

Just as the corrections institutions were assumed to be users of the CCH/OBTS system after a few years, they were also estimated to have implemented an on-line OBSCIS system at about the same time. It has been pointed out that such a system of inmate tracking is operated in a batch mode at the present time, but that it is not likely to be placed on-line for a few years. Even though its implementation is uncertain, it was included in the Ohio STACOM system for completeness, and because team discussions with Ohio officials indicated that such a system has not categorically been ruled out for the time period of this study. On the contrary, if funding is available, the state has every intention of implementing such a system.

Ohio is not yet involved in processing fingerprints by automatic pattern recognition equipment, and state officials currently believe that there are many smaller jurisdictions that will never have the fingerprint traffic volume to justify automatic fingerprint processing facilities. Instead, they see a three-tier arrangement of fingerprint processing in the future - and within the time horizon of the STACOM study: A few large cities will probably convert manual fingerprint processing to computerized systems within the next several years. However, just as in the case of the courts, this will probably be confined to only the largest five or six metropolitan areas. Gradually, these cities will probably begin sending fingerprints to state files already compressed and classified so that they can be sent over the same lines that will be carrying criminal history and court information. Another group of jurisdictions will not be able to afford or justify the expense of automatic fingerprint processing equipment, but they will be able to purchase high quality, rapid facsimile transmission machines for sending fingerprints to the state files over a network separate from the state criminal information system. This separate network is anticipated because of the large volume of data in an unprocessed fingerprint card and the need to send the data at a high rate if card transmissions are to occur in a reasonable amount of time - say, a few minutes. These separate lines could be dedicated to facsimile transmission between large cities, or they could be portions of other communications systems such as community antenna television (CATV) networks or dial-up communication lines. For purposes of the STACOM study in Ohio, therefore, the discussions with state officials suggested that this analysis should only include the processed fingerprints from the largest cities on the state network that would also carry the other types of criminal justice information. Finally, smaller rural communities will still likely continue to mail fingerprint cards into state files throughout the period of this study since their volume does not justify even a facsimile machine.

The managers of the Ohio state criminal files estimate that traffic from their data conversion operation to the state files will likely remain at the 1977 level throughout the decade of the STACOM study. This level is anticipated to be maintained because the department has reached its maximum expected staffing, and because, if criminal activity increases as expected, entries will gradually be made directly from users in the field rather than from the central state data conversion facility. The estimates of the state officials for traffic from this central BCII facility were then those used throughout the decade of this study.

4.4 DATA ANALYSIS TECHNIQUES AND NEW DATA FORECASTING METHODOLOGY

4.4.1 General Methodology

The components of new data that were estimated through 1985 are the nine listed in Section 4.1. Section 4.4 describes the approach taken to predicting new data type traffic in the two model states. The calculations based on these techniques and the results of the calculations are given in Section 6. The procedure that was used to analyze the data gathered from the model states and to estimate future traffic was:

(1) Determine average messages per day for each component of traffic for the entire state between the user agencies and the central files

(2) Compute an average message length for each new data component for messages to and from the state files, and an average for both directions combined

(3) Determine the aggregate peak characters per minute for each component of new data for traffic to and from the state center to the users

(4) Distribute the aggregate traffic in peak characters per minute to and from the state files between the individual users of the system so that traffic volumes to the localities throughout the state can be determined.

This process is shown schematically in Figure 4-1. The following paragraphs describe how this process worked for each of the components of new data types.

4.4.2 Arrest-Dependent Traffic

4.4.2.1 CCH/OBTS.

4.4.2.1.1 Average Messages Per Day. Aggregate statewide CCH/OBTS traffic was determined by estimating the total criminal activity in future years, determining how many offenders flow through each step of the criminal process from the criminal procedure diagram of Figure 4-2, and estimating the information needs at each step from the message use matrix of Figure 4-3. This process is shown schematically in Figure 4-4.

A complete list of the factors used in computing future CCH/OBTS traffic is given below and the factors are explained in the following paragraphs:

Total Statewide CCH/OBTS Traffic in Average Messages per day =

Estimated statewide arrests per year
× Technology penetration factor
× Number of transactions with the CCH/OBTS files per arrest
× Number of messages per CCH/OBTS transaction
× Time conversion to convert from years to day

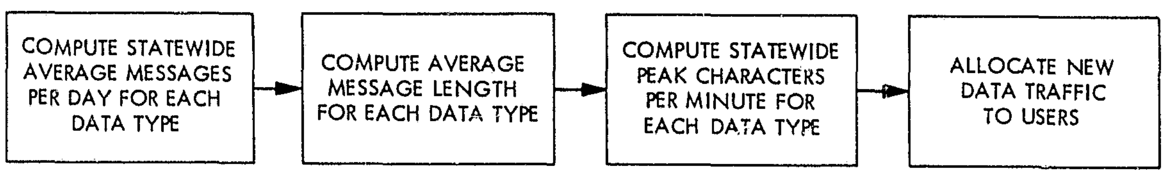
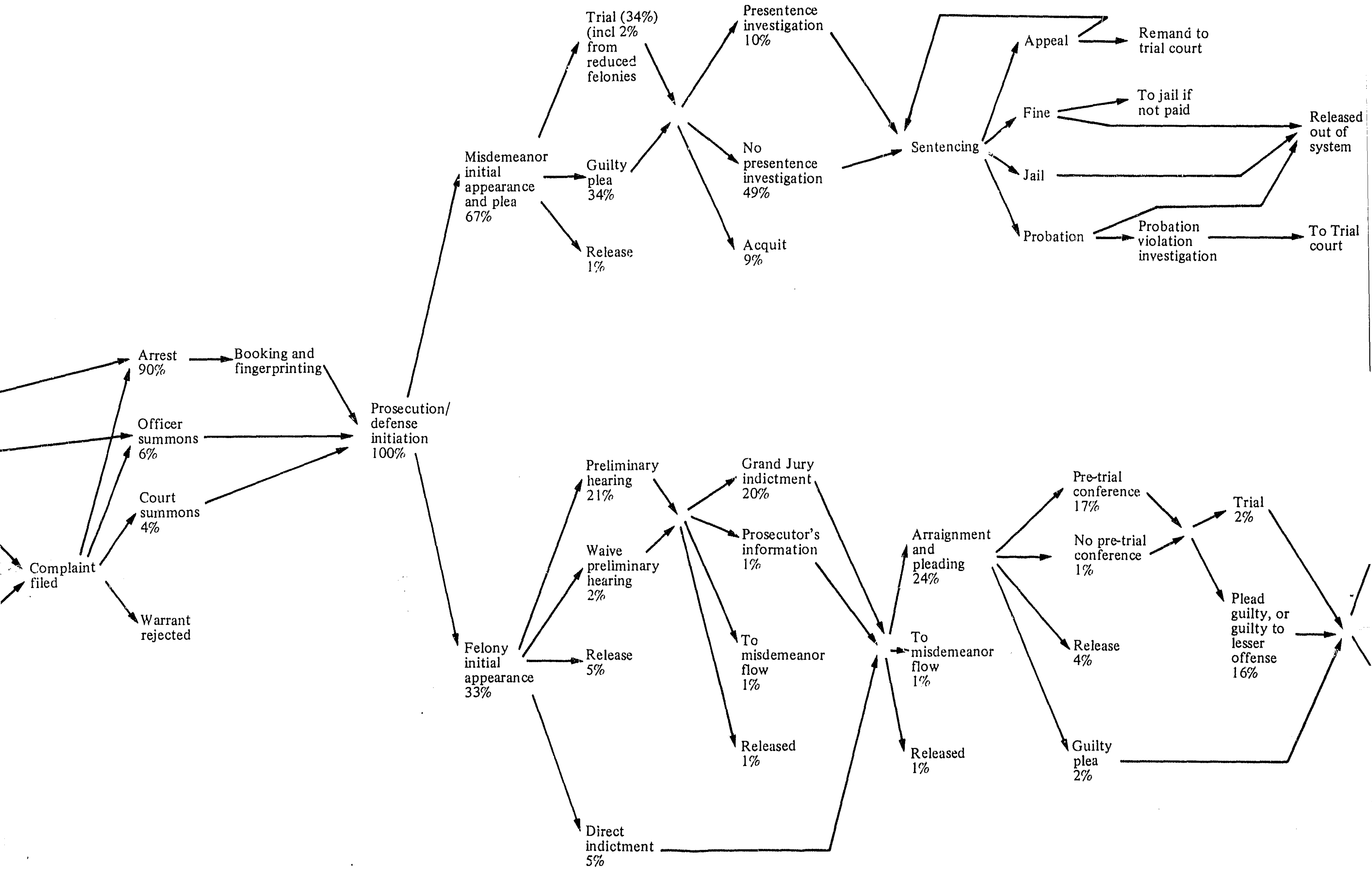


Figure 4-1. New Data Type Analysis, Forecasting and Distribution Methodology


Non-vehicular crime without officer present
Verification
Investigation
Baseless
Suspect unknown
Suspect identified
Non-vehicular crime, officer present
Vehicular crime, officer present
Vehicle identified
Suspect identified
Vehicle unknown
Suspect unknown
Verification
Investigation
Baseless
Vehicular crime without officer present



Complaint filed
Arrest 90%
Officer summons 6%
Court summons 4%
Warrant rejected
Booking and fingerprinting
Prosecution/ defense initiation 100%
Misdemeanor initial appearance and plea 67%
Trial (34%) (incl 2% from reduced felonies
Guilty plea 34%
Release 1%
Presentence investigation 10%
No presentence investigation 49%
Acquit 9%
Sentencing
Appeal
Remand to trial court
Fine
To jail if not paid
Jail
Probation
Probation violation investigation
Released out of system
To Trial court
Felony initial appearance 33%
Preliminary hearing 21%
Waive preliminary hearing 2%
Release 5%
Direct indictment 5%
Grand Jury indictment 20%
Prosecutor's information 1%
To misdemeanor flow 1%
Released 1%
Arraignment and pleading 24%
To misdemeanor flow 1%
Released 1%
Pre-trial conference 17%
No pre-trial conference 1%
Release 4%
Guilty plea 2%
Trial 2%
Plead guilty, or guilty to lesser offense 16%

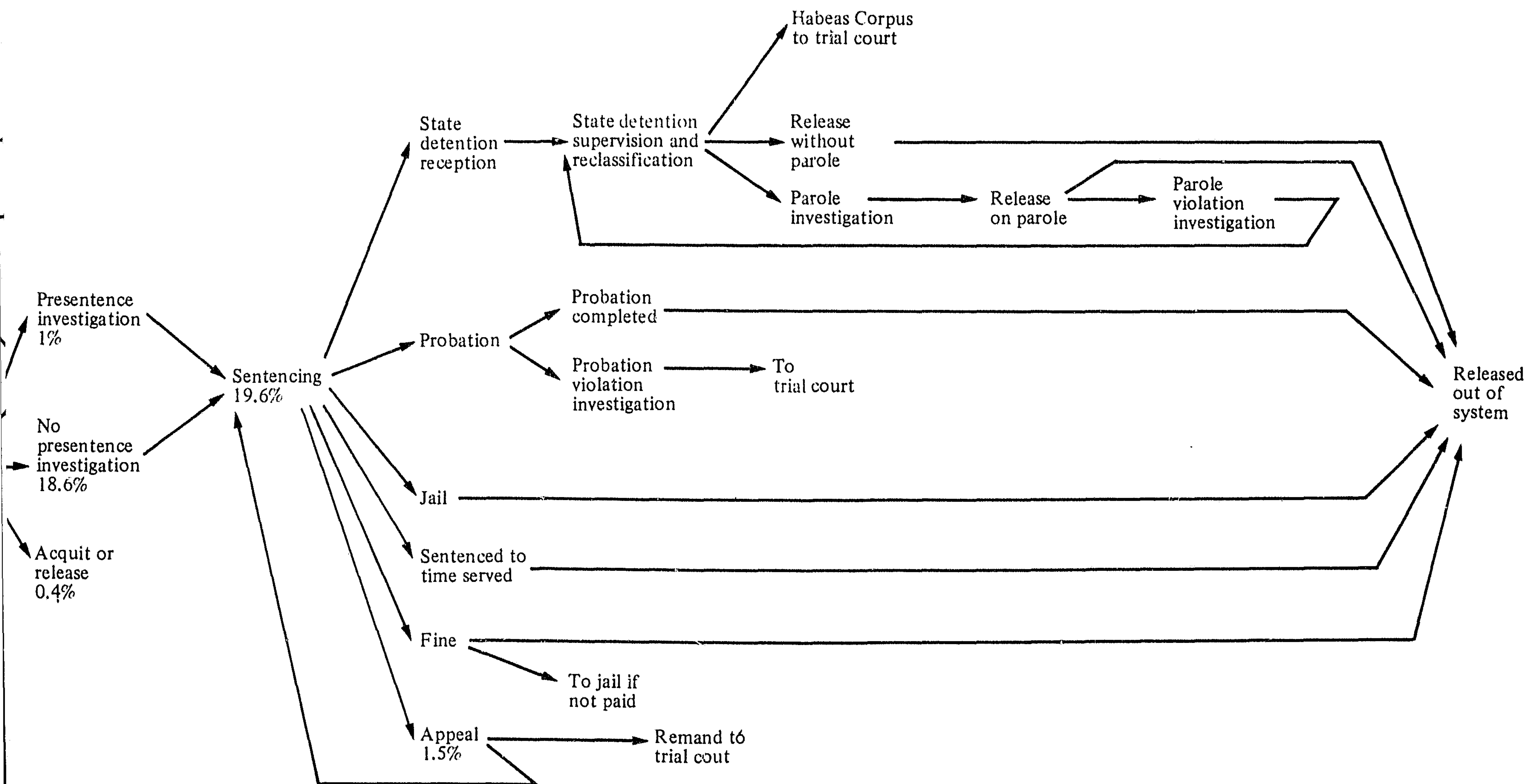


Figure 4-2. Criminal Procedure Diagram

CCH TRANSACTION TYPES

CRIMINAL JUSTICE PROCESS STEPS		CCH NCIC SEARCH ZR	RETRIEVE IDENTIFICATION DATA ZI	RETRIEVE CRIMINAL HISTORY GR	RETRIEVE CRIMINAL SUMMARY GH	ENTER MASTER ID EH	MODIFY MASTER ID MH	ENTER APPENDED ID DATA EHN	ENTER ARREST DATA ER2	MODIFY ARREST DATA MR2	CANCEL ARREST DATA XR2	ENTER BAIL DATA ER5	MODIFY BAIL DATA MR5	VALIDATE MASTER ID VH	VALIDATE APPENDED ID DATA VHN	VALIDATE ARREST CHARGE VR2	VALIDATE JUDICIAL HISTORY VR3	ENTER LOWER COURT DATA ELC3	MODIFY LOWER COURT DATA MLC3	ENTER FELONY COURT DATA EFC3	MODIFY FELONY COURT DATA MFC3	ENTER JUDICIAL COUNT ER3	ENTER SUPPLEMENTAL COUNT ER3A	ENTER CUSTODY SUPERVISION ER4	MODIFY CUSTODY SUPERVISION HR4	TOTALS
POLICE 18.6	INCIDENT VERIFICATION	0.2	0.2		0.2																					0.6
	INCIDENT INVESTIGATION	0.5	0.5		0.5																					1.5
	SUSPECT IDENTIFICATION	2.5	2.5		0.5																					5.5
	COMPLAINT WARRANT				0.5																					0.5
	OFFICER AFFIDAVIT	0.1	0.1		0.1																					0.3
	POLICE SUMMONS	0.1	0.1		0.1																					0.3
	ARREST	0.9	0.9		0.9																					2.7
	BOOKING AND FINGERPRINTING	0.9	0.9	0.5	0.5	0.5	0.5	0.3	0.4																	4.5
	VALIDATE ARREST													0.5	0.3	0.9										1.7
	POLICE BAIL											0.4														0.4
	COURT BAIL											0.5														0.5
	DETENTION																							0.1		0.1
PROSECUTION 6.3	PROSECUTION REVIEW	0.5			0.3					0.5								1.0	3.0		1.0					6.3
LOWER COURTS 4.8	MISDEMEANOR SUMMONS	0.1	0.1		0.1	0.1	0.1	0.1	0.1																	0.7
	MISDEMEANOR BAIL VIOLATION MODIFICATION												0.1													0.1
	MISDEMEANOR COURT ACTIVITY										0.1							0.7	1.4							2.2
	MISDEMEANOR SUMMONS VALIDATION													0.1	0.1	0.1										0.3
	MISDEMEANOR PRESENTENCE INVESTIGATION			0.1																						0.1
	MISDEMEANOR SENTENCING																		0.6			0.1	0.1			0.8
	VALIDATE MISDEMEANOR DISPOSITION																0.6									0.6
CORRECTIONS 1.3	MISDEMEANOR CUSTODY																							0.3	1.0	1.1
PROBATION 1.3	MISDEMEANOR PROBATION																							0.3	1.0	1.3
FELONY COURTS 4.1	FELONY SUMMONS	0.1	0.1		0.1	0.1	0.1	0.1	0.1																	0.7
	FELONY SUMMONS VALIDATION													0.1	0.1	0.1										0.3
	FELONY BAIL/VIOLATION MODIFICATION												0.1													0.1
	FELONY INITIAL APPEARANCE										0.1								0.3							0.4
	FELONY PRELIMINARY HEARING										0.1								0.3	0.3						0.7
	FELONY INDICTMENT										0.1										0.3					0.4
	FELONY ARRAIGNMENT PLEADING										0.1										0.3					0.4
	FELONY PRE-TRIAL CONFERENCE										0.1										0.2					0.3
	FELONY TRIAL										0.1										0.2					0.3
	FELONY PRESENTENCE INVESTIGATION			0.1																						0.1
	FELONY SENTENCING																				0.1	0.1	0.1			0.3
	VALIDATE FELONY DISPOSITION																1.0									0.1
PROBATION 1.1	FELONY PROBATION																							0.1	1.0	1.1
CORRECTIONS 1.1	FELONY CUSTODY																							0.1	1.0	1.1
PAROLE 1.1	FELONY PAROLE																							0.1	0.1	1.1
	TOTALS	5.9	5.4	0.7	3.8	0.7	0.7	0.5	0.6	0.5	0.7	0.9	0.2	0.7	0.5	1.1	0.7	1.7	5.6	0.3	2.1	0.2	0.2	1.0	5.0	39.7

Figure 4-3. Ohio CCH/OBTS Message Use Matrix

For purposes of this study, statewide arrests were projected to increase linearly at a rate equivalent to about 2% of 1975 arrests per year between 1975 and 1985. This has been the national rate of increase during the past decade, although this growth has been very erratic. Figure 4-5 shows national arrest trends over the past decade based on figures from the FBI Uniform Crime Reports (UCR) and "United States Statistical Abstracts." The upper curve is estimated total arrests throughout the nation while the bottom line is actual reported arrests. As noted in the figure, estimated total arrests were either computed by the FBI using information about the population and arrest statistics of jurisdictions that do and do not report arrests or they were computed in the course of this study (those with a subscript "c") by multiplying actual arrests reported by the ratio of total national population to population in the jurisdictions reporting arrests. These reported arrests grow at approximately 6.2% per year, but much of that increase must be caused by improved reporting since the estimated actual arrests only grow at linear rate of about 193,000 arrests per year, which is 2.08% of the 9.27 million estimated arrests in 1975. This growth rate in arrests was then applied to Ohio in this study, which yielded an arrest increase of 9,018 per year from the 433,571 arrests in Ohio in 1975.

Consideration was given during this study to using total FBI index crimes as a method of projecting future criminal justice information system traffic. However, traffic will likely be a function of police activity as measured by arrests, rather than of criminal activity as measured by reported crimes, since it is the criminal justice agencies using the information system that generate traffic, not the offenders or victims of crime.

Total arrests in Ohio were computed from FBI UCR data in 1975, which showed that, on a national level, 0.82 arrests for felonies and nontraffic misdemeanors were made per index crime. This ratio was applied to the index crimes estimated for Ohio in 1975 to determine the estimated statewide arrests.

The technology penetration factor accounts for the extent to which hardware is available to users, for the gradual familiarization process user agency personnel go through, and for the availability of

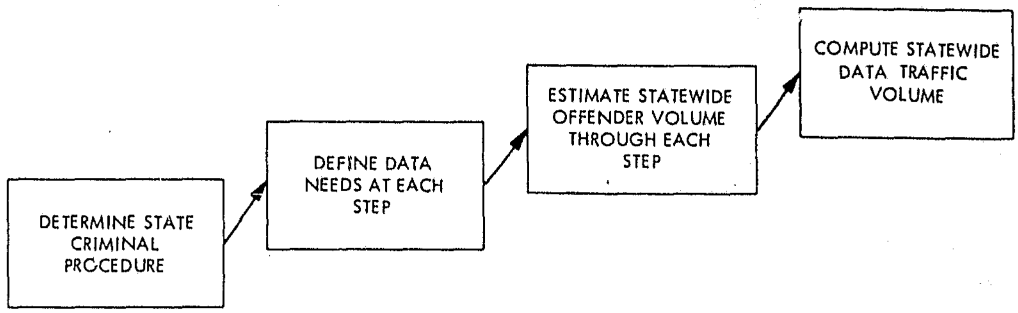


Figure 4-4. CCH/OBTS Traffic Forecasting Process

funding to implement the several types of new data. In most cases, this factor, which varies from 0 to 1, was estimated based on the suggestions of state criminal justice information system experts about when the several types of new data would be implemented in the state. In Ohio, two assumptions were made which caused this technology penetration factor to increase very rapidly from 0 in 1977 to 1 in 1979. The first was that LEADS terminals would very quickly begin to use the CCH/OBTS files after these records were made available to them in 1977. Second, proposals are pending in the Ohio Legislature which would require reporting of both felony and misdemeanor arrests by local police agencies. Local agencies are understood to be opposed to this legislative suggestion because of the increased workload it would impose, but its passage was assumed so that the system could handle this increased traffic if it should appear on the network.

The number of transactions with the CCH/OBTS files can be determined by estimating the number of transactions per arrest from Figure 4-3. The criminal procedure flow diagram of Figure 4-2 shows the number of offenders through each step in the criminal justice process per arrest, and Figure 4-3, the messages use matrix, uses this information to derive the information needs at each step, per arrest. Multiplying by the total number of arrests in the state yields the total transactions with the CCH/OBTS files. Summing these transaction volumes over any part of the criminal justice establishment - say courts or corrections, for example - one can then compute the traffic generated by each institution.

The number of transactions with the CCH/OBTS files per arrest will be noted to be quite high, especially for law enforcement and court activity. In the case of law enforcement, this is caused by the expected large number of inquiries prior to arrest that never result in an arrest. Statistics from the FBI Uniform Crime Reports for 1975 show that only 21% of index crimes were cleared by arrests, implying that most crimes are not cleared by arrests or that arrests that are made do not clear crimes and result in dropped charges. Thus, in deriving the message use matrices and assigning the number of transactions per arrest that occur prior to an

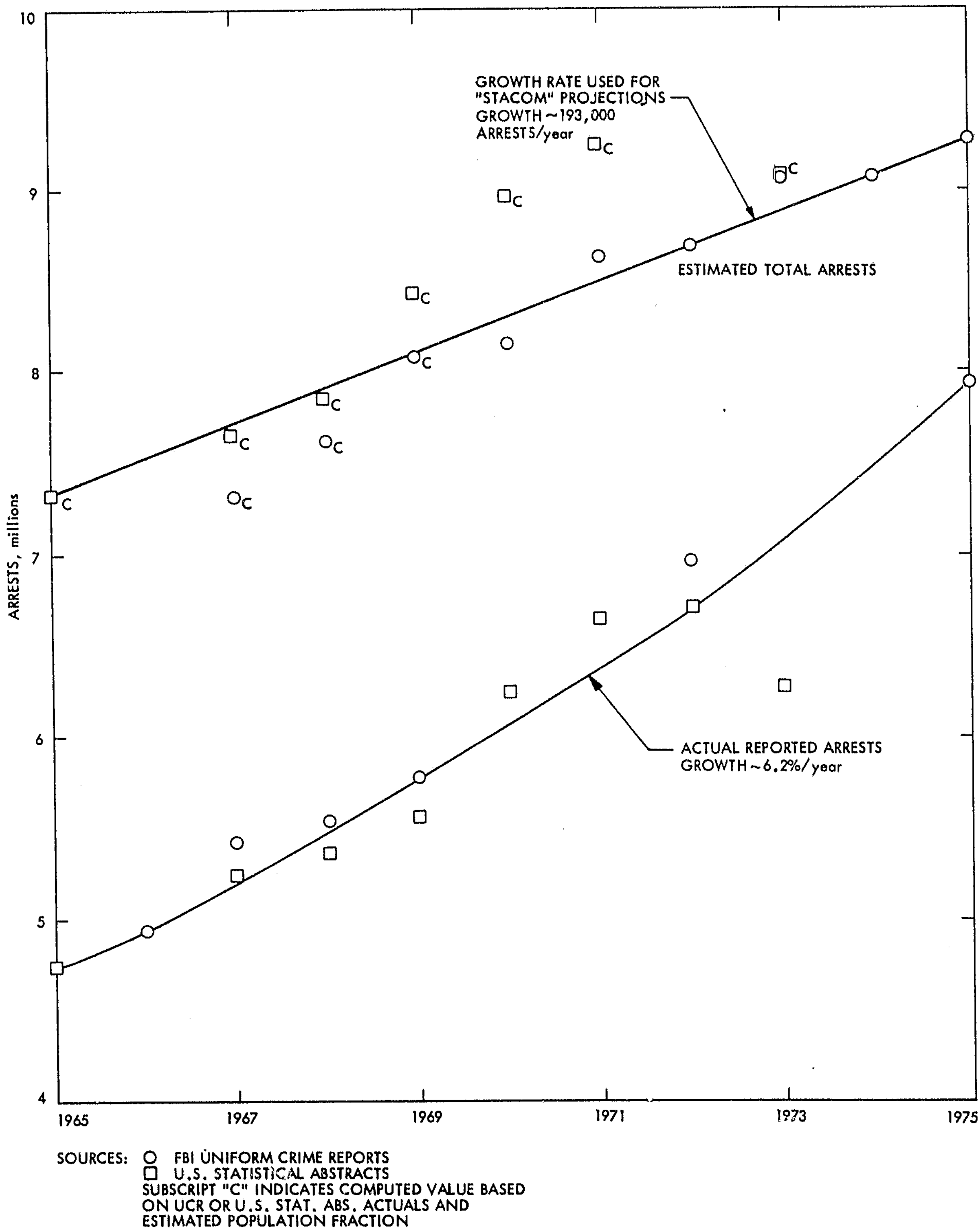


Figure 4-5. National Arrest Trends

arrest, a large multiple is included to account for these interactions with the state criminal justice information system that never result in arrests. In the case of the courts, the relatively large number of transactions per arrest is due to the multiple hearings and appearances, including continuances and re-hearings that are part of the judicial process. Both in the case of law enforcement and judicial interaction with the state data system, the values derived in this study are close to those estimated independently by officials of Ohio.

Since each transaction requires a message to the state files and an accompanying response, there are two messages per transaction. This accounts for an inquiry and response for each inquiry transaction, and an update and acknowledgment for each data entry transaction.

The time conversion factor is either 365 days per year for law enforcement agencies or 250 days per year (to delete weekends and holidays) for other agencies. This factor is necessary to convert from total arrests per year to messages per day.

4.4.2.1.2. <u>Average Message Length in Characters</u>. Average message length of CCH/OBTS traffic is computed by weighting the length of the various types of messages by the fraction of the traffic that each message type provides. Inquiries are considered to be brief: usually one to three lines of whatever high-speed terminal is in use. Responses can be of widely varying length, depending upon whether the inquiry resulted in a "hit" or "no-hit." "Hit" responses are taken as a large fraction of a terminal page - perhaps 1000 characters - while the percentage of "no-hit" responses and their length are derived from the experience of the operators of the present state systems, or from their estimate of future traffic. The fractions of message types generated by the various institutions in the criminal justice system - e.g., the fraction of data entries by law enforcement agencies or the fraction of inquiries into the CCH/OBTS system by the courts - are derived from the message use matrix of Figure 4-3. The weighted message lengths are then summed to obtain: 1) average message length to the central state files, 2) average message length from the state files to the users, and 3) the average length of messages traveling both directions on the state network.

4.4.2.1.3 <u>Peak Traffic in Characters Per Minute</u>. Traffic volume in average messages per day has been computed above, and this can be converted to peak characters per minute by multiplying by average message length and several other time and peak-to-average conversion factors. The complete relationship between average messages per day and peak characters per minute is:

CCH/OBTS traffic in peak characters per minute = Average messages per day

x Peak-to-average ratio (taken as 2 throughout this study)

÷ Number of messages per transaction to or from the state files (taken as 2 throughout this study because inquiries generate responses and entries generate acknowledgments)

÷ Time conversion factor for changing daily rate to rate per minute (taken as 1440 minutes per day for law enforcement inquiries and updates and 480 minutes per day for all other traffic)

x { Average message length to state files or Average message length from state files }

= { Peak characters per minute to state files or Peak characters per minute from state files }

The peak-to-average ratio of 2 was determined by obtaining current daily traffic statistics from the model states, computing the daily average traffic volume, and observing that the average was about half the peak traffic.

This technique for converting average messages per day to peak characters per minute was used for all new data types considered in this study. Different message lengths and time conversion factors were used where appropriate, but peak-to-average ratio and the number of messages per transaction always were assumed to be 2.0.

4.4.2.1.4 Traffic Distribution to User Agencies. The final step in predicting criminal justice information system traffic from new data types is the distribution of the traffic to the local users throughout the state. This calculation is done by computer in the case of law enforcement use of CCH/OBTS files, because there are several hundred law enforcement terminals in each state presently connected to the state systems. The distribution of CCH/OBTS traffic to courts, corrections, or parole agencies is done manually, since, in the early years, there is usually only one regional terminal or headquarters terminal operating, and when the systems are completed there are not usually more than a dozen terminals.

New data traffic to law enforcement agencies is distributed according to the ratio of index crimes in the jurisdiction served by the agency to the total number of index crimes in all appropriate jurisdictions with terminals. This traffic is distributed to local police and sheriff departments and is not assigned to state police stations or federal offices. Traffic from these other offices is allowed to grow at a rate predicted by the growth algorithm for existing data types. The existing data traffic and new data type traffic are then added for each terminal, and the result printed for review and provided to the network designers on tape. Distribution of law enforcement CCH/OBTS traffic according to index crimes in each jurisdiction was made because such data are readily available each year from both state and national law enforcement statistics agencies and because criminal activity is a reasonable measure of the need for information in law enforcement agencies. Other measures such as the number of personnel in a local law enforcement office or the population, or the number of arrests in the jurisdiction could be used, but, except for raw population data, these other measures are less readily available and less current, so distribution was made according to local index crimes.

Court CCH/OBTS traffic is distributed according to the number of court dispositions in each of the largest appellate judicial districts in Ohio. One region is assumed to be an experimental facility in the early years and the remaining large metropolitan areas are added within a few years.

Traffic between the corrections facilities and the CCH/OBTS files is distributed according to the number of inmates in each institution, except that a larger percentage of traffic is assigned to the corrections department headquarters. Ohio officials also suggested that a higher volume of traffic should be assigned to the reception centers.

Any traffic to or from the state parole agency was assumed to flow entirely between that agency's headquarters and the state CCH/OBTS files.

4.4.2.2 Automated Fingerprint Traffic.

4.4.2.2.1 Average Messages Per Day. Within the next decade it is anticipated that Ohio will implement some sort of automated fingerprint encoding, classification, and transmission process. It is likely, however, that equipment for this will be available only in the largest cities since it is quite expensive and requires a large fingerprint volume to justify it. For this reason, the factors used for computing the average fingerprint message volume per day, which are the same factors used in the relationship of Section 4.4.2.1.1 above, include a technology penetration factor that begins with just one large city participating in the program in the early years and expands to several of the largest metropolitan areas at maturity.

The number of fingerprint transactions per arrest is an estimate based on 1973 FBI crime statistics which showed that about 21.2% of index crimes were closed by an arrest, or 4.72 crimes were committed per arrest. If latent fingerprints are associated with 25% of these crimes, approximately 1.18 fingerprints would be transmitted per arrest for the purpose of identifying the latent print. In addition, every arrestee would be fingerprinted and a 10-print card would be processed and sent to state files. The total number of transactions including both latents and full cards, then becomes 2.18 per arrest.

As with the CCH/OBTS average traffic volume, two messages per fingerprint transaction are assumed because each transaction would include a message to the state files and an acknowledgment. Fingerprint transmission was assumed to take place during a normal work week, so a value of 250 working days per year was assumed for the time conversion factor.

The other factors used in the computation of average fingerprint volume per day are the same as those used in the derivation of average CCH/OBTS traffic in Section 4.4.2.1.1.

4.4.2.2.2 Average Message Length. To compute average message length for digital fingerprint transmission, a decision must first be made about which steps in the fingerprint processing should be performed in the local agency and which steps should be done at a central state facility. The process for fingerprint analysis based on the analysis of minutiae (ridge ends and ridge bifurcations) is shown in a simple schematic in Figure 4-6.

The data volumes shown are those for systems such as those sold by Rockwell International, Anaheim, California, and Calspan Technology Products, Buffalo, New York. The Sperry system presently in use in Arizona produces an 8-bit byte of information at every point of a 30 x 30 matrix on each print, based on ridge slope analysis. The 72,000 bits thus generated for each set of 10 prints are then reduced to 240 8-bit bytes per card for permanent storage. For the purposes of this study, the Rockwell-Calspan system was assumed to be the one that would be used, because it would produce a larger volume of data and would therefore yield a conservatively designed system.

The alternative to transmitting 2 million or 0.5 million, or 2,500 bits per print from a minutiae-based processor to a central file is to have only one minutiae-based system at a central location and send raw

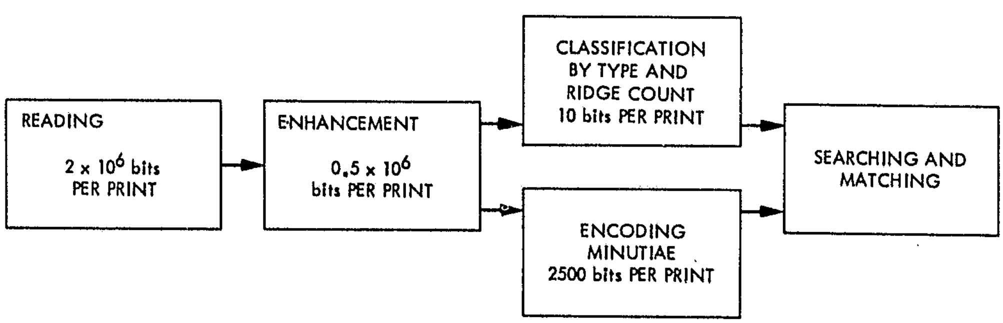


Figure 4-6. Automated Fingerprint Processing Diagram

or enhanced fingerprints from the remote agencies by digital or analog facsimile equipment such as that manufactured by Harris Corp., Melbourne, FL, or by Dacom, Inc., Santa Clara, CA. Such equipment presently scans fingerprint images at between 100 and 400 lines per inch, quantizes the gray scale into 2 to 16 shades (1 to 4 bits), and compresses the data by a factor of 2 or 3. This still leaves on the order of a few million bits that must be transmitted per 8-in. x 8-in. fingerprint card. Over a 2400-baud line, this takes about 10 to 20 minutes which would allow a few dozen cards to be processed per 8-hr work day at each terminal. This is inadequate for a large police agency like Cleveland which had 52,022 index crimes committed in 1974. If we assume 0.82 felony and misdemeanor arrests per index crime (the 1975 nationwide ratio from FBI UCR reports), and a growth rate of 900 arrests per year (the average nationwide rate applied to Cleveland) Cleveland would have 52,558 arrests in 1985 or 210 arrests per work day. If we further assume that every arrest requires that a set of fingerprints be sent to the central files, this is 210 sets of fingerprints per day. In addition, if we assume that there are 4.72 felonies and misdemeanors per arrest, and that 25% of these crimes have latent prints associated with them, this is an additional 1.18 prints per arrest that must be sent to the state files. The resulting 400 or more images that must be sent each day are therefore not compatible with a facsimile capability that requires 10 or 20 minutes per image. Note that facsimile speeds are now approaching 1 minute per fingerprint card from some vendors, but even this speed would only marginally satisfy the needs of a large city in the next decade.

The answer to this problem might be to use special wideband microwave links between the major cities and state files. This, however would remove fingerprint transmission from the state telecommunications network to such a special high data rate system. For the purposes of this study, therefore, it was decided to assume that the largest police agencies would each have equipment to read, enhance, encode minutiae, and classify fingerprints, so that they would only need to transmit about 2500 bits per print to the central state facility, which could be done over a lower speed state telecommunications line. This analysis is supported by one manufacturer who suggests that having a reader/classifier is appropriate for agencies processing more than 50 fingerprint cards per day, serving populations about 0.5 million. He estimated each reader/classifier would cost about $150,000.

With this decision, average message lengths for fingerprint transmission were computed by assuming that one full 10-print card and 1.18 latent prints were transmitted per arrest. A card was assumed to require 25,000 bits (2500 characters) for the 10 prints plus 960 characters for the alphanumeric data. The response was assumed to require 240 characters. For transmission of latent prints, one print was assumed to require 2500 bits (250 characters) plus 240 characters of alphanumeric data. The response was calculated by assuming 10% hits at 960 characters and 90% no-hits at 240 characters for an average of 312 characters. Averaging both types of transactions over the 2.18 transactions per arrest yields the average message lengths of Table 4-1.

Table 4-1. Computation of Average Automated Fingerprint Message Length

Message Type	Transactions Per Arrest	Message Length in Characters		Weighted Message Length Computation		
		To State Files	From State Files	To State Files	From State Files	To and From State Files
Card input	1.0	3,460	240	1,587	110	849
Latent input	1.18	490	{0.1 x 960, 0.9 x 240}	265	169	217
Totals	2.18			1,852	279	1,066

4.4.2.2.3 Fingerprint Traffic Distribution. In Ohio, fingerprint traffic was prorated to the large cities in the ratio of their index crime volume. It was assumed that Cleveland would obtain the necessary equipment earlier than the others, but that several of the largest areas would be processing prints automatically by 1985.

4.4.3 Offender-Dependent Traffic

4.4.3.1 OBSCIS.

4.4.3.1.1 Average Messages Per Day. The OBSCIS system is devoted exclusively to the needs of the departments of corrections, which in Ohio, includes the parole agency. OBSCIS traffic will be from the several corrections institutions to the corrections department's headquarters. In Ohio, the ODRC headquarters are in Columbus.

Instead of being based on the number of arrests in Ohio, OBSCIS traffic is determined by the number of transactions with the system per inmate-day. An estimate is made of the frequency of inquiry or update for each inmate, and this is converted to the number of transactions per inmate-day. The relationship for converting this to average messages per day is:

OBSCIS traffic in average messages per day = Total inmates in corrections department

x Technology penetration factor

x Transactions per inmate-day

x Messages per transaction

The number of inmates in state correctional institutions was assumed to grow at a rate estimated by state correctional system planners, or, if no estimate was obtained from State planners, at the same rate as arrests have grown over the last several years, as explained in Section 4.4.2.1.1. In Ohio, the correctional institution population was assumed to grow linearly at a rate equivalent to 2% of the 1975 population per year.

Implementation of an OBSCIS system on a state network was estimated to take place after 1980, although Ohio presently has data processing capabilities in its headquarters. For purposes of estimating communications traffic, however, the technology penetration factor does not reach a significant value until early in the next decade. For the first few years, the traffic was confined to the headquarters office and the reception centers. Toward the end of the study, the traffic on the state network was distributed to the institutions.

The number of OBSCIS transactions per inmate-day was estimated by picking the frequency of transactions for each inmate and converting this to a number of inquiries or entries per inmate-day. In general, it was assumed that an inquiry and a record update would occur for each inmate every 2 to 4 weeks. This rate of between 2 transactions per 2 weeks and 2 transactions per month implies between 0.07 and 0.14 transactions per inmate-day. Ohio officials estimated a slightly higher value to account for the increased traffic from reception centers.

All new data type traffic was assumed to generate a response for every inquiry and an acknowledgment for every update, which means two messages are generated by every transaction.

4.4.3.1.2 Average Message Length. OBSCIS average message lengths are again computed by weighting the types of messages according to how frequently they are sent. The lengths of each transaction type are multiplied by the fraction of total transactions per inmate-day used for that data type, and the results summed for messages to the corrections department's headquarters, from the headquarters, and for an average in both directions.

4.4.3.1.3 OBSCIS Traffic Distribution. In later years when the OBSCIS system is assumed to be fully operational throughout the state and using the state communications system, traffic is distributed between the institutions by the number of inmates in each facility. In addition, a slightly larger proportion of traffic is assigned to the reception centers and headquarters. In the early years of an OBSCIS system, traffic is assumed to come only from the headquarters of the corrections department or from the reception centers.

4.4.4 Other New Data Types

4.4.4.1 State Judicial Information System.

4.4.4.1.1 Average Messages Per Day. Instead of being based on the number of transactions per arrest as CCH/OBTS traffic is, or the number of transactions per person-day as is traffic in the OBSCIS and juvenile institutions, SJIS traffic is estimated based on the number of transactions per court disposition including both criminal and civil cases in the courts that handle felonies and non-traffic misdemeanors. The algorithm for computing SJIS traffic is:

SJIS traffic in average messages per day = Number of criminal and civil dispositions per year from courts that handle felonies and non-traffic misdemeanors

x Technology penetration factor

x Transactions per disposition

x Messages per transaction

x Time conversion factor from years to days

The growth in court dispositions was assumed to be linear in Ohio and the annual increase was based on the growth rate for the past several years in the state. This was about 8% of the 1975 dispositions in Ohio. These rates of growth were then extended linearly to 1985.

The technology penetration factor was chosen to reflect the fact that the SJIS system would likely be implemented first in one major metropolitan area and then expanded into a few other large cities. This factor therefore reflects the fraction of total court dispositions in the appellate judicial districts served by the SJIS system.

Since all SJIS case tracking, record keeping, and calendar setting functions are assumed to be confined to the local level, and the state-level traffic will be limited to statistical reporting, the number of transactions per disposition has been taken as 1.0. This does not mean that every case will be reported once, but that the average volume will be at that level.

As with the other traffic types, each SJIS transaction generates a data entry and response, so two messages are generated per transaction. The time conversion factor assumes that there are 250 court days per year.

4.4.4.1.2 Average Message Length. Since SJIS messages are statistical inputs, they are assumed to consist of a large amount of data sent to the state data center followed by a brief acknowledgment. In Ohio, therefore, messages to the state data center are taken as one page in length, followed by only a few lines of acknowledgment.

4.4.4.1.3 Distribution of SJIS Traffic. In Ohio, the volume of court dispositions is broken down by appellate judicial district, so, after the first year of operation when all traffic is assumed to come from the experimental area, SJIS traffic can be prorated according to the number of case dispositions in each of the respective appellate districts.

4.4.4.2 State Data Conversion.

4.4.4.2.1 Average Messages Per Day. Ohio has an office that converts the thousands of existing criminal histories to automatic records, and that enters current offenders into the files, since field users are not yet able to do so. This agency is the Bureau of Criminal Investigation and Identification, in London, near Columbus. Traffic from this agency into the state criminal history files was taken as the current level or a value that state officials estimated would be reached in the near future. The traffic level was kept constant between the present and 1985 because it was assumed that, as a gradual increase in criminal activity takes place, an increasing number of updates to the records will be made directly from user terminals, thereby avoiding the data conversion process at the state criminal records agency. Ohio provided current traffic levels in numbers of transactions per day. This value can be multiplied by the number of messages per transaction to get the average number of messages per day, as was done with all new data types analyzed previously.

4.4.4.2.2 Average Message Length. Average message length from the many terminals in the central state facility was likewise computed just as it was for the other data types. Each message type was weighted by the fraction of the time it was sent, and the resulting sum over all messages going to the state files, from the state files, and in both directions yielded the average lengths in characters for each direction. Most messages from the criminal records center to the state files are data entries, and these were taken as a whole page of the terminal. Acknowledgments were assumed to be a few lines at most. If, before updating an offender's file, an operator desires to inquire whether the offender is a new entry or a recidivist and already in the files, this inquiry was assumed to be a few lines and the response a major fraction of a page. No distribution of this traffic to other state agencies is required since the only source is the group of terminals in the state criminal records agency.

SECTION 5

COMBINATION OF NEW AND EXISTING DATA TYPES

The traffic projections for existing data types in Section 3, and those for new data types in Section 4 were developed under the assumption that there were no information system hardware or software constraints to traffic growth. In both cases it was assumed that computer capacities were sufficient to handle as much traffic as the users could generate. In this section, the traffic demands are added together and constraints are applied, to impose realistic limits to the volume of allowable traffic based on the capacity of the central computers processing the criminal justice messages.

Besides being assumed to be unconstrained, the new and existing data types were each computed assuming complete independence. For instance, an assumption was made that the volume of inquiries into the wanted persons files from a local law enforcement terminal did not affect the traffic into the CCH/OBTS files when these files are made readily available and are in wide-spread use. In this case, the new CCH/OBTS traffic was assumed to be independent from the existing traffic into the wanted persons files. This assumption of independence also extended to other existing data types such as license plates and drivers and to all the new data types from law enforcement, to courts, corrections, and parole agencies.

The assumption of independence between the data types allowed the projected traffic simply to be added together throughout the period of the study. This traffic sum was then the total traffic throughout the state, except in the cases in which the total statewide traffic from new and existing data types approached or exceeded the capacities of the central computers. In this situation, the total traffic level was reduced slightly below the capacity limit as it approached saturation, an assumption was made that the computer capacity was increased significantly, and the traffic growth was then allowed to continue in an unconstrained fashion. After the computer upgrade, new data traffic was even allowed to accelerate beyond its expected growth rate to include the traffic that was not included during the period near saturation.

This process of constraining traffic growth as it reaches the computer capacity is illustrated in Figure 5-1. Unconstrained projected traffic is computed for each 6-month period throughout the study. When the expected unconstrained traffic exceeds the computer capacity, it is reduced to 1 to 2% below the capacity limit. In the next 6-month period it is assumed that the computer installation has been upgraded significantly and presents no constraint to traffic growth. In the period following the upgrade, the growth rate in baseline existing data types displays the slow growth characteristic because of the newness of the system. The new data types and existing data type traffic affected by system improvements are allowed to grow at their expected unconstrained rate, and an additional increment from these new data types and existing traffic affected by system improvements is included in the period following an upgrade. This additional increment equals the difference

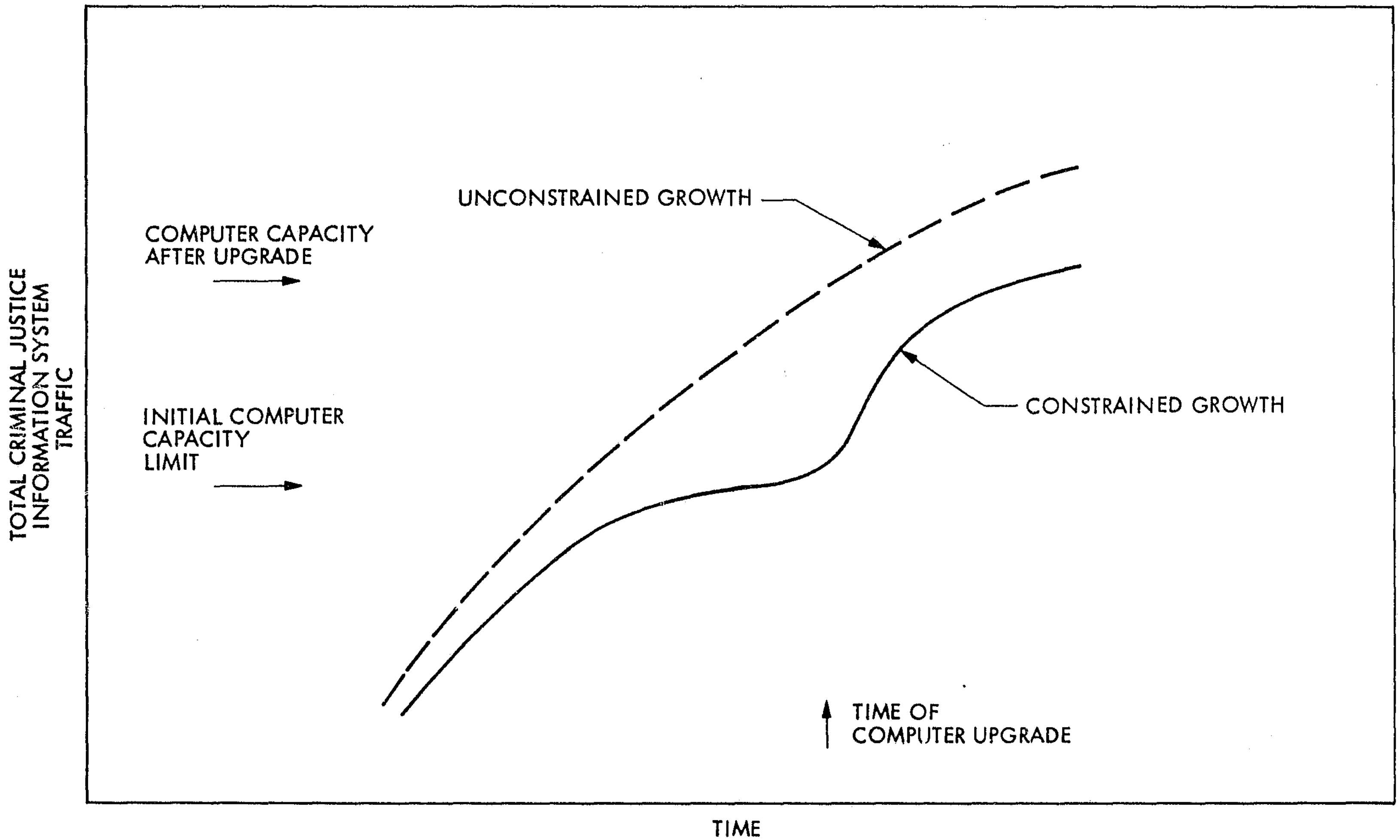


Figure 5-1. Total Statewide Traffic Growth Constrained by Computer Capacity

between the unconstrained traffic in the saturation period and the constrained traffic during that period.

The details of this process of adding new data traffic to existing traffic are shown for all the 6-month periods of the study in Section 6. The aggregate totals are shown in summary form in the tables of Section 1. Table 1-1 shows total criminal justice information system traffic every 2 years between 1977 and 1985. Traffic volumes are given in both average messages per day and in peak characters per minute. Figure 1-3 presents the same traffic growth information as the table in graphical form.

