CASE STUDY
OF THE
DEVELOPMENT OF THE
NAVAL TACTICAL DATA SYSTEM

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Chapter I
INTRODUCTION

The Naval Tactical Data System (NTDS) is a large scale, complex, military command and control system whose introduction into the fleet is having far-reaching effects. The development of the NTDS was a success in terms of producing a system meeting the initial technical and operational requirements within a fairly tight time and cost framework. This report is a case study of the development phase, covering the time period 1955-1962, with emphasis on how scientific and engineering personnel were utilized.

The first part of the study concerns itself with a description of the system, its function, technical requirements, and major components. Since a number of projects preceeding the NTDS were instrumental in initiating its development, the more important ones are discussed and the major milestones in the program itself are listed.

The Bureau of Ships, Department of the Navy, was the government agency responsible for the development phase of the NTDS. BUSHIPS received technical and operational assistance within the government from the Navy Electronics Laboratory (NEL) and the Chief of Naval Operations (CNO). Remington Rand Univac functioned as the lead contractor, responsible for the building of the unit computer and the systems design. Hughes Aircraft developed the displays and Collins Radio, the communication link for the system.

The second portion of the study examines in some detail the development of the NTDS from the standpoint of the government, Remington Rand Univac, and Hughes Aircraft. The way in which the project was organized within the government and contractors' organizations is described. The Navy Electronics Laboratory and the two contractors furnished data from which charts have been drawn depicting the amount of engineering manpower expended by them on various phases of the NTDS project. In addition, the key technical personnel, their education, time on the program, and major contributions are identified. Finally, some of the factors contributing to the overall success of the development such as its organization and the competency and dedication of its technical personnel are discussed.

The case study is based on interviews with key individuals in the Bureau of Ships, NEL, Remington Rand Univac, and the Ground Systems Division of Hughes Aircraft. In addition, personnel were contacted who were associated with the program but have subsequently retired from the Navy or are now associated with firms other than the contractors concerned. Progress reports, manpower schedules, and correspondence relating to the NTDS program were also scrutinized. Excellent cooperation was received from all quarters and it is only lack of additional time that prevents the inclusion of additional data.

In the course of the investigation, data was gathered on two areas unrelated to the specifics of the NTDS case but concerned with the general topic of effective utilization of technical talent. These areas were the cost of hiring engineers and the productivity of newly recruited engineers, inexperienced and experienced. This information is presented as part of the appendices.

Chapter II
THE NAVAL TACTICAL DATA SYSTEM AND ITS DEVELOPMENT

Command control systems refer to the means by which a Naval commander controls his forces and weapons, gains and assimilates knowledge of enemy capabilities, and takes into proper consideration factors such as the operational environment bearing upon these forces. The speed with which these systems operate is directly related to the rate of delivery of enemy weapons.

The forms of command control have evolved from the coast watchers who sighted the Armada from the English Channel cliffs to the World War II Combat Information Center where information received from radar sensors or via communication links is plotted for the commander's evaluation of a particular tactical situation. In today's modern warfare era of Mach 3+ aircraft and missiles, present day CIC's, limited to grease-pencil plotting and voice-telling techniques, can be saturated and confusing. Threats can develop with such high speed and in such numbers that current operators using voice communication procedures, could not generate a meaningful tactical picture in a short enough time to permit effective defensive action. Clearly, there is a need to provide commanders of forces and commanding officers of ships with a clear, concise picture of the tactical situation so that action can be taken in time to meet the threat.

Function of the NTDS

The function of the Naval Tactical Data System is to increase the volume, speed, accuracy, and ease of interpretation of target information which must be made available for the effective execution of the command function.

It provides up-to-date displays of the immediate environment, with emphasis on the tactical air situation, for assisting in command appraisal and evaluation. It develops information required for the assignment of areas of responsibility to specified ship, aircraft, and weapon capabilities. It assists weapons control systems in the acquisition and assignment of targets, and in the coordination of intercept and weapons control functions. It provides for the exchange of target information between elements of the fleet.

The present operational NTDS is concerned principally with the air defense situation. The system capability is being expanded to incorporate other military parameters as specified by operational doctrine.

General Requirements

Early in the development, a number of general requirements were enumerated that guided the development program.

Single ship capability was required. An earlier system concept had been rejected because of its dependency on multi-ship operation. The NTDS was to operate in concert with other ships, but it had to be constructed in such a manner that each ship contained the proper assembly of components to handle target information within its own surveillance capabilities.

In the exchange of target information, the system had to be compatible with national and international systems then in use.

Flexibility had to be built into the system so that it could be made adaptable to the wide variety of ships that would carry its equipment. It had to be able to accommodate advances in equipment design that would allow the system to meet increased operational requirements.

Speed had to be an inherent part of the system. Information exchange and the presentation of the tactical situation had to take place at a high enough rate to be of value to the operator. The exchange had to be a "real-time" process, i.e., one which appears to be instantaneous and causes no practical degradation to tactical information because of time of computation or presentation.

Major Components

The NTDS consists of four basic elements:

a) analog to digital converters
b) computing equipment
c) communications equipment
d) visual displays

A/D Conversion Equipment. This includes analog to digital converters to permit direct entry of information from radar and sonar sensors. In addition, provision is made for the manual entry of data such as air operations and navigational information.

Computing Equipment. The storage and processing of large quantities of information requires high-speed, large-capacity digital computers. The NTDS computer not only provides data exchange facilities but also permits execution of programmed functions at computer speeds and computer solution of problems which are currently handled by voice and/or manual means. The NTDS computer may be precisely described as being a digital, general-purpose, stored-program computer having a very high-speed, random-access memory. The internally stored program feature is required to preclude obsolescence of the entire system, since the computer program may be changed instead of hardware as the tactical application changes.

Computer programming is an obvious integral part of the computing equipment. The NTDS computer will solve a particular problem by executing instructions which are stored within its memory. The computer will perform any number of tasks including solving threat evaluation/weapon assignment problems as long as strict rules for the solution of these tasks can be set forth and these rules are stored within the computer memory. The development of computer programs is as essential to the operation of the NTDS as the development of the computer hardware.

Communications Equipment. To perform integrated combat direction, it is necessary to exchange tactical information between commands, or units of one command, at a very high rate. The high-speed data links allow all echelons of command to be continuously appraised of the total tactical situation. Since the computers can communicate directly with one another via the data links, it is possible for all units within a task force to operate in an extremely coordinated fashion.

Visual Displays. To allow the NTDS to be interpreted by a human for choice or decision, the output of the computer must be presented on display consoles. Once the computer has processed the data fed into it via data links or sensors, the particular tactical situation is displayed in a manner allowing the operators of the system to read its status and enter new instructions into the system. Various consoles are used for detection, for tracking, for identification, for threat evaluation, for weapons assignment, and for intercept control. The consoles are grouped into two general categories, input consoles and utilization consoles. In addition, raw radar data can be presented on the consoles before conversion to digital form. Auxiliary readout equipment is available for presentation of information by alpha-numeric characters.

Modular Construction of the NTDS

The requirement for flexibility in the system necessitates the adoption of the "building block" philosophy and limits the development to a few basic units which can be used in combinations to fill the system requirements of the different ship types. Hence, the NTDS computer has been termed the "unit computer." The display area consists of a basic display unit which can be modified for different functions through the use of mode switches and the communication terminal equipment which can be used to handle a variety of data links. The system can be varied by adding or subtracting modular units and by changing the number of type of input or output devices.

Outline of the NTDS Development

The basic ideas for the Naval Tactical Data System were derived from a number of different sources. Chapter III discusses some of the early background.

Government Role

During the development phase, the Bureau of Ships exercised complete coordination control of the program. This meant BUSHIPS exercised control over the work of the contractors developing the system components, the efforts of Navy laboratories in technical evaluation and testing, and the coordination of technical specifications, and financial RDT&E budgets. There was no prime contractor.

The Bureau of Ships wrote the technical requirements of the system and the Chief of Naval Operations supplied the operational requirements. The Naval Electronics Laboratory (NEL), San Diego, California, functioned as the "lead" naval laboratory and provided the Bureau with the continuous technical monitoring and evaluation required in a program of this magnitude.

The system's compatibility requirement involved extensive coordination with other military groups. Shipboard surveillance, detection, and navigation devices were linked to the NTDS. It was necessary that the NTDS be compatible with the output characteristics of these systems. The Marine Corps (MTDS) and airborne (ATDS) data links required technical liaison to ensure successful functioning with NTDS. Also, the established requirement for information exchange with the Canadian and United Kingdom data systems required working with technical and operational agencies of the foreign government concerned. Likewise, the output characteristics of NTDS had to be compatible with the input requirements of action or weapon devices such as missile systems or intercept control equipment.

Contractors' Role

Three major contractors were involved in the development of the NTDS. They were Remington Rand Univac (RRU) Division of Sperry Rand Inc., Hughes Aircraft Co., and Collins Radio Co. None of these were considered prime contractors, although RRU functioned as the lead contractor because of its role as Systems Designer. In addition to developing the unit computer and various peripheral equipment, and for interfacing the various components of the system. The Ground Systems Division of Hughes Aircraft developed the display design and produced the display equipment. Collins Radio was responsible for the design and production of the AF data communication link. Essentially, two phases were involved in equipment development. The initial sets of contracts concerned the production of experimental equipment for testing at NEL. The second round of contracts was for the production prototype models of fleet operational equipment to be used for the Service Test.

A program as complex and far reaching as the NTDS requires continuous coordination between contractors,and between the government agencies involved and any single contractor. Frequent meetings of all the groups concerned were held throughout the development phase. There were a tremendous number of technical problems encountered. A number of groups outside of the major contractors and BUSHIPS helped supply solutions. Among them were the Control Systems Laboratory, University of Illinois; Cornell Aeronautical Laboratories; and Applied Physics Laboratory, John Hopkins University. Close contact between BUSHIPS, NEL, and the contractors was continuously maintained. This was especially true as the system was assembled for testing and evaluation at NEL.

Test Program

The approach taken in the building of this system was to assemble the equipment produced under the research and development contracts in an experimental NTDS at the Applied Systems Development and Evaluation Center (ASDEC) of the Navy Electronics Laboratory, San Diego. Tests were conducted on individual equipment and on the total systems performance. Sufficient R&D equipment existed, beyond that required by the ASDEC area, to equip a mobile van and a picket ship for purposes of testing multiple station data exchange.

Following the evaluation of the experimental system, an NTDS was installed aboard each of three ships for Service Test purposes. The hulls concerned were DLG-10 and DLG-11, two guided missile frigates just being built, and CVA-34, a carrier then in fleet operation.

These systems are in fleet operational use today. Shortly after the Service Tests were completed, Service Test type equipment was installed aboard the CG(N)-9, a nuclear-powered guided missile cruiser and CVA(N)-65, a nuclear-powered carrier.

Major Milestones

The development phase of the NTDS program covers a time period running from mid-1955 through 1961. It begins with the definition of the requirements of the system and ends with the first fleet installation of the NTDS aboard the Service Test ships USS Oriskany (CVA-34), USS King (DLG-10) and USS Mahan (DLG-11). The following, listed in chronological order, represent the major milestones in the program during this period.

1) ONR Committee on Tactical Data Processing formed (mid-1955)

2) Bureau of Ships Technical Requirements for the Naval Tactical Data System completed (fall of 1955)

3) First NTDS problem assignments (NEL J1-5 and N4-3) accepted by NEL (December 1955)

4) Development Characteristics and Operational Requirements completed by CNO (spring 1956)

5) Bureau of Ships contracts to Remington Rand Univac for development of a unit computer and computer programs (May 1956)

6) Bureau of Ships contract to Hughes Aircraft Company for display development (June 1956)

7) Bureau of Ships contract to Collins Radio Company for development of data link (August 1956)

8) Delivery of R&D equipment to NEL began in February 1958 and continued for approximately 18 months.

9) Testing of the experimental NTDS installed in the Applied Systems Development and Evaluation Center (ASDEC) at NEL (April 1959 - November 1961)

10) Contracts for NTDS Service Test equipment awarded by Bureau of Ships to RRU, Hughes, and Collins (1959)

11) Fleet Computer Programming Center, Pacific commissioned (July 1961)

12) Service Test equipment installed on USS Oriskany (CVA-34), USS King (DLG-10), and USS Mahan (DLG-11) (September 1961)

13) Service Test operations conducted by OPTEVFOR (October 1961 - April 1962)

Chapter III
HISTORICAL BACKGROUND

The NTDS was an outgrowth of several development and study programs conducted by various government and university groups. Of these, Project Cornfield, Project Cosmos, and Project Lamplight were of prime importance. It was Project Lamplight that recommended the building of the Naval Tactical Data System.

Early Work

Some of the early work in the display area was carried out at the Navy Electronics Laboratory. NEL, in the early days following World War II, became involved in the development of electronic training devices such as CIC and ASW trainers, in which the tactical situation was displayed visually on a scope. The early display equipment utilized analog techniques. In 1951, BUSHIPS let an R&D contract to the Teleregister Company for the development of the Semi-Automatic Air Intercept Control System (SAAICS). NEL provided technical assistance. This system was based on digital techniques and, while never completed, contributed to the knowledge of digital displays.

Also, in 1951-1952, the British, using analog techniques, had developed the CDS or Comprehensive Display System. The U. S. Navy was interested and actually purchased a system for testing by COMOPTEVFOR at Norfolk, Virginia. However, it was limited in the number of targets it could handle. As the target capability was increased, so was the complexity of the system. It was an unwieldy system and was never adopted by the U. S.

The Naval Research Laboratory (NRL) developed (1951-1956) a system called the Electronic Data System (EDS). This was based on analog computers and used conductive glass data pickoff, capacitor storage, manual rate-aided tracking, and intercept control computation. Target data registering on one display would be transmitted to the other displays via a computer. The Motorola Company built a number of these systems for the Bureau of Ships, using the NRL design. However, the units were limited in capability, lacked the accuracy desired, and as a result never became operational.

A further early development that preceded the NTDS was the development of the Intercept Tracking and Control Console (INTACC) under a BUSHIPS contract to Cornell Aeronautical Laboratories (1953-1956). Analog techniques were used again.

Project CORNFIELD

This was a tri-service contract to the University of Illinois, Control Systems Laboratory (1953-1957). It explored the use of digital computers for the logical solution of threat evaluation and weapons assignment problems and the rapid correlation and dissemination of information derived from a network of search radars. At the time of Project CORNFIELD, only vacuum tube digital computers were available. These computers took up so much room that it would have been difficult to conceive of placing one on board every ship. CORNFIELD proposed using a "master ship" crammed with electronic gear: in essence, a computer center. Target data received by other ships in a fleet would be fed into the central ship, worked on, and then returned to individual ships for appropriate action. While very advanced for its time, this system did not contain single ship capability, and as an operational concept, was rejected.

Project COSMOS

This was a Bureau of Ships contract to the Bell Telephone Laboratories (1952-1956) for a comprehensive study covering communications and data processing. The data system proposed included manual detection, tracking, track number assignment, height and identity consoles, with electronic aids and a store for local tracks. Each ship would transmit in succession the data in its local store at a high rate so that either the total picture on the data link or any selected category could be displayed on cathode ray tubes. COSMOS was the most comprehensive of the studies preceding Project LAMPLIGHT. It described what the Navy had to do to handle its data and particularly pinpoint the communication aspects of such a data handling system.

Project LAMPLIGHT

Early in its history COSMOS posed a number of unanswered questions and produced some controversy within the Navy. By now the SAGE (Semi-Automatic Ground Environment) System had come into being. This was concerned with the problem of continental air defense and incorporated automatic computing devices on a large scale. The Navy recognized that there would be technical problems arising out of plans to employ naval forces in extending the continental air defense to seaward. For this reason the Office of Naval Research (ONR) proposed a study group in the summer of 1954 to examine the questions. Project LAMPLIGHT was born.

LAMPLIGHT was administratively handled by MIT's Lincoln Labs. The study group contained nearly 100 experienced technical personnel. In addition to civilian scientists, there were representatives from the Navy, Army, Air Force, and NATO. The two representatives from ONR were Capt. Hunter and Cdr. I. L. McNally. NEL was represented by Mr. E. E. McCown. The work of the project was carried on by several groups, each studying a particular aspect of the total problem of the Defense of North America. In February and March of 1955, the project produced a series of LAMPLIGHT Reports which summarized the work of the various groups.

One of the Reports recommended the development of a Fleet Data System. The report, rather than spelling out an exact system, was more philosophical in tone. It made two general recommendations with regard to the data system. Phase I called for the interim implementation of the EDS aboard ship. Phase II recommended a digital oriented system. (The British experience pointed up the fact that the cost and complexity of an analog system designed to handle hundreds of targets was astronomical in comparison to a digital system.) Phase II initiated the NTDS.

Early Stage of the NTDS Development

The task of implementing Phase II fell on the Bureau of Ships. Cdr. McNally, transferred to BUSHIPS in 1954, was given the task of writing the technical specifications for the NTDS. McNally asked for assistance in the computer area. Cdr. E. C. Svendsen was in charge of the Special Applications Branch in the Electronics Division of BUSHIPS at the time. This branch was responsible for computer work. Svendsen joined McNally to write the specifications. In the spring of 1955, the Committee on Tactical Data Processing was formed with ONR as Chairman and representatives from BUSHIPS, BUAER, and BUORD.

During the summer of 1955, Svendsen and McNally, with little outside assistance, wrote the full technical requirements for the NTDS. Svendsen supplied the computer knowledge and McNally the radar and display background. This was quite a feat considering the fact that the technical specifications embodied a complex system, requiring electronic gear not at the time available,and yet when the NTDS became operational, these specifications had not been materially changed.

They submitted their report in the fall of 1955 to the Committee on Tactical Data Processing who did some editing of it and passed it on to CNO with the request that it be used as the planning document for the system. CNO then wrote the operational requirements.

While the report was going through the technical review process, Svendsen and McNally visited a number of outside groups that might offer technical advice: NRL, Lincoln Labs, Cornell Aeronautical Labs, Applied Physics Lab, Control Systems Lab, and the British and Canadians. The Canadians had done some interesting work on a similar system called DATAR that had never gotten out of the planning stage. Svendsen and McNally also made trips to a number of potential contractors to evaluate their capabilities for developing the system.

In the fall of 1955, BUSHIPS received the go-ahead from CNO and put in a request for emergency R&D funds. By now some basic decisions had been made concerning who should work on the various technical aspects of the project. There was a strong feeling that no contractor, with the possible exception of Bell Labs, had the capability of handling the whole project. Bell was deeply engaged at that time in other government work. In addition, it was felt that no commercial concern would understand all the Navy operational problems, problems that had to be considered in the successful development of such a system.

It was decided to enlist the aid of the best contractors available for the different elements of the system and bring them together "in-house." At that time, only one contractor was building solid-state digital computers — Remington Rand Univac. They were picked to develop the unit computer and act as the system design contractor. The display and communications portion of the system went out on bid. Hughes Aircraft was chosen to develop the displays and Collins Radio to produce the HF communication link.

On the "in-house" side, NRL was the most proficient lab for computer work but they were very strongly analog oriented. NEL had done excellent work in the communication and radar display area. Also, McNally had worked at NEL from 1950-1955 and knew its technical capabilities well. NEL was chosen as the lead laboratory, and in late 1955 several tasks were established at NEL covering work on NTDS problems. Contracts to the three commercial firms were awarded in mid-1956, and work on the development of an operational NTDS was begun. In June of 1956, McNally retired from the Navy for personal reasons[1].

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[1] McNally is now Department Manager, Range Instrumentation and Surveillance at Raytheon's Wayland, Mass. laboratory.

Chapter IV
GOVERNMENT ROLE IN NTDS DEVELOPMENT

The Bureau of Ships was the lead government bureau involved in the NTDS development. They received technical support from the Navy Electronics Laboratory and operational support from the Chief of Naval Operations. The project was staffed within the government by a group of technically competent, dedicated Navy officers. Both NEL and BUSHIPS had the further support of well qualified civil service engineers within their own organizations. This chapter will explore the organization of the project within the government and the key contributors to it.

BUSHIPS-NTDS Organization

From an organizational standpoint, the NTDS development was initially located in BUSHIPS under Code 800, the Assistant Chief for Electronics. Code 800 was made up of four groups, one of which was Design & Development, Code 810. This code was made up of a number of branches, among them Radar, Sonar, Communications, and Special Applications (SAB). There was a computer development section under the Special Applications Branch. NTDS was set up as Code 810B, reporting to Code 810, Design and Development. Cdr. McNally initially occupied 810B. A memorandum of 17 May 1956 from Code 810 spelled out the Charter of Code 810B.

"Coordination responsibility for the NTDS program in the Bureau of Ships has been assigned to Code 810B. This responsibility includes the following:

a. Coordinate the activities of the branches on all work specifically related to NTDS. Act as Chairman for technical coordination meetings.

b. Assign to the Branches specific areas of responsibility for the development and procurement of specific equipments or parts of the system.

c. Review R&D and Service Test Budgets of all Branches as they relate to NTDS.

d. Act as BUSHIPS member on the Technical Working Sub-Committee of the Joint ONR, BUAER, BUORD, BUSHIPS Committee on Tactical Data Processing.

e. Act as BUSHIPS member on the joint CAN-UK-US Naval Data Transmission Working Group.

f. Technical liaison with CNO on NTDS."

In 1958, the Bureau of Ships was reorganized and the position of Assistant Chief for Electronics abolished. The four groups comprising Code 800 were reformed and most of their elements were placed in a new code, 670. This was the new Electronics Division, and it reported to the (newly created) Assistant Chief for Technical Logistics. Code 810B became 677 reporting to Code 670.

The Bureau went through another reorganization shortly thereafter and 677 became 671, still reporting to the Director of Electronics, Code 670. Code 671 was termed Special Projects Officers. Initially, the NTDS was the major project in 671. Eventually, there were three others and NTDS carried the Code designation of 671A. The "Electronic Divisions Functions and Responsibilities," dated 30 March 1960, written by the Electronics Division Director, Capt. J. E. Rice and approved by the Deputy Assistant Chief for Logistics, Capt. J. E. Halligan carried the following description of Code 671.

Code 671 Special Projects Officers

"Act for the Director in assuring timely completion of urgent programs and projects assigned. These projects may involve other bureaus of the Navy Department, Office of the Chief of Naval Operations, and other offices of the Navy Department, Department of the Army and Air Force, government laboratories and civilian contractors. Coordinate specified programs of great military importance. Provide policy level representation for the Bureau of Ships at all conferences on these programs. Complete coordination and management control responsibility rests with each project officer in the execution of projects assigned. Project officers assist Code 300 in a dual billet capacity when required."

By now, the Special Applications Branch had been combined with the Communications Branch as Code 686. Initially, Code 671 did not have direct line authority over the branches (radar, sonar, communications, etc.), but it did have the use of certain key technical personnel in these branches who were concerned with the NTDS. Code 300 involves the control of RDT&E funds. The above position description gave 671 authority and responsibility over the development funds for the NTDS by being "double hatted" as Code 363. With control over personnel and funding, Code 671 did function as a strong project office.

The BUSHIPS special projects code that NTDS was developed under has now evolved into BUSHIPS Command and Control Systems Management Office. The Command and Control Systems Office, with regard to projects it is responsible for, has cognizance over current funding, technical planning and interfacing with the systems of other bureaus. In light of the fact a former NTDS project officer wrote the directive establishing this office, it can be said that the experience gained from the managing of the NTDS development has contributed significantly to the strengthening of project management within BUSHIPS. A copy of the directive can be found as Appendix A.

The outfitting of the three service test ships (DLG-10, DLG-11, CVA-34) was done under BUSHIPS direction. The service tests themselves were run under the jurisdiction of COMOPTEVFOR (Commander, Operational

Test & Evaluation Force Atlantic) located at Norfolk. Largely because of the outfitting of the Service Test ships on the West Coast, COMOPTEVFOR set up a Pacific detachment at North Island, Naval Air Station, San Diego, California, sometime in 1960. The function of COMOPTEVFOR was to run an operational evaluation of the NTDS and report their findings to CNO. OPTEVFOR is not under BUSHIPS' jurisdiction. Concurrently, BUSHIPS conducted a technical evaluation of Service Test NTDS equipment.

BUSHIPS — Key Technical Personnel on NTDS

All of the key BUSHIPS military personnel connected with the NTDS development were Engineering Duty Officers (EDO's). EDO's are, in essence, the technical and management officers of the Bureau of Ships. Nearly all of them have advanced degrees from the Navy Post Graduate School at Monterrey, California[1] (up to 1951, this school was located at Annapolis) or have gone through a Navy "short course" at a civilian engineering school. EDO's are, recruited by the Bureau of Ships from the ranks of outstanding junior line officers in the fleet, who possess technical understanding and maturity of purpose. At present, there are slightly less than 1,000 EDO's in the entire Navy, but billet spaces available for 1,200. Recruitment difficulty has been experienced partially because of resistance within certain sectors of the Navy to the concept of the EDO's. With the technological revolution sweeping through seapower and warfare, this number of technically skilled officers seems hardly adequate. The EDO has been

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1 The Navy PG School offers a two-year course leading to a Certificate of Completion or a Bachelor of Science Degree in Aeronautical Engineering, Communication Engineering, Electrical Engineering, Engineering Electronics, Management, Meteorology, Mechanical Engineering, Nuclear Science or Physics. They offer a three-year program that leads to a Master of Science Degree in Aeronautical Engineering, Electrical Engineering, Engineering Electronics, Management, Mechanical Engineering, Meteorology or Physics. A PhD program has recently been established.

further defined as that individual who must bridge the gap between the needs of the military and the capabilities of industry to meet these needs. If anything, the success of the NTDS development points up the value of having technically competent military personnel running these programs.

Engineering Duty Officers (Officer Designator - 1400) carry engineering qualification codes, depending on their specialties. The NTDS EDO's carried qualifications in the Electronics Engineering Field (Code 5000-5999). The Naval Officer Billet Code Manual defines this field as follows:

"Comprises billet classifications, the primary duties of which involve planning, research, design, manufacture, procurement and distribution of naval electronic equipment and technical maintenance, alteration and repair thereof; and classifications which involve planning, design and development, production, inspection, and maintenance of synthetic training devices. Excludes aviation and fire control applications of electronics elsewhere classified under 'Aviation' and 'Ordnance'."

There are nine major groupings in the Electronics Engineering Field: Radar, Sonar, Radio, Navigational Aids, Identification Friend or Foe (IFF), Electronic Special Equipment, Countermeasures, Special Devices, and General. The NTDS EDO's had qualification codes in the Electronic Special Equipment and General groupings.

Within the Electronic Special Equipment there are seven Officer Billet Codes. One in particular applied to the EDO's managing the NTDS program. This was the Electronic Special Equipment Design Officer (General) - Code 5510. The Manual defines the position as follows:

"Supervises or performs engineering design and development of special electronic equipment. Receives and analyzes information concerning research advances and information as to physical and performance characteristics needed in various types of special electronic equipment, supervises or engages in preparation of equipment plans, drawings and manufacturing specifications for gear incorporating new advances and possessing requisite characteristics; standardizes such equipment and component parts to extent feasible; prepares and reviews instruction books for equipment involved; analyzes tests and trials of equipment from standpoint of engineering design. Specializations include:

5511 Electronic Special Equipment Design Offices (Infrared Equipment)
5512 Electronic Special Equipment Design Offices (Radiac Equipment)
5513 Electronic Special Equipment Design Offices (Communications Security Equipment)
5517 Electronic Special Equipment Design Offices (Electronic Computers)"

Most of the EDO's connected with the NTDS carried the 5517 Qualification Code.

Chart IV-1 is an over-all view of the EDO staffing of the NTDS project office (at various times, Code 810B, 677, 671A). The last name of the individual is listed, his technical background and approximately when he was attached to the NTDS program — either in Washington's project office, on assignment to NEL, to one of the shipyards outfitting Service Test ships or as a Bureau of Ships' Technical Representative (ESTR) stationed at a contractor's installation to oversee BUSHIPS contracts. An EDO's assignment after leaving the NTDS program has also been indicated.

The chart shows that 22 EDO's were connected with the NTDS at some point during its development phase. Twelve of these officers had the equivalent of a Masters degree in electronic engineering. The rest, with the exception of one, had Bachelor degrees in engineering. The project office in Washington never contained more than six EDO's and usually numbered only four. Considering the size and complexity of the total program, this appears to be an incredibly small management group.

The following are the military personnel in BUSHIPS who contributed most to the development and implementation of the NTDS.

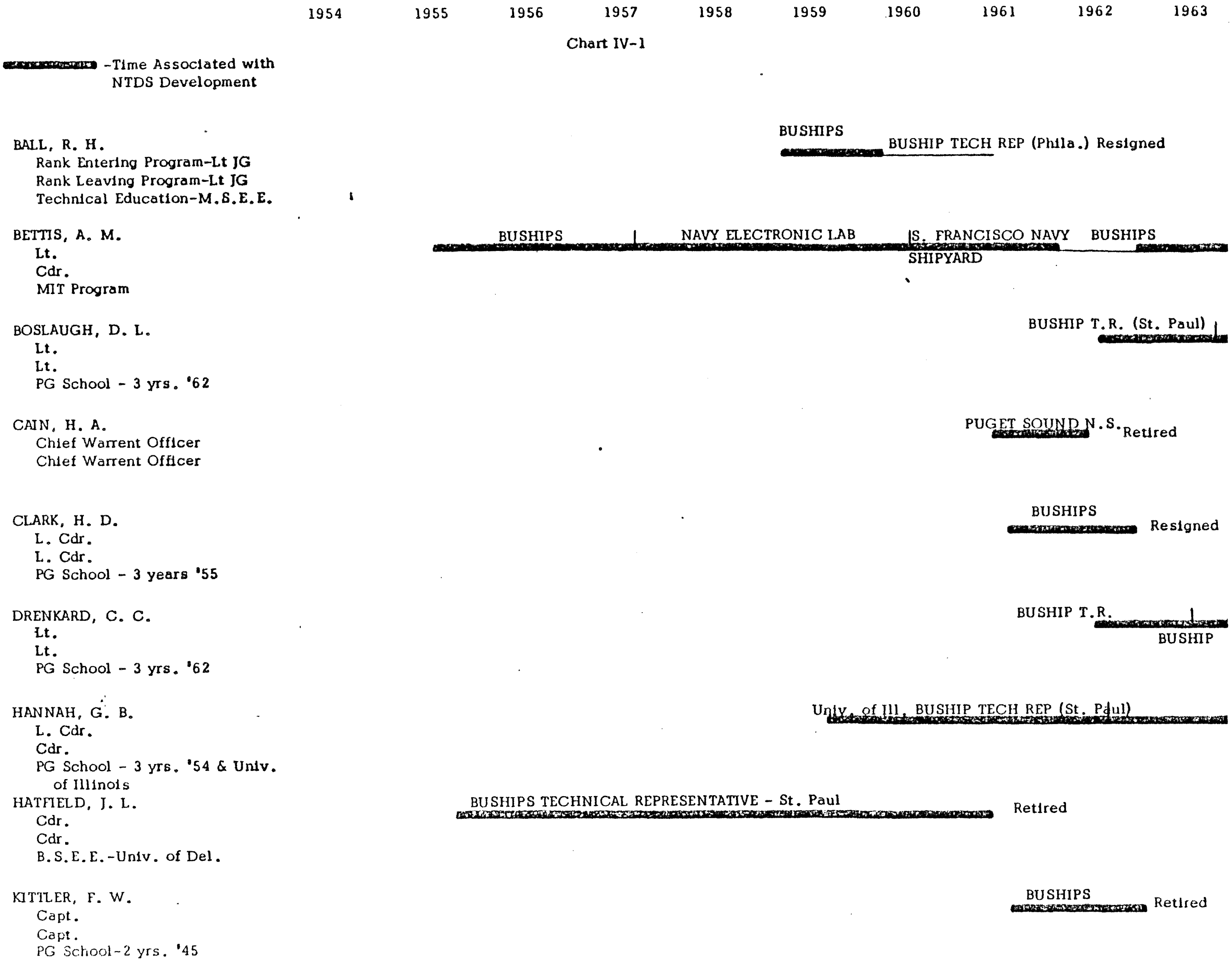

1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
-Time Associated with NTDS Development
BALL, R. H.
Rank Entering Program-Lt JG
Rank Leaving Program-Lt JG
Technical Education-M.S.E.E.
BUSHIPS
BUSHIP TECH REP (Phila.) Resigned
BETTIS, A. M.
Lt.
Cdr.
MIT Program
BUSHIPS
NAVY ELECTRONIC LAB
S. FRANCISCO NAVY SHIPYARD
BUSHIPS
BOSLAUGH, D. L.
Lt.
Lt.
PG School - 3 yrs. '62
BUSHIP T.R. (St. Paul)
CAIN, H. A.
Chief Warrent Officer
Chief Warrent Officer
PUGET SOUND N.S.
Retired
CLARK, H. D.
L. Cdr.
L. Cdr.
PG School - 3 years '55
BUSHIPS
Resigned
DRENKARD, C. C.
Lt.
Lt.
PG School - 3 yrs. '62
BUSHIP T.R.
BUSHIP
HANNAH, G. B.
L. Cdr.
Cdr.
PG School - 3 yrs. '54 & Univ. of Illinois
Univ. of Ill.
BUSHIP TECH REP (St. Paul)
HATFIELD, J. L.
Cdr.
Cdr.
B.S.E.E.-Univ. of Del.
BUSHIPS TECHNICAL REPRESENTATIVE - St. Paul
Retired
KITTLER, F. W.
Capt.
Capt.
PG School-2 yrs. '45
BUSHIPS
Retired

Chart IV-1

KNIGHT, F. S.
Cdr.
Capt.
PG School-3 yrs. '48

LEICHTWEISS, D. L.
Ens.
Lt. JG
PG School-(in program now)

MAHINSKE, E. B.
L Cdr.
Cdr.
MIT Program-1948

McNALLY, I. L.
Cdr.
Cdr.
B.S.E.E.-Univ. of Minn.

