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Computer time-sharing (T-S) "an engineering tool" for the engineering applications of the small company

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COMPUTER TIME-SHARING (T-S)

"AN ENGINEERING TOOL"

FOR THE ENGINEERING APPLICATIONS OF THE SMALL COMPANY

BY

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THESIS

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ABSTRACT

The objectives of this investigation were to illustrate the capabilities of the time-sharing (T-S) industry, identify the means by which the small sized company, with a need to solve engineering problems, can best be served through T-S, and to present T-S to these potential users.

Investigation was made of distinctive T-S services to formulate a composite of the T-S industry. Examples of three distinctive T-S services were used within this composite to exemplify the variations of services within the industry. The methods a small company could use to utilize computer services were identified emphasizing T-S as the method best suited for small engineering applications. Lastly, examination was made of the considerations that require complete evaluation prior to subscribing to a T-S service.

It was determined from this investigation that there are great variations in both capabilities and services offered by different T-S companies. Both the selection of the T-S company and method of utilizing the company's service depends on the needs and objectives of the user.

PREFACE

To the Reader:

Mistakes in planning for computer applications for the corporate giant have proven costly. A mistake by a small company in selecting its entry point into the "computer world" could permanently damage or destroy an otherwise promising future. Before selecting a computer system care must be taken to answer several questions. These questions are: What applications presently exist within the organization that could be accomplished better with the aid of a computer? What systems and services are needed now and will be needed in the future? Who can provide the equipment and services to fulfill these needs? Will additional talent be required within the company to implement a computer capability? Will this venture show a profit? There is no easy answer for these questions. Whether the use of this relatively "new tool" should be applied to any company will be a decision that the leadership of that company will have to make.

With the expansion of T-S over the past few years more and more small businesses have been able to take advantage of the computer in accomplishing company objectives. Time-sharing is becoming competitive as a commodity. Managers of small companies are becoming aware of and are now evaluating T-S as an "engineering tool". A number of engineering companies already using T-S have found that their capabilities have been multiplied without costly manpower increases. Through T-S other small companies may be able to make use of the benefits offered through computer application to engineering problems.

Preparation and investigation leading to the development of this thesis

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TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

I. INTRODUCTION

A. Definition

Computer time-sharing (T-S) is the sharing of a computer systems capabilities by subscribers using remote access terminal equipment. In T-S applications the subscriber (user) is capable of contacting the computer system (T-S service) for the purpose of solving problems, storing or retrieving data, or generating reports. In the functional T-S system the user maintains direct communication with the T-S computer system in executing programs.

B. History

The idea of "time-sharing" in the development of the present day computer industry is not new. What is new is the technology developments that have made computer systems compatable with the T-S concept. As early as 1940, Bell Labs (1) connected an electromechanical calculator to a teletype-writer and demonstrated the speed of such a configuration. By the 1950's many elaborate and expensive advancements had been made in computer technology. As in most areas where vast amounts of capital are needed to make the necessary technological advances, the Defense Department was the first to implement an effective system utilizing remote terminal inputs. The SAGE antiaircraft warning network system used multiple computer systems, direct data input, visual display, and the latest programming techniques. During this early implementation period the developmental expenses were so great and the system was so specialized that commercial uses could not be economically justified. Even during this period many technical minds did not fully visualize the industry that would develop within twenty years. Late in the 1950's Massachusetts Institute of Technology

and the Systems Development Corporation (1) developed the first commercially functional terminal system that could handle 40 remote terminals simultaneously. In 1962 Dartmouth University (2) developed the BASIC computer language, the first real T-S language, and one that is still widely used today. Using these advancements General Electric in 1964 offered T-S to the commercial market. This system allowed the user to remotely communicate with the computer using the BASIC language and the teletypewriter to send and receive data (3).

The present day T-S service company, of which there are approximately 100 (4), can provide ready access to advanced EDP and engineering programs that would have been considered impossible only a few years ago.

C. On Publications

Much has been said and written concerning T-S. Current text on management, systems, data processing, or production control usually mention T-S. Unfortunately, from a technology transfer point of view, most of these references will merely state that T-S does exist and that it is a method of which more and more organizations are availing themselves in making use of the expanded capabilities of computer technology.

There exist computer consulting companies that prepare complete and detailed reports on the T-S industry, providing comprehensive and detailed analysis on all phases of T-S. The cost alone makes a service such as this prohibitive to most of the smaller organizations that are trying to learn something about the industry, without first committing the $400 to $1200 annual fee necessary to subscribe to such a service. AUERBACH Information Incorporated

provides a complete user orientated guide to T-S services for $425 the first year and $390 per year renewal (4). This service provides more than the information of interest to a small potential user.

Currently, technical journals are probably the best composite source of information on the industry. The major limitation in this area is that most of the data needed to effect a wide understanding of the trends and capabilities of the industry are directed towards the industry's own peers. A review of the 1969 Professional Civil Engineering Journal and Abstracts revealed that only one article appeared concerning the T-S industry. Not one T-S advertisement was found in the ASCE Journal for that same period. Generally speaking, other professional publications also revealed a definite lack of information on this area of computer technology. Professional publications that are associated with the computer industry usually have a limited number of T-S articles. These same journals are virtually saturated with advertisements by T-S companies all of which profess the unique capability of their service.

During this investigation of the industry, ten organizations were contacted. The volume of information received from these T-S services was extensive. However, one must realize that the data presented by each individual organization was biased and required extensive editing in an effort to develop a realistic picture.

A variety of reasons has undoubtedly brought about the situation just described. In the past, much of the industry's documentation that would have been beneficial to the potential user was out of date before it could be published.

Secondly there has been such a great demand for the T-S services by larger organizations that the T-S industry was benefiting from a sellers market and therefore did not have the need to reach out for the smaller organizations. Also, T-S companies had limited services available and therefore the use of T-S may not have been economically justified through one T-S service while knowledge about other T-S services offering a more complete service was just not available. A need exists to present to the potential user a "user's view" of this new industry--an industry whose influence may someday be as important as the telephone is today.

D. Objectives

The basic objectives of this study were:

1. To formulate a composite picture of the T-S industry from a sampling of companies within the industry, providing to the potential user a general description of the T-S industry, accompanied by examples of different types of corporations that are providing T-S services.
2. To describe the entry points that the small company has available in making a selection of the services offered by the industry.
3. To identify and amplify several considerations that will require extensive evaluation when a small engineering company is considering the use of a T-S service.

E. Scope

The range of activity covered by this investigation was data collection, the description of the composite industry, and analysis.

Data collections for the investigation included:

1. Communication with selected professional journals related to the industry.
2. Communication with professionals within both the T-S and Engineering industries.
3. Communication with selected T-S services.
4. Visits to four T-S companies and one user.

Formulating the description of the industry and investigations of entry points into the industry included:

1. Identifying the characteristics of the industry and illustrating how these characteristics help to determine the type of speciality a company will develop.
2. Classifying and describing the entry points to the industry.

Analysis included:

1. Discussing and amplifying several important considerations a potential user must evaluate prior to subscribing to a T-S service.
2. Developing an example illustrating how a small engineering company could make use of a T-S service.

II. REVIEW OF LITERATURE

Publications prior to 1968 concerning T-S provide little if any insight to the present day industry. The 1965 idea as to the capability of this new industry contemplated the development of a system that would be capable of performing anything for everybody. In 1968, Business Week (5) pointed out that the then current state of the art was a long way from that of the theorist of 1965.

Data Processor (6) reported on an interplant computer terminal system installed in 1967 within North-American Rockwell's California facilities. The engineers of North-American Rockwell, when supplied with terminals and programs, had at their fingertips a means to increase their engineering capability. With this system and a very limited training program, North-American was able to make maximum use of the engineer's knowledge while using the computer to execute much of the detail work.

April 25, 1968, records the organization of Systems Professionals (7). This corporation was initially made up of eleven civil and structural engineering firms, who have since expanded their capability to provide computer services to professional subscribers. The corporation by-laws require that subscribers be registered professional engineers.

It is not the intent of Systems Professionals to provide a consulting service, but to relieve engineers of repetitive work thereby increasing engineering capability. Norman Grove, manager of Systems Professionals said (7),

> "We find the greatest use of the computer is in preliminary design where it is necessary to have both speed and accuracy, and where we can quickly explore a number of alternatives."

> "We regard the computer as a tool which performs time-consuming detailed calculations so that our engineers have more time to consider what they are doing and why they are doing it, rather than how to do it. We feel that the computer is the only way we can hold our costs and still do the job that brings forth an economical solution to the problems that are getting more and more complex every year."

Constructor Magazine (8), in an article by Patricia Holt, reported that any construction firm no matter how small can afford to automate some of its activities. She also stated that the purchase of computer equipment requires large expenditures of capital and employment of computer personnel and then pointed out that T-S is less expensive and that it is currently being utilized by many small firms.

Mr. Philip Dorn stated in the November, 1969, issue of Datamation (9).

> "If the service was physically available in a convenient location you bought it. Seldom if ever did the user have more than one or two alternatives, but this was before the great time-sharing explosion of 1969."

Mr. Dorn also cited the phenomenal growth associated with the industry and mentioned briefly that the growth has caused problems. Little, if any, user protection exists, and the user's first exposure to T-S often came from the vendor and not from a general knowledge of the industry.

Maurice Allen and Walter J. Huelsman (10) warn of the pitfalls of the failure to evaluate the objectives of an EDP system without having first defined the goals of the company. The authors indicate that between 70% and 80% of computer users are not satisfied with their computer system. They suggest that the criteria considered when selecting a service should be cost, processing time, technical support, available software, and reliability.

In the February, 1970, issue of Datamation (11), Mr. C. J. Keelan stated that information system uses of T-S have been neglected. He goes on to illustrate that using a T-S terminal can actually reduce the cost of preparing six reports by as much as 25%. This reduction alone justified the utilization of a T-S service. Add to this the capability of using the same terminal as an "engineering tool" and a significant contribution can be made to a company's potential.