SECTION 6

OHIO TRAFFIC MODELING

This section presents more detailed information on the traffic modeling and distribution techniques developed in Ohio. Planners in Ohio will find this section useful as it discusses details of our analysis that apply uniquely to their state. The general reader may find it interesting to observe the types of problems to be encountered when trying to apply the methodologies discussed in Sections 3 and 4 to a particular state. Methodologies, data, and data analysis discussed in Sections 3 and 4 will not be presented again in this section. Instead we will refer the reader to the appropriate part of Sections 3 or 4.

6.1 EXISTING DATA TYPES

6.1.1 Data Gathering

In Section 3.2 there was a discussion in general terms of the data collection results. This section will present in further detail the data collected from Ohio in response to the state level questionnaire and the user agency questionnaire. Recall that copies of these questionnaires are contained in Appendices A and B. Readers should interpret this data as the basic set of information required to perform the existing data type analysis.

Responses to the Ohio state level questionraire follow:

<u>Question 1</u>

Figures 6-1 and 6-2 present the current configuration of the Law Enforcement Automated Data System (LEADS) in Ohio. LEADS has one central data base and switcher located in Columbus. Figure 6-1 shows all 150 baud circuits while Figure 6-2 shows all 2400 baud circuits.

Recent changes to the communication system were:

Sept. 18, 1971	370/155 computer operational.
March 24, 1972	Wants/Warrants file placed active on line. Full operation.
Sept. 11, 1973	Queries into vehicle registration file automatically forwarded into NCIC.
March 25, 1975	UNIVAC computer operational. All communication lines upgraded to 150 baud or 2400 baud.

Figure 6-1. Configuration of Current Ohio Low-Speed Lines

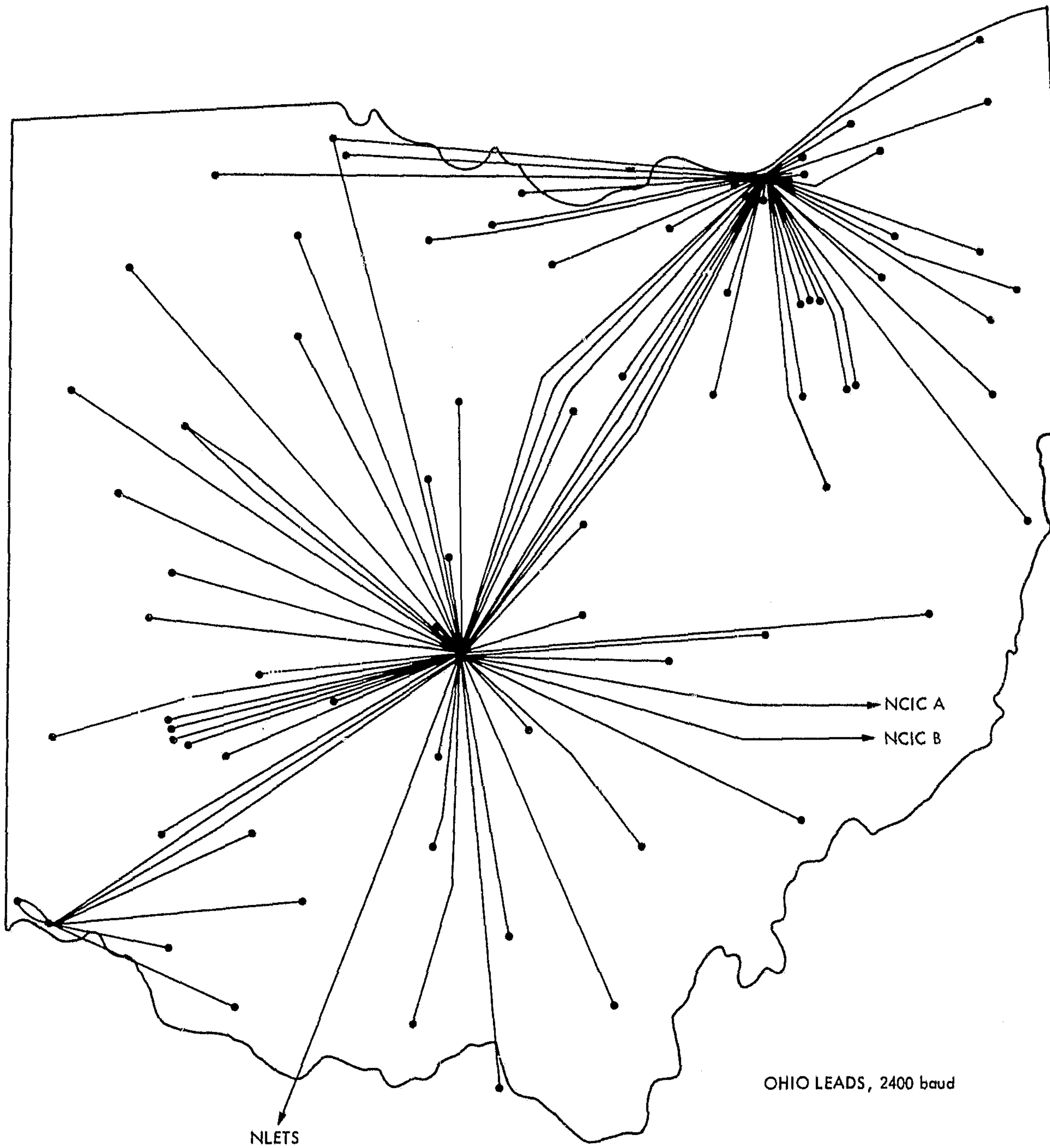


Figure 6-2. Configuration of Current Ohio High-Speed Lines

In addition to these changes, the Ohio State Patrol provided us with a list of all terminals added to the system each month beginning in October 1971 through August 1975 (See Table 6-1). In this time approximately 75 agencies became new LEADS users.

Table 6-1. New Ohio User Agencies Since October 1971

October 1971	Cambridge SO
November 1971	Oberlin PD Amherst PD
December 1971	Youngstown University
April 1972	Lakeland Community College (Off system) Millersburg SO
May 1972	Streetsboro PD
June 1972	Columbus Military (Army) (Off later)
August 1972	Columbus OSP
September 1972	Wadsworth PD Ontario PD Xenia SO
October 1972	New Richmond PD
November 1972	Campbell PD Walton Hills PD
December 1972	Germantown PD
February 1973	North Ridgeville PD Mentor on the Lake PD Tipp City PD Wooster SO Norwalk SO
March 1973	Miami Twp. PD
May 1973	Carrolton SO Waverly SO Perrysburg Twp. PD
June 1973	Austintown PD Paulding SO

Table 6-1. New Ohio User Agencies Since October 1971 (Continuation 1)

July 1973	Remove Lakeland Community College
	Bellevue PD
	Port Clinton PD
August 1973	Richmond (Ind) (Later removed)
	Xenia PD
September 1973	Cleveland Metro Park Rangers
October 1973	Kirtland PD
	Delaware PD
	Cuyahoga Community College
November 1973	Perry Twp. PD (Franklin Co.)
	Aurora PD
	Columbus OSP
December 1973	Sylvania PD
June 1974	Columbus Military (Removed)
	Columbus SO
June 1975	Ashland SO
	Beaver Creek Twp. PD
	Cadiz SO
	Chester Twp. PD
	Circleville PD
	Columbiana PD
	Conneaut PD
	Fremont SO
	Marysville PD
	Ravenna PD
	Sandusky SO
	Sheffield Lake PD
	Saint Marys PD
	Wapokeneta PD
August 1975	Bethel PD
	Boardman PD
	Bratenal Village PD
	Broadview Hgts PD
	Brooklyn PD
	Brookville PD
	Clinton Twp. PD
	Copley PD
	Delphos PD
	Inglewood PD
	Fairlawn Village PD
	Greenville PD

Table 6-1. New Ohio User Agencies Since October 1971 (Continuation 2)

Kenton PD
Madison Twp. PD
Minervia PD
New Carlisle PD
New Philadelphia PD
Ottawa SO
Pepper Pike PD
Perkins Twp. PD
Shelby PD
Sidney PD
Waverly PD
West Union PD
Willard PD
Wright Patterson AFB

Question 2

Data file types in Ohio are:

- Auto Alert File
  - Stolen vehicle
  - Felony vehicle
  - Stolen or missing license plate
- Vehicle Registration File
- Operators License File
- Warrants and Wanted Persons File

In addition, users have access to all NCIC files as well as a link with the NLETS system. These files have all been available since 1971 except for the Warrants and Wanted Persons File which came on line in March 1972.

Question 3

Traffic statistics were provided to us in the form of Figure 6-3. This represents only one page of the 25 pages needed to present statistics for all participating agencies during March 1976. Traffic is given in total messages per month and average messages per day and is broken out by user agency and message type. These statistics were provided for September 1971 through March 1976.

Question 4

Message lengths were provided from two sources. The first was a table supplied by the Ohio State Patrol (Table 6-2).

POLICE TERMINAL STATISTICS HI-TO-LOW
MAR. 1976

TERM-ID	DEPT NAME	AA-IN	VR-IN	OL-IN	WE-IN	ADM-IN	TOT-IN	NCIC-TOT	WW-TOT	ADM-OUT	TOT-OUT	GRAND-TOT
OH0430600	MENTOR PD	2,333 75	2,128 69	1,236 40	14	315 10	8,599 277	258 8	2,315 75	1,839 59	10,134 327	18,733 604
OH0670300	KENT PD	2,862 92	2,518 81	820 26	8	347 11	8,985 290	337 11	2,093 68	362 12	9,005 290	17,990 580
OH0250001	COLUMBUS SO	2,304 74	1,927 62	753 24	62 2	188 6	7,859 254	290 9	2,335 75	1,771 57	9,446 305	17,305 558
OH0181500	CLEVELAND HGTS PD	2,318 75	1,968 63	1,724 56	10	153 5	8,575 277	190 6	2,212 71	161 5	8,599 277	17,174 554
OHBMV0300	BMV INDEX		934 30	5,129 165	109 4	1,456 47	7,628 246			3,165 102	9,192 297	16,820 543
OHCLP9500	CLEVELAND PD RECORDS	2,831 91	889 29	452 15	14	877 28	6,905 223	594 19	1,248 40	2,598 84	8,299 268	15,204 490
OH0184800	SHAKER HGTS PD	1,907 62	1,541 50	875 28	23 1	204 7	6,615 213	266 9	1,799 58	1,862 60	8,215 265	14,830 478
OH0650000	CIRCLEVILLE SO	1,967 63	1,410 45	455 15	45 1	382 12	6,679 215	319 10	2,101 68	1,594 51	7,907 255	14,586 471
OH0760000	CANTON SO	1,793 58	1,509 49	520 17	36 1	411 13	6,409 207	325 10	1,815 59	2,058 66	8,013 258	14,422 465
OH0570500	KETTERING PD	1,767 57	1,486 48	572 18	25 1	184 6	6,255 202	288 9	1,933 62	1,291 42	7,378 238	13,633 440
OH0250900	UPPER ARLINGTON PD	1,576 51	1,453 47	1,118 36	87 3	42 1	6,200 200	261 8	1,663 54	1,296 42	7,424 239	13,624 439
OH0182900	MAYFIELD HGTS PD	1,627 52	1,498 48	987 32	24 1	62 2	5,944 192	235 8	1,511 49	1,567 51	7,458 241	13,402 432
OH0090200	HAMILTON PD	1,873 60	1,582 51	453 15	32 1	125 4	6,124 198	238 8	1,821 59	1,196 39	7,207 232	13,331 430
OH0181800	EUCLID PD	1,599 52	1,509 49	681 22	30 1	287 9	5,882 190	215 7	1,541 50	1,801 58	7,434 240	13,316 430
OHBMV0900	BMV SAFETY RESPONSIBILITY		3,671 118	2,700 87	19 1	76 2	6,466 209			88 3	6,576 212	13,041 421
OH0760400	CANTON PD	1,609 52	1,420 46	1,027 33	25 1	256 8	5,477 183	224 7	1,116 36	1,860 60	7,255 234	12,932 417
OH0670000	RAVENNA SO	1,434 46	1,268 41	532 17	61 2	768 25	5,661 183	197 6	1,401 45	2,270 73	7,154 231	12,815 413

Figure 6-3. Ohio Police Terminal Statistics High to Low

Table 6-2. Message Length by Message Type and Function

					NCIC	
Message Function/ Message Type	Auto Alert	Wants/ Warrants	Vehicle Registration	Operator License	Vehicle	Wants/ Warrants
Enter	52 - 112	100 - 406	X	X	52 - 112	100 - 406
Modify	32 - 61	32 - 237	X	X	32 - 61	32 - 237
Cancel	32 - 47	22 - 52	X	X	32 - 47	22 - 52
Locate	41 - 56	42 - 194	X	X	41 - 56	42 - 194
Clear	32 - 61	22 - 52	X	X	32 - 61	22 - 52
Query	18 - 32	23 - 48	7 - 36	10 - 40	18 - 32	23 - 48
"Hit" Response	58 - 125	250 -	250 - 250	211 - *	165 - 165	145 - 8500
"No Hit"	38 - 45	115 - 140	35 - 40	35 - 58	49 - 50	51 - 76

*Depends on individual's driving record.

This table presents minimum and maximum message lengths in units of characters per message. The second source was the LEADS user manual which presented formats for each message type. By examining these formats we were able to construct Table 6-3.

Information in the two tables was compared by calculating overall message length for each message type in Table 6-3. This required knowledge of the distribution by message function for each message type. When the minimum and maximum traffic was averaged, there was good agreement between the two sources.

Administrative messages were an average of 250 characters per message. Overall message length was 116 characters per message.

Question 5

Detailed terminal to terminal traffic statistics were not available.

Question 6

The LEADS computer does extensive automatic generation of data base transactions. Automatic generation is defined as the process of a communication message originally directed to one data base file being automatically sent to another data base file. Figure 6-4 shows direct transactions in Ohio and the transactions they automatically generate. For example, if a system user queried the auto alert file, he would automatically trigger inquiries into the LEADS wants/warrants file and the NCIC stolen vehicle and wanted person files.

Table 6-3. Message Length by Message Type

Message Type	In	Out
Auto Alert	11	80
Wants/Warrants	56	55
Vehicle Registration	11	175
Operators License	17	285
NCIC	50	90

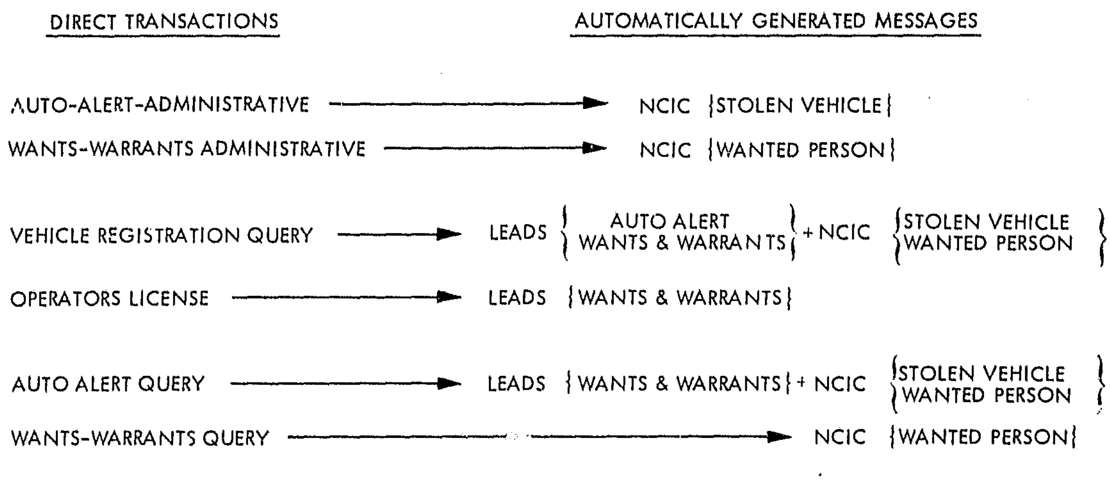


Figure 6-4. Automatic Generation of Messages

Question 7

The primary planned upgrade that would affect traffic against current LEADS files is the replacement of all low speed circuits with high-speed circuits. This is expected to occur by the end of 1977. State planners do not expect to add new agencies to the LEADS system.

USER SURVEY

In Ohio 80 agencies responded to the user agency questionnaires. Results from responding agencies are presented here.

Traffic Statistics

Traffic statistics obtained from user agencies agreed well with the traffic statistics provided by the state. One statistic of interest obtained from the user survey is a measure of the hourly peak to average traffic ratio at each terminal. The highest peak to average traffic ratio was reported by the Wapakoneta Police Department at 3.33. The average overall reporting terminals was 1.67.

Response Time

We asked the user agencies to give us inputs on acceptable response times. Figure 6-5 is a frequency diagram showing the number of responses falling within acceptable response time ranges. For example, four agencies indicated an acceptable average response time of 10 sec or less. The most frequently chosen time was 30 sec and 85% of the

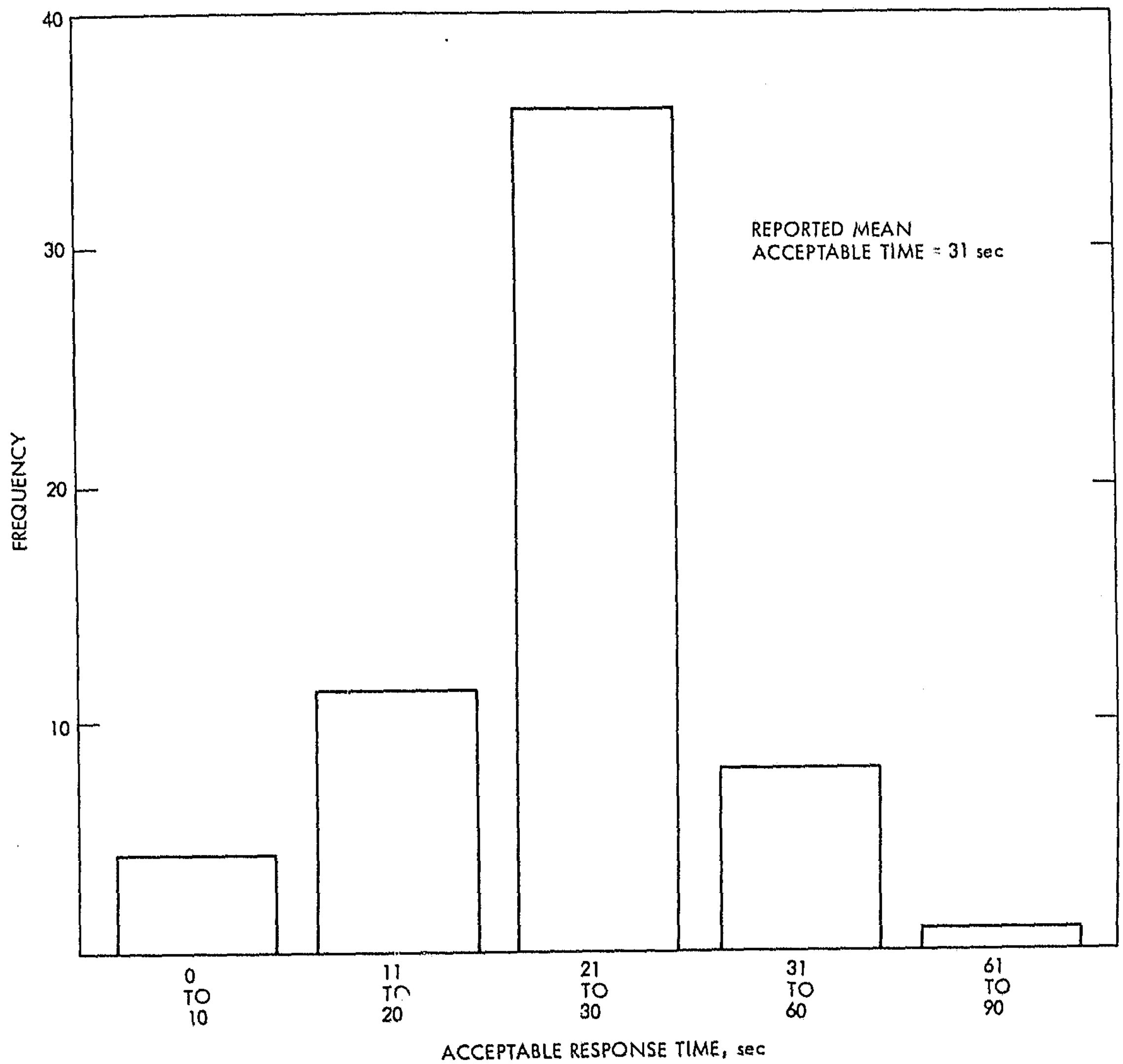


Figure 6-5. Acceptable Response Time

responding agencies specified an acceptable average response time of 30 sec or less. It is of interest to note that agencies in general reported acceptable response times that were only slightly shorter than their existing response times.

User Agency Characteristics

Because not all user agencies returned the user survey, other sources were identified to obtain population, personnel, and crime rate statistics. The primary source of data was a listing of uniform crime reports by county (Figure 6-6). Each county is broken out by incorporated or unincorporated areas and statistics are presented on population and the FBI's seven index crimes. An example shown in Figure 6-6 is Greene County where there are five cities: Fairborn, Xenia, Yellow Springs, Bellbrook and Beavercreek Township. The population and number of index crimes occurring in each of these cities is presented as well as the totals for the incorporated areas. The next line shows population and incidence of crime for the unincorporated area of the county. These numbers describe the population served by the Sheriff's Department in each county. Finally the total county population and incidence of crime statistics are presented. These statistics were available for all counties in Ohio and were used to determine population and crime rates for LEADS user agencies.

Additional personnel data were obtained from the Uniform Crime Reports issued annually by the FBI entitled Crime in the United States. Under the Police Employee Data section, tables are included showing the number of full-time police department employees in cities 25,000 and over in population and in cities 25,000 and under in population. In addition to Uniform Crime Report, the number of personnel stationed at each Ohio State Patrol post was obtained from planning divisions of the Ohio State Patrol. Jurisdiction served by each patrol post was also provided and shown by arrows in Figure 6-7.

6.1.2 Analysis Methodology Applied to Traffic Statistics

Section 3.3.2 referred to the problem of determining whether traffic statistics describe communication messages or transactions. (See definitions in Section 3.3.1.) Historical traffic statistics were not consistent in this regard. Between September 1971 and February 1975, while an IBM computer was in service, the traffic statistics were consistent and counted communication messages. However, after upgrading to a UNIVAC computer in March 1975, the new UNIVAC statistical package counted some message types as communication messages and others as transactions. Due to the extensive automatic generation of messages in Ohio, there is a considerable difference between the number of communication messages into a data file and the number of transactions into the same file.

The UNIVAC statistics package was intended to count transactions into each data file. However, by examining the statistics, inconsistencies become evident. As an example, during one month the total system traffic statistics given in units of average messages per day are shown in Table 6-4.

	LTY SMA ORI		PCP	INDEX	MURD	MANS	RAPE	ROBB	ASSLT	BURG	LARC	AUTCS
	027 OH02701 6 GALLIPOLIS		7,041	179				2	1	44	121	11
NORPT	027 OHC2700 8 GALLIA		20,261	340			1	2	13	123	186	15
		COUNTY TOTAL	27,302	519			1	4	14	167	307	26
		RATE PER	100,000	1,901.0			3.7	14.7	51.3	611.7	1,124.5	95.2
	028 170 OH02801 6 CHARDON		4,406	148	1				4	56	80	7
	028 170 OH02806 6 SOUTH RUSSELL		3,062	30					8	6	14	2
EST	028 170 OHC2807 5 CHESTER TOWNSHIP		10,546	143					12	40	88	3
EST	028 170 OHC2808 6 RUSSELL TOWNSHIP		4,781	47			1		1	12	31	2
		TOTAL	22,795	368	1		1		25	114	213	14
	028 170 OHC2800 9 GEAUGA		39,703	812			3	7	54	269	423	56
		COUNTY TOTAL	62,498	1,180	1		4	7	79	383	636	70
		RATE PER	100,000	1,888.1	1.6		6.4	11.2	126.4	612.8	1,017.6	112.0
	029 207 OHC2901 4 FAIRBORN		36,125	1,474		1	4	27	11	201	1,160	71
	029 207 OHC2903 4 XENIA		26,900	989			2	28	17	194	687	61
	029 207 OH02904 6 YELLOW SPRINGS		4,610	191			5	3	5	68	103	7
	029 207 OHC2905 6 BELLBROOK		6,422	225		2		2	1	84	133	5
	029 207 OHC2911 4 BEAVERCREEK TOWNSHIP		28,100	589			1	21	3	166	359	39
		TOTAL	102,157	3,468		3	12	81	37	713	2,442	183
	029 207 OHC2900 9 GREENE		24,352	751	2		4	17	34	268	395	31
		COUNTY TOTAL	126,509	4,219	2	3	16	98	71	981	2,837	214
		RATE PER	100,000	3,335.0	1.6	2.4	12.6	77.5	56.1	775.4	2,242.5	169.2
	030 OH03001 5 CAMBRIDGE		13,315	478		1	3	11	3	68	386	7
NORPT	030 OHC3000 8 GUERNSEY		24,782	415	1		2	2	15	150	227	18
		COUNTY TOTAL	38,097	893	1	1	5	13	18	218	613	25
		RATE PER	100,000	2,344.0	2.6	2.6	13.1	34.1	47.2	572.2	1,609.1	65.6
	031 165 OHCIP00 1 CINCINNATI		435,151	30,800	67	22	258	1,653	1,203	10,511	14,253	2,855
	031 165 OH03102 6 AMBERLEY		4,712	69					1	22	45	1

Figure 6-6. Ohio Uniform Crime Reports

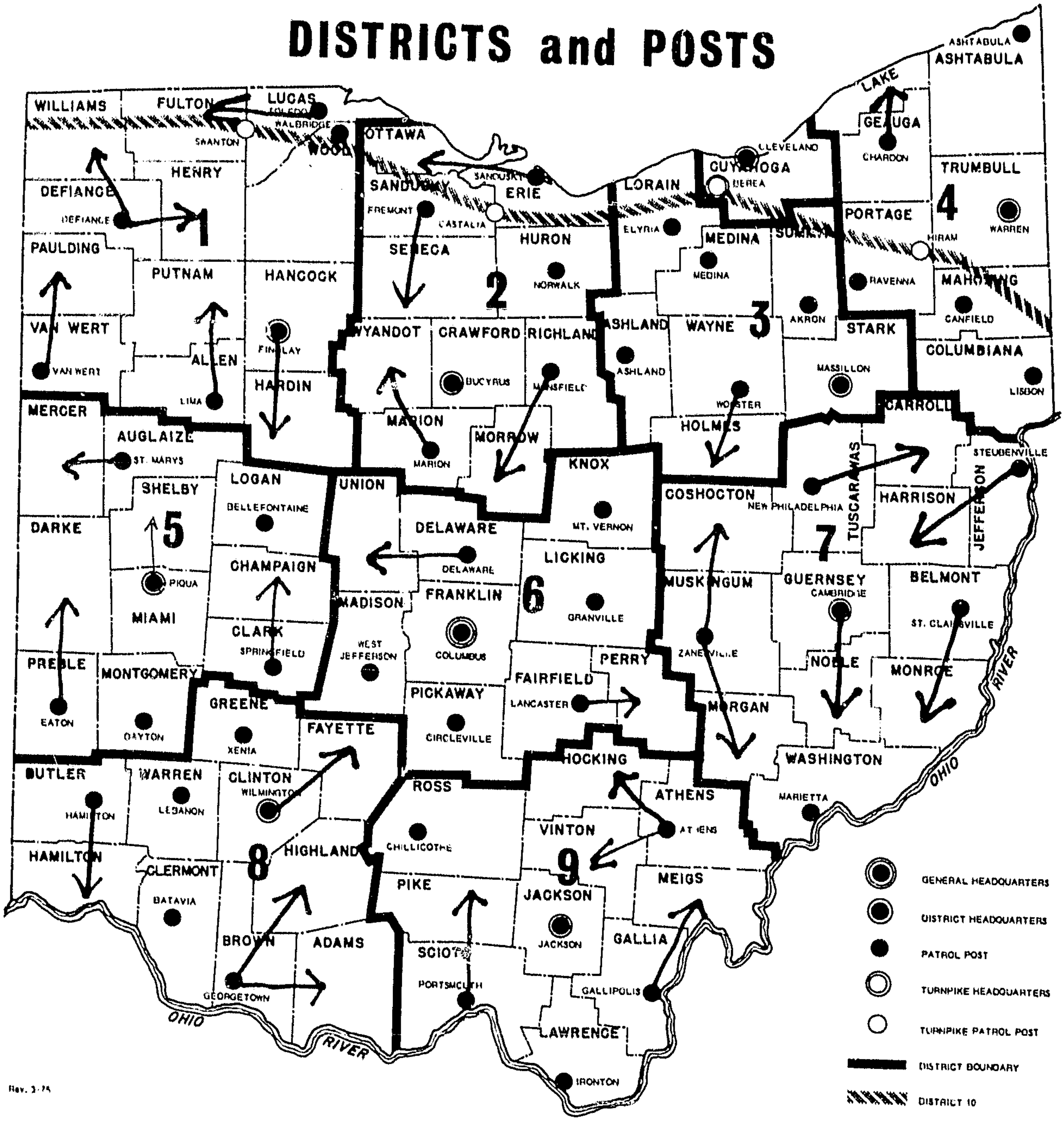


Figure 6-7. Ohio State Patrol Jurisdiction

The UNIVAC statistics present the values under the column direct + automatic. This is equivalent to transactions as it includes data base transactions coming in directly over communication lines and those data base transactions that are automatically generated by the Columbus computer. For each data file we know that total data base transactions should equal the sum of direct data base transactions and automatically generated transactions.

Given a knowledge of automatic generation procedures (Figure 6-4) we can determine the number of direct transactions and the number of automatic transactions. The following files receive automatically generated messages:

(1) NCIC Stolen Vehicle and Wanted Person

(2) LEADS Auto Alert

(3) LEADS Wants and Warrants

Thus we know immediately that all transactions into the Vehicle Registration and Operators License files are direct. Only queries into the Vehicle Registration file automatically generate messages into the Auto

Table 6-4. Average Daily Traffic - April 1976

	Direct + Automatic	Direct Only	Automatic Only
Auto Alert	17,300	6,300	11,000
Vehicle Registration	11,600	11,600	0
Operators License	7,500	7,500	0
Administrative-In	3,100	3,100	0
NCIC-Total	13,700		17,300
Wants/Warrants Total	15,400		22,000
Administrative-Out	12,700	12,700	0

Alert file. So we can easily calculate the number of automatic transactions into the auto alert file as being:

Auto Alert (Automatic) = 0.97 X Vehicle Registration (Total)

and:

Auto Alert (Direct) = Auto Alert (Total) - Auto Alert (Automatic)

The factor 0.97 is used because 97% of Vehicle Registration transactions automatically generate Auto Alert transactions. Also 73% of Operators License transactions generate transactions into the Wants/ Warrants file. Messages are automatically generated into the Wants/ Warrants file from direct Auto Alert transactions, Operators License transactions and Vehicle Registration queries. We can calculate Wants/Warrants automatic message volume as:

Wants/Warrants (Automatic) = Auto Alert (Direct)
+ 0.73 X Operators License (Total)
+ 0.97 X Vehicle Registration (Total)

and:

Wants/Warrants (Direct) = Wants/Warrants (Total) -
Wants/Warrants (Automatic)

Finally transactions into Auto Alert files, Vehicle Registration files and Wants/Warrants files generate automatic transactions into NCIC files. Only about 10% of State Wants/Warrants transactions are passed on to NCIC. Thus,

NCIC (Automatic) = Auto Alert (Direct) + 0.97 X Vehicle Registration (Total) + 0.10 X Wants/ Warrant (Direct)

and:

NCIC (Direct) = NCIC (Total) - NCIC (Automatic)

We now have the capability of calculating the number of direct and automatic transactions into each data file. When we attempt this, we find that the number of automatically generated transactions into the LEADS Wants/Warrants file and the NCIC files exceeds the total number of transactions for each of these data files (see Table 6-4). Assuming we have correctly identified automatic generation procedures, there is clearly an error in the traffic statistics.

Conversations with the Ohio State Patrol verified problems with the UNIVAC statistics package. In the opinion of the OSP, the problem with the statistics stemmed from the fact that not all automatically generated messages were being counted. They were fairly confident that the Auto Alert message count was correct but felt that Want/Warrants and NCIC transactions were being under-counted. Our approach was to begin by calculating the number of automatically generated transactions into each data file. If this number exceeded the number reported by the statistics as being the sum of direct and automatic transactions, we estimated the number of direct transactions. Estimates were made by examining the pre-March 1975 statistics when only direct transactions were reported. Total transactions into each file were then taken to be the sum of direct plus automatic transactions. Using this approach Table 6-5 is a revised version of Table 6-4.

Note the difference is the increase in Wants/Warrants and NCIC transactions.

6.1.3 Peak/Average Traffic Ratio

In determining required communication capacity to satisfy performance requirements, we would like to use a measure of demand that reflects the load on the system during the busiest hours. All previous traffic statistics have given message volumes averaged over a day. To derive the desired traffic measurement we establish the ratio of traffic volume during the busiest hour and average traffic volume and designate it the peak to average ratio. Average traffic volumes are then multiplied by this ratio to give peak traffic volumes.

Table 6-5. Average Daily Traffic - April 1976 Revised

	Direct + Automatic	Direct Only	Automatic Only
Auto Alert	17,300	6,300	11,000
Vehicle Registration	11,600	11,600	0
Operators License	7,500	7,500	0
Administrative-In	3,100	3,100	0
NCIC	16,700	100	16,600
Wants/Warrants	23,800	1,700	22,100
Administrative-Out	12,700	12,700	0

The peak to average ratio was established in Ohio by examining a complete month of transaction statistics. The number of transactions was given for each hour of each of the 31 days during May 1975. The ratio of computer transactions during the busiest hour and average transactions was found to be 1.82. To insure that we would not underestimate traffic, a peak to average ratio value of 2 was used in Ohio.

6.1.4 Traffic Growth Modeling

6.1.4.1 Past Traffic Growth. After correcting inconsistencies in the Ohio traffic statistics, we were able to construct the curve of past growth in communication messages as shown in Figure 6-8.

The curve shows a pattern of steady growth; however, there is generally a decline in traffic during the spring. These declines were caused by the obsolescence in April of the vehicle registration file. This occurred each year because all vehicles were issued new license plates once a year in April. A period of several months was required to enter updated license plate information in the vehicle registration file. Since law enforcement personnel were aware of this yearly renewal procedure and the update delay problem, they drastically reduced vehicle registration inquiries each spring. The problem will not be as severe in the future because Ohio plans to renew license plates only once every 3 years.

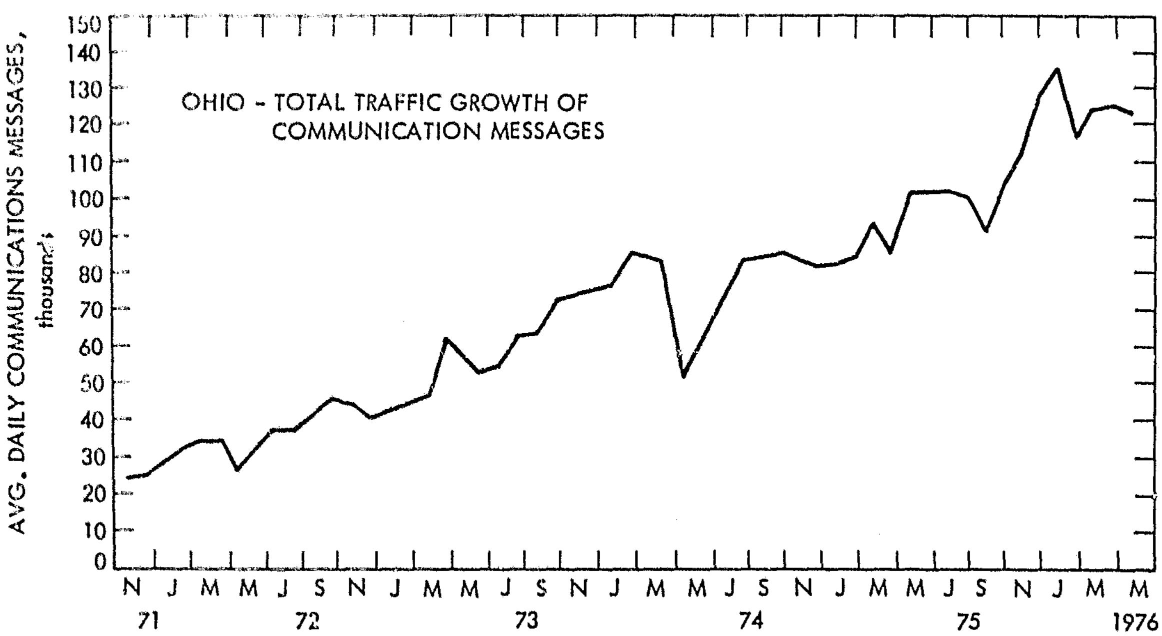


Figure 6-8. Ohio Past Communications Traffic Growth

Between November 1971 and March 1974 yearly growth in traffic volume occurs at a rate of 23,000 msg/day. Growth then almost stops between March 1974 and March 1975 with an increase in traffic of only 5,000 messages per day. Traffic between March 1975 and March 1976 increases by 38,000 messages per day. From this growth pattern, it becomes clear that there was a growth inhibiting factor between March 1974 and March 1975. We presume this factor to be limitation of computer capacity. In March 1975, when the computer was upgraded from an IBM to a UNIVAC, traffic once again began to increase rapidly.

6.1.4.2 System Improvements. A portion of past traffic growth can be related directly to system improvements. Past improvements were:

(1) Addition of new system users

(2) Addition of new data files

(3) Substitution of low-speed communication lines with high-speed lines and new terminal equipment

(4) Easier access to information contained in national files

(5) Implementation of mobile digital terminals

In Ohio 75 law enforcement and 14 Bureau of Motor Vehicle terminals were added to the LEADS system between October 1971 and the present. The total increase in traffic caused by adding these terminals is 14,600 messages per day with 4,000 messages per day coming from the new law enforcement terminals. The fact that only 4,000 new messages per day come from the 75 law enforcement agencies suggests that all major law enforcement agencies were subscribers to the LEADS system before October 1972. The added agencies are generally smaller and send and receive a relatively small number of messages.

The addition of the Wants/Warrants data file and the automatic pass-through of vehicle registration messages to NCIC also caused increases in past traffic which are discussed in Section 3.4.3.1.

In March 1975, LEADS upgraded circuits serving the Ohio State Patrol terminals to 2400 bps lines. To measure the impact of this line upgrade we compared the growth in traffic from Ohio State Patrol terminals with the growth from all other terminals. Figure 6-9 shows graphically this comparison. Note that after the upgrade, which occurred in the last month of Winter 1975, OSP traffic increases while traffic from all other terminals decreases. The magnitude of the traffic increase due to high-speed lines was 7,000 messages per day.

The last communication system improvement which caused a sudden increase in traffic was the implementation in Cleveland of mobile digital terminals. Between March 1975 and April 1976, 100 of Cleveland's police cars were equipped with mobile digital terminals. This represents

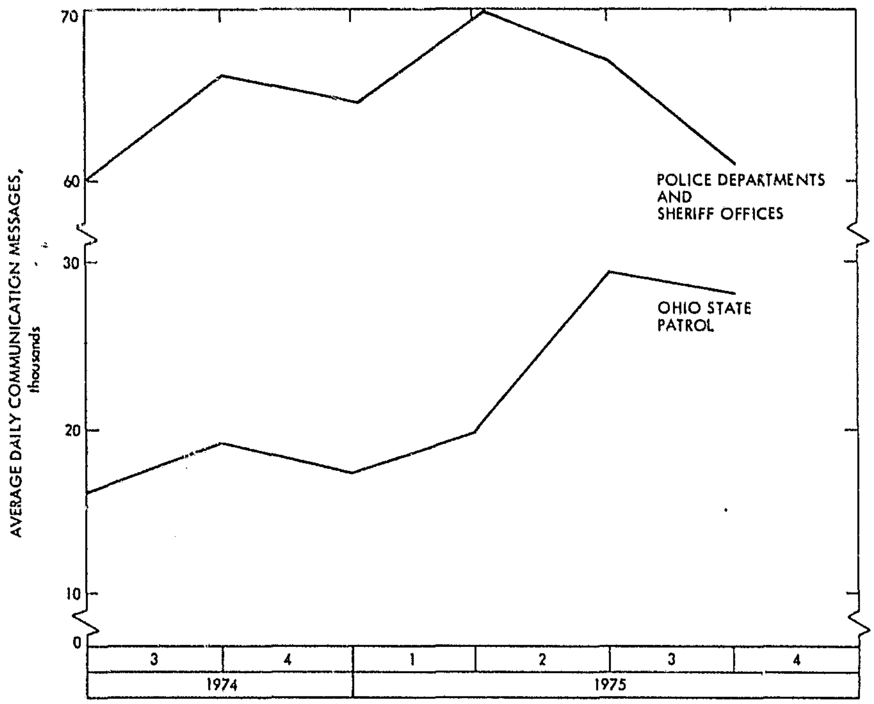


Figure 6-9. Comparison of Ohio State Police and Other Law Enforcement User Traffic Growth

approximately one-half of their patrol fleet. During this period, traffic increased between the Cleveland Police Department computer and LEADS from 6,000 messages per day to 11,500 messages per day. Over the same period, total LEADS traffic increased from 110,000 messages per day to 145,000 messages per day. Thus, while the average users traffic volume increased by 32%, Cleveland's traffic was increasing by 92%. If Cleveland's traffic would have increased at the average rate, traffic volume would be 7,920 messages per day. The difference between 11,500 and 7,920 is assumed to be the impact on traffic from Cleveland of implementing mobile digital terminals (Figure 6-10).

To obtain baseline growth we subtract out all past traffic increases caused by system improvements. Figure 6-11 shows graphically this subtraction process. The top line represents total LEADS traffic averaged over three-month periods. The next line down is LEADS traffic with increases due to the addition of new terminals subtracted out. Successive lower lines represent the subtracting out of traffic caused by new data files, automatic NCIC pass-through, high-speed lines, and mobile digital terminals. Finally the bottom line represents baseline growth and it is this growth curve which we will use to project future traffic growth.

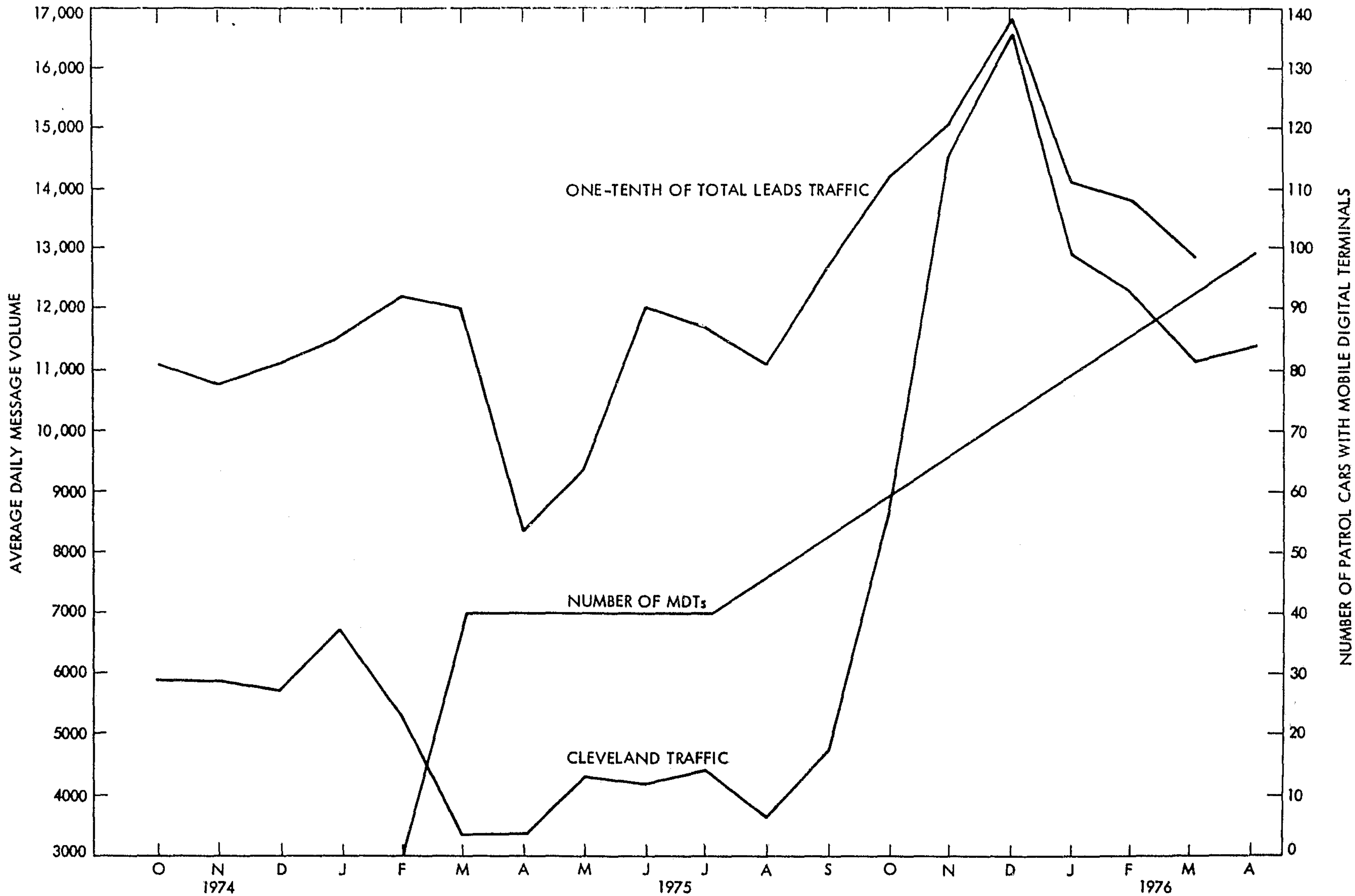


Figure 6-10. Cleveland Mobile Digital Terminal Implementation and Traffic Growth

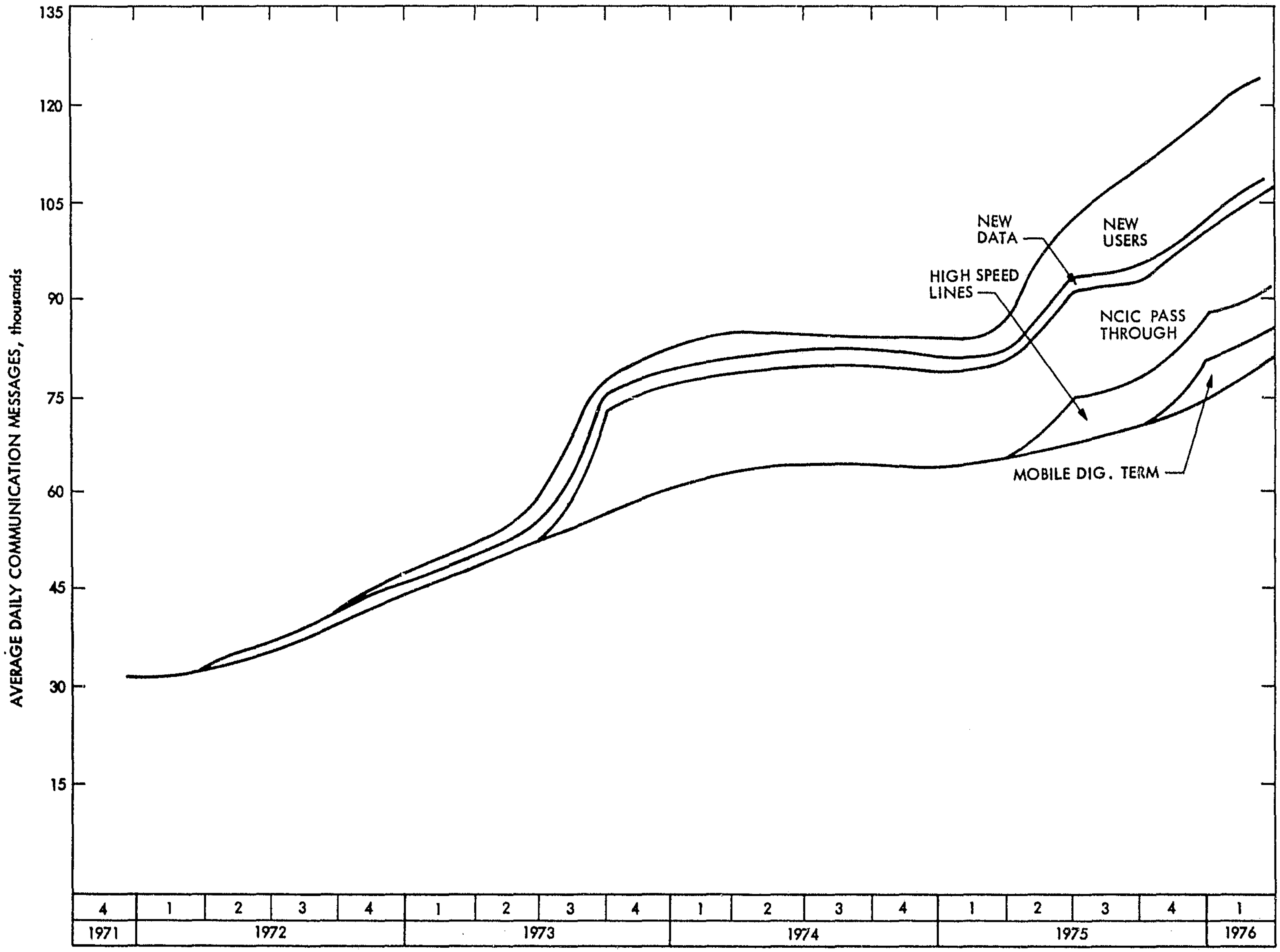


Figure 6-11. Total Growth and Baseline Growth

6.1.4.3 Traffic Projections. The baseline growth curve developed in the previous section is used to project future baseline traffic growth. We have shown that, in the past, baseline growth displayed an S-shaped curve with growth being slow before and after system upgrades and linear between these periods. In order to predict future traffic growth we must thus make assumptions regarding actions to be taken by Ohio decision makers in upgrading communication capacity. Conversations with Ohio planners led us to the assumption that it is not likely that the states will increase capacity before saturation effects begin to occur. However, once these effects become evident, funding necessary for increasing capacity will be obtained rapidly.

Figure 6-12 shows the Ohio baseline growth data points. Periods of slow growth after upgrade, unconstrained growth, and slow growth resulting from system saturations are identified.