MORGAN, G. E.
L Cdr.
Cdr.
PG School-3 yrs. '53 & Univ. of
Chicago (MS)

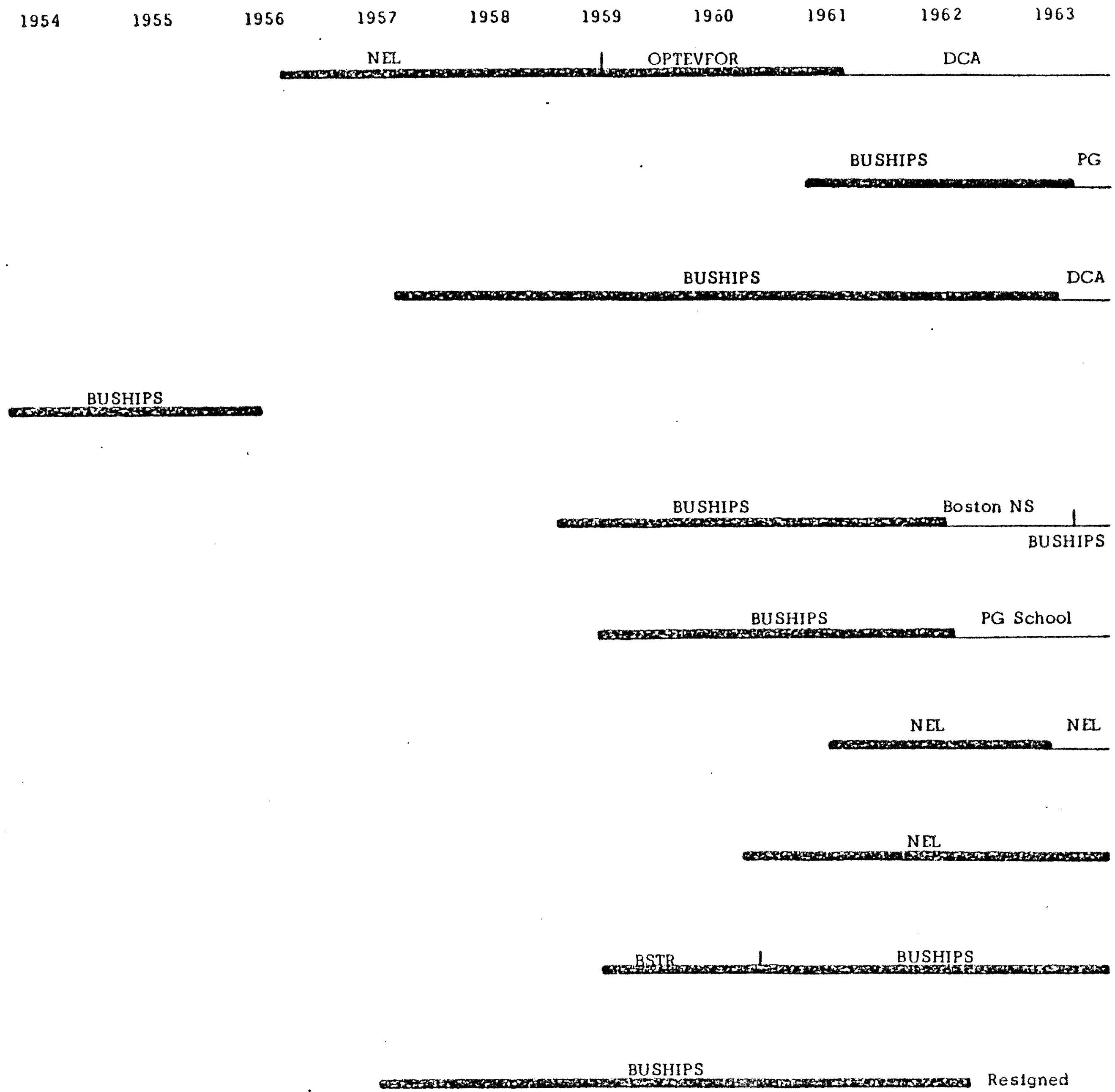
MORRIS, H. G.
Ens.
Lt JG
PG School-(in program now)

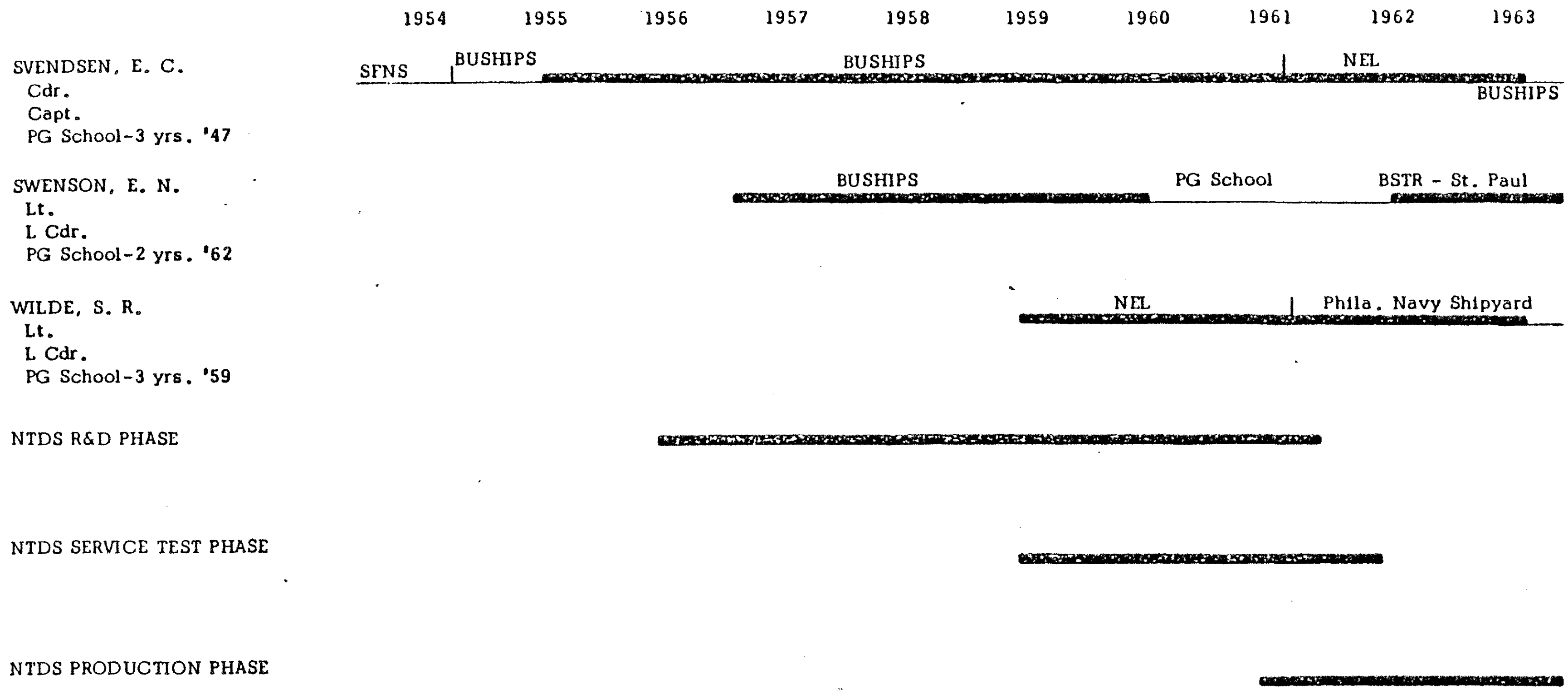
POTTER, W. W.
L Cdr.
L Cdr.
PG School-3 yrs. '59

RADJA, J. E.
Lt.
L Cdr.
PG School-3 yrs. '58

RANDOLPH, J. L.
Lt.
L Cdr.
PG School-3 yrs. '59

STOUTENBURGH, J. S.
L Cdr.
Cdr.
MIT Program-1948




1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
SVENDSEN, E. C.
Cdr.
Capt.
PG School-3 yrs. '47
SFNS
BUSHIPS
BUSHIPS
NEL
BUSHIPS
SWENSON, E. N.
Lt.
L Cdr.
PG School-2 yrs. '62
BUSHIPS
PG School
BSTR - St. Paul
WILDE, S. R.
Lt.
L Cdr.
PG School-3 yrs. '59
NEL
Phila. Navy Shipyard
NTDS R&D PHASE
NTDS SERVICE TEST PHASE
NTDS PRODUCTION PHASE

Cdr. I. L. McNally has already been mentioned as having been instrumental in conceiving the system idea. While McNally was in the Navy, he made a number of important contributions in the field of radar.

Cdr. E. C. Svendsen (later Captain) functioned as the NTDS project manager. If only one individual was to be singled out as having made an outstanding contribution to the program, it would be Svendsen. His technical competence and perserverance won him the respect of those who worked for him and with him. Mute testimony to the outstanding job he did in managing the NTDS program is the fact that he is now managing an even larger program, the SEAHAWK. From 1947-1951, he was stationed at the U. S. Navy Computing Machine Laboratory at St. Paul, Minnesota. This was a small 20-man Navy effort that worked in conjunction with Engineering Research Associates (later acquired by Remington Rand) on computer developments. It was here that Svendsen acquired his computer background and became acquainted with those individuals making contributions in this field, especially those at ERA. From 1951-1954, he was stationed at the San Francisco Navy Shipyard. In 1954, Svendsen was transferred to BUSHIPS-Washington where he was put in charge of the Special Applications Branch (SAB) of the Electronics Division. He worked with McNally on the writing of the NTDS technical requirements, and when McNally retired, assumed responsibility for the NTDS program. In the middle of 1961, Svendsen was transferred to NEL and occupied the billet of BUSHIPS Representative for NTDS Testing. In the spring of 1963, after the NTDS tests were completed, he returned to Washington to take over the SEAHAWK program.

Cdr. E. B. Mahinske joined the NTDS project office in August, 1957. He was with the program until 1963 except for a nine-month tour in 1958 on a high-priority radar project. His previous exposure to computers had been through work with one of the Navy Security Groups from 1949 to 1951.

His major function during the development phase was to oversee the work in the communications area of the NTDS. He also worked on the problem of the NTDS message format to be compatible with other U. S. (ATDS, MTDS), Canadian (DATAR) and British (ADA) data systems. Mahinske is now with the Defense Communication Agency (DCA).

L. Cdr. E. N. Swenson served in the Navy as an enlisted man before attending the University of Rochester where he went through on the G.I. bill. He was then employed by Westinghouse Electric Corp. on their Graduate Student program, until recalled for the Korean War. During the Korean conflict as an Ensign, he worked directly under Cdr. Svendsen at the San Francisco Navy Shipyard. Later, as a civilian, he went to work for Eastman Kodak as an engineer. During a reserve tour in 1956, he met with Cdr. Svendsen in Washington who persuaded him to come back into the Navy and assist him on the NTDS development. He joined the program in February 1957 and left in the middle of 1960 to attend Navy PG School at Monterrey. He functioned as a very effective administrator on the program. He handled a great deal of the administrative details personally, including cost control work. In fact, when one of the NTDS project officers was asked how the NTDS was done without a PERT/COST system, he answered, "Simple, Swenson was our PERT/COST." He is now the Bureau of Ships Technical Representative at St. Paul.

Cdr. J. S. Stoutenburgh joined the NTDS program in June 1957 and stayed with it until the middle of 1962. He had had no previous experience with computers, but had been an instructor in electronics at the Navy Academy just prior to joining the NTDS. While at Annapolis, he participated in writing a textbook on the fundamentals of electronics.

Stoutenburgh concentrated on the display section of the NTDS development. He was also a prime mover behind the TEWA (Threat Evaluation/Weapons Assignment) Committee, made up of representatives from university laboratories, contractors and Navy bureaus to investigate the threat evaluation problem. When Capt. Svendsen took over the billet at NEL in the middle of 1961, Stoutenburgh became the NTDS program manager (Code 671A). He resigned from the Navy a year later for personal reasons and is now with the TECON Company, a heavy construction firm in Dallas, Texas.

These four, Svendsen, Mahinske, Swenson, and Stoutenburgh, in the main, were the NTDS project management team. They worked together very closely and, in fact, were physically located in the same room in the Main Navy Building, Washington. While each of them specialized in certain areas (Svendsen - computers, Mahinske - communications, Stoutenburgh - displays, Swenson - administration), they knew what the others were involved in and were able to operate effectively in all areas of the program when necessary. It is estimated that 10-20 per cent of their time was spent in the solving of special technical problems associated with the system and the rest in managing the project. All four were engineers, EDO's, and naval officers with fleet experience, thus permitting rapid personal communications between themselves, as well as other EDO's. The technical or administrative problems that were not resolved by the contractors or BUSHIPS' field activities were referred to this group for resolution.

There were other key contributors. Cdr. A. M. Bettis headed up the Computer Development Section of the Special Applications Branch when Svendsen was in charge of the Branch. When Svendsen was working with McNally on the concept of the NTDS, they received part-time assistance from Bettis and one of his civil service engineers, D. L. Ream.

In the middle of 1957, Bettis was transferred to NEL and functioned as the NTDS Representative. In the middle of 1960, he went on to the San Francisco Navy Yard to oversee the outfitting of the NTDS on the two Service Test ships, the CVA-34 and the DLG-11.[1] Bettis performed a very important function as an extention of the NTDS project office at NEL and at SPNY. He is now heading the Command & Control Systems Management Office in the Technical Logistics Division of BUSHIPS, where the NTDS program is presently housed.

L. Cdr. G. E. Morgan, Jr., joined the project office in February, 1959, and was with it until the middle of 1962. He was responsible for the detailed planning and implementation of the computer programming effort for NTDS (now implemented in accordance with his planning as Fleet Computer Programming Center, San Diego, California and Dam Neck, Va.). Morgan had a Masters degree in Math and Physics from the University of Chicago and had had computer programming experience before joining the project office.

Lt. (JG) H. G. Morris was assigned to the NTDS project office in the middle of 1959 until he left for the Navy PG school in the middle of 1962. He was responsible for coordinating the installation, planning and scheduling for the Service Test equipment.

L. Cdr. S. R. Wilde was the NTDS program officer at NEL after Cdr. Bettis moved to SPNY. Wilde was responsible for coordinating the planning of the Service Test communication tests. After NEL, he was assigned to the Philadelphia Navy Shipyard to coordinate the installation of NTDS on the CG (N)-9.

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[1] The third Service Test ship, the DLG-10 was outfitted at the Puget Sound Navy Shipyard.

L. Cdr. J. E. Radja was at NEL from the middle of 1960 to the middle of 1962 where he was a major contributor to the technical support of the Service Test evaluation on the Oriskany, King, and Mahan. Here he was concerned with solving technical interface problems and collecting and analyzing NTDS technical reliability data during the BUSHIPS Technical Evaluation. He is presently working on new developments in NTDS.

The Bureau of Ships employs a large number of civilians in a variety of capacities. The Bureau's technical branches are staffed with engineers holding civil service ratings. A small number of these engineers, working in the radar, communications, and computer areas of the Bureau's Electronic Division worked full time or part time on NTDS problems throughout its development phase.

D. L. Ream, a Bureau of Ships Project Engineer, made a major contribution to the program. He worked in the Computer Development Branch, under Bettis, when the NTDS was first proposed. From 1955-1958, roughly 60 per cent of his time was spent on NTDS. This shifted to 100 per cent of his time during 1958-1961. Ream was the Bureau's computer engineer on NTDS and recognized as being an outstanding one by those within the Bureau and the contractor organizations who dealt with him. His academic background is in chemistry and physics and he taught chemistry before joining the government. Some of his early computer experience was gained with one of the Navy security groups from 1948-1953. Ream's function on the NTDS program was not only solving technical problems, but also assisting in the monitoring of the work done by the computer contractor, Remington Rand Univac. Since NEL was strong in the communications and display area and not as well grounded in the computer area, Ream's part in the NTDS development was doubly significant.

F. A. Russell was a Bureau of Ships Project Engineer in the Radar Branch of the Electronics Division. He was considered a highly competent engineer and made a major contribution in the display area of the development especially in overseeing the work done by Hughes. Russell was involved in the NTDS somewhat after the project office was formed and worked on the program on a part-time basis through the development phase.

Recognition

The above individuals within BUSHIPS have been singled out as having made substantial contributions to the development of the NTDS on the basis of opinions expressed by a number of individuals closely associated with the program. Recognition by authority outside the program went to three of them. For their part in the program, Svendsen, Mahinske, and Stoutenburgh received the Legion of Merit, the highest award in peace time to officers of less than flag rank. Others made significant contributions but evidence of any major recognition of their role is lacking.

Navy Electronics Laboratory

NEL functioned as the lead laboratory on the NTDS and was responsible for the testing of the system. NEL is a Bureau of Ships laboratory with major facilities at San Diego, California. They do some work for other agencies, but assignment is made through BUSHIPS. The present scientific endeavors of NEL are directed to three areas, underseas technology, electromagnetics technology, and data systems and evaluation. The largest effort is in underseas technology. NEL is well equipped to undertake research work in any of these areas. NEL presently employs about 1,100 people of which about 500 are scientists or engineers.

NEL-Organization of NTDS Development

The civilian structure at NEL, at the time the NTDS project was being established, was headed by a Chief Scientist or Technical Director. Under the Chief Scientist there were two Associate Directors, each responsible for certain research areas, with a Division Head over each area. One of the Associate Directors had three Division Heads reporting to him, Sonar, Electro Magnetics, and Systems. The Systems Division was headed by C. S. Manning. In addition to this organization, a Dr. Halstead, in charge of a Computer Programming Group, reported directly to the Technical Director.

Manning's System Group had three branches. The Special Equipment Branch was headed by R. G. Nye, the Operations Analysis Branch was operated by M. J. Sheehy and the Data Processing Systems Group was headed by W. P. Mitchel. When NEL became involved in the NTDS, the program was placed in the Systems Division and Manning, in effect, became NEL's NTDS Project Director. Another group at NEL became involved in the NTDS but was not under the jurisdiction of the Systems Division. This was the Communications Technique Group headed by H. G. Wolff.

When NEL was first approached concerning the NTDS, there was some question as to the role they would play. There were thoughts expressed that NEL should take over complete management of the program rather than just provide technical assistance to the BUSHIPS project office. However, control of the program did remain with BUSHIPS.

The work on the NTDS program at NEL was performed under various "problem numbers" or "tasks." Since NEL is under BUSHIPS cognizance, these tasks are normally originated by BUSHIPS. The formal procedure is for such a work request (sometimes with a fixed cost ceiling) to come through the Technical Director of the Laboratory.

It is then discussed with the Section Head or Division Head that might be interested in the problem. After evaluating the technical and manpower aspects of the problem, it is turned over to the particular Branch Head who would be involved. He then develops a proposal estimating the cost of materials and amount of manpower necessary to reach a solution. This proposal is then reviewed up the line within NEL and BUSHIPS before a problen number is assigned and work begun. Because of informal lines of communications that have been established between various technical groups within NEL and their interested counterparts in BUSHIPS, this procedure, in some cases is a formality. Often times the problem has been thoroughly discussed on an informal basis between the technical parties concerned before a proposal is written. As an example, E. E. McCown, NEL's display expert would, in many cases, correspond directly with Russel, BUSHIPS display man informing Manning and Svendsen of the results, after agreement between themselves.

The work done at NEL on the NTDS development was done under approximately a dozen problem numbers. Appendix B contains a brief description of some of these problem numbers. The title of the problem, its objective, when it was accepted, some of the major tasks accomplished, and the NEL Technical group involved are noted. The first three problems established at NEL (in late December, 1955) in connection with the NTDS, were concerned with providing BUSHIPS with technical backup in three major areas of the development; displays, communication, and system design. Once contractors were established in these areas, the work under these problem numbers included monitoring Hughes, Collins, and RRU. Another problem number (J3-3) was established to cover the setting up and operating of the experimental NTDS in the

ASDEC area. Several problems were written covering computer programming and data conversion. Finally, toward the end of the development phase, a problem was established to extend some of the NTDS techniques to the design of a Small Ship Combat Direction System (SSCDS).

ASDEC

As mentioned earlier, one of the chief functions of NEL in the NTDS program was the assembling and testing of the various pieces of hardware in a mockup of the system. The Applied Systems Development and Evaluation Center (ASDEC) at NEL had been used to evaluate other, less complex systems. The initial hardware contracts let to Hughes, Collins, and RRU were for the supplying of system components for the setting up of an experimental NTDS in ASDEC. The testing of this mockup in ASDEC commenced in April 1959 and was completed in November 1961. This work provided valuable experience in operating and servicing the equipment and in programming the unit computer.

System Definition

When first involved in the NTDS, NEL produced a document that defined the system in sufficient detail to be of value to the contractors in hardware design and an aid in putting together the NTDS mockup. This document was referred to as the "Blue Book" and was published in September, 1956. Revisions were issued up through 1957. Even before the ASDEC tests were finished, a series of "Purple Books" were written describing the NTDS Service Test instrumentation for the DLG-10, DLG-11, and the CVA-34.

Key People at NEL on NTDS Development

There were a number of individuals who made valuable contributions to the program, either through effective administration of a technical team or by providing solutions to technical problems. Brief background sketches of some of these individuals are contained in Appendix C. C. S. Manning as the project manager at NEL, E. E. McCown, one of the Navy's leading experts in the field of displays, R. P. McManus, a major contributor in the communications area and largely responsible for coordinating the installation of the experimental NTDS in the ASDEC and forcing the solution to many interface problems between contractors and equipments involved in the program, and M. Sheehy who headed the Operations Analysis Branch were some of the key people on the program.

NEL issued a number of outstanding performance awards to individuals or groups for work done on the NTDS. These awards carried a cash prize of up to $300. At least two group awards and a dozen individual awards were made for work done by NEL personnel on the NTDS. In addition, Dr. Halstead received the Laboratory's "Outstanding Scientist of the Year" award for his work on NELIAC, a computer compiler involved in the NTDS development.

Source of Technical Manpower at NEL

In its buildup to handle NTDS problems, NEL never resorted to mass hiring. A number of individuals working on NTDS problems came to this work from other groups within NEL. Some outside hiring was done. NEL had the problem any government laboratory had, in not being able to compete on the same salary level as industry, especially in the aerospace field in whose area they were geographically located. In the late 50's, a number of top level people at NEL were lost to industry. This exodus did not appear to have seriously affected the NTDS program.

Engineering Manpower Spent by NEL on NTDS

Appendix D contains charts of the engineering manpower expended by NEL on some of the key NTDS problems from 1957-1961. Total man-months of engineering time charged to the various NTDS problems from January 1957 to July 1961 are listed below.

Problem Number	Title	Engineering Man-Months Charged from 1/57-7/61
J3-2	System Analysis	536.4
N4-3	Displays	992.0
N4-6	Communications	945.8
R1-5, 7	Electronics Maintenance	224.4
J3-3	Experimental NTDS	1,370.1
N4-4,7,9	Data Conversion and Processing	172.1
N4-10	Computer Programming	715.3
N5-6	Human Engineering	32.9
J3-4	SSCDS	83.4
N4-5	?	10.5
N4-8	?	16.3
	Total	5,100.0

Total costs (labor, materials, overhead) charged against NTDS problems for the years 1957-1961 are listed below:

1957	$1,099,377
1958	1,806,287
1959	2,201,527
1960	2,108,870
1961	2,140,441
	$9,356,502

The NTDS program utilized a substantial percentage of the total laboratory's scientific and engineering manpower. Below is a table showing approximate total manpower at NEL and manpower charged to the NTDS for the period 1957-1961.

Year	Approximate Total Number of Engineers & Scientists Employed at NEL	Approximate Number of NEL Engineers & Scientists on NTDS	Per Cent of Total on NTDS
1957	420	60	14%
1958	430	110	26
1959	440	130	30
1960	450	110	24
1961	460	60	17

Training of Military Personnel to Operate NTDS

Another function of NEL not previously mentioned in relation to the NTDS development was the formulation of the military training program for the system. A decision was made early in the development that Navy operating personnel should be strongly involved in the evaluation of the experimental NTDS in ASDEC. Since these people would be handling the system if it should become operational, their evaluation of it from a functional point of view was most important. In addition, since they were line personnel, they were well aware of operating problems that the developers of the system might not be aware of.

In the middle of 1958, a small group of officers and enlisted men were assigned to NEL and became the nucleus of the military training group. Initially they were working with wooden mockups of the display consoles until the first displays were delivered from Hughes toward the end of 1958.

Capt. J. F. Felter (then Cdr.) headed up this first group. Cdr. B. F. Brown headed up the CIC evaluation team at NEL during the testing of the experimental NTDS and made major contributions to the formulation of functional specifications of the Service Test system. Cdr. E. L. Ball was another of Felter's officers. He was the Weapons Officer assigned to the CIC evaluation and made an excellent contribution to the formulation of interface specifications between the NTDS and fire control systems.

Once the Service Test planning was approved, the need for trained Navy personnel to operate and maintain the system became a requirement. Capt. Felter was instrumental in getting authorization from the Navy to establish a training facility for operating personnel.

By the end of 1959, a training program for military personnel including computer programming school was being established at NEL. Cdr. F. N. Quinn organized and implemented a complete training program for military personnel (maintenance, programming, and operator training). The initial group that went through this training facility were the Navy personnel that operated the Service Test NTDS. They trained at night in the ASDEC facility since this was the only complete shore-based system that existed before delivery of Service Test equipment. This school was eventually moved to the Fleet Anti Aircraft Warfare Training Center (FAAWTC) at San Diego. Cdr. R. E. Sink organized the first computer programming school for the NTDS. Remington Rand Univac assisted in the operation of this school. Graduates from this training establishment formed the nucleus of the Fleet Computer Programming Center, Pacific (FCPCP) that was commissioned in July, 1961, as a part of FAAWTC.

The training of operating personnel, while not a major consumer of scientific and engineering talent and hence not the focus of this study, was vital to the success of the NTDS. One of the major arguments within the Navy against the adoption of the NTDS, was the question who would operate and maintain such a complex system? Mute testimony to the success of the training program was the fact that Navy personnel operated and maintained the Service Test equipment aboard the three Service Test ships without the assistance of contractor personnel.

CNO-NTDS Development Organization

The NTDS has been described as having about the same effect on naval operations as the introduction of steam power had. There is no question that there was a strong body of opposition to the introduction of such a system within the operating arm of the Navy. One informal survey among Navy line officers during the early development phase showed the feeling to be 20 to 1 against the NTDS. Many fleet personnel with little technical understanding of the proposed NTDS looked upon the system as being a threat to the "divine right of command."

As the NTDS would not have been a success without a strong technical organization and a competent training group involved in its development, so it also needed strong backing from within the Chief of Naval Operations (CNO). The fact that Adr. Burke, Chief of Naval Operations backed the NTDS concept during its formative stage was extremely important to its ultimate success. In addition, there were other top ranking officers in CNO who took a personal interest in the program and as a result an NTDS project office was established within CNO.

Capt. Van Leunen, Jr., and Cdr. Foote formed the CNO-NTDS project office in 1956-1957. At the beginning of 1958, Capt. Folsom joined the group. He had had some computer programming experience at the Navy War College simulating combat situations. Cdr. Swallow and Cdr. Butcher contributed significantly as part of the CNO-NTDS project office. This project office was continually engaged in briefing Navy personnel on what the NTDS was all about. Military explanation of the program was an important function performed by this group. They were also responsible for solving problems involved with making the system fleet operational. As the NTDS was going through the Service Test, problems were still evident of the reluctance of line officers to accept a system that required new thinking, and one that they felt was too radical in composition. Yet, without the previous groundwork laid by the NTDS group in CNO, the lack of system knowledge could have been of such a scale to have seriously impaired its success.

Chapter V
REMINGTON RAND UNIVAC'S ROLE IN THE NTDS DEVELOPMENT

Remington Rand Univac's St. Paul Group was responsible for the development of the unit computer and the system engineering on the NTDS. In their capacity as the system designer, they served as the "lead" contractor on the NTDS.

Early Background

Remington Rand Univac was a division of the Sperry Rand Corporation formed through a merger of the Remington Rand Company and Sperry Gyroscope Incorporated in 1955. The Univac Division was the computer development arm of Remington Rand and evolved from acquisitions in the early 50's of Engineering Research Associates, Inc. and Eckert-Mauchly Computer Corporation.

Eckert-Mauchly was established by a group of engineers who had worked on computer developments during World War II at the Moore School, University of Pennsylvania. Engineering Research Associates was founded in St. Paul, Minnesota in the late 40's by a group of ex-Navy personnel who had been associated with the Navy Computing Machine Laboratory, Dayton, Ohio. Under ERA they continued researching computers for the Navy.

Computer Work at Univac

Several of the programs under development at RRU's St. Paul operation in the early and mid-1950's contributed to their later work on the NTDS. One of these called for the development of a special purpose computer. In the 1955-1956 period a computer called MAGSTEC was built under this project. The computer utilized magnetic circuitry, more reliable and faster in operation than vacuum tube circuitry. Magnetic circuits turned out to be a level below transistors and were not utilized in the construction of the NTDS unit computer. However, the work on MAGSTEC answered a number of questions concerning computer design that were pertinent to the NTDS development. MAGSTEC was followed closely by TRANSTEC, an experimental computer built using transistor circuitry. This work was done in 1956-1957 and when completed, represented the largest transistorized computer then in evidence. Work on MAGSTEC and TRANSTEC was government sponsored.

Another development that contributed indirectly to the NTDS was work that St. Paul had done in developing a general purpose, stored program, vacuum tube computer for the Navy. This work eventually led to the building of a commercial scientific computer called the 1103. The 1103 was used extensively by the St. Paul engineers in the design of circuitry for the NTDS computer. The mechanized designing of the unit computer is credited with speeding up the design procedure by a considerable factor.