In conducting a review of literature on the T-S industry an area of consideration must be directed to evaluating what is not said as opposed to what is said. Detailed technical studies concerning details of organizations in the T-S field are limited. That which has been published appears to be coming from within the T-S industry and much of it is promotional information attempting to sell a service, or it is protected information that is being maintained to sell to users. It appears at this time that, within the T-S industry, companies are competing for a major portion of the market and therefore they are temporarily withholding information which could be used by their competition.

III. INVESTIGATION PROCEDURE

The newness and recent developments in the T-S industry had a definite effect upon the approach that was utilized in conducting the research for this project. First, as previously stated, published references covering the subject are limited. Secondly the T-S industry is expanding rapidly, thereby limiting industry documentation. Third, the collective and comparative information that has been published is not for general use. The investigation therefore consisted of collecting information from professional journals and industry literature published by individual companies within the industry, and interviewing representatives from companies which provide and companies which use T-S services.

IV. RESULTS OF THE INVESTIGATION

A. The Time-Sharing Industry

1. Concept of Time-Sharing

A computer system is a highly complex grouping of data processing units (hardware) combined with internally stored sets of instructions (software) (12). The hardware accepts and stores the data, performs computations, and produces required results in a planned formate under the direction of the internally stored software. The T-S definition (page 1) does not reveal anything about the complexity of combining the multi-programming and the real-time operations necessary to create the impression to the terminal user that he has sole access to a centralized computer system. In the central computer of a T-S system, user programs and information files are continuously being manipulated by monitor programs in an effort to maximize the number of programs being operated upon by the computer. Thereby producing apparent simultaneous solutions.

Terms that are important in understanding the T-S concept are "swapping", "rolling", "paging", and "time-slicing" (13). It would be unrealistic to expect a computer to maintain every bit of information that it may be required to use within its core memory. The size of the computer necessary to accomplish this would obviate any chance of economic justification of the system (13). Therefore, computer manufactures design their computers to "swap", "roll", or "page" information between the core memory and external storage facilities (14). In "swapping" and "rolling" this is accomplished by transferring complete blocks of non-active programs to an external drum or disk memory

for recall when the information is needed. "Paging" is a more powerful technique to accomplish the same objective. In the "paging" system only the part of the program being worked upon is called from the storage facility to the core memory. When the computer has completed the operations required by a specific "page" the "page" is no longer needed and may be returned to external storage.

The term "time-slicing" describes a method used to give each program successive time on the computer by allocating fixed time increments to the incoming programs. Time-slicing becomes a very complex operation when priorities are established on length, time, and different types of incoming programs. Time-slicing is executed by means of a complex software system called the "time-sharing monitor", which is contained within the computer unit (13). The monitor allocates and schedules the resources of the system amoung simultaneous users, protects users from interfering with each other, and records the activity of each user of the system. In the actual calculation and manipulation of data, each simultaneous user receives the effect of constant attention from the system.

2. Structure of the Industry

The T-S industry is made up of three distinctive types of organizations. These are the manufacturer of computer equipment, the corporation with a large in-house need for computer technology, and the software oriented company in the business solely to provide service to others.

Several manufactures of computer equipment have first expanded to the development of software systems and more recently have established time-

sharing services. This type of expansion by the manufacturer of computer equipment can be related to a need to maintain a proportional percentage of the computer market. It is probably clear to the manufacturers that the capability to lead in software development would have a major effect on the hardware market. Having developed all of the ingredients for a T-S service it is only natural that the manufacturing company should enter the T-S business. The General Electric Corporation and its entry into the T-S industry in 1964 is an excellent example of a complete line T-S company. The General Electric Information Service (GE-ISD) is the largest in the commercial T-S industry with more than 50 T-S operating centers located in the United States and abroad (3).

The second distinctive type of organization offering T-S services is the corporation with a large in-house need for computer technology. This organization can, by expanding an existing automation center, enter the T-S industry with very limited risk. In turn this organization will receive corporate benefits from growth, technology, and potential of the expanded computer capability. Several large companies have developed large in-house T-S services a few of which have entered the commercial market. McDonnell Automation's Direct Access Computing System is an example of a corporation that has entered the industry in this manner (15) (Fig. 1).

The third type of corporation in the T-S business is the software oriented company that uses the computers developed by other manufactures, usually developing their own software capabilities. Several of these T-S services owe their origin to individuals who have broken away from the large

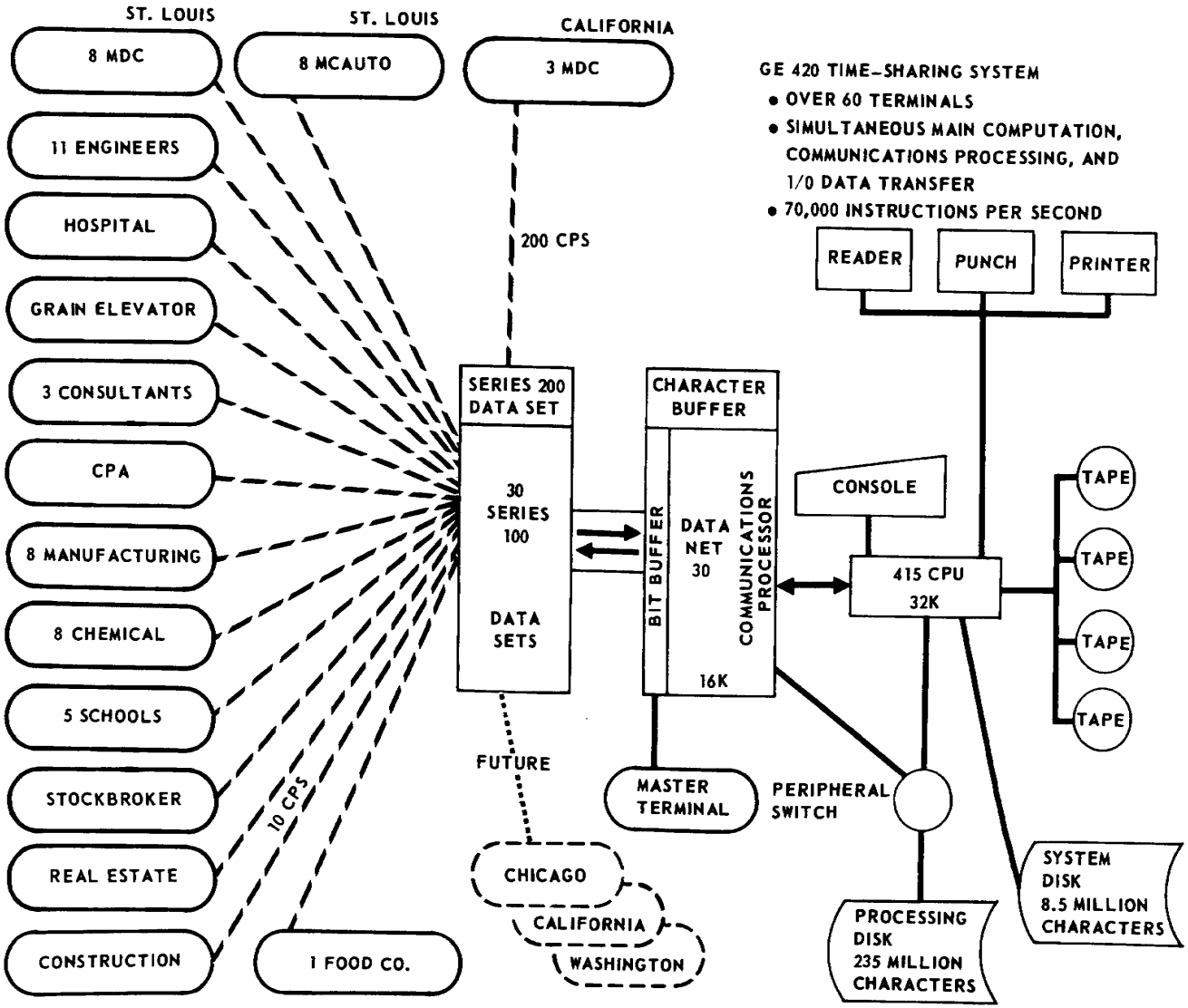


Fig. 1. McDonnell Automation Direct Access Computing System (15).

computer services to establish competitive services. Often these T-S services have started with a very low investment, eventually evolving into multi-million dollar businesses, simultaneously expanding and producing computer hardware. Applied Logic Corporation's (AL/COM) growth since 1966 is fairly representative of the leading companies in this area (Fig. 2). A variation to the organization just identified is the special type service that is very limited in its support capabilities. This T-S service is usually developed by a collective effort from outside the industry. The ultimate user identifies a common need for a computer application and then organizes a collective that enters the T-S field. This type of service has been most effective in providing T-S capability to common groups with limited assets. Although it cannot be classified as a T-S service, Computer Automotive Reporting System (CARS) is an excellent example of a computer service that has been developed along these lines (16). CARS is not an engineering oriented computer service but because of its unique organization it is of interest to potential time-sharing users (See Appendix). An engineering association developed along the lines of the CARS system could be ideally suited to small businesses with engineering applications (17).

In the last two examples the more speculative and most numerous type of T-S organizations have been identified. Because of limited capability, technology and management, many of the smaller T-S services have been unable to produce a product that would satisfy their customers. Time-sharing is no different than any other business. The future will probably see many of the smaller less established companies that have been seeking overnight success being absorbed by the more powerful well established organizations (18).