During the slow growth period of October 1971 through June 1972, traffic increased from 30,800 messages per day to 32,500 messages per day. The "best fit" regression line shown in the figure has a slope of 850 messages/3-month period which is interpreted as an increase of 850 messages/day each 3-month period. When projecting traffic growth after an upgrade, we will assume an increase of 1,700 messages per day during the 6-month period after the upgrade.

The "best fit" regression line during the unconstrained growth period has a slope of 4,100 messages/3-month period. Thus during periods of unconstrained growth we will project average daily traffic increases of 8,200 messages each 6-month period.

During periods when traffic levels are near capacity, traffic growth almost stops. The length of this period is dependent on the time required for state planners to obtain additional capacity. Past baseline growth suggests that system capacity was reached in January 1974 and we know a system upgrade occurred in March 1975. Thus, 15 months passed before capacity was increased. In the future Ohio state planners advised us to assume that this period will be reduced to 6 months. Future periods of slow growth due to system saturation will therefore be assumed to be short.

Using the expressions developed in analyzing baseline traffic between October 1971 and March 1974, we can project traffic between January 1975 and March 1976. The lines drawn during these periods in Figure 6-12 represent the projections. Notice that we project a traffic level of 81,000 messages per day during January March 1976 while the actual value was 79,300 msg/day.

In addition to increases in traffic volume caused by baseline growth, there will be increases caused by communication system improvements. In Ohio two areas of improvement were identified: conversion from low-speed to high-speed lines and implementation of mobile digital terminals.

LEADS communication circuits serving Ohio State Patrol agencies were upgraded from low- to high-speed circuits in the winter of 1975. Total OSP traffic jumped from 19,000 to 28,000 messages per day, an

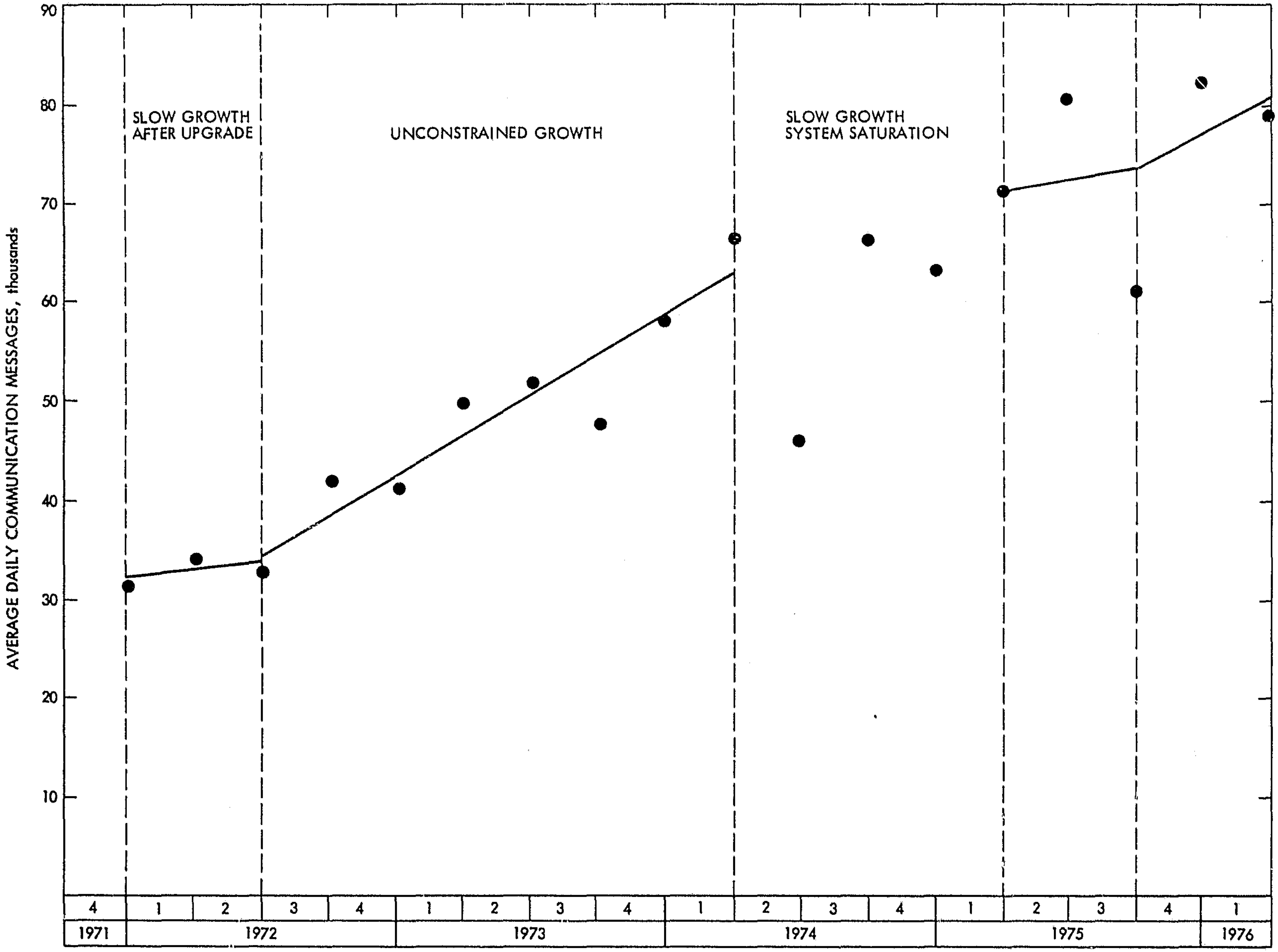


Figure 6-12. Baseline Growth

Table 6-6. Guide to Ohio Criminal Justice Information System New Data Type Traffic Projections with References to Methodology

Table Number	Topic	Description of Methodology
6-7	Computation of Ohio CCH/OBTS Average Messages per Day	4.4.2.1.1
6-8	Computation of Ohio Law Enforcement CCH/OBTS Average Message Length in Characters	4.4.2.1.2
6-9	Computation of Ohio Court and Corrections CCH/ OBTS Average Message Length in Characters	4.4.2.1.3
6-10	Ohio Statewide CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.3
6-11	Distribution of Ohio Court CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.4
6-12	Distribution of Ohio Corrections CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.4
6-13	Computation of Ohio Automated Fingerprint Messages per Day	4.4.2.2.1 and 4.4.2.1.1
6-14	Distribution of Ohio Automated Fingerprint Traffic in Peak Characters per Minute	4.4.2.2.3
6-15	Computation of Ohio OBSCIS Average Messages per Day	4.4.3.1.1
6-16	Distribution of Ohio OBSCIS Traffic in Peak Characters per Minute	4.4.3.1.3
6-17	Distribution of Combined Ohio Corrections CCH/OBTS and OBSCIS Traffic in Peak Characters per Minute	
6-18	Computation of Ohio SJIS Average Messages per Day	4.4.4.1.1
6-19	Distribution of Ohio SJIS Traffic in Peak Characters per Minute	4.4.4.1.2, and 4.4.4.1.3

Table 6-6. Guide to Ohio Criminal Justice Information System New Data Type Traffic Projections with References to Methodology (Continuation 1)

Table Number	Topic	Description of Methodology
6-20	Distribution of Combined Ohio Court CCH/OBTS and SJIS Traffic in Peak Characters per Minute	
6-21	Ohio BCII Data Conversion Traffic for 1977 to 1985 (average messages per day, average message length, and peak characters per minute)	4.4.4.2
6-22	Total Ohio New Data Traffic Projection in Average Messages per Day	
6-23	Summary of New Data Type Average Message Lengths by Data Type and by Year	

CCH/OBTS and combined court CCH/OBTS and SJIS traffic; automated fingerprint traffic. No traffic distribution is shown for law enforcement CCH/OBTS traffic because of the large number of terminals involved. This traffic was combined with existing data type traffic to these terminals and is displayed in Table 6-27 for a representative year.

6.3 EXISTING AND NEW DATA TYPES COMBINED

This section combines the projections for the growth of existing criminal justice information data types from Section 6.1 with the estimates for future new data type traffic from Section 6.2 to obtain a total criminal justice information system traffic projection for Ohio. The methodologies used to project future growth in existing traffic types are explained in Section 3, and the techniques used to estimate the start and growth of traffic in new data types are described in Section 4.

6.3.1 Traffic Projections

The three growth components are baseline growth, growth due to system improvements and traffic into new data bases. Table 6-24 presents potential new traffic to be caused by system improvements and new data type traffic. The values in the table are the increases in traffic above the previous six-month period.

approximate 50% increase (Figure 6-9). We therefore project a 50% increase for all user agencies when communication lines are upgraded.

Mobile digital terminals are expected to be implemented in Ohio's three largest cities, Cleveland, Columbus and Cincinnati, by 1985. In Section 8.1.4.2 we discussed the impact on traffic in Cleveland when mobile digital terminals were implemented. The traffic increase due to MDTs was estimated to be 3,600 messages per day. Since only one-half of Cleveland's patrol cars were equipped with MDTs we project that traffic would have increased by 7,200 messages per day if the entire fleet had been converted. Since pre-MDT traffic levels from Cleveland were 6,000 messages per day a 120% increase in Cleveland's traffic resulted from implementation of MDTs. We assumed that traffic from Columbus and Cincinnati will also increase by 120% when their police departments implement mobile digital terminals.

In this section we have presented the baseline rate of traffic increase and increases due to system improvements. After discussing growth in traffic due to new data types in Section 6.2, we will combine the increases in this section with the new data type projections to give total future Ohio traffic growth in Section 6.3.

6.2 NEW DATA TYPES

When the techniques of Section 4.4 are applied to Ohio's crime statistics, the traffic projections given in tables below are obtained. These tables break out the traffic estimates by component so that, for example, traffic from the courts into the CCH/OBTS system can be distinguished from court traffic into the SJIS system. The results are combined in Table 6-22 which shows total Ohio new data traffic in average messages per day. This same information is shown in graphical form in Figure 1-2.

Table 6-6 is a guide to the tables describing the Ohio new data type traffic projections. In addition to summarizing the contents of each table, it lists the sections in this report which explain the derivation of the traffic volumes. Tables 6-7 through 6-23 are then provided to give the new data type traffic for each of the traffic components.

These tables of Ohio new data traffic estimates also display the processes, described in Section 4.4, used to obtain the estimates. Tables 6-7 through 6-10 show the methodology for computing CCH/OBTS traffic volume, starting with the parameters that are used in computing the average CCH/OBTS messages per day, then estimating the average CCH/OBTS message length, and finally converting the average messages per day to peak characters per minute.

Several of the tables show how one of the traffic components is distributed throughout the state. Tables 6-14 and 6-16 show how fingerprint and OBSCIS traffic volumes are allocated to the user agencies. Distributions are likewise shown for: corrections CCH/OBTS and OBSCIS and combined corrections CCH/OBTS and OBSCIS traffic; SJIS traffic, court

Table 6-6. Guide to Ohio Criminal Justice Information System New Data Type Traffic Projections with References to Methodology

Table Number	Topic	Description of Methodology
6-7	Computation of Ohio CCH/OBTS Average Messages per Day	4.4.2.1.1
6-8	Computation of Ohio Law Enforcement CCH/OBTS Average Message Length in Characters	4.4.2.1.2
6-9	Computation of Ohio Court and Corrections CCH/OBTS Average Message Length in Characters	4.4.2.1.3
6-10	Ohio Statewide CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.3
6-11	Distribution of Ohio Court CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.4
6-12	Distribution of Ohio Corrections CCH/OBTS Traffic in Peak Characters per Minute	4.4.2.1.4
6-13	Computation of Ohio Automated Fingerprint Messages per Day	4.4.2.2.1 and 4.4.2.1.1
6-14	Distribution of Ohio Automated Fingerprint Traffic in Peak Characters per Minute	4.4.2.2.3
6-15	Computation of Ohio OBSCIS Average Messages per Day	4.4.3.1.1
6-16	Distribution of Ohio OBSCIS Traffic in Peak Characters per Minute	4.4.3.1.3
6-17	Distribution of Combined Ohio Corrections CCH/OBTS and OBSCIS Traffic in Peak Characters per Minute	
6-18	Computation of Ohio SJIS Average Messages per Day	4.4.4.1.1
6-19	Distribution of Ohio SJIS Traffic in Peak Characters per Minute	4.4.4.1.2, and 4.4.4.1.3

Table 6-6. Guide to Ohio Criminal Justice Information System New Data Type Traffic Projections with References to Methodology (Continuation 1)

Table Number	Topic	Description of Methodology
6-20	Distribution of Combined Ohio Court CCH/OBTS and SJIS Traffic in Peak Characters per Minute	
6-21	Ohio BCII Data Conversion Traffic for 1977 to 1985 (average messages per day, average message length, and peak characters per minute)	4.4.4.2
6-22	Total Ohio New Data Traffic Projection in Average Messages per Day	
6-23	Summary of New Data Type Average Message Lengths by Data Type and by Year	

CCH/OBTS and combined court CCH/OBTS and SJIS traffic; automated fingerprint traffic. No traffic distribution is shown for law enforcement CCH/OBTS traffic because of the large number of terminals involved. This traffic was combined with existing data type traffic to these terminals and is displayed in Table 6-27 for a representative year.

6.3 EXISTING AND NEW DATA TYPES COMBINED

This section combines the projections for the growth of existing criminal justice information data types from Section 6.1 with the estimates for future new data type traffic from Section 6.2 to obtain a total criminal justice information system traffic projection for Ohio. The methodologies used to project future growth in existing traffic types are explained in Section 3, and the techniques used to estimate the start and growth of traffic in new data types are described in Section 4.

6.3.1 Traffic Projections

The three growth components are baseline growth, growth due to system improvements and traffic into new data bases. Table 6-24 presents potential new traffic to be caused by system improvements and new data type traffic. The values in the table are the increases in traffic above the previous six-month period.

Table 6-7. Computation of Ohio CCH/OBTS Average Messages per Day (Refer to Section 4.3.2.1.1 for Methodology)

Factor	1977	1979	1981	1983	1985
Estimated arrests per year:	451,607	469,643	481,679	505,715	523,951
Technology penetration factor:					
Law enforcement	0	1.0	1.0	1.0	1.0
Courts	0	0.142	0.687	0.687	0.687
Corrections	0	0	0.73	1.0	1.0
CCH/OBTS transactions per arrest:					
Law enforcement	29.7	29.7	29.7	29.7	29.7
Courts	8.9	8.9	8.9	8.9	8.9
Corrections	1.1	1.1	1.1	1.1	1.1
Number of messages per transaction	2	2	2	2	2
Time conversion from annual to daily average:					
Law enforcement	1/365	1/365	1/365	1/365	1/365
Courts	1/250	1/250	1/250	1/250	1/250
Corrections	1/250	1/250	1/250	1/250	1/250
Result: Average CCH/OBTS messages per day:					
Law enforcement	0	76,552	79,492	82,432	85,371
Courts	0	4,748	23,855	24,737	25,619
Corrections	0	0	3,133	4,450	4,609

Table 6-8. Computation of Ohio Law Enforcement CCH/OBTS Average Message Length in Characters

(Refer to Section 4.4.2.1.2 for Methodology)

Operation	Transactions Per Arrest	Message Length: To BCII	Message Length: From BCII	Weighted Average Message Lengths: To BCII	Weighted Average Message Lengths: From BCII	Weighted Average Message Lengths: Average to/from BCII
Police inquiry:	14.2	300	{0.6 X 180 0.4 X 960}	143	234	189
Police entry:	4.4	960	180	142	27	85
Prosecution inquiry:	0.8	300	960	8	26	17
Prosecution entry:	5.5	960	180	178	33	106
Jail entry:	1.3	960	180	42	8	25
Probation entry:	2.4	960	180	78	15	47
Parole entry:	1.1	960	180	36	7	22
Totals	29.7			627	350	491

Table 6-9. Computation of Ohio Court and Corrections CCH/OBTS Average Message Length in Characters

(Refer to Section 4.4.2.1.2 for Methodology)

Operation	Transactions Per Arrest	Message Lengths To BCII	Message Lengths From BCII	Weighted Average Message Lengths To BCII	Weighted Average Message Lengths From BCII	Weighted Average Message Lengths Average to/from BCII
Court CCH/OBTS Use						
Inquiry	0.8	300	960	27	86	57
Entry	8.1	960	180	874	164	519
Totals	8.9			901	250	576
Corrections CCH/OBTS Use						
Entry	1.1	960	180	960	180	570

Table 6-10. Ohio Statewide CCH/OBTS Traffic in Peak Characters per Minute

(Refer to Section 4.4.2.1.3 for Methodology)

Traffic Component	1977 TO BCII	1977 FROM BCII	1979 TO BCII	1979 FROM BCII	1981 TO BCII	1981 FROM BCII	1983 TO BCII	1983 FROM BCII	1985 TO BCII	1985 FROM BCII
Law Enforcement	0	0	33,300	18,602	34,579	19,317	35,858	20,031	37,136	20,745
Court CCH/OBTS Use	0	0	8,912	2,474	44,776	12,428	46,431	12,888	48,087	13,347
Corrections CCH/OBTS Use	0	0	0	0	6,266	1,175	8,900	1,669	9,218	1,728

Table 6-11. Distribution of Ohio Court CCH/OBTS Traffic in Peak Characters per Minute

(Refer to Section 4.4.2.1.4 for Methodology)

Court District Location and Number	Year 1979 To Columbus	1979 From Columbus	1981 To Columbus	1981 From Columbus	1983 To Columbus	1983 From Columbus	1985 To Columbus	1985 From Columbus
Cleveland (8)	0	0	9,851	2,734	10,285	2,846	10,651	2,956
Cincinnati (1)	8,912	2,474	9,402	2,610	9,588	2,661	9,930	2,756
Dayton (2)	0	0	7,164	1,988	7,526	2,098	7,795	2,164
Columbus (10)	0	0	6,269	1,740	6,672	1,852	6,910	1,918
Toledo (6)	0	0	6,269	1,740	6,370	1,768	6,598	1,831
Akron (9)	0	0	5,821	1,616	5,990	1,663	6,203	1,722
Totals	8,912	2,474	44,776	12,428	46,431	12,888	48,087	13,347

Table 6-12. Distribution of Ohio Corrections CCH/OBTS Traffic in Peak Characters per Minute

(Refer to Section 4.4.2.1.4 for Methodology)

Institution	1981		1983		1985	
	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus
Mansfield	3,128	587	3,244	608	3,361	630
Columbus	2,182	409	2,261	424	2,343	439
Marysville	956	179	991	186	1,026	192
Lebanon	0	0	595	111	613	115
Lucasville	0	0	587	111	613	115
London	0	0	486	91	500	94
Marion	0	0	382	72	395	74
Chillicothe	0	0	354	66	367	69
Totals	6,266	1,175	8,900	1,669	9,218	1,728

Table 6-13. Computation of Ohio Automated Fingerprint Average Messages per Day

(Refer to Sections 4.4.2.2.1 and 4.4.2.1.1 for Methodology)

	Year				
Factor	1977	1979	1981	1983	1985
Estimated arrests in Ohio per year	451,607	469,643	487,679	505,715	523,751
Technology penetration factor	0	0	0.107	0.403	0.403
Fingerprint transactions per arrest	2.18	2.18	2.18	2.18	2.18
Messages per fingerprint transaction	2	2	2	2	2
Time conversion from/ to daily average	1/250	1/250	1/250	1/250	1/250
Automated fingerprint average messages per day	0	0	910	3,554	3,744

Table 6-14. Distribution of Ohio Automated Fingerprint Traffic in Peak Characters per Minute (Refer to Section 4.4.2.2.3 for Methodology)

Source	1981 To BCII	1981 From BCII	1983 To BCII	1983 From BCII	1985 To BCII	1985 From BCII
Cleveland	3,511	528	3,648	549	3,843	577
Columbus			2,756	414	2,903	437
Cincinnati			2,166	326	2,282	343
Toledo			2,084	313	2,195	330
Dayton			1,645	247	1,733	261
Akron			1,412	212	1,488	224
Totals	3,511	528	13,711	2,061	14,444	2,172

Table 6-15. Computation of Ohio OBSCIS Average Messages per Day (Refer to Section 4.4.3.1.1 for Methodology)

Factor	1977	1979	Year 1981	1983	1985
Ohio Department of Corrections Inmates	12,325	12,806	13,287	13,768	14,249
Technology Penetration Factor	0.023	0.023	0.75	1.0	1.0
Transactions per Inmate-Day	0.432	0.432	0.432	0.432	0.432
Messages per Transaction	2	2	2	2	2
OBSCIS Traffic in Average Messages per Day	250	260	8,610	11,896	12,311

Table 6-16. Distribution of Ohio OBSCIS Traffic in Peak Characters per Minute (Refer to Section 4.4.3.1.3 for Methodology. This table assumes 960-character data entries to Columbus and 180-character acknowledgments to institutions.)

	1977		1979		1981		1983		1985	
Institution	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus
ODRC Headquarters	500	94	520	98	540	101	560	105	580	109
Mansfield	0	0	0	0	8,340	1,564	8,364	1,569	8,653	1,623
Columbus	0	0	0	0	5,838	1,095	5,808	1,089	6,011	1,127
Marysville	0	0	0	0	2,502	469	2,556	479	2,645	496
Lebanon	0	0	0	0	0	0	1,626	305	1,683	316
Lucasville	0	0	0	0	0	0	1,626	305	1,683	316
London	0	0	0	0	0	0	1,394	261	1,443	270
Marion	0	0	0	0	0	0	929	174	962	180
Chillicothe	0	0	0	0	0	0	929	174	962	180
Totals	500	94	520	98	17,220	3,229	23,792	4,461	24,622	4,617

Table 6-17. Distribution of Combined Ohio Corrections CCH/OBTS and OBSCIS Traffic in Peak Characters per Minute

Institution	1977 To Columbus	1977 From Columbus	1979 To Columbus	1979 From Columbus	1981 To Columbus	1981 From Columbus	1983 To Columbus	1983 From Columbus	1985 To Columbus	1985 From Columbus
ODRC Headquarters	500	94	520	98	540	101	560	105	580	109
Mansfield	0	0	0	0	11,468	2,151	11,608	2,177	12,014	2,253
Columbus	0	0	0	0	8,020	1,504	8,069	1,513	8,354	1,566
Marysville	0	0	0	0	3,458	648	3,547	665	3,671	688
Lebanon	0	0	0	0	0	0	2,221	416	2,296	431
Lucasville	0	0	0	0	0	0	2,213	416	2,296	431
London	0	0	0	0	0	0	1,880	352	1,943	364
Marion	0	0	0	0	0	0	1,311	246	1,357	254
Chillicothe	0	0	0	0	0	0	1,283	240	1,329	249
Totals	500	94	520	98	23,486	4,404	32,692	6,130	33,840	6,345

Table 6-18. Computation of Ohio SJIS Average Messages per Day

(Refer to Section 4.4.4.1.1 for Methodology)

Factor	1977	1979	1981	1983	1985
Statewide court dispositions	2,789,557	3,190,795	3,592,033	3,993,271	4,394,509
Technology penetration factor	0	0.15	0.42	0.69	0.69
Transactions per disposition	1	1	1	1	1
Messages per transaction	2	2	2	2	2
Time conversion factor	1/250	1/250	1/250	1/250	1/250
SJIS traffic in average messages per day	0	3,829	12,069	22,043	24,258

Table 6-19. Distribution of Ohio SJIS Traffic in Peak Characters per Minute

(Refer to Sections 4.4.4.1.2 and 4.4.4.1.3, for Methodology. This Table assumes 960-character data entries to Columbus and 180-character acknowledgments to court districts.)

Court District Location and Number	1979		1981		1983		1985	
	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus	To Columbus	From Columbus
Cleveland (8)	0	0	4,586	860	9,699	1,818	10,674	2,000
Cincinnati (1)	7,658	1,436	8,207	1,539	9,258	1,736	10,188	1,910
Dayton (2)	0	0	3,138	588	2,054	1,323	7,763	1,456
Columbus (10)	0	0	2,897	543	6,172	1,157	6,792	1,274
Toledo (6)	0	0	2,655	498	6,172	1,157	6,792	1,274
Akron (9)	0	0	2,655	498	5,731	1,075	6,307	1,183
Totals	7,658	1,436	24,138	4,526	44,086	8,266	48,516	9,097

Table 6-20. Distribution of Combined Ohio Court CCH/OBTS and SJIS Traffic in Peak Characters per Minute

Court District Location and Number	1979 To Columbus	1979 From Columbus	1981 To Columbus	1981 From Columbus	1983 To Columbus	1983 From Columbus	1985 To Columbus	1985 From Columbus
Cleveland (8)	0	0	14,436	3,594	19,984	4,674	21,325	4,956
Cincinnati (1)	16,570	3,910	17,610	4,149	18,846	4,397	20,118	4,666
Dayton (2)	0	0	10,302	2,576	14,580	3,421	15,558	3,620
Columbus (10)	0	0	9,166	2,283	12,844	3,009	13,702	3,192
Toledo (6)	0	0	8,924	2,238	12,542	2,925	13,390	3,105
Akron (9)	0	0	8,476	2,114	11,721	2,738	12,510	2,905
Totals	16,570	3,910	68,914	16,954	90,517	21,154	96,603	22,444

Table 6-21. Ohio BCII Data Conversion Traffic for 1977 to 1985

(Average Messages per Day, Average Message Length, and Peak Characters per Minute. Refer to Section 4.4.4.3 for Methodology)

<u>Average messages per day</u>

Year:	1977	1979	1981	1983	1985
Average messages per day (Estimate from Ohio state data center officials)	14,000	14,000	14,000	14,000	14,000

<u>Average message length</u>

		Message Lengths		Weighted Average Message Lengths		
BCII Data Conversion Operation	Operation Fraction	To Columbus	From Columbus	To Columbus	From Columbus	Average to/from Columbus
Inquiry	0.28	300	{0.6 x 180}	86	141	114
Entry	<u>0.72</u>	960	{0.4 x 960}	<u>686</u>	<u>129</u>	<u>408</u>
	1.0		180	772	270	522

<u>Peak characters per minute</u>

Year	1977	1979	1981	1983	1985
Peak characters per minute					
To Columbus:	22,517	22,517	22,517	22,517	22,517
From Columbus:	7,876	7,786	7,876	7,876	7,876

Table 6-22. Total Ohio New Data Traffic Projections in Average Messages per Day

New Data Type	1977	1979	Year 1981	1983	1985
BCII data conversion	14,000	14,000	14,000	14,000	14,000
Law enforcement CCH/OBTS	0	76,552	79,492	82,432	85,371
Court CCH/OBTS	0	4,748	23,855	24,737	25,619
Corrections CCH/OBTS	0	0	3,133	4,450	4,609
SJIS	0	3,829	12,069	22,043	24,258
OBSCIS	250	260	8,610	11,896	12,311
Automated fingerprints	0	0	910	3,554	3,744
Total	14,250	99,389	142,069	163,112	169,912

Table 6-23. Summary of Ohio New Data Type Average Message Lengths by Data Type and by Year

	To Columbus	From Columbus	Average to/from Columbus
By Data Type:			
BCII data conversion	772	270	522
Law enforcement CCH/OBTS	627	350	491
Court CCH/OBTS	901	250	576
Corrections CCH/OBTS	960	180	570
SJIS	960	180	570
OBSCIS	960	180	570
Automated fingerprints	1852	279	1066
By Year for all New Data Types:			
1977	775	268	552
1979	675	327	501
1981	751	297	524
1983	786	286	536
1985	789	286	538

Table 6-24. Increase in Ohio Average Daily Communication Messages

Six Month Period	System Improvement Traffic	New Data Type Traffic
77	6000	391
77/78	6000	21,285
78	6000	21,285
78/79	0	21,285
79	0	21,285
79/80	2400	10,670
80	2400	10,670
80/81	2400	10,670
81	2400	10,670
81/82	2400	5,261
82	2400	5,261
82/83	2400	5,261
83	2400	5,261
83/84	2400	1,700
84	2400	1,700
84/85	0	1,700
85	0	1,700

The word potential is used because if these traffic increases cause total traffic to exceed system capacity, then the increases will be delayed. For example let's assume that total traffic in 1980 is projected to be 295,000 messages per day and system capacity is 300,000 messages per day. The increases in traffic projected to occur in time period 80/81 would have to be delayed until system capacity was increased. This process is explained in Section 5.

We will now summarize procedures used for projecting future growth and show the results. Procedures are:

(1) Periods of 6-month duration will be used.

(2) Due to baseline growth, traffic is 1,700 messages per day higher one period after an upgrade, 6,700 messages per day higher two periods after an upgrade and 14,900 messages per day higher three periods after an upgrade. After the third period, traffic is 8,200 messages per day higher each subsequent period.

(3) System improvement traffic growth and new data type traffic growth occur as specified in Table 6-24.

(4) Current system capacity in Ohio is 150,000 messages per day.

(5) Traffic grows each period until a period is reached where projected traffic exceeds system capacity. At this point all three components of traffic growth are reduced so that total traffic is less than system capacity by 3,000 messages per day. During the next period a 150,000 average message per day increase in system capacity is assumed. The increase in average daily message volume due to baseline growth is 1,700 msg/day. Growth due to system improvements and new data type traffic is the sum of the growth specified in Table 6-24 and the amount of the reduction during the previous period. Traffic then continues to grow until once again system capacity is reached.

(6) System capacity levels are:

150,000 messages/day

300,000 messages/day

450,000 messages/day

600,000 messages/day

Tables 6-25 and 6-26 show the application of these procedures to Ohio. Note that capacity increases are required in periods 76/77, 79/80, and 84/85. Table 6-26 shows that by 1985 over 450,000 messages per day will be transmitted over the LEADS system. Traffic projections are also presented in peak characters per minute to show how the longer message lengths of the new data types cause them to contribute a large portion of the traffic in characters per minute.

Table 6-25. Ohio Traffic Growth Each Six Months - 1975-1985

Period	Item	Growth	Cumulative
	Starting		91,800
75	BG	1,700	
	SU	19,400	
	NDT	0	
		21,000	112,900
75/76	BG	8,200	
	SU	5,800	
	NDT	0	
		14,000	126,900
76	BG	8,200	
	SU	0	
	NDT	0	
		8,200	135,100
76/77	BG	8,200	
	SU	0	
	NDT	13,900	
		22,100	157,200*
	BG	4,415	
	SU	0	
	NDT	7,485	
		11,900	147,000
77	BG	1,700	
	SU	6,000	
	NDT	6,800	
		14,500	161,500
77/78	BG	5,000	
	SU	6,000	
	MDT	21,300	
		32,300	193,800
78	BG	8,200	
	SU	6,000	
	NDT	21,300	
		35,500	229,300
78/79	BG	8,200	
	SU	0	
	NDT	21,300	
		29,500	258,800
79	BG	8,200	
	SU	0	
	NDT	21,300	
		29,500	288,300
79/80	BG	8,200	
	SU	2,400	
	NDT	10,700	
		21,300	309,600*
	BG	3,350	
	SU	980	
	NDT	4,370	
		8,700	297,000
80	BG	1,700	
	SU	3,820	
	NDT	17,030	
		22,600	319,600
80/81	BG	5,000	
	SU	2,400	
	NDT	10,700	
		18,100	337,700
81	BG	5,000	
	SU	2,400	
	NDT	10,700	
		18,100	355,800
81/82	BG	8,200	
	SU	2,400	
	NDT	5,300	
		15,900	371,700
82	BG	8,200	
	SU	2,400	
	NDT	5,300	
		15,900	387,600
82/83	BG	8,200	
	SU	2,400	
	NDT	5,300	
		15,900	403,500
83	BG	8,200	
	SU	2,400	
	NDT	5,300	
		15,900	419,400
83/84	BG	8,200	
	SU	2,400	
	NDT	1,700	
		12,300	431,700
84	BG	8,200	
	SU	2,400	
	NDT	1,700	
		12,300	444,000
84/85	BG	8,200	
	SU	0	
	NDT	1,700	
		9,900	453,900*
	BG	2,485	
	SU	0	
	NDT	515	
		3,000	447,000
85	BG	1,700	
	SU	0	
	NDT	2,900	
		4,600	451,600

LEGEND:

BG - Baseline Growth
SU - System Upgrade
NDT - New Data Type

*Exceeds capacity.

Table 6-26. Ohio Traffic Growth by Two Year Periods
Average Messages Per Day

	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	147,200	14,300	161,500
1979	188,800	99,500	288,300
1981	213,500	142,300	355,800
1983	255,800	163,500	419,300
1985	281,200	170,300	451,500

Traffic Summary - Peak Characters Per Minute

	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	23,720	10,960	34,680
1979	30,420	69,240	99,660
1981	34,400	103,560	137,960
1983	41,200	121,720	162,920
1985	45,300	127,250	172,550

6.3.2 Traffic Distribution

Ohio Traffic Distribution Results

Distribution of messages to users in Ohio is discussed in detail in Section III and needs no further discussion here. However, the results of the distribution task are presented in Table 6-27 for 1985. The table shows the projected traffic in units of peak characters per minute to and from the state data center for each of the several hundred terminals in the state criminal justice telecommunication system.

In addition to determining the amount of traffic to and from each terminal, we must determine the distribution of total traffic by message type. This is needed to calculate the overall message length into and out of the computer and also over the communication network. It is also used to convert communication message statistics to computer transaction statistics.

Table 6-28 shows our projection for this distribution in 1985. Units are average messages per day and average characters per message.

Table 6-27. Ohio 1985 Traffic To and From Each User Agency

Each line shows user agency name, city identification number, traffic from user agency to Columbus, and traffic from Columbus to user agency. Traffic is given in units of characters per minute and represents activity during the busiest hour.

WEST UNION S.O.	1	35.17	29.60
DELPHOS P.D.	2	35.62	34.82
LIMA P.D.	3	237.45	170.65
LIMA S.O.	3	153.01	113.12
LIMA O.S.P.	3	51.90	77.85
ASHLAND P.D.	4	52.68	45.44
ASHLAND S.O.	4	45.81	55.40
ASHLAND O.S.P.	4	82.55	123.82
ASHTABULA P.D.	5	134.14	96.49
ASHTABULA OSP	5	67.31	100.96
CONNEAUT P.D.	6	39.86	37.43
JEFFERSON S.O.	7	105.41	92.54
JEFFERSON TWP P.D.	7	14.74	15.38
ATHENS P.D.	8	23.59	18.74
ATHENS S.O.	8	38.95	32.07
ATHENS O.S.P.	8	42.03	63.05
NELS[illegible]VILLE P.D.	9	33.44	38.16
OHIO UNIV. P.D.	10	50.54	75.81
SAINT MARYS P.D.	11	65.81	79.83
SAINT MARYS O.S.P.	11	55.48	83.22
WAPAKONETA P.D.	12	31.83	33.77
WAPAKONETA S.O.	12	43.58	43.35
MARTINS FERRY P.D.	13	29.74	34.72
ST. CLAIRSVILLE OSP	14	60.04	90.04
GEORGETOWN OSP	15	40.68	61.02
FAIRFIELD P.D.	16	62.89	56.50
HAMILTON P.D.	17	399.59	271.97
HAMILTON S.O.	17	146.51	110.41
HAMILTON OSP	17	77.13	115.69
MIDDLETOWN P.D.	18	247.26	159.57
OXFORD P.D.	19	64.41	47.63
CARROLLTON S.O.	20	6[illegible].79	57.03
URBANA P.D.	22	53.03	48.72
URBANA S.O.	22	71.98	62.46
NEW CARLISLE P.D.	23	34.90	36.08
SPRINGFIELD P.D.	24	357.95	216.77
SPRINGFIELD S.O.	24	146.55	114.66
SPRINGFIELD OSP	24	89.70	134.55
BATAVIA S.O.	25	122.69	99.86
BATAVIA OSP	25	83.30	124.95
BETHEL P.D.	26	14.38	15.55
NEW RICHMOND P.D.	27	16.24	17.14
WILMINGTON OSP	29	109.19	163.79
COLUMBIA P.D.	30	23.39	28.52
E. LIVERPOOL P.D	31	56.93	48.55
LISBON S.O.	32	40.83	43.47
LISBON OSP	32	89.26	133.89
SALEM P.D.	33	52.79	47.39
COSHOCTON S.O.	34	43.75	41.30
BUCYRUS P.D.	35	68.46	55.54
BUCYRUS S.O.	35	30.02	33.10
BUCYRUS OSP	35	46.04	69.07
GALION P.D.	36	69.14	60.10
BAY VILLAGE P.D.	37	37.01	31.40
BEACHWOOD P.D.	38	59.40	59.92
BEDFORD P.D.	39	64.85	55.24
BEDFORD HGTS. P.D.	40	65.00	57.03
BEREA P.D.	41	57.26	44.39
BEREA OSP	41	143.71	215.57
BRATENAHL VIL. P.D.	42	25.65	34.08
BRECKSVILLE P.D.	43	31.02	34.01
BROADVIEW HGTS. P.D.	44	25.09	27.01
BROOKLYN P.D.	45	82.78	70.47
BROOK PARK P.D.	46	110.67	100.71
CHAGRIN FALLS P.D.	47	30.41	36.69
CLEVELAND F.B.I.	48	26.51	39.76
CLEVELAND MPR	48	22.03	33.04
CLEVELAND S UNIV. PD	48	35.46	53.20
CLEVELAND P.D.	48	4386.17	3168.21
CLEVELAND S.O.	48	63.26	70.64
CLEVELAND OSP	48	9.74	14.61
CLEVELAND HGTS. P.D.	49	240.00	160.58
CUYAHOGA COM. COL.	49	30.20	45.30
CUYAHOGA HGTS. P.D.	50	17.02	23.18
E. CLEVELAND P.D.	51	238.89	178.80
EUCLID P.D.	52	193.13	151.42
FAIRVIEW PK. P.D.	53	50.35	43.13
GARFIELD HGTS. P.D.	54	86.00	54.58
LAKEWOOD P.D.	55	157.46	121.45
LYNDHURST P.D.	56	52.51	47.36
MAPLE HGTS. P.D.	57	103.47	72.66
MAYFIELD HGTS. P.D.	58	96.98	99.05
MAYFIELD VIL. P.D.	59	28.00	32.82
MIDDLEBURG HGTS. P.D.	60	104.63	106.20
NEWBURGH HGTS. P.D.	61	19.69	24.22
N. OLMSTED P.D.	62	100.64	92.02
N. ROYALTON P.D.	63	37.00	38.90
OAKWOOD VIL. P.D.	64	24.84	28.73
OLMSTED TWP P.D.	65	19.24	22.04
PARMA P.D.	66	198.87	133.35
PARMA HGTS. P.D.	67	56.24	39.11
PEPPER PIKE P.D.	68	33.65	38.94
RICHMOND HGTS. P.D.	69	43.51	43.57
ROCKY RIVER P.D.	70	50.06	42.44
SHAKER HGTS. P.D.	71	210.29	170.92
SOLON P.D.	72	50.66	54.81
S. EUCLID P.D.	73	63.66	52.80
STRONGSVILLE P.D.	74	60.12	54.51
UNIVERSITY CIR. P.D.	75	117.98	81.66
UNIVERSITY HGTS. PD	76	60.39	55.64
WALTON HILLS P.D.	77	24.64	32.04
WARRENSVILLE H. P.D.	78	134.68	121.69
WESTLAKE P.D.	79	47.08	46.22
GREENVILLE P.D.	80	41.35	39.92
GREENVILLE S.O.	80	83.10	71.75
DEFIANCE SO/PD	81	99.76	76.27
DEFIANCE OSP	81	52.47	78.70
DELAWARE P.D.	82	74.51	58.91
DELAWARE S.O.	82	66.12	58.07
DELAWARE OSP	82	70.96	106.44
CASTALIA OSP	204	9.62	14.43
HURON P.D.	83	35.84	36.91
PERKINS TWP P.D.	84	39.76	31.18
SANDUSKY P.D.	85	160.73	104.63
SANDUSKY S.O.	85	45.14	38.06
SANDUSKY OSP	85	63.85	95.77
VERMILLION P.D.	86	37.89	42.86
LANCASTER P.D.	88	102.46	73.75
LANCASTER S.O.	88	63.95	58.02
LANCASTER OSP	88	63.65	95.48
WASHINGTON CO. P.D.	89	45.32	39.92
WASHINGTON CO. S.O.	89	80.53	65.51
BEXLEY P.D.	90	67.62	53.82
CLINTON TWP P.D.	91	49.83	51.25
COLUMBUS HUT	91	2.70	4.04
COLUMBUS ACA, OSP	91	3.88	5.82
COLUMBUS P.D.	91	2984.09	1897.83
COLUMBUS S.O.	91	304.84	226.32
COLUMBUS OSP	91	37.91	56.86
GAHANNA P.D.	92	56.75	50.89
GRANDVIEW HGTS. P.D.	93	44.03	43.00
GROVE CITY P.D.	94	56.31	50.89
HILLIARD P.D.	95	44.60	42.50
MADISON TWP. P.D.	91	83.92	79.17
OHIO ST. UNIV. P.D.	91	25.61	38.41
PERRY TWP. P.D.	91	33.13	31.28
REYNOLDSBURG P.D.	96	55.96	48.25
UPPER ARLINGTON P.D.	97	114.90	98.11

Table 6-27. Ohio 1985 Traffic To and From Each User Agency (Continuation 1)

WESTERVILLE P.D.	98	69.97	59.59
WHITEHALL P.D.	99	138.10	93.06
WORTHINGTON P.D.	100	66.12	59.90
SWANTON OSP	150	8.48	12.72
WAUSEON S.O.	101	56.56	50.62
GALLIPOLIS OSP	102	46.96	70.43
CHARDON S.O.	103	91.03	83.30
CHARDON OSP	103	68.47	102.71
CHESTER TWP. P.D.	104	19.46	19.82
BEAVER CRK TWP P.D.	105	41.28	23.30
FAIRBORN P.D.	106	107.69	64.89
WRIGHT S. UNIV. P.D.	107	16.99	25.48
XENIA P.D.	108	81.56	57.48
XENIA S.O.	108	90.33	86.24
XENIA OSP	108	60.18	90.27
YELLOW SPRS. P.D.	109	32.12	35.66
CAMBRIDGE P.D.	110	57.15	54.38
CAMBRIDGE S.O.	110	43.23	37.63
CAMBRIDGE OSP	110	77.24	115.87
CINCINNATI P.D.	111	2599.37	1879.43
HAMILTON CO. CTR.	111	21.45	32.18
MIAMI TWP P.D.	112	28.51	40.59
R.C.I.C.	111	761.82	1142.73
FINDLAY P.D.	113	107.91	70.06
FINDLAY S.O.	113	58.68	48.08
FINDLAY OSP	113	55.42	83.13
KENTON P.D.	115	34.19	33.51
KENTON S.O.	115	73.04	53.76
CADIZ S.O.	116	35.68	33.91
NAPOLEON P.D.	117	42.96	41.88
NAPOLEON S.O.	117	37.46	27.74
HILLSBORO P.D.	118	51.06	57.64
LOGAN S.O.	119	42.72	33.93
MILLERSBURG S.O.	120	43.76	51.03
NORWALK P.D.	121	77.92	84.29
NORWALK S.O.	121	46.05	48.45
NORWALK OSP	121	54.86	82.30
WILLARD P.D.	122	33.59	35.63
JACKSON S.O.	123	28.31	25.48
JACKSON OSP	123	29.52	44.27
STEUBENVILLE P.D.	124	169.38	118.87
STEUBENVILLE S.O.	124	92.17	64.56
STEUBENVILLE OSP	124	55.14	82.72
MT. VERNON P.D.	125	57.88	54.68
MT. VERNON S.O.	125	77.95	66.44
MT. VERNON OSP	125	30.27	45.40
EASTLAKE P.D.	126	52.11	43.15
KIRTLAND P.D.	127	38.65	42.92
MENTOR P.D.	129	161.10	126.25
MENTOR OTL. P.D.	129	27.03	29.73
PAINSVILLE P.D.	130	68.88	61.87
PAINSVILLE S.O.	130	95.67	81.27
WICKLIFFE P.D.	132	47.99	40.11
WILLOUGHBY P.D.	133	74.84	63.34
WILLOUGHBY HILLS PD	134	46.23	46.39
WILLOWICK P.D.	135	51.66	41.16
IRONTON S.O,	136	67.08	49.86
IRONTON OSP	136	44.88	67.32
GRANVILLE OSP	137	64.75	97.12
NEWARK P.D.	138	142.82	97.64
NEWARK S.O.	138	72.25	40.66
BELLEFONTAINE P.D.	139	48.77	43.38
BELLEFONTAINE OSP	139	45.65	68.48
AMHERST P.D.	140	37.86	39.09
AVON LAKE P.D.	141	34.87	35.86
ELYRIA P.D.	142	114.40	73.90
ELYRIA S.O.	142	82.77	68.13
ELYRIA OSP	142	39.31	58.97
LORAIN P.D.	143	174.18	97.58
N. RIDGEVILLE P.D.	144	42.47	38.72
OBERLIN P.D.	145	35.61	33.86
SHEFFIELD LAKE P.D.	146	24.76	25.34
MAUMEE P.D.	147	85.41	69.76
NORIS	152	25.48	38.22
OREGON P.D.	149	64.68	56.17
SYLVANIA P.D.	151	70.02	58.74
SYLVANIA TWP P.D.	151	50.14	42.44
TOLEDO P.D.	152	2220.01	1387.76
TOLEDO S.O.	152	152.64	117.43
TOLEDO OSP	152	44.39	66.58
UNIV. OF TOLEDO P.D.	152	20.11	30.17
WALBRIDGE OSP	153	72.26	108.40
LONDON BCI	154	39.87	59.80
W. JEFFERSON OSP	155	88.43	132.65
AUSTINTOWN P.D.	156	106.90	80.31
BOARDMAN P.D.	157	97.23	61.82
CAMPBELL P.D.	158	49.13	42.67
CANFIELD OSP	159	61.99	92.99
STRUTHERS P.D.	160	54.37	43.72
YOUNGSTOWN P.D.	161	610.49	429.51
YOUNGSTOWN S.O.	161	81.36	69.55
YOUNGSTOWN UNIV. PD	161	19.57	29.35
MARION P.D.	162	173.42	109.39
MARION S.O.	162	87.09	76.13
MARION OSP	162	57.09	85.64
BRUNSWICK P.D.	163	42.43	37.88
MEDINA P.D.	164	84.18	63.97
MEDINA S.O.	164	105.29	89.53
MEDINA OSP	164	51.93	77.89
WADSWORTH P.D.	165	68.55	54.24
CELINA P.D	166	84.22	74.25
PIQUA P.D.	167	113.31	81.05
PIQUA OSP	167	79.12	118.68
TIPP CITY P.D.	168	29.99	32.45
TROY P.D.	169	78.84	60.50
TROY S.O.	169	101.04	89.98
BROOKVILLE P.D.	170	31.08	35.86
CENTERVILLE P.D.	171	68.47	56.35
DAYTON P.D.	172	1711.98	1030.55
DAYTON S.O.	172	465.03	346.49
DAYTON OSP	172	84.37	126.56
ENGLEWOOD P.D.	173	40.59	40.49
GERMANTOWN P.D	174	40.32	38.44
KETTERING P.D.	175	252.41	168.13
MADISON TWP. P.D.	179	118.43	98.44
MIAMISBURG P.D.	176	111.27	79.89
MORAINE P.D.	177	63.59	60.83
OAKWOOD P.D.	178	68.11	67.09
TROTWOOD P.D.	179	84.21	67.10
VANDALIA P.D.	180	46.74	47.35
W. CARROLLTON P.D.	181	48.98	43.77
WRIGHT-PAT AFB PD	182	9.34	14.01
MT. GILEAD SO/PD	183	67.58	63.27
ZANESVILLE P.D.	184	70.31	46.72
ZANESVILLE S.O.	184	80.68	62.27
ZANESVILLE OSP	184	53.41	80.11
OAK HARBOR P.D.	185	21.74	25.86
PORT CLINTON P.D.	186	39.62	40.15
PORT CLINTON S.O.	186	59.12	46.85
PAULDING S.O.	187	42.36	37.38
N. LEXINGTON S.O.	188	44.03	37.86
CIRCLEVILLE P.D.	189	47.21	41.51
CIRCLEVILE S.O.	189	95.44	90.19
CIRCLEVILLE OSP	189	64.01	96.01
WAVERLY P.D.	190	30.48	33.58
WAVERLY S.O.	190	25.47	24.97
AURORA P.D.	191	31.64	34.27
HIRAM OSP	192	7.06	10.59
KENT P.D.	193	84.40	48.11
KENT ST. UNIV. P.D.	193	19.68	29.51
RANDOLPH TWP. P.D.	194	23.49	32.79
RAVENNA P.D.	195	60.91	50.78
RAVENNA S.O.	195	169.43	127.42
RAVENNA OSP	195	89.05	133.57
STREETSBORO P.D.	196	38.42	32.91
EATON P.D.	197	21.17	30.00
EATON OSP	197	52.34	78.00
OTTAWA S.O.	198	40.16	38.00
MANSFIELD P.D.	199	227.43	148.69
MANSFIELD S.O.	199	129.18	102.22
MANSFIELD OSP	199	72.11	108.17
ONTARIO P.D.	200	39.40	39.96
SHELBY P.D.	201	33.49	34.10
CHILLICOTHE P.D.	202	85.13	68.61

Table 6-27. Ohio 1985 Traffic To and From Each User Agency (Continuation 2)

CHILLICOTHE S.O.	202	64.54	56.09	GIRARD P.D.	227	42.57	38.67
CHILLICOTHE OSP	202	35.20	52.80	HOWLAND TWP. P.D.	228	151.46	103.83
BELLEVUE P.D.	203	31.18	38.33	HUBBARD P.D.	229	27.40	29.75
FREMONT P.D.	205	80.29	65.36	LIBERTY TWP P.D.	230	49.58	42.63
FREMONT S.O.	205	41.21	39.53	WARREN P.D.	231	235.52	154.45
FREMONT OSP	205	57.94	86.91	WARREN S.O.	231	190.38	131.32
PORTSMOUTH P.D.	206	143.52	102.23	WARREN OSP	231	69.01	103.51
PORTSMOUTH S.O.	206	95.37	65.73	DOVER P.D.	232	41.50	40.09
PORTSMOUTH OSP	206	38.85	58.28	N. PHILADELPHIA P.D.	233	51.20	42.12
FOSTORIA P.D.	207	55.70	52.33	N. PHILADELPHIA S.O.	233	72.58	63.62
TIFFIN P.D.	208	91.00	70.48	N. PHILADELPHIA OSP	233	45.78	68.67
TIFFIN S.O.	208	52.25	48.72	MARYSVILLE P.D.	234	22.05	30.78
SIDNEY P.D.	209	70.22	59.62	MARYSVILLE S.O.	234	43.23	48.31
SIDNEY S.O.	209	39.21	45.83	VAN WERT P.D.	236	46.98	42.73
ALLIANCE P.D.	210	87.93	68.49	VAN WERT S.O.	236	15.21	15.60
CANTON P.D.	211	530.43	367.36	VAN WERT OSP	236	31.69	47.53
CANTON S.O.	211	335.90	229.58	FRANKLIN P.D.	247	80.32	60.29
LOUISVILLE P.D.	212	29.39	30.11	LEBANON P.D.	238	40.74	44.65
MASSILLON P.D.	213	128.62	84.27	LEBANON OSP	238	74.83	112.24
MASSILLON OSP	213	70.86	106.30	MARIETTA P.D.	239	82.25	66.47
MINERVA P.D.	211	23.70	31.55	MARIETTA S.O.	239	42.78	34.67
N. CANTON P.D.	214	29.27	30.39	MARIETTA OSP	239	43.52	65.28
PERRY TWP. P.D.	213	105.76	75.74	ORRVILLE P.D.	240	39.63	39.12
AKRON P.D.	215	1500.90	934.62	RITTMAN P.D.	241	16.64	9.29
AKRON S.O.	215	276.35	205.24	WOOSTER P.D.	242	91.68	76.51
AKRON OSP	215	61.93	92.89	WOOSTER S.O.	242	99.26	83.32
BARBERTON P.D.	216	147.20	93.73	WOOSTER OSP	242	56.45	84.67
COPLEY P.D.	217	35.94	34.65	BRYAN SO/PD	243	88.19	62.85
CUYAHOGA FALLS P.D.	218	116.94	78.96	BOWLING GREEN P.D.	244	98.51	96.03
FAIRLAWN P.D.	219	64.71	53.59	BOWL.GR.ST.UNIV. P.D.	244	33.23	49.85
HUDSON P.D.	220	31.31	35.23	NORTHWOOD P.D.	148	32.01	36.51
NORTON P.D.	221	55.22	53.19	PERRYSBURG P.D.	245	176.82	117.97
RICHFIELD P.D.	222	29.90	32.06	PERRYSBURG TWP. P.D.	245	38.82	37.28
STOW PD.	223	69.05	59.44	WWYNE TWP P.D.	246	3.11	2.16
TALLMADGE P.D.	224	64.13	52.34	UPPER SANDUSKY S.O.	247	52.10	41.38
TWINSBURG P.D.	225	45.94	47.67	NCIC	248	5921.47	8882.20
BROOKFIELD TWP P.D.	226	21.98	29.70	NLETS	249	482.73	724.09

Table 6-28. Distribution of Ohio 1985 Traffic by Message Type

	Number of Messages		Message Length
LEADS			
Operators Lic - In	15,910		17
Operators Lic - Out	15,910		285
Vehicle Regis - In	27,710		11
Vehicle Regis - Out	27,710		175
Auto Alert - In	12,170		11
Auto Alert - Out	12,170		80
Wants Warrants - In	3,700		56
Wants Warrants - Out	3,700		55
NCIC			
Columbus → NCIC	38,760		50
NCIC → Columbus	38,550		90
Columbus → User Agency	38,550		90
NLETS			
To Oper Lic from O.S.*	190		35
From Oper Lic to O.S.	140		300
To Veh Reg from O.S.	1,030		50
From Veh Reg to O.S.	990		175
User Agency → Columbus	780		50
Columbus → NLETS	780		50
NLETS → Columbus	690		200
Columbus → User Agency	690		200
NLETS Adm → Columbus	4,760		300
User Agency (Adm) → Columbus	1,240		300
Columbus (Adm) → NLETS (Adm)	1,240		300
Adm - In	6,720		250
Adm - Out	30,300		250
$\sum$	284,400		
New Data Types			
Law Enf. CCH - In	42,690		627
Law Enf. CCH - Out	42,690		350
Courts CCH - In	12,810		901
Courts CCH - Out	12,810		250
Corrections CCH - In	2,300		960
Corrections CCH - Out	2,300		180
SJIS - In	12,130		960
SJIS - Out	12,130		180
OBSCIS - In	6,160		960
OBSCIS - Out	6,160		180
Fingerprints - In	1,870		1,852
Fingerprints - Out	1,870		279
BCII Data Conv - In	7,000		772
BCII Data Conv - Out	7,000		270
$\sum$	169,920	454,300	

*Other States

6.4 LEADS and BMV Integration

Currently in Ohio the Law Enforcement Automated Data System (LEADS) and the Bureau of Motor Vehicles share a common set of Vehicle Registration and Drivers License files. However each system maintains a separate set of communication links tying their users into these common files. Because of budgetary constraints, Ohio is considering the integration of communication links serving LEADS and BMV users.