In 1955 the Univac-St. Paul group had the task of developing a ground guidance computer for the Titan I missile. This was an Air Force project called ATHENA. One of the major technical efforts on ATHENA was the development of a high degree of reliability on the part of the electronic components. The knowledge gained in the area of reliability was used extensively in the NTDS development.[1]

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[1] A measure of the reliability of electronic equipment is its mean-time-to-failure. In the case of the unit computer, BUSHIPS initial goal was 200 hours. In fact, the initial MTF of the unit computer turned out to be 1500-1700 hours and has since been exceeded. In a system such as the NTDS, this degree of reliability is essential.

No measure of the engineering manpower expanded on these developments is available. The MAGTEC and TRANSTEC work consumed a small number of engineers compared with the NTDS. ATHENA was a considerably larger program in terms of manpower than the NTDS. There is no evidence of any project work undertaken at St. Paul in the programming and systems area that contributed directly to RRU's role as the system designers of the NTDS.

The concept of the NTDS was first presented to the St. Paul group by the Bureau of Ships in late 1955. One of the fundamental questions asked of RRU by BUSHIPS at this time was, "Can you design a computer that will work in a shipboard environment?" The idea of the system originated with BUSHIPS and none of the contractors engaged in extensive "selling" efforts. Remington Rand Univac-St. Paul was working for the Navy in a number of areas at this time under a long-term contract Nobsr 63010. Development work on the NTDS began in late 1955 with the establishment of several new tasks[1] under Nobsr 63010.

There were no Requests for Proposals sent out by the Bureau of Ships on the computer or systems development. The principals involved at BUSHIPS, Svendsen and MacNally, had surveyed the field extensively in late 1955 and were aware of the capabilities of possible contractors in this area. Svendsen was especially familiar with the technical capabilities of the individuals at RRU-St. Paul. On the basis of the work being done at St. Paul and the technical competence of the engineers involved, the decision was made to award RRU the contract for the

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[1] Contracts such as Nobsr 63010 and later 72769 established the general terms under which Univac did business with the Navy. There was no price or performance discussed. They simply stated that from time to time, various tasks would be undertaken. These tasks were then agreed upon between BUSHIPS and Univac, and spelled out in a firm contract although the work definition might be fairly short. This was possible only because of the resident BUSHIPS office (BSTR) which directly participated in the task execution on a day-to-day basis.

Organization of the NTDS Development Within RRU-St. Paul

At the start of the NTDS program within RRU, the St. Paul operation was organized into two major groups, both reporting to a General Manager, Mr. Norris. One group was concerned with military systems, the other with commercial computer developments. The military systems area contained about 65 per cent of the technical manpower at St. Paul and was headed by F. Mullaney. There were a number of projects under Mullaney, one of which was the NTDS program. From the start the program at St. Paul was strongly project-oriented. There was one individual in charge of the various tasks involved in the development, with the title NTDS Project Manager. Almost from the start the work under the Project Manager was separated in two areas, each headed by an Assistant Department Manager. One group, the Development Engineering Section, was concerned with the construction of the unit computer. The other group, Systems Development Analysis and Programming, was involved with the system design of the NTDS.

NTDS Contracts

All of the BUSHIPS contracts involved in the development stage were cost plus fixed fee (CPFF). Contract dates were met and no overruns of the agreed to contract costs were evident.

The NTDS program at RRU started with the issuing of Task 44[1] under Nobsr 63010. The objective of this project was to make available to the Navy an inventory of reliable computer components from which

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[1] Actual work began before the issuing of a contract or task order. Apparently this was not unusual especially with Navy contracts. The contractor was assuming all the risk, but he may have been willing to take this risk if the project was sound, and it appeared certain that the contract would be funded.

evaluation/weapon assignment studies. When Task 46 was completed, work in this area was continued under Task 51. Task 51 amounted to about $3.5 million. Under this task certain peripheral components were developed including video processing equipment, unit display console, and magnetic tape units.

During 1959, a number of NTDS tasks (6, 7, 8, 9, 12, 13) were established under a new BUSHIPS contract, Nobsr 72769. Some of these were concerned with the development of additional peripheral equipment. The largest tasks in terms of dollars and manpower were Task 6, involving programming for the Service Test, and Task 9, which was an extension of Task 51.

The Service Test computers were designed and built under BUSHIPS contract Nobsr 75750. This was established in late 1959 and ran into 1962. It amounted to over $10 million. Under this contract, RRU delivered 17 unit computers, termed the AN/USQ-20, and various pieces of peripheral equipment. The unit computer AN/USQ-20 was redesigned from the AN/USQ-17, under 75750. About 80 per cent of the engineering manpower charged to this contract was in the area of engineering design. (It is estimated that manufacturing costs on the Service Test computers amounted to roughly $8 million of which about $1.5 million was for engineering labor.)

In 1960, several small BUSHIP contracts were awarded to RRU covering the design and construction of equipment for interfacing the unit computer with the rest of the system.

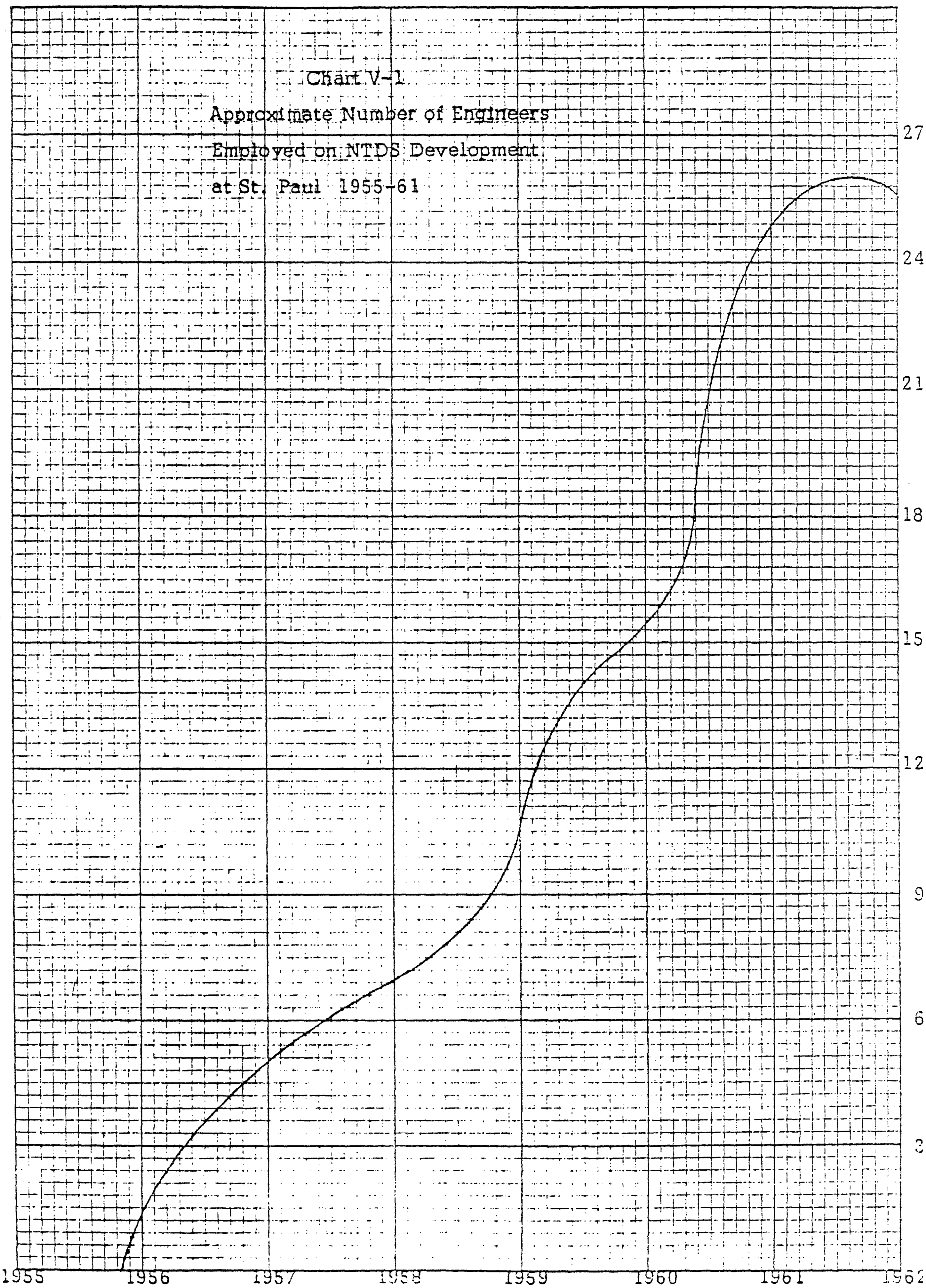
Nobsr 85214 was awarded in the beginning of 1961 to RRU. This was for the production of such peripheral equipment as magnetic tape units, system monitoring panels, and card testers. In April 1961, Task 6 (Service Test programming) was extended by the award of BUSHIPS contract Nobsr 85400.

Engineering Manpower Utilization on NTDS Contracts

Chart V-1 is an overview of the total engineering manpower expended by RRU on the NTDS both in the areas of computer development and system design. Chart V-2 shows the buildup on Task 48, the development of the R&D unit computers. Chart V-3 depicts the engineering manpower utilization on 75750, the construction of the Service Test computers. These charts are based on monthly NTDS personnel reports filed with BUSHIPS. The system design area involved the establishment of a programming group at NEL in San Diego in addition to the work at St. Paul. Chart V-4 is an overview of the system development effort of RRU at both locations as carried out under Tasks 46, 51, 6, 9, and Nobsr 85400. Charts V-5 and V-6 break down the systems effort by major task areas at St. Paul and San Diego.

The curve depicting total engineering manpower utilized by RRU on the NTDS development, Chart V-1, shows a continual buildup of engineering talent from the projects inception in 1955 to the end of the development phase in 1962. Data is not available to judge how effectively this talent was utilized. Detailed personnel records and interviews with many of the participants in the program would be required before valid conclusions could be drawn. Data on the buildup of Task 48, the development of the R&D unit computer, and Nobsr 75750, the development of the Service Test computer, shows a rapid increase in numbers of engineers employed and then an equally rapid decrease after the peaking of these projects. One can conclude from this data that once

Chart V-1
Approximate Number of Engineers
Employed on NTDS Development
at St. Paul 1955-61



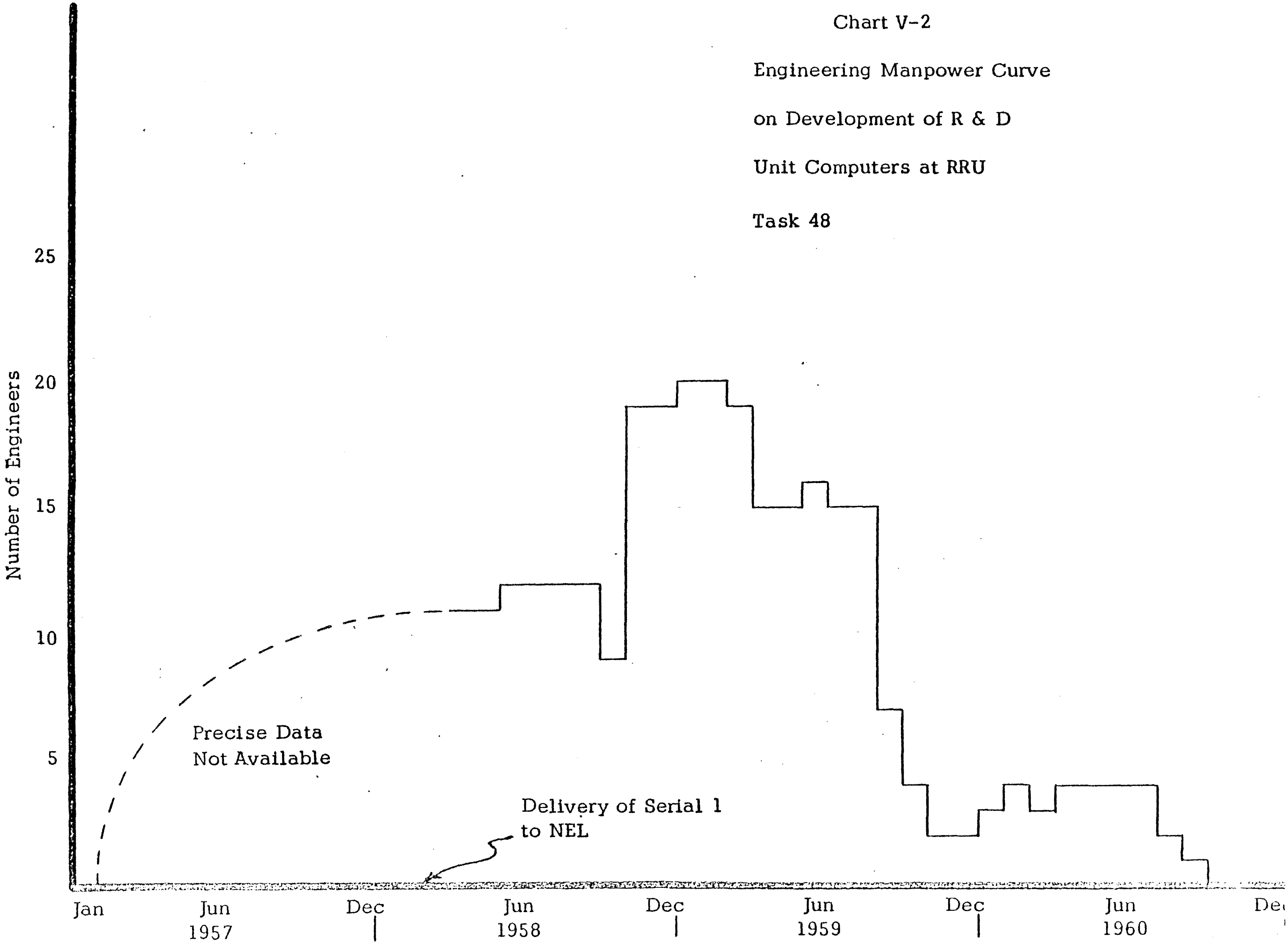


Chart V-2

Engineering Manpower Curve

on Development of R & D

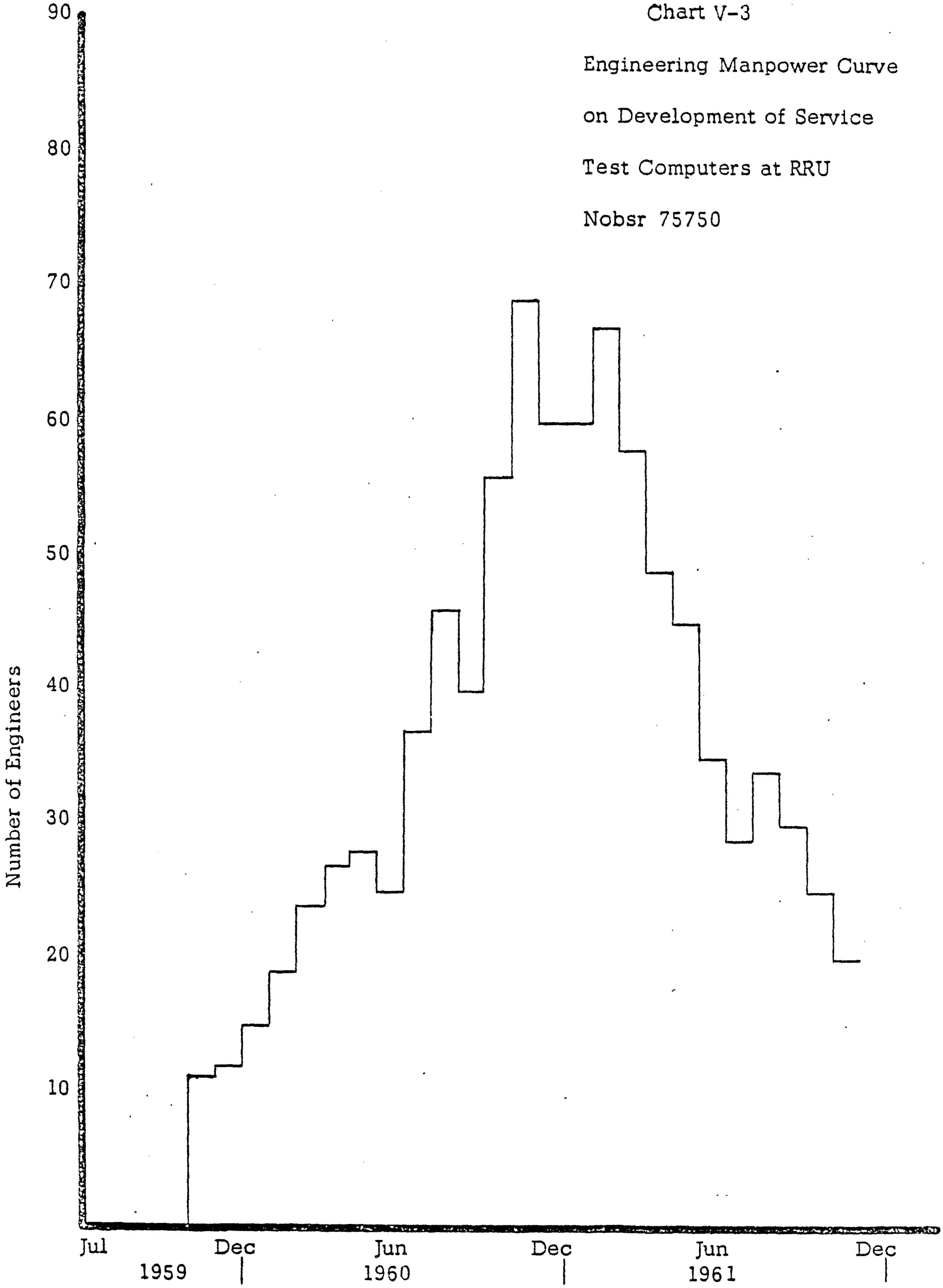
Unit Computers at RRU

Task 48

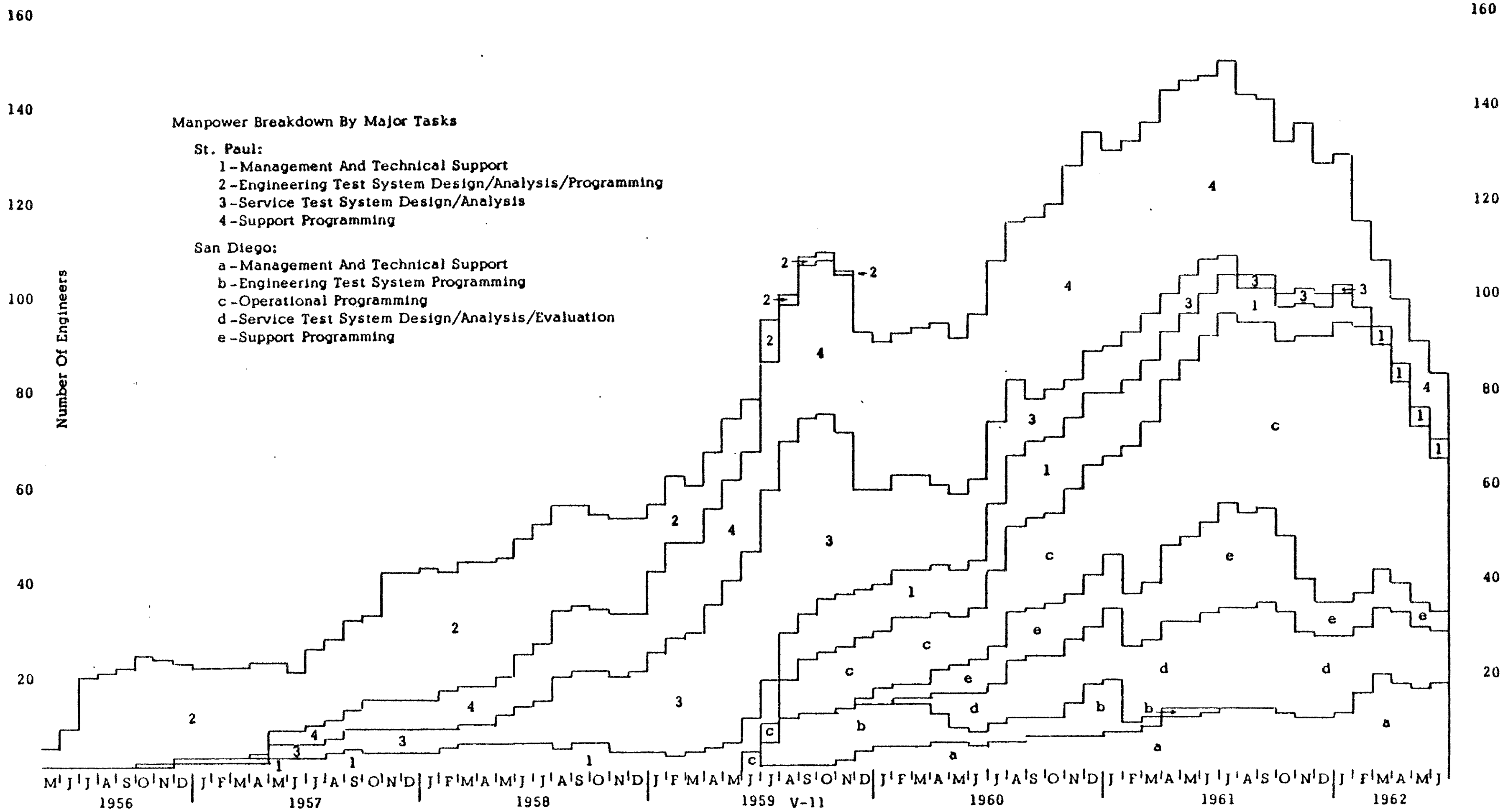
Chart V-3

Engineering Manpower Curve on Development of Service Test Computers at RRU

Nobsr 75750



V-4
Engineering Manpower Expended By RRU At St. Paul And San Diego On Systems Development Phase Of NTDS 1956 - 1962



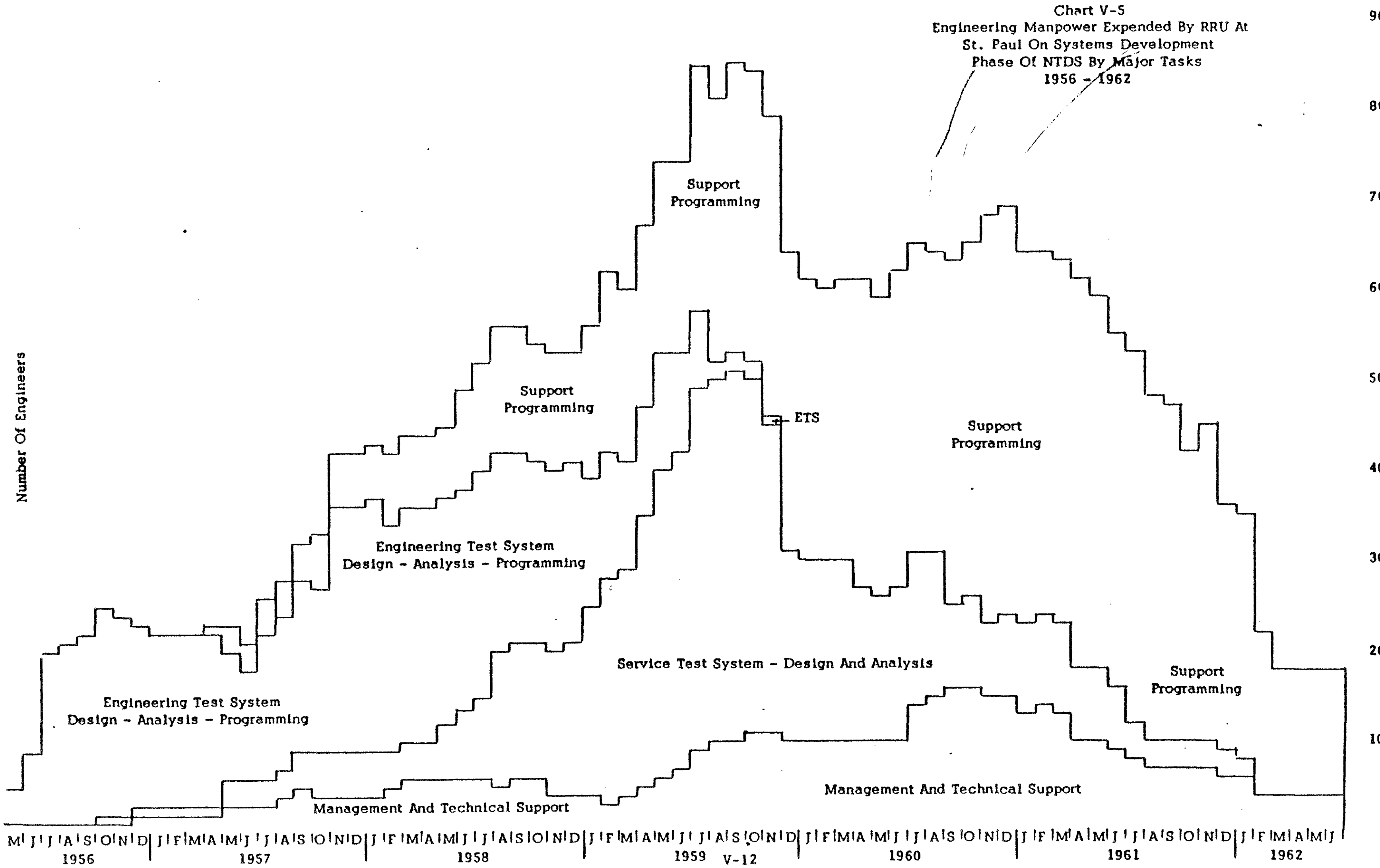
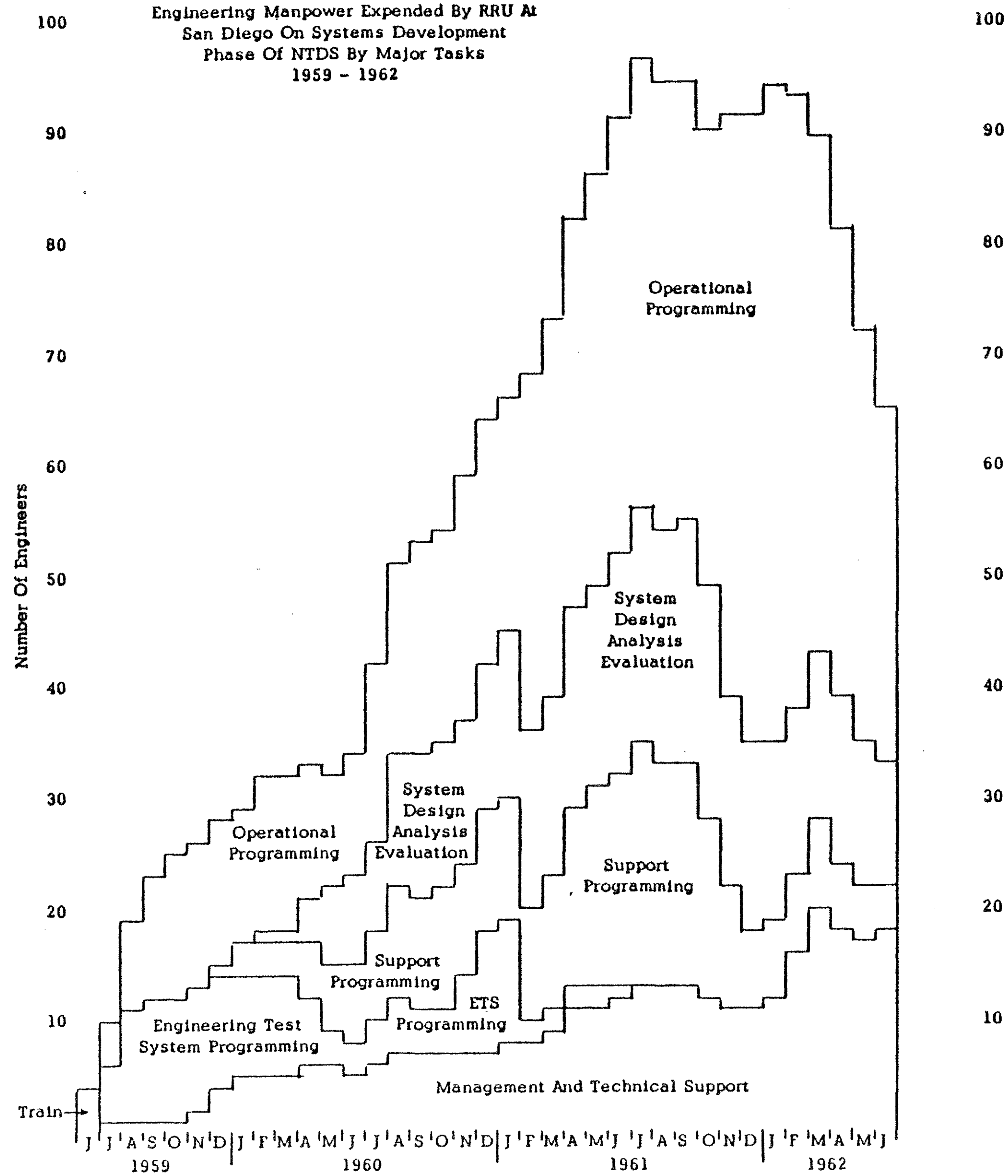


Chart V-5
Engineering Manpower Expended By RRU At St. Paul On Systems Development Phase Of NTDS By Major Tasks 1956 - 1962
Number Of Engineers
90
80
70
60
50
40
30
20
10
Support Programming
Support Programming
ETS
Support Programming
Engineering Test System Design - Analysis - Programming
Service Test System - Design And Analysis
Support Programming
Engineering Test System Design - Analysis - Programming
Management And Technical Support
Management And Technical Support
1956
1957
1958
1959
1960
1961
1962

Chart V-6
Engineering Manpower Expended By RRU At San Diego On Systems Development Phase Of NTDS By Major Tasks
1959 - 1962



the specific job was finished, engineers were not kept on this particular phase of the program until further work developed. They either moved to other phases of the NTDS or left the program completely. Charts V-4, V-5, and V-6 show the same buildup and drop off in engineering manpower in relation to the systems development effort of RRU. These charts were prepared by RRU and an exact interpretation depends on the definitions they have applied to the various task areas indicated. This information is not available. As with the analysis of Task 48 and Nobsr 75750 data, it can be seen that system development tasks built up and then phased out. There is little evidence of plateauing. Again, the lack of plateauing could be interpreted as indicating full utilization of those engineers charged to the systems development phase of the NTDS.

The following chart shows the relationship of total professional employment at RRU-St. Paul and the approximate number of professionals employed at St. Paul on the NTDS program from 1955-1961. Professional employment at RRU-St. Paul consists nearly entirely of degree-holding engineers.

Year	Approximate Total Number of Professionals at St. Paul	Estimated Number of Professionals on NTDS	Per Cent of Total on NTDS
1955	230	15	6
1956	430	35	8
1957	900	60	7
1958	1000	80	8
1959	850	140	16
1960	1550	200	13
1961	1890	260	14

There were two other large military programs underway at St. Paul during the time of the NTDS and both consumed more engineering time. One was the ATHENA program previously mentioned. The other was the TACS program. This was an Air Force contract that called for the development of a reporting and control system.

Source of Engineering Manpower

Remington Rand Univac had a substantial operation in Philadelphia as a result of their acquisition of the Eckert-Mauchly Computer Corporation. This group was concerned with commercial computer developments. One of their developments was the LARC (Livermore Automatic Research Calculator), a solid-state digital computer built for the AEC. While it might appear that the Philadelphia operation would have been a source of technical talent and ideas for the NTDS development, in reality there was very little communication between St. Paul and Philadelphia. In fact, St. Paul initially competed with Philadelphia for the LARC development. Both submitted proposals to the AEC. Remington Rand Univac also had a research operation at South Norwalk, Connecticut. Again, there was no exchange of engineering manpower between this group and St. Paul.