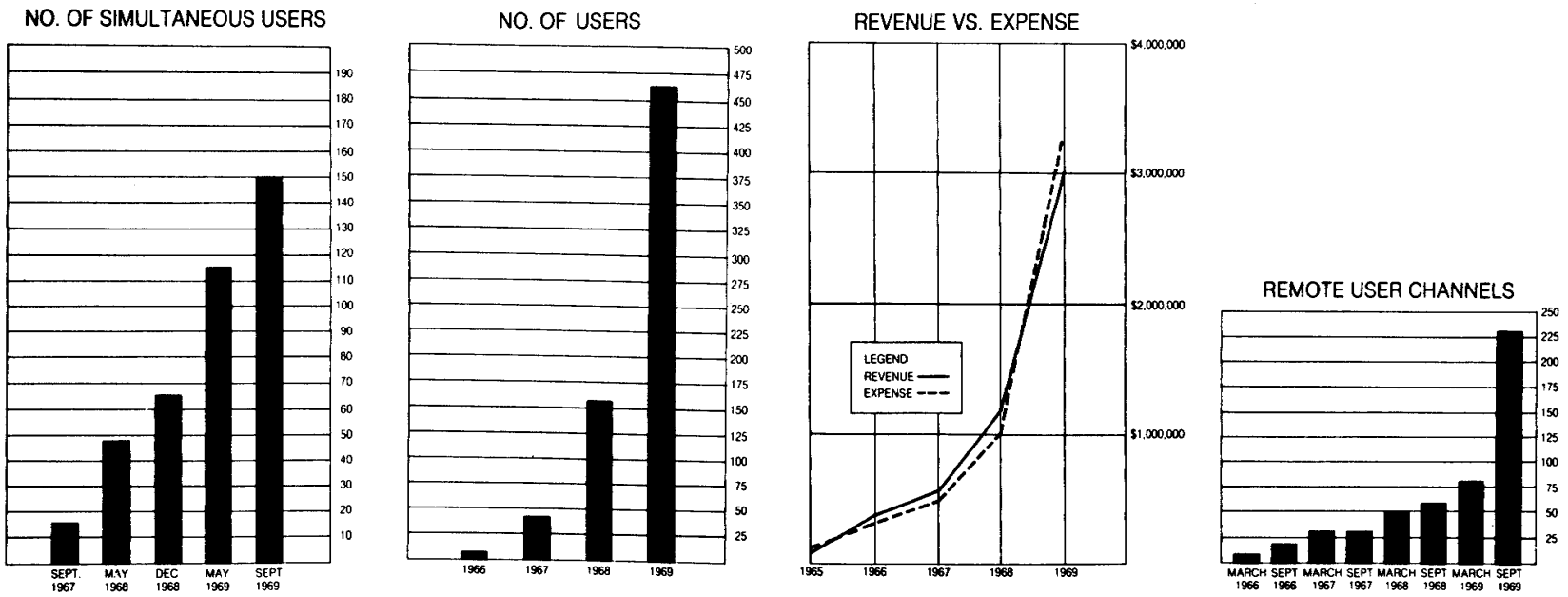


Fig. 2. Growth of AL/COM A Leading Time-Sharing Company (2)

3. Centralization

The trend in the T-S industry is towards centralization (19). Initially the major T-S companies planned for regional organization with associated computer centers that would be capable of supporting all activity within a specific geographical area (2). This concept placed every phase of the business from marketing to program development at the regional level. As computer technology developed further, it became evident that larger and larger computer systems, although requiring a larger investment, are more efficient than a collection of smaller regional systems (19). If this trend continues, multibillion dollar centralized computer systems will be developed that will provide computer services to thousands on a world-wide basis (19).

Through the use of high speed multiplexors efficient economical communications between distant remote terminals and the centralized computer are possible (2). The multiplexor simultaneously collects input from two or more sources and transmits the information to the centralized computer on one telephone line (Fig. 3).

One advantage of centralization is optimizing the rate of computer utilization. Regional systems have a peak period of computer use that generally ranges over eight hours and conforms to the local work day (20) (Fig. 4). Coast to coast time zone differentials will enable centralized T-S services to prolong the peak time-sharing period. Other advantages are increased system reliability, better service, and that one central file or data base could be shared by users throughout the network. The advantages and disadvantages of centralization have not been fully justified to the satisfaction

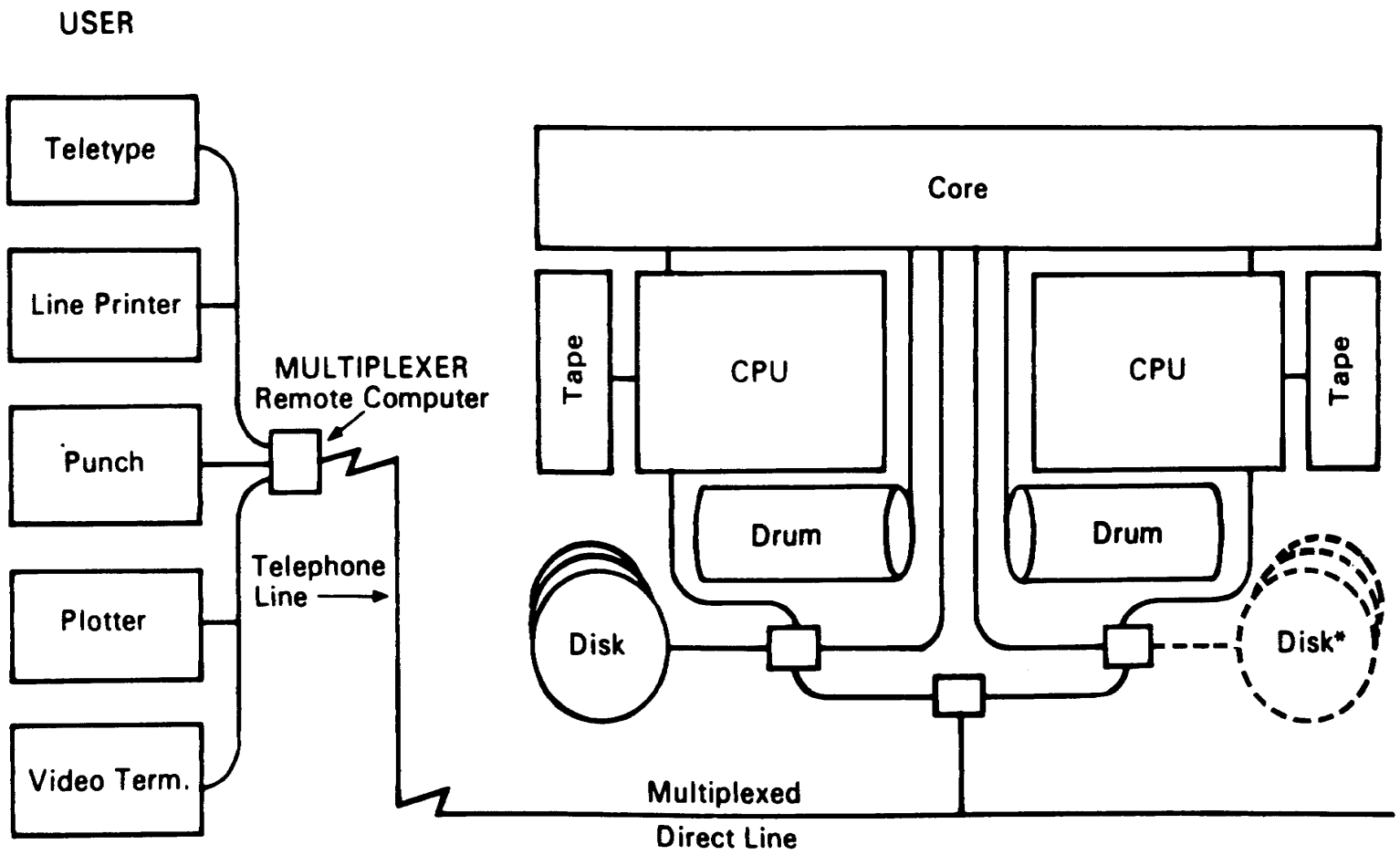


Fig. 3. Typical Time-Sharing Hardware Configuration (2).

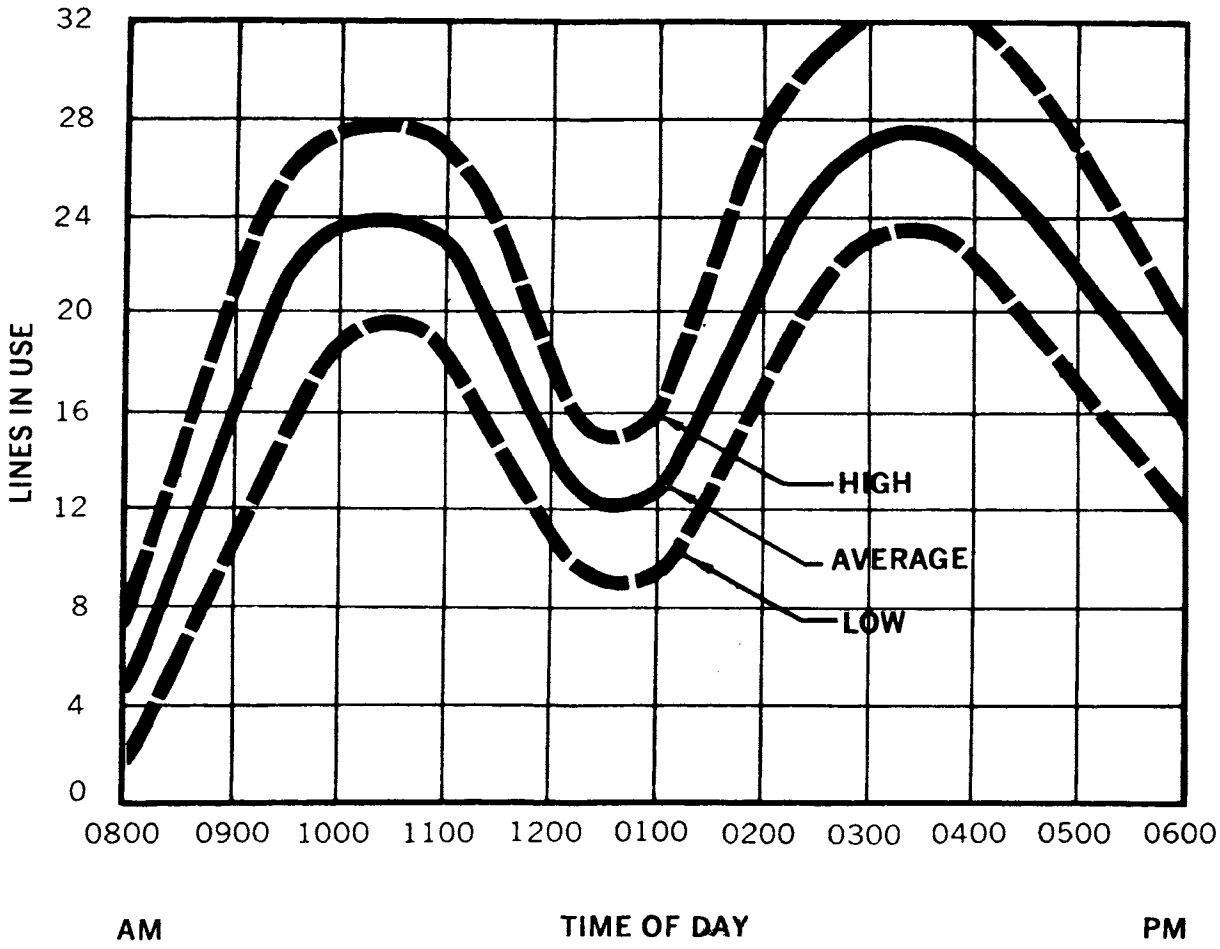


Fig. 4. Lines in Use vs. Time of an In-House T-S Computer System (20).