Design of such an integrated system as well as cost comparisons with the existing two separate systems can only be accomplished if the amount of communication traffic transmitted on the BMV system is known. In this section current BMV traffic volumes will be given and projections will be made of future BMV traffic out until 1985. Traffic is also distributed to the over 200 BMV branch offices. It should be noted that BMV traffic can not be categorized as criminal justice traffic and as such was not included in the general discussions of the assessment of criminal justice communications user requirements. However since the state of Ohio is considering the integration of the BMV and LEADS communication systems, an assessment of current and future BMV traffic levels is required.

We received traffic statistics from the Ohio BMV which detailed the amount of traffic transmitted on each of the 28 communication lines over the last year. Traffic was separated into two types; DRINQ and DRCOL. DRINQ refers to checks made of past driving records and DRCOL are messages sent in the early morning hours updating driving records. Total messages were calculated by adding DRINQ inquiries, DRINQ responses and DRCOL messages over all communication lines. Using a four percent per year growth rate, projections of total drivers license message levels were made.

The Ohio BMV expects in the future to utilize their communication system in processing vehicle registration renewals. They plan to have converted from the present mail-in system to electronic data transfer by 1978. Ohio planners say that there will be approximately three times as much vehicle registration traffic as drivers license traffic because vehicle registrations must be renewed each year. We thus assumed an additional traffic component of vehicle registration messages beginning in 1978 and of magnitude approximately three times as large as the number of drivers license messages. A four percent yearly growth rate was applied to this new message type as well. The sum of drivers license messages and vehicle registration messages thus became the predicted total BMV message volumes.

Data was not available which described the amount of traffic to and from each terminal. We assumed that the amount of traffic to and from a terminal was proportional to the population served by the terminal. Thus we distributed traffic on each line to the between 5 to 12 terminals per line according to the relative population served by each terminal. We also assumed that during and after 1978, vehicle registration renewals would occur in the same locations as drivers license renewals are currently processed.

In order to perform network design, two measures of BMV traffic volumes are required. They are the average number of messages per day and the number of characters transmitted during a peak minute. Recall that currently drivers license record checks and the corresponding responses occur between 8 A.M. and 5 P.M. while transmission of updated records is not done until the early morning hours. The functional requirements for our network call for message prioritization, so instead of dumping updated license renewals during pre-dawn hours, we will assume them to be transmitted over the entire 24 hour period as low priority messages.

Measures of BMV traffic for periods prior to 1978 are obtained as follows. From the statistics we know that in 1976 there were:

1,815,000 DIINQ messages
1,815,000 DRCOL messages

We also know that each DIINQ into Columbus results in a response which is sent back out to the terminal which we call a DIRESP message. Thus total messages equals:

	Yearly Msg. Vol.
DIINQ	1815000
DIRESP	1815000
DRCOL	1815000
TOTAL	5,445,000

To calculate peak characters per minute we assume the peak occurs between 8 A.M. and 5 P.M. If we let X equal total BMV traffic in messages per year then we know:

Number of Yearly DIINQ messages = 1/3X
Number of Yearly DIRESP messages = 1/3X
Number of Yearly DRCOL messages = 1/3X

To convert from messages per year to messages per minute we must use a conversion factor of the number of minutes per year. Since DIINQ and DIRESP messages can be sent 8 hours a day and 6 days a week

$$\text{TIME 1} = \frac{8\text{ hrs}}{\text{day}} \times \frac{6\text{ days}}{\text{weeks}} \times \frac{52\text{ weeks}}{\text{yr}} \times \frac{60\text{ min}}{\text{hr}} = 149760\ \frac{\text{min}}{\text{year}}$$

DRCOL can be sent 24 $\frac{\text{hrs}}{\text{day}}$ and 6 days per week. Thus

$$\text{TIME 2} = \frac{24\text{ hrs}}{\text{day}} \times \frac{6\text{ days}}{\text{week}} \times \frac{52\text{ weeks}}{\text{yr}} \times \frac{60\text{ min}}{\text{hr}} = 3 \times \text{TIME 1}$$

The conversion from messages to characters is made by knowing that there are 120 characters per message for DRCOL and DIRESP messages and

40 characters per message for DIINQ messages. Finally the peak to average ratio is assumed to be 1.5. If Y equals BMV traffic in peak characters per minute then:

$$Y = 1.5 \left\{ \begin{pmatrix} \text{Number of} \\ \text{DIINQ Msgs} \end{pmatrix} \times \frac{1}{\text{TIME } 1} \times 40 + \begin{pmatrix} \text{Number of} \\ \text{DIRESP Msgs} \end{pmatrix} \times \frac{1}{\text{TIME } 1} \times 120 + \begin{pmatrix} \text{NUMBER OF} \\ \text{DRCOL Msgs} \end{pmatrix} \times \frac{1}{\text{TIME } 2} \times 120 \right\}$$

$$Y = 1.5 \left(1/3X \frac{1}{\text{TIME } 1} \times 40 + 1/3X \frac{1}{\text{TIME } 1} \times 120 + 1/3X \; 3 \frac{1}{\text{TIME } 1} \times 120 \right)$$

$$Y = 1.5X \, \{(200/(3x\text{TIME } 1)\}$$

$$\boxed{Y = .000668 \quad X}$$

After 1977, when vehicle registration renewals are added to the system, it is assumed that total traffic is 4.3 times as great as traffic volumes would have been had there been no addition of vehicle registration renewals. We further assume that for each vehicle registration renewal there will be a query of the vehicle registration file, the corresponding response, and the transmission of the updated file. Message lengths of these three message types are equivalent to DIINQ, DIRESP and DRCOL message types respectively. Peak characters per minute can thus be computed as before by using the equation

$$\boxed{Y = .000668 \quad X}$$

Using the above methods and assumptions we have generated Bureau of Motor Vehicle traffic estimates for the years 1977, 1979, 1981, 1983 and 1985. Traffic projections are equivalent whether or not BMV is integrated with LEADS. Projected values are:

	Number of Avg. Daily Messages	Peak Characters Per Minute
1977	8,965	1868
1979	78,887	16441
1981	84,907	17696
1983	92,357	19249
1985	98,362	20500

SECTION 7

NETWORK ANALYSIS AND DESIGN TOOLS

This section describes the principal network and analysis design tools developed and utilized during the STACOM Project.

Section 7.1 discusses the Network Topology Program. Section 7.2 develops the approach to network reliability and availability analysis. Sample calculations are presented for the Ohio LEADS systems. Section 7.3 derives the approach to network queueing analysis that leads to the development of network response time analysis techniques. Sample calculations are also given.

7.1 THE STACOM NETWORK TOPOLOGY PROGRAM

Two types of analysis are involved in designing a communication network. The first is concerned with arriving at acceptable line loadings; the second involves the achievement of optimal (least cost) line configurations. The STACOM program has been developed to accomplish both types of analysis.

Before describing the STACOM program itself, we will examine a state criminal justice information system and its communication network as an example of a typical communication network. We will then discuss the goal of the STACOM program.

7.1.1 State Criminal Justice Information System

An information system is usually developed to provide a systematic exchange of information between a group of organizations. The information system is used to accept (as inputs), store (in files or a data base) and display (as outputs) strings of symbols that are grouped in various ways. While an information system may exist without a digital computer, we will consider only systems which contain digital computers as integral parts.

Information systems can be classified in various ways for various purposes. If classification is by type of service rendered, the type of information system which serves a criminal justice community in a state can be considered as an information storage and retrieval system. This type of information system is the subject of our interest. For example, the state of Ohio has an information system with data base located at Columbus. The data base contains records on wanted persons, stolen vehicles and stolen license plates. Also included in the same computer are files of the Bureau of Motor Vehicles (BMV) which contain records on all licensed drivers and motor vehicles in the state.

7.1.2 State Digital Communication Network

For a given state information system, storage and retrieval of data to/from the data base can be accomplished in various ways for different user requirements. In general, the users of a state criminal justice information system are geographically distant from the central data base computer. Since fast turn-around time is a necessity for this particular user community, direct in-line access to the central data base by each criminal justice agency constitutes the most important user's requirements. In addition, it is required to quickly move message data from one agency to another at a different location. All of these goals require a data communication network. Because the computer deals only with digital data, only digital data communication networks are considered here.

A digital communication network consists mainly of a set of nodes connected by a set of links. The nodes may be computers, terminals or some type of communication control units in various locations, while the links are the communication channels providing a data path between the nodes. These channels are usually private or switched lines leased from a common carrier. A simple example of a network is given in Figure 7-1, where the links between modems are the communication lines leased from a common carrier. The communication control unit in city E is used to multiplex or concentrate several lower speed terminals onto a high-speed line. The line which connects cities C, D, and others is called multidrop line which connects several terminals to the data base computer.

7.1.3 A STACOM Communication Network

For the purposes of the STACOM study, a communication network is defined as a set of system terminations connected by a set of links. Each system termination consists of one or more physical terminals or computers located at the same city.

7.1.4 Communication Network Configurations

The communication network for an information system with a central data base computer will be one of three basic network configurations: the star, the multidrop, or distributed connection. These three types are shown in Figure 7-2.

As shown in the figure, the star network consists of four direct connections, one for each system termination. Each connection is called a central link. The multidrop network has one line with two system terminations and two central links. In the distributed network shown, more than one path exists between each individual system termination and the central data base.

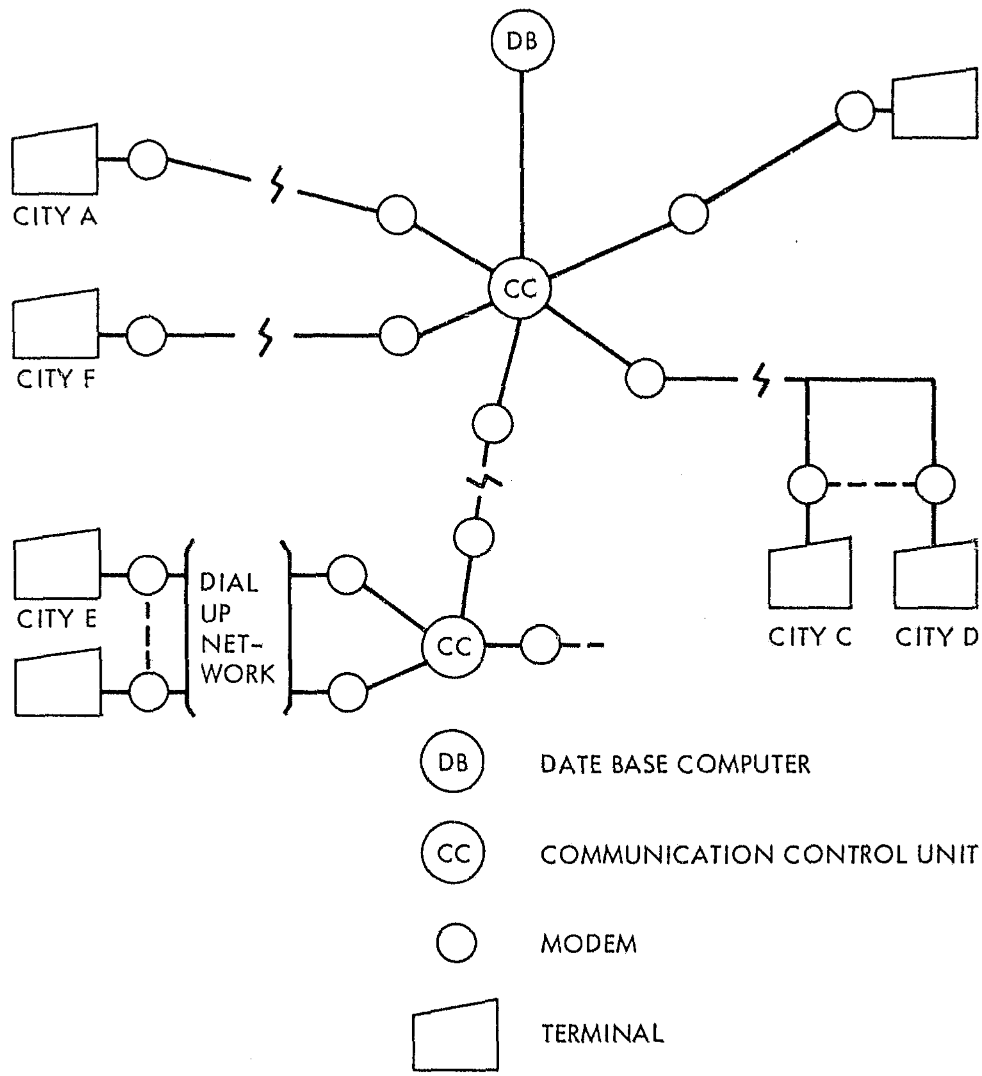


Figure 7-1. Example of a Digital Communication Network

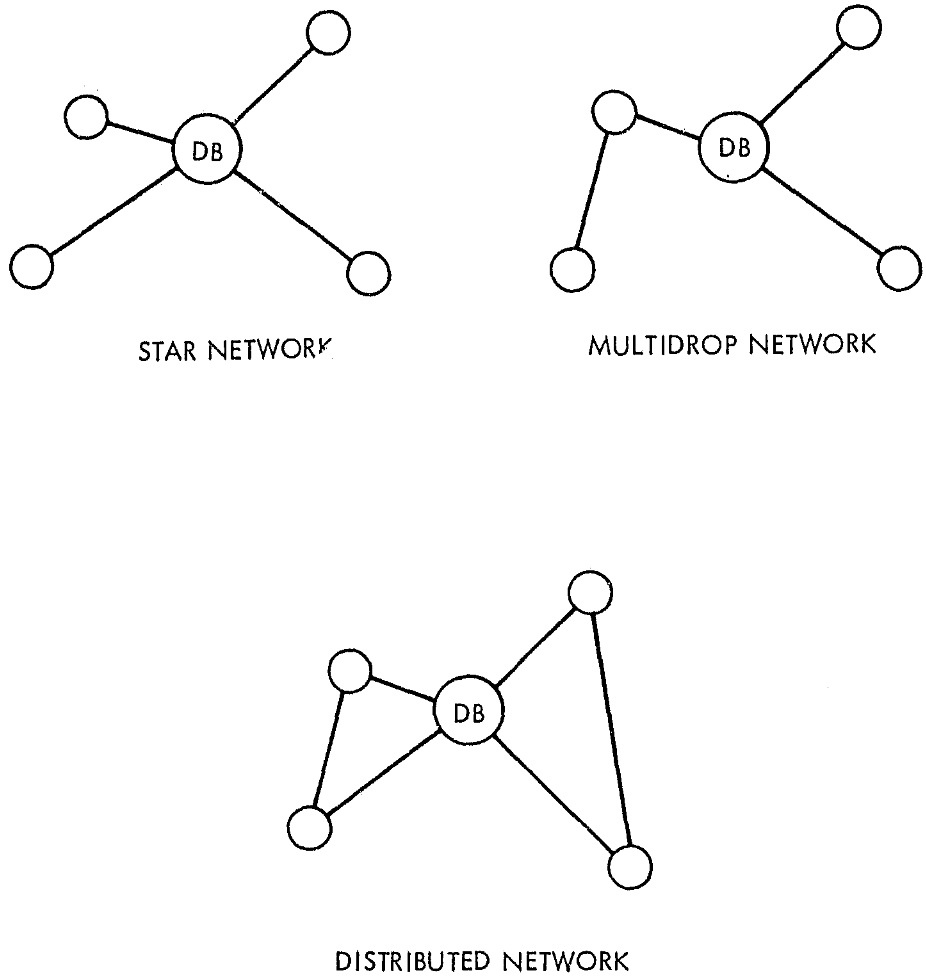


Figure 7-2. Basic Communication Network Configurations

7.1.5 Network Optimization

Given a communication network, the operating costs for the various types of lines or common carrier facilities required are governed by tariffs based upon location, circuit length and type of line. Experience suggests that the operating cost of a network can often be substantially reduced by an initial investment in a configuration analysis. In other words, some efforts in network optimization generally provide cost-saving.

There are two ways of constructing a communication network in a geometrical sense. One can divide a communication system into several regions, construct a minimum cost regional communication network for each region, and then build an inter-regional network connecting all of the regional centers to the central data base center. Each regional center is responsible for switching messages issued from and returned to each system termination in the region. Alternatively, one can consider the whole system as a region which is entirely made up of system terminations, and perform optimization for that region.

7.1.6 The STACOM Program and its Purposes

One of the objectives in the STACOM study is to design minimum cost and effective communication networks which will satisfy the predicted future traffic load for both selected model states, Ohio and Texas. In order to achieve this objective, the STACOM program was developed and utilized for the analysis and synthesis of alternative network topologies. It is also the project's goal that the final product be a portable software package which can be used as a network design tool by any user.

In network design, two major problems are the selection of a cost-effective line configuration for given traffic, and the design of a least cost network to arrive at lower operating costs.

The goal of the STACOM program is to provide a user with a systematic method for solving both problems. In other words, the main purpose of the STACOM program is to provide the network designer with a tool which he can use for line selection and for obtaining least-cost line connections.

7.1.7 Functions Performed by the STACOM Program

The STACOM program is a software tool which has been developed for the purpose of designing least cost networks in order to achieve lower operating costs. It utilizes a modified Esau-Williams technique to search for those direct links between system terminations and a regional switching center (RSC) which may be eliminated in order to reduce operating costs without impairing system performance below that specified. The RSC either provides a switching capability or is a data base center or both.

Inputs for the STACOM program contain data such as traffic, terminal locations, and functional requirements. The network may be divided into any number of desired regions in any given program run. Each region has an RSC which serves terminals in its region. RSCs are finally interconnected to form the complete network. Upon receipt of a complete set of input data, the program first performs formations of regions and, if needed, selection of RSCs. The program then builds a regional network in which only system terminations in the region are connected. The program then optimizes the regional network for each region requested by the user.

The formation of regions is performed by the program on the basis of attempting to arrive at near equal amounts of traffic for all regions. After finding the farthest unassigned system termination from the system centroid (a geographical center), the program starts formation of the first region by selecting unassigned system terminations close to this system termination until the total amount of traffic for that region is greater than a certain percentage (90% in this implementation) of the average regional traffic. The average regional traffic is simply the total network traffic divided by the number of desired regions. The same process is repeated by the program in forming the rest of the regions.

The selection of an RSC is based on the minimal traffic-distance product sum. In the selection process, each system termination is chosen as a trial RSC and the sum of traffic-distance products is then calculated. The location of the system termination which provides the minimal sum is then selected as the RSC. The location of the RSC for a given region may also be specified by the user. The optimization process consists of two basic steps, i.e., searching for lines whose elimination yields the best cost saving, and updating of the network. The two steps are repeated until no further saving is possible.

Before performing network optimization, the STACOM program constructs an initial star network in which each system termination is directly connected to the regional center. It then starts the optimization process. At the termination of this process, a multidrop network is generally developed. In a multidrop network, some lines have more than one system termination; these are called multidrop lines.

When needed, the STACOM program will continue to form an interregion network, which consists of a set of regional centers and has a direct link between any two region centers. The program then performs optimization on the network.

The process for interregional network optimization involves the same two steps: searching and updating. However, the searching step is primarily for finding an alternate route to divert traffic between two regional switching centers with the best saving.

Based on the data provided, a successful run of the STACOM program generates a regional printer output and, if requested, a CalComp plot. The printer output contains data such as initial regional network and optimized network, assignments of system terminations, etc. The CalComp plot shows the geographical connections of the optimized network in which multidrop line actually connects all of the system terminations.

Figure 7-3 gives examples of regional star networks and initial inter-regional network; Figure 7-4 gives examples of optimized regional networks and inter-regional network obtained from Figure 7-3.

7.1.8 Main Features

As described in Paragraph 7.1, the STACOM program has been developed for the purpose of performing analysis and synthesis of alternative network topologies. The following is a list of features which characterize the STACOM program:

(1) The Esau-Williams routine has been modified, tested, and utilized for determining near optimal (least cost), network topology.

(2) A tree type structure is used as the storage structure in the program.

(3) The program execution has been made flexible; for example, constraint on response time for a multidrop line is an input parameter.

(4) A response-time algorithm has been implemented in the program.

(5) A CalComp plotting routine has been included for drawing resulting multidropped networks.

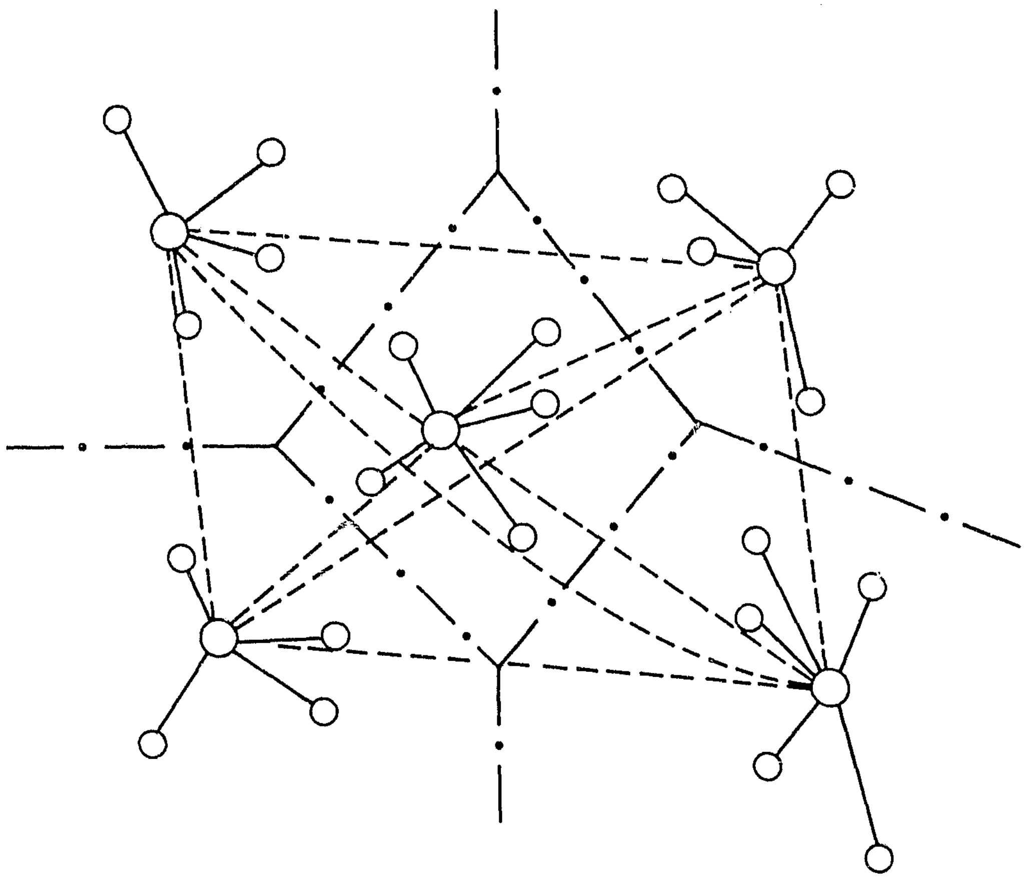
In the rest of this subsection, these main features are discussed in detail.

7.1.8.1 <u>Structure</u>

7.1.8.1.1 <u>Storage</u>. Since a multidrop network can be viewed as a tree composed of sub-trees, it was determined that a tree-type data structure would be appropriate and convenient for representing a multidrop network.

A tree-type storage structure is therefore needed in the program. This tree-type storage structure is implemented by defining a set of storage cells.

Each system termination (data) is represented internally by a storage cell in the program. Each cell consists of five fields and each field occupies one word (i.e., a 36-bit word for UNIVAC 1108 computers).



○ REGIONAL SWITCHING CENTER

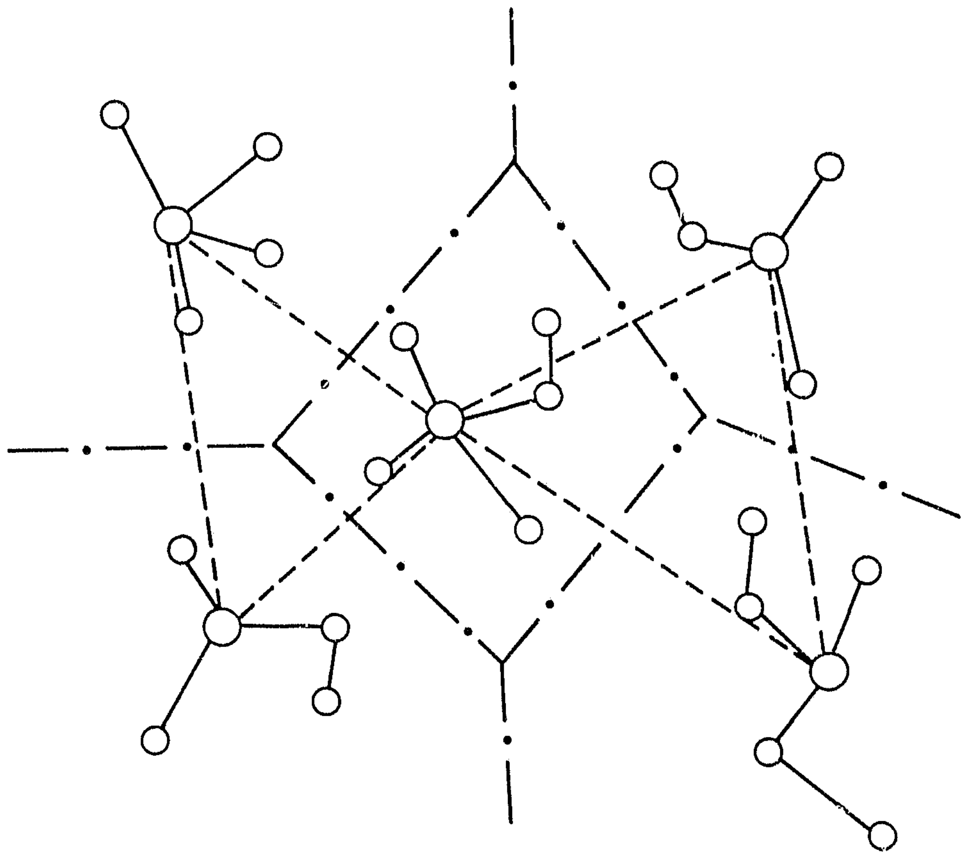
o SYSTEM TERMINATION

—— LINE CONNECTION BETWEEN SYSTEM TERMINATIONS

– – – LINE CONNECTION BETWEEN RSCs

–·–·– REGIONAL BOUNDARY LINE

Figure 7-3. Example of Initial Region Network and Initial Interregion Network



O REGIONAL SWITCHING CENTER
o SYSTEM TERMINATION
——— LINE CONNECTION BETWEEN SYSTEM TERMINATIONS
— — — LINE CONNECTION BETWEEN RSCs
—·—·— REGIONAL BOUNDARY LINE

Figure 7-4. Example of Optimized Regional Networks and Optimized Interregion Network

Defining that system termination X as a successor of Y, and Y a predecessor of X if X branches out from Y, and defining X as the root of a tree if it has no predecessor before it, then the basic storage cell for system termination A can be described as follows:

A

I_A

f_1	f_2	f_3	f_4	f_5

Let $c(f_i)$ = content of i-th field in a storage cell I_A, where I_A is an internal index for a system termination A (data), then

$c(f_1)$ = no. of system terminations under A

$c(f_2)$ = a pointer which points to the first successor of A

$c(f_3)$ = a pointer which points to the next system termination whose predecessor is the same as A's

$c(f_4)$ = a pointer which points back to the previous system termination whose predecessor is the same as A's

$c(f_5)$ = a pointer which points to A's predecessor

When there is a "zero" in a field, this indicates there is no one relating to A under that specific relationship. Given a tree as Figure 7-5, A is root of the tree; it has 4 descendents, i.e., B, C, D, and E. Figure 7-6 is the internal representation of that relationship among indice I_A, I_B, I_C, I_D and I_E which are internal cardinal numbers for system terminations A, B, C, D and E.

The first field of storage cell I_A indicates that there are 4 system terminations under I_A; the pointer to I_B says that I_B is its first successor. Since I_A is the root of the tree, the other three fields are left with zeroes.

In the case of I_C, I_D is its next successor of I_A, and its previous successor of I_A is I_B. Its third field has a pointer pointing to I_D, and its fourth field a pointer pointing to I_B.

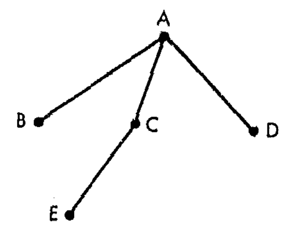


Figure 7-5. A Tree with A as its Root

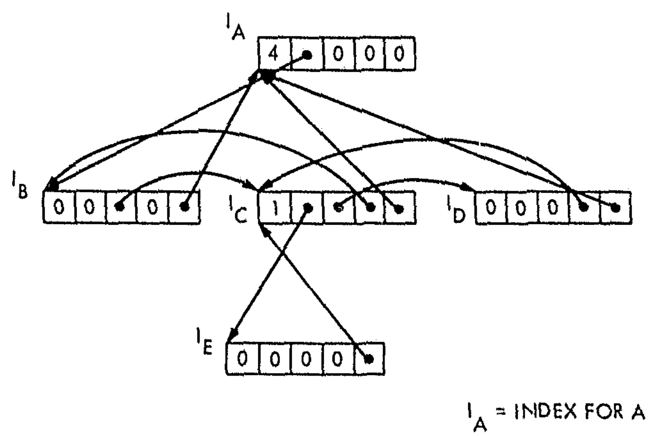


Figure 7-6. Internal Representation of the Tree in Figure 7.5

7.1.8.1.2 Program. The STACOM program consists of twelve functionally independent routines. Figure 7-7 shows the basic structure of the program. The functional interrelationship is indicated by arrows.

An arrow from routine A to routine B indicates that routine B will be called upon by routine A during its execution. In addition, all of these routines communicate to each other through the COMMON block besides the normal subroutine arguments.

Major functions of these eleven routines are given below:

(1) MAIN Routine
This is the master routine of the STACOM program. In its execution, it reads in all the data required from an input device (card reader or demand terminal) and performs calculations of distances between any two system terminations. It assigns system terminations to

regions, and, if necessary, selects the regional switching center by finding the system termination in the region with the minimal traffic-distance product sum. It calls upon routine RGNNET to build a star network and then performs network optimization, if required, for each of these regions.

It also performs the construction of an inter-regional network and its optimization by calling subroutine IRNOP.

In addition to these processings, the MAIN routine also prints out distance matrix, traffic matrix, and lists of system terminations by region.

(2) RGNNET Routine
This routine is called upon to act only by the MAIN routine. Its main functions are the formation and optimization of regional star networks. During the formation of a regional star network, each system termination is linked directly to the designated or selected Regional Switching Center (RSC) by assigning the RSC index to the last field of each associated storage cell. Tree relationships are built among system terminations by assigning pointers to the third and fourth fields of each storage cell. The resulting star network is then printed on the printer.

The optimization process utilizes the Esau-Williams algorithm with some modifications. It consists of two steps: searching for a central link (a direct link from a system termination to RSC) with best cost savings under constraints (such as response-time requirement), and subsequent network updating. This network optimization process is executed only upon request. When no further cost improvement is possible, this routine prints a resulting network with data such as number of system terminations and the response time, traffic, cost, etc., associated with each multidrop line. Routine PLOTPT is then called upon to plot the resulting network layout.

(3) IRNOP Routine
This routine is called upon to act by routine MAIN. It forms an interregional network and then performs its optimization. The interregional lines are assumed to be full-duplex lines. During the optimization process, no line between two RSCs can be eliminated if traffic between them cannot be handled through only one intermediate RSC. Also each RSC requires at least two lines to other RSCs.

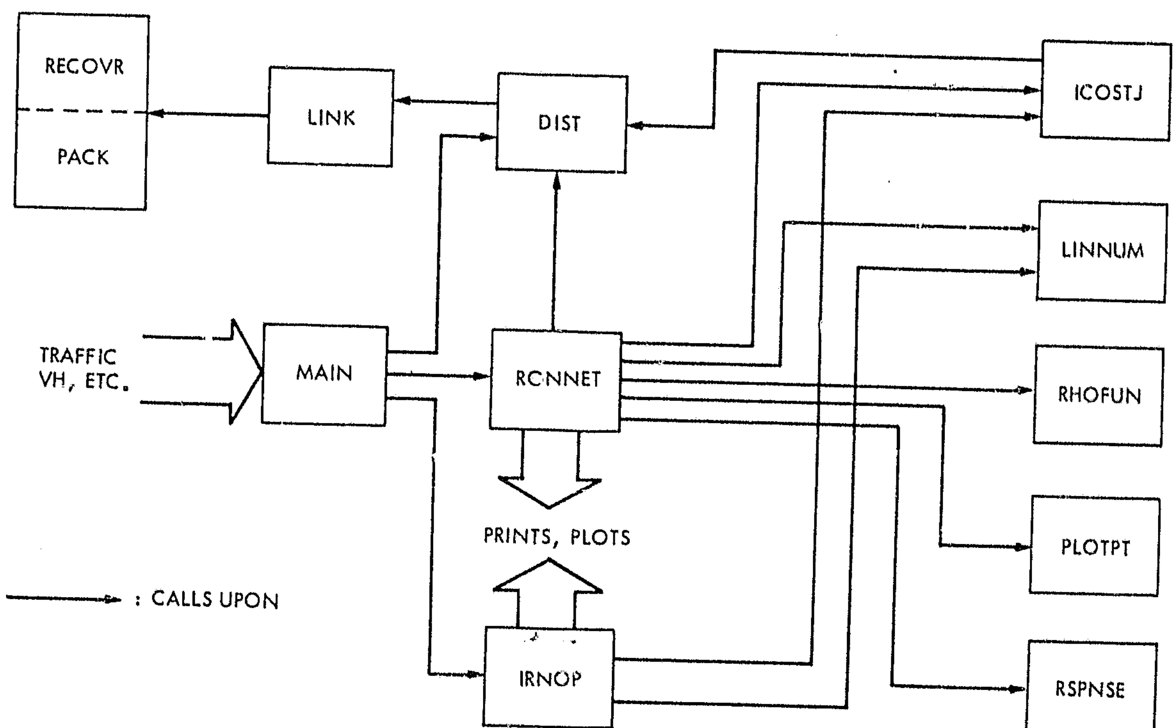


Figure 7-7. STACOM Program Structure

(4) LINNUM Routine
This routine provides an estimated line configuration required to satisfy a given traffic and is mainly called upon by routine RGNNET. During its execution, utilization of selected lines are calculated against the given traffic by calling RHOFUN so that effective line utilization is less than the pre-determined number.

(5) RHOFUN Routine
This routine calculates the line effective utilization for a given traffic and line configuration.

(6) ICOSTJ Routine
Given the line configuration and indices for any two system terminations, this routine calculates the installation costs and annual recurring costs for the line and other chargeable items required. In calculating line costs, it calls upon routine DIST for distance data between two given system terminations. Resulting cost data are arranged by chargeable item type.

(7) DIST Routine
This routine retrieves distance data between any two system terminations by calling routine PACK. When the distance is greater than 510 miles, it retrieves distance data by calling routine RECOVR.

(8) PACK Routine
This routine stores or retrieves distance data between any two system terminations. It is called upon by routine MAIN for distance data depositing, and called upon by routine DIST for its retrieval. For the purpose of saving storage, distance data has been compressed, and each 36-bit word has been divided into four subwords of 9 bits. Therefore, any distance datum with value equal to or greater than 511 is stored in another specified area; its retrieval calls upon routine RECOVR.

(9) RECOVR Routine
During distance data retrieval in the execution of the DIST routine, if the return value from routine PACK is 511, this routine will be called upon to provide the actual distance data, which is equal to or greater than 511.

(10) LINK Routine
Since the distance between any two system terminations I and J is independent of how I and J are referred to, the routine LINK provides a mechanism for preserving such an independency by mapping I and J into an absolute index.

(11) PLOTPT Routine
This routine provides instructions for plotting a given point on a CalComp plotter. Location of a point is calculated by its associated V-H coordinates.

7.1.9 Response Time Algorithm - RSPNSE Routine

There is a limit on the number of terminals which can be linked together by a multidropped line due to constraints on reliability and response time. However, it would be an oversimplification to just use a particular number as the main constraint in determining how many terminals a multidrop line can have. In reality, the response time of a given multidrop line depends on the amount of traffic, the number of terminals on the line, and very heavily, on the number of transactions to be processed in the data base computer system.

In the STACOM program, a response time algorithm is implemented in such a way that during the network optimization process it is used to accept or reject the addition of a given terminal to a multidrop line. This response time routine calculates the average response time on the given multidrop line, given the number of terminals and amount of peak traffic on the line. Before its inclusion in the STACOM program, the fidelity of this algorithm was evaluated by simulation and found to be acceptable.

7.1.10 Flexibility

At the outset of the STACOM project it was anticipated that the STACOM program would be used for states with varying traffic requirements; it was decided that the resulting program should be as flexible and general as possible. With this in mind, the STACOM program has been implemented with the following features which make it flexible and thereby enhance its capabilities:

(1) Rate Structures, Line Types, and Chargeable Items

Because a state can have more than one rate structure (tariff) applicable at any one time, the STACOM program has been designed to accommodate this.

Under a specific rate structure, any combination of line types with their names, line capacities, and basic cost figures can be prescribed to the program. In addition to the line cost, any number of chargeable items associated with each line type can be prescribed to the program. For example, any combination of cost items such as service terminals, drops, modem and others can be used. Furthermore, under the Multischedule Private Line (MPL) tariffs given by AT&T for interstate communication lines, the monthly line charge between any two terminals is now a function of both the inter-city distance and the traffic densities of both terminal cities.

The STACOM program has been implemented in such a way that it can take line-cost figures based on MPL tariffs or other tariffs.

(2) Region Formation, Switcher Selection, and Network Optimization.

Given a set of system terminations dividing them into regions can be performed in either of the following ways: the user can preassign some or all of the terminations into preselected regions, alternatively the user can let the program perform the region formation by simply providing the system centroid. Following the formation process, the STACOM program will start selecting regional switching centers for regions without a preassigned switching center. The process of regional network formation and its optimization will then follow.

(3) Number of Terminals per Multidrop Line and Average Response Time

It may be desirable to set a limit on the number of terminals on a multidrop line. In its implementation, the STACOM program takes this number from the user's input data as a constraint during its optimization process.

Besides the limit on the number of terminals allowed on a multidrop line, a good network design also requires a constraint on the average terminal response time on a multidrop line. The STACOM program allows a user to specify the limit on a run basis.

7.1.11 Programming Language

The STACOM program is implemented with the FORTRAN V language of UNIVAC systems, compiled with the EXEC-8 FORTRAN Preprocessor and mapped by its MAP processor.

7.1.12 Operating System Requirements

The EXEC-8 operating system of the UNIVAC 1108 computer has been used in the development of the STACOM program. The current edition of the STACOM program can only be executed under the EXEC-8 system. Furthermore, since a CalComp routine is linked with the program, the plotter must be part of the operating system. If such a hardware unit is not included in the system, the STACOM program must be updated to reflect this environment.

In addition, the current STACOM program has been designed with the feature that all the desired output be put into a FORTRAN file designated as 100. Before executing this program, a file with the name 100 must be assigned. Otherwise, regular WRITE unit 6 will be the destination output file, e.g., print output will go to the user's demand terminal when it is run as a demand job.

As an example, the following is a complete list of EXEC-8 control statements which need to be prepared or typed in after the run card for properly executing the STACOM program.

```
@ASG,UP 100
@SYM,P PUNCH$,,G9PLTF
@XQT File.Element
          ⁓
       (data)
          ⁓
@BRKPT 100
@FREE  100
@SYM   100,,T4
```

The @SYM,P command directs the resulting plot card images to a CalComp plotter designated G9PLTF. The last @SYM command directs print output to the slow hardcopy printer designated T4.

7.1.13 Functional Limitations

While the STACOM program has been designed and implemented with the intention that it be applicable as widely as possible, it does have certain limitations. These are due mainly to the limit of program size (sum of I and D bank) allowed under the EXEC-8 system for simplistic programs. The maximum program size allowed is 65k words per program. Although it is more convenient for later use to assign all parameters with maximum values as long as the overall program size is within limits, this results in greater expense in later use of the program due to the higher core-time product. Therefore, it is recommended that all parameters be set at values just high enough for anticipated use.

After setting parameter values, the STACOM program capabilities are then limited to these assigned values. If a run requires that certain parameter value be exceeded, the STACOM program must be recompiled and remapped.

7.2 SYSTEM RELIABILITY AND AVAILABILITY ANALYSIS

While cost may be a major concern in deciding the option for network implementation when several alternatives are available, the factor of system reliability (survival probability) and availability as a function of alternate option does deserve some considerations. The reliability and availability of a system not only depends on how the system is built up, it also depends on how each component of the system behaves as time passes by. In the following sections, we will present assumptions and definitions of terms and equations which are to be used later in calculating system reliabilities and availabilities. The constraints of subsystems to be investigated and results from applying these equations for both Ohio and Texas are then presented.

7.2.1 Assumptions

The true reliability (survival probability) of a given component as a function of age is impossible to describe exactly and simply. However, in many cases, a component's reliability can be practically and usefully represented as a unit with a "bathtub" shape failure rate function as shown in Figure 7-8. In other words, a component can be well described as having a failure rate that is initially decreasing during the infant mortality phase, constant during the so-called "useful life" phase, and, finally, increasing during the so-called "wear-out" phase.

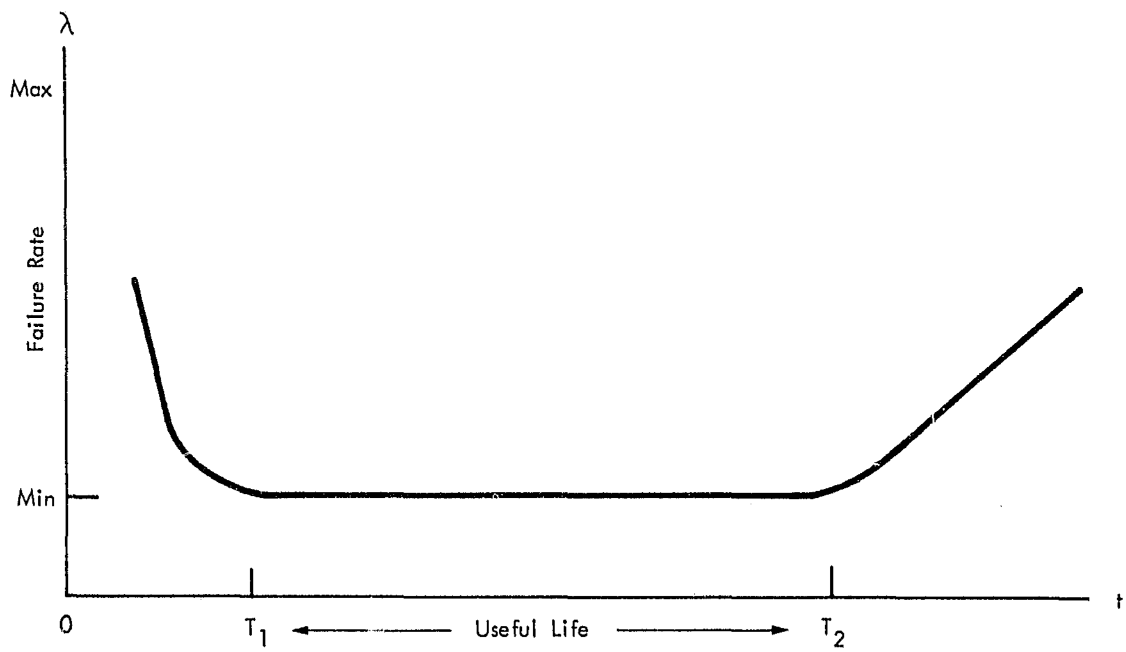


Figure 7-8. "Bathtub" Failure Rate Function

In this study, we assume that all components are to be operated within the constant failure rate phase. Several distribution functions do have such a constant failure rate case. However, in the following discussions, we use the exponential distribution to represent the reliability function for each individual component. An important property of the exponential distribution is that the remaining life of a used component is independent of its initial age (the "memoryless property"). With the exponential distribution it follows that:

(a) Since a used component is as good as new (statistically), there is no advantage in following a policy of planned replacement of used components known to be still functioning.

(b) The statistical estimation data of mean-life, percentiles, reliability and so on, may be collected on the basis only of the number of hours of observed life and of the number of observed failures; the ages of components under observation are irrelevant.

7.2.2 Definition

For the purpose of convenience in later discussions, we give definitions to the following terms and notations:

(a) λ_i = Failure rate for component i

(b) μ_i = Mean time between failures (MTBF) for component i

(c) ν_i = Mean time to repair (MTTR) for component i

(d) R(t) = Reliability function as a function of time, t

(e) A(t) = Availability function as a function of time, t

(f) A_{av} = The limiting average availability

(g) $\gamma_i = \nu_i/\mu_i$

(h) λ = System failure rate

(i) μ = System MTBF

(j) ν = System MTTR

7.2.3 System Reliability and Availability

Given a system with n (≥ 2) components, it is in general impossible to derive its exact reliability and availability. However, if the statistical interrelationship among its components can be described, we can then relate the system reliability and availability to the reliabilities and availabilities of the components. For the simplest case, if all of the components are statistically independent and each of them has a constant failure rate λ_i, then the overall system reliability R(t) for a series system (a system which functions if and only if each component functions) is

$$R(t) = e^{-\lambda t} \tag{1}$$

where $\lambda = \sum_{i=1}^{n} \lambda_i$

n = number of components in the system

If the system has a parallel structure (a system which functions if and only if at least one component functions), its reliability becomes

$$R(t) = 1 - \prod_{i=1}^{n} \left(1 - e^{-\lambda_i t}\right) \tag{2}$$

where denotes the multiplication operation.

