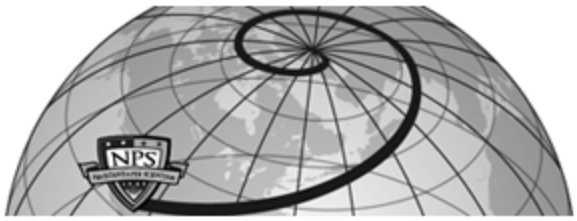

CONFIGURATION AND MANAGEMENT ANALYSIS OF THE NAVAL POSTGRADUATE SCHOOL TELEPHONE SYSTEM

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Monterey, California

THESIS

Configuration and Management Analysis
of the Naval Postgraduate School
Telephone System

by

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March 1974

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ABSTRACT

This thesis is a study of the telephone system at the Naval Postgraduate School, Monterey, California. It describes the facilities available, their current management, and their costs. Potential methods for evaluation of cost-effectiveness are developed and their implementation is explored. The overall conclusion is that greater management control is desirable. Specific recommendations for improvement in this management at national and local levels are offered.

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I. SUMMARY

This thesis is a study of the Naval Postgraduate School (NPS), Monterey, California administrative telephone system. The study examines the configuration and operation of the system, the organization in which it operates and that through which it operates. Primary emphasis has been placed on the local aspects, but many of these characteristics can be applied to other installations. The analysis encompasses the physical facilities, current management organization and techniques, cost identification and analysis, determination of requirements and the options available for their satisfaction.

Research conducted included a review of existing directives governing the system. Study was conducted of the installed equipment through personal observation and inventory listings and Telephone Company (TELCO) publications covering service and equipment availability and tariffs. Fiscal data was obtained from TELCO bills for the last three years, and from NPS bills to tenants for those charges which are reimbursable. Numerous system management and operating personnel were interviewed, including Public Works Department (PWD) personnel and some users. Information concerning the determination of communications requirements and ways in which they may be satisfied was obtained via interviews with an independent telephone systems consultant, representatives

of several non-Bell System interconnect equipment vendors and the local TELCO Marketing Representative. The statistical data in the areas of utilization and costs was compiled and representative methods for analysis were formulated.

The study concludes that overall and individual Navy telephone management is not integrated or coordinated. No standards or uniform policies, other than the limits of delegated authority, are observed or promulgated. There is no master plan for development at the overall or local level. Knowledge of telephone systems and analysis of fiscal and usage data are lacking.

Findings specifically applicable to NPS include:

1. Overall NPS telephone system cost to the Navy is approximately $30,000 per month.
2. Service Charge accounts for 80% of the total bill and of that, 57% is attributable to key system lines and features.
3. Key system features (buttons, lights, intercoms) cost $2600 per month or $31,000 annually.
4. Overhead is buried in the cost to the user, thus he cannot accurately identify his true service cost.
5. Line overhead and AUTOVON overhead increase cost by 20 to 50%. Equipment installation, relocation and mileage inflate costs still further. The total of these surcharges can easily double the basic cost of a line to the user.

6. Both statistical and subjective measures for evaluating service requirements are necessary. Statistical methods quantify numbers of lines and places and their costs. Subjective methods relate statistical figures to the practical and personal activity requirements.

In view of the conclusions it is recommended that an all-Navy master plan for telephone management be developed and maintained. The plan should address:

1. organization
2. analytical effort
3. education and training.

On the level of individual telephone systems the foremost recommendation is for provision of a knowledgeable, authoritative coordinator. His areas of responsibility should include:

1. inventory of equipment and analysis of cost and utilization data
2. education of management personnel
3. education of users.

The following specific recommendations are made for NPS:

1. Automate toll allocation and reimbursable billing.
2. Conduct a physical equipment inventory.
3. Analyze statistically and subjectively the current utility versus cost.

4. Demand strict toll call accountability and justification with particular emphasis on long-duration calls.
5. Review "general use" and dedicated lines to determine their necessity.
6. Minimize and consolidate service charges.

The conclusions and recommendations are neither all-encompassing in range nor exhaustive in depth. They do serve to illuminate some relatively unexplored regions of managerial requirements and performance and also to emphasize areas in which more concentrated study is necessary.

II. BASIC DESCRIPTION

The present telephone system at the Naval Postgraduate School (NPS), like those at most Naval activities, is provided as a utility service by the local Bell System telephone company. In Monterey, this is the Pacific Telephone and Telegraph Company (TELCO). The service provided is essentially a Central Exchange (CENTREX I) with multiple key systems for primary administrative voice traffic and numerous peripheral circuits and facilities.

A. PHYSICAL EQUIPMENT AND LAYOUT

All equipment and lines are TELCO-owned and leased to the Navy by means of the Basic Termination Contract and monthly "service charge." NPS supplies building space, electrical power, heat and lighting required for the exchange and the conduit for those lines between buildings on-base at the main campus and at the Annex, approximately one and one quarter miles away. Appendix B is a map of the facilities. Lines and their support facilities, poles or underground conduit, to the Annex and other outlying areas are Bell owned and maintained. The exchange switching is automatic, electromechanical, using step-by-step relays. The Central Exchange is located in the basement of Herrmann Hall, the administration building. The switchboard is also located in Herrmann Hall. A switchboard operator is required only for information service, outside line and AUTOVON

dialing for stations without this access, and for connecting some conference calls. Of the 772 operating lines in June 1973, 324 were totally unrestricted and could call or receive on-base, off-base on Monterey trunks or AUTOVON, 383 could access outside but not AUTOVON, and 65 could call only on-base but receive unrestricted. Assignment of particular accesses to particular lines is purely administrative; physical capability exists for all lines to be unrestricted.

CENTREX or Central Exchange service is a system which provides separate switching equipment from that at the telephone company's central office for all telephones within a particular building, military base, campus, or among buildings or locations belonging to a common firm or other organization. The CENTREX provides a number of characteristics not available to the individual line subscriber, and also provides a means for common integrated billing for all services used by the organization. There are many configurations of CENTREX, depending upon subscriber needs, budget restrictions, and specific assets of the serving telephone company. The NPS CENTREX I system discussed here may be considered as a typical but not universal service.

Two basic definitions are necessary for understanding all of the system descriptions which will follow:

1. A "line" is an individual telephone number. For NPS, it is each separate four-digit number whose prefix is "646." A "straight line" is a number which is

not subconnected into a key system.

2. A "telephone" is a single instrument, i.e., a regular desk set, six-button desk set, wall phone or multi-button Call Director.

The CENTREX system provides a large number of possible on-site lines while requiring a considerably smaller number of trunks between the base and the Monterey Central Office. The Central Office directs all incoming calls with the 646 prefix to the NPS Central Exchange. Outgoing calls, to other than 646 numbers, are directed by the CENTREX to a Central Office trunk and then handled just as a call from any individual number. Intra-base service is obtained by dialing only the four-digit unique line number and only CENTREX is involved without use of any Central Office trunks.

Additional subsidiary functions are also available in the CENTREX:

1. Line finding, or "rotary hunt" which causes an incoming call to be automatically transferred to the next higher number when a busy line is encountered. (This must be pre-set in the exchange equipment for the groups of lines for which desired.)
2. Manual switchboard services performed by a telephone operator. These include:
   a. Conferencing up to five connections (one trunk and four CENTREX lines or five CENTREX lines).
   b. Transfer of any incoming call to any other line.
   c. Directory service.

The manual switchboard is manned only during normal working hours. At other times, calls to the basic switchboard number are automatically transferred to the Information Desk at Herrmann Hall. The switching equipment for the NPS CENTREX has a capability for handling 900 lines and 80 Central Office trunks. At present about 770 lines and 50 trunks are connected.

A key system is an arrangement of telephones within an office or department or other functional grouping which allows for the following:

1. Individual telephones to be used on more than one line. (This might be used where all incoming lines are initially answered at a central point, e.g., receptionist or department secretary, and then diverted to the appropriate receiving station.)
2. A dial intercom feature which permits communication between selected telephones within the key system without use of a line.
3. "Hold" for one line on a key telephone while another is answered or intercom is used.
4. Lighted indication of lines being used or held.
5. After-hours switching of lines on unattended telephones to an attended telephone.

Key system features are independent of those available through a CENTREX. In many cases they are used as an alternative to a CENTREX to obtain some of the flexibility and

versatility without the cost and complexity of a CENTREX. This is particularly applicable to organizations whose needs are too small to require the minimum one hundred station CENTREX installation. Either one can be installed without the other. In the NPS case, and in most cases, both are used and they complement each other. There are 82 key systems installed, individually composed of from 2 to 23 lines. Appendix C itemizes the systems, their features and related costs by department/Activity.

AUTOVON, the Automatic Voice Network of the Department of Defense, is a network of leased facilities linking DOD installations worldwide. As described in OPNAV Instruction 2305.15, AUTOVON is:

> "...the principal long distance nonsecure voice network of the DOD. AUTOVON will be used only for official communication and service will be provided only to the most essential elements of commands that require long distance telephone communication in support of command, operation, intelligence, logistics, diplomatic matters and administration."

Eleven leased lines terminate at the NPS CENTREX, seven useable for incoming or outgoing calls and four for incoming calls only.

Additional dedicated circuits exist, separate from the CENTREX lines for various special functions and other voice communications. Their use is not covered herein, however they are noted as components of the overall installation in the cost analysis section of this thesis.

Slightly over half of all lines at NPS are straight lines, not parts of a key system. Most NPS departments have

both straight lines and key system lines. The only areas in which straight lines predominate are in the academic departments and the Computer Center. This is due to the provision of a private line in each faculty member's private office.

Of the key systems, the size distribution, shown in Figure 1 on the next page, can be summarized as follows:

39% are two station systems

61% have three or fewer stations

75% have four or fewer stations

84% have five or fewer stations

89% have seven or fewer stations.

The Dudley Knox Library key system, KTS #41, was chosen to illustrate the features present, not because it is typical, (there is no "typical" system) but because it is neither the largest nor the smallest and because it incorporates all of the specific key system features present in any of those installed. Figure 2 is a diagram of the system. Table 1 lists the lines incorporated and their use and features.

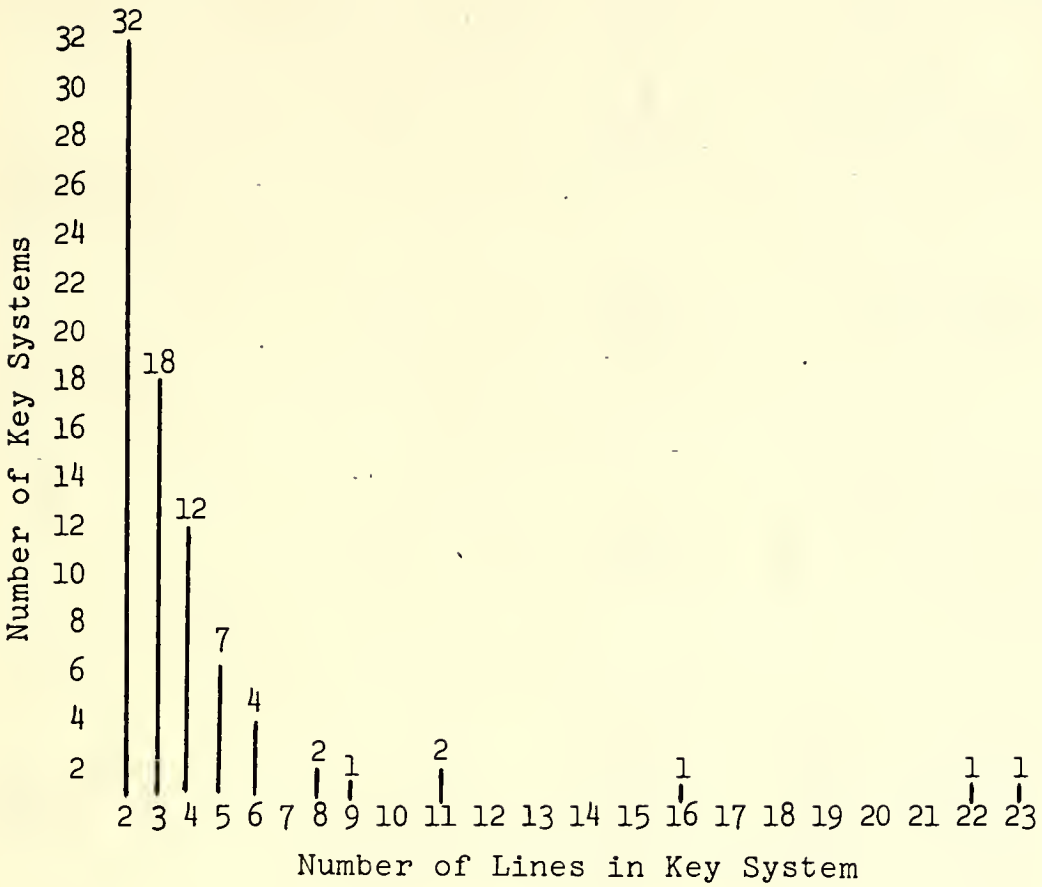


Figure 1. Distribution of Key Systems by Size

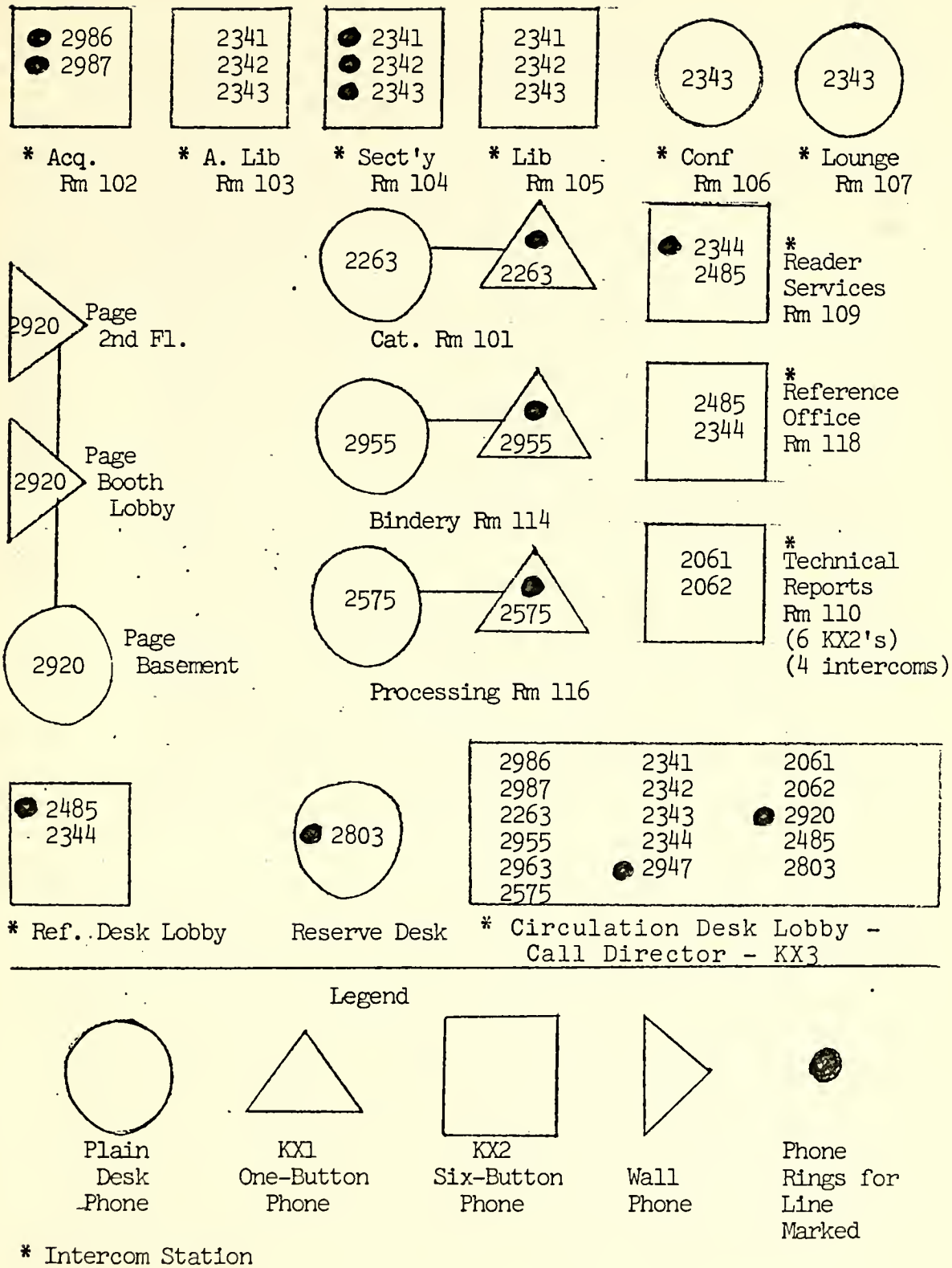


Figure 2. Dudley Knox Library Key System #41.