Within the St. Paul operation there was little transferring of technical manpower between the commercial and military areas.[1] Most of the project work undertaken at St. Paul was for the military.

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[1] It is interesting to note that there has been some fall-out in the commercial area from the development of the NTDS computer. RRU is marketing a commercial computer called the 490, which is a repackaged version of the AN/USQ-20, the Service Test computer. Their 1206 is an exact replica of the AN/USQ-20. The 1218 is closely related to the AN/USQ-20B, the NTDS computer RRU is presently producing.

The staffing of the NTDS program was accomplished by transferring people from one of the two major government projects then in the house, the ATHENA and TACS programs. Concurrently, a considerable number were hired on the outside. The exodus of certain key individuals to the Control Data Corporation (CDC) aggravated the staffing problem.

The Development of the Unit Computer

The development of the TRANSTEC and MAGSTEC computers allowed operational evaluation of several new electronic components, primarily transistors. These solid-state devices permitted a substantial reduction in the physical dimensions of a computer and at the same time increased its degree of reliability. Without their development, the unit computer would not have been built. Task 44, the first contract work by RRU on the NTDS involved an extensive evaluation of these components. S. R. Cray was responsible for the circuit design of TRANSTEC.

Cray was the NTDS Project Supervisor for RRU from the start of the program in late 1955 until he left Univac in the middle of 1957. The initial work on the unit computer consisted of circuit design work. Cray, almost singlehandedly, put together the circuit and logic design for the unit computer. He made extensive use of the 1103 computer in checking design logic. A more radical computer design was being advanced by others within Cray's group, but it was dropped because it appeared impractical.

When Cray left in July, 1957, he was supervising Task 44, 46, and 48. J. E. Thornton who had been working for Cray became the Project Supervisor of Task 48, the development of the unit computer. In the summer of 1957, actual construction of the six R&D unit computers began. This work did not follow the normal product evolution pattern of first constructing a breadboard model, then a prototype, then a production model. The breadboard version was bypassed and work began on the assembly of the R&D computers. In January, 1958, Thornton became NTDS Project Supervisor (Dr. Coon had succeeded Cray), and D. H. Toth was appointed Project Supervisor of Task 48. He had been working on the TRANSTEC computer.

The six R&D computers were built essentially one at a time, and therefore advances in the state of the art were incorporated as progress was made. The six computers incorporated 32,000 words (of 30 bits) in their core memories. The packaging of the computers was changed after Serial 4 was constructed to permit easier maintenance access. Serials 1, 2, and 3 were completed by the end of 1958 and two of them were delivered to NEL. One was retained at St. Paul. Serials 4, 5, and 6 were assembled and debugged by the spring of 1959 and delivered to NEL. Toth left Univac shortly before the completion of Serial 6.

By now attention was being directed toward the design of the Service Test unit computers to be built under Nobsr 75750. The six R&D computers had been developmental models and had not been built using Military Specifications. However, the Service Test computers would have to be built with MIL Specifications in mind. The specifications on other data systems such as MTDS (Marine Tactical Data System) and ATDS (Airborne Tactical Data System) were beginning to read, "compatible with NTDS." Transistor technology had been advancing to the point that it was felt higher performance components were available than those used in the construction of the R&D computers. Also, it was necessary, from an operational standpoint, to redesign the mechanical packaging of the computer.

R. J. Malone was now heading the Computer Development Group. V. Leas had been brought into the NTDS program from ATHENA to act as the project's coordinator. He reported directly to St. Paul's General Manager. In the fall of 1959, Leas assembled a small group of engineers to seriously consider the question of redesigning the computer. They presented their findings to Univac-St. Paul's top management with a firm recommendation that redesign be undertaken. With the approval of top management, the case was then presented to BUSHIPS in January, 1960. With the understanding that the original time frame on the delivery of the Service Test computers would not be jeopardized nor increased material costs incurred, BUSHIPS accepted the program for redesign. A. P. Hendrickson was named NTDS Department Manager with Leas still acting as coordinator.

Two groups were immediately established to carry out the mechanical and electrical redesign of the computer. Mechanical improvements were incorporated and the circuitry was revamped. The groups completed their work by the spring of 1960. Malone left Univac in May, 1960. Construction of the Service Test computer was initiated in the summer of 1960 and delivery commenced by the end of the year.

System Design of the NTDS

The system design of the NTDS began with Task 46 under the direction of M. Macaulay. One of their major initial tasks was to construct programs for the computer Cray was designing. Macaulay left Univac in September, 1958, and founded his own company, Data Display Inc.

At the time he left, Task 51 had been established as a continuation of work under Task 46. G. G. Chapin was appointed Supervising

Engineer. He continued as supervisor of the system development effort through the Service Test phase. Remington Rand Univac had described their total effort in the systems area of the NTDS development as comprising the following missions:

1. Functional Specifications for all UNIVAC-produced equipment including the AN/USQ-17 and AN/USQ-20 computers.

2. Functional Specifications for portions of non-UNIVAC produced equipment.

3. Over-all NTDS system design, including display and communication interfaces, man-machine relationship, grounding system, I/O specifications, system recovery, etc. (Much of this was generated by NEL, not RRU.)

4. Mathematical analysis.

5. Mathematical and Operational Specifications for entire system and each system function.

6. Operational Program design, production, and checkout.

7. Support Programming, including data reduction, simulation, input/output, conversion, mathematical and program diagnostic routines.

8. CS-1 compiling system, including preliminary user training and all documentation.

9. Operations Research and Modeling for the Threat Evaluation/ Weapons Assignment problem. (Much of this was generated by NEL, not RRU.)

10. System integration and checkout, including Programmed Operational and Functional Appraisal (POFA) programs and procedures. (Applies to Service Test, not experimental NTDS.)

11. System checkout tests and procedures for the operational system.

12. Establishing and operating two computing centers.

13. Design and conduct of tests conducted at land-based site and at sea for Service Test phase of development.

14. Evaluation of system performance.

15. Documentation of all aspects of job.

It should be noted that the systems group developed a substantial effort at San Diego to aid in the ASDEC tests and provide programming assistance for the Service Test. Chart V-6 shows the manpower utilization at San Diego.

The system area produced little hardware. It was the most nebulous aspect of the program and the most difficult to measure. It was also the "meeting ground" for all the contractors' contributions and the Navy's technical and operational requirements. There was bound to be friction between various parties at this stage. This development was no exception. The surprising thing is that in view of the complexity of the system, more friction did not develop.

In providing the over-all system design, it was necessary to assemble a small scale NTDS complete with radar sensors for live target inputs. In late 1957, such a Development Center was established at RRU-St. Paul. This modified system aided materially in studying the interfaces between system components and man-machine relationships.

Key Individuals

As in the case of the government and other contractors groups involved in the NTDS development, there were many individuals at Remington Rand Univac that made important contributions. There were a number whose names were mentioned frequently by those familiar with the program.

S. R. Cray was the major contributor to the design of the original unit computer. He is considered to be one of the world's leading computer engineers. While some of his work was improved upon in the redesign phase, the basic design was still Cray's.

Thornton and Toth were further contributors in the computer development area and continued Cray's work after he left. Macaulay materially aided the program in its earlier stages in the systems design area. Chapin was responsible for the bulk of RRU's efforts in the systems area. Hendrickson, under N. T. Stone, chief engineer, was instrumental in bringing about the redesign of the unit computer, a major task in view of the time and financial constraints placed upon it. Osofsky, Pence, Grahamberg, and Raymond aided in this effort. (Pence and Raymond came to the program from the ATHENA project.) Hileman and Slattery were two other engineers who were mentioned as having contributed, the former in the area of systems and the latter in the development of video processors. Leas materially aided the program as an able administrator during the redesign and Service Test phase.

It should be mentioned that RRU-St. Paul had a number of scientists working on research projects partially sponsored by government funds, partially by RRU. Most of their work was in the area of thin films. Among them were Dr. S. Rubens, Dr. T. Rossing, Dr. A. V. Pohm, and Dr. A. A. Cohen. Their work, while not directly involved with the NTDS, benefited the program.

Appendix E contains biographical sketches of some of the key individuals involved in the NTDS development.

Recognition

No specific award system was used at Univac to recognize the contribution of outstanding individuals. Theoretically, these individuals received recognition in the form of increased salaries and rapid advancement. There is some evidence that the corporate management of Remington Rand, located in New York City, had little knowledge of the work being done in St. Paul and therefore even less of an idea who the outstanding individuals were. As one engineer put it, "Remington Rand was an old line typewriter company, run by typewriter people, not a company that understood the kind of work ERA was doing." This is not to imply that Univac-St. Paul's top management was not aware of the contributions being made by those within its own organization. They were aware, but received no support from New York.

This lack of understanding on the part of the top corporate group was mirrored in the attitude of a number of engineers at RRU-St. Paul about the time the NTDS development was started. "I wondered whether the company was really making a profit. I didn't even know who was running the company," was the comment by one key contributor to the NTDS. There was also a feeling that Univac's Philadelphia operation had an inside edge with top management in terms of company funds although St. Paul personnel felt New York's policy in this manner vacillated to such an extent that one never really knew which operation would get the support of top management.

As a result of this attitude, many of the early contributors to the NTDS program, specifically those who had been with ERA before the acquisition, indicated a higher loyalty to the Navy, than they did to Remington Rand. Yet this loyalty did not prevent an exodus of key NTDS personnel from Univac when they felt their individual contribution had been made. It should be emphasized that these comments concerning Remington Rand's policies refer to the environment in the middle 50's and do not reflect the present day situation.

Effect on the NTDS Program of the Loss of Key Individuals

In the middle of 1957, four people, including the General Manager and the Manager and the Manager of Military Systems, left Univac-St. Paul and formed the Control Data Corporation in Minneapolis, Minnesota. Shortly thereafter, S. R. Cray announced he was leaving to join them. At that time he was the NTDS Project Supervisor. Over the next few years other key NTDS personnel such as Thornton, Toth, Malone and Stone left the program for CDC.

The effect on a research and development effort of the demise of any of its major contributors depends at what point they leave, and whether their knowledge has been passed on. Conceivably, a program can collapse with the leaving of certain individuals. Usually this is not the case. The NTDS development was no exception. People left, but the work continued and was brought to a successful conclusion. It can be argued that it may be a good thing for a program to replace key individuals with others who may take a fresh approach to the problem at hand. This may depend at what point in the program's evolution the influx of new ideas takes place.

Cray's leaving probably had the greatest impact on the program, since he was a major contributor and the first to part from it. It has been stated that most of his work was done when he left, and that he left at a plateau in the project's development. On the other hand, Cray was a strong individual and he had given definite direction to the program. This direction was not easily restored after his departure. It has also been speculated that had Cray remained with the NTDS, the unit computer may never have been redesigned, an effort that certainly increased its value.

Probably the greatest harm done to the NTDS program by the exodus of technical talent, primarily to CDC[1], was in the rumors created by people at Univac-St. Paul in the 1957 era. The effect was demoralizing on the technical staff. While individuals who had resigned indicated a willingness to stay on the job long enough to "train" their replacements, RRU could not afford, from a morale standpoint, to keep them on. The initiation of a law suit by RRU against CDC in 1957 did not improve the situation.

The Navy, and more particularly Svendsen and his people, were very disturbed over the leaving of certain key contributors. Some of the individuals notified Svendsen of their intent to resign before they told RRU. While the Navy project officers might try to persuade a man to stay on, they had no real control over the situation. The best they could do was to take such administrative action as was necessary to minimize the loss. There was some feeling expressed that the exodus of technical talent prevented Univac from fully carrying out its role as the system designers. However, the fact that contract dates and costs were met is testimony that the loss of some talent was by no means fatal and that RRU continually staffed the program with competent technical personnel.

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1 CDC was not the only company formed by those associated with the NTDS. Data Display Inc., founded by Macauley, has a number of NTDS engineers on its staff. In addition, there were a number of other smaller off-shoots, some successful, some not.

Chapter VI

THE ROLE OF HUGHES AIRCRAFT IN THE NTDS DEVELOPMENT

The Ground Systems Division of Hughes Aircraft Co., located at Fullerton, California, was responsible for the development of the display equipment for the NTDS. The Ground Systems Division had never had a Bureau of Ships contract before the advent of the NTDS. They had done a considerable amount of work in the display area with other government agencies and had a reputation as a leader in the field of display technology.

Early Background

Previous to the NTDS development, the Ground Systems Division was called the Data Processing Laboratory of Hughes Aircraft. This laboratory was organized along functional lines with three functional groups: systems, circuits, and equipment.

One of the major projects in the Data Processing Laboratory just prior to the NTDS was the development for the Army Signal Corps of a control system called the MSG-4 for the NIKE Missile. It involved a new class of displays that would convert radar data to digital signals and feed this information into a computer. This work gave Hughes a commanding lead in the area of display development and contributed heavily to its obtaining the NTDS display contracts. At this time, there were between 100-150 engineers working in the Data Processing Laboratory.

Organization of the NTDS Development Within Hughes

When the first contract for the NTDS display development was issued to Hughes in mid-1956, it was set up as a separate project within the Data Processing Laboratory, cutting across the three functional areas. A Mr. Bernie Diener headed up the project shortly after its inception. In August, 1959, Diener left and Mr. John Smith took over as NTDS project head and was with it until December, 1961.

Throughout the development phase the NTDS program was project oriented. It had a number of functional areas, including systems and circuits, within its own organization. The project was housed in a separate facility from the other projects in the laboratory and had its own clerical and procurement staff. From 1956-1961, it was a small effort in comparison to other programs of the laboratory. The table below is an estimate of the per cent of total engineering manpower of the Data Processing Laboratory that was utilized on the NTDS during the development period.

1956 —	3%
1957 —	10
1958 —	15
1959 —	10
1960 —	10
1961 —	10

A feeling has been expressed that one of the reasons the project was a success within the Hughes organization was because of its smaller size in relation to other programs in house. It did not suffer from over-management nor was it "raided" to staff other groups. If anything, there was a feeling among Hughes' engineers that the NTDS project was a desirable one to be working on because of the strong, yet small, project organization operating it.

The manpower loading charts (Chart VI-3, VI-4, VI-7) for the three development contracts do not indicate wide fluctuations in the staffing of the project. Nor do they show how effectively the personnel were utilized. In order to determine whether technical talent was stored and not continuously utilized, it would be necessary to examine personnel records in some depth and interview a cross section of the engineers assigned to the project. Since the NTDS development was a small effort in relation to other programs at Hughes, it can be concluded that if stockpiling of technical talent on the NTDS was ever in evidence it would have involved only a few individuals.

All of the work being done in the Data Processing Laboratory was under government contract. There was no company-sponsored effort taking place. The two big projects that were underway at the same time the NTDS work was in progress were the MSG-4 and a radar development, the SPS-26.

The Data Processing Laboratory was eventually reorganized and the Ground Systems Division formed. Hughes Aircraft now has four divisions: an Aerospace Division, a Products Division, a Ground Systems Division, and a Research Division. The Ground Systems Division is made up of five sections: Field Service and Support, Manufacturing and Parts Service, Radar, Systems, and Data Processing Products. The NTDS project is presently located in the Data Processing Products Section as one of four military programs.

NTDS Contracts

Hughes' work on the NTDS through the service test phase was covered under three Bureau of Ships' contracts: Nobsr 72612, Nobsr 77515, and Nobsr 77604. The first contract was a development contract that ran from 1956-1958; the second, an interim contract covering work done in 1959; and the third, the contract that covered the delivery of displays for the Service Tests. All of these were cost plus fixed fee (CPFF) contracts.

Nobsr 72612

This was Hughes' original contract on the NTDS. In the spring of 1956, BUSHIPS put out RFP's to a number of potential suppliers of display equipment for a development contract on the NTDS. Hughes had heard of the NTDS idea a few weeks before the RFP came through, but did nothing toward preparing a proposal. When the RFP arrived, Mr. Durham, an engineer at Hughes who had been working on the configuration of the MSG-4 displays, recognized that his work could be of definite value in the proposed NTDS displays. He and three or four others wrote the proposal in about three weeks. Based largely on work they had done for the Signal Corps, it was an unusually complete proposal.

The Bureau of Ships received about ten proposals in answer to their RFP. They paid a visit to Los Angeles to discuss the approach Hughes had taken to the problem. The Bureau of Ships had never worked with Hughes before and had heard that it had a reputation for doing excellent but expensive technical work. For these reasons there was some reluctancy among certain Navy personnel to award the contract to Hughes. The contract was finally awarded to Hughes about two months after the receipt of the RFP. The basis of the award was the three years' research experience Hughes had developed through their work on the MSG-4, knowledge that was evidence in the depth of Hughes' proposal.

Work on 72612 began in July or August of 1956. It was split into two phases. Phase I was a short study program that ran until January, 1957. In the meantime, NEL issued its Blue Book outlining in some detail the specifications in the display area. In January, 1957, Phase II was started. This ran through 1958 and into 1959. Under this program a full display system was developed and sent piecemeal to NEL beginning late in 1958, for evaluation in the experimental NTDS in ASDEC. A minimum system was sent to RRU and a minimum system retained by Hughes. Nobsr 72612 amounted to approximately $9 million.

Hughes listed as the objectives under the development contract the following:

1) Simultaneous video and symbol display — no loss of detection capability
2) Display configuration for optimum understanding and judgment
3) Action buttons for simplicity and ease of operation
4) Maximum use of height and size data
5) Solid state design, front accessibility, standard packaging
6) System flexibility at reasonable cost

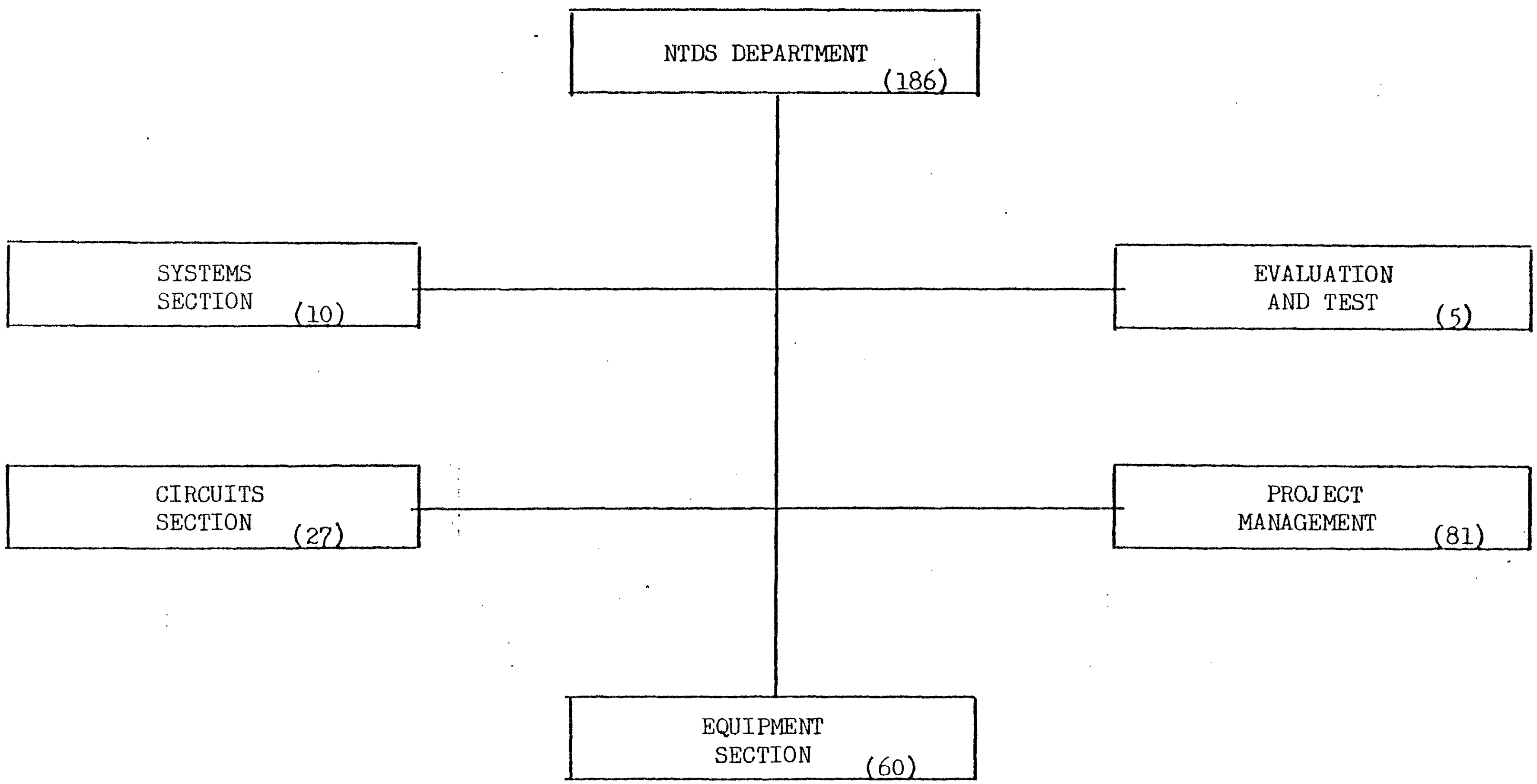
Chart VI-1 shows the organization of contract 72612. The numbers in parenthesis indicate the people, engineers, and technicians, assistant engineers, draftsmen, etc., on the contract near its peak. Those that can be considered engineers in the terms of the Committee's definition would be members of the technical staff (MTS) at Hughes[1]. Chart VI-2 shows that 42 engineers (MTS) were involved on 72612, with 7 of them considered key individuals. Most of these engineers were located in the Systems and Circuits Sections. Chart VI-3 depicts the build-up of manpower under 72612. Nearly all of the people in the MTS category that worked on the development contract came to the project from within Hughes.

There were roughly five major changes in the development contract before it was terminated. Each of these changes required a renegotiation. These changes took place in one of two areas. Either there was a change in the engineering direction on the program, or there was a change in the numbers and/or types of equipment called for delivery.

[1] This is nomenclature used by Hughes. Anyone in the category of MTS usually has a four-year engineering degree from an accredited institution. There are exceptions. Diener, who ran the NTDS program and is considered the outstanding man on NTDS at Hughes, does not have a degree. Obviously, he is considered by Hughes to be in the MTS category.

Chart VI-1

ORGANIZATION CHART 72612
Organization of NTDS Contract 72612 Within Ground Systems Division

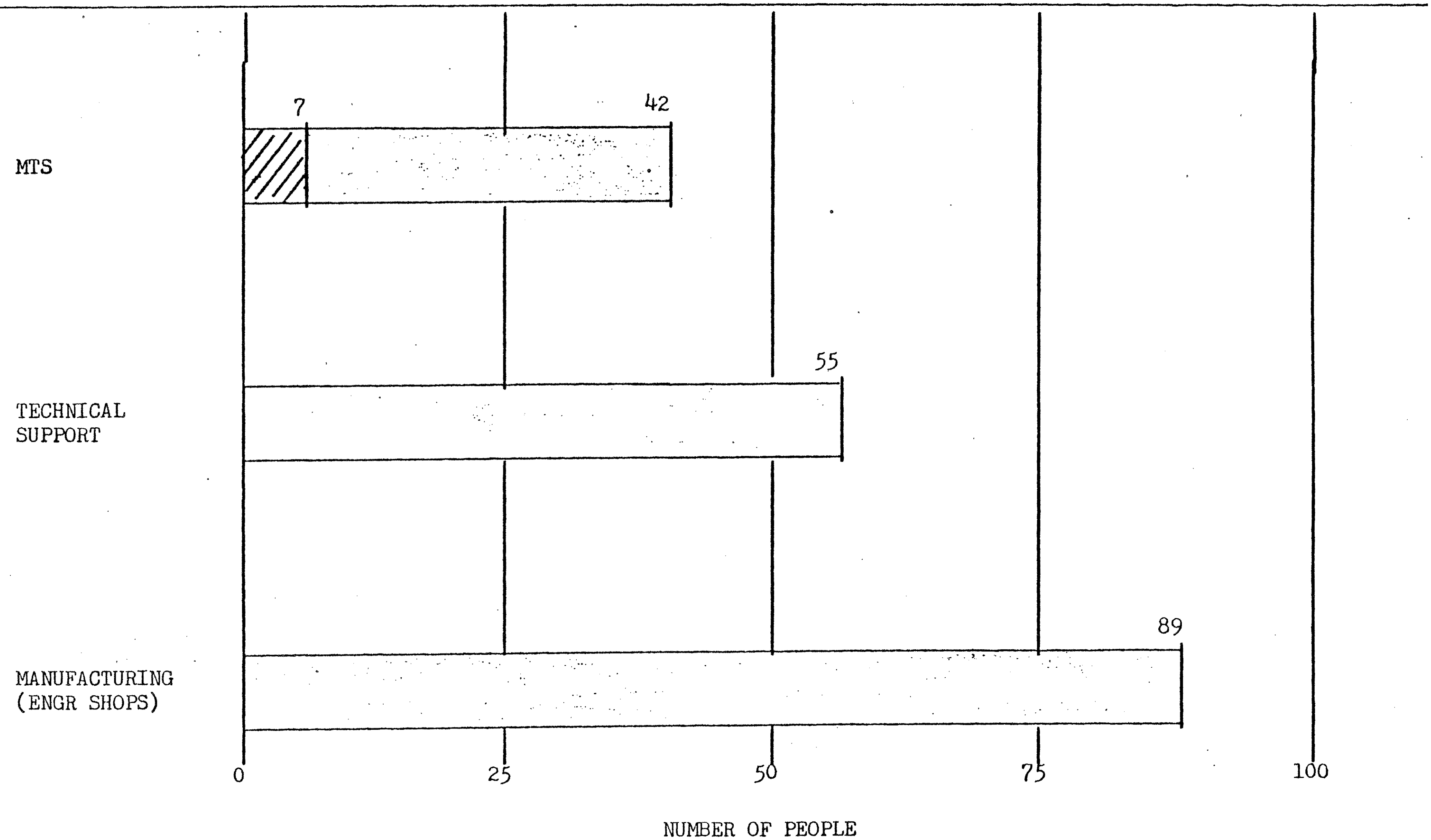


Numbers in parentheses indicate engineers and technicians employed on contract 77604 during peak period.

Chart VI-2

PERSONNEL BREAKDOWN 72612

Number of Engineers and Technicians Employed on NTDS Contract 72612 During Peak Period

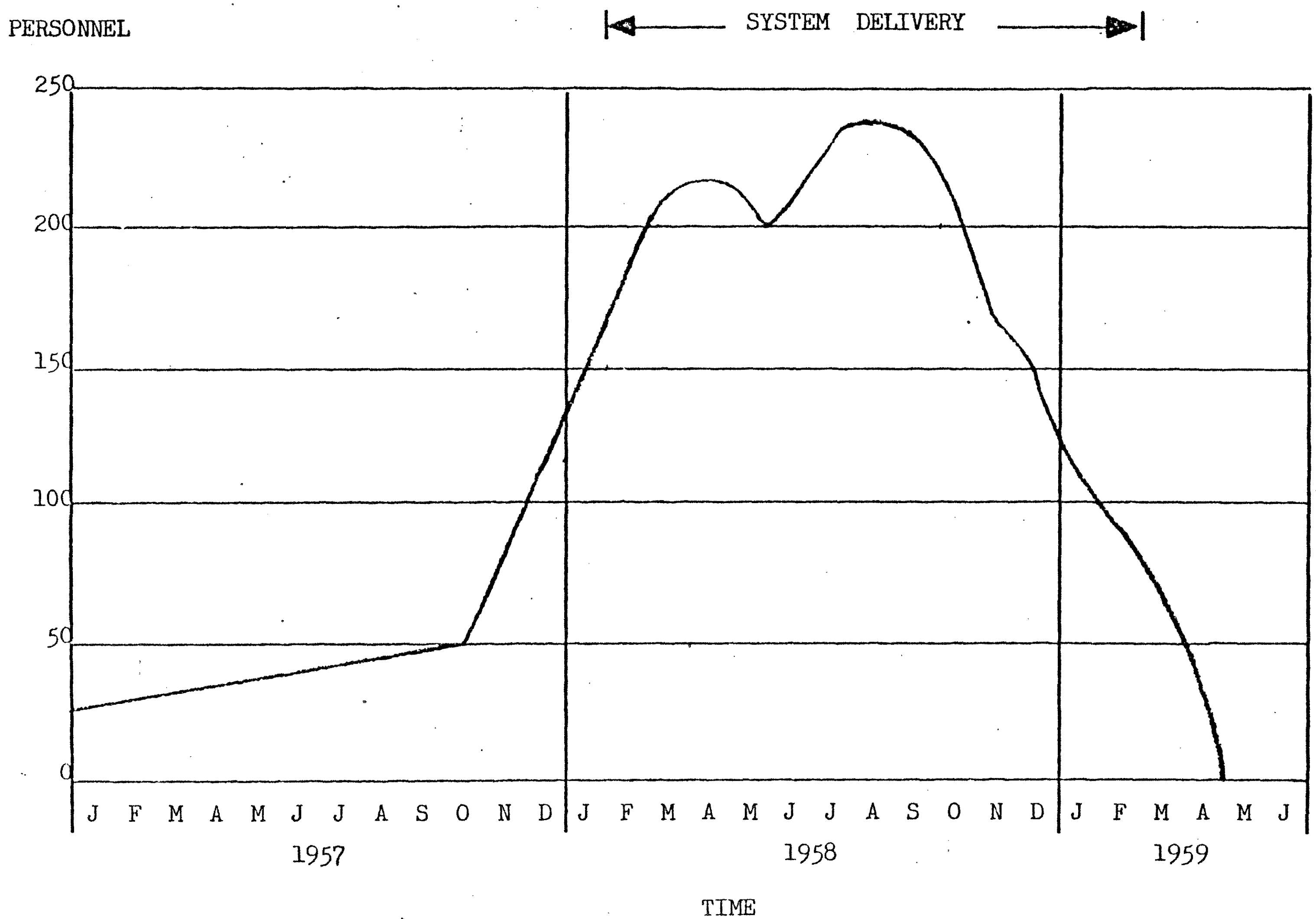


MTS — Members of the Technical Staff — degree engineers.
Crosshatched area indicates total number of key engineers.

Chart VI-3

MANPOWER SPREAD 72612

Total Manpower Buildup on NTDS Contract 72612



These changes were initiated by either Hughes or the Bureau of Ships. Hughes was late in delivery[1] on the system to NEL and produced a cost overrun.

Nobsr 77515

This was an interim contract and did not involve the production of any hardware. It did involve studies on how the equipment produced under 72612 could be improved. Among the areas that required investigation was that of a central power supply. The development displays delivered to NEL utilized a central power supply to generate all the voltages for the system. If the central power source should fail, the entire system would shut down. Another problem was the use of an analog wave form in the displays. A digital sweep would improve the accuracy and quality of the equipment. Also, semi-conductor technology was advancing rapidly enough that changes in the state-of-the-art might be incorporated in the display circuitry that would produce a quantum jump in the reliability of the system. These areas were investigated under 77515.

Hughes also indicated that this contract allowed them to maintain the engineering team that had been built up under the previous contract. That contract was terminating and the contract for Service Test equipment had not been awarded. This could have forced Hughes to disband the

[1] The Bureau of Ships was quite concerned about this late delivery. The Navy was committing three ships, two destroyers, and one carrier to the Service Test phase. They did not want to hold three ships out of the line any longer than was absolutely necessary. Any delays on delivery of Service Test equipment could be serious. As a precaution against this possibility, and as a move to develop another display source, the Bureau of Ships awarded a contract to the Hazeltine Company in 1959 to develop some display gear. Hazeltine ran into trouble and their equipment was not evaluated for the NTDS because Hughes did deliver the Service Test displays on time.