of every professional of the computer industry (14).

It is conceivable that a T-S civil engineering centralized system will be developed that will provide a complete data-bank information system with application programs for all civil engineering or related engineering projects. Systems Professionals has organized along this line. A small service, it is currently using the IBM 1130 computer system including card, disc, and printer. However, Systems Professionals is an expanding organization planning for a complete engineering T-S service (7).

World wide centralization is also possible. The General Electric Corporation has established a data terminal link with Europe through existing satellite relay systems (3).

If the communications industry can serve as a historical example, the T-S user can expect that advanced technology and centralization will result in reduced rates (19). As mentioned previously there is an economic advantage gained by using larger computers serving more subscribers. Current indications are that the larger T-S services in their efforts to control the market will pass greater economic benefits on to the user which will then force the smaller services to merge if they are to survive (18). It is because of this that some knowledgeable individuals in the T-S industry feel that T-S may someday be classified as a public utility (7).

4. Service

Service is an important part of the T-S company's product. Often it is in this area that the greatest variation between T-S companies can be identified. In many places the service department and the sales department of a

T-S company are closely related sharing the same offices. The larger services have established regional sales and service offices located in larger cities throughout the United States. These offices may or may not be owned by the T-S service.

The different technical and non-technical services performed by the T-S service departments and whether or not the user is charged for these services depends upon individual contractual arrangements made between the user and the service.

5. Training

The sales and service facility is usually charged with the responsibility of training programs offered by the T-S services. Leading well-established T-S companies offer training programs that last from 1 to 5 days with a few technical courses lasting as much as two weeks. In the conduct of these courses the user is given an introduction to equipment, assembly coding, specific application programs and languages.

In addition to the regular training courses, a limited number of services offer specialized training programs. General Electric has developed TUTOR which is a series of T-S programs covering T-S, consisting of explanations, examples, questions and test (3). The TUDOR system can be used to train new operators on established T-S systems or to expand user capability in new developments being offered by the T-S service. TUTOR's main advantage lies in the ability of an individual to use the remote terminal to call a lesson and to execute the lesson at the user's speed.

During initial training periods several T-S services offer a basic set of training courses and technical manuals expense free. However, continued training, development and additional technical manuals usually incur a nominal fee.

The majority of the training programs and technical manuals available to the user are designed to meet a specific need. It can be generally stated that the T-S services encourage management personnel to participate in the training programs (16). As the T-S industry becomes more competitive, the services are being forced to direct attention towards developing and retaining satisfied customers (16). Developing satisfied customers can only be accomplished through adequate training programs that will protect the user from costly mistakes because of an inability to effectively use the T-S service (12, 17).

6. Equipment

The T-S computer with its associated hardware and internal software is designed to meet the specialized requirements of many simultaneous users. Only recently has computer hardware been developed that can adequately implement the T-S task. Previous computer configurations consisted of common computer hardware systems with highly complex software systems and relatively crude interface equipment. New T-S computer hardware developments have in the past two years opened up the T-S industry to expanded T-S capabilities (13).

In T-S, it is the terminal equipment that the non-technical user sees. The most common terminal is the teletype of which there are several models

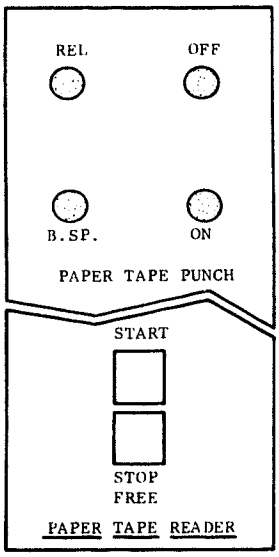
in use (Fig. 5, 6). The teletype is considered slow by users but is still the most economical and widely used terminal. The teletype is especially adaptable to low volume users who use the system randomly as opposed to an organization with a continuous demand. Depending on monthly demand, a small business could rent a teletype and subscribe to a service for less than $200.00 a month (1).

For slightly higher volume users ($250-$500 a month) adding additional capability to the terminal system could result in reduced service charges. The 5C DATAspeed "750" was designed to be used in conjunction with the teletype to make the system responsive to the commands of the time-sharing service (Fig. 7). In this modified T-S system during low evening usage periods the computer will call the 5C DATAspeed "750" receive the prepared input, process this input, and then the computer activates the teletype printing the output. This system increases the capability of the computer by providing it with uniform loading, thereby decreasing the user's cost. In the CARS system, 290 such configurations are used and in each case, the additional rental fee of the 5C DATAspeed "750" is justified by the reduced computer service charges (16). The teletype rental and computer service charges are justified by the inventory control information output that was not possible prior to implementing the CARS system (16).

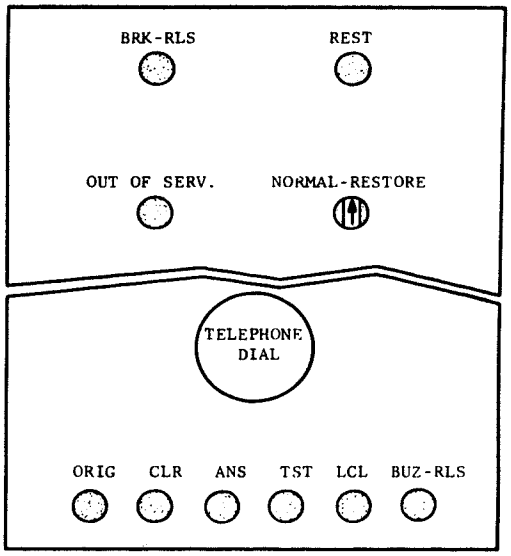
Many other user equipment configurations are available and may suit the requirements of a particular organization much better than the teletype-writer. The Auerbach Corporation provides a complete breakdown and comparison of the different type of T-S terminal equipment (Fig. 8).

Fig. 5. Typical Time-Sharing Remote Terminal (3).

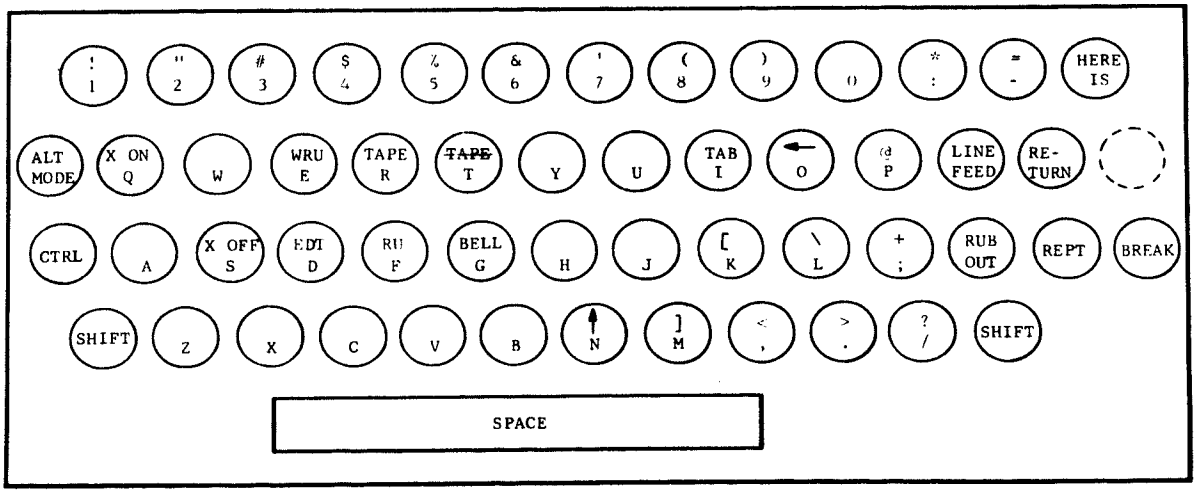
Model 33 Teletypewriter Keyboard and Controls



Operator's Left Control Unit

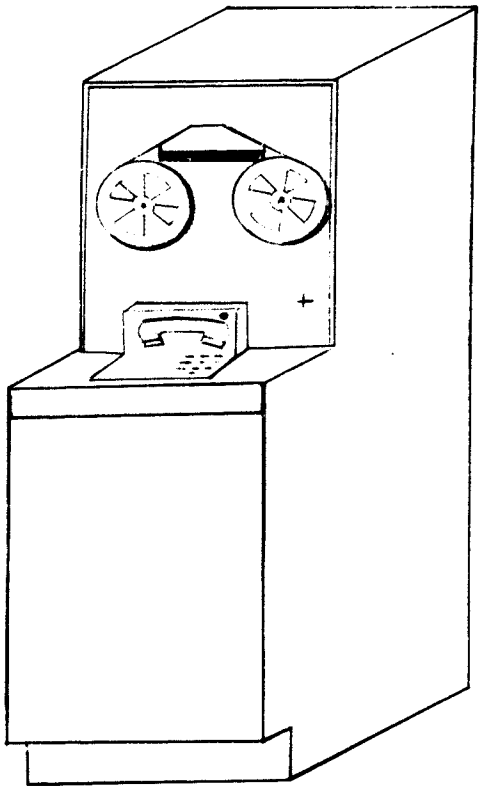


Operator's Right Control Unit



Keyboard

Fig. 6. Operator Keyboard Teletype Model #33 (15).