STATION NUMBER	DESCRIPTION
2341	Rings at KX2 in Secretary's Office, Rm 104, may be used at KX2 in Librarian's Office, Rm 105 or Asst. Librarian's Office, Rm 103.
2342	Same as 2341.
2343	Same as 2341, plus extensions in Conference Room, Rm 106, and Lounge, Rm 107.
	Line finder equipped.
2986	Rings at KX2 in Acquisitions, Rm 102.
2987	Same as 2986.
	Line finder equipped.
2263	Used in Cataloging, Rm 101 only.
2275	Same as 2263.
2955	Used in Bindery, Rm 114 only.
2963	Used in Processing, Rm 116 only.
2803	Used at Reserve Desk only.
2947	Used at Circulation Desk only.
2920	Rings at Circulation Desk only - used at Paging Booth in Lobby or extensions in basement and on second floor for answering of telephone paging of library patrons.
2485	Rings at Reference Desk KX2 only - may be used at KX2 in Reference Office, Rm 118, or KX2 in Reader Services Office, Rm 109.
2344	Rings at KX2 in Reader Services Office only - may be used at KX2 in Reference Office or KX2 at Reference Desk.
2061	Rings at one KX2 in Technical Reports, Rm 110 - may be used at any KX2 in Technical Reports
2062	Same as 2061.
	Line finder equipped.

NOTES:

1. Any telephone instrument intercom-equipped can call any other telephone in the key system so equipped by dialing the appropriate one or two digit number.
2. All stations light at the KX3 Call Director at the Circulation Desk whenever in use.
3. All stations except 2485 and 2803 may be shifted to ring at the Call Director when unattended, such as after regular day-time hours when the Circulation Desk is still open. This shift is normally done each evening. (In the cases of 2263, 2575, 2955, and 2963 this is the only reason for a one button telephone. In the cases of 2986/7 a one button telephone could be substituted for the KX2 six button one were it not for this feature.)

Table I. Key System #41 Line Operation.

III. CURRENT MANAGEMENT

Current management policy in the Department of the Navy provides a dichotomy of management into command communications considerations and business administration considerations. This is set forth in OPNAV INSTRUCTION 2300.4A which is the policy directive for operation and management of Navy telephone systems, as follows:

> "(1) Within the shore establishment, the administration of telephone communications has a dual nature; vis.:
>
> a. as an instrumentality of communications the telephone serves and is administrated by command;
> b. from the viewpoint of business administration the telephone is a utility.
>
> (2) When the telephone is considered as an instrumentality of communications serving command, command responsibilities ... will be discharged by commanders at each level of command; i.e., activity, district or area level as appropriate.
> (3) When the telephone is considered as a utility, the procedures for local telephone system maintenance, procurement and detailed business administration shall be those applicable to other utilities ... and under the technical control of the Chief, Bureau of Yards and Docks [Commander, Naval Facilities Engineering Command]."

This basic separation of functions or fields of concern establishes the framework for the organizational relationships which exist for telephone management. Figure 3 demonstrates this graphically for the Postgraduate School.

A. NATIONAL LEVEL

Commander Naval Telecommunications Command (COMNAVTELCOM) is assigned as the executive agent for the

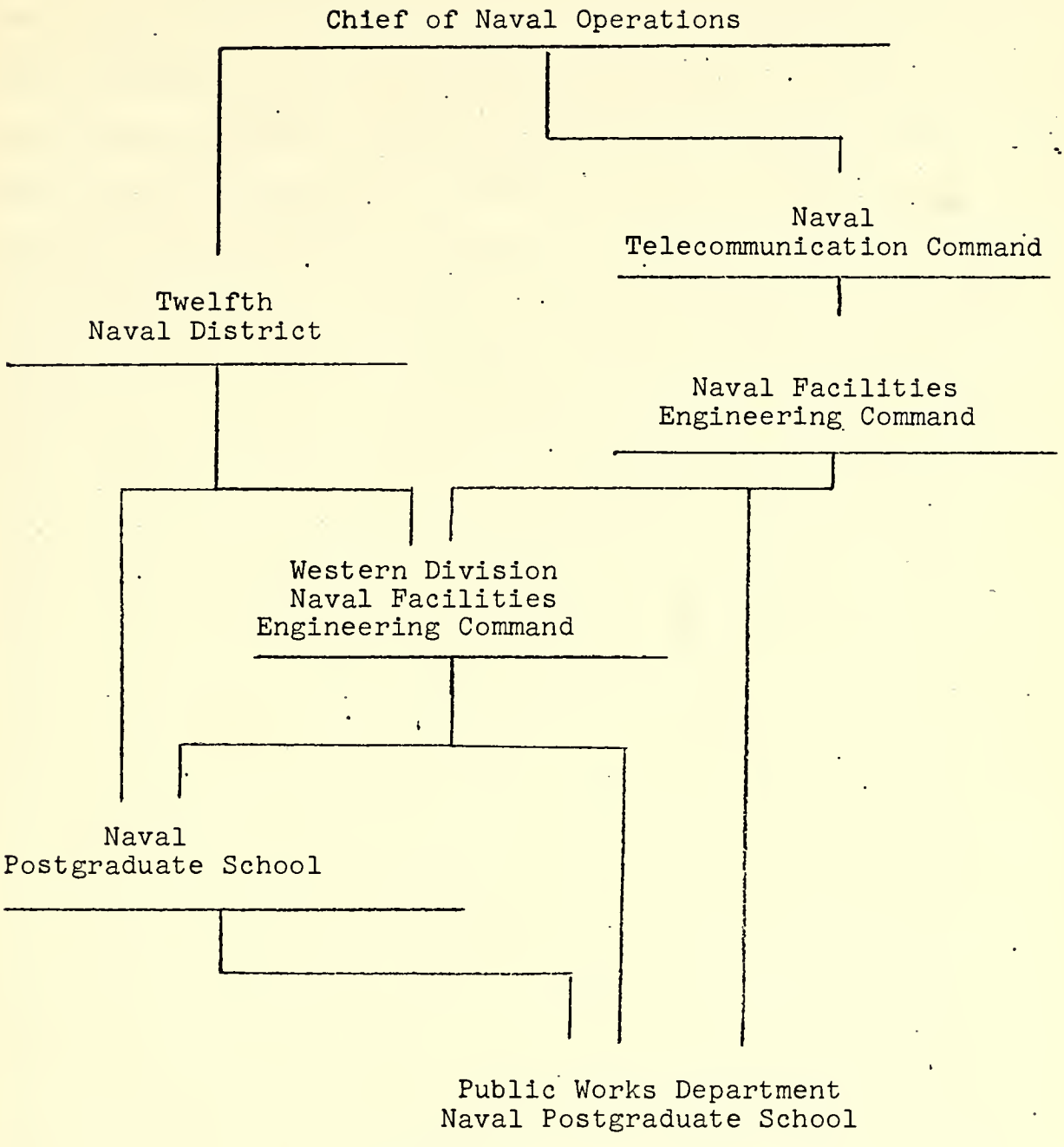


Figure 3. Navy Telephone Management Organization.

Chief of Naval Operations (CNO) for all naval shore communications, and as such has overall command responsibilities for telephone systems. Commander Naval Facilities Engineering Command (COMNAVFACENGCOM) is assigned as the business agent and administrator. He has been delegated authority to make and administer contracts on behalf of the Department of the Navy for all landline services, to place orders under such contracts for local telephone service and to provide technical assistance to subscribers. Uniform contracts have been executed jointly by the three Department of Defense military departments with all affiliates of American Telephone and Telegraph Company (AT&T) for local telephone services and by the Defense Communications Agency (DCA) with AT&A for services of its long lines department. Navy telephone services are procured under a general contract, by submission of Communications Service Authorization (CSA) DD form 428. New installations, activation of inactive installations, complete rearranging of an existing system, expansion of an existing system by more than one hundred lines over the last approved switchboard capacity, changes in ownership, conversion from manual to dial operation and similar major modifications are submitted to CNO for approval, via the appropriate chain of command. The CNO passes such requests to COMNAVFACENGCOM for action subsequent to a review of military considerations involved.

B. REGIONAL LEVEL

District Commandants and activity Commanding Officers are designated to exercise command functions depending upon the system involved. In the case of "local telephone service," that provided by a local telephone system to just one activity, or several activities under management control or financial responsibility of a common office, the Commanding Officer of the activity operating the system acts directly for the CNO in command functions. In the case of "local integrated telephone service," such as that at NPS, a common system serving multiple activities for which different offices have management control or financial responsibility, command functions rest with the District Commandant. He is charged with ensuring that the operation and administration of the system is in accordance with current directives, and with coordinating the determination of each activity's pro-rata share of overall local service expense. Within the Twelfth Naval District (12ND) staff, administration is handled by the District Landline Officer, a civilian subordinate of the District Communications Officer. His primary concern is with communications landlines of all types, and those specifically for administrative telephones are only a minor portion. His only involvement is in the coordination of services and facilities within the District, not in administering details of individual commands' requirements or service. Coordination means avoidance of

conflicts and duplication, by consolidation or sharing, as appropriate.

At this regional level, NAVFAC's agents are the Engineering Field Divisions. For NPS this is the Western Division (NAVFACWESTDIV) who acts for both NAVFAC and 12ND. Functions are performed specifically by the Commercial Utilities Service Branch. This branch has one trained communications specialist assigned and three other personnel generally experienced in utilities administration but not formally trained in telephone technology or management. NAVFACWESTDIV is authorized to negotiate, prepare, and execute orders for local telephone service and facilities. To obtain greater efficiency, NAVFACWESTDIV may delegate its authority to order minor changes to CO's of major activities remotely located. The specific delegation to NPS is noted later in this thesis.

For all services exceeding those delegated or new installations or major rearrangements where the aggregate value is one thousand dollars or more, NAVFACWESTDIV must make a finding that the service to be procured is engineered in a manner to provide the service in the most efficient and economical basis, consistent with the purpose and mission of the activity. NAVFACWESTDIV is authorized to place orders for work where the estimated cost does not exceed $1999 on a negotiated basis. For work in excess of $2000 such services should be procured by competitive bidding. When the cost exceeds that value and competition is not

practicable, NAVFACWESTDIV must forward the request to NAVFAC showing estimated cost of the work, reasons that bidding is impractical, and justification for the work's performance. When approval as to operational and military needs by higher authority is required, NAVFACWESTDIV must provide with the request the contractor's recommendation, his own independent engineering and technical study, cost of the requested service, and differences, if any, between those recommendations. In addition, NAVFACWESTDIV maintains a complete current inventory of all equipment installed. The inventory control function may be delegated, and is to NPS. The field division is also responsible for an annual review of invoices including such items as determination of application of the telephone company's most favorable rate, credit for outages, accurate toll billing and agreement between inventory and billing. This review may be delegated to receiving activities as is done at NPS. Local commands certify invoices as to satisfactory receipt of services.

C. LOCAL LEVEL

It is evident that at the preceeding levels the prime emphasis in management is directed at procurement of large installations or high cost components. Those other managerial functions which are performed, as well as the smaller day to day procurement functions are handled for NPS by the Public Works Department (PWD). This includes the major

functions of requirements determination, facilities planning and financial accounting. There are also subsidiary functions such as telephone directory preparation and distribution and telephone operator administration.

Department personnel, noted in the department organization chart, Figure 4, who are involved in the telephone management are:

1. Finance Clerks (2) - receive telephone company bill, separate toll calls by responsible department or tenant command and provide listings of same for their verification of responsibility, prepare billings for reimbursible costs, and type CSA's. One half of one clerk's work time is devoted to telephone business, and of this, approximately sixty man-hours per month are spent in toll charge responsibility determination.

2. Electrical Planner and Estimator - prepares CSA's based on requests for service or changes in physical layout or organization.

3. Assistant Public Works Officer - reviews CSA's for approval. None of these people were formally trained in telephone systems prior to their assumption of duties. In December 1973, the planner and estimator and the finance clerks attended a two day indoctrination course presented by the marketing division of the local telephone company. Information provided was mainly explanation of Uniform Service Order Codes and tariffs.

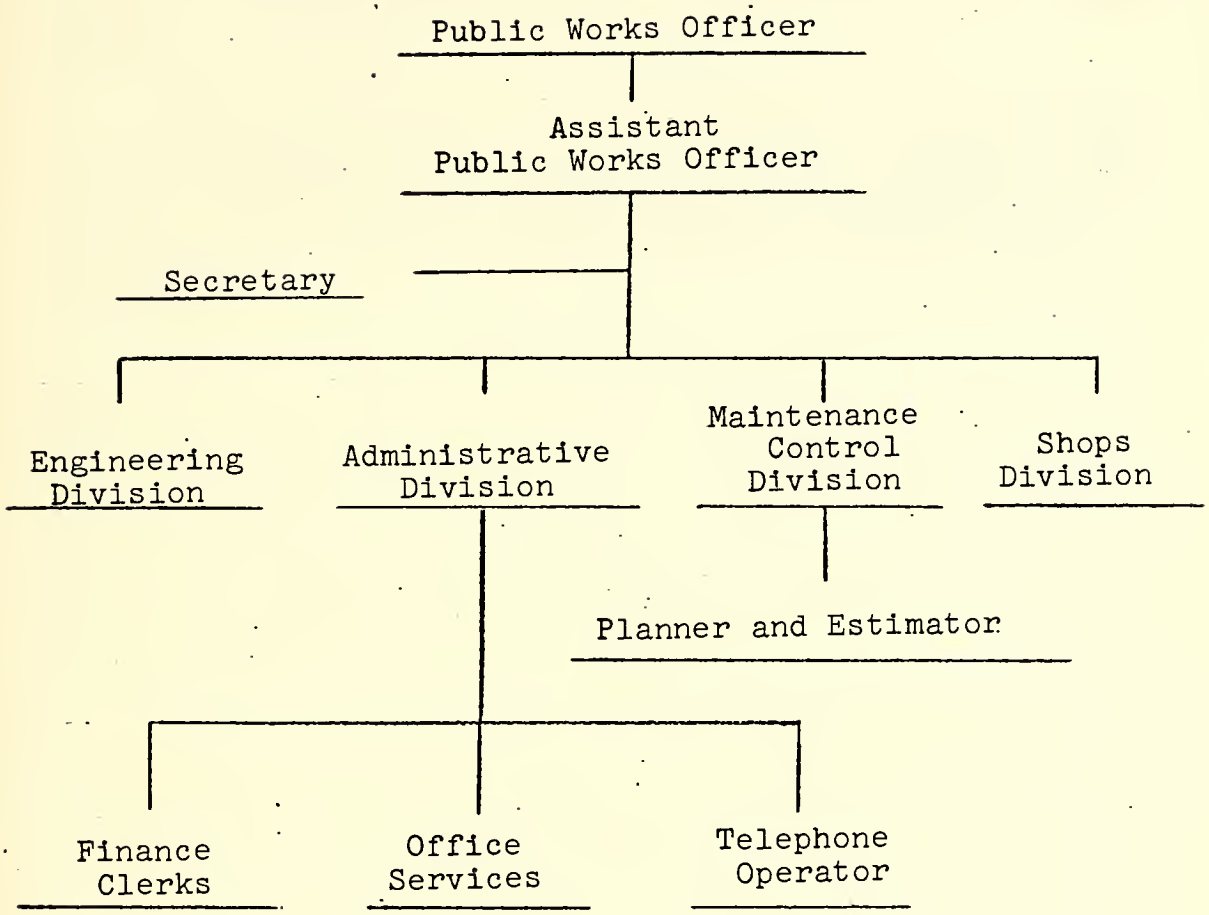


Figure 4. Naval Postgraduate School Public Works Department Telephone Management Organization.