NTDS engineering group and either transfer them to other projects or lay them off. In fact, Hughes decided to fund some of the initial work under 77515 to maintain their engineering cadre until a Service Test contract was awarded. Management issued a PCA, pre-contract authorization, to cover this effort. Hughes uses this system when a firm contract has not been issued, but every indication is that one will be forthcoming shortly. In the few cases PCA's have been issued, the company has nearly always recovered its costs. The total cost of 77515 was approximately $800,000.

Chart VI-4 shows the manpower build-up on 77515. About 80 per cent of these individuals were engineers in the category of MTS.

Nobsr 77604

This contract involved the development and production of displays for the Service Test program. It covered the delivery of displays for the three Service Test ships and for one CG(N) (nuclear powered guided missile ship) and one CVA(N) (nuclear powered carrier). Also the delivery of display consoles to FAAWTC, San Diego, and Mare Island, San Francisco, for training purposes was made under this contract.

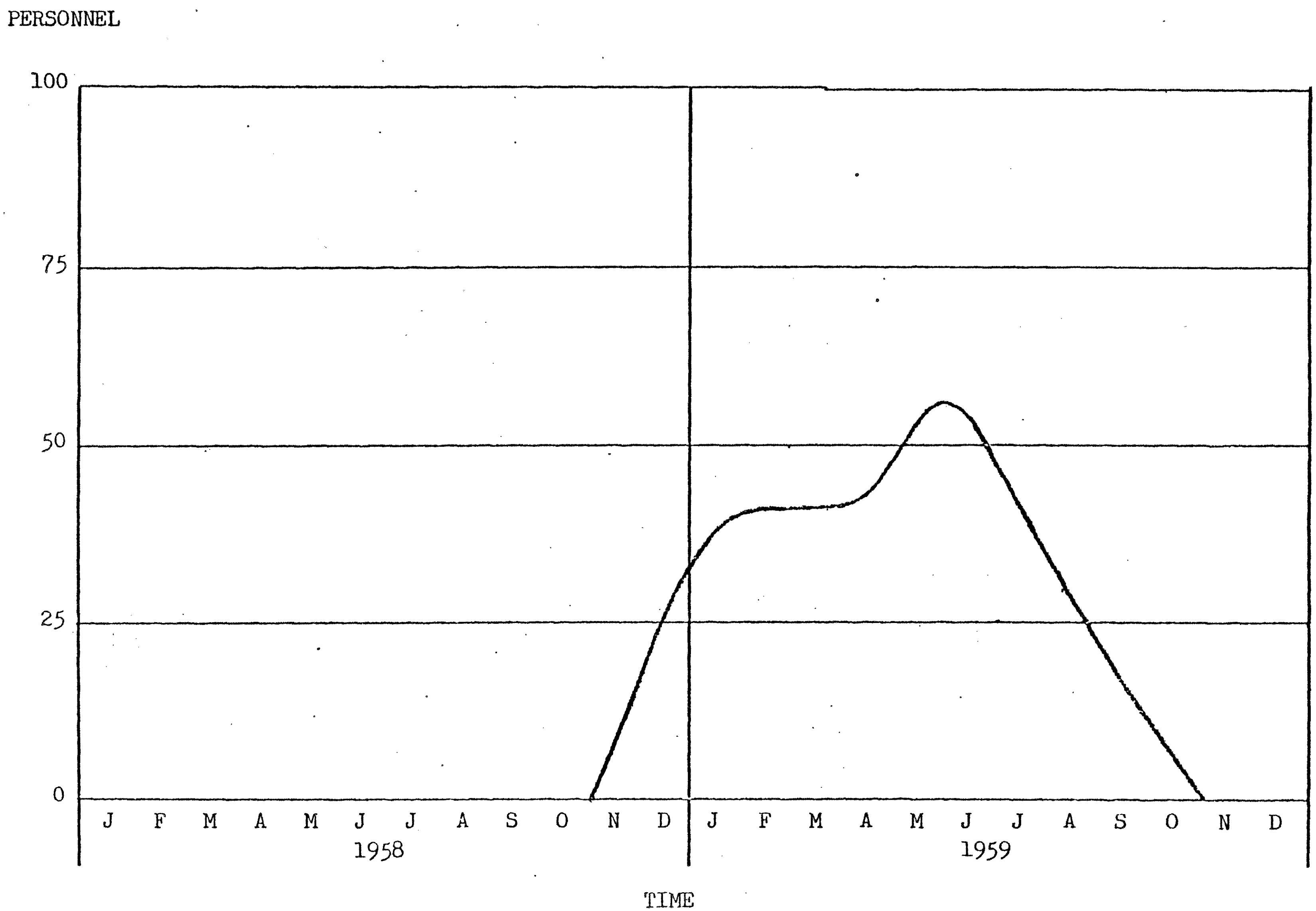
The bulk of the work done under 77604 essentially involved a redesign of the display system. The major improvement achieved over the R&D displays was in making the system digital. The following were the objectives aimed for under this contract.

Improve Accuracy by
- eliminating central display generator and routing of analog sweeps
- eliminating center power supply and routing of DC power
- positioning video and symbols digitally except for shared analog circuits

Chart VI-4

MANPOWER SPREAD 77515

Total Manpower Buildup on NTDS Contract 77515



Improve Availability by — utilizing transistor-resistor logic

— reducing vacuum tubes

— utilizing military specification components

— adding redundancy

— utilizing automatic test routines

— utilizing standard racks and circuits

Improve Display Quality by — eliminating 5-inch display

— substituting projection readouts for Typotron

— improving symbol generation techniques

— abandoning secondary intensities

Simplify Controls by — simplifying category selection

— improving track ball

Increase System Flexibility by — reducing seven console types to three

Chart VI-5 depicts the organization of the NTDS project under 77604. A large manufacturing effort was necessary to produce the Service Test displays. At this point in the development, the manufacturing group was still under the cognizance of the engineering team. The total NTDS department near the peak of its build-up contained 229 engineers, technicians, etc. and had direction over a manufacturing effort of 700 people.

Chart VI-6 shows the personnel breakdown near the peak of 77604. There were 110 engineers (MTS) on the program of which 16 were considered key people. Most of the engineers were in the Field Service and Support Section, the Circuit Section, and the Systems Section. Chart VI-7 graphs the build-up in manpower over the course of the contract. The bottom

Chart VI-5

ORGANIZATION CHART 77604
Organization of NTDS Contract 77604 within Ground Systems Division

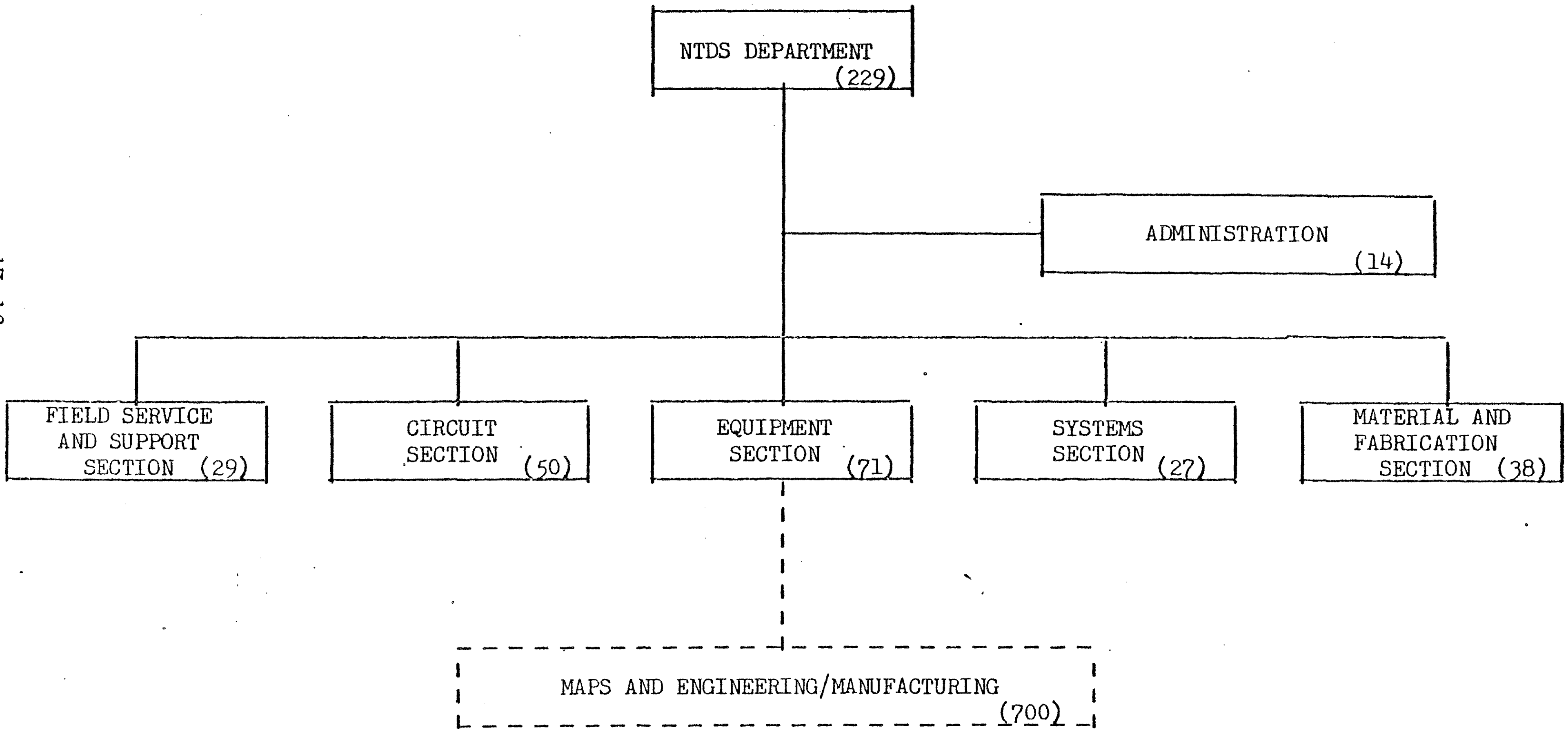
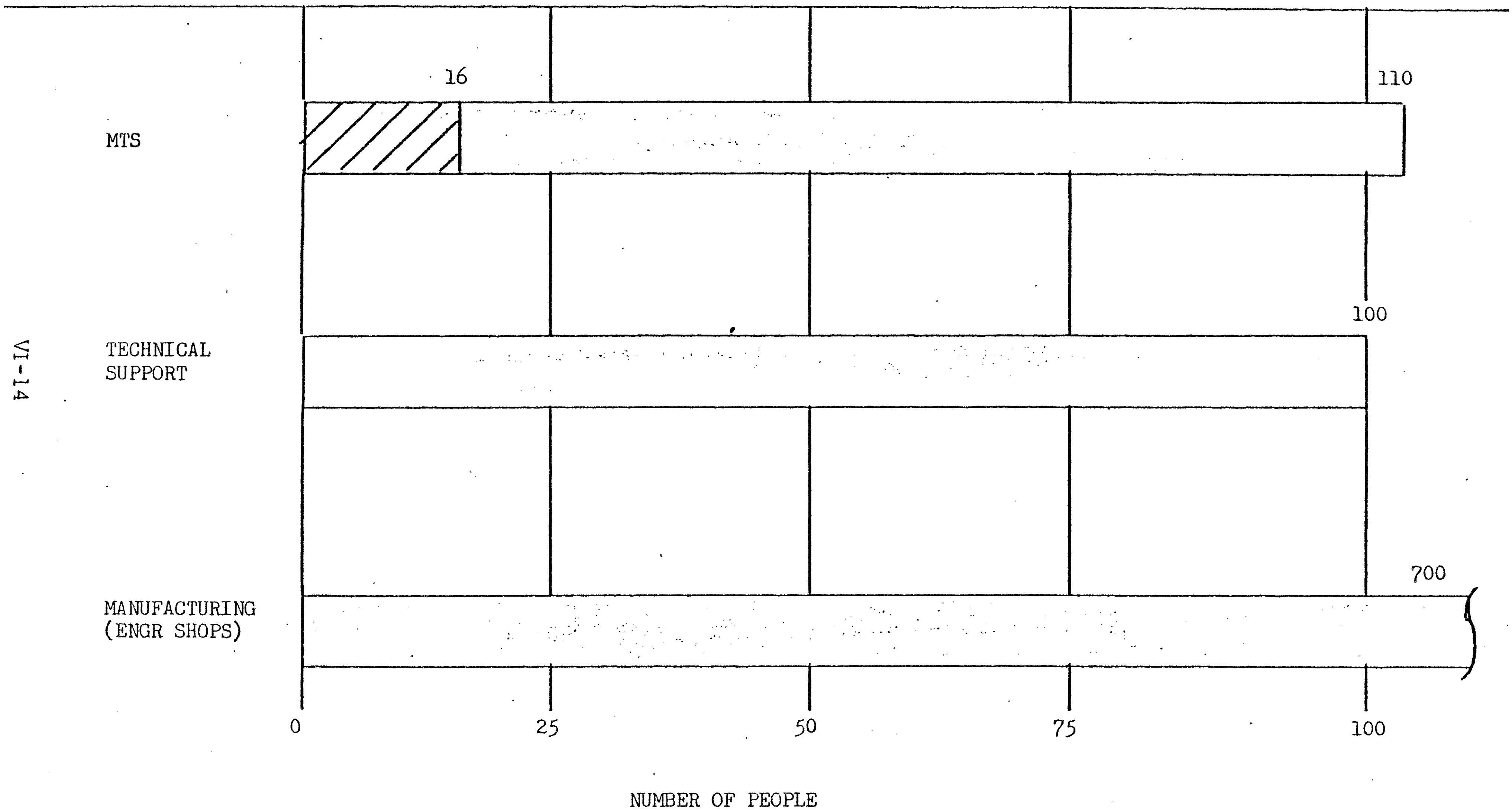


Chart VI-6

PERSONNEL BREAKDOWN 77604

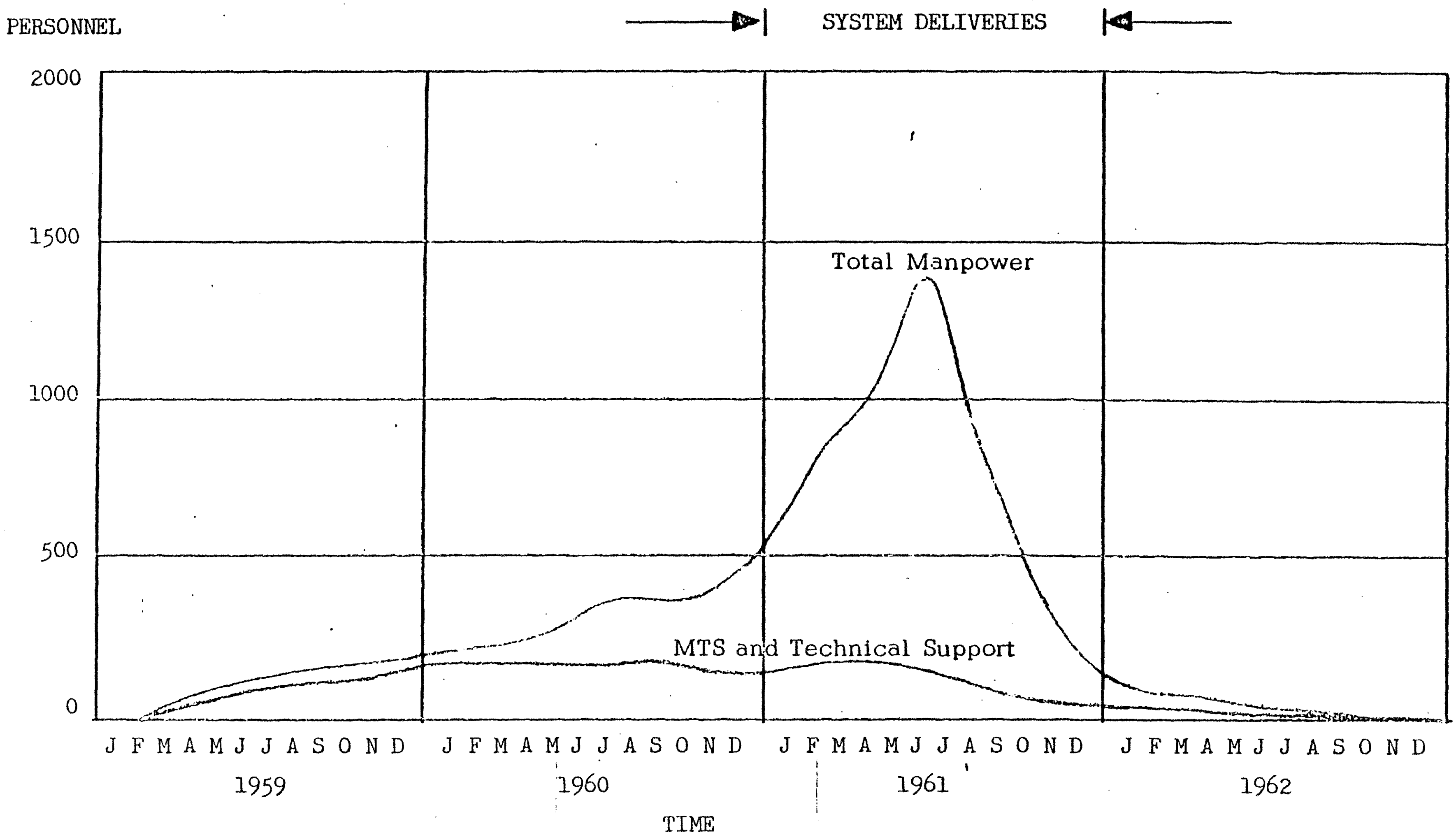
Number of Engineers and Technicians Employed on NTDS Contract 77604



MTS — Members of the Technical Staff — degree engineers
Crosshatched area indicates total number of key engineers

Chart VI-7

MANPOWER SPREAD 77604



Green line indicates total manpower buildup on NTDS contract 77604
Red line indicates engineering and technicians manpower buildup on NTDS Contract 77604

curve refers to engineers and technical support personnel. The top curve refers to total manpower, manufacturing plus engineering.

Nearly 80 per cent of the 110 engineers who were members of the technical staff and worked on 77604 were hired from the outside. A quarter of these outside hires came from a single source. North American Aviation had just laid off a large group of technical personnel because of the termination of a contract, and Hughes hired a number of them.

Nobsr 77604 amounted to roughly $29 million. There were a number of changes in the contract as the work progressed but only about four of them could be considered major. Hughes delivered the systems according to schedule but encountered an overrun.

Overhead

The Hughes people estimated that indirect labor (clerical, purchasing, etc.) involved in the NTDS was small. The overhead rate for the Ground Systems Group was never less than 120 per cent and never more than perhaps 145 per cent during the program.

Key People

Within Hughes, Bernie Diener was the outstanding single contributor. He was not only a strong administrator, but also contributed technically in the circuit design area. Diener left Hughes during the work on the Service Test displays. The Bureau of Ships was concerned about the departure of a key individual having suffered through such problems with RRU. However, there is no evidence of a serious setback to the program because of Diener's leaving. John Smith took over the program. Smith came from within the Hughes organization and had been working on one of their radar projects.

The reason given for not elevating someone within the NTDS program to take over after Diener's departure was that most of the men under Diener were young engineers already carrying major responsibilities. A number of these engineers made valuable contributions to the program. Those mentioned were Houck, Swigart, Cox and Brown.

Apparently, Hughes top management did not immediately recognize the contributions made by these engineers. However, with time, those that did make major contributions were recognized in terms of salary and position. Those still with Hughes are occupying responsible positions. As an example, Swigart is now a Senior Scientist and Houck is heading up the Circuit Section of the Ground Systems Division.

The Hughes people mentioned that the total NTDS program was somewhat unique in the support it received from its "customer", the Navy. McCown at NEL was credited with having generated many technical ideas that Hughes incorporated. Stoutenburgh at BUSHIPS provided direct military participation. The cooperation between the CNO group and BUSHIPS was credited with keeping the program on firm financial ground. Both NEL and BUSHIPS provided technical and operational direction to Hughes.

Chapter VII
EVALUATION OF THE NTDS DEVELOPMENT

The Naval Tactical Data System has been judged a success and has improved the Navy's Command and Control facilities to such an extent that it is now being installed in the fleet. Many problems existed during the development phase and all was not harmony between the various groups involved. Yet, in the evolution of a system as revolutionary and complex as this one, problems were bound to arise. In the final analysis, it is the ability of the end product to meet its technical and operational requirements and to be developed within a realistic time and cost framework that will qualify it as a success. In terms of this definition, the development phase was a success. What were some of the factors that contributed to the outcome of the NTDS program?

Organization

The fact that the project office was staffed by a small group of strong-willed, highly dedicated individuals who were ultimately endowed with authority and responsibility for the program was one of the reasons the BUSHIP organization was so effective. Initially, the project office operated without official control over the expenditure of funds. Unofficially, however, they assumed this role almost from the start and part way through the program received official authorization to control funds. From the program's inception, the project office was given authority to act as the coordinating and expediting agency for BUSHIPS. The office had the full backing of the Chief of the Bureau of Ships.

The size of the project office was also a contributing factor. There were never more than six and generally only four Engineering Duty Officers assigned to it. It was a small enough group that everyone concerned was well aware of the status of the total program, yet they were able to concentrate on those areas where their individual talents could best be utilized.

In addition, the office had the support of engineering specialists from within the Bureau's Electronic Division. They also had at least one representative at the lead laboratory, NEL, and at the lead contractor, Remington Rand Univac, who kept in constant communication with the project office. The small NTDS office within CNO assisted immeasurably in getting the system accepted operationally.

In any overview of the project's organization from the government's aide, the small size of the groups involved in running the total program stands out. The few individuals involved both in BUSHIPS and CNO allowed for rapid communications and, while they may have been overloaded with work, the small number of people concerned must be construed as a positive factor rather than a detriment.

The two contractors studied, Remington Rand Univac and Hughes Aircraft, also had strong project-oriented organizations. During the development stage they each had one individual who functioned as the NTDS Project Head and had control over the NTDS work their respective companies were responsible for. These organizations varied in size, but never appeared top heavy. About halfway through the program, the lead contractor chose to appoint a strong coordinator, reporting directly to top management, to expedite their phase of the project.

The knitting of the components of the system was accomplished at NEL. In the interfacing of the work of the various groups involved, problems arose. Many were solved internally, others were settled by the BUSHIPS project office which was vested with the authority to do so.

Technical Competence

The technical competence of the EDO's manning the project office was an aspect of the program that was continually stressed by the contractors involved. Not only were they effective administrators, but they also contributed to the development technically. In a system such as the NTDS, it is vital to its over-all success that individuals directing its development have a strong engineering background. This is necessary if they are going to fully perform their function. Some of the EDO's came into the program with previous experience in certain technical areas and this proved to be of real benefit. All of them had been or eventually went through the Navy PG School or the program given at MIT in the late 40's. There appears to be little question that the technical know-how, gained through a program of graduate engineering education and on-the-job experience, was vital to the effective administration of the NTDS program.

A high level of technical competence was also evident within the civil service structure of the Bureau of Ships. Several of the BUSHIP Project Engineers that were heavily involved in the NTDS were highly respected by the contracting personnel. NEL was also well staffed with excellent technical talent. As with BUSHIPS, there were a few that stood out above the others. When one considers the inequities in salary structure between civil service engineers and their counterparts in industry, especially in the aerospace field, the fact that the government has highly competent technical talent within its structure might not be readily assumed. If present talent is to be preserved and new talent attracted, the salary differential, especially at the higher grades, needs close examination. Without the technical backing of BUSHIP and NEL engineers, the NTDS development would not have been the success it was.

The contractors were equally well endowed with engineering talent. Remington Rand brought some outstanding engineers to bear on NTDS problems. Hughes had a reputation for doing excellent technical work that was further enhanced as a result of their contribution to the program.

It is of some interest to examine the technical backgrounds of the key contributors to the NTDS development. Within the BUSHIP project office, 12 of the EDO's had the equivalent of a Masters degree in Electronic Engineering; the rest, with the exception of one, had Bachelor degrees in engineering. Of the four principal administrators, only one, Svendsen, had gone through the three-year program. Most of the principal contributors at NEL had Bachelor degrees in Electrical Engineering. At Remington Rand Univac several of the key contributors (Leas, Fischer, Hendrickson) had technical schooling but held no Bachelor degrees. The same was true of the NTDS project head at Hughes, Bernie Diener. While these people would not be considered engineers in terms of the Committee's definition, in actual fact they not only contributed individually to the project as engineers but played a major role as engineering administrators. The majority of engineers employed by the contractors on the NTDS program held Bachelor degrees, with several at the Masters and Doctoral level.

Effective Utilization of Technical Personnel

It can be implied that since the development phase of the NTDS was successful, technical personnel assigned to the project were effectively utilized. If this was in fact the case, it would have been another factor contributing to the eventual outcome of the program.

Not enough information was made available to conclusively answer the question. Detailed personnel records would have had to be examined and interviews conducted with many of the engineers who participated in the program. The limited information available indicated productive use of engineering talent. With regards to several specific NTDS contracts administered by Hughes or RRU, it showed a rapid buildup in engineering manpower and an equally rapid fall-off from the peak loading. There was little evidence of plateauing. It can be concluded from this that once a contract was completed, the contractor did not continue to charge engineering time to it but moved the technical talent to other phases of the work or off the program altogether. The comments received from the few engineers interviewed indicate that this, in fact, happened and that engineers were continually being utilized in productive work and not held in limbo until further contracts came through.

Continuity of Personnel

Inherent in Navy doctrine is the principle of rotation. A Navy officer generally spends only two to three years at one post before moving on to the next. Remaining in one location for a long period of time can be detrimental to one's career. Obviously, the system of rotation has merits that need not be discussed here. However, when applied to a small group of Navy officers managing a large, complex development program whose life extends beyond the normal tour of duty, the principle loses some of its advantages. To change management in the middle of a program or during a critical phase can be disastrous, especially if the managing group has been operating successfully and the program is not in serious difficulty. If a change is made purely because of a system, then the outcome of programs so affected is unpredictable.

The BUSHIP project office did not suffer from lack of personnel continuity. The four principal Engineering Duty Officers assigned to the office each served in the program more than three years. Svendsen, the program head, functioned in this capacity more than five years. Had these men been moved out of the program when, according to procedures, they should have been, the NTDS development would have suffered.

Continuity was also evident at NEL. Several of the key individuals had been with NEL a number of years before becoming involved on the NTDS. They remained on the program as long as their talent was required. In fairness to the other side of the question, it should be stated that one can remain too long on a program. Certainly if a program is being badly administered, a change in management may be in order. Technical problems that have defied solution may require fresh approaches that only outsiders can bring to bear. As a program goes through its evolutionary cycle from research and development to testing to production, different groups of people will be involved. It can also be argued that it is dangerous for a research-oriented engineer to become attached to a specific program for an excessive length of time. Technology is advancing with such rapidity that if a man gets isolated on one particular system too long, his usefulness may rapidly decline.

The contractors were not as fortunate as the government with respect to the continuity issue. Remington Rand Univac had some real problems in this area. These were discussed in Chapter V. They were able to cope with the situation, but not without some qualms on the part of BUSHIPS. In the case of Hughes there was no real continuity problem with the possible exception of Diener's departure, and this did not appear to seriously affect the program.

Dedication

There is no question that the dedication of all key individuals to the program played a major role in its over-all success. This is especially true with respect to the BUSHIPS organization, both in the Washington office and at NEL. Obviously, this factor is difficult to measure. Long hours were put in, weekend work was standard operating procedure, and travel was frequent. Certainly on the part of the Navy personnel, this dedication was based on a desire to see the job done rather than any monetary or position gain. The element of dedication must be present in any successful program. In the development of the NTDS, this element was very much in evidence.

Appendix - A

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
BUSHIPS 5430.600 SUP-1
Ser 607-1
14 January 1963

BUSHIPS INSTRUCTION 5430.600 SUPPLEMENT 1

From: Chief, Bureau of Ships
To: All Assistant Chiefs of Bureau, Director of Contracts and Comptroller

Subj: Supplement 1 to BUSHIPSINST 5430.600, Subj: Establishment of Buships Command and Control Systems Management Office

Encl: (1) Command and Control Systems Management Office Organization Chart
(2) Definition of Integrated Command and Control System as Applied to BUSHIPS INSTRUCTION
(3) Command and Control Systems Management Officer Duties Under Codes 360, 601 and 410 (450)

1. Purpose. To provide within the Bureau of Ships organization a central staff with directing authority and program control which will be responsible for:

a. The coordinated planning and timely execution of development, test and production of integrated command and control systems under cognizance of the Bureau of Ships and falling within the definition provided by enclosure (2).

b. The formulation of policy and system design standards for the development and production of strategic and tactical command and control systems within the time and funds available and which will insure:

(1) That BUSHIPS technical direction is consistent with applicable OPNAV policy directives.

(2) That risks to warship and shore command operability and schedules are minimized when mandatory development is included in system configurations.

(3) That technical direction provides the best possible balance of capability, reliability, initial cost and long range support costs of equipment, computer programming, installation, testing and potential subsequent evolution of the system.

(4) That the available manpower in the Bureau codes and field activities are brought to bear on the various design, development,

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installation, test and production problems in a manner which permits the most effective use of their capability and time.

2. Cancellation. This instruction cancels and supersedes BUSHIPS INSTRUCTION 5430.51 Ser 671A-182 of 10 January 1962.

3. Background. Within the applicable definition of command and control systems provided by enclosure (2) there are two basic categories:

a. Strategic: A system which provides command echelons afloat or ashore with a facility for the collection, processing, correlation and evaluation of information of a strategic nature.

b. Tactical: A system which provides command echelons with the facility necessary to collect, exchange, process, correlate and evaluate information of a tactical nature and effectively control weapon systems.

Integrated command and control systems as defined by enclosure (2), and for which NTDS and NECPA serve as examples, have received consistent priority and emphasis from the Chief of Naval Operations. The nature of these systems is such that it is not possible to clearly isolate an element or subsystem and treat it separately without regard for the other parts, and in particular the programming aspects. System design often includes direct electrical interconnection and computer programming to serve BUWEPS equipments. Computer controlled communication facilities precludes development independent of other system considerations or of operational and technical agreements with the other U. S. systems, and systems of the CAN-UK-US and NATO navies. Therefore, it is essential that the Bureau of Ships provide a single office to insure the evolution of competent system design and interface definition for elements under BUSHIPS cognizance and to provide a technically informed and consistent Bureau position when dealing with agencies and offices outside of the Bureau of Ships.

Within the Bureau of Ships these systems are being prosecuted under every Assistant Chief. The majority of the effort lies within the 300, 400 and 600 codes. For any given system configuration, the Bureau devotes the greatest total engineering effort in Code 600 where equipment design, fabrication, test and associated computer program design are executed under cognizance of the branches of the Electronics Division. Heretofore responsibilities have been fragmented. System design has been prosecuted under one major division and occasionally equipment specifications will accompany this system definition, but responsibility to execute will reside in another major division. Although provision for review and comment is made, it has proven ineffective and has resulted in considerable time lost and waste of the highest calibre engineering manhours even with the best efforts of all concerned. A more efficient use of available engineering manpower is an objective of this instruction.