Furthermore, for a series system, its limiting average system availability can be described as

$$A_{avg} = \left(1 + \sum_{i=1}^{n} \gamma_i\right)^{-1} \tag{3}$$

and the average of system downtime (MTTR) becomes

$$\nu = \mu \sum_{i=1}^{n} \gamma_i \tag{4}$$

where μ = system MTBF

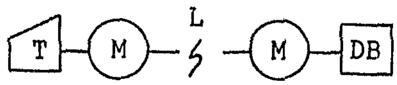
$$= \left(\sum_{i=1}^{n} 1/\mu_i\right)^{-1} = \left(\sum_{i=1}^{n} \lambda_i\right)^{-1} \tag{5}$$

7.2.4 System Reliability and Availability for the Ohio Network

7.2.4.1 Reliability System Structures. The communications network for Ohio currently consists of one central switcher with data bases and may have regional switchers in the future. The regional switchers serve as intermediate message switchers between local terminals and the central switcher. With this in mind, the reliability system structures from an individual user terminal can be described as follows:

Case 1 - One Central Switcher with Data Bases.

Figure 7-9 shows the reliability system structure for the user terminal when its communication with the data bases has to go through the central switcher directly.



where  = user terminal

 = Modem

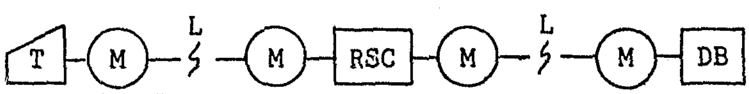
 = Columbus data base computer, i.e., Univac 1100/42

L = communication line from the user modem to the central switcher modem

Figure 7-9. Ohio Reliability System Structure for Case 1

Case 2 - One Central Switcher with One Regional Switcher

In another configuration, the user terminal communicates with the central switcher with the data bases through the regional switcher. Its reliability system structure can be described as Figure 7-10.



Where  = Regional Switching Center

Figure 7-10. Ohio Reliability System Structure for Case 2

7.2.4.2 Empirical Components' Failure Statistics. With reliability system structures obtained, estimation of system availability and reliability is then obtainable by simply applying empirical statistics for system components. Table 7-1 shows failure statistics for all of relevant components as given in Ohio reliability system structures. These data were provided by different sources, as indicated in the table. The statistics for the terminals were provided by vendor Bee-Hive, Inc.; these terminals have capacities of 1200 bps and up. For the switcher computer, the data provided by Action, Inc. was used.

7.2.4.3 System Reliabilities and Availabilities.

Case 1:

The effective failure rate for this system is equal to

$$\lambda_1 = \lambda_T + 2\lambda_M + \lambda_L + \lambda_{DB} + \lambda_{ENV} \text{ (Environment)}$$
$$= 0.02966$$

Its reliability function as a function of time becomes

$$R_1(t) = e^{-\lambda_1 t} = e^{-0.02966\, t}$$

Applying t = 24, $R_1(24)$ becomes 0.491.

In other words a terminal user will expect to have on the average one daily failure, half of the time for an expected 24-hour operation period.

Similarly,

$$\gamma_1 = \gamma_T + 2\gamma_M + \gamma_L + \gamma_{DB} + \gamma_{ENV}$$
$$= 0.012182$$

and its average availability is equal to

$$A_1 = (1 + 0.012182)^{-1} = 0.9880$$

In other words, given a 24-hour operational period, the system will have on the average a sum of 1440 x (1-0.998) = 17.3 minute outages. These results are tabulated in Table 7.2.

Table 7-1. Empirical Components Failure Statistics

Component	μ_i MTBF (hours)	ν_i MTTR (hours)	$\lambda_i=1/\mu_i$ Failure Rate ($\times 10^{-3}$)	A_i Average Availability	$\gamma_i={\nu_i}/\mu_i$ ($\times 10^{-3}$)	Source
Terminal	6000 to 1000	4-5	0.167	0.9993 0.9994	0.83	Bee-Hive Inc.
Modem	5000	3	0.2	0.9994	0.6	Ohio Western Union
Line	668.5	1.4	1.496	0.99791	2.1	Ohio Western Union
Columbus Data Base Computer	37.3	0.24	26.81	0.9936	6.43	Ohio DPS
Ohio DB Environment	350.8	0.57	2.85	0.9984	1.62	Ohio DPS
Switcher Computer	1000	3	1	0.997	3.01	*

*STACOM Team Estimate; UNIVAC Data Unavailable

Table 7-2. Ohio System Reliabilities and Availabilities for a 24-hour Operation Period

	System 1	System 2
Reliability	0.491	0.4357
Availability	0.9880	0.9818
Daily Outage	17.3 minutes	26.2 minutes

Case 2:

The effective system failure rate is equal to

$$\lambda_2 = \lambda_T + 4\lambda_M + \lambda_{RSC} + 2\lambda_L + \lambda_{DB} + \lambda_{ENV}$$
$$= 0.034619$$

and its reliability function becomes

$$R_2(t) = e^{-0.034619\,t}$$

Applying $t = 24$, $R_2(24)$ becomes 0.4357.

In addition, the system availability is obtained by letting

$$\gamma_2 = \gamma_T + 4\gamma_M + 2\gamma_L + \gamma_{RSC} + \gamma_{DB} + \gamma_{ENV}$$
$$= 0.01849$$

and it is equal to

$$A_2 = (1 + 0.01849)^{-1} = 0.9818$$

In other words, given a 24-hour operational period, on the average the system will have a sum of

$$1440 \times (1 - 0.9818) = 26.2 \text{ minute outages}$$

These results are also tabulated in Table 7-2.

7.3 RESPONSE TIME ALGORITHM

This section describes a network response time algorithm which models mean response time values at network user terminals. Response time is defined as that time interval between the time a network user initiates a request for network service and the time at which a response is completed at the users inquiring terminal.

Section 7.3.1 describes a general approach to network response time modeling. Following this background material, specific models used in Ohio are discussed in Sections 7.3.2.

7.3.1 General Response Time Modeling Approach

7.3.1.1 <u>Approach</u>. Components of the model described in this section can be assembled to mimic response time behavior at any terminal imbedded in any network configuration incorporating terminals, lines, message switching computers and data base computers.

To facilitate discussion, we shall consider the components for a response time model for the general network depicted in Figure 7-11, although the principles of model component development apply to any network configuration.

In the network shown, Regional Switching Computers, (RSCs), service terminals within their defined regions. RSCs from each region are connected to a central RSC which provides a data base for inquiry/response transactions.

The longest response time at a system termination will occur on a multi-dropped line served by a remote RSC. The response time model discussed here treats this condition.

Figure 7-12 presents a simplified drawing of the configuration of interest. The remote RSC services a multidrop of M terminals and receives a single regional traffic load from all other terminals in the region. In our discussion, intraregion lines are half duplex and interregion lines are full duplex. Again, the general approach is not limited to these specific choices.

The central RSC connected to the data base receives traffic from the remote RSC of interest, and from both terminals in its region, and other RSCs in the network.

In this scheme, messages transmitted from multidrop terminals to the data base and back to the appropriate multidrop terminal, encounter a series of queues.

The total time spent in any queue is defined as the time spent waiting for service from a facility plus the time spent by the facility in servicing the transaction. The response time model developed here considers average or mean values for all variables, so that,

$$E(\text{Queue Time}) = E(\text{Wait Time}) + E(\text{Service Time})$$

Facilities in the model consist of transmission lines and computers.

Figure 7-13 shows seven distinct queues encountered by a data base inquiry and response operation from a multidropped terminal. The wait time and service time components of each queue are delineated in the figure. Inquiry input to the data base moves across the top of the figure from left to right. Response output from the data base moves across the bottom of the figure from right to left. Each of the queues, seven in all, are numbered for later easy reference when specific equations are discussed.

Each of the queues is considered to be a single server queue, with the exception of the data base RSC computer which may be treated as a double server queue (dual CPUs) if desired.

7.3.1.2 General Equations. We shall now develop a set of general equations for a response time model. In this model, response time is defined as that time from initiation of a request for network service at a terminal to the time that a response is completed at the requesting terminal. We wish to develop equations for the queues outlined in Figure 7-13 for a network capable of handling three types of message priorities. In addition, for purposes of this discussion, output from the computer onto the multidrop line is given priority over input messages to the computer from the multidrop line.

Thus, there are really 4 types of priorities to deal with. Consider the three message priority types as being

Priority 1 = Message type A
Priority 2 = Message type B
Priority 3 = Message type C

Then, on the multidrop, the model will need to handle the following four priority types

Priority 1 = Output of Message type A
Priority 2 = Output of Message type B
Priority 3 = Output of Message type C
Priority 4 = Input of all Message types

This approach is necessary since messages cannot be prioritized until they reach a computer, at which point, message types can be examined and appropriate priorities assigned to each. It is assumed here that it is not desirable to allow network users to assign priorities to messages.

On interregion full duplex lines, output does not interfere with input so that the model need deal with input and output of the three priority types, messages A, B, and C only.

The following assumptions are made for model development:

(1) Traffic arrival patterns at facilities are Poisson.

(2) Inter-arrival times of messages are exponentially distributed.

(3) Output messages from the computer to the multidrop line have priority over input messages from the terminals to the computer.

(4) Message dispatching is first in, first out, (FIFO).

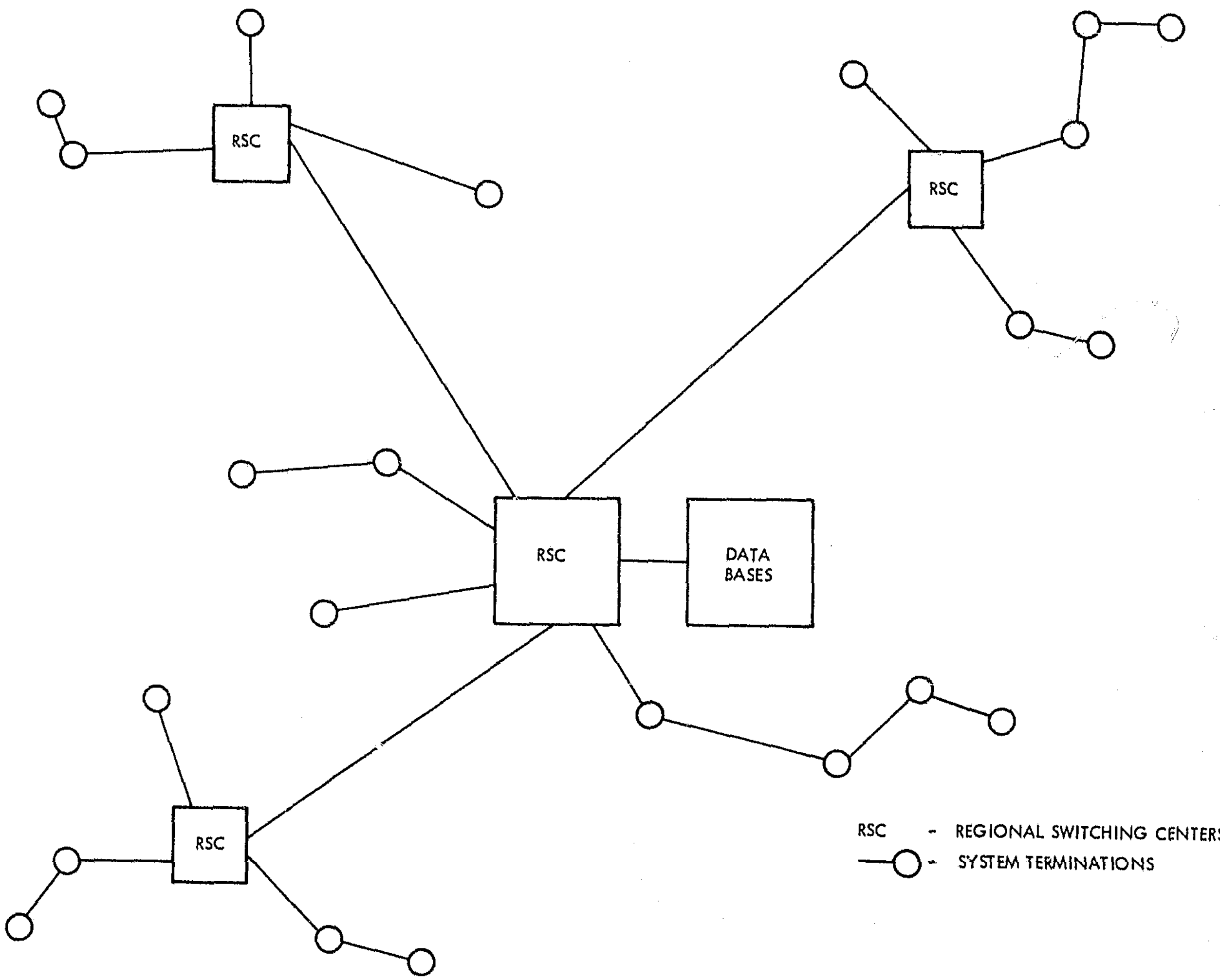


Figure 7-11. A General Network

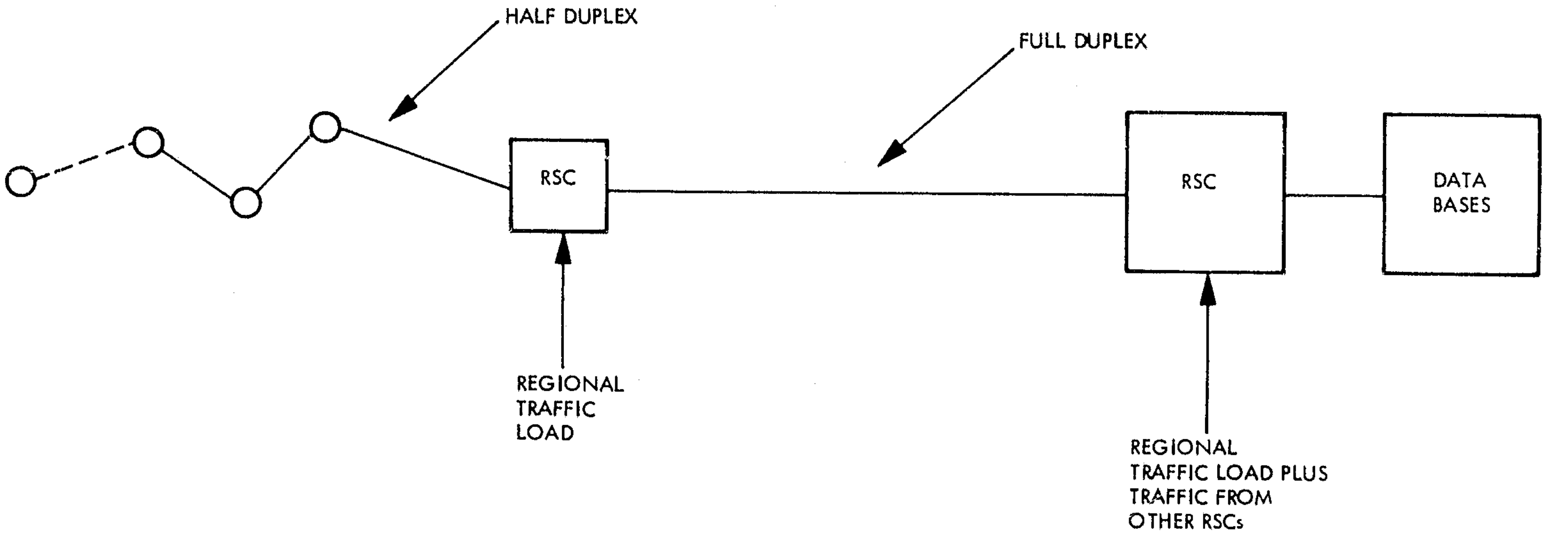


Figure 7-12. Simplified Configuration For Response Time Analysis

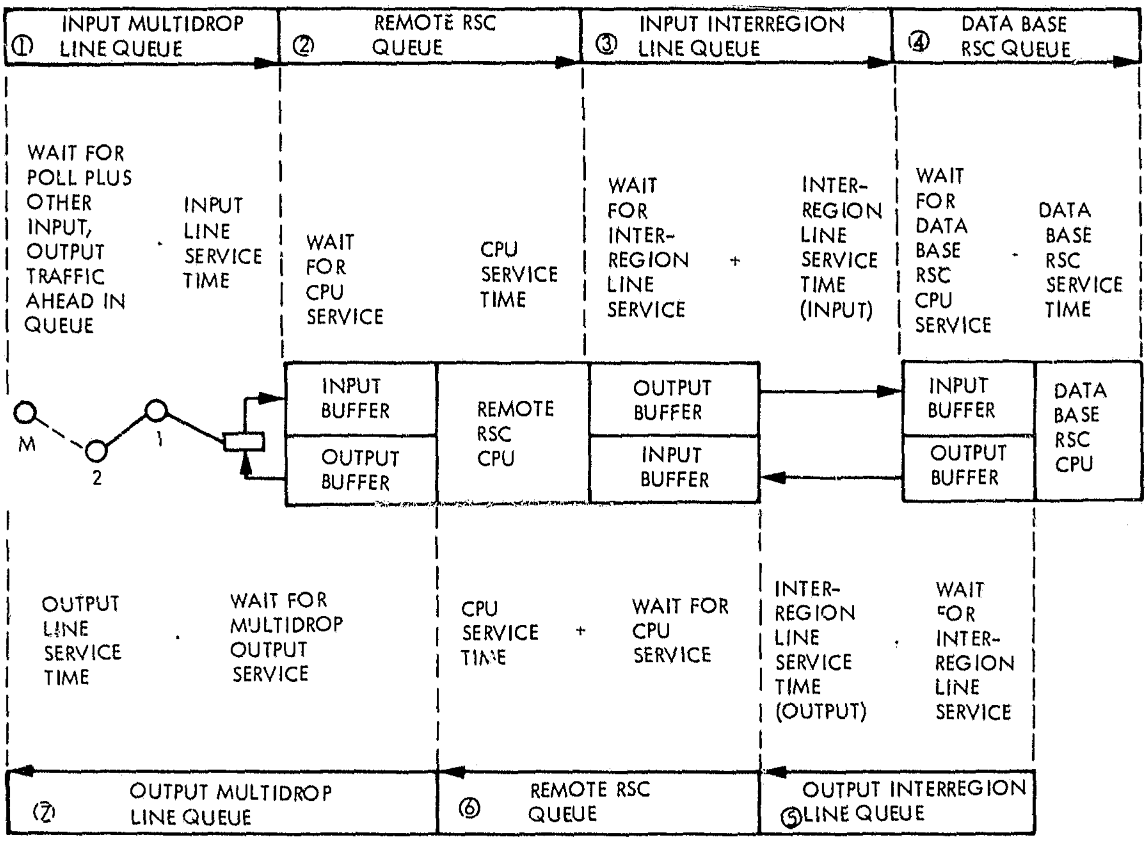


Table 7-13. System Message Queues

(5) No messages leave queues without first being serviced.

(6) Polling is cyclic on the multidrop with equal weighting for each terminal.

(7) Message handling is on a non pre-emptive basis, that is, messages are not interrupted once they are placed on a transmission line.

(8) When dual CPU's are considered, they are assumed to be evenly loaded.

(9) Users on the multidrop line do not hold the line for more than one message before polling is resumed.

Under conditions of the above assumptions, the mean waiting time, E(tw), in a single server queue is

$$E(tw) = \frac{\rho E(ts)}{1 - \rho} \qquad (1)$$

where E(ts) = mean service time (sec)

and $\rho = E(n) \times E(ts)$

where E(n) = average number of transaction arrivals per second

The mean queue time is therefore

$$E(tq) = E(tw) + E(ts)$$

or

$$E(tq) = \frac{\rho E(ts)}{1 - \rho} + E(ts)$$

or simplified

$$E(tq) = \frac{E(ts)}{1 - \rho} \qquad (2)$$

The term, ρ, is a measure of facility utilization and is equal to the fraction of time that a facility is in use serving transactions. The term, ρ, takes on values betwen 0 and 1. When $\rho = 1$ it means that the facility is 100% utilized. We shall see that ρ values should generally not exceed 0.700.

For dual server queues, such as computers with twin processors where an incoming transaction is serviced by the first processor which is not busy, the waiting time for service, E(tw), is given by

$$E(tw) = \frac{\rho^2}{1 + \rho} \frac{E(ts)}{1 - \rho} \qquad (3)$$

and in this case the traffic value, E(n), should be halved in calculating ρ; that is

$$\rho = \frac{E(n)}{2} E(ts)$$

Before presenting specific equations for the queues outlined in Figure 7-13, we shall consider the general equations for waiting times when it is desired to handle messages of different priority types.

The ability to prioritize messages can be an important network feature when there is a mixture of long and short messages on the network, that is, when there is a wide range of average message lengths for different message types. For example, in the law enforcement environment, when long message types such as digital fingerprint data, Computerized Criminal History data, digital facsimile data or long administrative messages are included in a network along with shorter inquiry/response messages related to officer safety, it may be expedient to transmit the latter message types with a higher priority over the network to insure shorter response times for these more important message types.

The response time model is capable of handling up to four message priority levels. The mean wait time components of mean queue times for the four priority levels are given below. Priority 1 is the highest priority.

Mean wait time, Priority 1,

$$E(tw1) = \frac{\rho E(ts)}{1 - \rho_1} \qquad (4)$$

Mean wait time, Priority 2,

$$E(tw2) = \frac{\rho E(ts)}{(1 - \rho_1)(1 - \rho_1 - \rho_2)} \qquad (5)$$

Mean wait time, Priority 3,

$$E(tw3) = \frac{\rho E(ts)}{(1 - \rho_1 - \rho_2)(1 - \rho_1 - \rho_2 - \rho_3)} \qquad (6)$$

Mean wait time, Priority 4,

$$E(tw4) = \frac{\rho E(ts)}{(1 - \rho_1 - \rho_2 - \rho_3)(1 - \rho)} \qquad (7)$$

In the above equations

ρ_i = facility utilization due to priority i message type i = 1, 2, 3, 4

and $\rho_i = E(n_i) \times E(ts_i)$

where $E(n_i)$ = arrivals per second of priority i type messages

and $E(ts_i)$ = service time for priority i type messages

so that the total facility utilization

$$\rho = \rho_1 + \rho_2 + \rho_3 + \rho_4$$

and the total message arrivals per second

$$E(n) = E(n_1) + E(n_2) + E(n_3) + E(n_4)$$

Finally, in the model, there are two types of service times to be calculated. One is service time for message transmission over communication line facilities and the other is service time for message switching and data base acquisition by computer facilities.

For the four priority types, service times for messages on communication lines are given by

$$E(tsi) = \frac{(Lmi + OH) \times Bc}{C} + MPSE \qquad (8)$$

where i = 1, 2, 3, 4,

and Lmi = average message length of a priority i type message in characters

OH = number of overhead characters that accompany a message on the network

Bc = number of bits per character

C = line capacity in Bauds

MPSE = time spent for pauses in transmission due to modem line turnaround time or other factors

The unsubscripted service time term, $E(\bar{t}s)$, (which appears with the unsubscripted ρ term in the numerators of equations 4 thru.7), is calculated similarly, but uses the overall network average message length, Lm, in place of Lmi,

$$Lm = P_1(Lm1) + P_2(Lm2) + P_3(Lm3) + P_4(Lm4)$$

where P_i = the percentage of priority i type messages on the network
$i = 1, 2, 3, 4$

The mean service time for a negative poll on the multidrop network is given by

$$E(tPOLL) = \frac{POH \times Bc}{C_m} + PPSE \qquad (9)$$

where POH = number of polling characters including overhead characters

Bc = number of bits per character

C_m = line capacity in Bauds

PPSE = total line pauses during a negative poll due to modem turnarounds, etc. There are two line turnarounds for a negative poll on a half duplex line.

Note that communication line service times do not include terms accounting for line transmission delays as a function of distance. These contributions to total response time are negligible and are not included in the model.

Mean service times for computers are estimated from data supplied by computer system vendors. Of interest is the average time required to process a transaction. For an RSC the time is that required to perform message switching. For a remote single server RSC, the mean queue time E(tqRC), is

$$E(tqRC) = \frac{E(tsRC)}{1 - \rho_{RC}} \qquad (10)$$

where E(tsRC) = mean service time for switching per transaction in a regional computer

ρ_{RC} = facility utilization for a regional computer

and $\rho_{RC} = E(nRC)\ E(tsRC)$

where E(nRC) = total transaction arrivals per second at the regional RSC

For an RSC connected to a data base, we shall assume that the computer is a dual processor so that it behaves as a dual server queue. In this case, the mean queue time for the data base switcher computer, E(tqCD), is

$$E(tqCD) = \frac{\rho_{CD}^2}{1 + \rho_{CD}} \frac{E(tsCD)}{1 - \rho_{CD}} + E(tsCD) \qquad (11)$$

where E(tsCD) = mean service time for switching plus data base access per transaction

ρ_{CD} = facility utilization for an RSC with data base

and $\rho_{CD} = \frac{E(nCD)}{2} E(tsCD)$

where E(nCD) = total transaction arrival rate per second at the data base RSC

Mean service times for computers are hardware and software configuration dependent, which necessitates vendor consultation in each case. Generally, computer mean service times will range from 100 ms to 700 ms.

In arriving at values for computer mean service times, it is important to visualize the computer facility as a single large queue, despite the fact that the operating system may involve many queues in reality. One approach, for example, may consider the mean number of program steps executed per transaction and the mean number of disc accesses per transaction. Typical numbers may be:

ITEM	SPEED	TIME
150,000 instructions per transaction	@ 1 microsecond mean instruction execution time	0.150
6 disc accesses per transaction	@ 47.5 milliseconds per access	0.285
	MEAN COMPUTER SERVICE TIME =	0.435 sec

Ideally, vendors or system users may have actual measurements available from operating statistics.

7.3.1.3 Inputs/Outputs. The general model requires the input data listed in Table 7-3. Table 7-4 describes the terms calculated by the model. Figure 7-14 clarifies where various terms apply in the model.

Once the calculated values are found, it is a simple matter to sum up the desired components of the seven queues involved, (outlined in

Figure 7-13), to arrive at desired values for response times by priority type. It is also possible to use the model for simpler network configurations which may or may not involve message prioritization. The following two examples will clarify model use.

Table 7-3. Model Inputs

Item	Symbol	Meaning and Units
1	Cm	Line capacity of the multidrop (Baud)
2	CR	Line capacity of interregion line (Baud)
3	OH	Overhead characters in line protocol (CH)
4	MPSEM	Total line turn-around time on multidrop (sec)
5	MPSER	Total line turn-around time on interregion line (sec)
6	M	Number of terminals on multidrop
7	UC	Units per character (bits)
8	L_1	Priority one output average message length (CH)
9	L_2	Priority two output average message length (CH)
10	L_3	Priority three output average message length (CH)
11	L_4	Input average message length (CH)
12	L_5	Priority one input average message length (CH)
13	L_6	Priority two input average message length (CH)
14	L_7	Priority three input average message length (CH)
15	Lm	Overall system average message length (CH)
16	E(nm1)	Mean arrival rate of priority one output messages to multidrop (msg/sec)
17	E(nm2)	Mean arrival rate of priority two output messages to multidrop (msg/sec)
18	E(nm3)	Mean arrival rate of Priority 3 output messages to multidrop (msg/sec)

Table 7-3. Model Inputs (Continuation 1)

Item	Symbol	Meaning and Units
19	E(nm4)	Mean arrival rate of all input messages from multidrop (msg/sec)
20	E(nRI1)	Mean arrival rate of Priority 1 input messages on interregion line (msg/sec)
21	E(nRI2)	Mean arrival rate of Priority 2 input messages on interregion line (msg/sec)
22	E(nRI3)	Mean arrival rate of Priority 3 input messages on interregion line (msg/sec)
23	E(nRO1)	Mean arrival rate of Priority 1 output messages on interregion line (msg/sec)
24	E(nRO2)	Mean arrival rate of Priority 2 output messages on interregion line (msg/sec)
25	E(nRO3)	Mean arrival rate of Priority 3 output messages on interregion line (msg/sec)
26	E(nCR)	Mean number of transactions/sec at RSC (trans/sec)
27	E(nCD)	Mean number of transactions/sec at the RSC with a data base (trans/sec)
28	E(tsCR)	Mean service time per transaction for the RSC computer (sec/trans)
29	E(tsCD)	Mean service time per transaction for the RSC data base computer (sec/trans)

Table 7-4. Calculated Values

Item	Symbol	Meaning and Units
1	E(tsmi) i = 1-7	Mean service time for messages on the multidrop line (sec/msg)
2	E(tsm)	Mean service time for messages on the multidrop using overall average message length (Lm) (sec/msg)
3	E(twmi) i = 1-4	Mean wait time for service on the multidrop line (sec/msg)
4	ρmi i = 1-4	Mean utilization of multidrop line for each priority type
5	ρm	Total mean utilization of multidrop line for all messages
6	E(tqCR)	Mean queue time of RSC (sec/msg)
7	E(tsRIi) i = 1-3	Mean service time for input messages on interregion line (sec/msg)
8	E(tsROi) i = 1-3	Mean service time for output messages on interregion line (sec/msg)
9	E(tsRI)	Overall mean service time for input messages on interregion line (sec/msg)
10	E(tsRO)	Overall mean service time for output messages on interregion line (sec/msg)
	ρRIi i = 1-3	Mean utilization of interregion line for input messages for each priority type
	ρROi i = 1-3	Mean utilization of interregion line for output messages for each priority type
13	ρRI	Total mean utilization of interregion line for all input messages.
14	ρRO	Total mean utilization of interregion line for all output messages
15	E(twRIi) i = 1-3	Mean wait time for input service on inter-regional line (sec/msg)
16	E(twROi) i = 1-3	Mean wait time for output service on inter-regional line (sec/msg)
17	E(tqCD)	Mean queue time of RSC with data base (sec/msg)

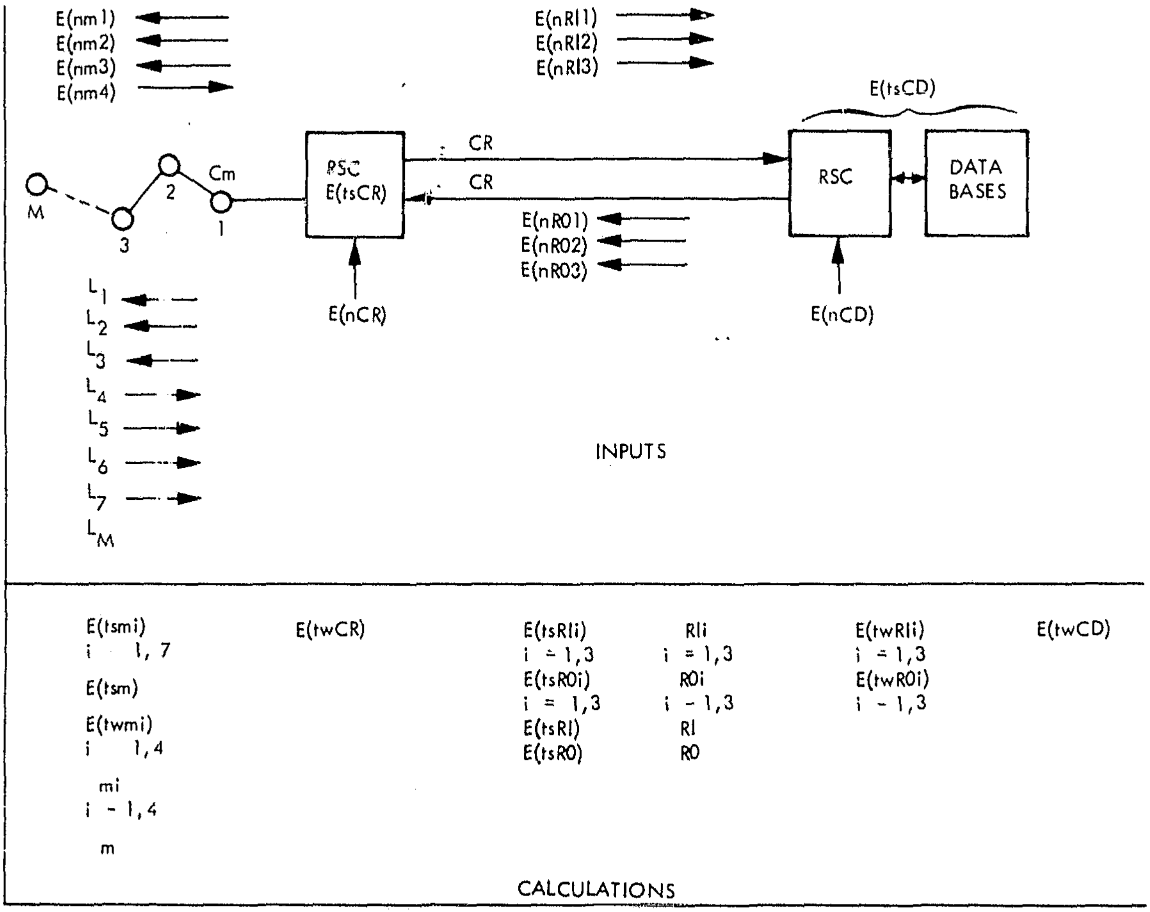


Figure 7-14. Model Inputs and Calculated Values

EXAMPLE 1

Suppose we wished to find response times for the network shown in Figure 7-14 under the following conditions:

- There are three priority type messages on the network, A, B, and C, with A being the higher priority
- Output of messages to the multidrop line has priority over input messages from the line multidrop
- Inquiry messages flow from the multidrop line through an RSC, over interregion lines to a data base RSC and response messages flow back

The equations for response time are presented below. There are three equations shown.

E(trA) = mean response time for a priority A message

E(trB) = mean response time for a priority B message

E(trC) = mean response time for a priority C message

Each equation is comprised of the appropriate wait and service time components calculated by the model. The equation for E(trA) is presented in more detail. The equations for E(trB) and E(trC) are of similiar construction, however, the wait times in queues are longer since they are of lower priority and the line service times are different since average message lengths are different. These differences are evident in the use of different subscripts. Note that the wait time for line service for an input message on the multidrop line is the same in all equations since input from the multidrop is visualized as priority 4 on the multidrop line, that is, input waits for all output onto the multidrop.

Term	Explanation (See Table 7-4)	Queue No. (See Figure 7-13)
E(trA)	Response time of priority A messages	Not applicable
$= \left[\frac{M-1}{2}\right]$E(tpoll)	Mean waiting time for poll at a terminal	1
+ E(twm4)	Mean waiting time for other input messages on multidrop that may be polled before terminal of interest.	1
+ E(tsm5)	Mean service time for Priority A input message on multidrop line	1
+ E(tqCR)	Mean queue time at RSC	2

Term	Explanation (See Table 7-4)	Queue No. (See Figure 7-13)
+ E(twRI1)	Mean waiting time for Priority A message for interregion line service	3
+ E(tsRI1)	Mean service time for Priority A message on interregion line	3
+ E(tqCD)	Mean queue time at RSC with data base	4
+ E(twR01)	Mean waiting time for Priority A message for interregion line service	5
+ E(tsR01)	Mean service time for Priority A message on interregion line	5
+ E(tqCR)	Mean queue time at RSC	6
+ E(twm1)	Mean wait time for output service of Priority A message onto multidrop line	7
+ E(tsm1)	Mean service time for output message of Priority A on multidrop line	7

$$E(trB) = \left[\frac{M-1}{2}\right] E(tpoll) + E(twm4) + E(tsm6) + E(tqCR)$$

$$+ E(twRI2) + E(tsRI2) + E(tqCD)$$
$$+ E(twR02) + E(tsR02) + E(tqCR)$$
$$+ E(twm2) + E(tsm2)$$

and

$$E(trC) = \left[\frac{M-1}{2}\right] E(tpoll) + E(twm4) + E(tsm7) + E(tqCR)$$

$$+ E(twRI3) + E(tsRI3) + E(tqCD)$$
$$+ E(twR03) + E(tsR03) + E(tqCD)$$
$$+ E(twm3) + E(tms3)$$

EXAMPLE 2

Suppose we wish to deal with the simpler network configuration shown in Figure 7-15. As before, the longest response time in this network will occur on one of the multidropped lines. Therefore, consider the simplification of Figure 7-16 where we consider one such line. Consider, also, the following characteristics of interest.

- There is no prioritization of messages.

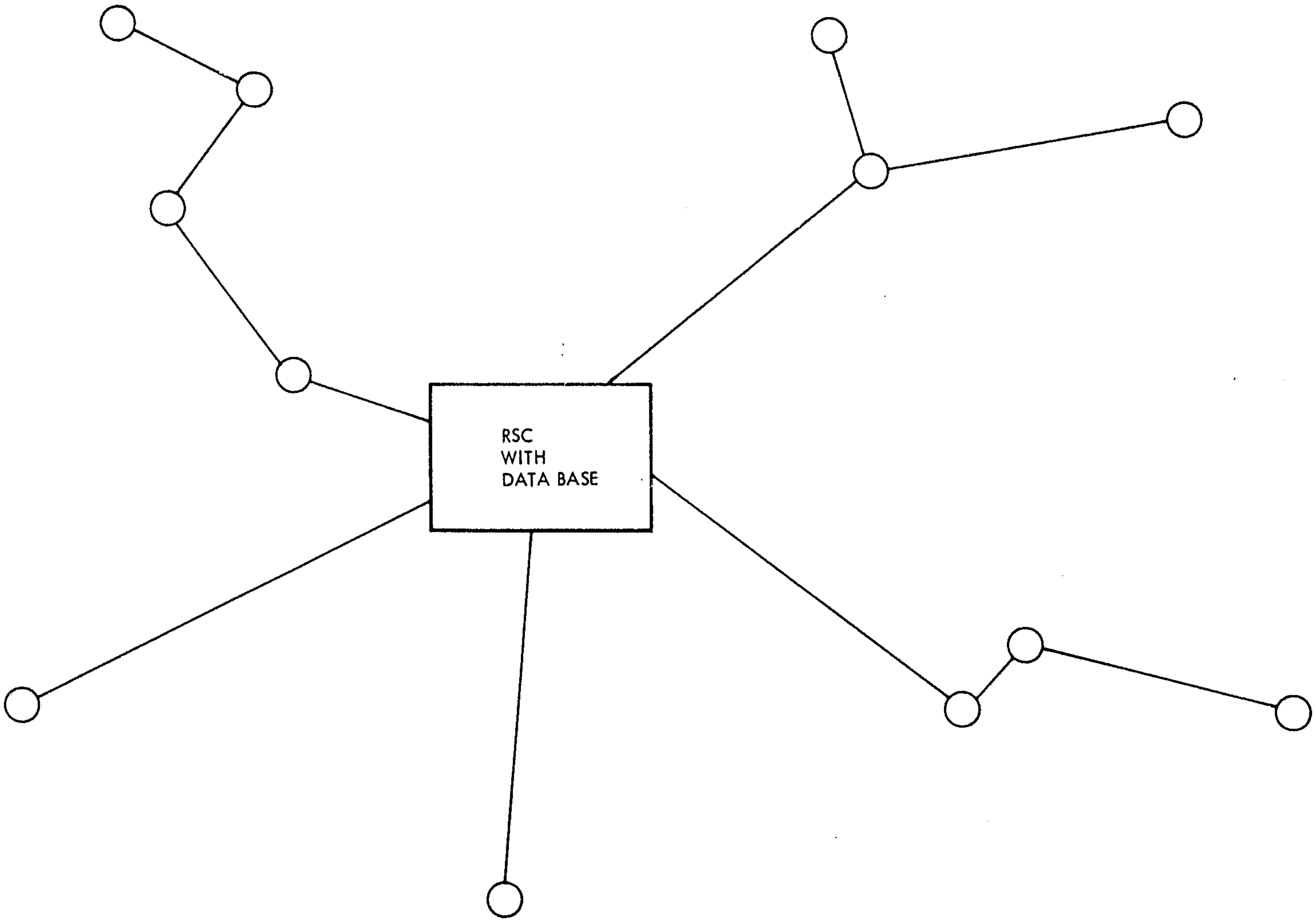


Figure 7-15. A Simpler Network

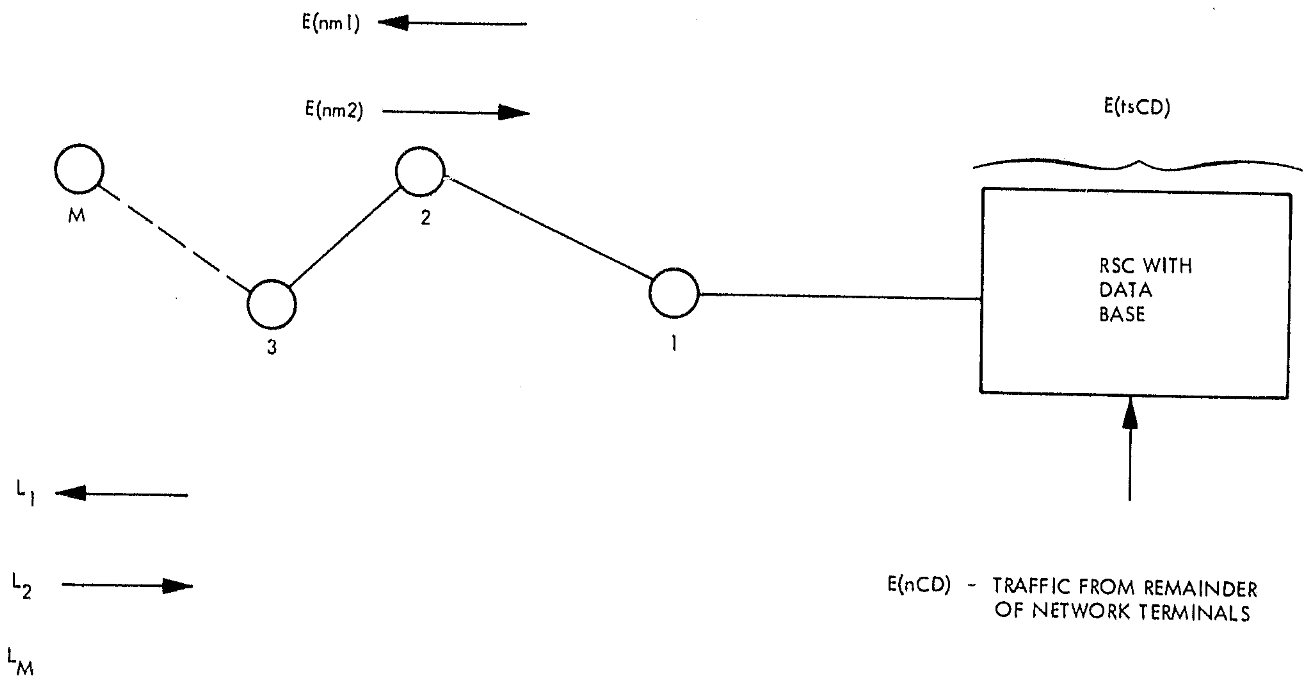


Figure 7-16. Network Inputs for Example 2

- Output of messages to the multidrop has priority over input messages from the multidrop
- A single RSC with data base is used in the network

Under these conditions, the response time, E(tr), for messages is given by

$$E(tr) = \left[\frac{M-1}{2}\right] E(tpoll) + E(twm2) + E(tsm2)$$

$$+ E(tqCD) + E(twm1) + E(tsm1)$$

In this equation, output is given priority one and input is given priority two.

7.3.1.4 Model Validation. The reader will note that simplifications have been introduced into the model. For example, mean queue time at computers is calculated without regard to average message lengths of transactions. This assumes that the mean number of software operations carried out per transaction (hence, mean time), as well as time for disc accesses, is fairly insensitive to the lengths of messages which are being handled. These and other simplifying assumptions are best tested by comparing model outputs with simulation. This exercise was performed with a GPSS program that simulated a network with the characteristics of Example 2 of the section entitled Model Inputs/Outputs, but with two priority message types, A and B, instead of no prioritization. Results are shown in Figure 7-17. These results show the model to be sufficiently close to simulation results to be of meaningful value as a design tool. Values used in these specific tests are shown in Table 7-5. Values in Table 7-5 for E(nCD), E(nm1), E(nm2), and E(nm3) correspond to a total network transaction level of 90,720 transactions per day. The curves of Figure 7-17 were generated by increasing, (or decreasing), these values proportionately to generate x coordinate values.

The equations for response times in this model were

$$E(trA) = \left[\frac{M-1}{2}\right] E(tpoll) + E(twm3) + E(tsm5) + E(tqCD)$$

$$+ E(twm1) + E(tsm1)$$

and

$$E(trB) = \left[\frac{M-1}{2}\right] E(tpoll) + E(twm3) + E(tsm6) + E(tqCD)$$

$$+ E(twm2) + E(tsm2)$$

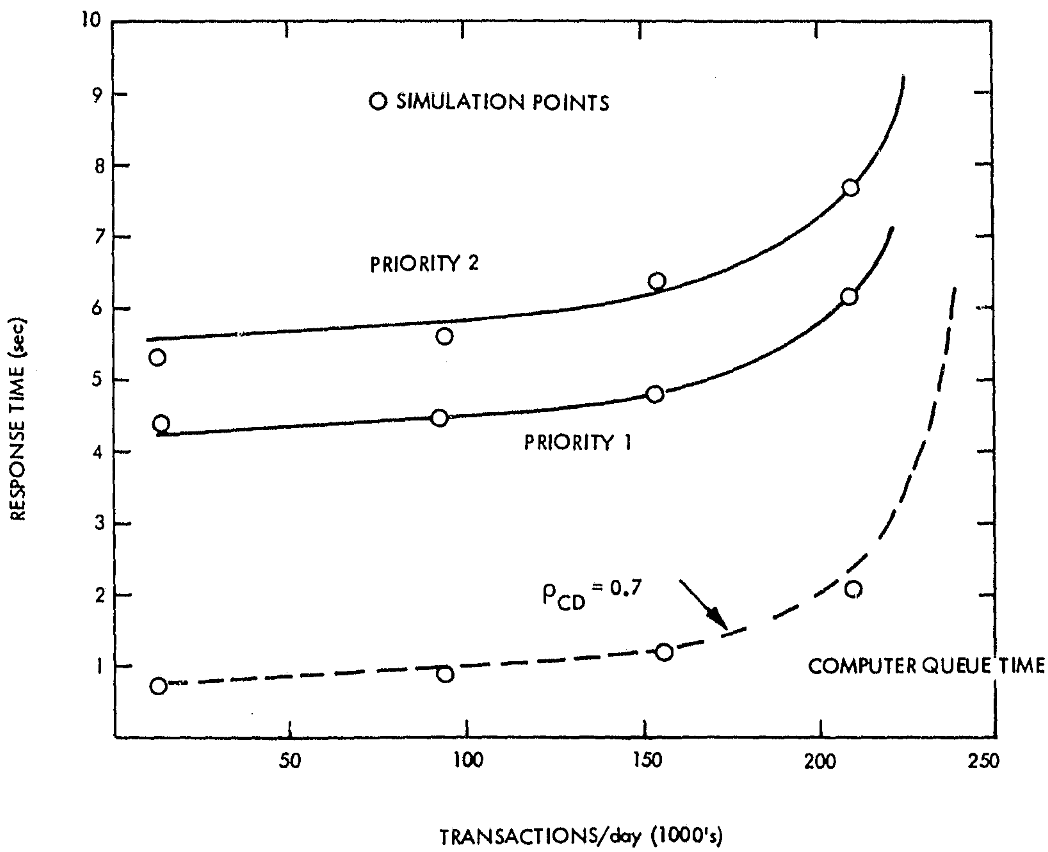


Figure 7-17. Response Time Model vs. Simulation

Table 7-5. Model Validation Input Values

Term	Value
Cm	2400 Baud
OH	13 characters
POH	10 characters
MPSEM	0.150 sec
PPSEM	0.150 sec
M	10 terminals
Uc	10 bits
L5	18 characters
L6	250 characters
L1	170 characters (output Priority 1)
L2	250 characters (output Priority 2)
L3	39 characters (input)
LM	108 characters
E(tsCD)	0.700 seconds
E(nm1)*	0.046
E(nm2)*	0.0042
E(nm3)*	0.0502
E(nCD)**	0.525

*Values for multidrop traffic used at E(nCD) = .525 (see text)

**E(nCD) = .525 for evenly loaded dual processors total computer transaction load = 2 x .525 = 1.05 transactions/sec or 90,720 transactions/day

The dotted line in Figure 7-17 represents the time spent in queue in the computer (see Equation 11). Note that the overall life of the system in terms of ability to handle throughput is limited by the computer performance. In the system shown, the computer utilization, ρ_{CD}, reaches 0.700 at approximately 173,000 transactions per day. At this point, excessive queues can develop in the computer with small variations in throughput demand. Consequently, designers should be well into planning an upgrade when mean computer utilization hovers near 0.700. The model can be used to find the new required computer mean service time to handle throughput demand for any number of years in the future. Mean service times may be reduced in any number of ways, the most typical being use of fixed head discs, improving communications software, obtaining faster core, and implementing multiple processing units.

7.3.2 The Ohio Response Time Model

The existing Ohio LEADS System consists of a single regional message switcher and data base computer located in Columbus. The computer facility employs a Univac 1100/42 dual processor, so that for the single region case, with output from the computer given priority over input from the multidrop, the following equation is applicable:

$$E(tr) = \left[\frac{M-1}{2}\right] E(tpoll) + E(tWM2) + E(tSM2) \qquad (12)$$

$$+ E(tQCD) + E(tWM1) + E(tSM1)$$

The meaning of these terms are described in Table 7-4 of Section 7.3.1.3. The value for E(tQCD) is calculated using the expression for a dual server data base computer presented in equation (11) of Section 7.3.1.2.

For multiple region cases, where inquiries pass from multi-dropped terminals, through a regional switcher, over interregional lines to the data base computer and back over the same path to the terminal on the multidrop, the following equation is applicable:

$$E(tr) = \left[\frac{M-1}{2}\right] E(tpoll) + E(tWM2) + E(tSM2) \qquad (13)$$

$$+ E(tQCR) + E(tWRI1) + E(tSRI1)$$

$$+ E(tQCD) + E(tWRO1) + E(tSRO1)$$

$$+ E(tWM1) + E(tSM1)$$

See Table 7-4, Section 7.3.1.3 for term descriptions.

Equation 12 is used to analyze the performance of the existing 150 and 2400 Baud lines in Ohio. This analysis is presented in Section 11 Both equations 12 and 13 are used as a basis for calculating network response times in the Topology Program for the generation of new or improved networks.

Sample Calculation --

By way of example, consider the response time on a 2400 Baud line with 10 multidropped terminals into the Columbus switcher and data base computer. For this example equation 12 is appropriate. The numerical values required for input to the model are listed in Table 7-6.