In the area of requirements determination and planning, PWD receives requests from NPS departments or tenants, plans and designs the system required and authorizes, or requests authorization for telephone company installation. In-house authorization authority extends only to changes as follows:

> "Changes in telephone service which do not materially affect the authorized capacity of a local telephone system.... This category may include lines (excluding trunk and tie lines) and telephone terminal equipment up to the approved capacity of the switchboard." (OPNAVINST 2300.4A)

Details of exactly what NAVFACWESTDIV has delegated to NPS are contained in the official delegation of authority, CO, NAVFACWESTDIV ltr 113.2 of 21 February 1973. NAVFAC Publication P-68 further directs that the local CO, or engineering field division, as applicable, should review requirements and negotiate with the contractor to determine the most favorable and economical method of providing the required service. Negotiation should be directed towards obtaining service for the government on the basis of economy, adequacy and reliability. The telephone company Marketing Representative (salesman) is the sole advisor and consultant employed. For other than simple additions, relocations, or removals of straight lines, he proposes the equipment and features to fulfill a request for service.

In the REQUIREMENTS section of this thesis various techniques and approaches to the determination of needed service are explored. At the present time, no standards, other than

the limits of delegated authority, or uniform guidelines are promulgated or observed. Each user requests according to his own criteria for utility. No review or analysis of costs versus service received is conducted at any level. No comparison of costs attributable to or services provided to the various component organizations is conducted. No one looks at trends in installation growth, complexity or cost, nor is any long range projection attempted.

Essentially, management at the local level is an accounting and clerical operation. Control is exercised only with respect to detailed accountability by organization for tolls.

IV. COST ANALYSIS

The objective of this section is twofold: first, to describe and identify all component costs relating to equipment and services provided by TELCO for the NPS and tenant commands; second, to describe and analyze the cost of the NPS CENTREX system.

A. DESCRIPTION OF COMPONENT COSTS

The scope of this sub-section covers the cost for all equipment and services provided by the TELCO, the cost for local management functions, and the cost for regional and national management functions directly supporting this system.

1. Equipment and Service Costs

a. CENTREX System Charges

The monthly TELCO telephone bill (statement) represents the charges for equipment rental and telephone services incurred over the past month by NPS and tenant commands using the CENTREX system. The eight cost elements are:

Message Units
* Long Distance
Directory Advertising
* Other Charges/Credits
* Monthly Service Charge

Local tax
U.S. tax

* Pay this Amount

Only four, those marked by asterisks, apply to the NPS CENTREX system. These elements are discussed first.

(1) Long Distance. This includes only those toll charges attributed to stations within the CENTREX system.

(2) Other Charges and Credits (OC/C). This includes those installation/connection charges related to straight or key system lines within the CENTREX system (i.e., new phones, lines, moving between offices, etc). Removals or deletions of any equipment are free. Rebates to the user are entered here separately and noted with the letters 'CR'.

(3) Monthly Service Charge. These charges encompass the rental of all equipment associated with the CENTREX system (i.e., switchboard, telephones, extensions, lines, key systems, etc.).

(4) Pay This Amount. This figure represents the total monthly bill for equipment rental and telephone services (long distance and OC/C) incurred during the billing period.

(5) Miscellaneous. Message units, directory advertising, U.S. and local tax are not applicable to this CENTREX bill but are mentioned briefly for reference purposes.

(a) Message Units. The Monterey area is a flat-rate area, consequently any number of local calls can be made at no additional expense. Message unit rates

generally apply to larger population areas (i.e., San Francisco, Los Angeles, San Diego) in which every local call costs approximately 3 - 5¢ each.

(b) Directory Advertising. NPS receives one free listing by renting the CENTREX system; however, additional listings are 75¢ each. There are 42 listings in the Monterey phone directory, but the charges for these listings are contained in the Monthly Service Charges (item (3)) of the statement.

(c) U.S. and Local Tax. Since the CENTREX system is located on government property it is not taxable.

It is important to mention the term "Basic Termination Contract" (BTC). The installation of any large expensive equipment, such as a switchboard, trunks and lines, etc. involves a large investment on the part of the Telephone Company. To protect its investment, the TELCO requires the activity which contracts for the new equipment to execute a BTC. Essentially, the activity agrees to retain the new equipment for a period of time (usually five years). Should the activity decide to terminate the use of the new equipment prior to the five year period, it would pay termination charges based on the time remaining in the contract.

b. Non-CENTREX Charges

Throughout the NPS installation, there exist several telephone systems independent of the CENTREX system. These systems are billed separately and use special dedicated lines for a limited period of time. During the month of

June 1973, for example, two such systems were in operation and are listed below along with their appropriate costs:

Department	Use	Long Distance	Service	Total
Computer Center	Computer Link with Berkeley	$394	$82	$476
Fleet Numerical Weather Central	Open-link	$56	$12	$68
	TOTALS	$450	$94	$544

The NPS and tenant command activities have several "general use" lines throughout the premises which incur a monthly charge. These lines are designed to carry specific signals or currents and serve as a connection between Navy terminal equipment (i.e., burglar alarms, fire alarms, hi-pressure cut out switches, etc.) and central guard stations, such as the security office. Many of these lines were installed as early as 1965 and have never been changed or modified. Their monthly costs are listed in Table II (Note, a complete breakdown as to use, installation date and charges is listed in Appendix D).

There are many lines which are specifically conditioned and used with various data networks associated with Fleet Numerical Weather Central (FNWC). These lines are leased from TELCO or AT&T and billed on the national level. These lines connect other terminals along the California coast as well as extend across the country. They

A.	EQUIPMENT/SERVICES		
	1. CENTREX Charges (Jun 73)		
	a. Long Distance ----------	$2,909	
	b. Other Charges and Credits	215	
	c. Service Charges ---------	11,539	
	Total CENTREX ----------		$14,563
	2. Dedicated Lines (Jun 73) ----------		544
	3. General Use Circuits ----------		122
	4. Special Conditioned Circuits ------		3,793
	Total Equipment/Services ----------		$19,022
B.	LOCAL MANAGEMENT		
	1. Administration		
	a. TELCO Coordinator ---------	$154	
	b. Acct Clerk ----------	25	
	c. Billing Clerk ----------	219	
	d. Dept. Billing Clerk -------	226	
	e. Directory ----------	221	
	Total Administration ----------		$845
	2. Logistics		
	a. Operators ----------	$806	
	b. Heat/Light ----------	12	
	c. Interior Conduit ----------	100	
	d. Exterior Conduit ----------	110	
	Total Logistics ----------		$1,028
	Total Local Management Costs ----------		$1,873
C.	REGIONAL/NATIONAL MANAGEMENT		
	1. NAVFACWESTDIV ----------		$3,600
	2. AUTOVON DCA ----------		4,620
	Total Regional/National Management Costs ------		$8,220
D.	TOTAL MONTHLY COST TO NAVY FOR NPS TELEPHONE SYSTEM ----------		$29,115

Table II. Monthly Navy Cost Breakdown for NPS Telephone Systems During June 1973.

are mentioned in this thesis because they exist and a percentage of their costs relates directly to local expenses, the lines are expensive and should be considered as an area of fruitful study, and the lines are complex and the possibility for duplication of effort and costs exists. Those lines which are not billed to NPS but are related to local operations are listed in Appendix D. The cost for local operations is $3800/month.

The total costs for equipment rental, CENTREX and non-CENTREX, are listed in Table II.

2. Local Management Costs

a. Administrative

(1) Telephone Coordinator Wages. A civil service employee attached to PWD who averages one hour per day in handling various telephone requests. The cost for this service is approximately:

22 hrs/month × $7/hr (average hourly wage) = $154/month.

(2) Accountant Clerk Wages. A civil service employee attached to PWD processes an average of 35 service charges per month. This requires 5.5 hours/month. The cost for this service is:

35 orders: 5.5 hrs/month × $4.50 (average hourly wage) = $25/month.

(3) Billing Clerk Wages. This task involves one accountant-clerk who averages 60 man hours per month. The work involves accounting for all long distance calls,

budget accounting, typing bills, tracing unknown charges, etc. The cost for this service is:

60 man-hrs/month × $3.65 (average hourly wave)
= $219/month.

(4) Department Billing. This task involves a secretary from each department to account for all tolls and expenses during the month. The estimated cost for this service is figured on a time of one hour/month. There are 62 billing departments:

62 × $3.65 (average hourly wage) = $226/month.

(5) NPS Telephone Directory. The PWD publishes 1500 copies of the NPS directory annually. Costs for this directory involve time and labor of 5 accountant-clerks, 1 printer and two supervisors plus materials. The cost for this service is listed below:

$ 900 - materials
1753 - labor
$2653 - cost of directory

On a monthly pro-rated scare, this equates to $221/month.

b. Logistics

(1) Switchboard Operator. Operation of the switchboard entails one full-time operator and one part-time relief. The approximate costs for these services are:

full time: 160 man-hrs/month 4.13 (average hourly wage) = $661
part time: 35 man-hrs/month 4.13 (average hourly wage) = 145
TOTAL = $806/month.

(2) Office Space. NPS provides approximately 1300 square feet of office and working space (includes room for exchange equipment and room for switchboard). Charges for heating (continually) and lighting (2 hrs/day) are as follows:

Heating: $107/year = $9/month
Lighting: 36/year = $3/month
TOTAL = $12/month

(3) Interior Conduit. The PWD furnishes and installs special conduit and junction boxes for all telephone lines within buildings. Cost for materials and labor attributed to this service is approximately $100/month.

(4) Exterior Conduit. The PWD furnishes and installs all cable-carrying conduit and inspection covers originating at the edge of school boundaries and extending to the Central Exchange in Herrmann Hall. The cost of materials and labor involved is approximately $5-6/foot. It is estimated that 5000 feet and approximately twenty inspection covers have been installed on the premises since 1949. The cost for labor and materials thus far is approximately $110/month.

3. Regional and National Management Costs

a. NAVFACWESTDIV

This activity employs engineers, analysts, accountants, etc. who function as managers of several telephone systems located within their region. The monthly

expense for this regional management is based on the number of used lines within an activity. This cost is:

777 NPS lines in use × $5/line = $3,600/month.

b. AUTOVON

The school pays for only the terminal equipment at the switchboard. The major expense for the AUTOVON line itself is borne by COMNAVTELCOM. Through the Defense Communications Agency NPS has 11 AUTOVON lines which cost $420/line/month. Total cost for NPS AUTOVON service approximates:

11 lines × $420 = $4,620/month.

4. Total Monthly Navy Costs

The total expense for operating, maintaining and monitoring the Navy's telephone system and services at NPS is listed in Table II by each cost element.

B. ANALYSIS OF CENTREX COSTS

During calendar year 1973, the average monthly CENTREX bill was $15,000. This represented charges for 775 lines, 1100 telephone instruments, 80 key systems and approximately $3000 in toll charges. The objective of this subsection is to describe those CENTREX charges which are significant, show allocation of those charges among users, and discuss trends over fiscal years 1971 to 1974.

1. Identification of Significant Charges

a. Service Charge

Particular attention is given the service charge since it accounts for 80% of the total June bill. Long distance charges and "other charges and credits" are not as significant at this point, but will be briefly addressed further on. Sample monthly charge for all elements as billed in the June 1973 statement, and their respective percentages of the total are:

Long Distance	$ 2,909	19%
OC/C	215	1
Monthly Service Charge	11,539	80
Pay this Amount (total)	$14,560	100%.

In order to obtain a clearer understanding of service charges, it is necessary to analyze the TELCO form A-701 2E (see Appendix E) commonly known as the "TELCO Green Sheets." The Green Sheets are issued along with the monthly statement. They list all equipment believed to be in operation on the premises. There are five major equipment sections to the Green Sheets and they are shown in Table III along with their appropriate charges. (These listings were taken from the June 1973 CENTREX Green Sheets and are typical for the year). Each equipment section is described as follows.

	ITEM	COST	PERCENTAGE OF SERVICE CHARGE
a.	C4B	$400	4.0%
b.	PBX	$216	2.0%
c.	MISC	$574	5.0%
d.	STATIONS	$3,726	32.0%
e.	KEY SYSTEMS	$6,621	57.0%
	TOTALS	$11,537	100.0%

Table III. Equipment Service Charges for June 1973.

(1) Description of Service Charge

(a) C4B. This is a flat monthly rate applied to the first 100 primary lines installed on the CENTREX. Normally this rate is $900 (or $9/line) and thereafter $6.50 is charged for each additional line. However, due to the vast number of telephone changes occurring throughout the school organization over the period of years, tracking each of the original 100 for cost purposes proves more expensive than would be worthwhile. As a result, the C4B rate equates to some estimated percentage (estimate 44%) of the remaining original 100 lines.

(b) PBX. This charge is for the rental of the switchboard equipment and its accessories.

(c) MISC. These charges pertain to AUTOVON terminal equipment connected to the NPS Central Exchange and Switchboard. It also includes directory listings: 42 listings at 75¢ each.

(d) Lines. These charges are for those straight lines (in use) and instruments not associated with a key system but connected to the CENTREX.

(e) Key System. The key system charge represents the rental of telephone lines (in use), instruments and key accessories distributed over all key systems associated with NPS CENTREX system. This charge is not totaled by the TELCO on its Green Sheets. Each of the subtotals pertaining to each key system must be added in order to arrive at the total figure.

(2) Straight /Key System Lines. It is particularly noteworthy that key systems account for 57% of the total service charges (or 46% of the total CENTREX bill). Straight line charges account for 32% of service charges (or 29% of the total CENTREX bill). Since these two areas are the bulk of service charges, they are examined in further detail.