4. Implementation.

a. The Bureau of Ships Command and Control Systems Management Office is hereby established. This office shall be responsible for all phases of system design, fabrication, installation, test and checkout for those systems which conform to the definition provided by enclosure (2) with the exception of Marine Corps Tactical Data System.

b. The Management Office shall be responsible to the Design Division Director (Code 450), the Deputy Assistant Chief for Technical Logistics (Code 601) and the Warfare Systems Division Director (Code 360) for their respective phases of the integrated command and control systems which are assigned to the management office for cognizance. This relationship is indicated in enclosure (1). For administrative purposes the management office will be assigned Codes 457, 607 and 363. The Management Officer shall derive his authority from Codes 410(450), 601 and 360 respectively. He shall carry out his responsibilities in the respective divisions acting for them and keeping the cognizant Division Directors informed of status, problems and corrective action being taken. In the event of unresolved differences between two or more Division interests in the area of responsibility being served by the Command and Control Systems Management Officer, the latter shall provide specific recommendations, but resolution shall be determined through normal Assistant Chief channels if necessary.

c. The Bureau of Ships Command and Control Systems Management Officer will provide liaison with outside Bureau activities, and will arrange for representation as necessary from codes within the Bureau and will keep cognizant Division Directors and Branch Heads informed.

d. The Bureau of Ships Command and Control Systems Management Officer will effect appropriate liaison and consultation with Bureau of Ships program managers and branches engaged in work destined to be interfaced either "on-line integrated" or "on-line converted" in its relation to a system under his cognizance. In such cases, a common understanding of the intended interface and functional relationship must be reached before funds are committed to hardware implementation.

e. The Bureau of Ships Command and Control Systems Management Officer will effect appropriate liaison and consultation with Bureau of Ships branches concerned with shore installation, training and logistic support of systems under his cognizance.

f. The outline of specific duties to be performed by the Command and Control Systems Management Office under Codes 360, 410(450) and 601 is provided in enclosure (3).

5. The Assistant Chief of Bureau for Technical Logistics is assigned administrative control and support for this office.

6. Review Date: The Command and Control Systems Management Office will be disestablished on 1 July 1967, unless the Chief of the Bureau approves its continuance, in which case a new termination date will be established.

7. Administrative Manual holders file copy in new binder under the tab marked "600"; other codes file in usual manner.

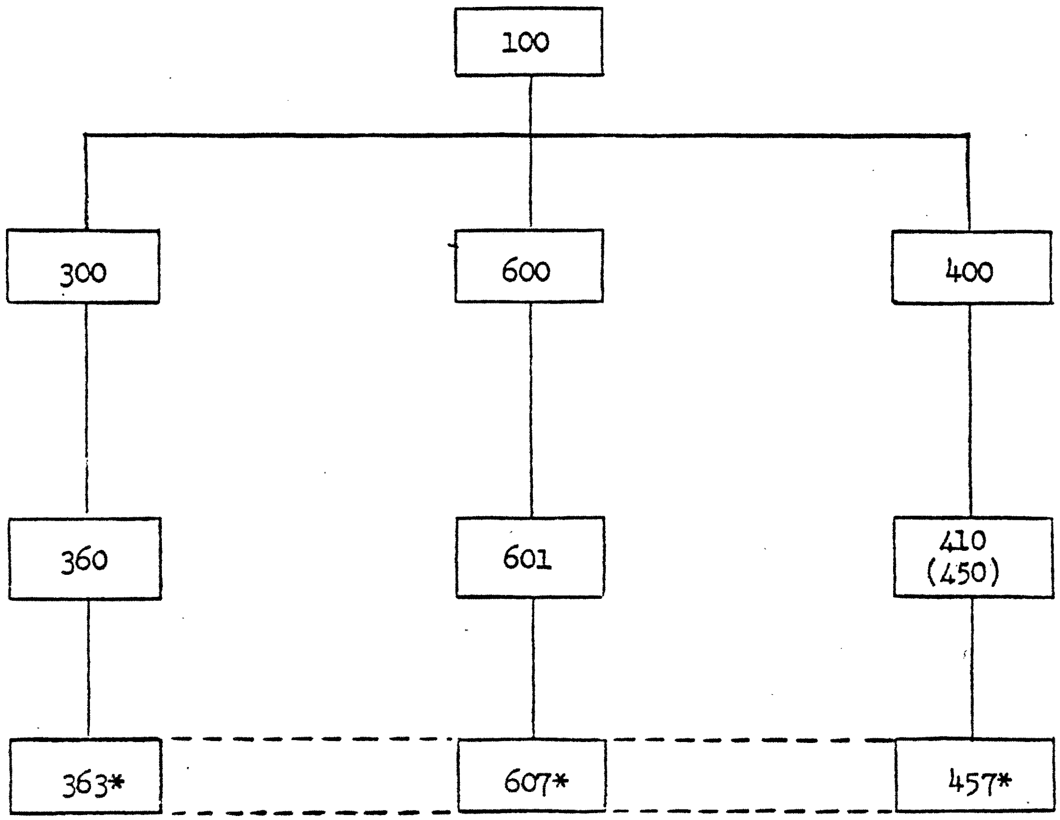
Copy to:

Special List X8

R. L. Moore, Jr.
R. L. Moore, Jr.
Acting

Command and Control Systems Management Office

BUSHIPS Organization Chart



*Command and Control Systems Management Office

1. The following terms and definitions are consistent with those found in applicable CNO policy documents and apply to this instruction:

<u>On-Line (Converted)</u>: Equipment which generates or uses tactical data but which can be inserted or removed from a digital data system by mechanical or electronic means, but which in the process requires translation or conversion in data formats. (For example a ships gyro can, through an added mechanism called an Analogue to Digital converter, electro-mechanically convert the synchro output to binary digits which could in turn be electronically connected to input registers in the computer.)

<u>On-Line (Integrated)</u>: Equipment which accepts as an input or generates as an output tactical data in a format suitable to digital data processing (i.e., encoded in proper binary form without requirement of converter for connection to input registers of the computer subsystem).

2. Figure 1 illustrates the definition of command and control system and those features for which the Director of the Command and Control Systems Office will be responsible.

3. The criteria for assignment of responsibility to the Management Office is outlined below:

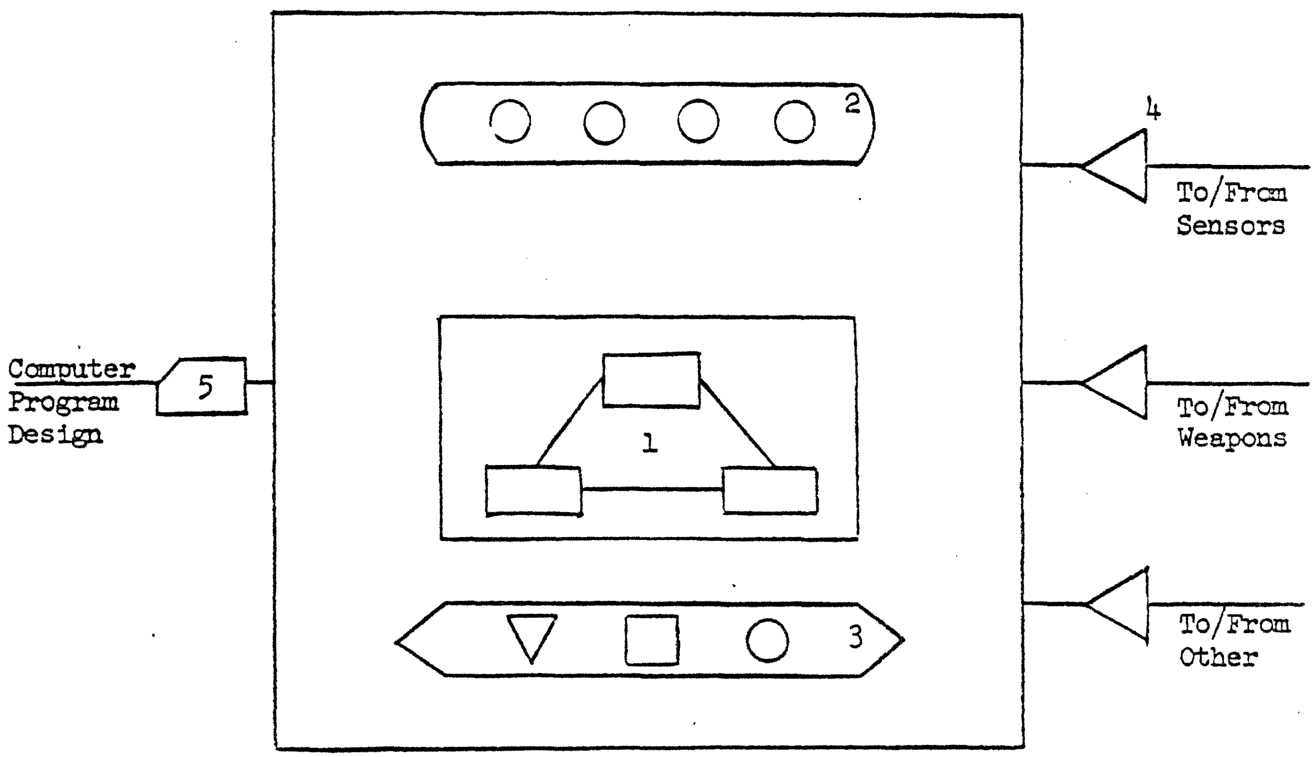
a. The system utilizes general purpose digital computers as the basic data processing facility.

b. The system requires the combined efforts of two or more branches in the Electronics Division for its equipment design and system specification, or, requires electrical and computer program design for interface with BUWEPS equipment.

c. The system is the primary tactical command and control system for the ship or the primary operational control center for the Operational Commander.

Definition of Integrated Command and Control System

as Applied to BUSHIPS INSTRUCTION ________



Characteristics

1. Digital Computer Subsystem
2. On-Line Integrated Display Subsystem
3. On-Line Integrated Communication Terminals
4. Interface with System Inputs and Outputs
5. Computer Program Design for 1-4

Figure 1

Command and Control Systems Management Officer Duties
Under Codes 360, 410 (450) and 601

1. Code 360

a. Perform all program manager functions for the overall system, including in particular:

(1) Formulating and maintaining current the Technical Development Plan.

(2) Formulating the RDT&E budget for the system. Present, defend and reclamma budgetary matters for the system.

(3) Exercise fiscal management control of current Fiscal Year RDT&E funds.

(4) Review laboratory programs for the system. Initiate redirection as required.

2. Code 601

a. Provide centralized technical review and direction as required for the following matters performed in the various equipment branches:

(1) Equipment specifications consistent with system performance and interface requirements.

(2) Timing of procurement request action to meet overall program objectives.

(3) Equipment procurement consistent with various shore activities' needs.

(4) Computer programming manpower and facilities consistent with overall program status, schedule and realistic planning.

(5) Direct and review technical aspects of concurrent evaluation plans. Maintain continuing detailed liaison with COMOPTEVFOR staff.

b. Provide centralized planning for the overall program as it overlaps in RDT&E, service evaluation and production in order to insure proper timing of support procurements and services as outlined below:

(1) Provide data necessary to formulate OPN budgets for Fleet Computer Programming Centers, Fleet Anti-Air Warfare Training Centers, Electronic Maintenance Schools, personnel training aids. (CNO, BUPERS)

(2) Provide budgetary data necessary to support APO backfit needs under the OPN budget. (CNO)

(3) Provide guidance for engineering services and training support.

c. Provide a centralized technical office to represent the Bureau in various national and international technical and operational standardization meetings:

(1) NTDS/ATDS/MTDS HF and UHF communications data link technical and operational compatibility. (CNO)

(2) USN/USAF inter-system standards. (CNO, BUWEPS)

(3) CAN-UK-US Tactical International Data Exchange (TIDE) negotiations. (CNO, BUWEPS)

(4) NATO, Navy and Air Defense technical and operational data link standards. (CNO, BUWEPS)

3. Code 410 (450)

a. Provide centralized guidance and detailed system data necessary for the 400 and 500 codes to:

(1) Provide overall system (including computer programming) representation in "whole ship" weapon system design where equipments under cognizance of other bureaus are interconnected "on-line" to the Command and Control System.

(2) Provide technical direction of system design for integrated Command and Control Systems portion of overall ships electronic design.

(3) Respond to SCB ship type study requirements.

(4) Formulate accurate EIP documents.

(5) Formulate cost data for end costing of new construction ships.

(6) Provide for the type desk or present as requested appropriate data for change review board considerations.

(7) Provide for the type desks the necessary system information in response to shipyard and supervisor's needs.

Appendix B
NEL-NTDS PROBLEMS

Problem No.: J1-5 — later changed to J3-2

Title: Naval Tactical Data System Analysis

Date Accepted: 29 December 1955

Objective: Conduct systems and operations analyses and provide consulting services to BUSHIPS and its contractors as requested by BUSHIPS, pertaining to the development of a high-capacity NTDS.

One of the major tasks conducted under this problem number from 1956-1961 was to function as a technical consultant to BUSHIPS on the System Design and its integration into the NTDS.

Problem Assigned to: Operations Analysis Branch (M. Sheehy)

Problem No. N4-3

Title: NTDS Information Processing and Presentation

Date Accepted: 29 December 1955

Objective: Investigate and specify technical requirements for developmental equipments or devices necessary for integration and implementation of functional NTDS test equipments and/or service equipments. Investigate and develop new techniques and components to improve reliability and performance of shipboard digital equipments and displays and/or meet performance requirements beyond the current state of electronic art. Develop and fabricate special equipments to implement or planning system layouts, and providing maintenance aids appropriate for improving the maintainability of Navy Tactical Data Systems as they evolve.

One of the major tasks performed under this problem number from 1959-1960 was to develop a maintenance philosophy for the NTDS based upon study of the maintenance problems in the system and its component equipments.

Problem No.: J1-6 — changed to J3-3 in January 1957

Title: Developmental NTDS Instrumentation and Evaluation

Date Accepted: November 1956

Objective: Plan instrumentation for, and conduct the progressive evaluation of the developmental Naval Tactical Data System.

One of the major tasks performed under this problem number from 1956-1960 was the preparation of facilities and supporting equipments for the installation, test, and evaluation of the developmental NTDS including instrumentation for providing real and simulated inputs, for utilization of NTDS data by weapon systems, and for performance measurements and analysis.

Problem Assigned to: Data Processing Systems Branch (Mitchell)

Problem No.: N4-9 — replaced Problem Nos. N4-4 and N4-7

Title: Data Conversion and Processing Techniques

Date Accepted: September 1957

Objective: Establish a high order of technical capability in the fields of data conversion and processing. Determine or develop techniques and circuitry to obtain technical performance data in order to furnish consultation service to BUSHIPS and information suitable for preparation of equipment specifications for procurement purposes. Investigate techniques in terms of increased efficiency, rapid access, increased storage, maximum reliability and environmental suitability.

Problem No.: N4-10 — initial work done under J3-3

Title: Computer Programming

Date Accepted: January 1958

Objective: Devise subroutines, pseudo-codes, and advanced programming techniques to reduce the number of man-hours required to program electronic computers assigned to the Laboratory and prepare flow charts and coded programs for these computers.

One of the major tasks accomplished under this problem number from 1958-1960 was the invention and implementation of the computer compiler, NELIAC, which allows the computer to be programmed in a formalized English. Another task was the preparation of the specific programs required in the testing and evaluation of NTDS programs.

Problem Assigned To: Computer Programming Group (Halstead)

Problem No.: N5-6

Title: Human Engineering of Shipboard Tactical Control Stations

Date Accepted: May 1958

Objective: Develop human engineering recommendations concerning equipment requirements, functional arrangement and personal considerations to assure effective operation of shipboard CIC's, command stations, and tactical information handling systems on current or proposed construction.

One of the major tasks undertaken was the analysis and discussion with equipment contractors and shipyard engineers of the layout problems related to installation, maintenance and operation of NTDS and related equipment on Service Test ships.

Problem No.:	J3-4
Title:	Small Ship Combat Direction System Program
Date Accepted:	March 1960
Objective:	Design, develop, and evaluate a unified data processing display and dissemination system suitable for naval vessels engaged primarily in anti-submarine warfare operations. Make maximum use of standard NTDS components wherever possible.

Other NEL Problem Numbers listed on NTDS Status Reports through 1961 and for which no detailed information was available were the following:

Problem No.:	N4-5
Problem No.:	N4-8
Problem No.:	N4-13
Problem No.:	J3-5

APPENDIX C

BIOGRAPHICAL SKETCH As of 12-13-63

CRAM, Charles C.

Mr. Charles C. Cram is Head of the Applied Systems Development and Evaluation (ASDEC), Instrumentation Section at the NEL since 1946 and with the ASDEC project since it was established in 1951. From 1943 to 1946 he was a U.S. Navy officer and served in the Loran Design Section, Bureau of Ships. He was an electrical and administrative Engineer with the L.R. Teeple Co. (now Electronics Division of Iron Fireman Mfg. Co.) in Portland, Oregon, from 1928 to 1943.

Mr. Cram was born 27 October 1905 in Webster Groves, Missouri. He received his Bachelor of Science in electrical engineering from Oregon State College in Corvallis, Oregon, in 1928. He has written a Navy instruction book and holds two patents in the temperature control field. Mr. Cram is a member of the Institute of Radio Engineers.

BIOGRAPHICAL SKETCH   As of 12-13-63

DALLEZOTTE, Frank R.   Code 3330, NEL
Supv., Electronics Engineer, GS-13

Educational Background:

BS degree in EE from Colorado University, Boulder, Colorado, 1950
In Army Air Force from September 1942 to October 1945, served as Staff Sgt.
University of Wyoming, Laramie, Wyoming; no degree

Professional Background:

Entered on duty at NEL in 1951 where he was assigned responsibility for design & development of tactical data display equipment. Later he was associated with the Time-surface display system (TSDS); he also cooperated in des. & dev. of the geographic plotter that was used in conjunction with the AN/BQS-2 sonar equipment. During the same period he also worked on the dev. of an interim harbor defense control center (HDCC). Later Mr. Dallezotte headed the group which studied the video data processing equipments & techniques to determine their applicability to the NTDS; he had responsibility for maintenance of NTDS equipment in ASDEC; he was head of technical test team which had 3 groups; display group, computer group; and periferal equipment group; this work resulted in the maintenance of the NTDS equipments, writing test programs, working with the programmers, and assisting in making sure that equipment worked properly during testing phases of NTDS. He also cooperated in the development of specifications, writing parts of the Appendices. Wrote first test programs to be generated for on-line testing of NTDS displays with the AN-USQ-17 computer. Assumed responsibilities of project leader in the special displays & computers section, assisting in preparation of equipment and system design specs based on operational requirement studies; acting as special consultant on BuShips contracts for advanced display systems or functional components thereof; and the design & dev. of special techniques or devices that may be assigned to the section. Also assisted in preparation of the production specs for the NTDS display equipments. Assumed responsibility of systems engineer for SSCDS. Mr. Dallezotte is currently associated with Mr. Nye on the Sea Hawk Project.

TM-27: Analysis and evaluation of a special magnetic deflection oscilloscope
TM-122, Sea tests of the Pantograph Optical Projection System
NEL Rpt 630, Evaluation studies of 3 harbor defense command centers (with others)
Patent on the Pantograph Optical Projection System.

BIOGRAPHICAL SKETCH As of 12-13-63

GOSS, Robert N.

Dr. Robert N. Goss is a Senior Mathematician in the Computer Center at the Navy Electronics Laboratory where he is developing new mathematical techniques for adaptation to computer uses. In addition to Laboratory assignments, Dr. Goss acts for the American Mathematical Society as a translator of mathematical articles published in Russian. His translations have been gathered in the series, "American Mathematical Society Translations and Soviet Mathematics."

Dr. Goss earned his AB from Drake University in 1942, and both his MS and Ph.D. from Iowa State University where he also served four years as Instructor. He moved to the University of Tulsa for one year, and then came to NEL in 1951. He was a special lecturer in mathematics at UCLA for two years, and became a member of the Reviewing Staff for Mathematical Reviews in 1957 — a position he still occupies. In this capacity he has reviewed some 230 articles in English, French, German, Italian, Russian, Spanish, Ukrainian, and Romanian languages.

He has written a number of NEL technical reports in the field of mathematics and is author of several papers for professional journals. Honorary and professional fraternities include Phi Beta Kappa, Phi Kappa Phi, and Sigma Xi. In addition to the American Association for the Advancement of Science, he is a member of the Mathematical Association of America, the American Mathematical Society, the Society for Industrial and Applied Mathematics, and the Societe' Mathematique de France.

HARSH, Charles M.

Dr. Charles M. Harsh is Head of the Human Engineering Branch, Human Factors Division, of the U.S. Navy Electronics Laboratory (NEL). He received his Ph.D. in psychology from the University of California in 1936. Earlier he had received his M.A. from the same University. He also holds a B.S. degree in chemistry from the California Institute of Technology (1932) where he graduated with honors.

Dr. Harsh is the author of many technical papers and numerous articles in psychology journals. He is co-author, with H. G. Schrickel, of a text book "Personality: Development and Assessment", the revision of which was completed in 1957.

Prior to coming to NEL, Dr. Harsh was in the education field. He served as professor at Pomona College and Claremont Graduate School 1950-51; as a professor of psychology, and as graduate chairman at the University of Nebraska, 1946-50; as a research associate, NDRC project, College Entrance Examination Board, 1943-45; as an assistant and associate professor, University of Nebraska, 1940-46; as an adjunct professor at Randolph-Macon Woman's College, 1939-40; and as an instructor and head tutor at Harvard University 1936-39.

Dr. Harsh is a member of the Psychometric Society, Sigma Xi, the American Association for the Advancement of Science, the San Diego Association of Psychologists and Psychiatrists, and the Human Engineering Society of America. Dr. Harsh is also a fellow of the American Psychological Association.

BIOGRAPHICAL SKETCH As of 12-13-63

HATCH, Alan R. Code 330, NEL
Electronics Engineer, GS-12

Educational Background:

Drafting School, Convair; 1943
Navy Radio Material School; 1944-1945
San Diego State College, preparatory course towards Elec. Engineering; 1947-1949
Univ. of So. California, B.S. degree in Elec. Engineering; 1949-1951.

Military Service:

Navy, from October 1943 to May 1946 as Radio Technician 2/C

Professional Background:

Entered on duty at NEL in 1951; first assignment designed units for the monitor cathode ray scope; helped in unitization & standardization of various types of servo systems; modified VK-5 radar repeater; designed electrometer type cathode follower; designed & developed two-channel electronic switch capable of handling $\pm$ 50 volts on input & with an accuracy of .005% on output; designed & developed a crystal oscillator & power amplifier; des. & dev. a transistorized electronic commutator to replace the formerly used mechanical version in Radux Navigation equipment; des. & dev. gated 10 mc transistorized oscillator & counter for use with the transistorized mortor locator computer.
More recent experience: Since 1956 was responsible for the design of portion of digital & analog circuits & logic used in the tracking computer & displays of the dev. NTDS station two van; Became project engineer for completion & testing of the NTDS station two van; monitored various display contracts issued by BuShips for NTDS; Supervised group in design & dev. of special purpose digital intercept computer; was member on BuShips panel to evaluate numerous proposals for the Tracking & Display System (TADS) for which a letter of appreciation was received from the Chief, Bureau of Ships; monitored SSCDS display modification contract by Hazeltine Electronics; Presently in charge of group envolved in testing & evaluation of encoders, converters, & state-of-the-art electronic circuits.

Professional Papers, etc.: (Cooperated in preparation of following reports:)

NEL Report 320: The XY-XZ Monitor Unit...
Engineering Features of the evaluation model of the XY-XZ
Three coordinate radar display.
Generic Servo & Unitization Manual
Transistorized Electronic Commutator

BIOGRAPHICAL SKETCH As of 12-13-63

MANNING, Charles S.

Mr. Charles S. Manning, an electronic engineer, is Associate Technical Director for Data Systems and Evaluation at the U. S. Navy Electronics Laboratory, in San Diego.

He has been employed by NEL since 1946 and his Associateship is one of the outstanding functional areas of the Laboratory. He was an officer in the Navy during World War II and won a commendation from the Bureau of Ships for his outstanding contributions.

Mr. Manning was born in Pullman, Washington, and received his degree from LaVerne College in 1932. He taught for nine years following graduation, taking graduate work at the same time from Claremont College and UCLA.

During 1942-43 he was a research physicist with the University of California Division of War Research. He is a member of the Institute of Radio Engineers, and belongs to the Operations Research Society of America.

BIOGRAPHICAL SKETCH As of 12-13-63

McCOWN, Everett E. Code 3330, NEL
Supv., Electronics Engineer, GS-14 EXT. 202/209

Educational Background:

E.E. Degree from Santa Maria Junior College, June 1942
40 units of Math, Elec. Engineering subjects at Univ. of Calif., L.A.
9 months radar engineer trainee (War Dept. school)
Military Service Schools: Canadian Radar School, Signal Corp School.

Professional Background:

Military experience from February 1943 to 1946: Signal Corp Radar School, Palm Beach; Duty at Gilfillian and MIT Radiation Lab; Schools at Canadian Radar School; Presidio at San Francisco.

Mr. McCown has made major contributions to the Navy's display and data processing programs. Initial projects were; Army Target Simulator (Project 4'4), Marine Corp Digital Mortor Locator Computer. He conceived, designed, and coordinated display equipment in 1949 which subsequently led to an extensive development contract for a Semi-Automatic Air Intercept Control System culminating in the production of Display Equipment for the Navy Tactical Data System. He has simultaneously guided the development of techniques which were introduced into the NTDS display equipment development program through all its phases and has served as the principal technical consultant on all contracts for the NTDS display equipment, from the experimental equipment to the first production equipment currently coming off the production line. Mr. McCown served as a full time member of the Navy's Project LAMP LIGHT, a six month study contract with MIT to develop the characteristics of a Fleet Data System. He is an Associate Navy Member on the Working Group on Special Devices of the Advisory Group on Electronic Devices for CNO. He headed a team of scientists commissioned with the responsibility for delineating the requirements for the Service Test NTDS. His outstanding leadership in this effort produced documentation which served as the basis for the development of the Service Test Equipment which was installed on five ships and at two shore stations.

Mr. McCown is co-inventor of (1) High speed magnetic switch; (2) Automatic Fishing Apparatus; (3) Repairable plug-in package unit. Current inventions are an integrated display control mechanism; and a laser deflection system display applications; plus several other inventions presently being reviewed.

BIOGRAPHICAL SKETCH As of 12-13-63

McMANUS, Robert Paul
Head, Automatic Communication Division

Educational Background:

U.S.C. - B.A. Math
Some graduate study but no degrees

Professional Background:

Outstanding Performance Rating - 1959, 1960, 1961, 1962
Sustained Superior Performance - 1962
Superior Accomplishment Award - 1959, 1960, 1962
Letters of Commendation from CNO

Professional Papers, Books, Inventions:

NEL Technical Memorandum - 394
NEL Technical Memorandum - 129

NEL Technical Memorandum - 641
(1) PIP Modulator, NC 37584
(2) INDAT "1" System - NC 33154
(3) Reliability of NTDS "A" Link Communications - NC31652
(4) Spectrum Analyser - NC 35009
(5) Simplified Diversity System - NC219

Societies, Associations and Professional or Honorary Memberships:

IRE - member
NATO - U.S. Technical Representative for meetings.
TIDE - U.S. Technical Representative for meetings.

BIOGRAPHICAL SKETCH As of 12-13-63

MITCHEL, Walter P.
Head, Data Control & Microsystems Division

Educational Background:

Kansas City Jr. College, A.S.
California Institute of Technology, BSEE
Bowdoin College
Massachusetts Institute of Technology
UCLA, all course work for MS

Professional Background:

General Electric Company - Industrial Control Engineer
Kellex Corporation - Electrical Engineer (Nuclear Instrumentation)
U.S. Navy - Technical Radar Officer
U.S. Navy Electronics Laboratory - Electronics Engineer (Section, Branch, Division Heac

Professional Papers, Books, Inventions:

Author of articles on ara-interruption phenomena, servomechanisms, microelectronics, simulation. Theoretical work in servomechanisms, experimental work in micro-barometry, computers, displays, servos, simulators. Major technical (responsibility for large-scale system development (NEWS, NTDS, NSACS). Direction of Microelectronics Laboratory, Digital Control Systems R & D, Applied Systems Development and Evaluation Center.

Societies, Associations and Professional or Honorary Memberships:

Tau Beta Pi
IEEE
American Association for Advancement of Science
Registered Professional Engineer in EE, California

BIOGRAPHICAL SKETCH As of 12-13-63

NYE, Glen

Electronics Scientist Glen Nye is Head of the Systems Equipment Branch at the Navy Electronics Laboratory. By his own description, a "self-educated" man, Mr. Nye graduated from high school and attended Kansas State Teachers College in Pittsburg, Kansas.

He joined NEL in 1942, when it was known as USNRSL under the University of California, serving as a civilian instructor in electronics theory at the Fleet Sonar School. When he was reassigned to the Laboratory his first job was the design and fabrication of a special purpose anti-submarine computer. He was immediately appointed project leader and designed or influenced the design of many of the Navy sonar trainers, some of which are still in use. He was promoted to his present position in the fall of 1952.

Mr. Nye's branch is mainly concerned with the pure digital computer and information display engineering problems. Their present problem is one of international importance, involving a major change in military electronics theory.

Mr. Nye was born in Brookfield, Missouri. He has authored and co-authored numerous reports and specifications incident to his job. His articles have appeared in Popular Mechanics and Electrical Mfg. He holds five patents for electronic hardware, circuits, and training devices.

BIOGRAPHICAL SKETCH As of 6-17-62

SCHANIEL, Carl L.
Operations Research Analyst, GS-13

Educational Background:

BA in Math; MS in Physics, San Diego State College
Additional work: UC Extension Division

Professional Background:

NEL Physicist, GS-5 to 11 2/23/51 to 7/26/59
NEL Operations Research Analyst, GS-12 to 13 7/26/59 to 6/17/62
Transferred to NOTS, China Lake 6/17/62 as Operations Research Analyst, GS-14

Professional Papers, Books, Inventions:

NEL Reports and TM's on sonar classification; NTDS analysis, particularly in regard to radar tracking problems and threat evaluation/weapons assignment; NTDS/TRANSIT navigation capability.

Societies, Associations and Professional or Honorary Memberships:

Operations Research Society of America

BIOGRAPHICAL SKETCH As of 12-13-63

SHEEHY, Myles J.
Supervisory Opers. Res. Analyst, GS-15

Educational Background:

BA, Physics, UCLA, 1936
Graduate work - USC and UC Ext. Division

Professional Background:

Asst. Geophysicist, Rieber Laboratories, 1936-1938
Science and Math teacher, Moorpark and Burbank High Schools, 1939-1942
Assoc. Physicist, Univ. of California Div. of War Research, 1942-1946
Physicist, NEL, 1946-1955. Section Head, 1959-1955
Operations Research Analyst, NEL, 1955 - date. Branch Head 1955-1962
Division Head 1962-date.

Professional Papers, Books, Inventions:

Approximately 40 professional papers, NEL, and UCDWR reports. NEL representative and occasionally chairman on several BUSHIPS, Navy, and CSC Committees. Who's Who in the West.

Societies, Associations and Professional or Honorary Memberships:

Acoustical Society of America (Vice President and President of San Diego Chapter)
Operations Research Society of America
U.S. Naval Institute, National Geographic Society
Executive Committee, Military Operations Research Symposia

BIOGRAPHICAL SKETCH As of 12-13-63

SPILMER, Beverly Herman
Electronics Engineer (General)

Educational Background:

Warrant Officers Radio Engineering School, Washington, D.C.
Capitol Radio Engineering Institute
University of California Extension

Professional Background:

Western Electric Co. - Telephone Repair
Merchant Marine - Radio Officer
Mackay Radio & Telegraph Co. - Radio Operator Station KEK, Portland, Oregon
U.S. Navy - Chief Warrant Radio Electrician (Radar, Sonar Officer)
U.S. Navy Electronics Laboratory (Jan. 1946) - Electronics Engineer

Professional Papers, Books, Inventions:

Author of article on Radio Instruction Panel for At Sea Training; formal reports on missile tracking and control systems, C.W. Radar, landing craft control system; Co-author of formal reports covering Operational Employment Studies for the Naval Tactical Data System (NTDS), interaction between NTDS and MTDS in an Amphibious Environment; NTDS Service Test Instrumentation requirements; Production Specification for NTDS Display Group; member NTDS Service Test Design Committee, Patent disclosure as co-inventor for "Dynamic Pert Programming System" Responsible to Problem Manager for Displays for system engineering - Tactical Data Processing Division.