The 5c DATAspeed "750" is a single unit data transmitter used to transmit data to a computer when activated by the computer. This system uses an 8 track paper punch tape prepared on the teletype. The teletype may serve as the receiver for this system.

Fig. 7. The 5c DATAspeed "750"

IDENTITY		Friden 7100 Conversational Terminal	Friden 7102 Communications Terminal		Teletype Model 33 Line		Teletype Model 35 Line	
REPORT NUMBER		60.250	60.255		60.400		60.405	
FUNCTION		Transmission and reception of data over a narrow-band line; keyboard input; printer output	Transmission and reception of data over a narrow-band line		Transmission of manually-keyed or punched tape data over a telegraph-grade line		Transmission of manually-keyed or punched tape data over a telegraph-grade line	
PREPARED INPUT	Medium	No provision	Punched tape		Punched tape		Punched tape	
	Code		any 8-level		8-level USASCII		8-level USASCII	
	Rated Speed-Char/second Cards/minute		12.2 —		10 —		10 —	
MANUAL INPUT	Method of Entry	50-key keyboard	53-key keyboard		45-key keyboard		45-key keyboard	
	No. of Characters	Variable	Variable		Variable		Variable	
OUTPUT	Medium	Printer	Punched tape	Printer	Punched tape	Printer	Punched tape	Printer
	Code	91 chars	any 8-level	8-level USASCII	8-level USASCII	80 char	8-level USASCII	80 char
	Rated Speed-Char/second Cards/minute	10 or 12.2 —	12.2 —	12.2 —	10 —	10 —	10 —	10 —
DATA TRANSMISSION	Line Type	Narrow-band	Narrow-band		Narrow-band		Narrow-band	
	Rated Speed, bps	100 to 134.2	122 to 134.2		110		110	
	Transmission Mode	Half-duplex	Half-or full-duplex		Half-duplex or full-duplex		Half-duplex or full-duplex	
	Transmission Code	8-level USASCII	8-level USASCII		8-level USASCII		8-level USASCII	
	Synchronization	Start/stop	Start/stop		Start/stop		Start/stop	
ERROR CONTROL		Character parity checking optional; manual retransmission	Character parity checking optional; manual retransmission		No provisions		No provisions	
APPROXIMATE RENTAL (per terminal per month)		$90 to $100	$140 to $176		See Comments and Teletype Report		See Comments and Teletype Report	
COMMENTS		Can transmit and receive entire 128-character USASCII set	Optional edge-punched/paper tape reader and punch can be substituted for paper tape reader and punch; can transmit and receive entire 128-character USASCII set		KSR set has printer and keyboard; ASR set adds punched tape I/O; leased from common carrier; purchased from Teletype; designed for light-duty usage		KSR set has printer and keyboard; ASR set adds punched tape I/O; leased from common carrier; purchased from Teletype; designed for heavy-duty usage	

Fig. 8. Sample Page AUERBACH Terminal Comparison Chart (4).

7. Languages

Time-sharing services offer a variety of languages of which FORTRAN, BASIC, COBOL, and PL/I are used most extensively. Of these, FORTRAN is the most commonly used T-S language (20). This is related to the fact that currently most T-S requirements are associated with mathematical calculations (Fig. 9). As the industry expands and smaller companies begin to make use of the services it is expected that other information based languages will receive greater usage (20).

The list of languages used by the time-sharing industry is nearly as long as the list of companies offering services. Many of these companies will modify an existing language and then tag it with a special applications name. Some of the additional languages found within the different services are: ALGOL, CAL, JOSS, QUICKTRAN, TELCOMP, OSCAR, BRUIN, CAMP, GRAPH, LYRIC, MUMPS, MEAT, PAL, ROSH, TENT, AID, LISP, MACRO-10, SNOBOL, ECAP, ICES, COGO-10, CSMP, and CPM. A terminology difference exists in this area of the industry. Different T-S services classify several of the mentioned languages as "application programs" while others prefer to use the term "application languages" (2, 3, 20). Some of these languages or programs, ECAP COGO-10, CPM, and others are only used to provide interface between the user and an application program and are not considered by the computer professionals to be languages or application programs (14). Before understanding the relationship between the application programs and languages offered by different T-S services a potential user may become unnecessarily confused.

T-S Usage Distribution for 343 Reporting T-S Users.

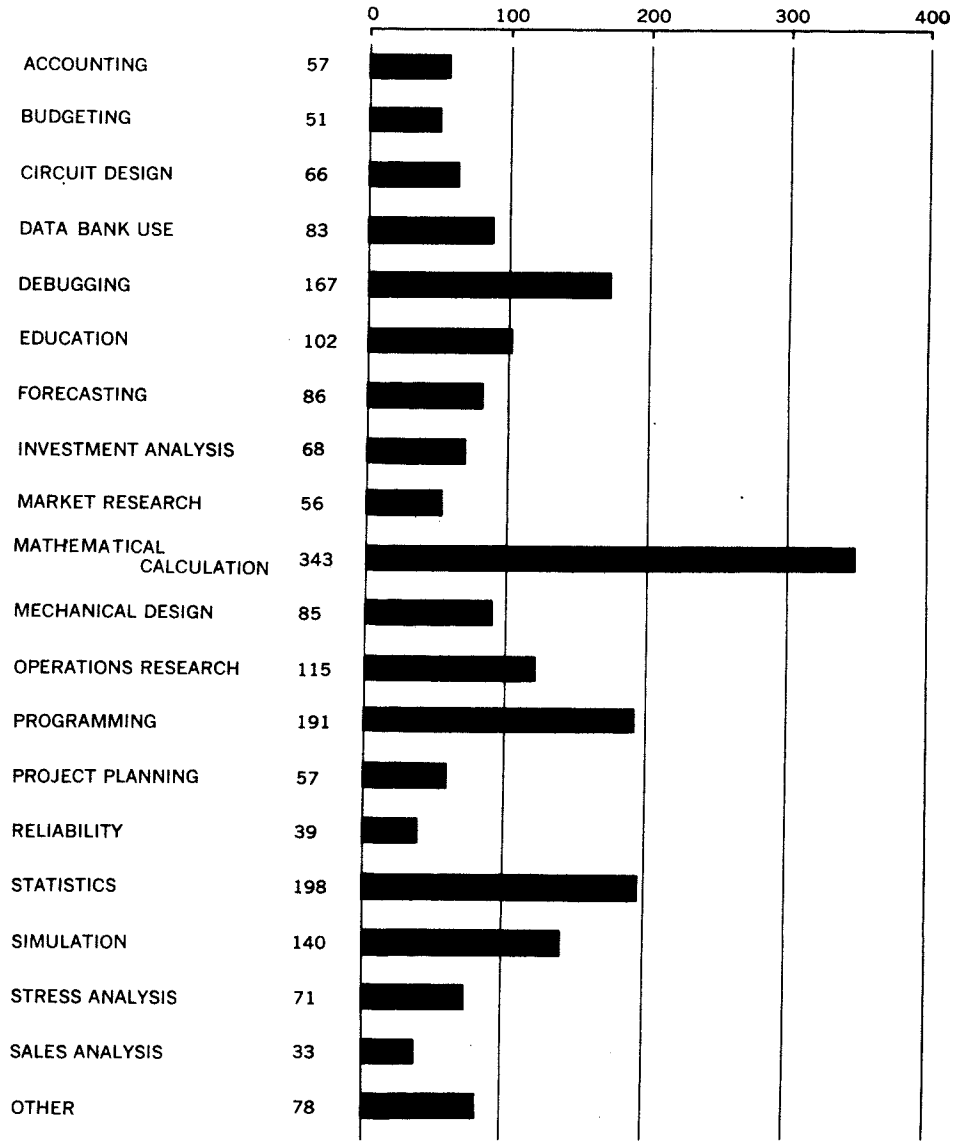


Fig. 9. Survey Results For Various Time-Sharing Applications (20).

One of the most versatile of the languages used by the T-S industry is FORTRAN IV. Usually associated with this language is an extensive library of mathematical subroutines and a high compatability rate for use with application programs. In order to use the FORTRAN language effectively, training in the language is a necessity (Fig. 10).

The BASIC computer language was developed by Dartmouth University and was designed to enable the noncomputer trained professional to make effective use of the computer for problem solving (4). This language uses standard mathematical and engineering terms in preparation of a program, while maintaining the computational capabilities of more powerful languages. BASIC was the first language actually designed for T-S application (3).

COBOL is offered by most T-S services and is considered to be the standard programming language for information systems. COBOL is used for preparing accounting reports where data files and programs are edited from remote terminals (2). Unfortunately, COBOL is a cumbersome language to use with the teletype T-S terminals (14).

PL/I is a more recent development in computer languages having been designed to combine the capabilities of ALGOL, COBOL and FORTRAN. PL/I is becoming widely accepted by the time-sharing industry and can be used to replace ALGOL, COBOL and FORTRAN systems (14).