There are 444 straight lines connected to the CENTREX system, but not associated to a key system. Each station (includes one phone) rents for $6.50/month. The total approximate costs are: 444 × $6.50 = $2900/month. However, straight line (stations) costs listed in Table III are $3726. The difference represents the total cost of special features added to these 444 lines (i.e., data phone terminals, extension phones, etc.).

There are 328 lines connected to the CENTREX system but distributed over 82 key systems. Each line (includes one phone) rents for $6.50/month. The total approximate costs are: 328 × $6.50 = $2130. However, key system costs listed in Table III amount to $6621. The difference between these two figures is: $6621 - $2130 = $4491. This difference represents key system features such as six-button telephones, extension phones, intercom systems, assorted lights and buzzers, etc.

If all 772 lines currently in use were installed as straight lines, the cost would be approximately: 772 × $6.50 = $5018. A comparison of this

figure with the summation of straight line and key system costs is shown below:

$10,348	Sum of line and KTS costs
5,018	Zero features
$ 5,330/month	Total features cost

Line and key system charges can be compared on the basis of cost per telephone. There are 1192 telephones distributed throughout the CENTREX system. There are 510 telephones associated with straight lines and 682 telephones associated with key systems. The cost per telephone per month for each type is listed below:

Type	Phones	Charges	Cost/Phone/Month
Straight Lines	510	$3726	$7.30
Key System	682	$6621	$9.73

If all telephones utilized in the CENTREX system were installed as straight lines, the total cost would be $7,740. If this is subtracted from the sum of key system and straight line cost, the difference is $10,348 - $7,740 = $2,608. The value of $2,608 represents the true features costs. This means that $2,608 is spent on push-buttons, lights, buzzers, intercoms, etc. The $2,608 spent monthly for the features totals to an annual expense of $31,000. Further, it represents a need for value analysis of telephone features.

The cost of a basic line (and one telephone) is $6.50. This cost may increase by as much as $3.50 if

the line extends outside the main campus boundaries. Activities with lines located at the Annex and connected to the CENTREX are subject to a mileage fee of 70¢ per quarter mile. There are five quarter-mile units from the main campus boundary to the Annex, hence the additional charge of $3.50 per line. This additional charge per line is incurred by both straight and key system lines. For example, KTS #98 at the Environmental Prediction Research Facility (EPRF) has 23 lines. The total cost for the lines is $230 of which $80 (35%) is for mileage. Substitution of a key system with fewer lines but more extensions might reduce this cost dramatically.

There are 65 restricted lines (S3) dispersed among straight and key system lines. These lines are restricted in the sense that outgoing calls are limited to the local on-base four digit numbers, however, incoming calls may originate from AUTOVON, off-base or on-base.

In some geographical areas, there is a line which can be purchased that is completely restricted to local on-base four digit numbers (in/out, on-base only). The cost of this line is $3.00/month. If this line were available and all 65 restricted lines were converted to fully restricted status, the difference in cost would be:

Restricted S3	65 × 6.50 =	423
Fully-Restricted	65 × 3.00 =	195
		$228/month

This difference represents $2,700 annually in savings.

(3) Key System Features. Since key systems account for most of the "true features," some examination of what these features are and how they are distributed among the 82 key systems is necessary. Appendix C lists all key systems in being for the month of June 1973. There are 82 key systems, yet the numbering sequence is 1-99. Since the inception of this CENTREX in 1967, various key systems have been deleted, and those newly acquired were assigned the next consecutive number. The following are characteristics and features of key systems.

1. Type Line/Extension
   a. NRX1: Number of lines which are treated S1.
   b. NRX3: Number of lines treated S3.
   c. NRX4: Number of lines treated S4.
   d. EXT: Number of extension phones on key system.
2. Button-indicator Arrangement
   a. KX1: Single two-way button.
   b. KX2: Six-button - one hold feature, one intercom feature, four line buttons.
   c. KX3: Call Director - varies according to requirement (12, 18, 32 buttons).
   d. KRM: Lights for each line connected to the key system.
3. Intercom
   a. FJZ: Buzzer.
   b. DA9: Nine two-digit intercom stations.

c. DAD: Each additional two-digit station after the first nine.

4. Additional Items

a. Extra features - conference, computer buffer, bells, extension cords.

5. Cost

a. Total cost/month of the key system.

The cost of each key system varies according to its lines and features. Table IV illustrates where these cost features are distributed. Approximately 51% of the KTS cost involves lines and extensions and 49% is allocated to true features which make the key system operable (lights, buzzers, intercom, etc.). The lowest cost key system is KTS #3 costing $13/month and consisting of two lines only. The highest cost key system is KTS #80, costing $449/month and consisting of 23 lines, 17 extensions, and a host of other features. If key systems are grouped according to the number of lines, variations in cost persist. For example, there are 32 two-line key systems. The average cost for this grouping is $36/month, yet the range extends from a low of $13.00 to a high of $86.00. This fact alone demonstrates the irregularity and uniqueness of each key system and further limits generalization about them.

There are 604 telephones (89%) in the key systems which are six-button phones. Buttons used are one for "hold" functions, one for intercom function and four for line selection. One hundred twenty-eight telephones are

1. Total Key System Costs for Jun 73: $6,621
   (See Table III)

2. Distribution of Key System Costs:

   a. Lines & Extensions (51%)

      (1) 328 Lines @ $6.50 each $2,130

      (2) 354 Extensions @ 3.50 each 1,239

      Total Lines & Extensions ---------- $3,369

   b. True Features (49%)

      (1) 604 KX2 @ 2.20 each $1,329

      (2) 45 DA9 @ 7.75 each 326

      (3) 92 DAD @ 1.25 each 115

      (4) 328 KFM @ 2.60 each 852

      (5) 327 Mileage units @ .70 each 229

      (6) MISC (Bells, Buzzers, etc.) 401

      Total True Features ---------- $3,252

   c. Total Key System Costs for Jun 73 --------- $6,621

Table IV. Distribution of Key System Features Costs for June 1973.

connected to 32 two-line key systems. One hundred thirteen (88%) are six-button instruments. This suggests that excess capability is being provided.

b. Tolls

The TELCO toll statement lists the extension called from, the city called, and amount of the charge. The duration of call is not routinely provided but is available upon request from the TELCO. The month of May 1973 was available to the authors. Since only one month was analyzed, only general comments are made.

Table V groups all tolls made in May 1973 into those of less than three minutes duration, those between three and ten minutes, and those greater than ten minutes. In general, tolls exceeding ten minutes in duration accounted for only 14% of the total number of calls made but accounted for 59% of the total bill. Comparison with the same analysis made in NELC/TD 250 shows similar results. This would suggest that effort should be directed to reduction of the number of calls of greater than ten minute duration.

c. Installation/Connection Charges (OC/C)

The average monthly OC/C charge from January through September 1973 was $915. The range of the charge was from $122 to $2978. High OC/C for several months due to major department shifts resulted in the inflated average figure. The billing finance clerk indicated that a normal monthly charge for OC/C was approximately $250-300.

Time Period in Minutes	No. of Calls	Percentage of Total	Cost	Percentage of Total Cost
<3	794	46%	$495	16%
>3<10	691	40%	$780	25%
>10	228	14%	$1,837	59%
TOTALS	1713	100%	$3,112	100%

Table V. Distribution of Toll Calls by Duration and Cost for May 1973.

In general, the following actions account for OC/C: MOVE, INSTALL, CONNECT, REARRANGE and CHANGE. Work accomplished on a key system generally runs $20 higher than the same work accomplished on a straight line. For example, adding one extension to a straight line costs $10. It costs $30 when accomplished on a key system. The reason for the higher costs is the installation of a KX2 (six-button phone) most commonly used on key system lines but not on straight lines. In reviewing two months' data, cost of moving or changing within a key system was found to be twice that of moving or changing within the straight lines. The problem of collecting specific data on specific orders is extremely difficult since direct comparison between CSA's and their resulting charge on a monthly statement is not made.

2. Allocation of CENTREX Costs

The NPS CENTREX system is a telephone communication system superimposed on several organizations. The cost for the rental of this equipment and services is distributed among these organizations. The NPS Public Works Department is assigned the responsibility of allocating these costs among the various users as well as ensuring the system effectiveness. The cost for local management support is roughly $1873 monthly. It is desirable, therefore, that some means exist for re-couping a percentage of these management expenses.

OPNAVINST 2300.4A of 21 June 1956 states,

> "the prorata share of communication costs attributed to each activity will be based upon its percentage of total lines in use. Communication costs include salaries, supplies, materials, lease charges, maintenance and other items chargeable to the operation of the telephone exchange."

This instruction makes it clear, therefore, that the assignment of overhead charges based on the number of used lines as well as overhead charges for those lines treated for AUTOVON-access (S1) is an appropriate and a logical means for retrieving management costs.

The organizations or activities responsible for a share of overhead expense are called for accounting purposes "Reimbursables" and fall into four classes, two of which impact on how much is paid. These classes are defined as follows:

1. Activities supported by non-appropriated funds - i.e., Navy Exchange, Credit Union.
2. Activities supported by appropriated funds from other source budgets - i.e., LaMesa Housing, ROICC.
3. Tenant commands or activities sharing the same CENTREX system for economies of scale - i.e., Fleet Numerical Weather Central, Environmental Prediction Research Facility.
4. Activities with whom particular tenant-host agreements exist, affecting items 1, 2, or 3.

Table VI lists all reimbursable activities affected by these overhead charges and the overhead rates per line.

	Activity	Class	Overhead $Charge/Line	Overhead $Charge/AUTOVON
1.	La Mesa	2	$2.82	$2.00
2.	ROICC	2	2.82	2.00
3.	FNWC	3	2.82	2.00
4.	EPRF	3	2.82	2.00
5.	Dean/Research	4	0	0
6.	Comm Ctr.	4	0	0
7.	Welfare/Rec	1.4	2.82	0
8.	Shore Electronics	1	2.82	0
9.	Navy Exchange	1.4	3.50	0
10.	Com-Open	1	3.50	0
11.	Credit Union	1.4	3.50	0
12.	FNWC-Local	3.4	0	0
13.	Defense Intelligence	2.4	0	0
14.	Navy Mgt. Sys.	2.4	0	0

Table VI. Line and AUTOVON Overhead Charges to Reimbursable Activities for June 1973.

All tenant-host agreements are re-evaluated annually and telephone service charges and toll costs are specifically covered in the review. The Defense Intelligence Service (#13) and the Navy Management Systems Center (#14) are supported entirely by NPS through tenant-host agreements and are not charged the overhead expenses. Fleet Numerical Weather Central - Local (#12), (that portion of FNWC located on the main NPS campus) pays only for toll charges and specific data equipment by virtue of a tenant-host agreement. NPS pays for their lines and key systems.

For those activities charged overhead expenses, NPS maintains an equipment inventory (see Appendix F). This inventory lists the quantity of lines and features held by the activity. The unit charge for all lines (normally $6.50) is adjusted by the line overhead charge. For example, EPRF (#4) has 23 lines with a unit cost of $9.82 (vice $6.50). The inventory also lists other charges and credits (OC/C) occurring during the month. AUTOVON overhead charges compose the final entry in the inventory list. It is important to note that the total cost of the inventory listing contains line overhead, AUTOVON overhead, and appropriate OC/C. This total cost represents the total "Service" bill to the respective reimbursable activity for the month. To understand the implications of this procedures, it is important to briefly review the billing process:

1. Monthly statement is received by PWD accountant clerk.

2. Toll charges are distributed to responsible Departments and activities.
3. The monthly service charges are calculated for each reimbursable activity. These charges incorporate all overhead charges plus appropriate OC/C charges.
4. The monthly service charges for all reimbursable activities are added together forming one figure called "Service."
5. The monthly Service charges and OC/C as listed on the CENTREX statement are added together and called "Service."
6. Reimbursable service is subtracted from the CENTREX revised "Service" and the difference becomes the Service bill to NPS.

From a management viewpoint, some confusion exists over the term Service charges. The incorporation of line and overhead charges plus the addition of OC/C tends to dilute the true service charge expense. To TELCO, "service" means equipment. To Navy management, "service" means something else. It is recognized that overhead charges must be paid and that appropriate activities be held accountable for additional charges (OC/C), but combining all these charges into one Service charge decreases the visibility of true equipment expense.

Table VII illustrates the impact of combining these expenses. The data is arranged by activity and broken down as follows:

Charges During 1st Half FY-74

Activity	(A) TELCO Equipment Service Charges (True Equip Expense)	(B) OC/C	(C) Line Overhead	(D) AUTOVON Overhead	(E) Navy Management Service Charges	(F) % Increase to (A) Due to Addition of (B)+(C)+(D)	(G) % Increase to (A) Due to Addition of (D)+(E)
La Mesa	$495	$45	$68	$24	$632	28%	18%
ROICC	315	16	51	36	418	32%	28%
FNWC	5,621	800	677	222	7,320	30%	16%
EPRF	4,035	28	812	432	5,307	31%	31%
Naval Elect.	147	0	17	12	176	0	19%
Welfare/Rec	136	0	17	0	153	0	12%
Exchange	598	193	151	0	942	58%	25%
Com-Open	156	0	84	0	240	0	53%
Credit Union	457	0	63	0	520	0	13%
FNWC-Local	3,891	000	0	0	3,891	0	0
NPS (1)	50,620	2,275	0	0	52,895	4.5%	0
TOTALS:			$1,940	$726			

Note 1: Due to NPS billing procedure, all AUTOVON and line overhead charges (C+D) must be added to NPS TELCO charges (A) to accurately reflect NPS true equipment costs: $50,620 + $1,940 + $726 = $53,286.

Table VII. Percentage Effect on TELCO Service Charges Due to Inclusion of OC/C and Overhead Charges for First Half FY-74.

1. Navy management allocated "Service." (E)
2. OC/C (B)
3. Line overhead (C)
4. AUTOVON overhead (D)
5. Direct equipment (A)
6. Percentage difference between allocated Service cost and direct service cost less OC/C. (G)
7. Percentage difference between allocated Service cost and direct service cost including OC/C. (F)

The effect of combining overhead charges and OC/C charges can inflate the true equipment (service) charges by as much as 58%. The overhead charges by themselves add 19-30% to the true equipment charges. For example, the Navy Exchange had a six-month service charge of $942 as allocated by Navy management. If, however, the OC/C and overhead charges are subtracted, the $598 remaining is the actual true service charge for equipment on hand. It is not suggested that these charges should not be allocated to the reimbursable user but rather that it is important to give the user a clear picture of what he is paying for.

The impact of overhead charges viewed with basic line costs, particularly when mileage is involved, is noteworthy. The cost for a basic line and telephone treated for DDD/AUTOVON and located at the main campus is $6.50, whereas the basic cost for the same line at the annex is:

Basic cost	$6.50
Line overhead	2.82
Mileage	3.50
AUTOVON overhead	2.00
TOTAL	$14.82

This fact is dramatically illustrated when the line costs during a six month period for key system #98 (EPRF) are reviewed below:

22 lines @ 6.50 × 6	$858.00
22 lines × overhead @ 2.82 × 6	372.24
130 mileage units @ .70 × 6	462.00
36 AUTOVON lines × overhead @ 2.00 × 6	38.00
TOTAL line costs	$1730.24

The line overhead, mileage and AUTOVON overhead charges double the basic cost of the lines to the user. It is important that all activities be aware of these cost elements prior to contracting for additional services. Alternatives may exist which will satisfy the needs.

3. CENTREX Cost Trends

The total monthly CENTREX bill is affected by three main components: tolls, other charges and credits, and service charges. It is necessary, therefore, to examine these components over a period of time in order to visualize important trends in the CENTREX bill.