Societies, Associations and Professional or Honorary Memberships:

IEEE

BIOGRAPHICAL SKETCH As of 12-13-63

WOLFF, Hubert G.
Electronic Engineer (Supv.) GS-14

Educational Background:

University of California at Los Angeles 1934-36
University of Cincinnati (Ohio) 1936-38
University of California (Berkeley) 1938-39 BS in EE

Professional Background:

Radio Engineer, Wright Field Aircraft Radio Laboratory, 1939-42
Signal Corps, E.S. Army, R & D Officer, Wright Field and HQ USAF in CBI 1942-46
Radio Engineer, Communications and Navigation Lab, Wright Field Hq. AMC Aug-Nov 1946
Electronic Engineer, NEL Dec 1946 to present
Currently Head of Communications Techniques Division, Code 3230

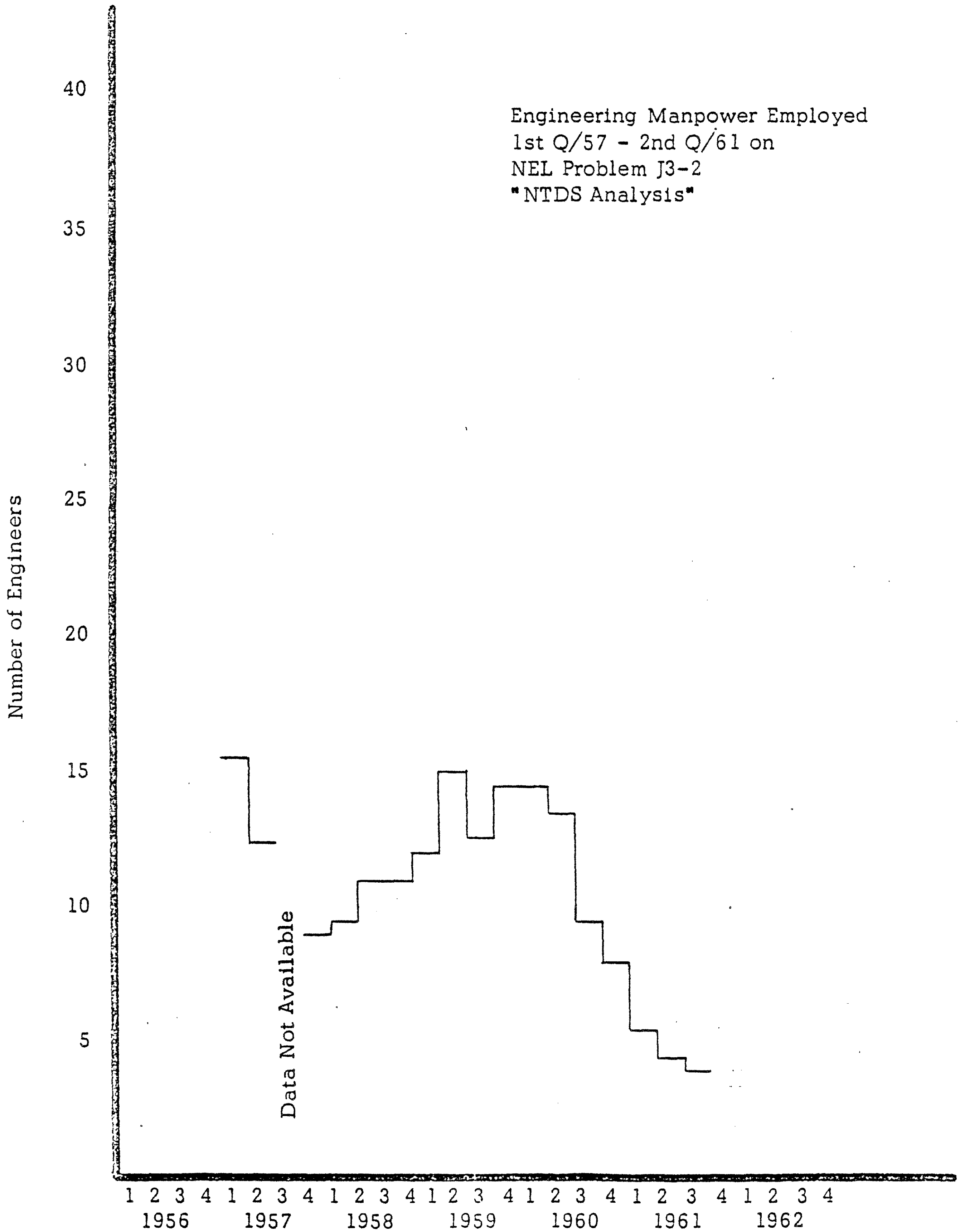
Professional Papers, Books, Inventions:

U.S. Patent No. 2,520,922 "Automatic Navigator and Indicator"
U.S. Patent No. 2,793,292 "Constant Amplitude Variable Frequency Oscillation Generator"
U.S. Patent No. 3,092,803 "Sonar Data Transmission System"
Numerous NEL reports (mostly classified)
IRE Transactions, Vol. CS-5, No. 3 Dec 1957, "High Speed Frequency Shift Keying of LF and VLF Radio Circuits."

Societies, Associations and Professional or Honorary Memberships:

Member, Institute of Radio Engineers

APPENDIX D



Engineering Manpower Employed
1st Q/57 - 2nd Q/61 on
NEL Problem J3-2
"NTDS Analysis"
Number of Engineers
40
35
30
25
20
15
10
5
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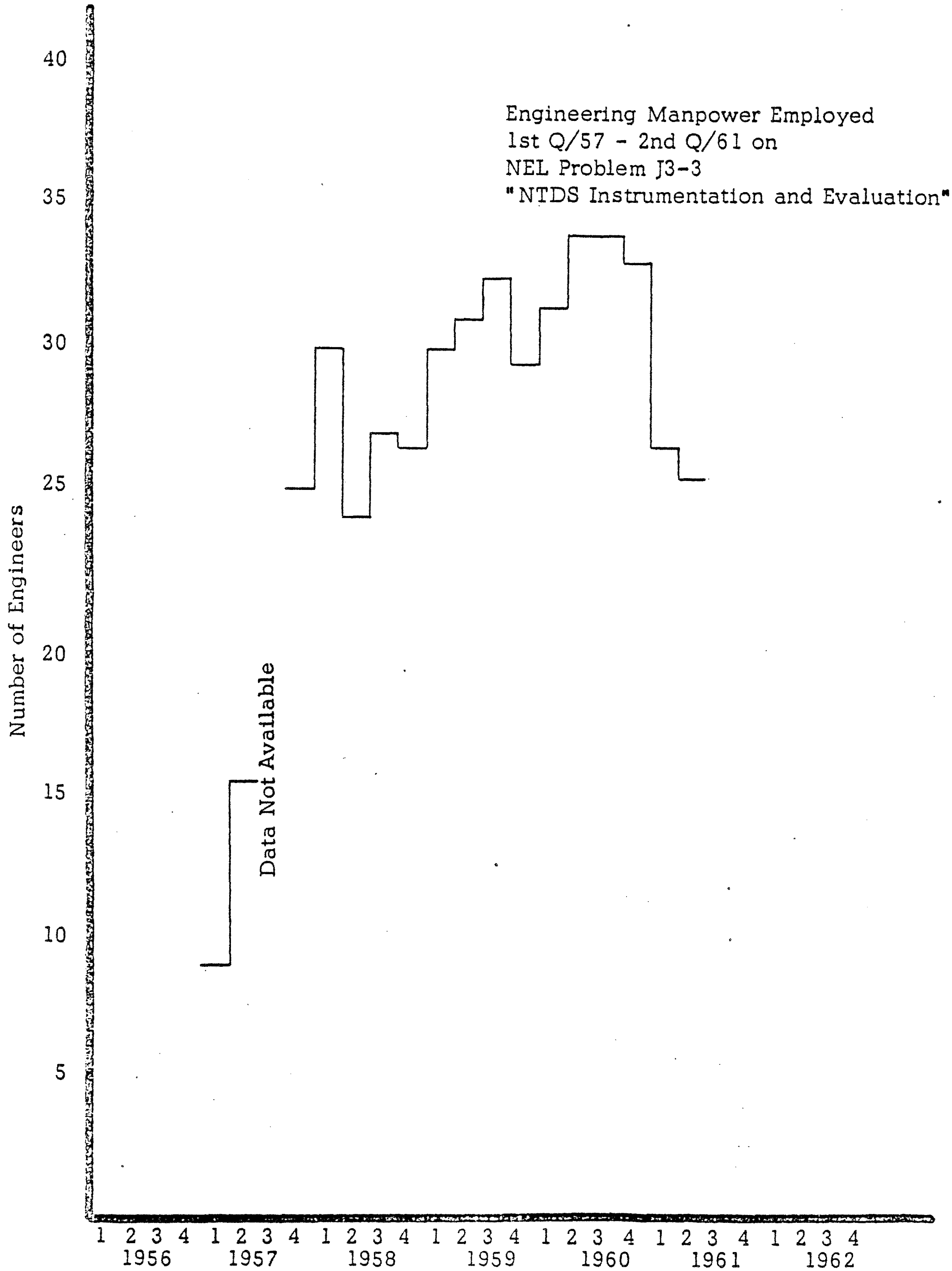
1957
1958
1959
1960
1961
1962


Engineering Manpower Employed
1st Q/57 - 2nd Q/61 on
NEL Problem J3-3
"NTDS Instrumentation and Evaluation"
Number of Engineers
40
35
30
25
20
15
10
5
Data Not Available
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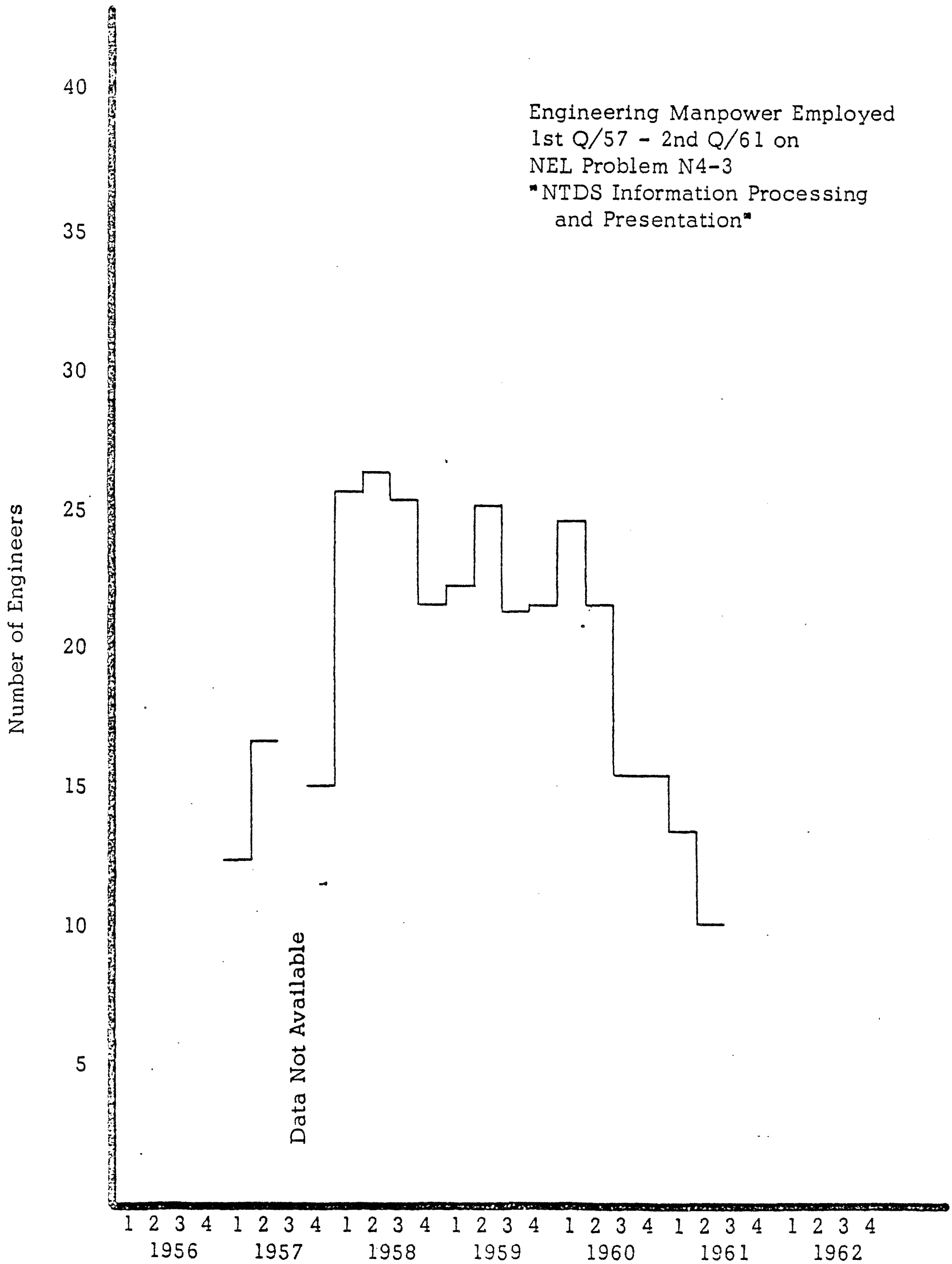
1956
1957
1958
1959
1960
1961
1962


Engineering Manpower Employed
1st Q/57 - 2nd Q/61 on
NEL Problem N4-3
"NTDS Information Processing
and Presentation"
Number of Engineers
40
35
30
25
20
15
10
5
Data Not Available
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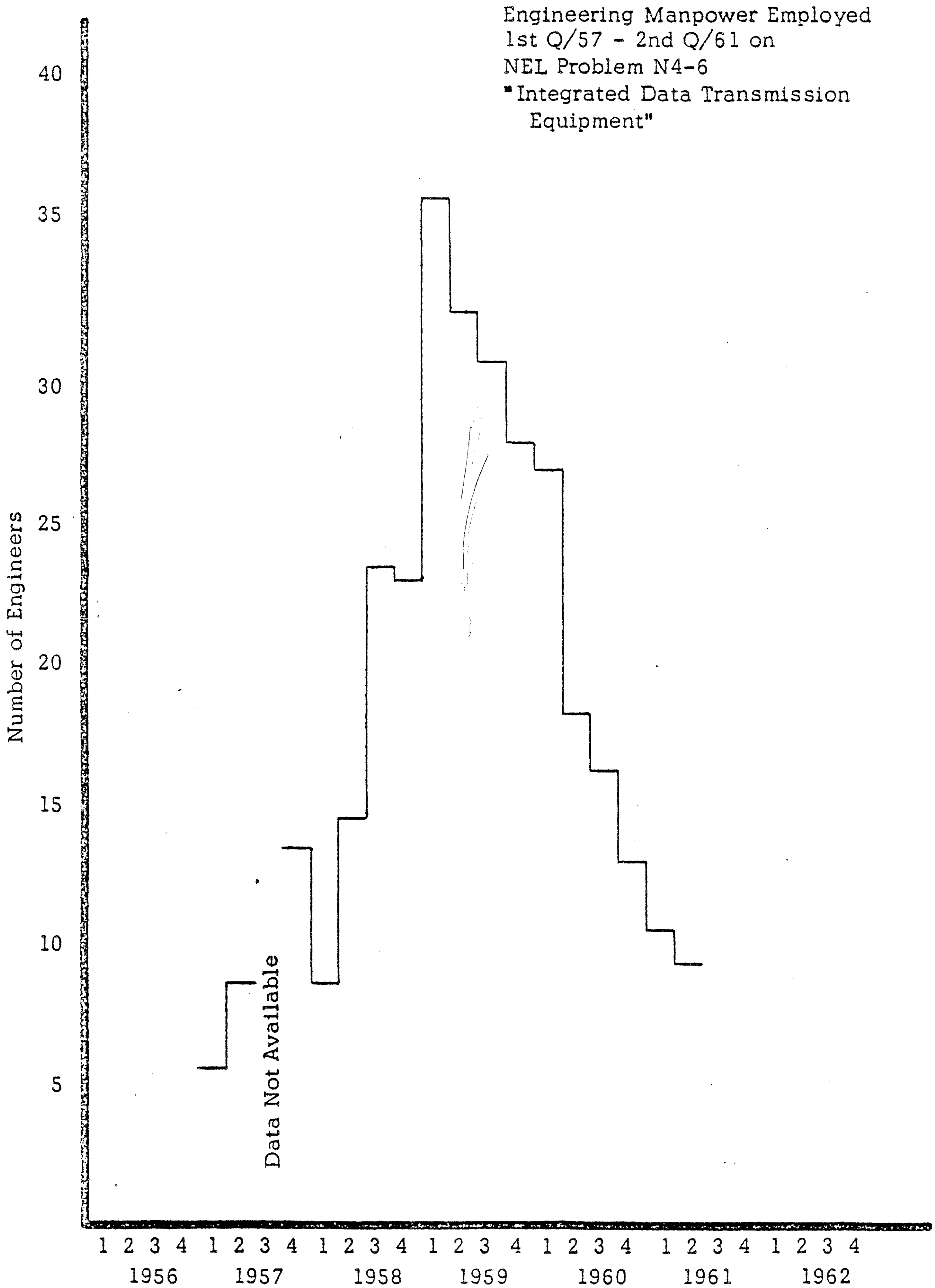
1956
1957
1958
1959
1960
1961
1962


Engineering Manpower Employed
1st Q/57 - 2nd Q/61 on
NEL Problem N4-6
"Integrated Data Transmission Equipment"
Number of Engineers
40
35
30
25
20
15
10
5
Data Not Available
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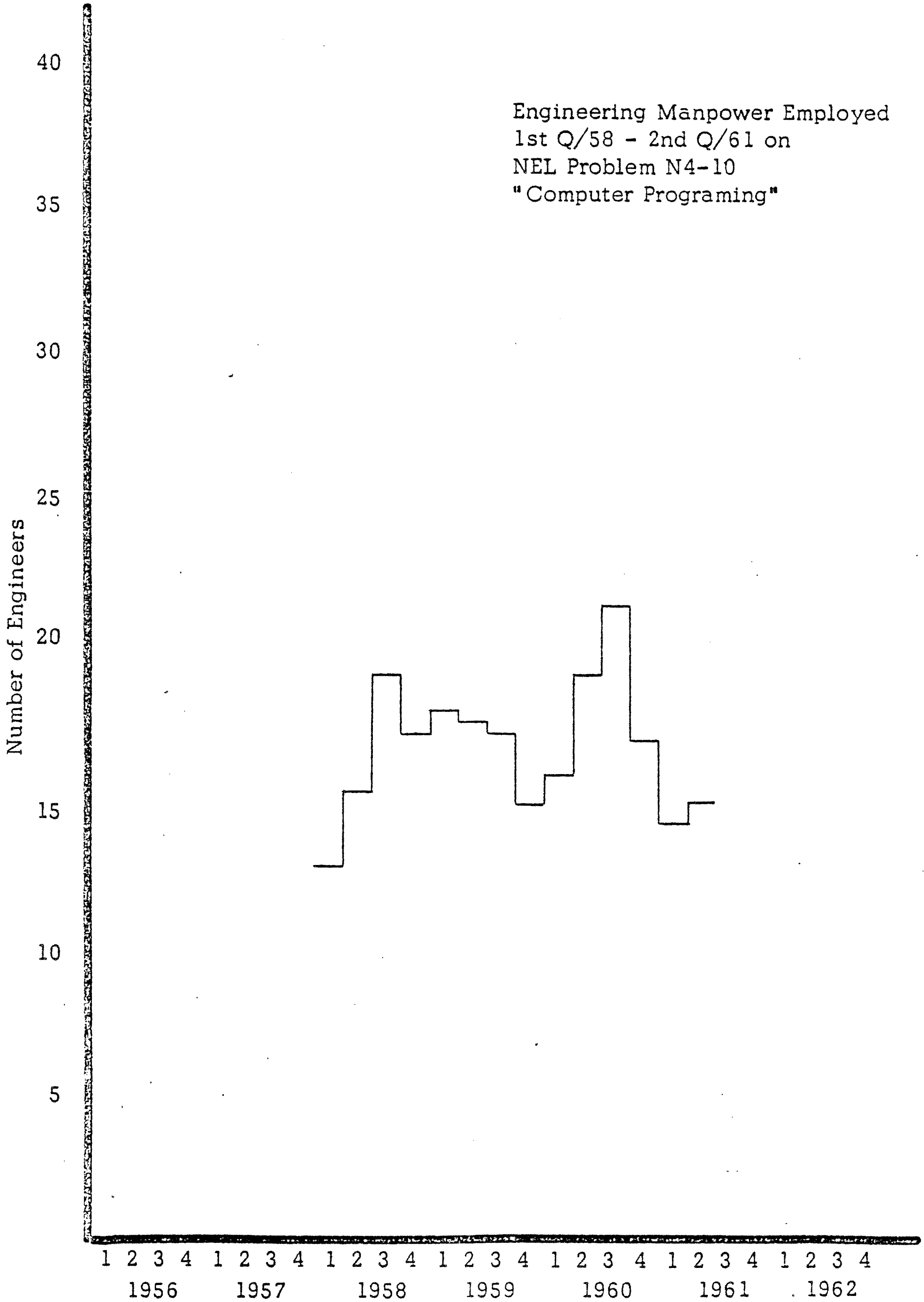
1956
1957
1958
1959
1960
1961
1962



Engineering Manpower Employed
1st Q/58 - 2nd Q/61 on
NEL Problem N4-10
"Computer Programing"
Number of Engineers
40
35
30
25
20
15
10
5
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1956 1957 1958 1959 1960 1961 1962

APPENDIX E

BIOGRAPHICAL SKETCH

CRAY, Seymour R.
Director of Development

up till 1958

Educational Background:

BSEE, University of Minnesota, 1950
MSEE, University of Minnesota, 1951

Professional Background:

1958 Control Data Corporation - Member of the Board of Directors and Director of Engineering. Supervised design, development and construction of the first Control Data Corporation 1604 Computer and associated equipment and large-scale, special-purpose data-processing systems.

1953-58 Remington Rand Univac - Department Manager. Supervised development of the Naval Tactical Data System, including design, coordination, programming and assembly of the system. Developed mechanized design programs for using a large-scale scientific computer to design other computer systems. Earlier, as a Project Supervisor, directed design and construction of a special-purpose computing system using solid-state components. Developed a generalized incremental computer logic for drift-free real-time computation in an airborne environment.

1951-53 Engineering Research Associates, Inc. - Project Engineer. Responsible for all aspects of fabrication and electrical checkout design of control section of the first ERA 1103 computer system. Designed pulse transformers for special digital circuit applications. Developed magnetic drum reading and writing circuits for a large digital system.

1949-51 University of Minnesota - Mathematics Instructor.

Patents:

U.S. Patent No. 2,741,758: Magnetic Core Logical Circuits
U.S. Patent Office Serial No. 771,428, filed November 3, 1958: Bi-Leval Amplifier and Control Device

Author:

"Computer Programmed Preventive Maintenance for the ERA 1103 Computer System", WESCON, August, 1954.
"A Progress Report on Computer Applications in Computer Design", WESCON March, 1956 (co-author).

BIOGRAPHICAL SKETCH

THORNTON, James E.
Chippewa Laboratory
Chippewa Falls, Wisconsin

Educational Background:

BSEE, University of Minnesota, 1950

Professional Background:

1962	Chief Engineer, Chippewa Laboratory. Control Data 6600 Computer System.
1960	Manager, 6600 Computer Department. Design and development of a new computer system several times the magnitude of 1604 Computer. Organization of manufacturing and testing of new system.
1958-60	Control Data Corporation - Manager, 1604 Computer Department. Responsible for logic design of Control Data Corporation 1604 Computer, and for design and construction of a large-scale, special-purpose computing system.
1954-58	Remington Rand Univac - Department Manager. Engineering and administrative responsibility for a large military data system (Naval Tactical Data System), including programming, design and construction of transistorized digital computers. Earlier, as Project Engineer, supervised design and construction of general-purpose magnetic and transistor computers.
1950-53	Engineering Research Associates, Inc. - Project Engineer. Member of development team which designed ERA 1103 Computer.

Patents:

U.S. Patent Application: Noise-suppressing transfer circuit for magnetic core logic

U.S. Patent Application: Memory apparatus for large-scale ferrite core memory

Author:

"Univac M-460 Computer", presented at Western Joint Computer Conference, Los Angeles, May 7, 1958

"Considerations in Computer Design - Leading Up to the Control Data 6600."

BIOGRAPHICAL SKETCH

TOTH, Dolan H.
Manager, Special Projects Department

Educational Background:

BSEE, Columbia University, 1946

Professional Background:

1960 — Control Data Corporation - Manager, Special Projects Department. Supervise and assist in design of new computers, special-purpose data handling machines and peripheral equipment. Supervise design of new building blocks. Propose new projects for company-sponsored research. Aid Sales Department in engineering sales support; prepare proposals.

1959-60 — Control Data Corporation - Supervisor, Advanced Circuits Design Section. Development of higher-speed digital computers.

1952-59 — Remington Rand Univac - Assistant Manager, NTDS Department. Directed design and development of digital computers and related peripheral equipments for Naval Tactical Data System. Supervised development of first transistor computer built by Univac.

1946-52 — Engineering Research Associates, Inc. - Participated in development of first magnetic drum. Developed magnetic drum circuits and heads and participated in developing magnetic core logic circuits used in ERA 1104 and other computers.

Patents

U.S. Patent No. 2,641,717: Transistor One-Shot Multivibrator
U.S. Patent No. 2,692,379: Blocking Oscillator Magnetic Recording Device

Author:

"Tester for Measuring Small-Signal Impedances of Transistors", Review of Scientific Instruments, Vol. 25, No. 1, January, 1954.

Professional Organizations

Institute of Radio Engineers, Associate Member

PROFESSIONAL STAFF
DATA SHEET
UNIVAC
DIVISION OF SPERRY RAND CORPORATION

DATE COMPLETED 22 October 1962
DATE UPDATED 18 October 1963

NAME George G. Chapin, Jr.

COLLEGE(S) ATTENDED	FROM	TO	MAJOR AREA	DEGREE AND DATE
Univ. of Minnesota	1943	1947	Chemical Engineering	BChE - 1947
Univ. of Minnesota	1947	1959	Applied Mathematics	Ph.D. - March 1959

PROFESSIONAL EXPERIENCE: (PRESENT POSITION LAST · ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
3 summers	University of Minnesota	Research Scientist	Applied research on heat transfer, compressible fluid flow, and material damping.
1947 - 1953	University of Minnesota	Instructor Mathematics & Mechanics	Taught all undergraduate courses offered in Mathematics and Mechanics.
1953 - 1955	University of Minnesota	Instructor Mechanics & Materials	Taught Engineering Mechanics and Mechanics of Materials.
Aug. 1955-May 1956	Remington Rand Univac	Mathe-matician	Systems Analysis Department.
May 1956-Dec. 1958	Remington Rand Univac	Electrical Engineer Mil. Engrg. Division	Supervisor-Advanced systems development, NTDS department. Experience in logical design of a computer, programing, mathematical analysis, and design of large scale surveillance and defense systems.
Dec. 1958-Oct. 1961	Remington Rand Univac	Asst. Dept. Manager	Responsible for NTDS Systems Development including all analysis, design, and development of system.
Oct. 1961-June 1962	UNIVAC	Manager	Responsible for NTDS Systems Development including all analysis, design, and programing. Also responsible for overall management of San Diego Engineering Center.
Jan. 1962-Sept. 1962	UNIVAC	Department Manager	Responsible for long range planning of all "software" activities for Military Systems.

A-1018-1V(Rev.9/63)

COMPLETE REVERSE SIDE

George G. Chapin, Jr.

Updated
18 October 1963

			PRINCIPAL DUTIES
Oct. 1962 - Present	UNIVAC	Systems Manager	Responsible for programing of most funded projects in St. Paul, for planning and management of Military Product Line developments, for any "software" related to Product Line, and for establishing and managing the Military Computer Center.

George G. Chapin, Jr. 16 October 1963

PERTINENT MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
1945	1946	U. S. Navy	Aerographer's Mate 3/c	

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

Ph.D. Thesis: One and Two Point Boundary Value Problems for Ordinary Linear Differential Equations Containing a Parameter. Also published as Office of Ordnance Research Report.

Co-Author of "Automatic Tracking for the Naval Tactical Data System", MITRE Tracking Symposium, 1958.

Author of "Programing a Shipboard Real-Time Computer System", Sperry Engineering Review, Summer 1963.

Author of "Organizing and Programing a Shipboard Real-Time Computer System" to be presente at the Fall Joint Computer Conference, November 1963.

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

Patent Application - Information Transfer System

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

American Mathematical Society
Institute of Electrical and Electronic Engineers
Member Tau Beta Pi (Honorary Engineering)
Member Phi Lambda Upsilon (Honorary Chemistry)
Member Alpha Chi Sigma - Chemistry Fraternity
Association for Computing Machinery

REMARKS:

August 14, 1963

PROFESSIONAL STAFF
DATA SHEET
UNIVAC

Robert R. Coon — Date of birth: 8-12-27

Purdue University	1951	Electrical Engineering	B.S.E.E.
Purdue University	1953	Engineering Mechanics	M.S.E.
Purdue University	1956	Electrical Engineering	Ph.D.

September 1951 - September 1953	University of Purdue	Instructor	Instructor of Engineering Mechanics. Instructed non-Engineering Mechanic junior and senior engineers in basic mechanics courses.
September 1953 September 1956	University of Purdue	Instructor	Instructor of Electrical Engineering. Instructed Electrical Engineering junior and senior classes in circuit theory, electrical measurements and tube theory.
September 1956 - September 1957	Remington Rand UNIVAC - NTDS	Electrical Engineer	Systems design on NTDS. Detailed logical design of NTDS Unit Computer.
September 1957 - February 1958	Remington Rand UNIVAC - NTDS	Department Manager	Manager for NTDS project. Supervised hardware development, logical development, programming and systems development of NTDS.
February 1958 - October 1959	Remington Rand UNIVAC - Military Eng. Systems	Engineering Director	Directed activities on NTDS, Nike Zeus and one other (classified) project.
October 1959 - November 1961	Remington Rand UNIVAC - Military Division	Technical Assistant to the General Manager	Assist the General Manager in the coordination of technical activities among the various groups in Saint Paul and with the Sperry Divisions.

COON, Robert R.

[illegible]

PROFESSIONAL STAFF
DATA SHEET

DATE COMPLETED August 14, 1963

PROFESSIONAL EXPERIENCE (PRESENT POSITION FIRST. ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DIVISION	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
November 1961 - June 1962	Remington Rand Univac	Midwestern Region Regional Training Mgr.	Manager of UNIVAC Commercial Training Center at Purdue University.
June 1962 - August 1962	UNIVAC Division of Sperry Rand	Staff Scientist	Assist the General Manager in the coordination of technical activities among the various groups in Saint Paul and with the Sperry Divisions.
September 1962 - August 1963	Department of Defense Team of National Defense Experts, Paris, France		(Leave of absence from Sperry Rand)
August 1963 - date	UNIVAC Division of Sperry Rand	Staff Scientist	Assist the General Manager in the coordination of technical activities among the various groups in Saint Paul and with the Sperry Divisions.

COON, Robert R.

PERTINENT MILITARY EXPERIENCE.