8. Application Programs

Mentioned as a language earlier but probably more accurately described as an application program is COGO-10. A brief look at this application program is useful in illustrating the ease with which most application programs may be

SECTION	ITEM			USAS I		Computer Sharing, Inc.		General Electric Co.	
	TOPIC	#	DESCRIPTION	Basic FORTRAN	FORTRAN	FORTRAN II	FORTRAN IV	MARK I FORTRAN	MARK II FORTRAN
1. PROGRAM FORM	.1 CHARACTER SET	.1	Special Characters	10	11	23	23	26	26
	.2 STATEMENTS	.1	Multiple Statements per Line	No	No	No	No	Yes	Yes
		.2	Free Format Lines	No	No	No	No	Yes	Yes
		.3	Number of Continuation Lines	5	19	9	9	No limit	No limit
	.3 STATEMENT LABEL	.1	Number of Digits in Integer Label	1-4	1-5	1-5	1-5	1-5	1-5
		.2	Alphanumeric Label	No	No	No	No	Yes	Yes
	.4 SYMBOLIC NAME	.1	Number of Characters	1-5	1-6	1-6	1-8	1-30	1-30
2. DATA TYPES	.1 PROPERTIES	.1	Integer Type	Yes	Yes	Yes	Yes	Yes	Yes
		.2	Real Type	Yes	Yes	Yes	Yes	Yes	Yes
		.3	Double Precision Type	No	Yes	No	Yes	No	No
		.4	Complex Type	No	Yes	No	Yes	No	No
		.5	Logical Type	No	Yes	No	Yes	Yes	Yes
		.6	Hollerith Type	No	Yes	No	Yes	Yes	Yes
3. EXPRESSIONS	.1 ARITHMETIC	.1	Mixed Mode: Real with Integer	No	No	No	No	No	No
	.2 RELATIONAL	.1	Relational Operators	No	Yes	No	Yes	No	Yes
	.3 LOGICAL	.1	Logical Operators	No	Yes	No	Yes	No	Yes
4. STATEMENTS	.1 EXECUTABLE	.1	Assignment Statements	No	Yes	Yes	Yes	Yes	Yes
		.1.1	GO TO Assignment						
		.1.2	Multiple Assignment	No	No	No	No	Yes	Yes
		.2	Control Statements						
		.2.1	Assigned GO TO	No	Yes	Yes	Yes	Yes	Yes
		.2.2	Logical IF Statement	No	Yes	No	Yes	Yes	Yes
		.2.3	DO Statement	Yes	Yes	Yes	Yes	Yes	Yes
		.2.4	Extended Range of DO	No	Yes	Yes	Yes	Yes	Yes
		.3	Input/Output Statements						
		.3.1	Unformatted READ and WRITE	Yes	Yes	No	Yes	Yes	Yes
		.3.2	PRINT Statement	No	No	No	No(1)	Yes	Yes
		.3.3	Printing Formatted Records	No	Yes	No	Yes	Yes	Yes
	.2 NON-EXECUTABLE	.1	Specification Statements						
		.1.1	Number of Allowable Dimensions	2	3	No limit	No limit	4	63
		.1.2	Adjustable Dimension	No	Yes	No	No	No	Yes
		.1.3	Labeled Common	No	Yes	No	No	No	No
		.1.4	Blank Common	Yes	Yes	Yes	Yes	Yes	Yes
		.1.5	External Statement	No	Yes	No	No	Yes	No
		.1.6	Type Statements	No	Yes	No	Yes	No	Yes
		.2	Data Initialization Statement	No	Yes	No	Yes	No	Yes
		.3	Format Statement						
		.3.1	Field Descriptors	5	9	7	16	5	5
		.3.2	Scale Factor	No	Yes	Yes	Yes	Yes	Yes
		.3.3	Format Specification in Arrays	No	Yes	No	Yes	Yes	Yes
5. PROCEDURES AND SUB-PROGRAMS	.1 FUNCTIONS	.1	Number of Internal Functions	13	55	33	70	49	27
	.2 SUB-PROGRAMS	.1	Block Data Statement	No	Yes	No	No	No	No

Notes:
(1) DISPLAY statement is used

Fig. 10 Sample Page AUERBACH Language Comparison (4).

applied.

COGO-10 was developed jointly by the Puerto Rico Department of Public Works, and the Department of Civil Engineering Massachusetts Institute of Technology (2), as a civil engineering problem oriented language that can be used in the solution of geometric problems such as:

a. control, land, and right-of-way surveys

b. highway and interchange design

c. construction layout

d. bridge geometry.

The most prominent features of COGO-10 are:

a. Problems can be written by the engineer in minutes.

b. Computer programming knowledge is not required.

c. Calculated data may be saved.

d. Output is easy to read and to associate with corresponding input data.

CPM application programs are also quite common and as COGO-10 are very easy to use.

Time-sharing services often combine the features of common application programs with their own internal software system. In doing this the service attempts to make the programs more attractive to the user. Easily applied, attractive application programs are being welcomed by the T-S users without extensive knowledge of computer techniques (21).

Computer application programs are usually designed to take raw or field data as input, converting this data to meaningful information (15). The calculations required for both COGO-10 and CPM are not complex, they are in

fact, basic engineering problems. It is the hours required to perform these task that contributes to cost build-up, and therefore, establishes the value of such applications programs. There are many other application programs especially ones associated with mathematical computations that are so complex that a manual solution is not possible, thereby lending themselves to computer solutions.

A partial listing of the application programs applicable to civil engineers offered by the various T-S services are:

a. beam loading analysis

b. bridge construction analysis

c. bridge construction design

d. cantilever retaining wall analysis

e. column loading analysis

f. column design

g. construction cost estimating

h. critical path method

i. cut and fill calculations

j. forecasting

k. frame analysis

l. gravity retaining wall analysis

m. hydrograph analysis

n. pipe network analysis

o. simple beam analysis

p. simulation analysis

q. slope stability

r. steel beam design

s. stream flow analysis

t. survey

u. T-beam analysis

v. transportation

w. truss analysis

There are many additional application programs listed under the headings of statistical analysis, mathematical analysis, and business oriented routines.

A complete listing of all application programs available to the civil engineer is not possible. Application programs are being continuously added to meet user requirements. If a required program or application is not listed in the T-S service library a subscriber may request that the program be made available. If the T-S service can justify the additional program, efforts are made to purchase or to develop the additional service. If the requested program would have applications unique to only one subscriber, it would probably fall upon the requestor to pay the development or purchase cost (22).

As T-S services centralize and develop common communication links, the number of applications programs available to any user will be vastly increased (19). A future consideration is for "Design Evaluation Application Programs". Programs of this nature would be used to validate the engineering design of a project before approval to construct is issued (23). Design application programs could be used to enforce building codes.

9. Service Fees

The T-S industry does not have an established standard for determining user rates nor is the terminology of service fees standard. Price schedules, schedule of charges, or service fee tables depending on the source of information, appear at first to be fairly standard. However, when the capability of the computer service is related to the service charges large variations may exist (Fig. 11). The following listing is a comparison of three distinctive T-S services and their corresponding charges (2, 3, 15).

	1	2	3
Terminal connect time/hour	$ 8.50	$10.00	$ 10.00
Computer resource units/unit	.05	.10	.10
Storage/unit month	1.75	.75	.75
Minimum monthly charge	100.00	None	100.00
Inactive files/unit month	---	.10	.10

The range of charges for the use of peripheral equipment illustrates a more pronounced disparity of fee standards and service capability (2, 3, 15).

	1	2	3
CalComp 30 inch drum plotter/hr.	---	---	$50.00
CalComp 12 inch drum plotter/hr.	---	$15.00	35.00
Line printer	---	16.00	50.00
Card Reader (size not specified)	---	15.00	50.00

Service #1 does not offer peripheral equipment services while service #2 and #3 have what appears to be a disparity in their respective rate assignments.

Each service lists a variety of discounts for different services. These discounts vary from 1 to 70 percent depending upon contract arrangements. Discounts are listed for the following services:

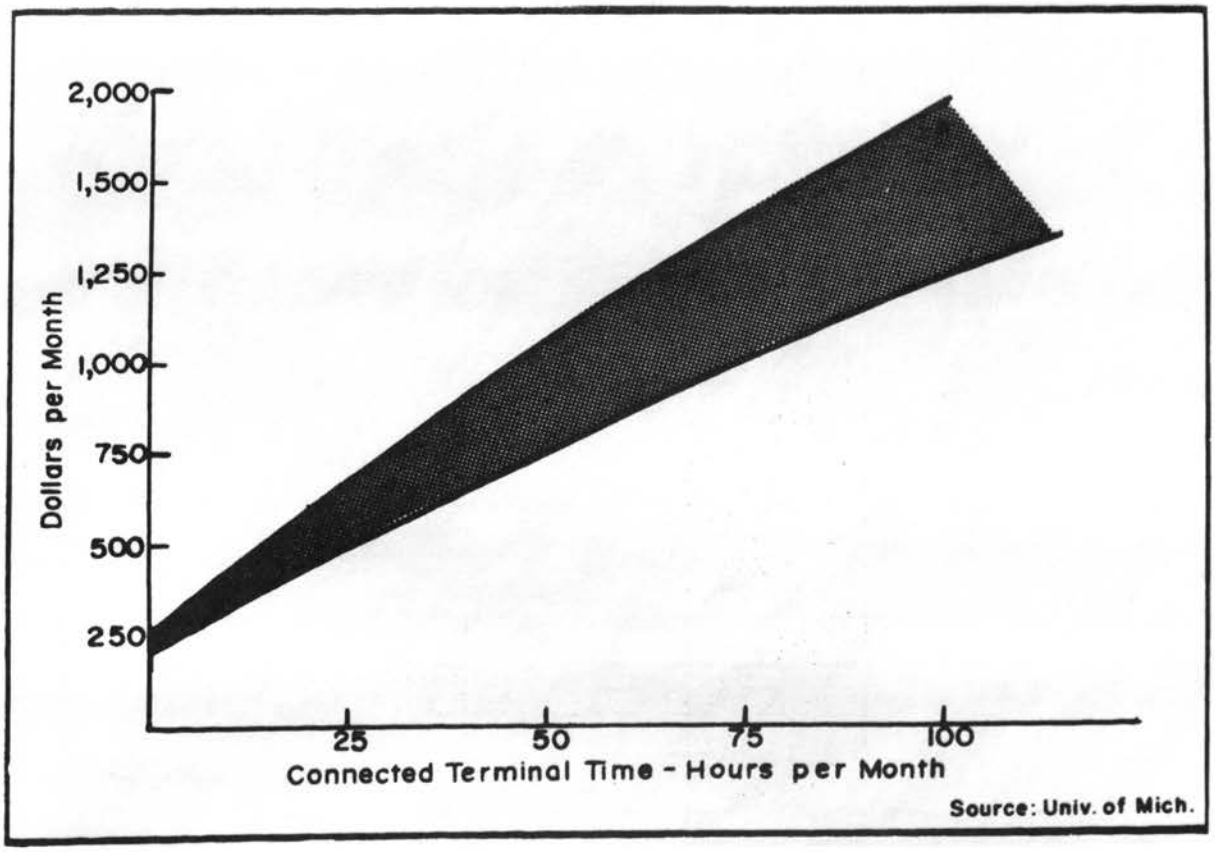


Fig. 11. The Range of Costs for Sharing a Computer (24).