Table VIII presents a comparison of quarters one and two of Fiscal Year 1971 with the same period in Fiscal Year 1974. Tolls accounted for the largest percentage increase in

Item Description	1st Half FY-71	1st Half FY-74	Percentage Inc/Dec
Tolls	$ 9,235	$20,166	118%(+)
OC/C	$ 2,904	$ 3,357	15%(+)
Service	$60,801	$70,041	15%(+)
Total CENTREX Bill	$72,940	$93,568	27%(+)
Straight Line Costs	$18,901	$22,782	20%(+)
Key System Costs	$35,913	$40,114	11%(+)
Number of Lines	682	790	16%(+)
S1 - AUTOVON/DDD	166	354	117%(+)
S3 - On Base	62	65	-
S4 - DDD	451	368	15%(-)
Students	1800	1370	27%(-)

Table VIII. CENTREX Equipment/Cost Comparison Between First Half FY-71 and First Half FY-74.

the bill. Service charges and OC/C accounted for a small percentage of the increase. Since toll charges account for the largest increase throughout the period, they are discussed first.

a. Tolls

In Figure 5, total tolls are shown along with Reimbursable and NPS tolls. The total toll charges follow the same pattern as the NPS toll bill, and the NPS tolls likewise follow the pattern of the Academic Departments' tolls. The behavior of the reimbursable tolls is, however, marked by a steady upward increase. The distribution for the tolls charges during the fiscal period 1971 to 1974 is listed below:

Activity	Costs	Percentage of Total
Reimbursable Activities	$26,176	26.2%
NPS Main Station	$73,381	73.8%

In comparing quarters one and two of Fiscal 1971 with the same period in Fiscal 1974, the percentage increase between the two activities is listed below:

Activity	FY 71	FY 74	Percentage Change
Reimbursable	7,858	13,469	71% inc
NPS Main Stat	1,377	6,697	380% inc

From Table IX, important trends may be noted. Tolls are increasing at an increasing rate for NPS activities during the first and second quarters for each fiscal year. Tolls are increasing at a decreasing rate for quarters three and

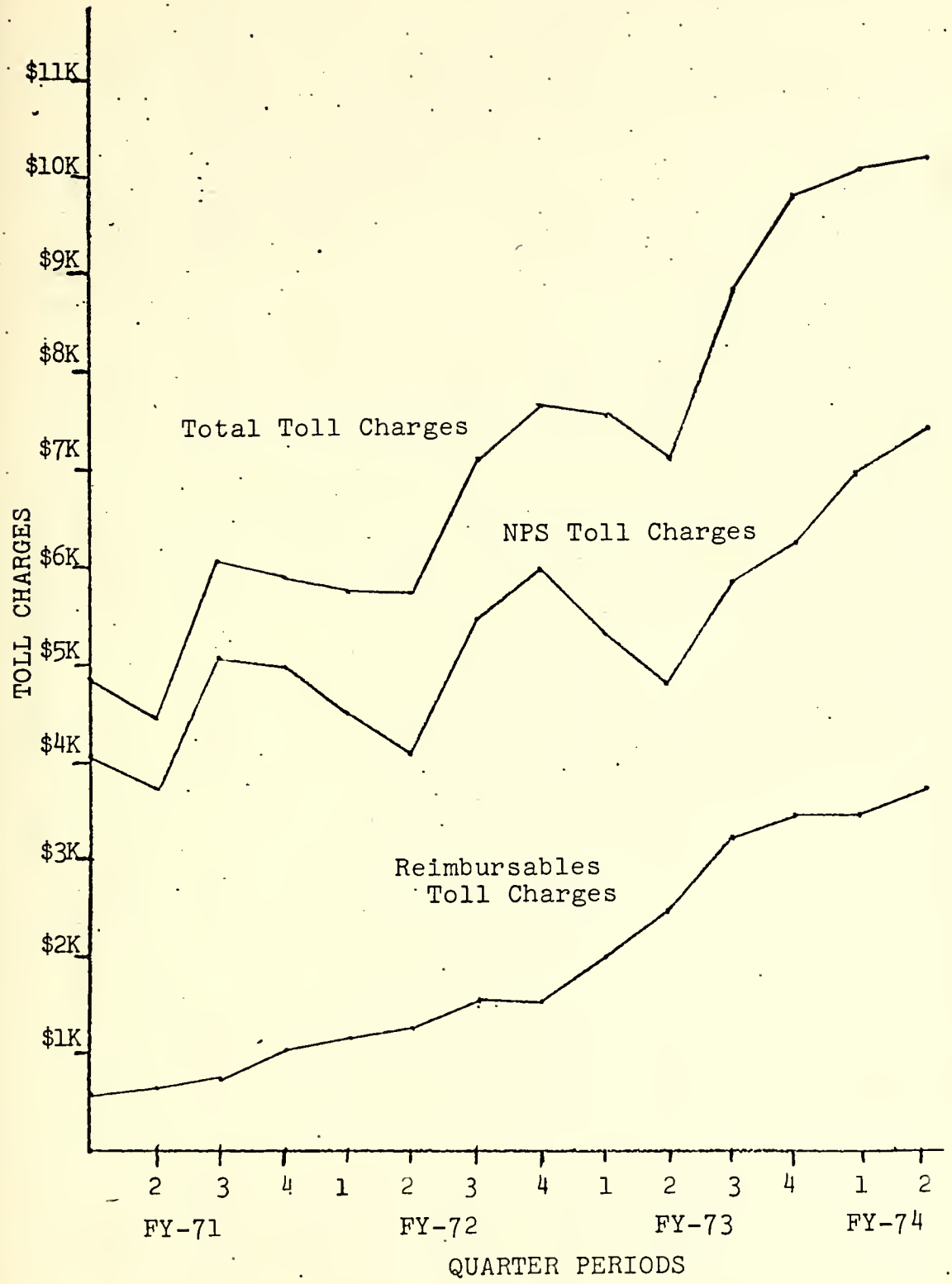


Figure 5. Toll Patterns for NPS and Reimbersable Activities During FY 71-74.

TOLL CHARGE COMPARISONS

	PERIOD	FY-71	PERCENTAGE CHANGE FY 71-72	FY-72	PERCENTAGE CHANGE FY 72-73	FY-73	PERCENTAGE CHANGE FY 73-74	FY-74
NPS	1st Half (Jul-Dec)	$7,858	8.3%	$8,508	19%	$10,174	32%	$13,469
NPS	Percentage Change (1st Half-2nd Half)	30%		34%		20%		
NPS	2nd Half (Jan-June)	$10,195	13%	$11,500	6.3%	$12,236		
REIMBURSABLE	1st Half (Jul-Dec)	$1,377	92%	$2,640	62%	$4,422	51%	$6,697
REIMBURSABLE	Percentage Change (1st Half-2nd Half)	27%		27%		36%		
REIMBURSABLE	2nd Half (Jan-June)	$1,746	96%	$3,371	79%	$6,023		

Table IX. NPS and Reimbursable Half Year Toll Comparisons for FY 71-74.

four for each fiscal year. Tolls, however, increase by approximately 30% between the first and second quarter and the third and fourth quarter for both NPS and reimbursable activities. Several possible explanations for such behavior are offered:

1. In considering a fiscal year period, tolls are higher in the second half of this year than in the first half. Since there is a tendency for government agencies to function at a reduced scale until fund obligation authority is received, increases in business activity occur when funds are allocated. This occurs in mid fall; hence, most agencies have only three to five months in which to commit funds. January through April is the time of maximum activity and this is reflected in the higher toll charges occurring during this period of the fiscal year.
2. Figure 5 illustrates toll charges decreasing each year at the end of Quarter Two. This might be construed as the Christmas syndrome. At this season, as the holidays occur much business activity is curtailed. Concurrent telephone activity decreases in a complimentary fashion.
3. The month of June represents the greatest push for completion of research projects, theses, etc. It is also the largest graduation period. It is plausible that these factors contribute to the increased tolls in the third and fourth quarters.

4. Transfers and retirements are most numerous in the third and fourth quarters. Personnel anxious to find out about their next duty station or their civilian prospects affect long distance usage during this period.

5. The right to work brings with it another expectation; the right to use the phone. This attitude may increase the toll charges. Further, the ease with which tolls may be placed in some departments encourages use beyond that really necessary.

b. Other Charges and Credits (OC/C)

Charges for OC/C remained relatively stable with minor exceptions. The average OC/C over the period from FY 1971 to FY 1974 was $600/month. It is important to mention, however, that a significant OC/C rate change occurred in August 1972. A comparison of equipment installation charges for July 1970 and July 1973 is listed below:

	Jul 70	Jul 73	Percentage Change
Line	$7.00	$10.00	42%
Extension	9.00	10.00	11%
KX2	15.00	20.00	33%
DA9	30.00	45.00	50%
	$61.00	$85.00	34%

There was a 39% increase in installation charge for a line with an extension, a KX2 (six-button phone) and a DA9 (dial intercom). This rate charge would have some

effect on cost comparison of all OC/C over the fiscal years cited, however, identifying the particular types of actions performed (i.e., installations, connections, relocations) is a formidable task, beyond the scope of this thesis.

c. Service Charges

Service charge has the lowest rate of growth of all elements of the CENTREX bill. Table VIII shows a 15% increase over the fiscal period which is considered appropriate in view of the 16% increase in the number of lines. There were, however, several rate changes which also affected the 15% growth pattern and it is necessary to describe them in terms of equipment affected.

	Jul 70	Jun 73	Percentage
Switchboard	150.00	195.00	30%
Lines	5.75	6.50	10%
Extensions	3.25	3.50	
Mileage	.60	.70	3%
KX2	2.00	2.20	
KFM	2.50	2.60	
DA9	7.75	7.25	
DAD	1.00	1.25	

For lines and extensions, the rate increase was roughly 10% and for key system features it was only 3%. The components of some charges, their percentage of the total service, and the resulting rate effect are:

Components	Percentage of Service	Rate Change	Rate Effect
PBX	2%	.30%	.006
Lines	76%	.77%	.077
Features	22%	.23%	.007
			.09 = 9%

The total effect of rate increases on the total service charges was 9%. In effect, therefore, only a 6% increase in equipment provided occurred over fiscal 1971 to 1974.

V. REQUIREMENTS DETERMINATION AND SATISFACTION

A. DETERMINATION OF REQUIREMENTS

It is the objective of any telephone system to satisfy user requirements. Obviously, determination of those requirements is one of the most important steps in planning a telephone system. However, most systems of concern are already installed and in operation before the management becomes aware of their costs. In addition, the lack of knowledgeable personnel places any organization in a tenuous position when dealing with the marketing personnel of the local telephone company. Thus, inevitably, a system is installed and in operation with new gadgets added and complex features interwoven. When commencing a review a manager must be aware of those needs for communication and methods for their determination in order to evaluate their satisfaction in a cost-effective manner.

The requirements for any telephone system may be broken into the following hierarchical categories:

1. Mandatory - those necessary for the accomplishment of a given task.
2. Convenience - those which ease or facilitate job accomplishment.
3. Prestige - those which contribute to user ego satisfaction.

The priority for satisfaction follows basically the same order, although some overlapping does occur among all three.

The scope of telephone communications requirements covers four broad questions:

1. Who does the user call?
2. How will he make his call?
3. Who calls the user?
4. How does he answer his calls?

The answers to these must be made in terms of the three categories noted. In practical terms, the manager must be able to differentiate among basic service, extra features, and local/long distance service. Basic service is the provision of a telephone to one or more users in a specific location. Extra features are those additions or arrangements which modify the basic service to increase its utility, convenience or prestige. Features such as key systems, extension telephones, dial intercoms, and answering service may serve to increase the user's convenience or prestige. The characteristics of long distance service which also affect requirements are number and frequency of outgoing calls, destination, average and peak duration per call.

This section concentrates on methods for evaluating a system which is installed and in operation. The NPS CENTREX is used as the example, and selected organizations and departments are analyzed for their cost-effectiveness.

B. DETERMINATION METHODS

1. Equipment Requirements

It is imperative that a complete equipment inventory be taken before any evaluation technique is initiated. This is accomplished by reviewing the TELCO "Green Sheets" (Appendix E). This form is provided with the monthly bill and lists all equipment, features and lines for which the TELCO is charging. When dealing with key systems, the TELCO will provide, upon request, key system worksheets (example Appendix G) for each key system. These worksheets illustrate for each key system the line composition, features attached, arrangement of telephones to lines and the telephone location. They are also used by the salesman and the installer in accounting for key system composition.

With the foregoing information, a physical inventory can be properly conducted. The results of this inventory will be a reference base from which to evaluate and also a potential source of service charge rebate. For those items being billed but not physically present, rebate is made for overcharges as far back in time as they can be identified. For those items located but not billed, the TELCO collects only the undercharge for two months past.

Three statistical tools were developed to measure cost effectiveness in the NPS CENTREX. They are defined thus:

a. Cost/Telephone/Month (CTM)

This is the total service charge per month allocated to a particular department for all telephone service (straight lines, key systems, etc.) divided by the total number of telephones in use in the department. A CTM was also computed for each individual key system.

b. Key System Premium Ratio (KSPR)

This is the difference between the monthly key system cost and the cost of the basic line charges for the number of telephones in the system, divided by the latter. For example: key system #21 has a monthly service charge of $141.00 and contains twelve telephones.

$$\frac{\$141 - (\$6.50 \times 12)}{(\$6.50 \times 12)} = \frac{141 - 78}{78} = .81$$

c. Line Access Cost Ratio (LACR)

This ratio is derived from the key system worksheet. It is the cost of the effective telephones minus the actual key system cost divided by the latter. The cost of effective telephones is the basic line charge ($6.50) multiplied by the number of individual telephones which would be required to provide the same line access as that available in the key system configuration. For example: key system #47 has three telephones which have access to three lines each. Therefore this key system is equivalent to nine effective telephones.

$$\frac{(\$6.50 \times 9) - \$34}{\$34} = \frac{24}{34} = .71$$

If these values are computed for all departments and key systems and ranked in numerical order, the highs and lows, as appropriate, provide an indicator for system evaluation. It must be noted that these numbers make up only an ordinal scale. They are not absolute values of anything. All these tools should be computed because some systems will be notable in only one of the measurements.

The ten greatest variants from the norm in each of the measurements are tabulated in Tables X , XI and XII. Ten was arbitrarily selected as the evaluation quantity solely for ease of handling and presentation. The depth to which comparison is made in practice would be a function of the time, personnel and funding available. For each measure, the other two are included for reference. These values provide a starting point in isolating departments or key systems where improvement effort may be most fruitful.

If the CTM and KSPR of a system are high, excessive features are indicated. If the LACR is low, this indicates that the arrangement of lines and telephones needs study. Sample evaluations of Tables X ,XI and XII follow.(Note: Missing LACR values are due to unavailability of applicable worksheets.)

Table X shows that key system #98 (EPRF) has a high CTM, approximately $7 above the norm. In addition it has a high KSPR and a very low LACR. Conversely, KTS #31 (Naval Engineering Curricular Office) has a high CTM ($13.10) and high KSPR (150); however, it has an excellent LACR of

COST/TELEPHONE/MONTH
(CTM)

DEPT/ACTIVITY	KTS #	CTM	KSPR	LACR
1st LT/Security	#26	$17.70	84	UNK
EPRF	#98	$16.53	150	-35
Computer Ctr.	#62	$13.70	110	41
Medical	#69	$13.23	110	23
Naval Engr	#31	$13.10	100	109
FNWC	#52	$12.86	98	112
1st LT/Security	AVG	$12.80	-	-
Dean of Research	#24	$12.16	90	40
BOQ	#91	$11.90	77	8.3
Legal	# 8	$11.90	77	9
Average		$ 9.50	53	74

Table X. Cost/Telephone/Month (CTM); Ten Highest Values for December 1973.