The components of equation 12 are then evaluated as follows:

$$\left[\frac{M-1}{2}\right] E(tpoll) = \left[\frac{M-1}{2}\right] \left[\frac{POH \times U_c}{C_m} + PPSEM\right] = 0.34 \text{ sec}$$

$$E(tWM2) = \frac{\rho_m \; E(tSM2)}{(1-\rho_{m1})\;(1-\rho_{m1}-\rho_{m2})} = 0.009 \text{ sec}$$

$$E(tSM2) = \frac{(L_2 + OH)\; U_c}{C_m} + MPSEM = 0.29 \text{ sec}$$

$$E(tQCD) = \frac{E(tSCD)}{1 - \rho_m{}^2} = 1.197 \text{ sec}$$

Table 7-6. Input Values for Sample Calculation

Term	Meaning	Value
Cm	Line Capacity of multidrop	2400 Baud
OH	Message overhead	13 char
POH	Polling overhead	18 char
MPSEM	Total line turn around time per message	0.008 sec
PPSEM	Total line turn around time per poll	0.016 sec
M	Number of multidropped terminals	10
Uc	Units per character	8 bits/char
L1	Average message length of messages from the computer onto the multidrop	155 char
L2	Average message length of messages from the multidrop into the computer	71 char
Lm	Overall average message length	121 char
E(nM1)	Rate of message flow from the computer onto the multidrop	0.024/sec
E(nM2)	Rate of message flow from the multidrop into the computer	0.016/sec
E(nCD)	Total arrival rate of transactions at the computer	1.04/sec
E(tSCD)	Mean service time of the computer	0.650 sec

$$E(tWM1) = \frac{\rho_m \; E(tSM1)}{1 - \rho_{m1}} \qquad = \quad 0.008 \text{ sec}$$

$$E(tSM1) = \frac{(L_1 + OH) \; U_c}{C_m} + MPSEM \qquad = \quad 0.57 \text{ sec}$$

Thus, the total response time, E(tr), in this sample calculation becomes:

$$E(tr) = 2.41 \text{ sec}$$

SECTION 8

OHIO NETWORK STUDIES

Ohio Network Studies consist of examining eight optional network configurations, and the execution of two additional network performance studies.

Options 1 through 4 investigate potential cost savings in trading off network line costs with regional switcher costs. Options 5 and 6 examine the cost tradeoff between maintaining separate LEADS and BMV networks, vs. integrating these functions in a single network. Options 7 and 8 study a similar concept for separate versus integrated LEADS and New Data type networks. Two additional network performance studies include consideration of network cost increases as terminal response time requirements are reduced, and an inquiry into the impact on network cost and performance due to adding digitized fingerprints data as a traffic type.

The following paragraphs outline these studies in more detail.

8.1 OPTIONS 1 THROUGH 4

As the number of regional switchers serving terminals within their regions are increased in a network, total network line costs may be expected to decrease due to the fact that total network line length has decreased. The placement of additional regional switchers, however, imposes an additional network cost which may or may not offset cost savings due to decreased line lengths.

Options 1 through 4 seek to understand whether the addition of regional switchers throughout Ohio has the potential to realize meaningful network cost savings.

Option 1 considers the present LEADS single region concept with a switching data base computer located in Columbus. Option 2 considers the cost effect of adding a regional switcher in Cleveland. In Option 3, two regional switchers are added -- one in Cleveland and one in Cincinnati and in Option 4 three regional switchers are considered with one in Cleveland, Cincinnati and Toledo.

In each of these cases, the STACOM Program described in Section 7 of this report, seeks near optimum, (least cost), network line topologies.

8.2 OPTIONS 5 and 6

A first observation of the present LEADS and BMV networks suggests that line cost savings may be realized through combining terminals of the now two separate networks into a single integrated LEADS/BMV Network.

The LEADS network alone is subject to interstate line tariff schedules and the BMV network alone operates under an intrastate tariff. Should the networks be combined, the single integrated network would be subject to an interstate tariff.

Option 5 considers cost totals for operation of separate optimized (least cost) BMV and optimized LEADS networks.

Option 6 considers cost totals for a single integrated LEADS/BMV network.

In both cases the LEADS network used for comparative purposes, shall be the least cost LEADS network that develops from the studies of Options 1 through 4.

8.3 OPTIONS 7 and 8

Options 7 and 8 are similar conceptually to Options 5 and 6 except that they investigate separate LEADS and New Data networks versus a single integrated LEADS/New Data network. The options are designed to understand cost and performance consequences of including non-law enforcement criminal justice data types of statewide interest on the LEADS network.

As in the case of Options 5 and 6, the LEADS network used for comparative purposes shall be the least cost LEADS network that develops from the studies of Options 1 through 4.

8.4 COST SENSITIVITY to RESPONSE TIME

A study designed to clarify the extent to which total network costs increase as terminal response times are reduced is to be carried out. As response times are reduced from the 9 second goal specified in the OHIO Functional Requirement, networks will be called for that drop fewer terminals on given multidrops and, hence, require more lines. Higher speed lines may also be required as response time requirements are made more stringent. These factors will tend to increase overall network costs.

This study will determine the extent of cost increases as a function of decreasing network response times for the least cost LEADS network that results from studies of Options 1 through 4.

8.5 IMPACT of ADDING FINGERPRINTS as a DATA TYPE

Estimates of fingerprint traffic in Ohio made in the traffic level estimation task of the Ohio project assume the use of automated digital classifying equipment at strategic locations throughout the state. The potential impacts of the addition of such data types to the LEADS network in terms of cost and performance are a matter of interest. From the performance standpoint the principal consideration is the extent to which the addition of fingerprint data may effect response time characteristics of higher priority officer safety type messages.

This study determines the extent of such impacts on the least cost LEADS network which develops from Options 1 through 4.

SECTION 9

OHIO NETWORK COST ANALYSIS

This section presents assumptions and bases for costing OHIO Network Options. Total network costs are comprised of recurring costs and one time installation costs. Table 9-1 shows the basic cost items considered and describes the meaning of each item.

The costs considered here include the primary items that affect relative costs between network configurations involving different numbers of switchers and different traffic types. Costs for required upgrades of the central data base computer in Columbus are not included, since these costs are present to the same degree in all of the alternative network configurations studied. Detailed costing of data base computer upgrades is not within the scope of STACOM Study which is primarily oriented toward network alternatives. Basic data base computer performance requirements, however, are treated in Section 12.2 of this report.

The following paragraphs develop costing values for each item listed in Table 9-1.

9.1 LINE, MODEM, and SERVICE TERMINAL COSTS

Two types of line tariffs were used in the STACOM/OHIO program. For the LEADS Network, or any networks that included the LEADS System, such as the integrated BMV/LEADS network and the integrated New Data/LEADS Network, the Interstate Multi-schedule Private Line, (MPL), Ohio tariff was used. The specific MPL tariff used is shown in Table 9-2. Cost for modems and service terminals under MPL are shown in Table 9-3.

For the BMV Network, which is wholly contained within the State of Ohio (intrastate), line, modem and service terminal costs shown in Table 9-4 were used.

9.2 TERMINAL COSTS

At the time of initiation of this study, the Ohio LEADS system employed 127 high speed terminals and 263 low speed terminals on a leased basis. Since the STACOM Functional Requirements call for line upgrade to 1200 Baud or higher, it is asumed that low speed terminals shall be replaced. It is also assumed that existing high speed terminals can now be replaced by lower cost units that meet terminal performance requirements.

Since the STACOM/OHIO Network designs are configured to last a period of greater than three years, (to 1985), it is more cost effective to purchase new terminals and carry maintenance contracts than to lease terminals. Therefore, terminal costing assumes purchasing rather than leasing. An industry wide representative cost for a pollable CRT terminal with keyboard, operation speed to 9600 Baud, printer and Univac

Table 9-1. Cost Items and Descriptions

Item	Recurring Costs	One-Time Installation Costs
Lines, Modems, Service Terminals	Annual Tariff Costs	Modem and Service Terminal Installation
Terminals	Maintenance Costs	Purchase Costs
Regional Switchers	Maintenance Costs	Purchase Costs
Switcher Floor Space	Regional Switcher Site Rental Costs	Regional Switcher Site Preparation Costs
Switcher Backup Power	Maintenance Costs	Purchase Costs
Switcher Personnel	Regional Switcher Personnel Salaries	Not Applicable
Engineering	Not Applicable	Network Procurement Costs

Table 9-2. MPL Line Tariff

Schedule		Mileage Breakdown	Cost ($)
I	Between any Schedule I cities listed:	1	$ 51.00
	Akron	2 - 14	51.00 + 1.80/mi over 1 mi
	Cincinnati	15	76.20
	Cleveland	16 - 24	76.20 + 1.50/mi over 15 mi
	Columbus	25	91.20
	Canton	26 - 99	91.20 + 1.12/mi over 25 mi
	Dayton	100	175.20
	Toledo	101 - 999	175.20 + 0.66/mi over 100 mi
	Youngstown	1000	769.20
		1000 +	769.20 + 0.40/mi over 1000 mi
II	Between Schedule I cities and any other city	1	$ 52.00
		2 - 14	52.00 + 3.30/mi over 1 mi
		15	98.20
		16 - 24	98.20 + 3.10/mi over 15 mi
		25	129.20
		26 - 39	129.20 + 2.00/mi over 25 mi
		40	159.20
		41 - 99	159.20 + 1.35/mi over 40 mi
		100	240.20
		101 - 999	240.20 + 0.66/mi over 100 mi
		1000	834.20
		1000 +	834.20 + 0.40/mi over 1000 mi
III	Between two non-schedule I cities	1	$ 53.00
		2 - 14	53.00 + 4.40/mi over 1 mi
		15	114.60
		16 - 24	114.60 + 3.80/mi over 15 mi
		25	152.60
		26 - 39	152.60 + 2.80/mi over 25 mi
		40	194.60
		41 - 59	194.60 + 2.10/mi over 40 mi
		60	236.60
		61 - 79	236.60 + 1.60/mi over 60 mi
		80	268.60
		81 - 99	268.60 + 1.35/mi over 80 mi
		100	295.60
		101 - 999	295.60 + 0.68/mi over 100 mi
		1000	907.60
		1000 +	907.60 + 0.40/mi over 1000 mi

Table 9-3. MPL Modems and Service Terminal* Costs

Baud Rate	Modems		Service Terminal	
	Install $	Maintenance $/mo	Install $	Maintenance $/mo
1200	54.15	32.50	50.00	25.00
2400	81.20	59.55	50.00	25.00
4800	163.00	135.00	50.00	25.00

*Also referred to as station charge

Table 9-4. Intrastate Line Tariff

Baud Rate	Line Cost/ mile/mo $	Modems		Service Terminals	
		Install $	Maint. $/mo	Install $	Maint. $/mo
1200	2.00	25.00	20.00	80.00	31.00
2400	2.00	138.00	55.00	80.00	31.00
4800	2.00	100.00	100.00	80.00	31.00

compatibility is $5540 per unit. A 35% quantity discount is assumed for the 390 required terminals so that the unit cost is $3,600. This unit cost includes installation costs. It is estimated that a maintenance contract is available at $50 per unit per month.

9.3 REGIONAL SWITCHER COSTS

A suitable Regional Switcher configuration that meets STACOM/OHIO Functional Requirements includes the following items:

- 64 line synchronous/asynchronous front end
- A Central Processing Unit
- 64K Bytes Memory
- I/O Controller
- 10M Byte Disk Storage
- U-100 Console
- Line Handling Equipment

A representative purchase price for this configuration, including all necessary software, is $180,000 per switcher with a monthly maintenance charge of $1,000. As in the case with terminals, the cost effectiveness of purchasing regional switching equipment as opposed to leasing, for systems whose life expectency is greater than 40 months is evident. It is assumed, therefore, in network options that involve the use of regional switchers that these switchers are purchased.

9.4 REGIONAL SWITCHER FLOOR SPACE

It is assumed that 1000 ft^2 of floor space is sufficient for housing a regional switcher facility including personnel office space. Facility preparation costs are estimated at $30,000 per switcher facility including personnel office space. Monthly rental is estimated at $0.40/$ft^2$ so that monthly rental per switching facility is $400.

9.5 SWITCHER BACKUP POWER

Uninterruptable power supplies, (UPS), are provided at each regional switching facility to ensure commercial power continuity during momentary power transients as well as over extended time periods.

Solid-state static inverter type UPS including a rectifier/charger, and autobypass switch are available at approximately $13,000 per unit. Batteries for the unit are estimated to cost $2,500. A gasoline engine generator for use when lengthy outages occur include weatherproof housings and auto transfer switches that operate when commercial power fails. These units are priced at $4,500 each.

The total one-time purchase price for each installation is, therefore, $20,000. A maintenance contract for both the UPS and engine generator is estimated at $500 per month.

9.6 ENGINEERING COSTS

Engineering costs associated with network implementation were estimated for single and multiple region configurations. Networks involving a single region concept are the LEADS single region network, (Option 1), the integrated LEADS/BMV network, (Option 6), the integrated LEADS/New Data network, (Option 8), the separate BMV network configuration, (Option 5), and the separate New Data network, (Option 7). Table 9-5 shows manpower estimates in man-months for assumed engineering costs. The values shown for the single region separate New Data network are reducedwith respect to other single region networks since the network is considerably smaller. Cost per mon-month including overhead and benefits is estimated at $4,000.

9.7 PERSONNEL COSTS

Regional switching facilities require supervisory, programming and computer operations personnel. This study assumes that each regional switcher facility requires one supervisor, two programmers and six computer operators. Two computer operators are provided per shift for safety reasons so that at no time during a 24-hour day the facility is manned by one person alone. Table 9-6 presents estimated salaries for the required personnel.

9.8 COST SUMMARY

Table 9-7 summarizes recurring and one-time installation costs developed in this section for convenient reference.

9.9 OHIO NETWORK IMPLEMENTATION

The networks presented in this study are designed to meet STACOM/OHIO traffic requirements through the year 1985. A cost analysis on the feasibility of constructing an intermediate network to meet 1981 traffic level requirements, and then upgrading this network in 1981 to meet 1985 traffic level requirements, as opposed to building a single network to meet traffic requirements through 1985, was carried out. It was found that building a single network now to meet 1985 traffic requirements would not involve additional cost over intermediate phasing of network upgrades. A single exception to this rule occurs in the cases of networks where New Data Types are involved, (Options 7 and 8).

Table 9-5. Engineering Cost Estimates (man months)

Task	2, 3, & 4 Regions	1 Region New Data Types	1 Region Others
Final Functional Requirements	2	1	2
Switcher Design Spec/RFP	4	-	-
Network Design Spec/RFP	4	1	4
Switcher Facilities RFP	4	-	-
Switcher Procurement Monitor	6	-	-
Network Procurement Monitor	6	3	6
Facilities Procurement Monitor	6	-	-
Switcher Test Plan	2	-	-
Switcher Testing	2	-	-
Network Test Plan	2	1	2
Network Testing	2	1	2
Documentation	6	1	6
Supporting Analysis	6	2	6
User Operators Manual	6	2	6
TOTALS - Man Months	58	12	34
APPROXIMATE COST AT $4K/MM ($K)	230	50	130

Table 9-6. Personnel Costs

Personnel	No. Required	($K) Annual Salary	($K) Annual Cost
Supervisor	1	20	20
Programmers	2	18	36
Operators	6	12	72
TOTAL PERSONNEL ANNUAL COST			$128K

Table 9-7. Cost Summary by Item

Item	Annual Recurring Cost Per Unit ($k)	One-Time Installation Cost Per Unit ($k)
Lines, Modems, Service Terminals	see Tariffs Tables 9.2, 9.3, 9.4	None
Terminals	0.6	3.6
Regional Switchers	12.0	180.0
Switcher Floor Space	4.8	30.0
Switcher Backup Power	6.0	20.0
Switcher Personnel	128.0	None
Engineering	None	50/130/230 See Paragraph 9.6

Growth in new data type volumes from the present through 1985 is such that it is less costly to implement one network to handle traffic volumes up to 1980 and to then add to the network to meet traffic demands from 1981 through 1985.

For these reasons costs presented in Sections 7 and 8 are based on the construction in 1978 of networks that will accommodate predicted traffic levels through 1985 with the exception of networks involving new data types that are phased as indicated.

Thus, STACOM/OHIO Networks can be regarded as involving cost over a period of eight years. Therefore, total eight year costs including installation and recurring costs are used as a basis of network option cost comparisons.

SECTION 10

OHIO NETWORK FUNCTIONAL REQUIREMENTS

This section presents the functional requirements as the top level network specification, to serve as a basis, for all lower level design specifications involved in the total network.

Included is a basic description of the Ohio STACOM network, the network elements and required functions.

The use of the term STACOM Network refers to a single network or a group of networks that meet the functional requirements outlined herein.

10.1 NETWORK PURPOSE

The purpose of the STACOM Network is to provide efficient telecommunications capable of transporting information between Ohio state criminal justice agencies on a statewide scale and to and from specific interstate criminal justice agencies. Criminal justice agencies are agencies whose primary functions encompass law enforcement, prosecution, defense, adjudication, corrections and pardon and parole. The network shall be designed to handle communication requirements among these agencies projected through the year 1985.

10.2. STACOM USERS

Users of the STACOM Network shall consist of any authorized agency within the Ohio Criminal Justice System. Users shall consist of the present users of the Ohio Law Enforcement Automated Data System, (LEADS), and other criminal justice agencies to the extent that their needs and contributions are compatible with the overall network goals of the Ohio STACOM Network Management.

10.3 BASIC NETWORK CONFIGURATION

The basic configuration of the STACOM Network is an array of network system terminations connected through Regional Switching Center, (RSC), facility(s) to a single data base located in Columbus, Ohio. There may be one or more networks comprising the STACOM Network to be determined during network analysis and design phases of the STACOM Project.

Each system termination on the STACOM Network shall be defined as one of three types:

(1) Individual terminals

(2) Groups of terminals in cities

(3) Interfaces to regional criminal justice systems

Any of the system terminations shall be able to communicate with any other system termination. Each system termination shall not be routed through more than one RSC in gaining access to the Columbus data base, not including the Columbus switching facility, during normal network operation.

Each system termination shall be connected to an RSC which serves the region in which the system termination is located. System terminations shall be connected to RSCs in minimum cost configurations that meet the functional requirements outlined herein. Direct connections between system terminations and RSCs and multidropped configurations shall be considered.

10.4 MESSAGE CHARACTERISTICS

10.4.1 Digital Message Types

The STACOM network shall handle the following five basic types of messages.

- Data File Interrogations/Updates
  These messages shall be inquiries, entries, modifiers, cancels, clears and responses to and from a data file at the state or national level. The text is generally in fixed format.

- Administrative Messages
  These are messages between network users which do not involve data file access. The text is in a less restrictive format.

- Network Status
  These messages shall provide information at terminals initiating messages in the event that destination terminals or intermediate switchers or lines are unable to function.

- Error Messages
  These messages shall contain information regarding the nature of errors detected in transmitted messages. Messages in which errors are detected are not automatically retransmitted on the network, but may be re-sent at the user's discretion.

- Fingerprints
  Digitized and/or analog representations of fingerprints shall be included on the STACOM Network.

10.4.2 Message Content

Criminal justice messages shall contain the following information in known locations:

Internal LEADS messages shall contain

- Message Origin
- Message Type

Regional LEADS messages, (RCIC, NCIC), shall contain

- Message Type
- Message Sequence Number
- Message Origin

The State Data Base Computer in Columbus shall determine for each message

- Message Destinations
- Message Number
- NCIC Identifiers of Sending Agency
- Sending Authority

10.4.3 Message Lengths

Digital messages transmitted over the STACOM Network shall not exceed 500 characters in length. Actual messages exceeding 500 characters shall be blocked in message segments which shall not exceed 500 characters each. Multisegment messages shall have a single overall message number and distinct message segment numbers. Each segment shall be transmitted as a separate message. The destination terminal(s) must reassemble the overall message upon reception.

10.5 NETWORK MESSAGE HANDLING

10.5.1 Message Routing

The STACOM Network shall provide communications routing for all messages between any two of its system terminations.

The following specific routing capabilities shall be provided:

- Data base inquiry/update messages shall be routed from the originating terminal to the Columbus data base through no more than one intermediate Regional Switching Center, not including the Columbus switcher, under normal network operation. Interface routing to NLETS and the NCIC shall be maintained as in the present Ohio LEADS system.

- Administrative messages shall be routed from the originating terminal to the destination terminal through no more than two RSCs under normal network operation. Administrative messages shall also have a capability for ALL POINTS routing as currently employed by the Ohio LEADS system.

- Digitized fingerprint data shall be routed from the originating terminal to the Ohio Bureau of Criminal Investigation, London, Ohio through no more than two RSCs under normal network operation.

Message routing shall be accomplished by the regional switcher(s) utilizing the destination information in the message. Single messages destined for the same region in which they originate shall be switched to the appropriate system termination by the regional switcher servicing that region.

When more than one system termination is specified as the destination point, the message shall first be routed through the Columbus switcher where STACOM Network Management may exercise the option to grant message approval. The Columbus switcher shall then generate the required number of messages and transmit them to designated system terminations in its own region, and shall transmit a single message to other regional switchers which serve system terminations that are also designated, where the appropriate messages shall be generated and transmitted.

10.5.2 Message Prioritization

Prioritization of messages shall be incorporated in the STACOM Network to the extent required to meet the message response time goals outlined in Paragraph 10.5.3.

Messages shall be handled on a non-preemptive priority basis. In this scheme, messages or message segments in process of being transmitted shall not be interrupted, but allowed to complete before higher priority messages are honored.

Under the above conditions, the STACOM Network shall be capable of recognizing and handling message types in accordance with the following prioritization:

Priority 1: Items that may be directly related to officer safety, such as inquiries into Auto Alert, Vehicle Registration, Operators License and Wants/Warrants files, and ALL POINTS Administrative messages of a tactical nature.

Priority 2: Administrative messages not related to officer safety or tactical needs, and CCH/OBTS, WE, SJIS, and OBSCIS messages.

Priority 3: Fingerprint data or other criminal justice data consisting of large numbers of message segments.

The assignment of message types by the STACOM Network to a given priority level shall be under computer software control so that such assignments may be altered by STACOM Network management as needs arise.

10.5.3 Response Time Goals

Response time for the STACOM Network is defined as the time duration between the initiation of a request for service of an inquiry message by the network at a system termination and the time at which a response is completed at the inquiring system termination.

The response times shown below are maximum times for mean response times and for response times of messages 90% of the time. These response times represent maximum allowable goal values on the STACOM Network.

Stacom Response Time Goals Maximums

Message Priority	Mean Response Time	90% of Responses to Inquiries Received in Less Than
1	9 sec	20 sec
2	1 min	2.3 min
3	2 hr	4.5 hr

10.5.4 Line Protocol

(1) Half Duplex:
The standard interface to system terminations shall be half duplex.

(2) Full Duplex:
Full duplex line discipline may only be used interregionally.

10.5.5 Message Coding

All STACOM Network messages shall be coded using the American Standard Code for Information Interchange (ASCII), USAS X3.4-1968. Message coding for interaction with the NCIC, RCIC, and NLETS systems shall conform to existing practices of the Ohio LEADS Network.

10.5.6 Error Detection

The STACOM Network regional switchers shall provide for bit error detection of erroneous messages. Error messages shall be transmitted to system terminations in accordance with present practices of the Ohio LEADS Network. The computer shall detect format errors and transmission errors on incoming messages and notify the sending terminal appropriately. The computer shall also detect off-line or inoperative terminals.

Messages shall not be automatically retransmitted upon error detection. Messages may be retransmitted at the discretion of the user.

10.5.7 Network Status Messages

The STACOM Network shall provide for notification to system terminations of any conditions which prevent operation in the normal specified manner. System terminations shall receive such status messages upon attempting to use the network when the network is in a degraded mode. System terminations so notified shall receive a further status message indicating normal network operation has been restored when malfunctions have been corrected.

10.6 SYSTEM TERMINATIONS

STACOM Network system terminations having interface capability of 1200 BPS or greater shall interface with the network using half duplex protocol. Terminals shall have the capability for off-line construction of input messages and for hard copy production of received messages.

All terminals shall be pollable and provide for parity error detection.

The number of system terminations per multidropped line shall not exceed 25.

10.7 REGIONAL SWITCHING CENTERS

The STACOM/Ohio Network shall be comprised of one dual processor Regional Switching Center (RSC) with a redundant data base located in Columbus and up to three additional RSCs without data bases. The following describes the capabilities of each type of RSC.

10.7.1 Switchers Without Data Bases

10.7.1.1 Communication Line Interfaces. An input communication line interface shall convert incoming serial bit streams into assembled characters and furnish electrical interface for the modem and logic required for conditioning.

An output communication line interface shall convert characters into a bit stream. It shall also provide logic necessary to condition the modem for transmission and furnish the necessary electrical interface.

RSCs shall be designed to handle either full or half duplex line protocols on any line interface.

10.7.1.2 Message Assembly/Disassembly. A message assembly unit shall assemble messages by deblocking the character stream.

A message disassembly unit shall segregate messages into logical blocks for output. It shall also disassemble the blocks into a character stream for presentation to the communication line interface.

10.7.1.3 Error Control. The error control function shall provide error detection capability and initiate error messages in accordance with requirements outlined in Section 10.5.6. The error detection function is highly dispersed. Character parity is most efficiently checked during assembly of characters in the interface. Block parities are checked upon assembly of blocks. Additionally, all internal data transfers shall require a parity check.

10.7.1.4 Message Control and Routing. The message control and routing function shall provide logic which examines the assembled message, determines its priority, destination, and forms the appropriate pointers and places them in the proper queue, (the pointers are queued, not the messages).

Message routing shall be performed by RSCs in accordance with procedures outlined in Section 10.5.1.

In addition, this function shall maintain network status information for the purposes of determining availability of alternate communication paths in degraded modes of operation.

10.7.1.5 Queue Control. This function shall provide buffer and queue storage used to assemble input messages, buffer them for output and to form space to queue the message pointers.

Regional switchers shall maintain necessary queues for each system termination they service and for interregional traffic. These queues shall hold messages that cannot be sent immediately due to line usage conflicts. However, the regional switchers shall not maintain a long term store and forward capability. In the event that queue space is full, the regional switcher shall not accept any more messages and shall notify the other switcher not to accept messages destined for the switcher in question.

This capability shall be provided through use of upper and lower queue threshold specifiable by the regional switcher operator. All system terminations sending messages to the regional switcher which would demand queue space in excess of the upper threshold shall be sent negative acknowledgement responses. Once the upper threshold has been exceeded, the regional switcher shall enter the input control mode (i.e., the regional switcher shall output only). Any request for regional switcher service while it is in the input control mode shall result in a wait acknowledgement being sent to that system termination. The regional switcher shall stay in the input control mode until the lower threshold is attained.

Queue control procedures at the regional switchers shall be comprised of the following basic functions:

- Provide three independent queues for each system termination by priority as required.
- Dynamic queue management where a common core pool is made available for queueing on an as-need basis.
- Queue overflow management as discussed above.
- Provide queue statistics for input to statistics gathering function, as discussed.

10.7.1.6 Line Control. The line control function shall provide the capability of controlling and ordering the flow of data between the various message switchers. It also determines which line discipline is to be used. Full-duplex, half-duplex, polled or contention line discipline capabilities shall be possible.

10.7.1.7 Network Statistics. The STACOM Network shall be capable of collecting statistical data fundamental to the continued efficient use of traffic level prediction and network design tools developed by the STACOM Project.

The STACOM Network shall be capable of collecting the following statistical data:

- Number of messages by message type received from each system termination at State Data Bases.
- Number of messages by message type sent to each system termination from State Data Bases.
- Average message lengths by message type received at State Data Bases.
- Average message lengths by message type sent from State Data Bases.

The STACOM Network shall provide for periodic sampling of the following statistics:

- Origin-Destination message volumes by system termination.
- Percent of "HITS" and "NO-HITS" on each data base type.

- Average waiting times of input messages at switching and data base computers for CPU service.
- Average waiting times of output messages at switching and data base computers for output lines after CPU service.
- Average CPU service time per message at switching and data base computers.
- Total number of messages received each hour at the State Data Base.
- Total response time for data base interrogations/updates of selected system terminations.

10.7.1.8 Operator Interface. The regional switcher shall provide means of interfacing with the operator. This interface shall be used to control and monitor the regional switcher and its network. The following functions are to be provided:

- The regional switcher shall provide a set of commands for the purpose of communicating with the operator.
- The regional switcher shall provide means of outputting data to the operator at a rate of at least 30 characters per second.
- The regional switcher shall provide means of accepting operator control input.
- The regional switcher shall provide high speed data output capability. This data output capability shall not be less than 300 lines per minute. A line shall have 132 characters.

10.7.2 Switchers With Data Base

RSCs with data base capability employ the additional function of providing file search and update capability. This function involves receiving messages from the switchers message control and routing function (see 10.7.1.5), and placing their pointers in queue by priority for access to data base files. Upon completion of data base access, messages are returned to the message control and routing function in preparation for output.

RSCs with data bases shall maintain redundant data base files, each of which is updated in parallel at the time of file update.

10.8 NETWORK AVAILABILITY GOAL

The availability goal for the STACOM Network shall be 0.979 for the worst case Origin-Destination, (O-D), pair of system terminations on the network. The worst case O-D pair is defined as that link from system termination to the data base computer that employs the largest number of system components in its path, or the one that is most vulnerable to failure.

Availability of 0.979 implies an average outage of less than or equal to 30.2 minutes per day for the worst case path.

10.9 TRAFFIC VOLUMES

The STACOM Network shall be designed to handle traffic projections through the year 1985. These projections shall include traffic estimates plus design margins for peak vs. average loading. The total network throughput projected from 1977 to 1985 is as follows:

Total STACOM Network Throughput

(Average Msg/Day in 1000s)

Year	Leads	BMV	New Data Types
1977	147	9	14
1981	214	85	142
1986	284	98	170

10.10 CONSTRAINTS AND BOUNDARIES

10.10.1 Data Handling Constraints

- All data transmission shall be digital with the exception of fingerprint data which may be transmitted analog, or digitally, or both.
- No unscrambling or decryption shall be performed within the STACOM Network. (Some modems perform scrambling in the normal course of their operation but this scrambling is transparent to the user.)
- Traffic loading by network users in excess of the traffic safety margins for which their system terminations are designed could result in degraded message response time.

10.10.2 Data Rate Constraints

The minimum service goal for the STACOM/Ohio Network shall be 1200 Baud half-duplex lines. All available line capacity services above this rate shall be eligible for consideration in a cost/performance effective manner.

10.10.3 Security and Privacy Constraints

The STACOM Network shall be configured to allow management control by an authorized criminal justice agency or group of such agencies. Only STACOM Network operating personnel who have been authorized by STACOM Network management shall have physical access to the network equipment. These personnel shall have been thoroughly screened. It shall be the responsibility of the STACOM Network management to institute and maintain security measures and procedures consistent with good practice.

It shall be the responsibility of the STACOM Network Management to insure that unauthorized personnel are not allowed access to system terminations and that authorized personnel do not employ the network facilities for any purposes other than those for which the STACOM Network is specifically intended.

STACOM Network design shall assist in the realization of adequate security to the extent that engineering considerations can contribute. The STACOM Network shall consider in its design methods to prevent any alteration of the content of messages once they have been routed over the network. All of the equipment comprising the STACOM Network, except for the communication lines, shall provide adequate physical security to protect them against any unauthorized personnel gaining access to the STACOM Network. The computers and other network accessing equipment comprising the STACOM Network shall be located in controlled facilities. Redundant elements should be configured such that a single act of sabotage will not disable both redundant elements.

SECTION 11

ANALYSIS OF EXISTING NETWORKS IN OHIO

This section presents a brief description of the existing LEADS system in Ohio and a comparison of network characteristics with the design criteria presented in the OHIO Functional Requirements.

Areas of discrepancy in the existing system are noted, analyzed and discussed.

11.1 THE EXISTING LEADS NETWORK

The LEADS Network presently consists of ten, 2400 Baud line configurations serving 102 Ohio State Patrol offices and twenty, 150 Baud multidropped lines serving 287 sheriffs and Police Departments. The network also provides lines for the Toledo NORIS System, the Cleveland Police Department, the Cincinnati CLEAR System, NLETS and the NCIC.

Figure 11-1 shows a layout for the 2400 Baud lines and Figure 11-2 shows the layout for the 150 Baud lines. The figures show the present LEADS system to consist of a single regional switching facility located in Columbus, along with state data bases, serving the Ohio law enforcement community.

The present system shows no more than 15 terminals multidropped on any one line. This restriction is due to earlier computer front end limitations when the LEADS system employed a UNIVAC 1106 dual processor in Columbus.

In December of 1976, the 1106 was replaced with a UNIVAC 1100/42 system which is presently in service.

Total costs for the present LEADS system for lines, modems and service terminal arrangements is $606,000 per year.

UNIVAC Uniscope-100 terminals are used on 2400 Baud lines and NCR 260-6 terminals are used on the 150 Baud lines. The total lease annual cost for terminals on the LEADS System is $745,000.

11.2 COMPARISONS OF EXISTING NETWORKS WITH STACOM/OHIO FUNCTIONAL REQUIREMENTS

Table 11-1 summarizes conformity to STACOM/Ohio Functional Requirements by existing networks. Two main areas of deviation exist;

(1) Response times on LEADS 150 Baud lines are inadequate. Response times on 2400 Baud lines are inadequate at times of peak traffic loading.

CONTINUED

3 OF 4

Figure 11-1. Present Ohio LEADS Network 2400 Baud Lines

Figure 11-2. Present Ohio LEADS Network 150 Baud Lines

Table 11-1. Conformity Summary of Existing Networks to STACOM Functional Requirements

Requirement	Section V Requirements Met	Section V Requirements Not Met
Message Characteristics	All	---
Network Message Handling	Routing, Protocol, Coding, Error Detection, Status Messages	Response Time on 150 Baud Lines (Note-1)
System Terminations	All	---
Regional Switching Centers	All	---
Network Availability Goal	All	---
Traffic Volumes	Average traffic levels	Peak traffic levels
Constraints and Boundaries	Data Handling, Security and Privacy	Data Rates

(Note-1); Message Prioritization Requirements Not Applicable in Existing Networks

(2) Line rate restrictions to 1200 Baud or greater are not met on the LEADS network.

The following section discusses the nature of these deviations in more detail.

11.2.1 Response Times

Response time for the STACOM Network is defined as the time duration between the initiation of a request for service for an inquiry message at a network system termination and the time at which a response is completed at the inquiring system termination.

The response time goal for the STACOM Network for law enforcement traffic is to achieve a mean response time of less than or equal to 9 seconds, which insures that 90% of the time, responses to inquiries shall be received in less than 20 seconds.

Figure 11-3 shows a plot of mean response time vs traffic loads in thousands of transactions per day for the 2400 Baud Lines in the existing LEADS system.

Three curves are shown for different computer configurations. The first is for the recently replaced (December 1976) 1106 computer; the second is for the existing 1100/42 configuration; and the third is for the existing 1100/42 with additional core and fixed head discs added. (The 1106 configuration has been included to provide a feeling for the significance of the upgrade from the 1106 to the present 1100/42).

Each configuration functions with the mean service times indicated in the figure. Table 11-2 presents a sample calculation used to arrive at a mean service time estimate for the existing 1100/42 using 8440 disc units. The mean service time of this configuration can be improved as future traffic requirements increase. For example, the addition of core memory units to the computer would relieve the necessity for periodic application software roll-in from disc. Also, replacement of the 8440 disc with a fixed head disc units with faster transfer rates, (such as the 8433 dual density disc with a transfer rate of 179,111 words/sec and a mean access time of 42.5 ms), would improve mean service time to 503 ms. Mean response time for this configuration is depicted as Curve 3 in Figure 11-3.

The response time curves can be used to anticipate system upgrade requirements. For example, at the time of the upgrade from the 1106 system with a mean service time of 790 ms to the 1100/42 with a mean service time of 650 ms, the LEADS system was handling approximately 170,000 transactions per day. At this point the computer utilization was approximately 0.80 for the 1106 system with a mean service time of 790 ms. The curve indicates that at this operating point, small deviations upward in the number of transactions per day will result in large increases in response times at terminals.

In particular, it is seen that during periods of peak loading when it is estimated that traffic may be as much as twice the average, system queues become excessive.

The second response time curve, (Curve 2, Figure 11-3), suggests that the current configuration with a mean service time of 0.650 seconds can sustain traffic volumes of 190,000 transactions per day before the computer utilization exceeds 0.70. It is desirable to maintain computer utilization at less than 0.70 to insure that service is not hampered by excessive queueing in the computer. Thus, to the extent that current traffic levels exceed 190,000 transactions per day on the average, or at points in the day when transaction levels exceed approximately 1/sec, the computer utilization will exceed 0.70 in the present dual processing system.

This analysis shows that there is little system margin over the current estimated 180,000 transactions per day, and that while most of the time the system provides adequate response times, (under 9 seconds), on 2400 Baud lines, system performance is not presently adequate during peak traffic demand periods.

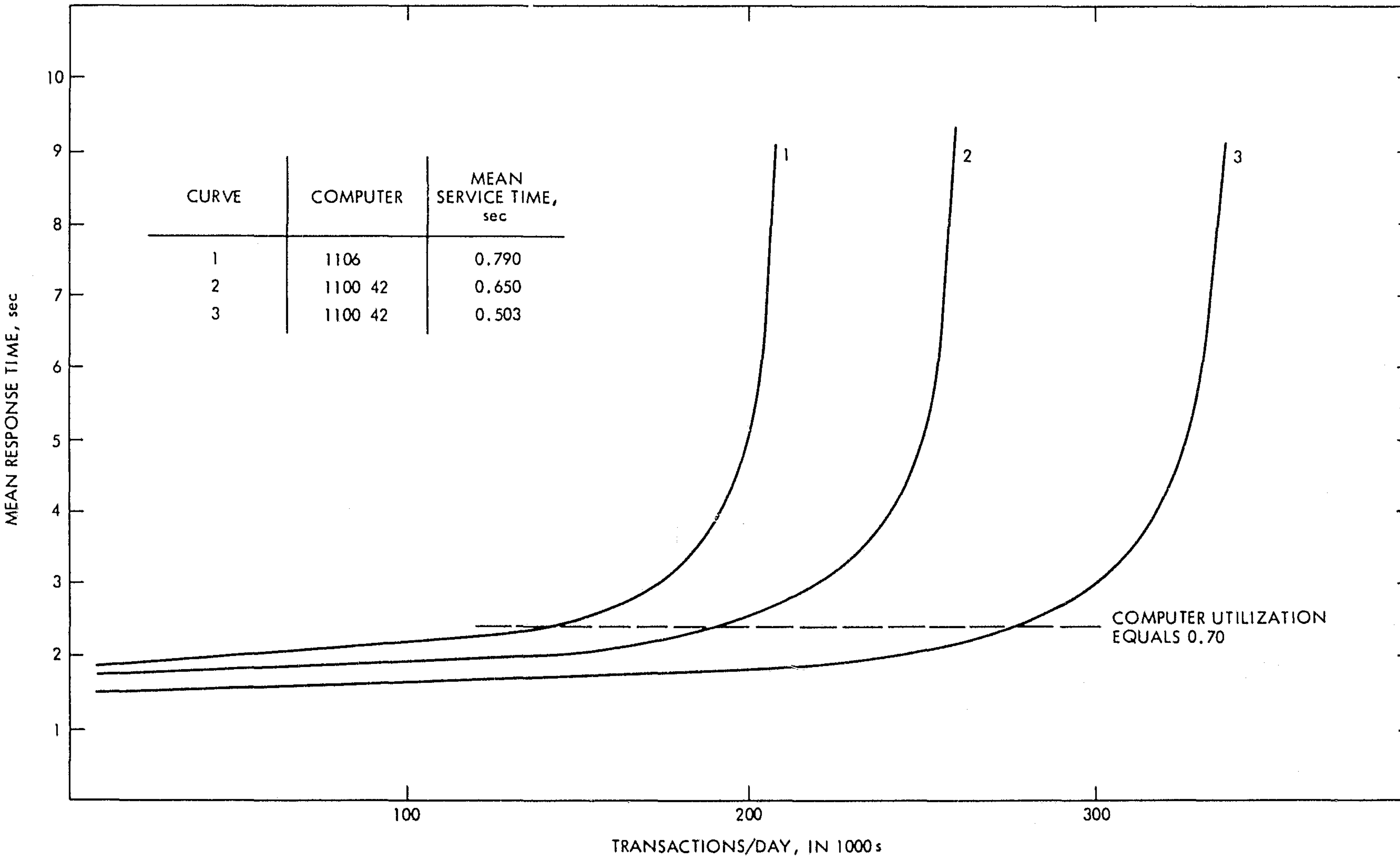


Figure 11-3. Existing LEADS Network Response Time vs Throughput--
2400 Baud Lines

Table 11-2. Mean Service Time Calculations
Leads UNIVAC 1100/42

Operation	Operation Mean Value Per Transaction	Disc Type	Disc Transfer Rate (Wds/ sec)	Disc Access Time (ms)	Mean Execute Time Per Instruction (ns)	Time (sec)
Program Roll In	16,000 Wds	8440	138,888	---	---	0.1152
System Software	150,000 Instructions	---	---	---	0.8	0.1200
Application Software	150,000 Instructions	---	---	---	0.8	0.1200
Disc I/O Access	6 I/O's	8440	---	47.5	---	0.285
Disc I/O Data	224 Wds 6 times	8440	138,888	---	---	0.010
			Total Mean Service Time = .650			

Response times at terminals for the existing 150 Baud lines on the LEADS Network are shown in Figure 11-4. The major component of waiting time for responses at these terminals is due to the low line speed employed, which dominates the response time characteristics. This is further evidenced by the fact that there is little difference exhibited in response time as a result of using the 1100/42 configuration with a mean service time of 0.650 seconds, (Curve 1, Figure 11-4), and the configuration with mean service time of 0.503 seconds, (Curve 2, Figure 11-4).

At all traffic levels, the present use of 150 Baud lines does not meet the functional response time requirements of the STACOM Network. For this reason, STACOM communication lines are limited to 1200 Baud or greater in capacity.

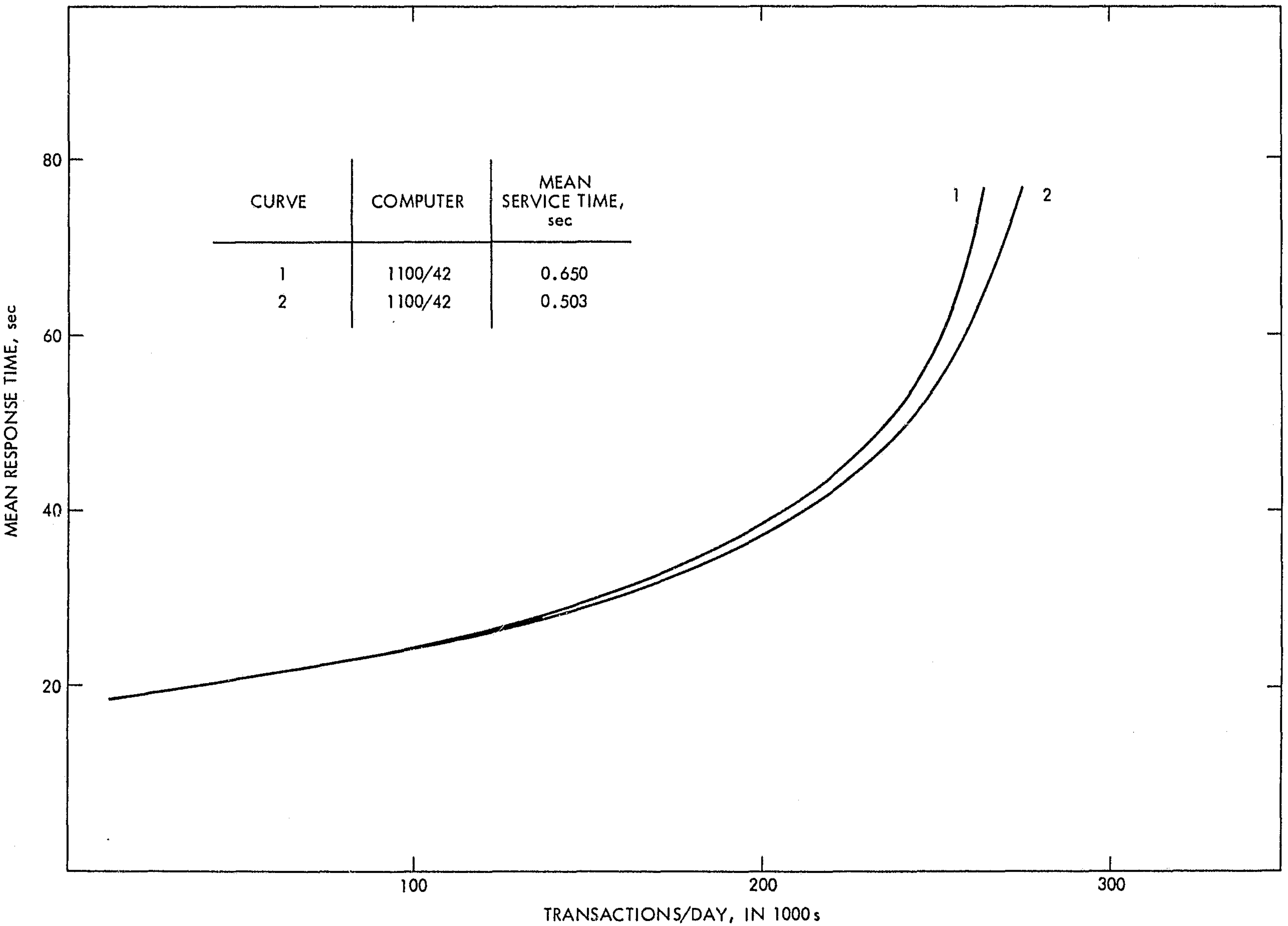


Figure 11-4. Existing LEADS Network Response Time vs Throughput--
150 Baud Lines

11.3 THE EXISTING BMV NETWORK

The existing Bureau of Motor Vehicles (BMV) network consists of 242 INCOTERM terminals distributed throughout BMV offices in the state of Ohio.

Vehicle registration and drivers license data is collected at each terminal during the working day and transmitted to Columbus during the evening to update LEADS, VR, and DL files. Inquires as to applicant status are made during the day hours into Columbus data bases as applicants appear at BMV offices. Figure 11-5 shows the present BMV network layout. The network employs 1200 Baud lines at a total annual cost of $295,000, for lines, modems, and service terminal arrangements.

Figure 11-5. Present Ohio Bureau of Motor Vehicles Network

SECTION 12

NEW OR IMPROVED STACOM/OHIO NETWORKS

This section presents detailed topology, cost and performance data for each of the network options as outlined in Section 8. Section 13 of this report presents a comparative discussion of cost and performance data for the options considered.

12.1 GENERAL CONSIDERATIONS

The networks presented here have been constructed subject to the MPL line tariff discussed in Section 9 for interstate networks, with the exception of those BMV and New Data network options that were considered as separate from the LEADS network and subject to an intrastate tariff. The high density MPL Ohio cities used in MPL runs are Akron, Cincinnati, Cleveland, Columbus, Canton, Dayton, Toledo, and Youngstown.

12.2 COMPUTER PERFORMANCE REQUIREMENTS

It is considered mandatory that STACOM/OHIO response time functional requirements are to be met for all network options at peak network traffic loads. To this end, computer mean service times per transaction at peak traffic loads have been assumed such that computer utilization never exceeds 0.700. It is important to realize that increasing line speeds does not appreciably decrease network response times when computer utilization becomes high, i.e., increasing line speeds is not an effective solution for alleviating computer queueing pressure.

Table 12.1 summarizes computer mean service time requirements per transaction required to meet estimated peak loading of the Columbus computer. The second column in the table labeled Average Messages per Day includes estimates of present law enforcement data types, law enforcement use of CCH and computer loading due to BMV transactions. It is assumed that the computer will be loaded by BMV transactions whether or not the BMV network consists of separate lines from the LEADS network. The figure presented is the number of messages arriving at the computer that result in computer switching or data base access demand.

The third column shows Average Transactions per Day. This value takes into account the fact that some data base inquiries automatically trigger inquiries/responses (transactions) to other data bases in the system. LEADS system computer studies indicate that there are 1.3 computer transactions generated on the average for each arriving message.

The fourth column presents the resulting Average Transactions per Second and the fifth column shows the resulting Peak Transactions per Second, LEADS traffic studies indicated that at the busiest time of day the peak traffic load is twice the overall daily average load.

Table 12-1. Mean Computer Service Times Required for Peak Loading

Year	Av Msg Per Day arriving at Computer (1000's)	Av Trans Per Day (1000's)	Av Trans Per Sec	Peak Trans Per Sec	Processor Config	Required Mean Service Time Per Transaction Per Processor (ms)
1977	99	129	1.5	3.0	2 x 2	467
1981	219	285	3.3	6.6	4 x 4	424
1985	274	356	4.1	8.2	4 x 4	342

Column six indicates the dual 2 x 2 and the 4 x 4 UNIVAC processor configurations assumed for the 1977, 81, and 85 network topology design runs.

The last column indicates the required mean service time per processor per transaction to maintain the computer utilization at less than or equal to .700 at all times.

For example, the following equation defines the data base computer RHO as:

$$\rho_{CD} = \frac{E(nCD)}{N} \times E(tSCD)$$

Where:

E(nCD) = Computer Transaction Arrival Rate per Second

N = Number of parallel processors

E(tSCD) = Mean Service Time per Transaction

Thus, the required Means Service Time is

$$E(tSCD) = \frac{N \times \rho_{CD}}{E(nCD)}$$

And for the 1977 case, we have,

$$E(tSCD) = \frac{2 \times .7}{3.0} = 0.467 \text{ seconds}$$

The network designs presented in the following pages of Section 12 call for an upgrade of the Columbus Computer at the present time to meet 1981 traffic levels and an additional upgrade in 1980-81 to meet 1985 throughput requirements shown in Table 12-1.

While it is not within the scope of this statewide network option study to detail computer system upgrade planning, general approaches to the problem do suggest themselves.

For example, roughly half of the six average disc I/O's carried out per transaction, are involved in catalogue access. If these master locator arrays, indexes and name files were implemented on fixed head discs, access time could be reduced to approximately 10 ms per access, or less. Allowing three remaining file accesses at 34 ms per access leaves 210 ms for mean CPU processsing time per transaction to total 342 ms as shown in Table 12-2.

Such an approach calls for a substantial change in existing telecommunications software, and is only intended here to clarify the order of magnitude of requirements. Obviously, any reduction in the mean number of disc accesses would substantially alleviate mean CPU processing time requirements. However, the values presented in Table 12-2 are not unrealistic in the present day state of the art at costs comparable to the 1100/44 type configuration.

As mentioned in Section 9, in the discussion of the approach to comparative network option costing, the costs for accomplishment of mean service time performance at the Columbus computer are not estimated in this report nor included in cost estimates for the specific network options which follow in this section.

This is not unreasonable, since the computer upgrades called for are a function of data base computer loading, and, as such, are essentially independent of network topology alternatives. The costing presented in this section is still valid in terms of providing relative cost advantages for all options considered.