Night-time useage	15%
Volume-use	$1\frac{1}{2}$%-3%
Fixed commitment	2-10%
Mass Storage	40-70%

It is very unlikely that the small subscriber would benefit from any of these discounts.

10. Security

Dual protection must be extended to the T-S user to insure that information and programs used within the system are secure. The security system must be adequate to protect the user from outside sources that are seeking competitive information and secondly, the user must be protected from a system failure (23, 25).

Code protection is used to restrict the use of files, programs, and T-S services to authorized users. Entry to T-S systems can be gained only after the system has received coded information concerning company identification, individual identification and project identification (15). Code protection is both the responsibility of the user and the service. Code security is usually fairly easy to control by allowing only authorized personnel to have access to the codes.

Because of reliability deficiencies of computer hardware and software systems the user's greatest concern is with system security (25). System failures have resulted in the loss of programs, files, and records. Slight damage to a system could result in invalid output. Computer backup systems, records duplication, periodic file printouts, and system test are used to reduce

the possibility of a component failure resulting in a system failure (25).

A T-S service that cannot reliably guarantee security for it's users will not survive in the T-S industry.

11. Future Trends

The highly competitive nature of the T-S industry is a result of the 1969 T-S expansion. To remain competitive and to increase their current portions of the T-S market, the major companies are engaged in research and development. The T-S services recognize that system efficiency and reliability must be upgraded (26). Development of new service features to overcome a constant obsolescence factor is a necessary objective if a company is to successfully remain in the T-S industry.

Because of irregularities in some limited phases of T-S business proceedings, the Federal Communication Commission (FCC) is conducting an inquiry into the T-S industry. The FCC is attempting to determine if existing federal statutes are adequate to protect the T-S user. The FCC may recommend enacting legislation to establish T-S standards (2). The T-S industry is concerned as to what effect any such regulation or new legislation may have on future operations.

Because of the competition and the FCC's inquiry, the structure of the T-S industry that will evolve in the next few years is difficult to predict. The best expectations of the future of the T-S industry would indicate that the trend is for continued growth through centralization with restrictive regulations forcing the industry to standardize its operations.

B. Computer Access

There are a limited number of ways in which the engineer associated with a small company can enter into and benefit from the services offered by the computer industries. The engineer could have access to leased or purchased equipment. His organization could subscribe to one or more of the different services offered by the computer service industries, such as batch processing, special purpose services, or time-sharing. Purchasing or leasing computer equipment implies additional expenditures in hiring qualified operators. In many cases, the small engineering company can not justify the hiring of additional personnel specifically to fulfill a limited computer need. However, there are other means available to these organizations. A brief look at the less expensive low initial investment services of the computer service industries will illustrate the approaches that the small company may find economically feasible. These are batch processing (B-P), special purpose services (S-P), and time-sharing (T-S).

Batch processing is an older and much larger computer service industry than that of time-sharing. Batching, as it is sometimes called, is a computer service where the user sends the work to be processed to the computer center. All information for a batching job must be entered prior to the job being compiled and processed by the computer service. The main advantage of batching is lower overall expense, however, the turnaround time for batching may be from a few hours to several days. Batching is well suited to the periodic processing of bulk data where little man-machine interaction is required. Unfortunately batching methods would be very ineffective in solving

engineering problems where many information exchanges are required between the user and the computer.

Several of the more active T-S companies started with a batching service using leased computers and are now successfully employing both systems on the same computer configuration.

Special purpose services are forms of time-sharing or batching. As mentioned earlier, many times the ideas for this type of service originate from outside the computer industry. The special service is unique in that it has a very limited application library and a very high-volume of usage (16). Government agencies such as the Department of Defense, the U.S. Army Corps of Engineers, IRS, the FBI, and state agencies such as highway departments are making good use of non-commercial specialized computer services which fulfill a specific need. As illustrated earlier, System's Professionals has established a specialized service for civil engineers and CARS (Appendix) has established a specialized service for the automotive industry. It is reasonable to expect that, as more non-computer professionals become aware of the ease with which a specialized system can be established, more specialized systems will be established. One area where specialized systems are likely to originate is from within the various professional organizations and professional societies of various disciplines.

The last system and possibly the one most widely used by the engineer is time-sharing, which has already been presented as a composite illustrating many of its capabilities when used as an "engineering tool".

V. DISCUSSION

A. General

A general knowledge of the T-S industry will not provide the potential user with enough information to accurately determine if his organization is or ever will be ready to subscribe to a T-S service. The potential user must be able to answer some very difficult questions: What applications presently exist within the organization that could be accomplished better with the aid of a computer? What systems and services are needed now and will be needed in the future? Who can provide the equipment and services to fulfill these needs? Will this venture show a profit? What additional talent will be required within the company to implement a proposed T-S system.

B. Acceptance

During the brief history of EDP services it has been estimated that between 70% and 80% of computer users are not satisfied with their computer system (10). The reasons for this high percentage varies from the computer company's failure to properly prepare a company for this new capability, to die-hard company individuals who refuse to accept the new systems. Stories of failures and of costly mistakes concerning computer applications are very common. Since their inception, computers have been associated with large expenditures of capital and large staffs to run the equipment. Until the T-S expansion of 1969, time-sharing was associated with the large corporations (18). Because of these facts the small business did not receive exposure to the T-S industry.

Small companies are usually fairly conservative in nature. The com-

panies have small staffs which probably have little if any exposure to computer technology. With all the fears developed from bad publicity or bad jokes concerning the computer industry and little if any internal computer technology within the company, it is easy to understand why many companies reject the idea of T-S before exploring the advantages that it can offer. Mr. Marvin Pygott of CARS related that users who were required by parent company policy to use the CARS system would try to disrupt the system by entering erroneous information. He went on to state that once these users developed the understanding and technology required to effectively use the system that they became avid supporters (17).

Disruption of an established system to implement a new system, the capabilities of which are not clearly understood, is a valid cause for non-acceptance. Engineers can and some do become tied to a system because it works and thereby reject new systems without affording them appropriate consideration.

Expanded instruction on computer technology within the colleges and universities to discipline outside of computer science will have a positive effect on the acceptance of T-S by small companies. Before T-S, developing computer technology within a company required a computer science specialist. Now companies are finding that they can employ engineers with a limited computer capability, a combination that is becoming very attractive to companies engaging in engineering activities. These companies are more interested in engineering than in maintaining a vast reservoir of computer technology. At the same time they recognize the advantages offered thru computer technology.

C. Technical Experience

The argument has been stated that effective T-S requires users with experience in programming (27). To support this argument two facts concerning T-S users are used. First the majority of todays T-S users have large in-house computer systems. And secondly the language most commonly used by the T-S users is FORTRAN. If these were valid arguments they are rapidly losing their validity. Many T-S services are offering expanded capabilities through application programs designed for a very limited background in computer languages. The ability to type is becoming more of a prerequisite for the user of the T-S terminal system than the ability to program. With the new capabilities offered through the T-S services an engineer could have access to the application programs initially justifying the T-S system through their use. At the same time the user could make use of a tutor system to develop the desired technology level for programming a technical language such as FORTRAN. Obviously the more experience a user has the more he can benefit from the T-S service. From a user's point of view, there is an economic breakeven point with regard to experience. With a specialized T-S service that offers application programs specifically directed to the user's objectives this experience breakeven point may be within the range of a small company budget.

D. Technology Transfer

Another advantage to the user is the ability to directly benefit from the experiences of others. With proven application programs developed by others, a business may be able to accept an engineering assignment that was previously considered beyond the capacity of the company.

Expanded capacity through the technology transfer associated with the application programs also gives each engineer a new potential. The engineer gains both in capability to solve engineering problems and he can be relieved of tedious and repetitious time consuming details. A small company could easily double its engineering capability for a very small relative investment. Imagine a city such as Rolla having its entire utility network designed by a city engineer using a specialized application program. An application program for a city water distribution system could require inputs for area population, street networks, and expected growth. Output information from such a program could supply the city engineer with optimal pipe networks, optimal pump station locations, materials listings, cost estimates, as well as other planning information. Currently Rolla is required to purchase this information for several thousand dollars every time a utility expansion is planned. The ability of small cities to organize and collectively use application programs to reduce cost of common city needs is a form of technology transfer that in principle is equally applicable to the small companies interested in T-S applications.

E. Liability

Suppose a T-S service executes a design from an application program and because of a system failure the output is in error. Who is liable--the engineer that requested the data or the T-S service? Systems Professionals in the organization of their civil engineering service has taken the position that the computer service does not provide a consulting service, it merely provides a very powerful tool that for a fee is available to the engineer (7). This tool is capable of solving many engineering application programs which

must be authenticated by the engineer. Conversely the question arises--What if the application program in use is restricted and the engineer has access only to the program's output and not the means by which this output was developed? In this case, because of the nature of the program being utilized and the T-S service's knowledge of what the application program is being used for, the T-S service could be held liable (23).