KEY SYSTEM PREMIUM RATIO
(KSPR)

DEPT/ACTIVITY	KTS #	KSPR	CTM	LACR
EPRF	#98	150	$16.53	-35
Med	#69	110	$13.23	23
Computer Ctr	#62	108	$13.70	41
Naval Engr	#31	100	$13.10	109
FNWC	#52	98	$12.86	112
Dean of Research	#24	90	$12.16	40
Bacc	#11	89	$11.60	120
1st LT/Security	#21	87	$11.70	UNK
FNWC	#16	85	$11.85	8
1st LT/Security	#26	83	$17.70	UNK
Average		53	$ 9.50	74

Table XI. Key System Premium Ratio (KSPR); Ten Highest Values for December 1973.

LINE ACESS COST RATIO (LACR)

	DEPT/ACTIVITY	KTS #	LACR	CTM	KSPR
TEN LOWEST	EPRF	#98	-35	$16.53	150
	BOQ	#91	8	$11.90	77
	Legal	# 8	9	$11.90	77
	FNWC	#16	10	$11.85	85
	PAO	#36	13	$11.30	68
	Elect. Engr.	#67	14	$ 8.65	47
	Physics-Chem.	#97	15	$ 5.60	-14
	Library	#41	18	$ 9.00	40
	Comm. Ctr	# 7	18	$ 9.18	42
	Dean of Cur.	#22	22	$10.73	68
	Medical	#69	23	$13.23	110
	Average		74	$ 9.50	53
TEN HIGHEST	Credit Union	#70	224	$ 7.50	17
	Meteorology	#66	220	$ 7.96	23
	Supply	#35	212	$10.00	27
	OR/AS	#50	210	$ 8.20	27
	PWD	# 4	204	$10.37	58
	Mil-Pers	#15	185	$ 7.70	18
	Av. Safety	#82	157	$10.00	57
	Govt Hum.	#18	157	$ 8.10	24
	Oceanography	#32	157	$ 8.20	22
	Civ-Pers	#33	140	$ 8.10	23

Table XII. Line Access Cost Ratio (LACR); Ten Lowest/ Highest Values for December 1973.

109. From this it may be concluded that a high price is being paid for excess equipment in KTS #98 and that the physical arrangement of that equipment is less than desirable. Conversely, the higher costs of KTS #31 are reflected in higher line utilization.

A review of the ten highest KSPRs, listed in Table XI, reveals the addition of KTS #11 and KTS #16, which might have otherwise been omitted from consideration if CTM were the sole criterion. In KTS #11 and #16 there exists a similarity of CTM and KSPR, yet there is a wide difference in line access, KTS #11 with 120 and #16 with only eight. The fact that KTS #16 is a likely candidate for improvement is obvious from this table but it could otherwise have gone unnoticed.

Table XII lists key systems by Line Access Cost Ratio. When using this technique, both the high and low values should be evaluated. Low values are the result of poor line arrangement whereas high values may indicate over-utilization and suggest a need for more service. For example: KTS #41 has an average CTM and is below the norm in KSPR, however, its line utilization is poor. This in itself demonstrates the need for evaluation by Line Access Cost Ratio. On the other hand, the Credit Union, with a high CTM and KSPR has in fact the highest recorded LACR (224). This extremely high value not only represents outstanding arrangement of lines and phones for cost reduction, but suggests that additional lines may be desirable for adequate service.

It is essential to point out that these statistical methods cannot be used by themselves in evaluation of cost-effectiveness. The unique nature of each department, its functions, personnel composition and office layout may in fact be a cause for a low statistical evaluation. It is necessary, therefore, that those systems which are flagged by statistical analysis be studied individually as well. This may be accomplished by personal interviews within the flagged department. As an example, during one department interview it was noted that, although costs were high, a great deal of personal concern for the work of each member was evident. The morale detected was a result, to large extent, of the telephone arrangement. The logical alternative was installation of all straight lines with a potential monthly savings of $30. The existing system is composed of four lines and twenty telephones, each connected to all four lines. Two secretaries answer the phones, call desired recipients, take messages for absentees, etc. The cost for this receptionist/operator service was calculated thus:

$$22 \text{ day work month} \times \frac{1 \text{ hr}}{\text{day}} \text{ telephone duty} \times \frac{\$3.60}{\text{hour}} \text{ salary}$$

$$= \$79.$$

The question the department head and telephone manager need to face jointly is whether the savings of $109 per month is worth the probable loss of personnel spirit and thus efficiency. Is modification or compromise possible?

In summary, the subjective method relates the statistical techniques to the real, personal, and practical office or department requirements. Both are absolutely necessary in determination of true cost-effectiveness and optimum requirement satisfaction.

2. Long-Distance Requirements

After completing an equipment evaluation of all departments, it is necessary to evaluate the utilization of local/long distance calls. Since the NPS CENTREX system is not concerned with message units, local calls can be deleted from this analysis. The real problem rests with the utilization of AUTOVON versus the use of commercial toll calls.

The scope of this thesis does not include AUTOVON usage although the recent NELC/TD250 document indicates that the average cost per telephone call on AUTOVON circuits is 27¢. In addition, it was impossible to analyze the commercial calls made to and from the NPS system since mechanical counters were not available. The only available information was a cost breakdown of toll charges by department.

Table XIII shows the cost of toll charges incurred by each organization during fiscal year 1972 to 1974. Percentage breakdowns are also given. From the table it can be seen that the academic departments account for 53% of the total toll charges incurred in that period. The department of Operations Research and Administrative Sciences was responsible for 35% of the academic departments' tolls. Reimbursable activities accounted for 29.4% of the total toll

ORGANIZATIONAL CATEGORY	FY 72-74 TOLLS	PERCENTAGE OF TOTAL	INDIVIDUAL DEPARTMENT(1)	FY 72-74 TOLLS	PERCENTAGE OF ORG (1)
Reimbursable Activities	$23,053	29.4%	FNWC	$10,404	45%
			EPRF	$ 6,408	28%
			Exchange	$ 2,618	11%
Staff	$ 1,903	2.4%	Civ-Pers	$508	27%
			Superintendent	$385	20%
			Dean of Rsh	$244	13%
Programs	$ 3,376	4.2%	EMD	$1,338	40%
			Computer Ctr	$1,250	37%
Operations/ Logistics	$ 6,675	8.5%	Supply	$3,120	46.5%
			PWD	$1,184	17%
			Welfare/Rec	$ 580	8.7%
Academic Dept	$41,869	54.6%	OR/AS	$14,992	35%
			Phy-Chem	$ 6,958	15%
			Elect-Engr	$ 6,119	14%
			AERO	$ 4,489	10%
Curricula Programs	$ 1,505	1.9%	Nav. Mgt Sys	$481	32%
			Env. Sci.	$352	23%
			AERO	$253	17%
TOTAL	$78,381	100 %			

Note (1): Only those departments with significant percentage of organization toll charges are listed.

Table XIII. Toll Charge Distribution Among Organizations/Individual Departments for FY-72 Through December 1974.

charges during the fiscal 1971 to 1974 period. Within these activities, FNWC accounted for 45% and EPRF accounted for 28%. The analysis of toll charges has many limitations, however, it does reflect the high cost users and, therefore, points to a direction in which to proceed.

It is noteworthy to mention the management term "control." During fiscal period 1971 to 1972, the Educational Media Department carried a significant toll charge in relation to its size and function. In the first half of FY 73, the chairman issued a notice that stated plainly that the telephone was not for personal business and that all toll charges required his approval. As a result of this action, the toll expense for succeeding quarters was reduced considerably as indicated below:

Fiscal Year 1972		Fiscal Year 1973		Fiscal Year 1974
1st Half	2nd Half	1st Half	2nd Half	1st Half
$267	$390	$437	$140	$60

In addition to identifying the high cost users of commercial long-distance calls, it is also important to determine the optimal means for communication outside the local area. The choices available are: Direct Distance Dialing (DDD); Wide Area Telephone Service (WATS), with which a customer can make unlimited calls to any telephone within a designated area by paying a fixed monthly cost, Foreign Exchange (FX), which is connection to nearby but non-local areas; and private tie lines which can be leased singly or in groups. Selection can be best accomplished

by traffic analysis. One tool for this is a computer printout of calling patterns (see Appendix H) which can be obtained on request from TELCO. This pattern reveals the numbers called, location, number of calls, duration, and the amount expended. Such actual analysis is beyond the scope of this thesis.

VI. CONCLUSIONS

Any Navy administrative telephone system of equipment and services, whether that of an individual command or activity or the collective grouping of all such facilities throughout the Department of the Navy is so complex that effective management as a simple utility is not possible. The overall telephone management in the Navy is not integrated or coordinated. Excessive fragmentation and duplication of responsibility and authority exist between the command chain and the business administration chain. Although administration telephone service should be an integral portion of the overall naval communications complex, there is no master plan for its development, utilization, or control. Detailed knowledge of telephone facilities, and more especially of tariff intricacies, is lacking. In no other military-industrial relationship is so much dependence placed upon the commercial vendors' dictation. Data analysis, from which to project needs for both service and finances, is not utilized. The overall system does work, satisfactorily and effectively, but not efficiently. Improvement is needed to maximize service and minimize cost; i.e., optimize cost-effectiveness.

All of the foregoing broad conclusions, related to the macro-management of the Navy system as a whole are also likewise carried downward to the local level. There is no

NPS master telephone plan. Needs are faced and satisfaction attempted on an "as requested" basis. Each component of the organization arranges its service as it desires, without control or guidance. Because of this, there is a wide disparity among departments' facilities. There is no systematic analysis of utilization or costs. No one is truly aware of what exists, where the costs are, or what alternatives are possible. Financial and clerical administration, while effective, is cumbersome and does not fully exploit its potential as a management tool.

The following specific findings contribute to the preceeding general ones, and are considered noteworthy:

1. Service (equipment) charge is the largest portion (40%) of total telephone costs, and key system equipment, at 23% of total, is the largest contribut or to that cost. Service charge increases with time are due more to TELCO rate increases than to increases in the amount or character of services. Telephone lines installed at the Annex, one and one-quarter miles distant from the main campus, on the average cost double those in use at main campus locations.
2. Installation and relocation (OC/C) is a significant portion of overall cost. Awareness of the different particular charges is necessary for efficient installation planning.
3. Toll charges are increasing with time at an increasing rate but it is not known whether this increase

is the result of tariff increases or usage increases. The academic departments are the overwhelmingly largest toll long distance users. Information sufficient for individual departments or tenant commands to identify and analyze the segment of tolls for which they are responsible is not extracted, systematized or made available, although requisite raw data does exist.

4. AUTOVON usage guidelines and access criteria do not exist. An arbitrary numerical allocation percentage based on the number of installed lines is not realistic or responsive to varying requirements.
5. The present manual billing process is executed in a devoted manner but is awkward in this modern data processing era.

VII. RECOMMENDATIONS

A. NATIONAL GENERAL

In order to optimize cost-effectiveness of Navy telephone service the greatest need is for a master plan. This should define the objectives of administrative telephone service and its position as one element of the overall naval telecommunications scheme. It should provide standards of service and the means for attainment of the goals established. General areas such a plan should address include:

1. the organization of management: Detailed recommendations are beyond the scope of this thesis, however, it is noted that telephone management at all levels needs greater coordination and compartmentation to avoid duplication of effort and ensure commonality of direction.
2. identification of analytical effort: This includes formulation of meaningful analytical tools and guidance for their use.
3. education and training: Personnel involved in all aspects of telephone management need broader and deeper knowledge of the system. Efforts should be made to acquire personnel with telephone management experience and to provide initial and continuing training for others. Provision should also be made

for use of the expertise available from commercial communications consultants.

B. LOCAL GENERAL

The single most powerful aid for NPS would be the assignment of a knowledgeable, single-point authoritative telephone coordinator. As a corollary, a plan is needed for inventory of equipment and analysis of cost and utilization data on a continuing basis. Further education is essential in two areas:

1. Management personnel need to be made aware and kept aware of service options available and their applicable tariffs.
2. Users need to be informed of what they are using and what they are paying for it. This applies to both equipment and tolls.

C. LOCAL SPECIFIC

The following actions may be performed locally within the present organizational framework:

1. Automate toll allocation and reimbursable billing. The raw data necessary for this is already available in essentially required form. While appreciable development in organization and programming of this data is called for, the potential benefits are high. Such a program should provide:

   a. simplified toll allocation,

b. visible overhead identification and allocation,

c. demonstration of individual activities' service and costs,

d. identification of high-volume, long-duration toll users.

2. Analyze current utility versus cost. The coordinator should study those activities and key systems "flagged" through statistical measurement to determine possibilities for potential improvement.

3. Conduct a physical equipment inventory and compare it with the Green Sheets and key system worksheets.

4. Activities require strict accountability and justification for toll calls of their members. Particular attention should be given and control exercised over those calls of greater than ten minutes duration.

5. Review "general use" and dedicated lines to ascertain their necessity. This is a high cost service for which alternatives may be available.

6. Minimize equipment changes and relocations. Advance planning can allow consolidation of orders, elimination of short-term moves and thus reduced OC/C.