12.3 OPTION 1 - SINGLE REGION LEADS

12.3.1 Topology

The STACOM/OHIO single region LEADS network layout is shown in Figure 12-1. The network consists of a single regional switcher and data base computer located in Columbus. There are 23 multidropped lines serving system terminations consisting of a mix of 1200 Baud and 2400 Baud

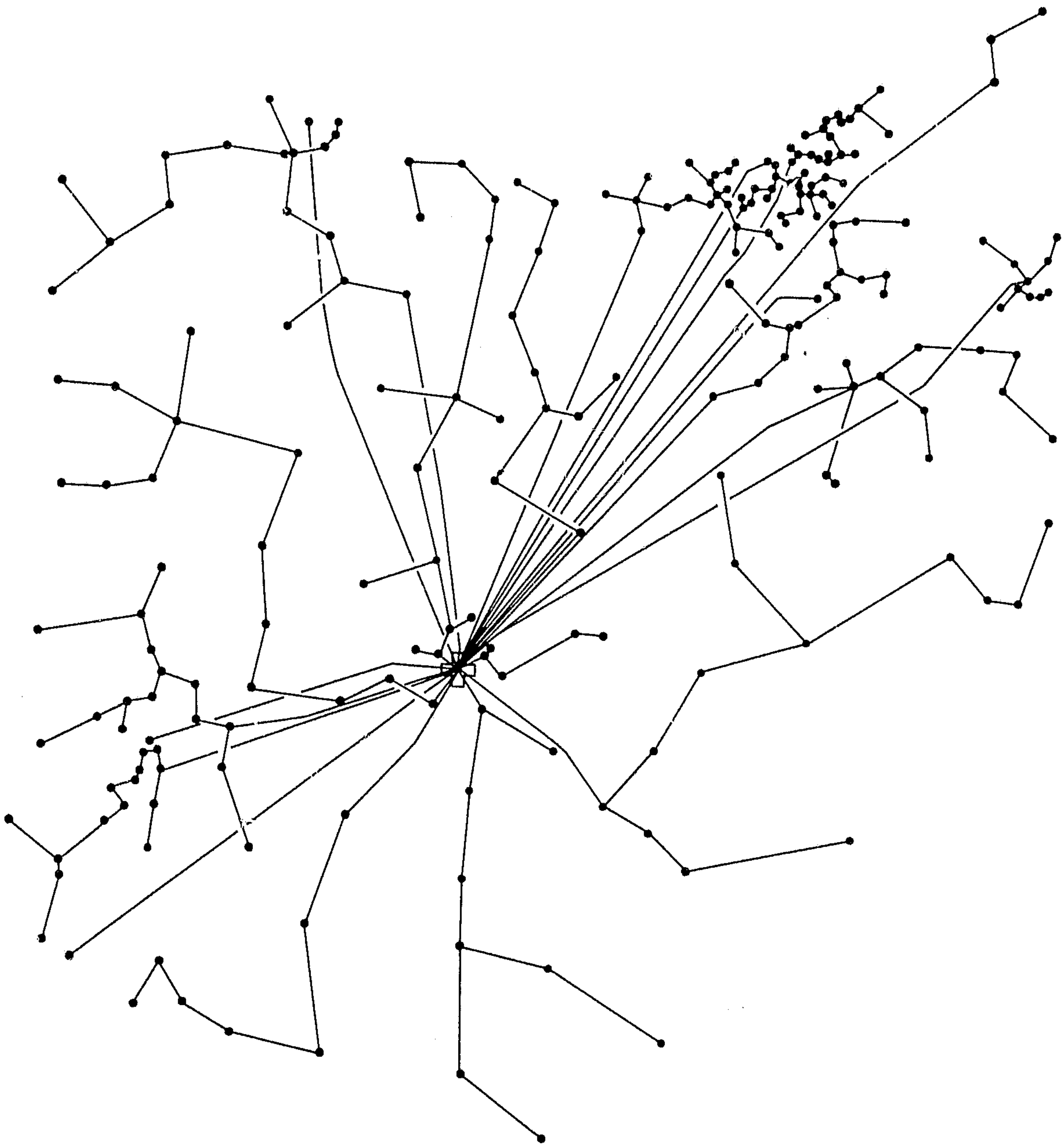


Figure 12-1. Single Region LEADS Network

Table 12-2. CPU Processing Time

Operation	Accesses	Time/Access	Total Time (ms)
Catalogue Access	3	10	30
File Access	3	34	102
CPU Processing Time	---	---	210
Mean Service Time			342 ms

lines. Table 12-3 presents the detailed terminal assignments for each of the 23 multidrops by PID Number. Reading from left to right, the table shows the line number, (1 to 23), the total number of terminals on the drop, the PID number of the first terminal out of Columbus, and the remaining PID numbers of terminals in the order in which they appear on the drop.

12.3.2 Costs

Total 8 year costs to 1985 for the single region case are presented in Table 12-4. Total 8 year costs amount to $7,960,000. About 40% of this total cost is due to terminal recurring and purchase costs. Lines, modems and service terminals account for almost 60% of costs. Regional switches are not required in this option.

12.3.3 Line Performance

Table 7-5 summarizes performance characteristics by line for the single region LEADS Network. Reading from left to right, the table presents the line number, the first terminal on the drop by PID number, the total number of terminals on the drop, the line capacity in Bauds, the peak line utilization value, total mileage on the drop, and the mean response time for any single terminal on the drop.

Mean response times on the single region network run between 1.8 and 7.5 seconds depending on the specific multidrop line. Of the 23 lines in the network, 8 have mean response times of 5 seconds or less. The worst case mean response time is 7.5 seconds.

12.3.4 Network Availability

The availability of the data base to any terminal on the network is 0.988 calculated in accordance with the procedure outlined in Section 7.4. An availability of 0.988 implies an outage of 17.3 minutes per day.

Table 12-3. Terminal Assignments

NETWORK OPTION: LEADS

NUMBER OF REGIONS: 1

REGION	LINE NO.	TOTAL NO.	TERMINALS STARTING	TERMINALS REMAINING
1				
	1	9	416	417,104,324,100,325,321, 99,322,
	2	25	353	108,109,335,328,117,346,345,157, 17,163, 154, 24,155, 18,160,166,159, 19,158,368, 162,164,165, 20,
	3	25	95	367,365,364, 45,366,161,357,356, 27,379, 378, 28,193,186, 30,382,377,371,180,181, 32,358,376,414,
	4	4	146	113,114,112,
	5	24	343	340,330,110, 98,329,349,336,138,142,152, 251,139,151,351,115,344,140,149, 16,144, 145,150, 25,
	6	12	323	107, 12, 0, 0, 0, 0, 0, 0, 0, 0, 0,
	7	5	1	26;173: 34;168:
	8	17	116	331,334,111,332,143,350,352,348,338,341, 102,318,101,339,319,148,
	9	25	383	380,169,178,178, 22,141, 23,182,171,171, 33,175,174,179,176,172, 35,362,360,361, 359, 21,156,363,
	10	5	64	354,247, 63,249,
	11	6	54	235,231, 52,238, 59,
	12	25	44	236,390,230,200,241, 56,265,393,225,220, 396,394,226, 55,219,223,224,216,221,243, 242,233, 38, 50,
	13	22	229	58,244,217, 57,222,388,397, 60,232,237, 387,248, 61,252,409, 62,245,246,218,386, 234,
	14	21	408	407, 67,194,198,392,196,189,190, 29,188, 195,187,192, 31,185,184, 37,191,197, 39,
	15	23	385	204,205,202,201, 47,212,389, 48,211, 49, 391,250,254,410,206,208,207,210, 51,395, 203,209,
	16	4	43	

Table 12-3. Terminal Assignments (Continuation 1)

			42, 41,406,
17	25	400	401, 68,402,255,257,266,215,214, 40,256, 258,262,259,261,263,267,264, 71, 70,147, 403,260,239, 72,
18	7	370	381,295, 76,423,415,419,
19	9	422	228,105, 46, 36, 85,337,421,347,
20	20	308	418, 96, 86,412,413, 88,320,315,316,314, 90,317, 94,420, 89, 93,300,301, 87,
21	24	302	303,311,309, 77,312,304, 78,298,399,292, 81,375,374,373, 80,305,306,307, 91,310, 404,405, 92,
22	16	84	275,274,295,273,272,271,270, 73,278,279, 283, 83,280,276,277,
23	19	74	75,286,297,287, 79,284, 69,282,269,291, 281,288,294,290,296,289, 82,372,

Table 12-4. Network Option Costs (Thousands of Dollars)

		Recurring Costs			One Time Installation Costs		
Item	No. Reqd.	Annual Cost Each	Total Annual Cost	Eight Year Cost	Unit Cost	Total Purchase Cost	Total Eight Year Cost by Item
Lines, Modems Service Terminals	-	-	564	4,512	-	42	4,554
Regional Switchers	0						
Switcher Floor Space	0						
Switcher Back up Power	0						
Terminals	310	0.6	234	1,872	3.6	1,400	3,272
Switcher Personnel	0						
Engineering					-	130	130
Subtotals			798	6,384		1,572	7,956
				Total Eight-year Cost			7,960

Table 12-5. Network Line Characteristics

Network LEADS Number of Regions 1

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	416	9	1200	0.161	145	4.9
2	353	25	1200	0.679	212	7.5
3	95	25	1200	0.503	195	6.8
4	146	5	2400	0.433	66	3.5
5	343	24	1200	0.518	183	6.8
6	323	3	2400	0.584	101	4.6
7	13	5	2400	0.460	120	3.6
8	116	17	1200	0.664	159	6.8
9	383	25	1200	0.540	256	7.0
10	64	5	1200	0.123	192	4.5
11	54	6	2400	0.412	126	1.9
12	44	25	1200	0.674	186	7.4
13	229	22	1200	0.590	188	6.9
14	408	21	1200	0.493	158	6.5
15	385	23	1200	0.498	190	6.7
16	43	4	2400	0.349	110	3.1
17	400	25	1200	0.574	184	7.1
18	370	7	1200	0.213	40	4.9
19	422	9	2400	0.649	0	5.2
20	308	20	1200	0.418	181	6.3
21	302	24	1200	0.448	229	6.6
22	84	16	1200	0.667	188	6.8
23	74	19	1200	0.659	227	7.0

12.4 OPTION 2 - TWO REGION LEADS

12.4.1 Topology

The STACOM/OHIO two region network is shown in Figure 12-2. In addition to the switcher data base computer located in Columbus, a regional switcher is located in Cleveland which serves system terminations in the northeast as shown. A single 4800 Baud line connects the Columbus and Cleveland computers.

There are twelve multidropped lines in the Cleveland Region, all of which are 1200 Baud lines with the exception of one 4800 Baud line. The Columbus region also has twelve lines, four of which are

Figure 12-2. Two Region LEADS Network

2400 Baud lines. The remaining eight lines are 1200 Baud lines. Table 12-6 details the terminal assignments to lines by PID number for the two region case.

12.4.2 Costs

Eight year total costs for the two region case are presented in Table 12-7. Total costs are $9,470,000.

The costs of the additional switcher amounts to about 16% of this total.

Note that costs for lines, modems and service terminals drop from $564,000 per year in the single region case to $561,000 in the two region case.

12.4.3 Line Performance

Table 12-8 lists line performance characteristics. Mean response times on the two region network vary between 3.7 seconds to 8.6 seconds on specific multidrop lines. On 13 of the total of 24 lines in the network the mean response time is less than 7 seconds. The worst case mean response time for any given line is 8.6 seconds.

12.4.4 Network Availability

The availability of the data base in Columbus to any system termination on the network is 0.982. An availability of 0.982 implies an average outage of approximately 26 minutes per day.

12.5 OPTION 3 - THREE REGION LEADS

12.5.1 Topology

The STACOM/OHIO three region LEADS network layout is presented in Figure 12-3. The network consists of regional switcher in Cleveland and Cincinnati, and the switcher data base computer in Columbus. A 4800 Baud line connects the Columbus computer to the Cleveland switcher and another 4800 Baud line connects the Columbus computer to the Cincinnati Switcher.

Line assignment details are presented in Table 12-9.

There are 11 multidropped lines serving the Cleveland region from the Cleveland switchers, all of which are 1200 Baud lines with the exception of one 2400 Baud line, and one 4800 Baud line.

The Cincinnati switcher handles three 1200 Baud lines and two 2400 Baud lines in its region. The Columbus switcher data base computer handles nine 1200 Baud lines in servicing the central region.

Table 12-6. Terminal Assignments

NETWORK OPTION: LEADS

NUMBER OF REGIONS: 2

REGION	LINE NO.	TERMINALS TOTAL NO.	TERMINALS STARTING	TERMINALS REMAINING
1				
	1	16	191	197, 39,185,184, 37,408,407, 67,198,392, 196,193,379,378, 28,
	2	24	207	208,204,385,205,188,189,190, 29,195,187, 192, 31, 30,382,377,371,180,181, 32,383, 380,169,186,
	3	18	390	236, 50,211, 49, 48,395,210, 51,206,389, 212,202,201, 47,203,209, 44,
	4	6	54	235,231, 52,238, 59,
	5	14	242	233,234, 58,244,217,386,222,388,218,409, 62, 57,219,
	6	14	60	397,232,237,387,248, 61,252,245,246, 64, 354,247, 63,
	7	12	200	230,241, 56,265,393, 38,410,391,215,214, 40,
	8	21	229	243, 55,394,216,223,221,239,260, 72,272, 271,270, 73,226,225,220,396,250,254,224,
	9	18	294	290, 83,283, 84,275,274,295,273,278,279, 280,276,277,296,289, 82,372,
	10	13	269	284, 69,282,286,297,287, 79, 74, 75,291, 281,288,
	11	4	43	42, 41,406,
	12	21	403	259,262,258,256,257,266,255,402,400,401, 68,399,298,261,263,267,264, 71, 70,147,
2				
	1	25	300	301, 87,303,302,305,306,307, 91,310,404, 405, 92,311,309, 77,312,304, 78,292, 81, 375,374,373, 80,
	2	18	370	381,295,308,418, 96, 86, 76,423,415,419, 376,367,365,364, 45,366,161,
	3	9	422	228,105, 46, 36, 85,337,421,347,
	4	23	353	416,417,412,413, 88,320,315,316,314, 90, 317, 94,420, 89, 93,104,324,100,325,321,

Table 12-6. Terminal Assignments (Continuation 1)

			99,322,
5	25	95	414,357,356, 27,194,356,163,154,178,178, 22,368, 24,155, 18,160,166,159, 19,158, 162,164,165, 20,
6	1	146	
7	24	343	340,330,110, 98,329,349,336,138,142,152, 251,139,151,351,115,344,140,149, 16,144, 145,150, 25,
8	3	323	107, 12,
9	5	13	26,173, 34,168,
10	19	33	23,182,141,179,176,171,171,172, 35,362, 360,361,359, 21,156,363,175,174,
11	9	108	109,335,328,117,346,345,157, 17,
12	17	116	331,334,111,332,143,350,352,348,338,341, 102,318,101,339,319,148,

Table 12-7. Network Option Costs (Thousands of Dollars)

Item	No. Reqd.	Recurring Costs: Annual Cost Each	Recurring Costs: Total Annual Cost	Recurring Costs: Eight-year Cost	One Time Installation Costs: Unit Cost	One Time Installation Costs: Total Purchase Cost	Total Eight-year Cost by Item
Lines, Modems Service Terminals	-	-	561	4,488	-	42	4,530
Terminals	390	0.6	234	1,872	3.6	1,400	3,272
Regional Switchers	1	12	12	96	180	180	276
Switcher Floor Space	1	4.8	4.8	38	30	30	68
Switcher Back-up Power	1	6.0	6.0	48	20	20	68
Switcher Personnel	1 set	128	128	1,024	-	-	1,024
Engineering						230	230
Subtotals			946	7,566		1,902	9,468
Total Eight-year Cost							9,470

Table 12-8. Network Line Characteristics

Network LEADS Number of Regions 2
Remarks Cleveland as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	191	16	1200	0.367	144	7.9
2	207	24	1200	0.416	159	8.6
3	390	18	1200	0.503	58	8.4
4	54	6	4800	0.417	0	3.9
5	242	14	1200	0.370	40	7.8
6	60	15	1200	0.408	81	7.9
7	200	12	1200	0.370	46	7.7
8	229	21	1200	0.516	92	8.7
9	294	18	1200	0.549	140	8.6
10	269	13	1200	0.544	111	8.2
11	43	4	2400	0.696	31	5.1
12	403	21	1200	0.494	132	8.6

Network LEADS Number of Regions 2

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	300	25	1200	0.496	241	6.9
2	370	18	1200	0.444	112	6.3
3	422	9	2400	0.649	0	5.3
4	353	23	1200	0.426	289	6.6
5	95	25	1200	0.623	233	7.3
6	146	5	2400	0.433	66	3.6
7	343	24	1200	0.518	183	6.9
8	323	3	2400	0.584	101	4.7
9	13	5	2400	0.460	120	3.7
10	33	19	1200	0.394	258	6.2
11	108	9	1200	0.321	78	5.3
12	116	17	1200	0.664	159	6.9

Table 12-9. Terminal Assignments

NETWORK OPTION: LEADS

NUMBER OF REGIONS: 3

REGION	LINE NO.	TOTAL NO.	TERMINALS STARTING	TERMINALS REMAINING
1				
	1	6	54	235,231, 52,238, 59,
	2	2	242	233,
	3	17	58	229,234,244,217,386,222,388,218,409, 62, 272,271,270, 73, 57,219,
	4	15	60	397,232,237,387,248, 61,252,245,246, 64, 354,247, 63,249,
	5	22	241	56,243, 55,394,216,223,221,226,225,220, 396,250,391,410,215,214, 40,254,224,265, 393,
	6	16	200	230, 38,390,236, 50,211, 49, 48,206,207, 210, 51,208,395, 44,
	7	22	389	212,202,201, 47,204,203,209,205,188,189, 190, 29,196,191,197, 39,195,187,192, 31, 385,
	8	18	294	290, 83,283, 84,275,274,295,273,278,279, 280,276,277,296,289, 82,372,
	9	7	269	284, 69,282, 74, 75,291,
	10	4	43	42, 41,406,
	11	22	260	403,259,262,258,256,257,266,255,402,400, 401, 68,261,263,267,264, 71, 70,147,239, 72,
2				
	1	14	322	321, 99,325,100,104, 98,340,330,110,343, 329,349,324,
	2	1	172	
	3	3	323	107, 12,
	4	13	148	319,102,318,101,339,351,115,144,145,341, 334,111,
	5	18	338	331,348,352,350,143,251,139,151,152,142, 138,344,140,141,332,116,146,
3				
	1	25	346	

Table 12-9. Terminal Assignments (Continuation 1)

			345,157, 17,163,154,150, 25,160,166, 24, 155, 18,368,162,164,165, 20,159, 19,158, 335,328,117,336,
2	25	365	364, 45,357,356, 27,194,193,379,378, 28, 358,198,392,186, 30,382,377,371,180,181, 32,185,184, 37,
3	17	370	308,300,301, 87,302,303,305,306,307, 91, 310,404,405, 92,381,419,
4	9	422	228,105, 46, 36, 85,337,421,347,
5	17	353	418, 96, 86,412,413, 88,320,315,316,314, 90,317, 94,420, 89, 93,
6	24	295	76,423,415,311,309, 77,312,304, 78,298, 399,286,297,287, 79,288,292, 81,375,374, 373, 80,281,
7	13	95	367,376,408,407, 67,414,366,161,108,109, 416,417,
8	5	13	26,173, 34,168,
9	25	383	380,169,178,178, 22,141, 23,182,171,171, 33,175,174,179,176,172, 35,362,360,361, 359, 21,156,363,

Figure 12-3. Three Region LEADS Network

12.5.2 Costs

Total eight year costs for the three region LEADS case amount to $10,950,000 as indicated in Table 12-10. The regional switchers amount to approximately 27% of the total cost.

Note that recurring costs for lines, modems and service terminals are slightly higher than in the two region case. The small increase is due to an increase in inter-regional line costs in the three region case. The intra-regional line costs in the two and three region cases are almost identical.

12.5.3 Line Performance

Line performance characteristics are presented in Table 12-11.

Mean response times on multidropped lines for the three region case vary from 4.0 to 8.7 seconds. On 11 of the total of 25 network lines the response time is less than 7.0 seconds. The worst case mean response time is 8.7 seconds.

12.5.4 Network Availability

Network availability for the three region case is 0.982 which corresponds to an average daily outage of 26 minutes per day.

12.6 OPTION 4 - FOUR REGION LEADS

12.6.1 Topology

The STACOM/OHIO four region LEADS network is shown in Figure 12-4. Three regional switchers in Cleveland, Cincinnati and Toledo service the network in addition to the switcher data base in Columbus. Line layout details are shown in Table 12-12. The Cleveland switcher handles nine 1200 Baud lines and one 4800 Baud line. The Toledo region is served by four 1200 Baud lines and one 2400 Baud line. The Columbus switcher data base computer services the central region with five 1200 Baud lines and one 2400 Baud line. The Cincinnati switcher handles the same terminals in the four region case as in the three region case consisting of three 1200 Baud lines and two 2400 Baud lines. The total number of lines in the four region LEADS network is 26.

The Cleveland, Toledo, and Cincinnati switchers are each connected to the Columbus switcher data base with a single 4800 Baud line.

Table 12-10. Network Option Costs (Thousands of Dollars)

Network LEADS Number of Regions 3

Remarks Data Base Switcher in Columbus; Regional Switchers in Cleveland and Cincinnati

Item	No. Reqd.	Recurring Costs: Annual Cost Each	Recurring Costs: Total Annual Cost	Recurring Costs: Eight Year Cost	One Time Installation Costs: Unit Cost	One Time Installation Costs: Total Purchase Cost	Total Eight Year Cost by Item
Lines, Modems Service Terminals	-	-	567	4,536	-	42	4,578
Terminals	390	0.6	234	1,872	3.6	1,400	3,272
Regional Switchers	2	12	24	192	180	360	552
Switcher Floor Space	2	4.8	1.6	76.8	30	60	136.8
Switcher Back-up Power	2	6	12	96	20	40	136
Switcher Personnel	2 Sets	128	256	2,048	-	-	2,048
Engineering				-		230	230
Subtotals			1,103	8,821		2,132	10,953
				Total Eight Year Cost			10,950

Table 12-11. Network Line Characteristics

Network LEADS Number of Regions 3

Remarks Cincinnati as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	322	14	1200	0.276	154	7.2
2	172	3	2400	0.423	49	5.5
3	323	3	2400	0.584	0	6.6
4	148	13	1200	0.465	106	7.9
5	338	20	1200	0.530	116	8.6

Network LEADS Number of Regions 3

Remarks Cleveland as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	54	6	4800	0.417	0	4.0
2	242	2	1200	0.098	1	6.5
3	58	17	1200	0.549	74	8.5
4	60	15	1200	0.408	81	7.9
5	241	22	1200	0.497	77	8.7
6	200	16	1200	0.433	51	8.1
7	389	22	1200	0.456	127	8.6
8	294	18	1200	0.549	140	8.6
9	269	7	1200	0.446	67	7.5
10	43	4	2400	0.349	31	5.1
11	260	22	1200	0.493	12	8.7

Table 12-11. Network Line Characteristics (Continuation 1)

Network LEADS Number of Regions 3

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	346	25	1200	0.673	231	7.5
2	365	25	1200	0.578	194	7.1
3	370	17	1200	0.345	132	5.9
4	422	9	2400	0.649	0	5.3
5	353	17	1200	0.332	163	5.9
6	295	24	1200	0.519	241	6.9
7	95	13	1200	0.257	115	5.4
8	13	5	2400	0.460	120	3.7
9	383	25	1200	0.540	256	7.0

Figure 12-4. Four Region LEADS Network

Table 12-12. Line Layout Details

NETWORK OPTION: LEADS

NUMBER OF REGIONS: 4

REGION	LINE NO.	TERMINALS TOTAL NO.	TERMINALS STARTING	TERMINALS REMAINING
1				
	1	6	54	235,231, 52,238, 59,
	2	19	242	233,241, 56,243, 55,394,225,220,396,250, 254,216,223,221,226,224,265,393,
	3	15	60	397,232,237,387,248, 61,252,245,246, 64, 354,247, 63,249,
	4	16	51	210,207,206, 48,395,389,212,202,201, 47, 204,203,209,385,208,
	5	17	200	230,390,236, 50,211, 49, 44,391,410,215, 214, 40,191,197, 39, 38,
	6	17	229	58,234,244,217,386,222,388,218,409, 62, 272,271,270, 73, 57,219,
	7	18	294	290, 83,283, 84,275,274,295,273,278,279, 280,276,277,296,289, 82,372,
	8	7	269	284, 69,282, 74, 75,291,
	9	4	43	42, 41,406,
	10	22	260	403,259,262,258,256,257,266,255,402,400, 401, 68,261,263,267,264, 71, 70,147,239, 72,
2				
	1	14	322	321, 99,325,100,104, 98,340,330,110,343, 329,349,324,
	2	1	172	
	3	3	323	107, 12,
	4	13	148	319,102,318,101,339,351,115,144,145,341, 334,111,
	5	19	338	331,352,350,143,251,139,151,152,142,138, 344,140,149, 16,332,116,146, 0,
3				
	1	21	35	362,360,361,359, 21,363,156,164,165, 20, 162,368, 24,155, 18,160,166,159, 19,158,
	2	5	13	26,173, 34,168,

Table 12-12. Line Layout Details (Continuation 1)

3	2	179	176,
4	25	371	180,181, 32,382,377, 30,186,195,187,192, 31,188,189,190, 29,196,379,378, 28,358, 163,154,193,205,
5	15	175	33,171,171, 23,182,141,169,178,178, 22, 383,380,172,174,
1	22	370	381,419,376,367,365,364, 45,366,161,357, 356, 27,194,408,407, 67,198,392,185,184, 37,
2	9	422	228,105, 46, 36, 85,337,421,347,
3	17	353	418, 96, 86,412,413, 88,320,315,316,314, 90,317, 94,420, 84, 93,
4	14	308	300,301, 87,302,303,305,306,307, 91,310, 404,405, 92,
5	24	295	76,423,415,311,309, 77,312,304, 78,298, 399,286,297,287, 79,288,292, 81,375,374, 373, 80,281,
6	16	95	414,108,107,416,417,335,328,117,346,345, 157, 17,150, 25,336,

12.6.2 Costs

Total eight year costs for the four region LEADS network amount to $12,410,000. These costs are detailed in Table 12-13. The three regional switchers, in this network account for approximately 36% of total costs. Costs for lines, modems and service terminals are higher in this network than in any of the other four LEADS options. The observed increment over the three region case is due to additional interregional line costs.

12.6.3 Line Performance

Line performance data for the four region case is shown in Table 12-14. Mean response times vary from 4.0 seconds to 8.7 seconds maximum depending on the multidrop line. Of the 26 total lines in this network, 10 have response times less than or equal to 7.0 seconds. Only one line in this network carries as many as 25 terminals.

12.6.4 Network Availability

Network availability for the three region case is 0.982 which corresponds to an average daily outage of 26 minutes.

12.7 OPTION 5 - BMV NETWORK SEPARATE FROM LEADS

12.7.1 Topology

The STACOM/OHIO BMV Network is shown in Figure 12-5. The network consists of a single region network serving BMV terminals throughout the state with lines separate from the single region LEADS network. Table 12-15 shows the detailed terminal assignments by PID number for the ten lines called for in the network. All ten multidrops in the network consist of 1200 Baud lines.

12.7.2 Costs

Total 8 year costs for the optimized BMV Network separate from the LEADS Network is $1,700,000. Totals are presented in Table 12-16. Costs for INCOTERM Terminals are not included in this analysis, nor are they included in the costing of Option 6 which considers the integration of LEADS with BMV. Since these costs are constant in both networks, the cost comparisons summarized in Section 13 are valid. The separate BMV network shown was optimized using the intra-state tarrif discussed in Section 9 of this report. Note that under this optimization, annual line costs are $193,000 as opposed to $295,000 in the existing system.

Table 12-13. Network Option Costs (Thousands of Dollars)

Network LEADS Number of Regions 4

Remarks Data Base Switcher in Columbus; Regional Switches in Cleveland, Cincinnati and Toledo

Item	No. Reqd.	Recurring Costs: Annual Cost Each	Recurring Costs: Total Annual Cost	Recurring Costs: Eight Year Cost	One Time Installation Costs: Unit Cost	One Time Installation Costs: Total Purchase Cost	Total Eight Year Cost by Item
Lines, Modems Service Terminals	-	-	570	4,560	-	42	4,602
Terminals	390	0.6	234	1,872	3.6	1,400	3,272
Regional Switchers	3	12	36	288	180	540	828
Switcher Floor Space	3	4.8	14.4	115.2	30	90	205.2
Switcher Back up Power	3	6	18	144	20	60	204
Switcher Personnel	3 sets	128	384	3,072	-	-	3,072
Engineering					-	230	230
Subtotals			1,256	10,051		2,362	12,413
Total Eight Year Cost							12,410

Table 12-14. Network Line Characteristics

Network LEADS Number of Regions 4

Remarks Cincinnati as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	322	14	1200	0.276	154	7.5
2	172	3	2400	0.423	49	5.5
3	323	3	2400	0.584	0	6.6
4	148	13	1200	0.465	106	7.9
5	338	20	1200	0.530	116	8.6

Network LEADS Number of Regions 4

Remarks Cleveland as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	54	6	4800	0.417	0	4.0
2	242	19	1200	0.478	55	8.4
3	60	15	1200	0.408	81	8.0
4	51	16	1200	0.370	62	7.9
5	200	17	1200	0.439	75	8.2
6	229	17	1200	0.549	73	8.5
7	294	18	1200	0.549	140	8.6
8	269	7	1200	0.446	67	7.5
9	43	4	2400	0.349	31	5.1
10	260	22	1200	0.493	112	8.7

Table 12-14. Network Line Characteristics (Continuation 1)

Network LEADS Number of Regions 4

Remarks Toledo as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	35	21	1200	0.449	192	8.5
2	13	5	2400	0.460	0	5.7
3	179	2	1200	0.043	10	6.2
4	371	25	1200	0.436	190	8.7
5	175	15	1200	0.351	85	7.8

Network LEADS Number of Regions 4

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	370	22	1200	0.595	148	7.0
2	422	9	2400	0.649	0	5.3
3	353	17	1200	0.332	163	5.9
4	308	14	1200	0.251	122	5.5
5	295	24	1200	0.519	241	6.9
6	95	16	1200	0.468	142	6.2

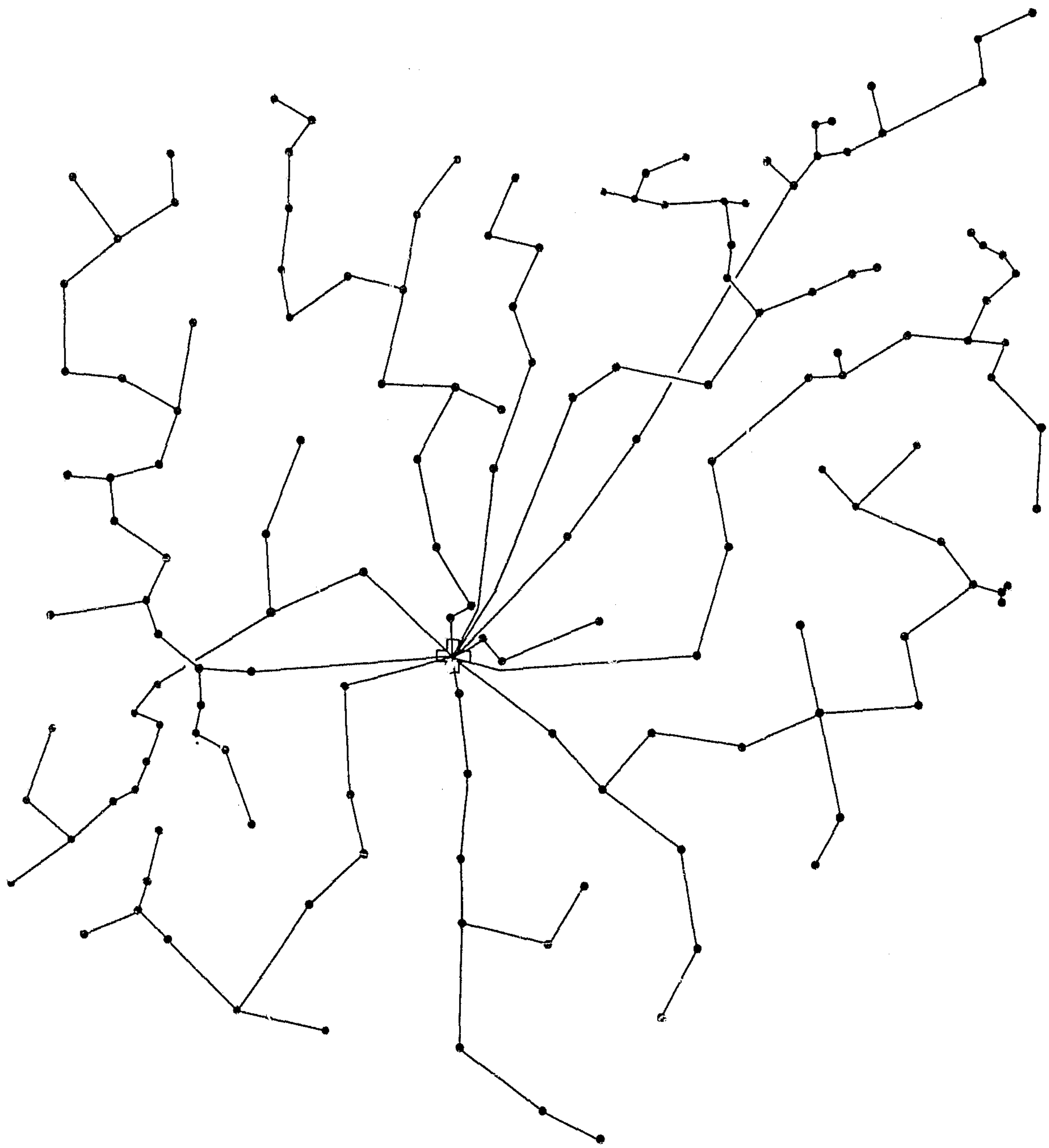


Figure 12-5. BMV Network

Table 12-15. Terminal Assignments

NETWORK OPTION: BMV

NUMBER OF REGIONS: 1

REGION	LINE NO.	TOTAL NO.	TERMINALS STARTING	TERMINALS REMAINING
1				
	1	24	435	436,645,644,578,598,439,440,441,454,453,448,449,450,652,451,452,653,655,656,657,654,455,442,
	2	25	643	565,566,567,568,666,665,664,579,659,660,580,581,582,584,585,586,587,588,599,600,601,602,603,569,
	3	18	649	445,437,438,646,590,591,592,593,594,595,596,662,663,647,661,446,650,
	4	22	552	668,479,669,670,671,489,571,672,572,651,573,574,575,576,635,636,637,638,639,673,674,
	5	21	467	468,469,470,471,459,473,474,472,460,462,461,546,547,548,464,465,463,475,476,477,
	6	23	444	487,533,562,563,564,641,642,480,553,554,555,557,556,558,559,560,534,457,541,542,543,544,
	7	25	458	545,524,525,535,536,537,515,526,527,528,538,539,549,550,516,517,518,519,529,530,531,520,521,522,
	8	23	508	507,620,621,622,623,628,629,636,631,632,633,613,614,615,513,606,607,609,610,611,616,605,
	9	6	488	490,491,493,492,675,
	10	25	481	482,506,502,497,498,499,500,501,509,510,511,512,503,504,617,618,484,483,494,495,485,624,625,626,

Table 12-16. Network Option Costs
(Thousands of Dollars)

Network BMV Number of Regions 1

Remarks Optimized Separate BMV Network

Item	No. Reqd.	Recurring Costs			One Time Installation Costs		Total Eight Year Cost by Item
		Annual Cost Each	Total Annual Cost	Eight Year Cost	Unit Cost	Total Purchase Cost	
Lines, Modems Service Terminals	-	-	193	1,544	-	30	1,574
Terminals							
Regional Switchers Switcher Floor Space							
Switcher Back-up Power							
Switcher Personnel							
Engineering					-	130	130
Subtotals			193	1,544		160	1,704
				Total Eight Year Cost			1,700

12.7.3 Line Performance

Line performance data for each of the ten 1200 Baud lines for the BMV Network is presented in Table 12-17. Mean response time at all terminals is fairly constant varying from 4.1 to 5.1 seconds with the exception of line 9 which is comprised of only six terminals each of which has a mean response time of 2.1 seconds.

Table 12-17. Network Line Characteristics

Network BMV Number of Regions 3

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	435	24	1200	0.218	334	4.8
2	643	25	1200	0.287	191	5.0
3	649	19	1200	0.273	215	4.1
4	552	22	1200	0.312	234	4.6
5	467	21	1200	0.150	347	4.3
6	444	23	1200	0.273	199	4.7
7	454	25	1200	0.304	253	5.0
8	508	24	1200	0.384	231	4.9
9	488	6	1200	0.059	121	2.1
10	481	25	1200	0.450	219	5.1

12.7.4 Network Availability

The network availability for the single region BMV network is calculated at 0.988 which corresponds to a daily average outage of 17.3 minutes per day.

12.8 OPTION 6 - AN INTEGRATED LEADS AND BMV NETWORK

12.8.1 Topology

The integrated LEADS and BMV Network is shown in Figure 12-6. The network is comprised of a single region with 30 multidropped lines out of Columbus. In general, there is a mix of terminals on these lines serving law enforcement agencies and BMV offices. Table 12-18 details terminal assignments to each of the 30 lines by PID number. There are two 4800 Baud lines in the network and four 2400 Baud lines in the network and four 2400 Baud lines. The remaining lines are 1200 Baud lines.

12.8.2 Costs

Total 8 year costs for the integrated LEADS BMV Network are shown in Table 12-19. The total cost is $9,800,000. These comparative costs include LEADS terminals as did the single region LEADS network costs, but not the already acquired BMV terminals. Lines, modems and service terminals amount to 64% of total costs as presented.

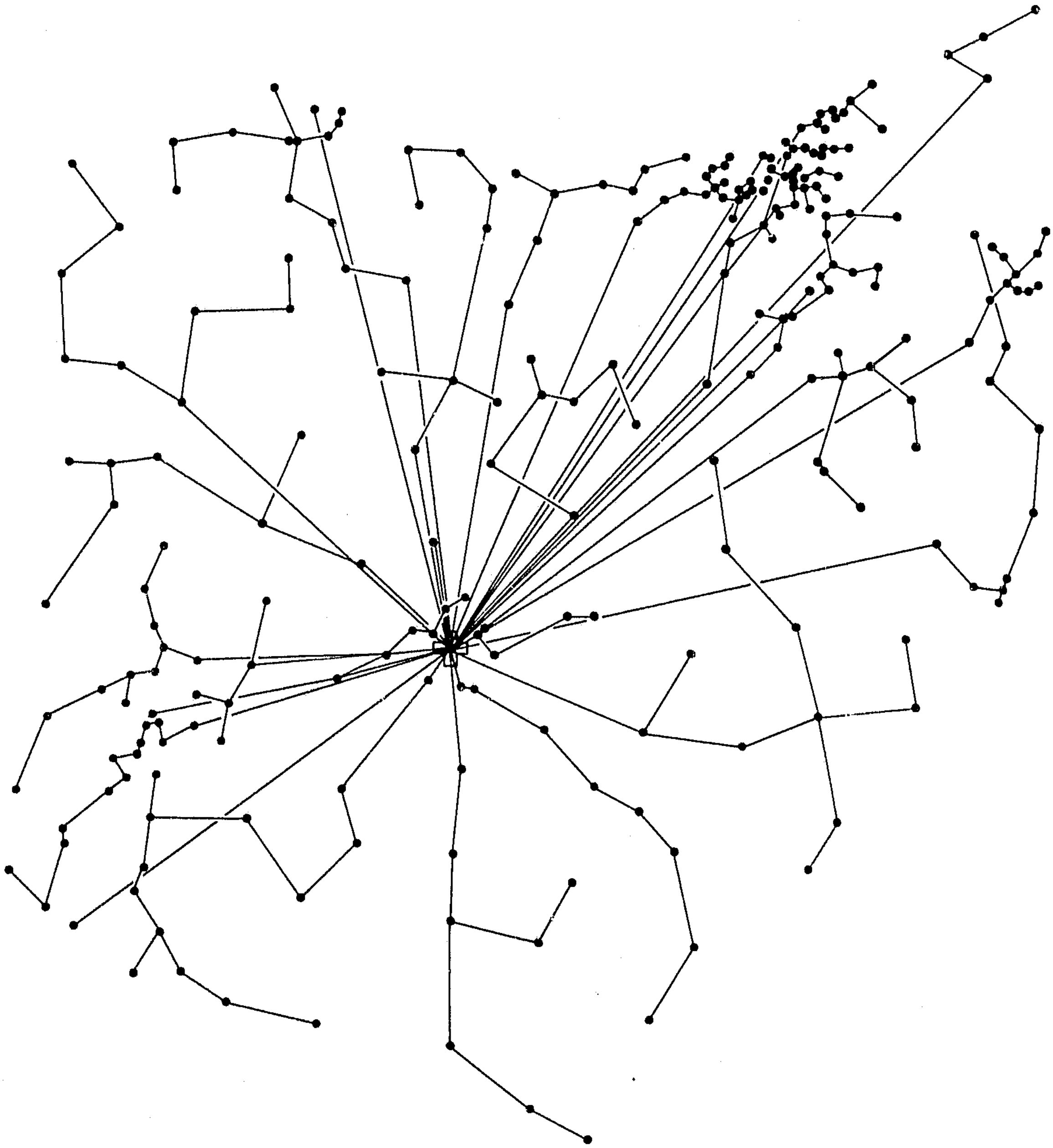


Figure 12-6. Integrated LEADS and BMV Network

Table 12-18. Assignments by PID Number

NETWORK OPTION: LEADS WITH BNV

NUMBER OF REGIONS: 1

REGION	LINE NO.	TERMINALS TOTAL NO.	STARTING	REMAINING
1				
	1	9	64	350,609,247, 63,610,249,611,608,
	2	25	220	225,393,265,620,621,622,623, 56,241,290, 230, 38,242,233,243,394,226, 55,219,223, 224,216,221,396,
	3	12	54	235,231, 52,238, 59,628,629,636,631,632, 633,
	4	17	60	397,616,388,232,237,387,605,248, 61,252, 409, 62,606,245,246,607,
	5	21	196	401,189,190, 29,493,188,205,494,204,483, 203,209,495,208,485,195,187,192, 31,675,
	6	18	408	407, 67,508,194,488,198,302,490,185,184, 37,481,191,197, 39,482,507,
	7	25	385	202,201, 47,484,212,389, 48,211, 49,617, 618, 44,391, 50,390,624,625,626,236,206, 207,210, 51,395,
	8	10	43	42, 41,406,497,498,499,500,501,509,
	9	23	402	255,257,266,502,256,258,262,259,261,263, 267,510,511,264, 71, 70,512,147,403,260, 239, 72,
	10	25	400	401, 68,506,215,214, 40,503,410,504,250, 229, 58,244,217,613,614,615,222,218,513, 386, 57,234,254,
	11	25	24	155, 18,449,450,368,652,178,179, 22,651, 573,162,451,164,165, 20,452,156,653,359, 21,655,363,654,
	12	25	336	436,138,142,437,438,152,251,139,646,151, 351,115,647,339,663,344,140,439,149, 16, 440,150, 25,441,
	13	15	335	328,117,435,346,345,445,343,340,330,110, 578,329,349,645,
	14	24	353	416,417,565,566,104,567, 98,598,334,111, 579,331,664,665,321, 99,666,325,100,568, 324,569,322,
	15	14	95	

Table 12-18 (Continuation 1)

			367,552,668,365,366, 45,669,376,479,414, 108,109,643,
16	4	146	333,113,114,112,590,591,592,593,
17	18	323	107, 12,659,660,590,581,592,584,585,586, 587,588,599,600,601,602,603,
18	10	13	26,173, 34,168,576,635,636,637,638,
19	23	357	356, 27,670,379,378, 28,671,193,489,186, 492, 30,382,377,674,371,180,181, 32,673, 358,571,
20	25	383	389,672,169,572,141, 23,182,574,171,171, 33,175,174,179,176,639,172,575, 35,362, 657,360,361,656,
21	22	366	161,649,157, 17,446,447,163,154,650,160, 166,448,159, 19,453,454,144,145,442,158, 455,
22	19	644	116,332,143,350,352,594,348,338,595,341, 596,102,318,101,662,319,148,661,
23	23	290	527, 83,516,283,280,276,277, 84,275,274, 295,517,518,519,520,530,531,273,520,521, 278,279,
24	13	370	381,534,295,457,541,542,543, 76,423,415, 544,419,
25	17	422	228,105, 46, 36, 85,337,421,347,486,487, 533,562,563,564,641,642,
26	25	292	461, 81,462,464,465,375,463,374,373, 80, 549,550,372,539,289, 82,538,296,528,272, 271,270, 73,522,
27	23	303	469,311,309, 77,458,470,471,312,304, 78, 459,298,545,399,524,404,405, 92,473,474, 472,460,
28	23	418	96, 86,553,412,413, 88,554,320,315,555, 420, 89,557,556,316,314, 90,558,317, 94, 559,560,
29	23	74	75,535,536,537,286,297,287, 79,547,546, 284, 69,282,525,269,515,291,281,288,548, 294,526,
30	17	480	308,300,301, 87,467,302,468,305,306,307, 91,310,475,476, 93,477,

Table 12-19. Network Option Costs (Thousands of Dollars)

Network <u>Integrated LEADS/BMV</u> Number of Regions <u>1</u>
Remarks <u>Single Network</u>

Item	No. Reqd.	Recurring Costs			One Time Installation Costs		Total Eight Year Cost by Item
		Annual Cost Each	Total Annual Cost	Eight Year Cost	Unit Cost	Total Purchase Cost	
Lines, Modems Service Terminals	-	-	790	6,320	-	68	6,388
Terminals	390	0.6	234	1,872	3.6	1,400	3,272
Regional Switchers							
Switcher Floor Space							
Switcher Back-up Power							
Switcher Personnel							
Engineering					-	130	130
Subtotals			1,024	8,192		1,598	9,790
				Total Eight Year Cost			9,800

The integrated network was optimized subject to the MPL tariff discussed in Section 9 of this report since the LEADS Network qualifies as an inter-state network.

12.8.3 Line Performance

Line performance data for the integrated LEADS BMV Network is presented in Table 12-20. Mean response time at terminals varies between 1.7 and 7.2 seconds. Message prioritization is not required to meet these response time values.

12.8.4 Network Availability

The network availability to any terminal on the integrated LEADS BMV Network is 0.988, which implies a daily average outage of 17.3 minutes.

12.9 OPTION 7 - NEW DATA NETWORK SEPARATE FROM LEADS

12.9.1 Topology

Growth of new data types is such that a new data network separate from the LEADS network should be constructed in two phases. An interim network to handle traffic through 1980 is shown in Figure 12-7. A complete network sufficient to handle predicted new traffic volumes from 1981 through to 1985 is shown in Figure 12-8. Both networks are basically starred networks with some lines involving a drop consisting of two terminals. Table 12-21 lists cities included in the network which functions through 1980 and whose PID numbers were used in the computer runs. Table 12-22 lists terminals for the final new data network to function from 1981 through 1985. The first network employs nine lines in total and the second network adds six new lines as shown.

12.9.2 Costs

Total eight year costs for the separate new data network amount to $724,000 as shown in Table 12-23. Costs for lines, modems, service terminals and network terminals are broken out for required network phasing. It is assumed that the first network is built in 1978 and the second in 1981. As in previous costing, new terminals for the network are purchased.

12.9.3 Line Performance

Line performance characteristics for the 1985 new data network are shown in Table 12-24. Response time varies from 2.2 to 14.2 seconds. These response times are in keeping with functional requirements for response times for these data types.