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
1945	1948	U. S. Navy	Elec. Technician	

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

I.R.E. - Institute of Radio Eng.
I.R.E. - Professional Group on Engineering Management
Eta Kappa Nu
Tau Beta Pi
Sigma Xi
Registered Professional Engineer
Amateur Radio WØJML
Masonic Lodge
Zurah Shrine
Chairman, Computing and Data Processing Section - Electronic Industries Association
~~REMARKS~~ Board of Directors - Electronic Industries Association

March 30, 1962

Updated November 1962

PROFESSIONAL STAFF

DATA SHEET

Remington Rand Univac

Robert P. Fischer

Univ. of Minn.	1941 1942	Electrical Engineering	
Univ. of Minn.	1947 1956	Electrical Engineering	part time enrollment in I.T.

1946 - 1949	Remington Rand Univac	Electrical Technician	Design and development of military special purpose communications equipment.
1949 - 1953	Remington Rand Univac	Electrical Engineer	Development of special purpose digital computer for military application..
1953 - 1956	Remington Rand Univac	Electrical Engineer	Development of general purpose digital computers(Univac Scientific).
Feb. 1956- Feb. 1957	Remington Rand Univac	Electrical Engineer	Technical Responsibility for special purpose digital data processing circuitry in AN/TSQ 13.
Feb. 1957 - Sept. 1957	Remington Rand Univac	Project Engineer	Technical supervision of design development, and prototype construction of AN/TSQ 13.
Sept. 1957 - June 1959	Remington Rand Univac	Supervising Engineer, TACS	Organization, direction, and supervision of design, development and acceptance testing of Aircraft Direction and Reporting System AN/TSQ 13.
June 1959 - date April 1962	Remington Rand Univac	Manager - NTDS General Engineering	Direction and supervision of design, development, and qualification testing of NTDS computers and peripheral equipment.

PROFESSIONAL STAFF
DATA SHEET

NAME Robert P. Fischer

PROFESSIONAL EXPERIENCE (PRESENT POSITION LAST; ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
April 1962 - July 1962	Remington Rand Univac	Proposal Manager	Coordination and technical direction in the preparation of a joint proposal with Lockhead Missiles & Space Co. to NASA for the design, construction and systems management of a program to develop the NOVA booster rocket.
July 1962 - November 1962	Remington Rand Univac - Plans & Policies Dept.	Staff Consultant	Formulate policies and operating procedures for the Military Systems, Research & Development Division.
November 1962 - date	Remington Rand Univac - MOCC	Systems Manager	Coordinate and direct the activities of all groups contributing to the development of the CP 667 computer.

Fischer, R.P.

			RANK	PRINCIPAL DUTIES
1942	1945	Army Signal Corps	S/Sergeant	Depot Maintenance of Airborne Radar Equipment.

(USE ADDITIONAL SHEETS IF REQUIRED)

Co-author "Automatic Testing and Selection of Magnetic Toroids", presented at AIEE General Meeting, 1955

(USE ADDITIONAL SHEETS IF REQUIRED)

None

SOCIETIES AND FRATERNITIES:

None

DATE COMPLETE 30 September 196

PROFESSIONAL STAFF

DATA SHEET

Remington Rand Univac

NAME Carl W. Glewwe

COLLEGE(S) ATTENDED	FROM	TO	MAJOR AREA	DEGREE AND DATE
Univ. of Minn.	Sept. 1946	June 1950	Electrical Engineering	BEE - June 1950
Univ. of Minn.	Sept. 1950	Dec. 1955	Electrical Engineering	MS - December 1955
Univ. of Minn.	Dec. 1955	Oct. 1958	Electrical Engineering	Ph.D. - December 1958

PROFESSIONAL EXPERIENCE: (PRESENT POSITION FIRST - ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
May 1953-Oct. 1958	Univ. of Minn. Electrical Engineering Dept.	Instructor & Research Fellow	Instruction of various electrical engineering courses - research in Electrical Noise and Vacuum Tubes, especially cathodes.
June 1957-Sept 1957	General Mills Mech. Division	Senior Engineer	Design and analysis of Analogue Computers. Study of Micro-wave Propagation.
Oct. 1958-Aug. 1960	Remington Rand Univac	Electrical Engineer	System design and analysis. Programming.
Aug. 1960-Feb. 1962	Remington Rand Univac	Supervising Engineer	Supervision of System Engineering Group and Computing Center (30 peopl[e]) Generally responsible for coordinati[ng] the interconnection of many equipments in a large scale system (NTDS).
Feb. 1962-Sept. 1962	Remington Rand Univac	Manager, Military Systems Engineering	Assist Director of Military Systems Development in long range planning for systems engineering.
Sept. 1962 to date	UNIVAC	Manager, Product Line Specifications	Maintain long range plan for Military Product Line. Manage development programs for company sponsored products.

Glewwe, Carl W.

PERTINENT MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
July 1945	July 1946	U. S. Navy	AT-3	Radio Technician School
Dec. 1951	Apr. 1953	U. S. Navy	AT-2	Maintenance of airborne electronic equipment.

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

MS. Thesis - 1956 - Some Properties of an Annular Electron Lens

Ph.D. Thesis - 1958 - Effects of Temperature Transients in Oxide Coated Cathodes

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

None

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

Institute of Radio Engineers
Honor Societies: Eta Kappa Nu
Tau Beta Pi
Gamma Alpha
Sigma Xi

REMARKS:

DATE COMPLETED May 10, 1961
Up-dated May 21, 1963
Up-dated October 14, 1963

PROFESSIONAL STAFF
DATA SHEET

Remington Rand Univac

Arnold P. Hendrickson

SCHOOLS ATTENDED	FROM	TO	MAJOR	DEGREE AND DATE
Dunwoody Institute	Oct. 1945	May 1947	Industrial Electronics	

PROFESSIONAL EXPERIENCE (PRESENT POSITION FIRST. ACCOUNT FOR ALL TIME)

FROM - TO	COMPANY AND LOCATION	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
June '39 - Feb '41	Madison Radio Service	Owner	Radio Repair work.
Oct '45 - May '47	Dunwoody Institute	Instructor	Construction and repair of radio and electronic equipment. Teaching part time.
May '47 - Dec '47	ERA	Technician	Construction and test of equipment to investigate NRZ magnetic drum recording techniques.
Dec '47 - Jan '51	ERA	Project Engineer	Design and development of an electronic equipment for adjusting magnetic head to drum spacing.
		Sr. Tech. and EE	Design and development of: magnetic drum storage system for ERA 1101 computer, photo electric punched paper tape reader and a digital shaft position indicator system using magnetic drum techniques.
Jan '51 - Aug '51	Remington Rand Univac	Electrical Engineer	Supervise design and development of magnetic storage and control section of a large fixed program digital computer.
Aug '51 - Aug '53	Remington Rand Univac	Project Engineer	Direction and supervision of design and development of a Flight Plan Storage System for the CAA using magnetic drum techniques.

Hendrickson, Arnold P.

DATE COMPLETED May 10, 1961
Up-dated May 21, 1963

			PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
Aug '53 - Apr '54	Remington Rand Univac	Project Engineer	Direction and supervision of design and development of a Sine Table Look-up Device using magnetic drum storage techniques.
Apr '54 - Mar '55	Remington Rand Univac	Project Engineer	Supervision of design and development of magnetic switch devices and associated circuits for computer applications.
Mar '55 - Mar '57	Remington Rand Univac	Project Engineer	Direction and supervision of design and development of the "Athena" digital computer system for use in the radio-inertial ground guidance of the ICBM TITAN missile.
Mar '57 - Sept '57	Remington Rand Univac	Sec. Supv., Ballis. Miss. Section	Direction and supervision of ICBM program at RRU.
Sept '57 - Feb '58	Remington Rand Univac	Dept. Mgr. Control Systems Dept.	Direction and supervision of ICBM TITAN Guidance Computer and BOMARC missile guidance computer development programs.
Feb '58 - June '59	Remington Rand Univac	Eng. Director, Systems II	Direction of the following programs; 1. Development of a digital guidance computer for the ICBM TITAN. 2. Development of a digital guidance computer for the BOMARC missile. 3. Development of equipment for a Tactical Air Control System.
June '59 to Aug '61	Remington Rand Univac	Eng. Director, Data Systems	Direction of the following programs; 1. Development of a digital guidance computer for the ICBM TITAN. 2. Development of an advanced digital device for missileborne applications using thin magnetic films. 3. Development of Automatic Antenna Couplers for use on aircraft and Navy ships. 4. System Engineering and hardware development for the Naval Tactical Data Systems.

Arn~ld P. Hendrickson

...NAL EXPERIENCE: (PRESENT POSITION LAST: ACCOUNT FOR ALL TIME)

(MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
August 1961 - September 1962	Remington Rand Univac	Eng. Director, Military Systems Development	Direction of the following programs: 1. Systems Engineering Management and Programming of the data handling sub-system of the Mobile Atlantic Range (MAPS) Tracking ship. 2. Systems Engineering Management and Programming of the Computer Controlled Radar Acquisition system for Antigua, Ascension Island and Pretoria, So. Africa. 3. Systems Engineering and Programming of the Naval Tactical Data Systems. 4. Systems Engineering Management and Programming of the computer sub-system of the Nike Zeus system.
September 1962 to date	UNIVAC	Engineering Director, Defense Systems Development	Director of the following programs: 1. Systems Engineering Management and Programming of Aerospace Systems (Athena space & orbital missions, Mobile Atlantic Range Systems, Pacific Missile Range Tracking and space vehicle activities, MRV, MBFVC). 2. Systems Engineering Management and Programming of Command & Control Systems (Naval Tactical Data Systems, Rome Air Development Center Intelligence, Weapons Direction Systems, Ships Operational Readiness Testing, Federal Aviation Agency Traffic Control). 3. Systems Engineering Management and Programming of Guidance and Control Systems (Multiple Array Radar Weapons System, Nike Zeus System, Nike X Study). 4. Systems Engineering Management and Programming of Defense Product Line and Defense Computer Centers.

Hendrickson, Arnold P.

From	To		Rank	Principal Duties
Feb. 1941	Oct. 1945	U.S. Army Air Force	T/Sergeant	Instructor, Chief Aircraft Radio Operator, Supervise Aircraft Radio Maintenance at Squadron Level. Supervise radio repair section at repair depot. Construction and repair of radio and electronic equipment. Teaching part time.

Message Storage and Processing with a Magnetic Drum Storage System.
A. P. Hendrickson, G. R. Williams, J. R. Hill.

ERA Docket 23 - Data Storage System, permanently recorded address.
2,771,595-20 Nov. 1956

ERA Docket 32 - Methods & Applications for setting magnetic transducing heads,
2,708,693/5-17-55

ERA Docket 72 - Magnetic Core Circuits Type 3 Switch

REMARKS

Amateur Radio WØJJJ

A-1018-1 V

DATE COMPLETED November 22, 1961
Updated March 13, 1963
Updated July 1, 1963

PROFESSIONAL STAFF DATA SHEET

Remington Rand Univac
DIVISION OF SPERRY RAND CORPORATION

NAME: Vernon E. Leas

COLLEGE(S) ATTENDED	FROM	TO	MAJOR AREA	DEGREE AND DATE
Dunwoody Industrial Institute	Aug 1939	Apr 1941	Electronics	Graduate
Univ of Ill (Ext)	1943	1944	Mathematics & Bus Adm	Graduate Night School

PROFESSIONAL EXPERIENCE: (PRESENT POSITION FIRST; ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
Apr '41-May '42	IBM (Chicago, Ill.)	Junior Customer Engineer	Customer Engineer for EAM-ITR equipment
May '42-June '43	IBM (Bloomington, Illinois)	Senior Customer Engineer	Customer Engineer for EAM-ITR equipment
June '43-June '44	IBM (Peoria, Ill.)	Supervisor, Customer Engineering	Supervisor, Customer Engineering, for a resident territory on EAM-ITR equipment. Recruited new employees from universities and colleges.
June '44-May '46	Military Service U. S. Army		
May '46-Dec '46	IBM (Minneapolis, Minnesota	Senior Customer Engineer	Customer Engineering supervision on EAM-ITR equipment for entire state of North Dakota.
Dec '46-Sept '47	IBM (Fargo, North Dakota	Acting Manager	Managed local office of IBM. Responsible for sales and service for entire state of North Dakota.

PROFESSIONAL STAFF
DATA SHEET

DATE COMPLETED November 22, 1962
Updated March 13, 1963
Updated July 1, 1963

PROFESSIONAL EXPERIENCE: (PRESENT POSITION FIRST: ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
Sept '47-Oct '48	Broadway Bowling Alley, Billings, Montana	Owner/ Proprietor	Owned and managed a bowling alley.
Oct '48-Dec '50	Farm & Home Electric, Red Lodge, Mont.	Owner/ Proprietor	Sold bowling alley. Organized and managed an electrical contracting and retail appliance business. This constituted repair, sale, and installation of anything electro-mechanical including refrigeration.
Dec '50-Aug '51	Bechtel Corp. Idaho Falls, Idaho	General Foreman	General foreman on electrical construction on ARCO Atomic Energy Project. Retained interest in electrical contracting business, which I organized in October 1948.
Aug '51-Aug '54	State Sales Co. Billings, Mont.	Business Partner	Partner in coin-operated music amusement and vending equipment. This venture was in addition to the electrical contracting business.
Aug '54-Aug '55	Vern Leas Distributing Co. Billings, Mont.	Owner/ Operator	Owned and managed a brokerage on wholesale produce and truck leasing. This venture was in addition to other business interests. Finally divested myself of all private business interests about 18 mos. after joining UNIVAC.
Aug '55-May '58	Remington Rand Univac, St. Paul, Minnesota	Supervisor, Production Engineering	Organized wire tabulations group for the first file computer system. I was responsible for fabrication and assembly of large prototype program involving 12 computers and approximately 30 pieces of peripheearl equipment. Scheduled entire program for engineering from design through test. Delivered all equipment on or ahead of schedule allowing manufacturing to assume responsibility at the 5th system instead of the 13th as originally planned. Performed principle liaison between St. Paul and Utica. Responsible for transfer of complete

A-1018-4V (Continuation Sheet)

PROFESSIONAL STAFF DATA SHEET

DATE COMPLETED November 22, 1961
Updated March 13, 1963
Updated July 1, 1963

PROFESSIONAL EXPERIENCE: (PRESENT POSITION FIRST. ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
			engineering design of file computer and all peripherals from engineering to manufacturing (St. Paul).
May '58-June '59	Remington Rand Univac, St. Paul Minnesota	Section Supervisor, Fab & Assem.	Responsible for the entire fabrication and assembly of 4 pre-production guidance systems. Had total responsibility for budget, personnel, production engineering, and production planning for these pre-production systems. Responsible for getting all design releases from engineering of the re-designed system, and delivery of product on time against a very tight schedule.
June '59-Jan '60	Remington Rand Univac, St. Paul Minnesota	Manager, Mfg. (ICBM Program)	As Manager of Manufacturing, ICBM Program, I was responsible for the entire manufacturing program of a guidance computer and several pieces of peripheral and ground support equipment.
Jan '60-Sept '61	Remington Rand Univac, St. Paul Minnesota	Coordinator, Naval Tactical Data Systems	Responsible for overall coordination of engineering, manufacturing, and military field engineering organizations through the design of the computer and 13 pieces of peripheral equipment. Responsible for direction of the planning for the manufacturing program for this $20,000,000 production program against the delivery schedule of 1 guidance system per month. This multi-million dollar program included hardware design, delivery of many pieces of equipment, programming for this equipment, and coordination with other prime contractors (Hughes, Collins) and with 3 Navy shipyards in the installation aboard 5 ships. A professional staff of approximately 300 were employed in this effort.
Sept '61-Oct '61	Remington Rand Univac, St. Paul Minnesota	Program Manager	Responsible for the program management functions of both NTDS and the ADD programs. The ADD program is an advanced miniaturized airborne guidance computer built for the Air Force. In this capacity I was responsible

1-1018-4V (Continuation Sheet)

PROFESSIONAL STAFF
DATA SHEET

DATE COMPLETED November 22, 1961
Updated March 13, 1963
Updated July 1, 1963

PROFESSIONAL EXPERIENCE: (PRESENT POSITION FIRST: ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
			for the overall direction of all phases of both programs.
Oct '61-Nov '62	Remington Rand Univac, St. Paul Minnesota	Director, Military Program Management	Responsible for program management functions of all Military Programs in St. Paul except highly classified DOD activities.
Nov '62-date	Remington Rand Univac, St. Paul Minnesota	Director, Navy Programs Management	Due to the sensitive nature and urgency of several Navy programs, and their importance to Univac, Management decided that my efforts should be concentrated on only Navy programs. As Director of Navy Programs Management I am responsible for all Navy activities in the St. Paul Operations.

LEAS, Vernon E.

A-1016-2 V

PERTINENT MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
June 1944	May 1946	U.S. Army ACD Sig. Corps	2nd Lt.	Machine records officer - 1 Yr. in mobile machine records unit; balance in planning conversion & implementing plan to mechanize stock control records in signal corps depots. Followed thru on 12 depots.

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

Sole inventor of U.S. PAT. 2482117 (Slide Shifters for projectors)

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

National Management Association
Minn. Soc. of Industrial Engineers

REMARKS:

PROFESSIONAL STAFF

DATA SHEET

UNIVAC

DIVISION OF SPERRY RAND CORPORATION

DATE COMPLETED 30 September 1963

DATE UPDATED

NAME Herman Osofsky

COLLEGE(S) ATTENDED	FROM	TO	MAJOR AREA	DEGREE AND DATE
Brooklyn Polytechnic Inst.		1953	Math. (Electronics)	B.S. - June, 1953

PROFESSIONAL EXPERIENCE: (PRESENT POSITION LAST - ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
June 1953 - April 1955	Westinghouse Baltimore Missile Grad. Control Engineer	Assoc. Engineer	Integration of 1104 Computer into AN/GAA-35 System. Programming analysis monitoring and peripheral equipment planning.
April 1955 - January 1960	Remington Rand Univac	Mathematician	New products planning, X 306 B planning, system and circuit work on several military projects. System and mathematical analysis for NTDS. New computer circuit, logical and system design.
February 1960 - September 1963	Univac	Pr. Dev. Engineer, Electrical	Supervise logic design of 1206, 1107, 1218, CP-642B, and CP-667 computers.

NAME Osofsky, Herman

[illegible] MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
None				

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

None

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

None

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

Institute of Radio Engineers
Professional Group on Electronic Computers

REMARKS:

None

A-1019-2 V (Rev.9/63)

July 27, 1962
August 15, 1962

PROFESSIONAL STAFF DATA SHEET

Remington Rand Univac

C. J. Pence

Univ. of Minn.	Sept. 1946	Aug. 1950	Electrical Engineering	BEE	Aug. 1950

Sept. 1950 - March 1951	ERA Physics Department	Electrical Engineer	Calibration and test of ERA self-recording Accelerometer.
March 1951 - Feb. 1952	ERA Development Engineering	Electrical Engineer	Circuit design and equipment test of digital data processing equipment for the Navy.
Feb. 1952 - April 1954	ERA Division of Remington Rand Univac, Military Engineering Department	Electrical Engineer	Design engineer on Navy program to develop a large-scale general purpose digital computer, (prototype of the Univac Scientific). Worked on logical design of arithmetic section. Design of chassis tester for use in maintenance of the computer.
April 1954 - March 1955	ERA Division of Remington Rand Univac, Military Engineering Department	Electrical Engineer	Design and development of oscilloscope display unit and high speed paper tape reader for the ERA 1103 general purpose digital computer, (Univac Scientific). Test and installation of an 1103, (ser. 2) for the Air Force at Elgin AFB.
March 1955 - Sept. 1957	Remington Rand Univac, Military Systems Division	Group Leader & Project Engineer	Development program for Athena Phase I: Logical design of control section. Technical direction of magnetic drum and input-output section development. Technical responsibility for all logical design in final systems tests. Supervision of installation and

PENCE, C. J.

PROFESSIONAL STAFF DATA SHEET

DATE COMPLETED July 27, 1962

August 15, 1963

PROFESSIONAL EXPERIENCE (PRESENT POSITION FIRST - ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
			operation at AFMTC, Florida.
Sept. 1957 - Feb. 1958	Remington Rand Univac, Military Systems Division	Supervising Engineer	Advanced design studies in connection with Athena Computer. Supervision of Command Computer design.
Feb. 1958 - Oct. 1959	Remington Rand Univac, Military Systems Division	Manager - Control Systems Department	Manage and direct the development of the guidance computer for Titan ICBM, (Athena). Direction and supervision of Command Computer design for Westinghouse (modified Univac Scientific).
Oct. 1959 - Jan. 1960	Remington Rand Univac, Military Systems Division	Staff Consultant-Systems Planning Department	Develop system and direct studies for the Pacific Missile Range Computer system prior to preparing a proposal to PMR.
Jan. 1960 - May 1960	Remington Rand Univac, Military Systems Division	Assistant Department Manager	Direction and supervision of the Service Test Computer design.
May 1960 - July 1961	Remington Rand Univac, Military Systems Development	Engineer Director - Control Systems	Plan, monitor and assist in the operation of the three departments-Nike Zeus, Tele-Control, and Special Applications; and serve as their representative in management functions.
July 1961 - Aug. 1962	UNIVAC, Military Systems Development	Engineering Program Manager - Range Tracking Systems	Manage and direct the development of data handling systems (both land-based and ship-board) for the Atlantic and Pacific Missile Ranges. Provide Technical assistance required by Marketing in obtaining new range business.
Aug. 1962 - March 1963	UNIVAC, Military Systems Development	Engineering Manager - Aerospace Systems	Management of Systems Engineering groups participating in Range and Aerospace computer contracts. Provide technical support to Marketing for additional range and Aerospace computer business.

PERTINENT MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
June 1944	June 1946	USNR	Elect. Tech. 3/C	Maintenance of shipboard radio and radar equipment. Installation and maintenance of land-based telephone and teletype equipment.

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES

Institute of Radio Engineers
Professional group on Electronic Computers
Professional Engineer, (in training)

REMARKS

PROFESSIONAL STAFF
DATA SHEET
UNIVAC
DIVISION OF SPERRY RAND CORPORATION

DATE COMPLETED October 9, 1963
DATE UPDATED

NAME: Sidney M. Rubens

COLLEGE(S) ATTENDED	FROM	TO	MAJOR AREA	DEGREE AND DATE
Univ. of Washington	1929	1934	Physics	B.S. - 1934
Univ. of Washington	1934	1939	Physics	Ph.D. - June 1939

PROFESSIONAL EXPERIENCE: (PRESENT POSITION LAST; ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
Sept. 1934 to June 1939	Univ. of Washington	Teaching Fellow	Research on plasma in low pressure, electrical discharges in gases.
Sept. 1939 to June 1940	Univ. of So. Calif	Physics Instructor	Taught general & engineering physics, physical optics.
June 1940 to July 1946	Univ. of Calif. Los Angeles	Research Associate	Research on spectroscopy of active nitrogen and upper atmospheric processes.
April 1941 to July 1946	Naval Ordnance Lab Washington, D.C. Research Division	Physicist	Magnetic measurements, protection of ships against magnetic mines, development of Naval Ordnance, Acting Head Infra-Red Research.
Aug. 1946 to Feb. 1952	ERA	Physicist	Supervision of research and development of magnetic storage techniques, dielectric recording, magnetostatic reading head system, magnetic amplifiers, seismic instruments, magnetic core memories, etc.
Feb. 1952 to March 1955	Remington Rand Univac	Director of Physics	
March 1955 to Aug. 1958	Remington Rand Univac	Manager, Physics Dept.	Planning, organization, and administration of physical research on new materials, components, devices and techniques.
Aug. 1958 to April 1961	Remington Rand Univac	Manager, Physical Research	Research & development on magnetic drum storage, static reading of magnetic records, underground explosion instrumentation, dielectric recording, thermoelectric generators, magnetic amplifiers, magnetic-core memories, computer components, transistorization of computers, magnetic thin films and their applications.

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COMPLETE REVERSE SIDE

PROFESSIONAL STAFF
DATA SHEET

NAME Sidney M. Rubens

PROFESSIONAL EXPERIENCE: (PRESENT POSITION LAST; ACCOUNT FOR ALL TIME)

FROM (MO. & YR.) TO	COMPANY AND DEPT. OR DIV.	TITLE	PRINCIPAL DUTIES (BE SPECIFIC - SEE SAMPLE ATTACHED)
April 1961 to date	St. Paul Operations Univac Division of Sperry Rand	Director of Research	Evaluates, proposes, and directs research programs leading to the development of materials, components, circuits and techniques for the advancement of the art of data processing.

NAME S. M. Rubens

PERTINENT MILITARY EXPERIENCE:

FROM	TO	BRANCH	RANK	PRINCIPAL DUTIES
1929	1934	USNR-V3	Radioman 2C	

PROFESSIONAL WRITINGS: (USE ADDITIONAL SHEETS IF REQUIRED)

Spherical Ground Joints for Vacuum Systems, S. M. Rubens and J. E. Henderson, Rev. Sci. Inst., 10, 49-51 (1939)

Temporal Effects in Nitrogen Afterglow, Joseph Kaplan and S. M. Rubens, Phys. Rev., 58, 188A (1940)

Afterglows in Nitrogen-Helium Mixtures, S. M. Rubens and Joseph Kaplan, Phys. Rev., 58, 188A (1940)

(See Attached Sheet)

PATENTS: (USE ADDITIONAL SHEETS IF REQUIRED)

2,743,320 - Variable Area Magnetic Recording System
392,041 - Magnetostatic Reading Head
~,900,282 - Vacuum Deposition of Magnetic Materials
2,995,631 - Magnetic Reading Device
3,017,607 - Acoustic Impedance Detecting Apparatus
3,030,612 - Magnetic Apparatus and Methods
3,080,549 - Magnetic Cores
845,604 - Methods and Apparatus for Switching Magnetic Material
3,092,812 - Nondestructive Sensing of Thin Film Magnetic Cores

Great Britain

PROFESSIONAL AND HONOR SOCIETIES AND FRATERNITIES:

American Geophysical Union
American Physical Society
American Optical Society
American Association for the Advancement of Science
Institute of Electrical and Electronic Engineers (Sr. Member)
Academy of Applied Science
Minnesota Academy of Science

REMARKS:

Professional Writings: (Cont'd)

The Characteristics and Function of Anode Spots in Glow Discharges, S. M. Rubens, and J. E. Henderson, Phys., 58, 446-457 (1940)

Anode Spots in Oxygen, J. E. Henderson and S. M. Rubens, Phys. Rev., 59, 213-4L (1941)

Excitation of the Auroral Green Line in Nitrogen Afterglows, Joseph Kaplan and S. M. Rubens, Phys. Rev., 59, 218A (1941)

Afterglows in Nitrogen Rare Gas Mixtures, Joseph Kaplan and S. M. Rubens, Phys. Rev., 59, 476A (1941)

New Spectra in Nitrogen, Joseph Kaplan and S. M. Rubens, Phys. Rev., 60, 163A (1941)

Cube Surface Coil for Producing a Uniform Magnetic Field, S. M. Rubens, Rev. Sci. Inst., 16, 243-5 (1945)

A Double-Yoke Plate Permeameter, William F. Brown, Jr., and Sidney M. Rubens, J. Appl. Phys., 16, 713-7 (1945)

A Compact Coincident-Current Memory, S. M. Rubens and A. V. Pohm, Proceedings of the Eastern Joint Computer Conference, Special Publication T-92, New York City, December 12, 1954

High Sensitivity Ballistic Fluxmeter, A. V. Pohm and S. M. Rubens, Rev. Sci. Inst., 27, 306-8 (1956)

Switching Studies of Deposited Iron-Nickel Films Showing Zero Longitudinal Magnetostriction Effect, A. V. Pohm and S. M. Rubens, Armour Symposium on Ferromagnetic Relaxation Phenomena, Chicago, April, 1956

The Effect of a Transverse Field on Switching Rates of Magnetic Memory Cores, T. D. Rossing and S. M. Rubens, Western Electronic Conference, Los Angeles, California, August 21, 1956

Effect of a Transverse Field on Switching Rates of Magnetic Memory Cores, T. D. Rossing and S. M. Rubens, J. Appl. Phys. 29, 1245-7 (1958)

Domain Structure and Dispersion of Preferred Axis in Ferromagnetic Films, S. M. Rubens and R. W. Olmen, Symposium over de Electrische en Magnetische Eigenschlappe Van Dunne Metaallagjes, Louvain, Belgium, September 5-9, 1961

Angular Dispersion and its Relationship with Other Magnetic Parameters in Permalloy Films, R. W. Olmen and S. M. Rubens, J. Appl. Physic., 33, Supplement, 1107-9 (1962)

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Appendix F
COST OF HIRING ENGINEERS

One of the contractors involved on the NTDS program conducted an analysis of the cost of recruiting new engineers. It was based on 503 engineers hired in 1960. The breakdown of the total in terms of experience at the time of hiring is listed below.

286 - engineers with 0 - 2 years experience
140 - engineers with 2 - 5 years experience
77 - engineers with 5+ years experience
503

The average cost of hiring was $849 per engineer. The total cost was $427,474 with moving, travel, and hotel expenses of the new employee the major item. The total expense was made up of the following items:

Relocation costs of new employee:	
Household move, storage, etc.	$116,295
Travel, hotel	158,196
Magazine advertising	43,941
Newspaper advertising	26,073
Other media advertising	5,934
Recruiters salary and expenses	43,500
Agency fees	33,035
Miscellaneous	500
	$427,474

A recruiting cost of $849 per engineer is considered to be low. The average in the aerospace industry is closer to $2,000. One of the reasons cited for the lower than average cost was the fact that a considerable number of the engineers were recruited locally.

Appendix G
PRODUCTIVITY OF NEWLY HIRED ENGINEERS

In generating background data on the NTDS development, opinions were gathered from engineering supervisors on the question of how long it takes a newly hired engineer to become productive. Two general categories were investigated, the engineer lacking previous experience and the engineer with experience.

Nonexperienced Engineers

Any answer to this kind of a question has to be qualified. The length of time it takes a newly hired engineer to become productive depends on such tangible factors as his scholastic record and his avocational interest in his field of study. The latter may be evidenced by his holding a ham radio license. It also is influenced by his ability to establish working relationships with other people. How well he is supervised is another important factor.

Estimates as to the actual amount of time ranged from "a few minutes" to "a lifetime." If it was assumed the newly recruited engineer had a good academic background and some previous exposure to the field of electronics either as a hobby or through the Armed Forces, the consensus of opinion is that it would take six months to a year. If such an individual is given a well-described job, on a routine basis he may be productive almost immediately. He is generally not considered productive until he can carry through an assignment with a minimum amount of supervision.

Both NEL and Remington Rand Univac employ Co-op engineering students. Once these students are finished with their program and are working full time, they generally contribute more at an earlier stage than the non Co-op students.

In describing the productivity of engineering people, one individual classified engineers into "bark men," "tree men," and "forest men." The bark man can just see the resistors, transistors, and condensors that go into a piece of electronic equipment; the tree men have a less limited horizon and can grasp the whole item; and the forest men can see the entire system. The last are the most productive and the hardest to obtain.

Experienced Engineers

If one hires an engineer for his experience, almost by definition he is expected to be productive immediately. In reality, it will take him a few weeks to learn how his new employer does business, who the people in the organization are, etc.

Several engineers felt a newly hired experienced engineer may not contribute to a program for some time. He may come in with preconceived ideas on how a problem should be solved. Other engineers on the project may not accept his approach, and the resulting conflict may neutralize a man's initial contribution. One company prefers to hire engineers directly from school, send them into the field to act as installation engineers, and after six months bring them back to the laboratory to work on development projects.

Since the field of computer engineering is relatively new, it is fairly difficult to find engineers with over five years' experience. The field is so specialized that the precise nature of a man's experience is extremely important. As an example, a man with analog computer background cannot easily transfer these skills to the digital field.