APPENDIX A

Glossary

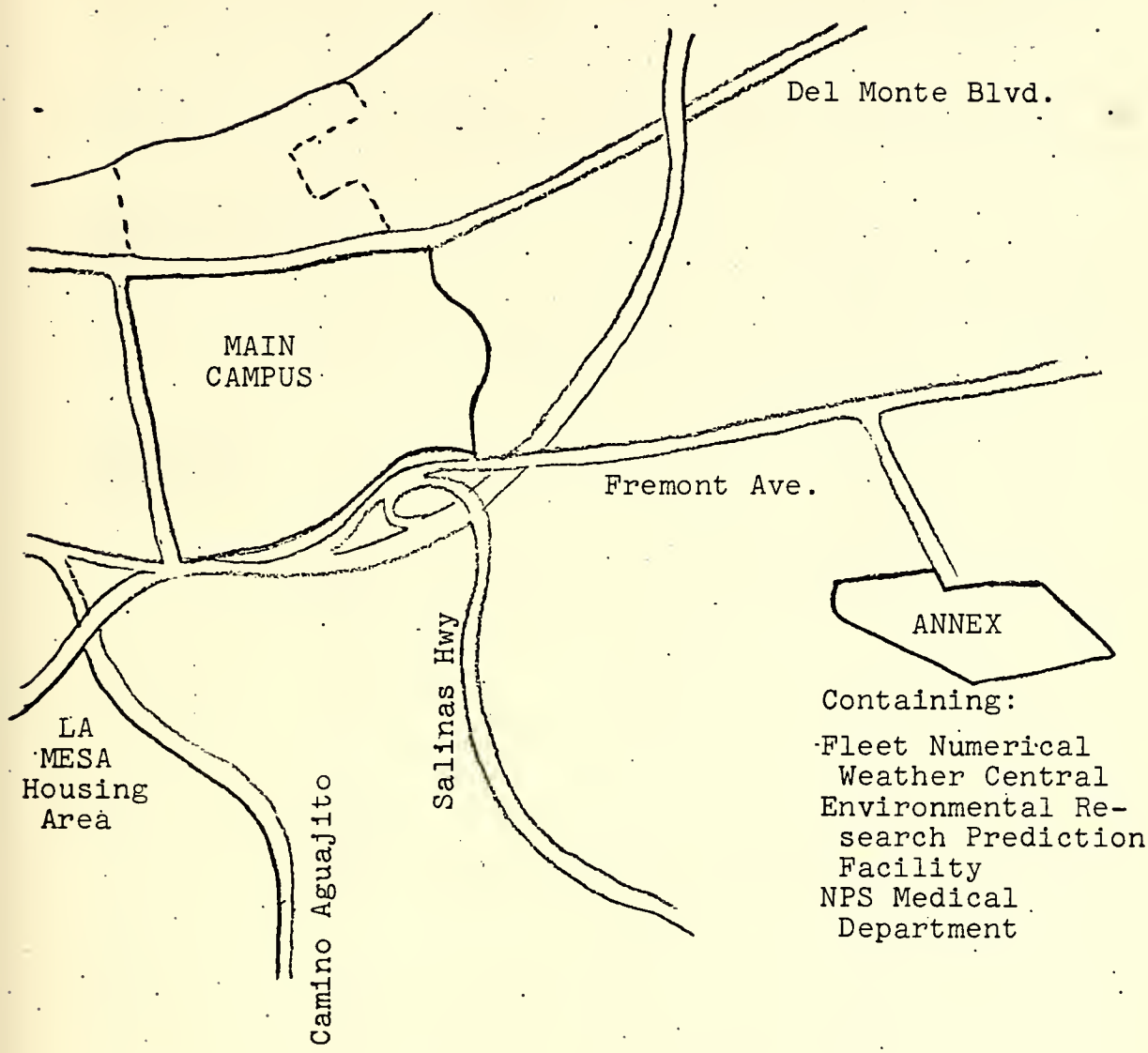
Central Exchange (CENTREX)	a system providing switching equipment separate from that at a central office for all telephones in a particular building, military base or other area.
Central Office	a telephone company building housing mechanical equipment to connect one telephone to another.
Central Office line	a pair of wires from a Central Office to a telephone.
extension	an additional telephone connected to a common telephone number or line.
Green Sheets	the telephone company monthly listing of all equipment for which a particular CENTREX is being charged.
key system	a group of key telephones interconnected by one or more lines.
key telephone	a telephone with external push buttons.
KTS	key telephone service or key system.
Private Branch Exchange (PBX)	the switching equipment of a CENTREX system.
TELCO	an individual Bell System telephone company. In this thesis, refers to The Pacific Telephone and Telegraph Company.
treatment	the dialing ability of a line or the restriction imposed on the dialing potential of a line.
trunk	a Central Office line between a Central Office and a CENTREX switchboard.

Uniform Service Order Code (USOC) — a computer code used by all Bell System companies to identify various items of service or equipment. All codes are either three or five characters in length. Commonly used USOC's in this thesis are:

DA9	dial intercom (first nine stations)
DAD	each additional dial intercom station over nine
EXT	extension telephone
KFM	light indicators for each line on button telephones
KX1	one-button telephone
KX2	six-button telephone
KX3	twelve, eighteen or thirty-button Call Director telephone
NRX	line access or treatment: NRX1 unrestricted NRX3 intra-CENTREX only NRX4 no AUTOVON access
RXR	basic CENTREX line
ILVBY	mileage charge for off-premises service

APPENDIX B

Map of NPS and Annex Grounds



APPENDIX C

Master Equipment Inventory by Organization/Department

Department	KTS or ST.*	Lines	Phones	KX2	DA9 DAD	CTM	KSPR	LACR	COST $
SUPERINTENDENT									
Aide	#21	8	12	12	1	11.70	80	X	141
	ST.	6	6			6.50	-	-	39
	TOT	14	18	12	1	10.00	-	-	180
Comptroller/ Disbursing	#14	3	8	8	1	9.20	40	X	73
	#47	3	3	3		11.30	78	71	34
	# 2	2	7	7	1	8.33	28	57	58
	#96	2	2	6	1	8.77	32	47	53
	TOT	10	24	24	3	9.10	-	-	218
Civ-Pers	#33	3	10	10	1	8.10	23	140	81
PAO	#55	3	5	5	1	10.51	62	83	53
	#36	2	2	2		11.30	68	13	23
	TOT	5	7	7	1	10.73	-	-	76
Provost	#59	2	3	3		9.56	46	X	29
	ST.	1	1			6.50	-	-	7
	TOT	3	4	3		8.30	-	-	36
Dean of Curricula	#22	2	3	3		10.73	67	22	32
	#40	2	3	3		9.43	47	39	28
	ST.	1	2			5.00	-	-	10
	TOT	5	8	6		8.81	-	-	70

* Straight Line

Department	KTS or ST.	Lines	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
Dean of Research	#24	3	3	3			12.16	90	40	37
	#45	3	6				8.66	30	120	52
	ST.	1	1				6.50	-	-	7
	TOT	7	10	3			9.48	-	-	96
Safety-Office	ST.	1	2				5.00	-	-	10
TOTALS		49	85				9.20	-		775
PROGRAMS										
Director/Plans	#54	5	8	7	1		10.40	59	X	83
	ST.	1	2				5.00	-	-	10
	TOT	6	10	7	1		9.29	-	-	93
Dpty Director	#53	3	6	6	1		9.70	48	101	58
Aviation-Safety	#82	4	13	13	1	11	10.00	56	157	132
Library	#41	16	27	17	1	4	9.00	40	18	246
	ST.	2	2				6.50	-	-	13
	TOT	18	29	17	1	4	8.90	-	-	259
Machine Fac.	ST.	1	2				5.00	-	-	10
EMD	#20	5	12	7	1		9.20	48	82	117
	ST.	4	6				5.50	-	-	33
	TOT	9	18	7	1		8.30	-	-	150
Computer Center	#62	3	3	3	1		13.70	105	41	41
	ST.	28	34				5.90	-	-	203
	TOT	31	37	3	1		6.60	-	-	244
TOTALS		72	113				8.90	-	-	945

Department	KTS or ST.	Lines	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
MIL. OPS & LOGISTICS										
Legal	# 8	2	2	2			11.90	77	8	24
Dir/Admin	ST.	5	6				11.00	-	-	66
Mil-Pers	#15	4	15	15	1	1	7.70	18	185	116
	ST.	2	5				4.70	-	-	24
	TOT	6	20	15	1	1	7.00	-	-	140
Admin-Services	#63	2	5	5			8.20	27	58	41
	ST.	2	3				5.50	-	-	17
	TOT	4	8	5			6.50	-	-	58
1st LT/ Security	#12	4	11	8	1		14.50	39	50	103
	#26	3	3	2			17.70	84	X	35
	#27	2	3	3			9.80	51	X	30
	#21	8	12	12	1		11.70	87	X	141
	ST.	4	6				6.50	-	-	39
	TOT	21	30				12.80	-	-	348
BOQ/Closed Mess	#91	2	2	2			11.90	76	8	24
	ST.	6	7				6.25	-	-	43
	TOT	8	9	2			7.35	-	-	67
Recreation	#61	2	5	5			9.24	44	41	46
	ST.	10	14				6.73	-	-	94
	TOT	12	19	5			7.41	-	-	140

Department	KTS or ST.	Lines	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
Public Works	# 4	5	6	6			10.37	58	204	62
	#60	3	5	5			9.35	46	106	47
	#81	11	22	22	1	2	9.22	41	81	203
	ST.	12	12				6.50	-	-	78
	TOT	31	45	33	1	2	8.67	-	-	390
Supply	# 1	8	12	11	1	1	10.00	52	112	120
	#17	2	4	4	1		10.31	57	27	41
	#35	4	12	12	1	1	8.20	28	212	99
	ST.	3	4				5.77	-	-	23
	TOT	17	32				9.35	-	-	283
Communications	# 7	2	3	2			9.18	42	18	28
Medical	#69	6	9	8	1		13.23	104	23	119
	#68	6	16	16	2		10.03	55	97	161
	ST.	3	3				6.50	-	-	20
	TOT	15	28	24	3		11.66	-	-	300
Dental	#72	2	7	7	1		8.60	32	52	60
Chaplain	#10	3	5	5	1		11.91	82	X	60
	ST.	6	9				5.76	-	-	83
	TOT	9	14	5	1		9.19	-	-	143
TOTALS		85	140				9.27	-	-	1283
ACADEMIC DEPT										
Meteorology	#66	4	20	20	1	11	7.96	21	220	159
	ST.	3	5				5.31	-	-	27
	TOT	7	25	20	1	2	7.43	-	-	186

Department	KTS or ST.	Lines	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
Elect. Engr.	#37	13	24	19	1	7	9.07	28	39	218
	#67	2	3	2			8.65	48	14	29
	#28	4	6	1			7.75	15	26	46
	ST.	48	48				6.50	-	-	312
	TOT	67	81				7.50	-	-	604
Mathematics	#39	3	5	5			10.38	48	50	52
	ST.	43	43				6.52	-	-	280
	TOT	46	48	5			6.92	-	-	332
OR/AS	#50	4	12	12	1		8.20	27	210	99
	#25	2	2				7.40	1	73	15
	ST.	80	80				6.50	-	-	520
	TOT	86	94	12	1		6.73	-	-	634
Government-Hum	#18	4	16	16	1	7	8.10	24	157	130
Aero-Engr	#56	6	9	9	1		10.45	59	95	92
	ST.	34	34				6.52	-	-	221
	TOT	40	43	9	1		7.28	-	-	313
Oceanography	#32	5	22	21	1	10	8.20	20	155	172
	ST.	7	9				5.84	-	-	53
	TOT	12	31	21	1	10	7.52	-	-	225
Mech-Engr	#44	3	12	12	1	2	8.40	29	117	101
	ST.	13	13				6.50	-	-	85
	TOT	16	25	12	1	2	7.40	-	-	186
Physics-Chemistry	#73	4	4	4			11.30	71	70	46
	# 5	4	13	12	1	2	8.25	45	56	108
	#97	3	6				5.60	-14	15	34

Department	KTS or ST.	Lines	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
Physics-Chemistry, cont.	ST.	42	42				6.50	-	-	274
	TOT	53	65	16	1	2	7.10	-	-	460
ASW	#38	2	3	3			10.30	59	26	31
Navy Mang. Systems Ctr.	#48	4	23	20	1	11	7.70	18	85	178
	ST.	2	3				5.50	-	-	17
	TOT	6	26	20	1	11	7.45	-	-	194
Compt-Sci Gp	#28	4	6	1			7.60	15	X	46
	ST.	8	8				6.50	-	-	52
	TOT	12	14	1			6.95	-	-	98
TOTALS		89	133				7.33	-		969
CIRRICULA OFFICES										
Ops-Anal	#93	2	6	6	1		8.80	32	47	53
Aero-Engr	#56	6	9	9	1		10.22	58	97	92
	ST.	2	2				6.50	-	-	13
	TOT	8	11	9	1		9.58	-	-	105
Comm-Elex	#42	2	5	5			9.00	37	43	45
Ord-Engr	#43	2	5	5			8.44	31	X	42
Naval-Engr	#31	4	4	4	1		13.10	100	109	52
Environmental Sci	#34	2	4	4			9.47	31	37	38
Mang/Compt. Sci	#29	2	5	5	1		9.41	42	38	47

Department	KTS or ST.	Line	Phones	KX2	DA9	DAD	CTM	KSPR	LACR	COST $
Baccalaureate	#11	4	5	5	1		11.60	90	120	58
	ST.	1	1				6.50	-	-	7
	TOT	5	6	5	1		9.77	-	-	65
TOTALS		27	46				9.72	-	-	447
Fleet Numerical Weather Central	#80	23	40	37	2	13	11.22	73	X	449
	#79	6	17	17	1	8	9.92	52	38	169
	#94	10	34	30	2	15	9.36	44	X	320
	#52	5	10	8	1		12.86	98	112	129
	#19	2	4				6.08	-4	112	24
	#16	2	3	2	1		11.85	85	8	36
	#30	4	8	8	1		11.15	72	20	89
	#65	4	8	8	1		11.21	72	81	90
	# 9	2	4	4			8.50	30	53	34
	ST.	22	24				5.96	-	-	143
	TOT	80	152	114	9	36	9.78	-	-	1482
Environmental Prediction Research Facility	#98	22	23	12			16.53	150	-35	380
		25	33				5.77	-	-	190
	TOT	47	56	12			10.17	-	-	570
Credit Union	#70	3	10	10	1		8.40		224	84
Navy Exchange	#64	2	6	2	1		7.00		X	42
	ST.	18	18				6.50		-	117
	TOT	20	24	2	1		6.60		-	159

APPENDIX D

General Use and Special Conditioned Circuits

1. GENERAL USE

REF #	LOCATION AND DESCRIPTION	DATE OF INSTAL-LATION	MONTHLY COST
096-4042	Annex - Line between gate and Dispensary	8/70	$5.67
096-4091	Bldg 220 - Customer owned intercom CKT	4/72	2.00
096-0029	Bldg 200 - Intercom CKT line	4/71	11.50
096-0052	Bldg 330 - Rm 364/135 data interface	4/71	2.00
096-0053	Bldg 220 - Rm 040 - Signal Channel to teletypes	4/71	2.00
096-0057	Bldg 220 - Rm 040 - Signal Channel to teletypes	4/71	2.00
096-0074	Bldg 203 - Rm 107 - Private Line Voice CKT	4/71	7.25
096-0056	Bldg 220 - R40 - Private Line CKT	4/71	2.00
150-6019	Security Residence - Security Radio Phone	9/72	2.15
150-4381	Herrmann Hall Tower - to Bldg 206, 226, 403, 406 - Radio Net for Security	8/72	8.40
150-6023	Bldg 3 - Annex - Radio Channel	9/72	8.00
150-0035	Bldg 235-218 Signal Channel - SEA WAVE Guage to measure Heights of waves	5/73	7.35
150-0041	Bldg 226 - 236 - 220 Alarm for Steam Plant	8/68	5.25
150-0175	Bldg 265 - Pump House - Signal Channel	10/65	4.20
150-0176	Bldg 337 - Signal Channel - Fire Alarm	3/69	8.40

REF #	LOCATION AND DESCRIPTION	DATE OF INSTAL-LATION	MONTHLY COST
150-8804	Bldg - La Mesa - Pump Control Tank #2	12/66	$6.30
150-3851	Bldg 258 - Signal Channel - Fire Alarm	11/73	6.30
150-3854	Bldg 258 - Signal Channel - Pumps Control	2/67	2.10
150-4450	Navy Exchange - Burglar Alarm	8/70	2.00
150-4457	Navy Exchange Warehouse - Fire Alarm	11/72	4.00
150-6020	Bldg 203 - Control Air Conditioning	5/73	6.00
150-6027	EPRF - Burglar Alarm	1/73	6.30
150-6039	Service Station - Fire Alarm	10/72	2.88
150-7143	La Mesa - Water level tank # 1	3/70	4.20
150-4954	Exchange - Burglar Alarm	6/70	4.00
	TOTAL - MONTHLY COSTS FOR GENERAL USE CIRCUITS		$122.25

2. SPECIAL CONDITIONED CKTS

50GT16	Bldg 220 to Navy Communication on Lighthouse Ave., Monterey	5/65	$8.40
16D6110	FNWC - Four Wire Data CKT; conditioned 2-way; nonsimultaneous	11/73	310.80
50GDP-6055	Bldg 4 Annex - Bldg 200 - Data	3/73	83.50
16W6014	Bldg 200 - UC Santa Barbara, Data CKT	1/73	797.00
16W6045	Bldg 200 - Time Share Corporation Palo Alto - Data CKT - Wideband - T.V. Quality	8/73	750.00

REF #	LOCATION AND DESCRIPTION	DATE OF INSTAL-LATION	MONTHLY COST
1GDP1539	Data CKT: Treasure Island, Redwood City, Moffett (NAS), Monterey, Pt. Mugu, Santa Anna, El Toro, Los Alimotos, La Jolla, North Island, University of Man, San Diego - a dial select CKT consisting of one of three data machines, plus voice - individual or collective addressing	6/66-68	$1,843
	TOTAL - MONTHLY COSTS FOR SPECIAL CONDITIONED CIRCUITS		$3,793

Note: Ten circuits are billed by AT&T to DECCO Washington (Navy) - charges and functions not available through local TELCO - CKTs are used by FNWC.