Table 12-20. Network Line Characteristics

Network LEADS with BMV — Number of Regions 1
Remarks Under MPL

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	64	9	1200	0.156	192	4.7
2	220	25	1200	0.636	175	7.1
3	54	12	4800	0.460	126	2.0
4	60	17	1200	0.394	171	5.8
5	196	22	2200	0.390	158	6.2
6	408	18	1200	0.376	126	5.8
7	385	25	1200	0.623	157	7.1
8	43	10	2400	0.419	110	3.3
9	402	23	1200	0.448	172	6.4
10	400	25	1200	0.513	160	6.7
11	24	25	1200	0.467	211	6.6
12	336	25	1200	0.460	143	6.6
13	335	15	1200	0.437	83	5.8
14	95	24	1200	0.362	202	6.2
15	146	14	1200	0.265	56	5.3
16	146	9	2400	0.465	66	3.6
17	323	18	2400	0.681	101	5.7
18	13	10	2400	0.515	120	3.9
19	357	22	1200	0.379	166	6.1
20	383	25	1200	0.439	193	6.5
21	366	22	1200	0.273	154	5.9
22	644	19	1200	0.700	142	6.9
23	290	23	1200	0.561	178	6.7
24	370	13	1200	0.300	40	5.3
25	422	17	4800	0.356	0	1.7
26	292	25	1200	0.532	216	6.8
27	303	23	1200	0.312	242	6.0
28	418	23	1200	0.359	162	6.1
29	74	23	1200	0.693	192	7.2
30	480	17	1200	0.257	110	5.5

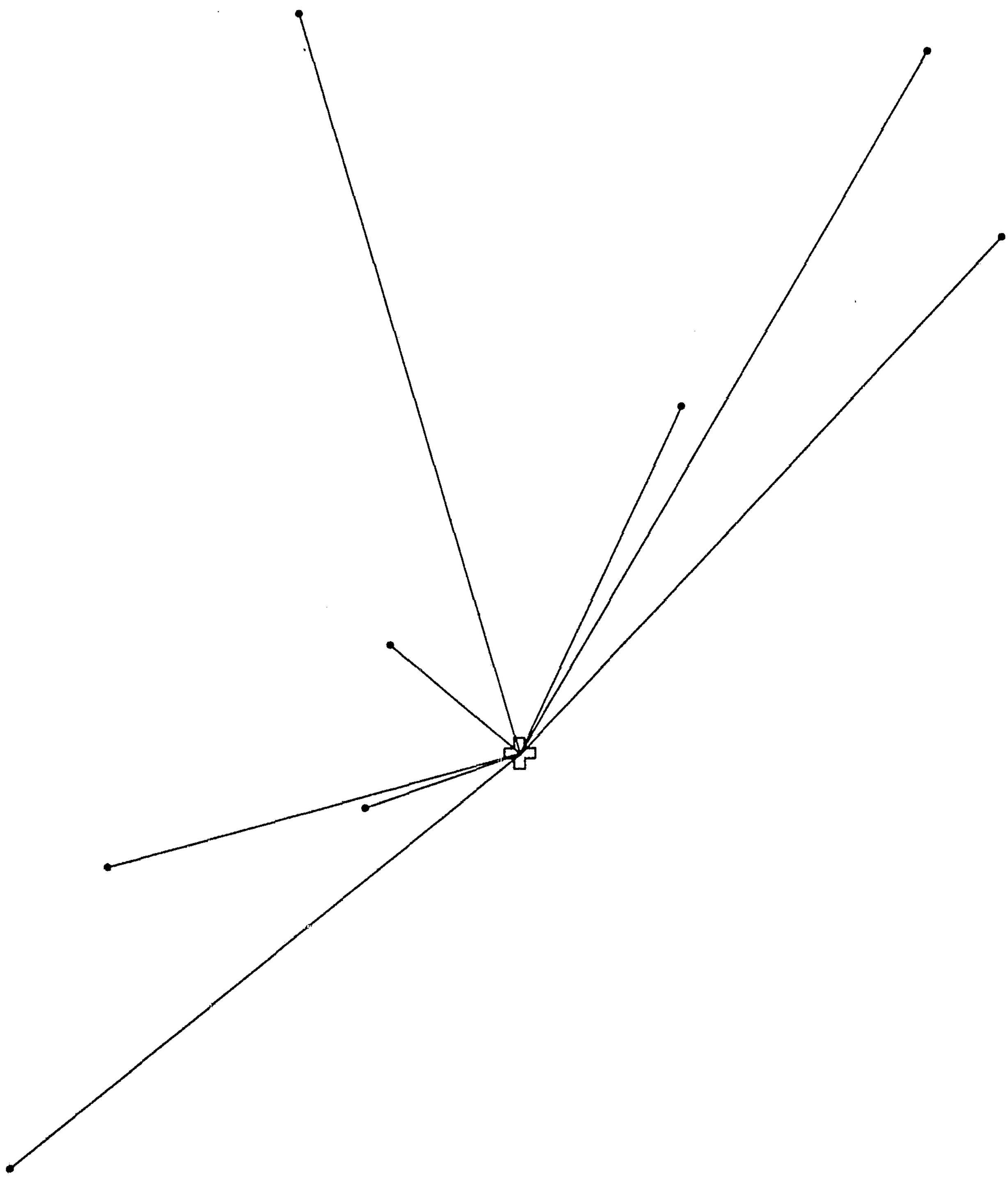


Figure 12-7. Interim New Data Network Through 1980

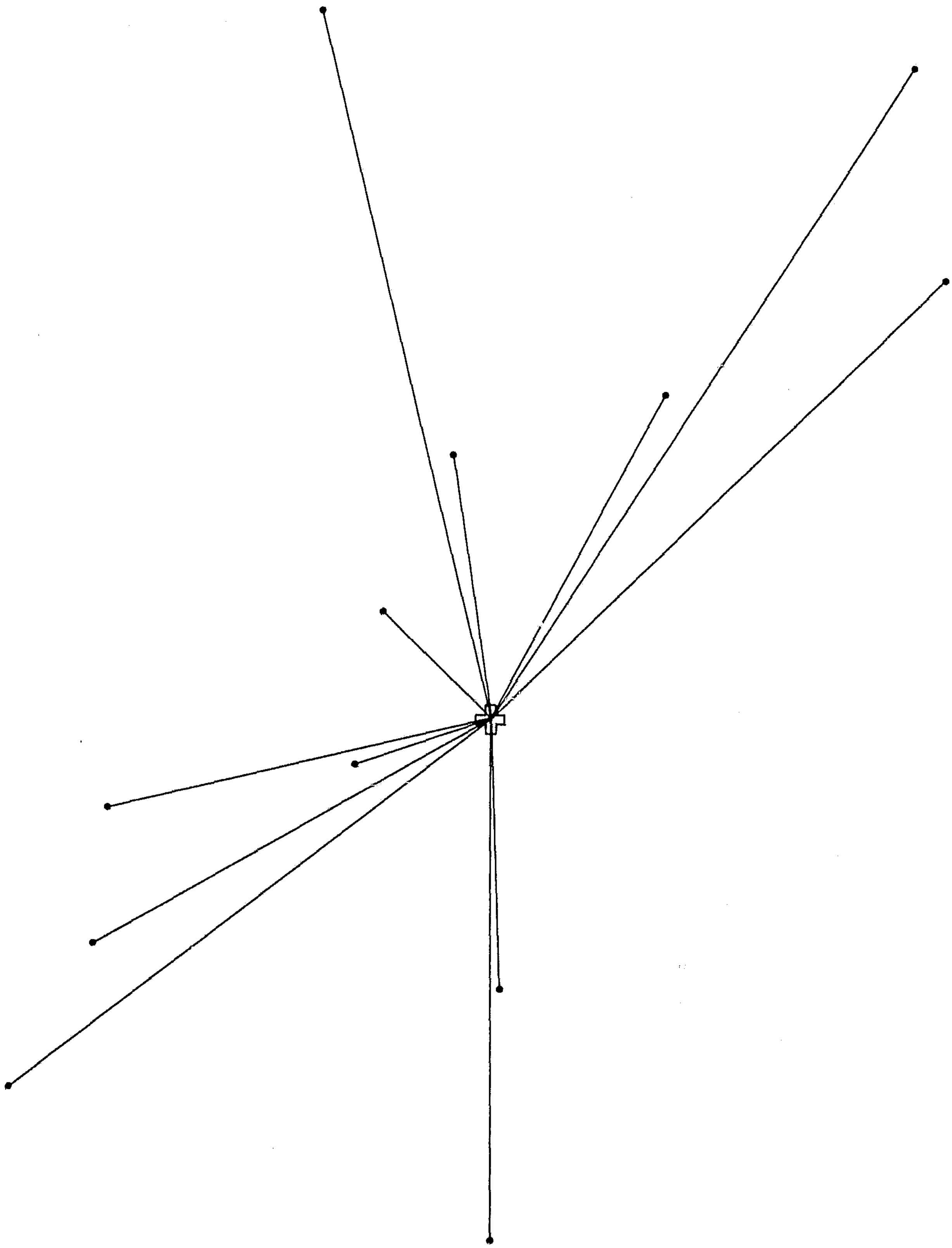


Figure 12-8. New Data Network after 1981

Table 12-21. Separate New Data Network Terminal Assignments Through 1980

Line No.	First PID No.	Remaining PID Nos	Terminal Location
1	701		Dist 8 Courts, Cleveland
2	702		Dist 1 Courts, Cincinnati
3	703		Dist 2 Courts, Dayton
4	705		Dist 6 Courts, Toledo
5	707		ODC Headquarters
		706	Dist 9 Courts, Akron
6	708		Mansfield ODC
7	709		Columbus ODC
		704	Dist 10 Courts, Columbus
8	710		Marysville ODC
9	716		London BCI, Data Conv.

Table 12-22. Separate New Data Network Terminal Assignments 1981 Through 1985

Line No.	First PID	Remaining PIDs	Terminal Location
1	701		Dist 8 Courts, Cleveland
2	702		Dist 1 Courts, Cincinnati
3	703		Dist 2 Courts, Dayton
4	704		Dist 10 Courts, Columbus
5	705		Dist 6 Courts, Toledo
6	706		Dist 9 Courts, Akron
7	707		ODC Headquarters
		710	Marysville ODC
8	708		Mansfield ODC
9	709		Columbus ODC
10	711		Lebanon ODC
11	712		Lucasville ODC
12	713		London ODC
13	714		Marion ODC
14	715		Chillicothe ODC
15	716		London BCI, Data Conv.

Table 12-23. Network Option Costs (Thousands of Dollars)

Network New Data   Number of Regions 1
Remarks Optimized Separate New Data Network

Item	No. Reqd.	Annual Cost Each	Recurring Costs: Total Annual Cost To 1980	Recurring Costs: Total Annual Cost 1981-1985	Eight Year Cost	One Time Installation Costs: Unit Cost	One Time Installation Costs: Total Purchase 1978	One Time Installation Costs: Cost 1981	Total Eight Year Cost by Item
Lines, Modems Service Terminals	-	-	50	78	540	-	4	4.3	548.3
Terminals	11/16	0.6	6.6	9.6	67.8	3.6	40	18	125.8
Regional Switchers									
Switcher Floor Space									
Switcher Back up Power									
Switcher Personnel									
Engineering							40	10	50
Subtotals			12	88	608		84	32	724

Total Eight Year Cost 724

Table 12-24. Network Line Characteristics

Network New Data Type — Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	701	1	9600	0.535	126	2.6
2	702	1	9600	0.499	101	2.4
3	703	1	9600	0.392	66	2.2
4	704	1	4800	0.689	0	5.9
5	705	1	4800	0.658	120	5.5
6	706	1	4800	0.619	110	5.1
7	707	2	2400	0.449	27	5.6
8	708	1	4800	0.641	61	5.3
9	709	1	4800	0.447	0	3.9
10	711	1	1200	0.469	74	14.2
11	712	1	1200	0.462	85	14.1
12	713	1	1200	0.383	25	12.7
13	714	1	1200	0.301	44	11.5
14	715	1	1200	0.279	44	11.2
15	716	1	9600	0.384	25	2.2

12.9.4 Network Availability

The network availability is 0.988, which implies an average daily outage of 17.3 minutes.

12.10 OPTION 8 - AN INTEGRATED LEADS AND NEW DATA NETWORK

12.10.1 Topology

Integration of new data type terminals into the LEADS network involves a two step implementation procedure as new data terminals are added to the network in the same manner that the separate new data type network implementation is phased (see Section 12.9). The network is basically the single region LEADS Network with the new data terminal star network added. The integrated network which serves through 1980 is identical with the exception that the five new data type terminals to be added in 1981 are absent from the network. The PID number of these five terminals are: 711, 712, 713, 714, and 715.

12.10.2 Costs

Total eight year costs for the integrated LEADS New Data Type Network are $8,580,000 as shown in Table 12-25. The phasing for line reconfiguration and addition of the five required terminals in 1981 is indicated.

12.10.3 Line Performance

Line performance for the integrated LEADS New Data Type Network is tabulated in Table 12-26. Response times vary from 1.2 seconds to 8.6 seconds. Line configurations are such that priorization of law enforcement message types is not required.

12.10.4 Network Availability

Network availability for the single region integrated LEADS New Data Type Network is 0.988, which implies an average daily outage of 17.3 minutes.

12.11 COMPILATION OF COST AND PERFORMANCE DATA - OPTION 1 THROUGH 8

Table 12-27 compiles cost and performance data presented for each of the eight options presented in this section. The next section discusses these findings and also presents results of additional network studies carried out in Ohio.

Table 12-25. Network Option Costs (Thousands of Dollars)

Network Integrated Leads/New Data — Number of Regions 1

Remarks Single Network

Item	No. Reqd.	Recurring Costs: Annual Cost Each	Recurring Costs: Total Annual Cost To 1980	Recurring Costs: Total Annual Cost 1981-1985	Recurring Costs: Eight Year Cost	One Time Installation Costs: Unit Cost	One Time Installation Costs: Total Purchase 1978	One Time Installation Costs: Cost 1981	Total Eight Year Cost by Item
Lines, Modems Service Terminals	-	-	598	638	4984	-	44	4.3	5032
Terminals	401/406	0.6	241	244	1943	3.6	1444	18	3405
Regional Switchers									
Switcher Floor Space									
Switcher Back up Power									
Switcher Personnel									
Engineering							130	10	140
Subtotals			839	882	6927		1618	32	8577
						Total Eight Year Cost			8580

Table 12-26. Network Line Characteristics

Network LEADS With New Data Type — Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	64	5	1200	0.122	192	5.4
2	54	6	4800	0.413	126	2.2
3	44	25	1200	0.669	186	8.6
4	229	22	1200	0.586	188	8.1
5	408	21	1200	0.490	158	7.6
6	385	23	1200	0.495	190	7.8
7	43	4	2400	0.350	110	8.5
8	400	25	1200	0.570	184	8.2
9	701	1	9600	0.547	126	1.4
10	708	1	4800	0.652	61	3.0
11	706	1	4800	0.629	110	2.9
12	365	20	1200	0.682	166	8.3
13	416	13	1200	0.697	180	7.8
14	353	23	1200	0.639	208	8.4
15	95	7	1200	0.524	41	6.7
16	146	5	2400	0.429	66	4.2
17	343	23	1200	0.485	165	7.7
18	323	3	2400	0.599	101	5.5
19	13	5	2400	0.456	120	4.3
20	116	15	1200	0.626	149	7.7
21	383	25	1200	0.536	256	8.1
22	366	3	2400	0.406	27	3.2
23	702	1	9600	0.510	101	1.4
24	703	1	9600	0.400	66	1.2
25	706	1	4800	0.669	120	3.2
26	706	1	4800	0.629	110	2.9
27	716	1	9600	0.391	25	1.2
28	422	9	2400	0.694	0	6.2
29	308	16	1200	0.563	130	7.5
30	302	25	1200	0.403	281	7.6
31	84	16	1200	0.662	188	8.0
32	74	18	1200	0.695	222	8.3
33	704	1	9600	0.355	0	1.2
34	707	8	1200	0.330	40	6.2
35	709	1	4800	0.455	0	2.2
36	712	6	1200	0.602	108	6.9

Table 12-27. Compilation of Cost and Performance Data for Ohio New or Improved Networks

	Option	1	2	3	4	5	6	7	8
	Network	1 Region	2 Region	3 Region	4 Region	LEADS BMV	LEADS and BMV	LEADS New Data	LEADS and New Data
Item	Parameter								
1	One-Time Cost ($K)	1.6	1.9	2.1	2.4	1.7	1.6	1.7	1.7
2	Eight-year Recurring Cost ($K)	6.4	7.6	8.8	10.1	7.93	7.9	7.0	6.9
3	Main Response Time (sec)	7.5	7.3	7.5	6.9	7.5/ 5.3	7.3	7.5/ 14	8.6
4	Availability	0.988	0.982	0.982	0.982	0.988	0.988	0.988	0.988

SECTION 13

STACOM/OHIO NETWORK COMPARISONS

This section provides a comparative overview of the eight STACOM/OHIO Network Options and also presents results of two additional studies. One additional study deals with impacts on the LEADS Network of the inclusion of fingerprint data, and a second study assesses the impact on network costs of reducing response time as required at terminals to less than the 9 seconds called for in the OHIO Functional Requirements.

13.1 COMPARISON OF THE FOUR LEADS OPTIONS

Each of the four LEADS options, Options 1 through 4, involving the use of from 0 to 3 regional switchers in addition to the existing Columbus switcher data base computer, have been designed to meet or exceed the STACOM/OHIO functional requirements. The principal issue of comparison between networks thus becomes cost. Costs presented here, and in the previous Section 12, are based upon total eight year installation and recurring costs for the years 1978 through 1985 as discussed in Section 4.

Figure 13-1 presents total eight-year costs for Options 1 through 4 and also includes eight-year costs for continuation of the present system for comparative purposes only. The single region LEADS Network is the cheapest. The two, three and four region options follow in order. These results show that line savings due to the use of regional switchers located throughout the state do not offset the additional costs incurred for regional switcher hardware, sites, personnel, interregion lines and increased engineering costs.

Since all networks meet functional requirements, the conclusion is that the STACOM/OHIO single region network is the most cost-effective option of the first four options.

13.2 SEPARATE VS INTEGRATED LEADS/BMV NETWORK(S)

The least cost LEADS network derived from Options 1 through 4, the single region case, was used to compare costs of separate vs integrated networks for LEADS and BMV traffic.

In considering the BMV network as a possible separate entity, network optimization was carried out subject to the intrastate tariff presented in Section 9. This led to a considerable annual recurring cost savings over the existing BMV network of approximately $100,000. When this value is added to recurring costs for a separate single region LEADS network, (which is subject to the interstate MPL tariff), a total annual recurring cost for separate networks is obtained. This value together with the total of one-time installation costs for each network is displayed in the left-hand portion of Figure 13-2. The bars to the right show one-time installation and annual recurring costs for an integrated

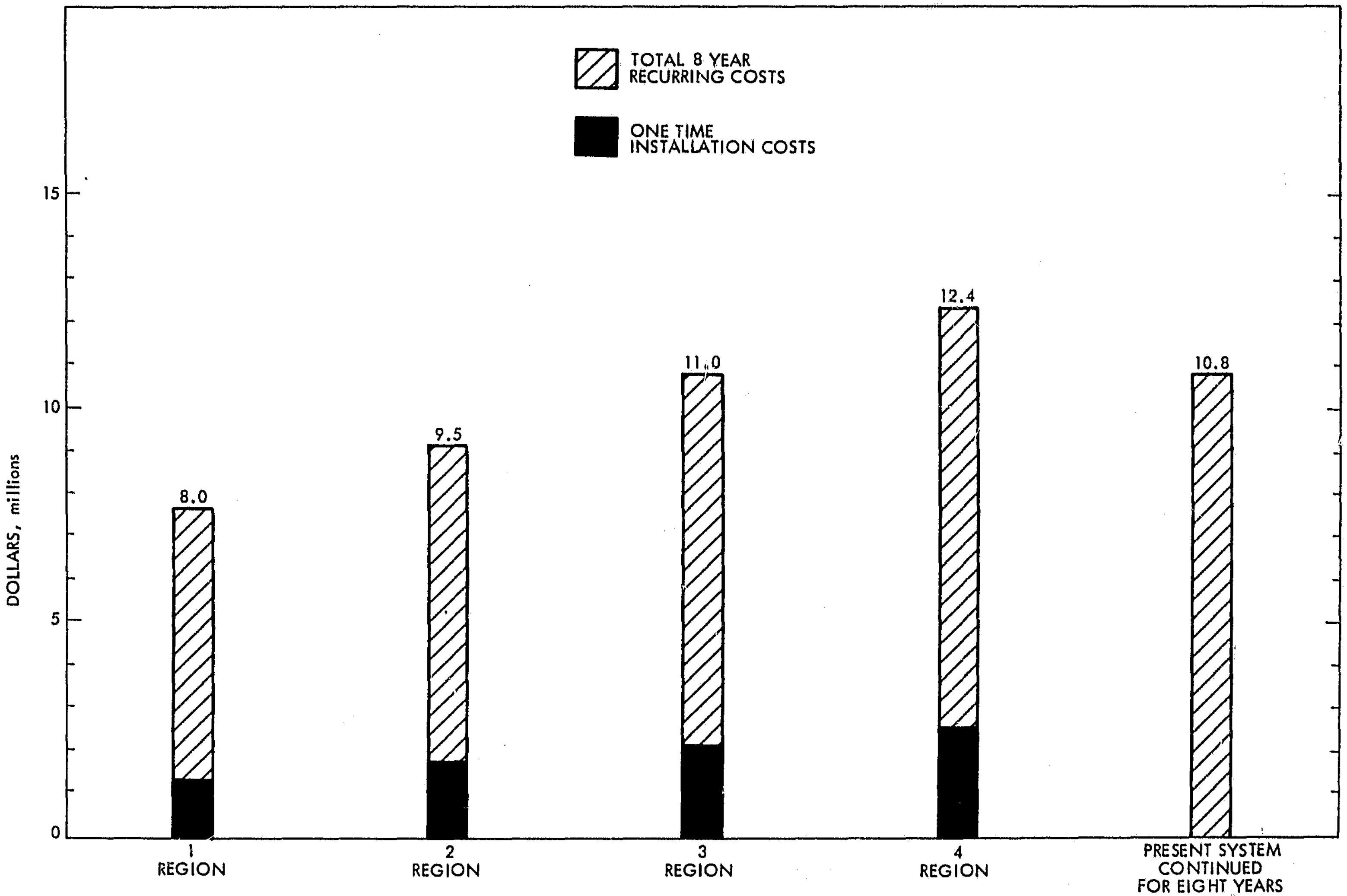


Figure 13-1. Total Cost -- 1978 Through 1985 Options
1 Through 4 and Present System

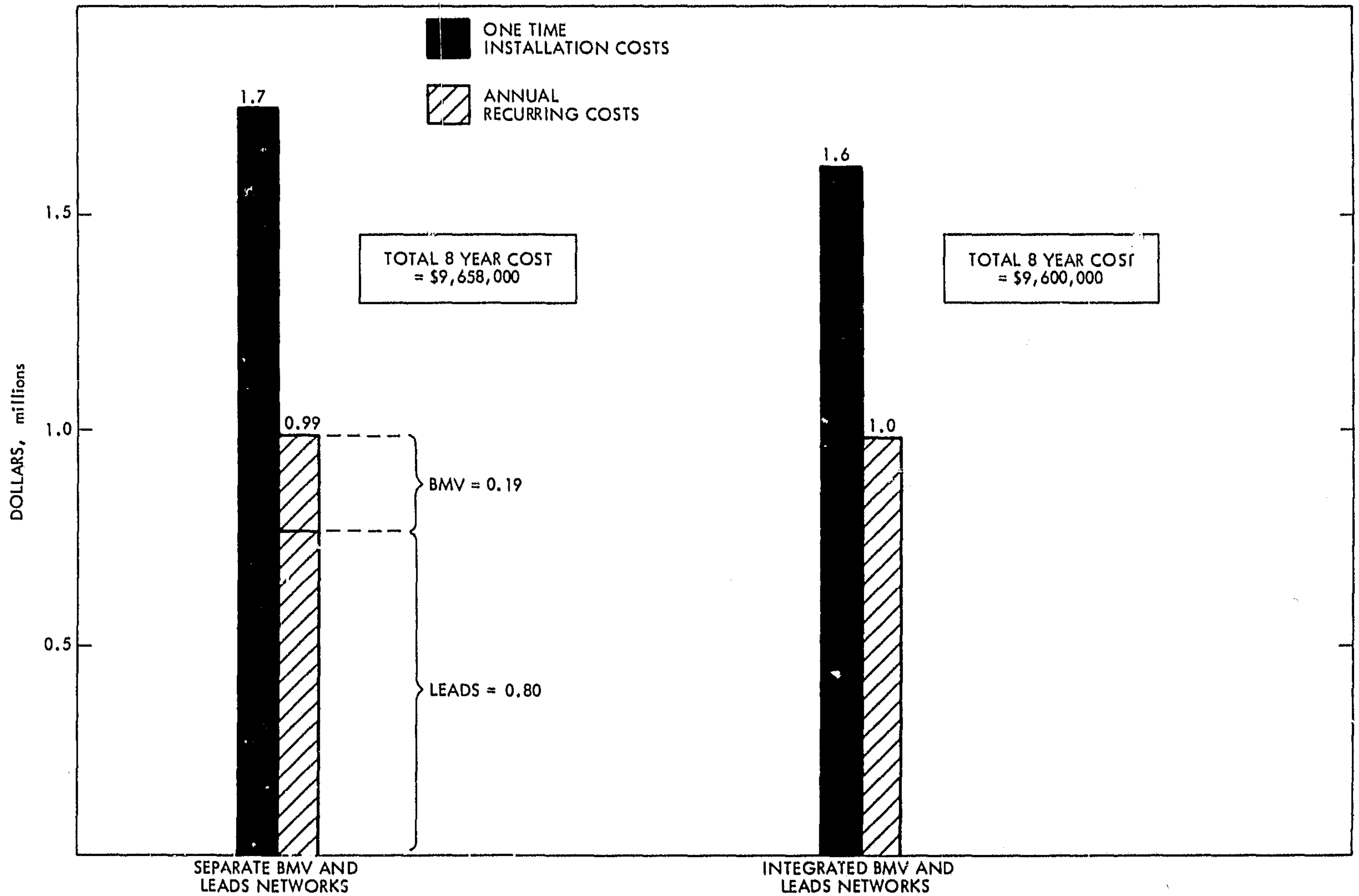


Figure 13-2. Separate vs Integrated BMV and Leads Network

LEADS/BMV Network with the entire network subject to the interstate MPL tariff outlined in Section 9.

The figures indicate that total eight-year costs are not appreciably different. For example, referring to Figure 13-2, the total eight-year cost for separate networks is:

1.73 + 8(.991) = $9,658,000

and for the integrated case:

1.60 + 8(1.0) = $9,600,000

The figures indicate an eight-year savings estimate of $58,000.

It is evident that the use of different tariff structures plays an important role in the final costings of the two alternatives. It would be reasonable to assume that a more substantial cost saving would be realized by combining two such state-wide networks if the same tariff were used in all cases. However, as long as the networks in question are subject to the tariff structures assumed in this study, it would appear that cost is not an overwhelming consideration to the management decision to integrate or not to integrate the two networks.

This is not the case, however, if the LEADS and BMV networks could be integrated under the intrastate tariff used for BMV alone. A separate investigation of this possibility was carried out. In this case, annual line costs would amount to $530,000 and line installation costs would be $72,000. Substituting these line costs, into Table 12-19, total network annual recurring and installation costs (including terminals and engineering costs) would be $764,000, and $1,600,000 respectively. This yields an eight year total cost of

1.6M + 8 (764K) = 7.712M

This represents a meaningful savings of $1,940,000 over the separate LEADS and BMV network, option 5.

13.3 SEPARATE VS INTEGRATED LEADS/NEW DATA NETWORK(S)

Whether integrated with the LEADS Network or not, the estimated growth of new data types from the present until 1985 calls for the implementation of 11 terminals through 1980, and the addition of 5 more terminals in 1981, for a total of 16 operational terminals from 1981 through 1985. This means that in each case there is a small additional one-time installation cost incurred in 1981. Figure 13-3 depicts these cost comparisons for the separate and integrated network cases. The family of bar graphs to the left shows that the LEADS and new data type networks taken separately require a total present installation cost of $1.66M and a total annual recurring cost of $840K through the year 1980. The 1981 upgrade requires a $77K investment and recurring costs increment to $885K. The family of bar graphs to the right of

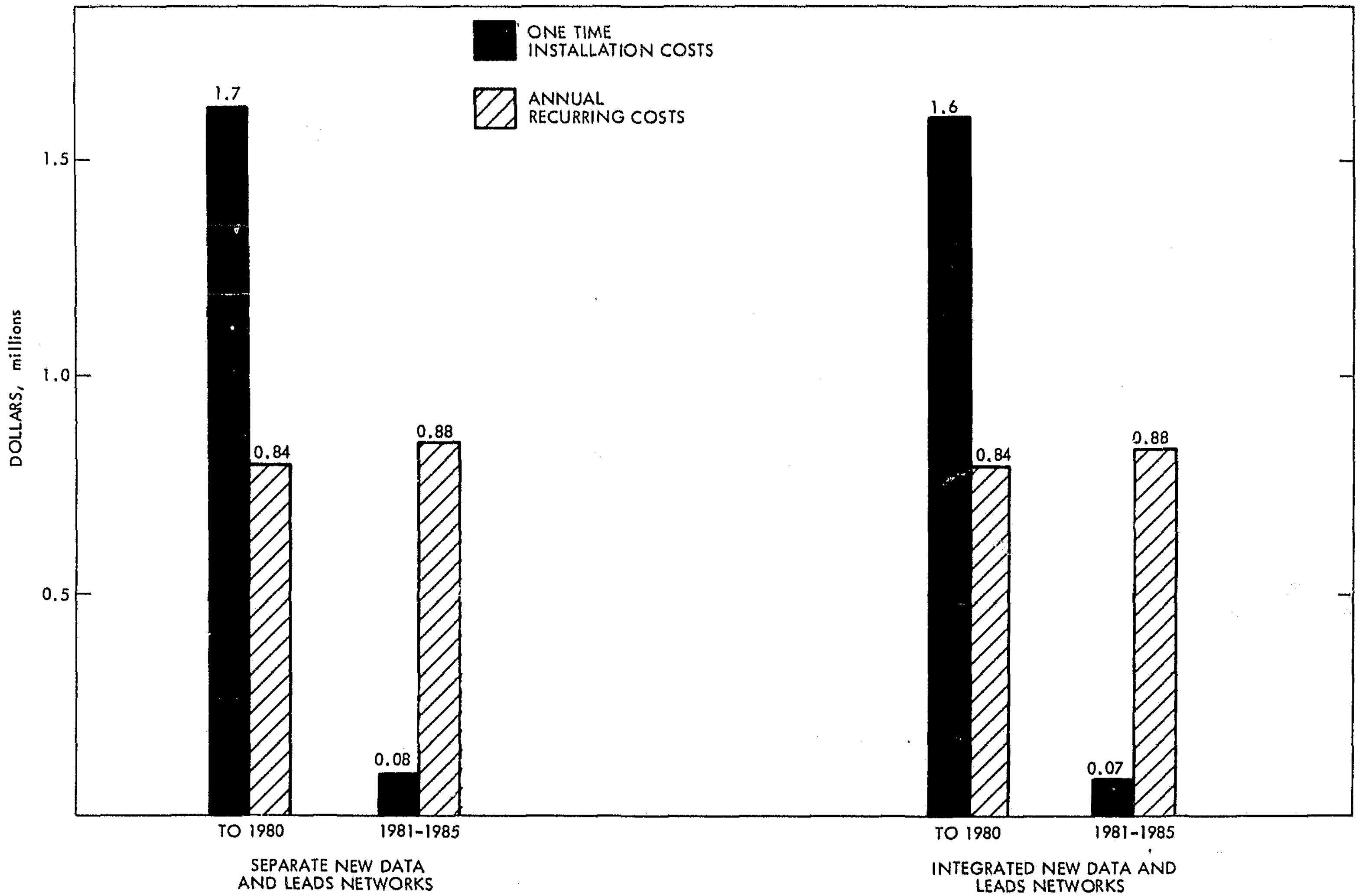


Figure 13-3. Separate vs Integrated New Data and Leads Network

Figure 13-3 show similar cost breakdowns for pre and post 1981 years for the case in which the two networks are integrated into a single entity.

Assuming that network implementation takes place in 1978, then the life of either network before upgrade is three years to 1980, and the life of the upgraded network is five years. The total eight-year cost estimate for the case where the networks are separate, then becomes:

$$1.66 + 3(.840) + 0.077 + 5(0.885) = \$8,682,000$$

and the total eight-year cost for the integrated option is

$$1.62 + 3(.840) + 0.072 + 5(0.882) = \$8,622,000$$

for an eight-year estimated difference of $60,000.

As in the case of considering BMV/LEADS integration, the monetary benefits of integration are not significant when compared to total cost. The reason, however, in this case is not due to tariff structures but is due to the fact that there are so few new data type lines in comparison to LEADS lines.

Both networks function within specifications of STACOM/OHIO network functional requirements. The conclusion, therefore, is that cost considerations alone do not represent a significant factor in the management decision to implement Options 7 or 8.

13.4 IMPACT OF FINGERPRINT DATA ON LEADS NETWORK

13.4.1 Topology

Predicted growth of fingerprint data types is contingent on the development and use of encoding and classifying equipment located in major Ohio cities. The implementation schedule calls for a first digitizer classifier to be located in the Cleveland PD in 1981 and five more to be added to the system in 1983 at PDs in Columbus, Cincinnati, Toledo, Dayton and Akron. The incorporation of these facilities involves a slight modification to the topology of the single region LEADS case, (see Paragraph 13.1). The LEADS Network with fingerprint data added as specified requires a total of 23 multidropped lines. These lines, and their principal characteristics, are summarized in Table 13-1.

13.4.2 Costs

Total eight-year costs for a LEADS Network which handles fingerprint data are broken down in Table 13-2. Costs for the LEADS Network from 1978 to 1985 are shown separately. In 1981, the increment costs for the first terminal in Cleveland are shown. These costs are incurred through 1985. The three-year costs for the addition of the final five terminals in 1983 through 1985 are also listed.

Table 13-1. Network Line Characteristics

Network LEADS with Fingerprint Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	416	9	1200	0.160	145	5.3
2	355	25	1200	0.677	212	8.0
3	95	25	1200	0.502	195	7.3
4	146	5	2400	0.678	66	5.8
5	343	24	1200	0.517	183	7.3
6	323	3	4800	0.458	101	2.2
7	13	5	4800	0.389	120	2.0
8	116	17	1200	0.662	159	7.3
9	383	25	1200	0.538	256	7.4
10	64	5	1200	0.123	192	4.9
11	54	6	4800	0.693	126	3.2
12	44	25	1200	0.672	186	7.9
13	229	22	1200	0.589	188	7.4
14	408	21	1200	0.492	158	7.0
15	385	23	1200	0.497	190	7.1
16	43	4	2400	0.562	110	4.5
17	400	25	1200	0.573	184	7.5
18	370	7	1200	0.213	40	5.3
19	422	9	4800	0.536	0	2.4
20	308	20	1200	0.417	181	6.7
21	302	25	1200	0.405	281	7.0
22	84	16	1200	0.665	188	7.2
23	74	18	1200	0.698	222	7.5

Total eight-year costs are $9,298,000. Costs for lines, modems, and service terminals, (listed as LINES in Table 13-2), account for about 3% of the eight-year cost increase over the single region LEADS without fingerprints and the costs for fingerprint processing equipment accounts for 97% of the additional cost.

As indicated in Table 13-2, the purchase cost for a single fingerprint encoder-classifier is estimated at $200,000 per unit. Annual maintenance is assumed to run at $12,000.

Table 13-2. Cost Summary by Year for LEADS Network with Fingerprint Data ($1000's)

Year(s)	Item	No. Reqd.	Annual Cost Each	Total Annual Cost	Eight Year Re-curring Cost	Unit Cost	Total Pur-chase Cost
1978-1985	Lines	-	-	564	4,512	-	42
	Leads Terminals	390	0.6	234	1,872	3.6	1,400
198 -1985	Lines*	-	-	1.5	7.5	-	0.25
	Fingerprint* Terminals	1	12	12	60	200	200
1983 - 1985	Lines*	-	-	7.5	22.5	-	1.25
	Fingerprint* Terminals	5	12	60	180	200	1,000
Totals					6,654		2,643
Total Eight-Year Cost							$9,297

*Added costs in years shown

13.4.3 Performance

The principal performance question of interest when considering the addition of messages with long average message lengths, such as fingerprint data, to the LEADS Network is the potential degrading effect on response times for higher "priority" type messages involving officer safety.

An analysis of the mean and standard deviation of message service times on the LEADS Network with fingerprint data added, indicates that mean response time goals specified in the OHIO Functional Requirements will be met satisfactorily without the necessity of message blocking or message prioritization by the computer.

This result stems from two considerations. First, the classification of fingerprint data allows for substantial reductions in the actual amount of data characters transmitted for each fingerprint (1852 characters). Second, while this message length is still comparatively long with respect to the normal LEADS message types, the occurrence of fingerprint messages on the network accounts for only about 2% of the total traffic predicted for 1985.

For these reasons, the mean response time goal of less than equal to 9 seconds is met for the network topology presented in Paragraph 13.4.1.

8.5 NETWORK COST SENSITIVITY TO RESPONSE TIME

The effect of reducing network response time requirements on annual recurring costs for lines, modems and service terminals in the single region LEADS case, (Option 1), was investigated. Network optimization computer runs were carried out at a number of points where the required response time was set at less than 9 seconds. The program then found the required networks and produced costs for each run.

Figure 13-4 shows the results of this analysis, which was carried out with the same mean service times for the Columbus computer to clarify the effect on network costs. The figure shows that for the OHIO single region LEADS Network, there is virtually no cost penalty for specifying a response time down to approximately 7.0 seconds. Stating the case alternatively, a network that meets a 9.0 second response time requirement also meets a 7.0 second requirement.

A slight increase in cost begins to appear at 6.0 seconds, due primarily to the reduction of the number of multidropped terminals on some of the lines. This reduction is required to meet the lower response time goal.

A substantial increase in cost of about 13% is required to realize a reduction in response time from 6.0 to 5.0 seconds. Reductions in mean response time below 5.0 seconds result in rapidly increasing costs.

The curve suggests that mean service times at network terminals in the neighborhood of 4 seconds would require substantial expenditures in the Columbus computer.

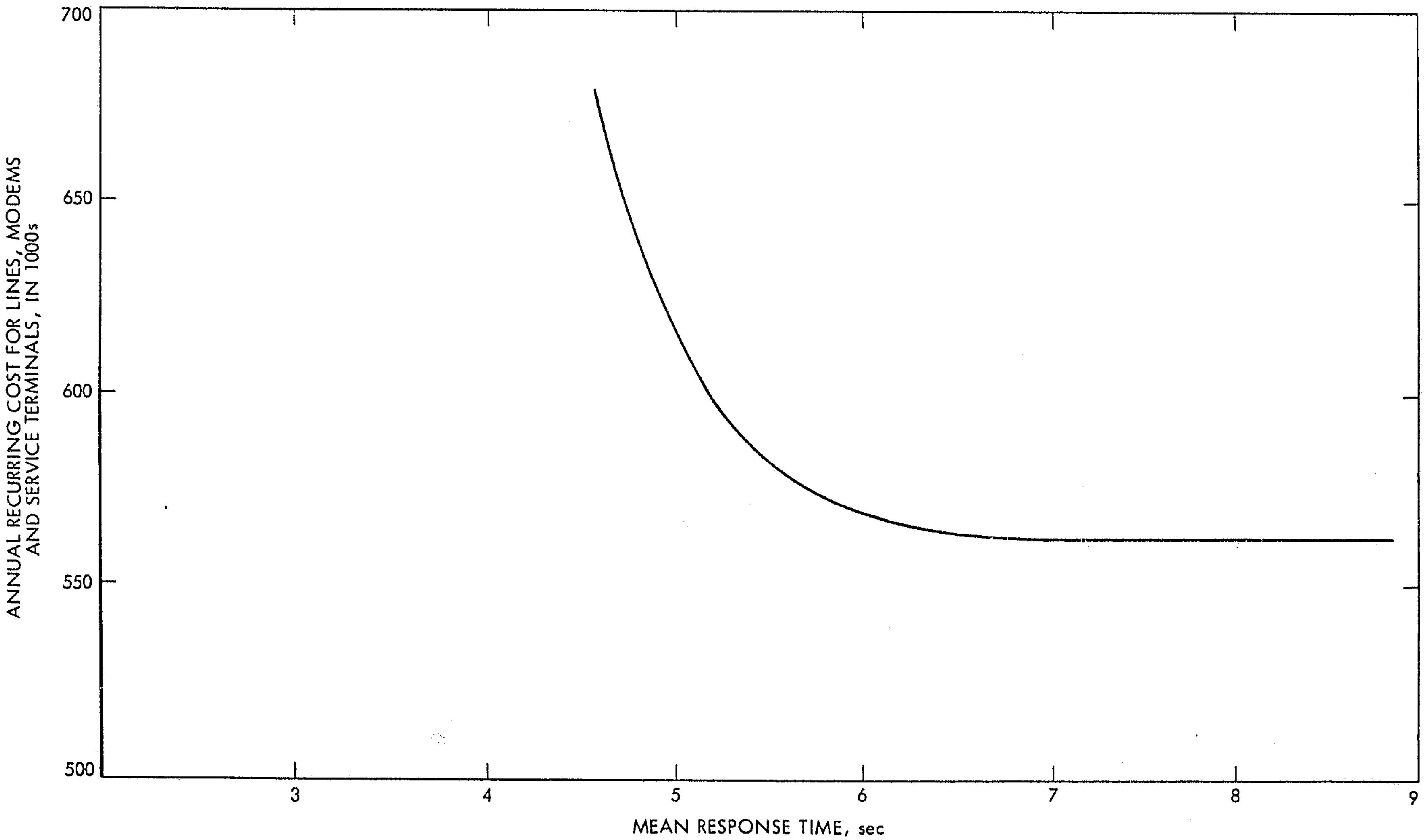


Figure 13-4. Recurring Line Costs vs Mean Response Time

SECTION 14

REFERENCES

3.1 Crime in the United States - Uniform Crime Reports, U.S. Government Printing Office, Washington, D.C., 1974.

3.2 National Criminal Justice Telecommunications Requirements, JPL Report 1200-133, Rev. A, June 28, 1974.

3.3 Joseph P. Martino, Technological Forecasting for Decisionmaking, American Elsevier Publishing Company, Inc., New York, 1972.

3.4 N. R. Draper and H. Smith, Applied Regression Analysis, John Wiley & Sons, Inc., New York, 1966.

SECTION 15

BIBLIOGRAPHY

1. An Analysis of Automated and Semi-Automated Systems for Encoding and Searching Latent Fingerprints, Technical Memorandum No. 9, Project SEARCH, Sacramento, Calif., March 1974.

2. Annual Report of Texas Judicial Council, Texas Judicial Council, Austin, Texas, Annual.

3. Biomedical Computer Programs, University of California Press, Berkeley and Los Angeles, Calif., 1975.

4. Bright, James R. and Schoeman, Milton E. F., A Guide to Practical Technological Forecasting, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

5. Crime in the United States - Uniform Crime Reports, FBI, U.S. Government Printing Office, Washington, D.C., Annual.

6. Criminal Justice Models: An Overview, NILECJ, LEAA, U.S. Dept. Of Justice, Washington, D.C., April 1976.

7. Directory of Automated Criminal Justice Information Systems, U.S. Dept. of Justice - Law Enforcement Assistance Administration, Dec. 1972.

8. Draper, N. R., and Smith, H., Applied Regression Analysis, John Wiley & Sons, Inc., New York, 1966.

9. Felkenes, George T. and Whisenand, Paul M., Police Patrol Operations, McCutchan Publishing Corporation, Berkeley, Calif., 1972.

10. Martino, Joseph P., Technological Forecasting for Decisionmaking, American Elsevier Publishing Company, Inc., New York, 1972.

11. National Criminal Justice Telecommunications Requirements, JPL Report 1200-133, Rev. A., June 28, 1974.

12. OBSCIS: The OBSCIS Experience, Technical Report No. 16, SEARCH Group, Inc., Sacramento, Calif., Nov. 1976.

13. OBSCIS: Volume 1, The OBSCIS Approach, Technical Report No. 10, SEARCH Group, Inc., Sacramento, Calif., May 1975.

14. Ohio Courts Summary, Ohio Administrative Director of Courts, Columbus, Ohio, Annual.

15. Report on Latent Fingerprint Identification Systems, Technical Memorandum, No. 8, Project SEARCH, Sacramento, Calif., March 1974.

16. SJIS: Final Report (Phase I), Technical Report No. 12, SEARCH Group, Inc., Sacramento, Calif., June 1975.

17. SJIS: Final Report (Phase II), Technical Report No. 17, SEARCH Group, Inc., Sacramento, Calif., Sept. 1976.

18. Standards for Security and Privacy of Criminal Justice Information, Technical Report No. 13, SEARCH Group, Inc., Sacramento, Calif., Oct. 1975.

19. U.S. Statistical Abstracts, U.S. Government Printing Office, Washington, D.C., Annual.

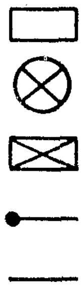
20. Esau, L. and Williams, K., "On Teleprocessing System Design; Part II-A, Method for Approximating the Optimal Network", IBM System Journal, Vol. 5, No. 3, 1966.

21. Barlow, R. and Proschan, F., Statistical Theory of Reliability and Life Testing Probability Models, Holt, Rinehart and Winston, Inc., 1975.

APPENDIX A

STACOM PROJECT
STATE LEVEL QUESTIONNAIRE

1) Please provide one diagram showing principal components used in information interchange between all criminal justice user agencies. Principal components are defined as:



Data Bases

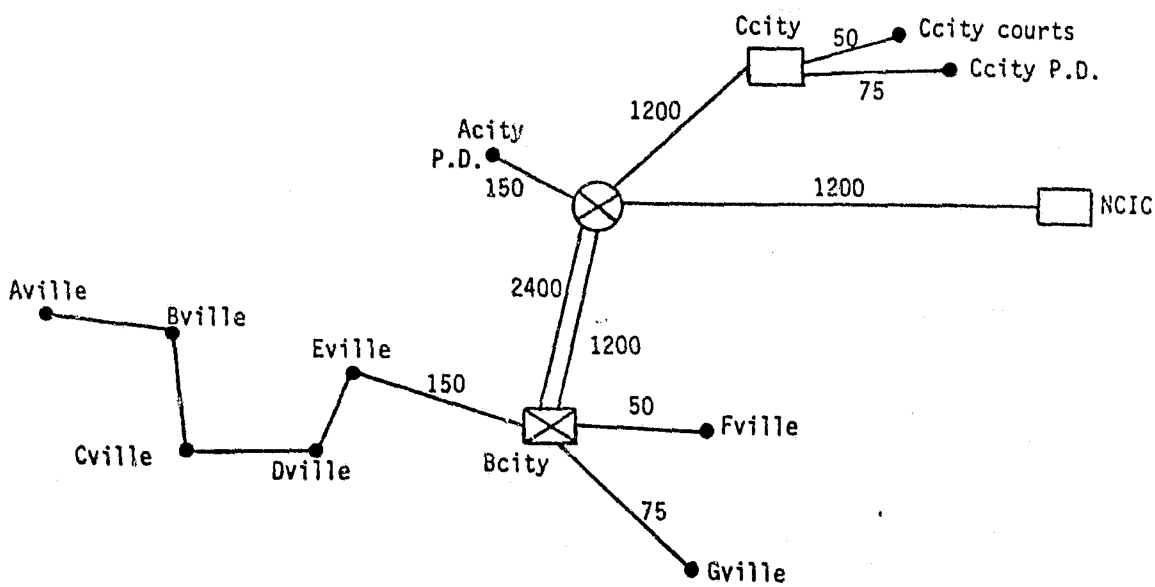
Switchers/Concentrators

Data Base and Switcher

Terminal(s)

Line

Please include line sizes in bauds. For example:



Please indicate system upgrades that have occurred since January 1971 and indicate when they have occurred. Also, please indicate system upgrades that are planned for the future. Make separate diagrams if necessary.

2) Please provide the information requested below regarding your state criminal justice information system.

	1971	1972	1973	1974	1975	1976
Number of Records in						
File Type 1						
File Type 2						
.						
.						
.						
File Type N						

3) Please supply past traffic volume data covering the period 1971 to the present. These traffic statistics should be broken out by user agency and message type.

4a) Please provide format details for all message types transmitted over your state criminal justice communications system.

4b) Please provide average message lengths by message type.

5) Please provide an origin and destination matrix showing yearly message volumes from each user agency to each other user agency in your state.

6) Are there instances where a query into one data file will automatically generate queries into other data files? If so please describe this process.

7) Please indicate any planned upgrade that would affect traffic against current law enforcement files. Examples are:

a) Increase the number of records in file.

b) Reduce response times.

c) Increase the number of law enforcement users.

8) The following is a list of 'new' data types

- computerized criminal histories - already in service
- offender-based transaction statistics (adult and juveniles)
- criminal court audit and management systems
- criminal justice planning information
- criminal intelligence data
- crime lab data including facsimile transmission, bibliographic exchange, firearm identification and spectral analysis
- corrections agency data systems (for management, training, education and rehabilitation which includes parole, probation, and corrections departments)
- criminal extradition and rendition system
- prosecutors management information system
- automated legal research
- video applications (including training, courts and corrections)
- digital mug shot identification
- digital fingerprint transmission
- boat registration file maintained by Parks and Wildlife Dept.

Include in this list others you are aware of.

8a) In your answers to questions 2) and 3) you have supplied us with information concerning data base characteristics and message volumes for the above 'new' data types already implemented on your state telecommunication system. For each of these already implemented new data types:

1) Do you plan to increase the number of records contained in the data files? If yes please discuss the phasing of this increase.

2) Will the number of users participating in the exchange of these new data types increase? If yes, please identify the new users.

8b) With respect to each of the 'new' data types in the list above which you have not yet implemented.

1) Is implementation planned? If yes

2) What is the time phasing?

3) What agencies will use it?

4) Which facilities will maintain data bases with this data type?

5) Is any state agency studying or testing the feasibility of one of these data types? If so, describe.

8c) With respect to all of the above new data types, are you aware of, or are you using, any new or recent commercial product or service which is specifically tailored to acquire, process, or display this data type. An example might be a special purpose fingerprint analysis and display terminal which sends and receives digitized fingerprint data.

9a) Please identify either federal or state privacy and security legislation that currently has an impact on the criminal justice information system, with regard to such things as data file update intervals, encryption requirements, personnel identification at the terminals, dedicated vs. shared systems, fingerprints supporting each file, etc. Please characterize these impacts.

9b) Are you aware of planned privacy legislation that will impact criminal justice information systems? If yes, please characterize these impacts.

10) Please identify administrative and legislative constraints to system development.

1) Regionalization within your state.

2) Requirements to utilize existing state equipment.

3) Interrelationships between state criminal justice agencies which may impede development of an integrated criminal justice telecommunication system.

4) Budget limitations

11) Are there other innovations or planning activities in the state that would aid us in predicting traffic levels? Examples are:

a) Are you in contact with and aware of the local Bell System operating company's (or other common carrier's) planning activities for your state? If so, please describe.

b) Are you in contact with the State Public Utilities Commission and maintain currency with their decisions on state tariffs and other related communication matters? If so, please explain the nature of your contact.

c) Can you provide descriptive material of the state's organizations dealing with telecommunications in general, and criminal justice telecommunications in particular?

12a) Has a criminal justice flow model been prepared that describes the offender's progress through your state's criminal justice system?

12b) Has the information needed to perform functions in the above flow process been identified? We are specifically interested in information that could be transmitted over the state criminal justice information system.

13) Please provide information on the number of criminal justice agencies in your state by agency type.

Agency Type	Number
Law Enforcement	
Courts	
Corrections	

14) Please provide the following court statistics.

1) Number of courts by type.

2) For each court type.

Number of Yearly Filings by Case Type

a) Case Type/Year	1972	1973	1974	1975

Number of Dispositions by Case Type

b) Case Type/Disposition, e.g.,	Conviction	Acquittal	Lesser Charge

3) Are there factors in the future that are likely to change these statistics?

a) Normal Growth

b) Decriminalization

c) Administrative Changes

d) Etc.

APPENDIX B

STACOM PROJECT
USER AGENCY SURVEY

USER AGENCY ______________________________

ADDRESS ______________________ DATE ____________

______________________________ RESPONDENT ____________

PHONE ____________

AVG. NO. OF MSG. SENT/DAY ______________________

AVG. NO. OF MSG. RECEIVED/DAY ______________________

NO. OF MSG. SENT DURING PEAK HR ______________________

CURRENT AVERAGE RESPONSE TIME* (sec) ______________________

ACCEPTABLE RESPONSE TIME (sec) ______________________

PERCENTAGE DOWN TIME ______________________

Please fill out as much as you can in the following table for the population area served by your terminal.

	1975	1974	1973	1972	1971
Crime Rate per Capita**					
Number of Personnel Requiring Info. over State C.J. Telecommunications System					

*Your best estimate of average response time. Response time is defined as time from the moment you request the network to take a message until a satisfactory reply is completed at your terminal.

**Includes crimes falling in the U.C.R. seven major crime categories. Murder and non-negligent manslaughter, forcible rape, robbery, aggravated assault, burglary - breaking or entering, larceny and auto theft.

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