Many legal questions concerning the T-S service's and the T-S user's responsibilities have evolved along with the recent T-S expansion. A T-S user can not presuppose a T-S service's liability for faulty information. Before utilizing any service the user, with legal counsel, should thoroughly examine details of contractual arrangements.

F. Safeguard Application Programs

Protection from liability may someday be the result of using specialized test application programs. A simulation analysis designed to check the soundness of engineering calculations could be used to insure conformation to design criteria. A similar analysis could provide decision makers with comparative information concerning construction methods and thereby show cause for the rejection of a specific method or process because of its effect upon the total system. It is possible that a comparison of safeguard routines concerning a specific project could be used as legal criteria for selecting or rejecting contracts. As computer systems become more common, it can be expected that control procedures such as safeguard type application programs, that are presently used in the simulation of space flights, will be adapted to common everyday commercial uses (12).

G. User Need

The small company planning to implement a T-S capability without having first established and evaluated explicit company objectives is inviting failure (9). Unfortunately too many small businesses in their efforts to maintain a profit, operate from day to day continually redefining company objectives. It would be very unlikely that a company operating in such an environment could ever realize the full benefits attainable through the use of T-S.

The small company in identifying a need for a T-S service must go beyond the immediate engineering applications in an effort to justify the service. Using the service as an administrative processor may provide a more substantial justification than the engineering applications. By approaching the selection of the T-S service from both the engineering application and the administrative points of view, the potential user may be able to select a service that could handle administrative workload as well as engineering applications.

The small company running a tight budget may ask how many people the T-S service will replace. The best answer is none (17). The use of a T-S service can increase engineering capability, and it can provide company visibility on equipment, inventory, and taxes that were previously hidden and possibly neglected. Time-sharing if used properly will probably result in acquiring additional employees to exercise increased company capability.

Carefully and slowly could best describe the method that the small company should use when first deciding upon a T-S service. Designating from $500 to $1000 for experimenting with one or more T-S services may return many dividends when selecting the T-S service.

H. A Civil Engineering Application

Repetitive use of T-S application programs to several projects is the basic justification for subscribing to a T-S service. In Missouri there are approximately 50 small consulting engineering firms that specialize in providing design service to small cities and towns (27). These firms have annual gross incomes ranging from $100,000 to $1,000,000 (27). Many of their consulting services are repetitive in that water distribution, electrical distribution, lighting, gas distribution, sewage and street design associated with each small town is similar. Of these companies none was found to subscribe to a T-S service. A civil engineering example relating the T-S applications that these companies could use will illustrate the capability of T-S.

With the possibility of attracting new industry small cities are finding that they must rapidly accelerate capabilities to house and care for new residents. Land developers are continually approaching city planning councils and planning boards with new developments that must be integrated into the existing city structure. The consulting engineer is called upon by both the developers and the city to design these new facilities. Different cities have established different codes in city planning and development. In one instance a city may assume responsibility for a sewer system and in the next it may be the developer's responsibility. Since our interest is with the consultant and the process of design, the fact as to who actually does the contracting to the consultant is unimportant.

In the design of a proposed housing development there are many considerations that must be made. Because of historical knowledge, many of

these considerations can be readily supported by engineering calculations. It is in this area that T-S becomes advantageous.

In identifying the ways in which T-S can be used in a land development project it will be assumed that if an application program is not available it can be requested for development by the T-S service or written by the user. This assumption has been made to show to a prospective user how an established company would be expected to use T-S realizing that initially a new user would be limited in its T-S capability.

The major areas that will be considered in a proposed development are:

1. drainage
2. road network
3. lot layout
4. survey
5. utility design.

The listing is not in the order of design, as most of the above listed items require simultaneous action. For example, drainage and lot layout would have a definite effect on the design of the road network.

Once the basic conceptual decisions have been made the consulting firm making the design will be required to properly document and make the concepts executable. The following types of application programs could be used by the consultant to document his recommendations and to reduce his repetitive calculations.

A drainage analysis of the proposed project and the surrounding area

is necessary for the developer to determine if the site is suitable to the proposed project. The consultant also needs the information for use in the design of drainage structures. UNIHYD*** (15) can be used to calculate and plot runoff. FLDPLN*** (15) is an application program for stream analysis. Results from both of these application programs could be extremely useful in determining major restrictions to the proposed development.

Once the major restrictions have been identified initial layout can begin. Optimum layout design by use of an application program will provide the consultant with several possibilities on layout design vs. cost that were previously too expensive to evaluate.

Once the layout has been established the complete area final survey must be recorded and calculated. CIVIL 1*** (15) offers the consultant a program that will execute these calculations in a fraction of the time necessary to calculate them in the engineering office.

With the layout established and the survey data documented street and drainage structures can be designed and cost estimates prepared. Application programs useful to the consultant would be ERTHWK*** (15) for calculating volume of cut and fill over a given area. RTNWAL*** (15) for designing cantilever retaining walls and analyzing cantilever and gravity retaining walls. BISHOP*** (15) for making slope stability analysis by the Bishop method. SEWER*** 2 (15) for storm sewer system design and cost estimates. Many additional very small application programs relating to culvert design are also available.

Utility design programs are being developed by the T-S services.

These programs will come in the form of network design and pressure analysis for gas and water distribution systems. Also there are programs for lighting systems, and power distribution design. Other programs calculate such things as pipe sizes for gas, water, and sewer systems; and line sag and wire size for electrical systems.

Other application programs in the form of cost estimating (CONSLD***) (15) and CPM analysis (CPM TWO***) (15) can also assist the consultant in his ability to provide a complete detailed service to his client.

In the design of a development it can be readily seen that the consulting agency could easily make use of five or more application programs all of which would contribute to the reduction of the time required to complete the project.

VI. CONCLUSIONS

Time-sharing can, when properly applied, be used as an effective "engineering tool" by the small company with an inherent need to use engineering applications in the course of daily operations. However, before the decision is made to use a T-S service the small company must make a detailed evaluation of both the company's objectives in making use of T-S and the T-S services capability to satisfy these objectives.

The T-S industry is continuing to develop and will eventually, through internal standardization from the effects of competition and perhaps FCC regulation, be able to provide uniform service to a majority of the small engineering associated businesses.

As the T-S industry expands, interface between T-S and other businesses will merge to develop application programs that will provide services with a wider range of capability than is presently possible.

Lastly, a company no matter how small or limited in its engineering capabilities should at least investigate the T-S industry to determine if T-S services could be used productively.

VII. RECOMMENDATIONS FOR FURTHER STUDY

Published results of a wide range of investigations into the T-S industry concerning the interface between the engineer and the T-S service are currently needed within the civil engineering society. Detailed analysis of several of the major topics discussed in this thesis could be used to good advantage by the engineer faced with a limited budget and a big job. In this area of T-S the published investigations conducted by the student could be extremely beneficial to the practicing engineer.

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IX. VITA

The author, James Binford Summers, was born on April 19, 1938, at Amarillo, Texas. He received his primary education in Albuquerque, New Mexico. He has received his college education from New Mexico Military Institute, Roswell, New Mexico; and Texas Technological College, Lubbock, Texas. He received a Bachelor of Science degree in Industrial Engineering from Texas Technological College in June, 1961.

He has been enrolled in the Graduate School of the University of Missouri - Rolla since September, 1968. Time between undergraduate school and graduate school was spent in commissioned service in the U. S. Army, stationed at various locations around the world from Germany to Vietnam. Upon completion of this thesis the author and his family will be moving to Kankakee, Illinois, where he will be joining industry.

X. APPENDIX

Computerized Automotive

Reporting Service Inc.

COMPUTERIZED AUTOMOTIVE REPORTING SERVICE INC.

The Computerized Automotive Reporting Service Inc. (CARS) is a complete automotive dealership reporting service providing management reports and detailed inventory control data to over 300 national dealerships with an average charge of $500 per month per dealership (16). The cost range per dealership runs between $200 to $1500 per month estimated (16). CARS does not own computer hardware not does it prepare its own software programs. CARS is the largest single subscriber of the McDonnell Automation Direct Access Computing Service. Each of the 300 plus terminals used by the CARS system communicates directly with McDonnell Automation. The CARS Corporation takes advantage of evening useage discounts and volume discounts offered by McDonnell Automation to pass savings on to CARS subscribers.

The CARS system was developed from ideas originated outside the computer industry by people with a need for automated service. The System is basically simple. CARS contracts with McDonnell Automation for high volume service. In turn CARS sells this service to auto dealerships in the form of a complete package providing dealers with the advantages of computer applications without the expense of training, program development, and maintenance, that would be required of owning computer equipment or the expense of developing software requirements for one organization. High volume is the key to CARS success. Each terminal is equiped with a teletype and the 5C DATAspeed "750" which are leased from the telephone company by CARS. CARS then conducts a comprehensive training program to insure proper user application. Once initiated the system works entirely between the McDonnell

computer and the dealership while CARS monitors all activities.

The daily operating controls executed by the dealership are simple. First, activity information is punched into a standard 8-track paper tape on a teletype (Fig. 6) which has a standard typewriter keyboard and provides readable printed copy. Second, at the end of the day the punched tape is placed in the data transmission unit (Fig. 7). Sometime during the evening the central computer from McDonnell Automation will call the transmission unit located at the dealership, causing the data to be transmitted to the computer. At the computer center the information is audited for accuracy and routines are executed. The computer then transmits this information to the dealership where hard copy is printed on the teletype for the dealers convenience. At the end of the month the dealership is billed by the computer and the fee is paid to CARS which has been continuously monitoring the system. For the rather nominal monthly fee a dealership receives 21 monthly and yearly reports in addition to the daily update just described. It is estimated by CARS that 3 to 4 full time well trained specialists would be required to provide the same service manually for each subscriber.

However, the CARS system does not advocate reduction of the work force. They instead justify their system on cash savings from improved inventory control and the greater business potential of the dealership.