A 70-15 (4-63) PAGE NO. 11 PRINT DATE 010873 AREA CODE 408 CUST. CODE 462 TEL. NO. 646 9011

DATE	A C T	QTY	USOC	LINE OR K.. .O	OFF PREM CODE	REF CODE	LISTI. S AND EXPLANATIONS	TOTAL
3 172		1	NRX 4	2286		A	BLDG 220 PHY PLSMA LAB	500
3 172		1	RXR	2286				150
3 172		1	NRX 3	2287		A	BLDG 205 CPC QTRS	500
6 370		1	EXT	2287				350
3 172		1	RXR	2287				150
3 172		1	NRX 3	2288		A	BLDG 228 BOWLING ALLEY -	500
52472		1	EXT	2288		A	NON DIAL	350
3 172		1	RXR	2288				150
3 172		1	NRX 3	2289		A	MN GATE HSE	500
3 172		1	RXR	2289				150
3 570		2	JKS	2289				
				2291			KS 54	
				2292			KS 54	
3 172		1	NRX 4	2293		A	BLDG 330 RM 336 -	500
3 172		1	RXR	2293				150
3 172		1	NRX 4	2298		A	BLDG 203	500
3 172		1	RXR	2298				150
3 172		1	NPX 4	2303		A	BLDG 221 RM 418	500
3 172		1	RXR	2303				150
3 172		1	NRX 4	2305		A	BLDG 232-RM 301C	500
3 172		1	RXR	2305				150
				2306			KS 48	
				2307			KS 48	
				2311			KS 56	
				2312			KS 56	
				2313			KS 56	
				2314			KS 56	

Sample TELCO Green Sheets

A 70125 (4-63) PAGE NO 33 PRINT DATE 010873 AREA CODE 408 CUST. CODE 452 TEL. NO. 646 9011

DATE	A C T	QTY	USOC	LINE/S OR KS/NO	OFF PREM CODE	REF CODE	LISTINGS AND EXPLANATIONS	TOTAL
8 172		1	RXR	6	AA		STA 2788	150
8 172		4	1LVBY	6	AA		STA 2788	280
8 172		4	KFM	6	AA			1040
112872		1	6ZV	6				20
113071		2	6ZV	6	AA			40
11 171		1	*RF	6	AA	A	LA MESA HSNG OFC	
8 172		43		6	AA		MTRMN 1101 FARRAGUT RD	
							SUBTOTAL KS NO 6	8100
3 172		1	NRX 4	7			STA 2457	500
3 172		1	NRX 1	7			STA 2458	500
1 572		1	EXT	7				350
111371		2	KX2	7				440
5 767		1	EXG	7				70
3 172		1	RXR	7			STA 2457	150
3 172		1	RXR	7			STA 2458	150
1 572		2	KFM	7				520
2 569		1	CUT	7				75
1 572		1	JKS	7				
5 767		1	*RF	7		A	COMM OFC BLDG 220	
							SUBTOTAL KS NO 7	2755
3 172		1	NRX 1	8			STA 2506	500
3 172		1	NRX 4	8			STA 2507	500
31771		2	KX2	8				440
11 569		2	FJZ	8				120
3 172		1	RXR	8			STA 2506	150
3 172		1	RXR	8			STA 2507	150
11 569		2	KFM	8				520
5 767		1	*RF	8		A	LEGAL DEPT BLDG 220	
							SUBTOTAL KS NO 8	2380

101

APPENDIX F

Sample Reimbursable Activity (EPRF #98)
Equipment Inventory Listing for FY-74

KTS #98 BLDG 14

NOTES	EQUIPMENT	JuLY	AUG	SEP	OCT
(1)	RXR @ 9.32 (22)	205.04	"	"	"
	EXT @ 3.50 (1)	3.50			
	KX2 @ 2.20 (12)	26.40			
	KX3 @ 4.65 (3)	13.95			
(4)	ILVBY @ .70 (110)	77.00			
	RSE @ 2.00 (11)	22.00			
	DLY @ 2.50 (5)	12.50			
	DC9 @ 24.00 (1)	24.00			
	KFM @ 2.60 (23)	59.80			
		444.19			

BLDG 4, 14, 22 TRAILERS

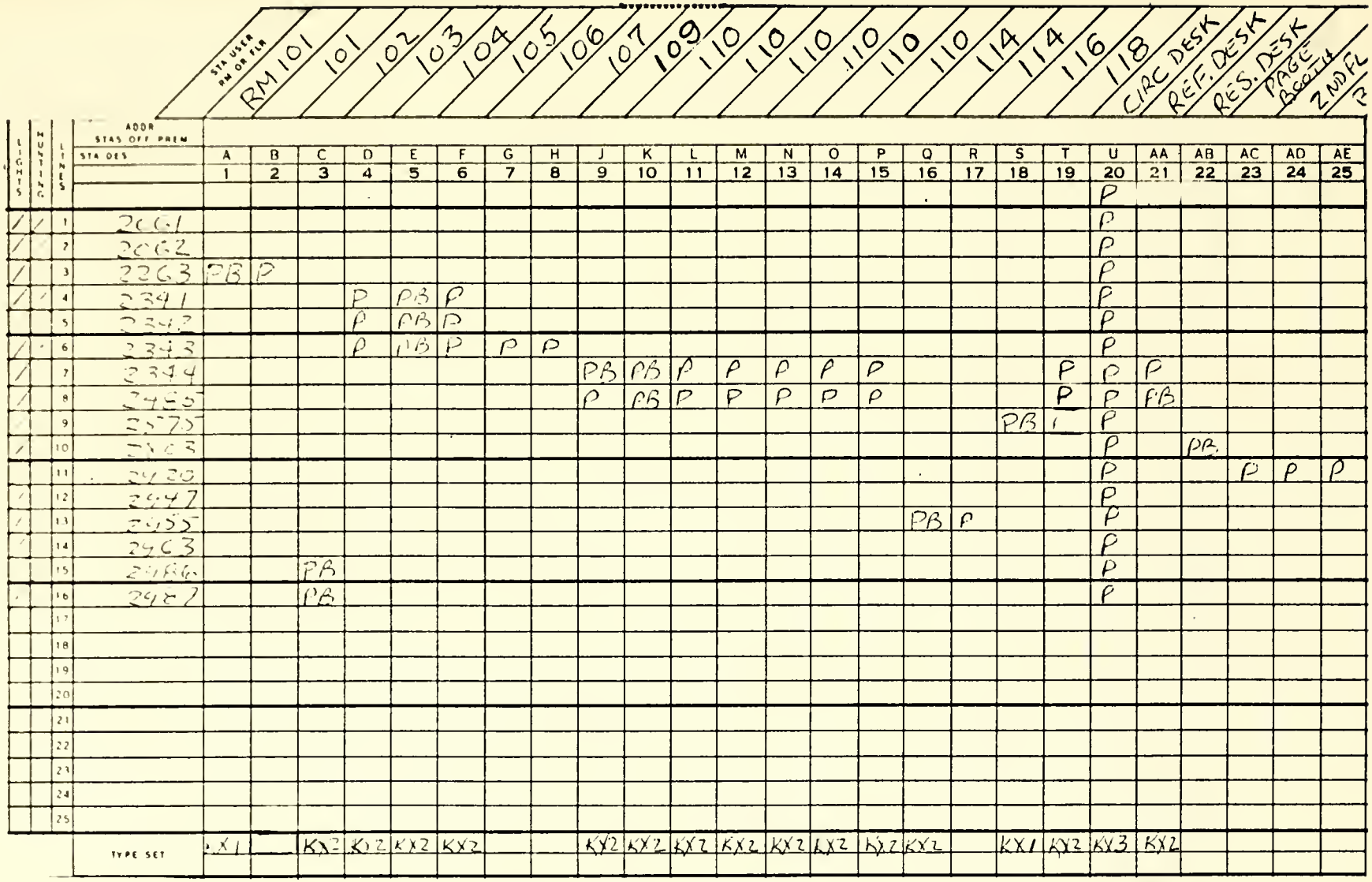
(1)	RXR @ 9.32 (26)	242.32
	EXT @ 3.50 (9)	31.50
(4)	ILVBY @ .70 (130)	91.00
(2)	OC&C	1.65
	INSTALLATIONS	0
(3)	AUTOVON @ 2.00 (36)	72.00
	CLTS @ .75	.75
	TOTAL	881.76

Notes: (1) RXR - Represent lines; basic cost is $6.50; with $2.82 line overhead, the cost/line is $9.32.

(2) OC/C - Added as part of equipment.

(3) AUTOVON - Overhead charges for each line with access - a part of equipment.

(4) ILVBY - Mileage units - will inflate equipment bill, particularly when a considerable number of lines are connected to system.



Sample Key System Worksheet

Sample TELCO Calling Pattern Printout

A 70128 I (4-69) PAGE NO. PRINT DATE | | AREA CODE CUST. CODE TEL. NO.

DATE	ACT	QTY.	USOC	LINE/STA/ OR KS/NO	OFF PREM CODE	REF CODE	LISTINGS AND EXPLANATIONS	TOTAL

CALLING PATTERNS FOR 408-246-9011 LOW LIMITS--CALLS TO NUMBER(10),PREFIX(25)

CALLED NO	PLACE	CALLED	CALLS	MU	MIN	DOLLARS
202-767-XXXX	WASHINGTON	DC	29		191	101.39
213-937-2292	LOSANGELES	CAL	18		46	23.80
408-227-7100	SAN JOSE	CAL	16		101	17.67
408-246-7501	SAN JOSE	CAL	10		88	14.92
408-422-XXXX	SALINAS	CAL	63		176	15.18
408-424-0102	SALINAS	CAL	11		16	2.20
408-424-2961	SALINAS	CAL	10		25	2.36
408-424-7316	SALINAS	CAL	33		97	8.10
408-424-8611	SALINAS	CAL	18		56	4.74
408-424-XXXX	SALINAS	CAL	167		536	44.26
408-484-XXXX	SALINAS	CAL	71		173	15.94
408-734-7962	SUNNYVALE	CAL	11		200	33.18
408-734-XXXX	SUNNYVALE	CAL	31		298	52.62
408-758-2777	SALINAS	CAL	11		23	2.32
408-758-XXXX	SALINAS	CAL	35		82	7.78
415-397-5200	SAN FRAN	CAL	11		72	13.23
415-843-2740	BERKELEY	CAL	30		85	20.46
415-843-XXXX	BERKELEY	CAL	32		88	21.56
612-831-1010	MINNEAPOLS	MINN	12		72	33.42
714-979-4770	SANTA ANA	CAL	10		46	19.28

WATS ZONE ANALYSIS AND MASK	1, 2, 3, 4, 5, 6, 7, 8, 0,				
INTERSTATE	ZONE 1	41		191	78.29
INTERSTATE	ZONE 2	17		64	29.10
INTERSTATE	ZONE 3	37		330	154.14
INTERSTATE	ZONE 4	70		578	250.76
INTERSTATE	ZONE 5	84		471	239.52
INTERSTATE	ZONE 6	256		1,407	757.53
CALIFORNIA	NORTH	1,166		4,781	813.90
CALIFORNIA	SOUTH	294		1,522	596.63
	STATE	1,460		6,303	1,410.53

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This thesis is a study of the telephone system at the Naval Postgraduate School, Monterey, California. It describes the facilities available, their current management, and their costs. Potential methods for evaluation of cost-effectiveness are developed and their implementation is explored. The overall conclusion is that greater management control is desirable.

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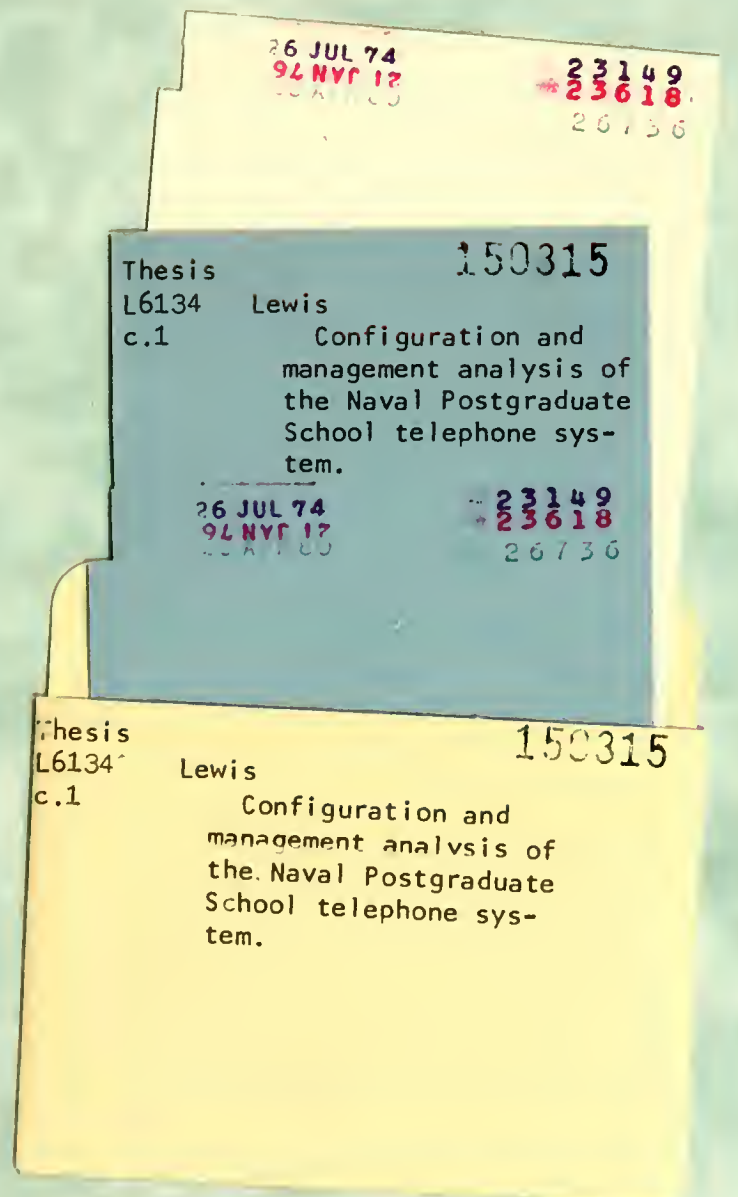
20. cont.

Specific recommendations for improvement in this management at national and local levels are offered.



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L6134 Lewis
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