CHAPTER IX

ENGINEERING AND DESIGN

The engineering and design of the Navy's shore facilities was a fundamental part of the Naval Facilities Engineering Command mission. For the most part, this was a task that the Command managed and the field divisions executed. The great bulk of engineering and design work was assigned to the field. However, a limited number of projects were designed at Command Headquarters. Some of these were designed there because of their newness or because their sophistication demanded close control. Other projects were selected to maintain a broadly experienced engineering staff at Headquarters. Principally, however, NAVFAC engineering and design was not a process of execution but of management.

The management process consisted of consultation, guidance and review. Headquarters maintained, developed, and provided technical drawings and criteria and set technical standards for use by Engineering Field Divisions. In addition, the Command monitored the output of the field staffs. This was done by means of consultations, technical reviews, engineering investigations, and through special programs and services.

From 1965 through 1974, much engineering and design work concentrated on routine, long-standing functions; but superimposed upon this essential work were new and short-term assignments. To accomplish this work, the Command needed competent professional engineers and architects. Toward this end the Command vigorously promoted the professional registration of its engineers and architects. While professional registration of civilian engineers and architects has long been an important individual index to the qualifications of a person to practice his profession, it was also one of the important aspects of the professional image of a technical organization.

To satisfy the need for criteria development, the Command reviewed, updated and supplemented the data embodied in design manuals, definitive drawings, standard drawings, guideline specifications, and design technical notes. Other important aspects of criteria development included the introduction of contractor quality control for construction contracts of $10,000 or more, the increased use of computers to prepare cost estimates, construction specifications and designs, and Command participation in the Defense Standardization Program. For most of this ten year period, the work of standardization was carried out by two field offices: one at the Construction Battalion Center, Port Hueneme, California and the other at the Construction Battalion Center, Davisville, Rhode Island.

Command management of design included the review, investigation and coordination of the engineering and design product of the field division. This was accomplished through review of Program Cost Estimates and Line Item Data Sheets, the Engineering Investigation Program which resolved shore facilities engineering problems that were beyond the Command's in-house performance capabilities; the

Value Engineering Program whose objective was to lower the cost of an item without adversely affecting its performance or effectiveness; and, the Awards Program which promoted excellence in architectural design. Additionally, headquarters personnel designed a broad group of projects. These in-house projects were selected by management to maintain an experienced staff at Command Headquarters.

During the Vietnam War the task of designing facilities in Vietnam was the responsibility of the Officer in Charge of Construction in Saigon. The staff of that office accounted for about 25 percent of the facilities designed and rose to between 30 and 40 percent in peak months. The remainder of the design work was performed by architectural-engineering firms with design staffs in Vietnam.

Because of the nature of the war in Vietnam, design of permanent structures for mass use, such as troop housing, was ruled out. For this reason, the wooden "hootch" became the standard for troop housing. However, design problems of more sophisticated facilities were not so easily solved.

Permanent facilities designed for the Antarctic started with concept studies made in 1967. These studies were the result of the decision to replace the austere temporary facilities with more livable permanent facilities. Most of the construction work was done at McMurdo Station. However, work was also done at the Polar Plateau Station, Siple Station and Byrd Station. Furthermore, an entirely new station, Palmer, was designed and constructed for marine biological research.

In addition to the facilities designed for tropical environments such as Southeast Asia and for the cold environment of the Antarctic, the Command designed many distinct groups of facilities that required special attention. These specialized programs included the Nuclear Engineering Program. This program promoted the use of nuclear shore power, heat, desalination, or any combination of them. In addition, the Command was the coordinator for the development and use of radioisotope power devices. Through the years, radioisotopic power devices became proven, reliable operational tools. As a result of the expertise gained by the Command in maintaining its radiological protection program, the Chief of Naval Material assigned to the Naval Facilities Engineering Command the responsibility for the Radiological Affairs Support Program.

Other important specialized programs were Fire Protection, Consultation Services, Medical Facilities, Interior Design, Systems Engineering and Facilities Certification.

Sound fire protection engineering was included as an element in the planning, design and construction of all structures. Navy fire protection guidance was based on the National Fire Codes published by the National Fire Protection Association.

Consultation Services analyzed and made technical reviews of the most difficult and unusual problems in functional planning, design, and the technical features of construction and the operation of public works and public utilities.

The Medical Facilities Program produced new concepts, and updated existing criteria to insure that Navy medical facilities incorporated the latest technological advances.

The Interior Design Program had as its responsibility the preparation or approval of specifications for procurement of furniture and furnishing. In addition to the work done on specifications, the Command provided consultation services, including development of complete interior design and color programs for VIP areas and special projects. The systems method of designing a building proved that it was possible to develop standard components for buildings and assemble them in ways that produced variety in building design.

The Command was an active participant in the certification of ocean engineering systems including deep ocean simulation facilities, decompression-recompression chambers, diving pressure tanks, and any pressure vessels used for testing equipment which were a part of the shore facility.

Engineering efforts were also directed toward new and unusual projects. These specialized projects included pollution control; energy conservation, preparation of a construction engineering handbook, the Trident Program support facilities and selected phases of the Sanguine communications project as well as other sensitive projects.

At the beginning of the ten-year period, the Command was given Navy-wide responsibility for environmental programs. These programs included corrective projects and engineering support in air, water, and land pollution control. The programs were later expanded to include noise pollution control at shore activities and oil spill control and clean-up in inland harbors and port waters.

In July 1974 the Command published the Construction Engineering Handbook. This handbook was a revision of the engineering part of the 1954 Inspection of Construction Projects, TP-Ad-5. This new handbook was recommended as a refresher on basics of almost any engineering found in facilities construction.

Another important undertaking by the Command was the planning, design and construction of the shore facilities for the Trident Program. The Command was also responsible for the award and administration of associated contracts.

Still another unique project was Sanguine, a one-way communications system intended for use in sending messages to submerged missile-launching submarines. All federally owned land in the continental United States was studied as a possible site for the installation. An important aspect in the selection of a site was the impact the installation would have on the local environment.

PROFESSIONALISM

In 1966 the Command began energetically to promote professional registration of its engineers and architects.[1] This was the focus

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[1] Dr. M. Yachnis, Chief Engineer, initiated and directed the Training Program for EIT and PE Examinations, Preparatory Courses for EIT and PE Exams (July 1966).

of the Professional Program for which the Command set registration goals by percentage each subsequent year. A second part of the program was the Command's encouragement to its staff to join and actively participate in professional engineering and architectural societies.

Although the Command's pursuit of a more professional image was not new, the emphasis on registration was. The drive for registration embraced engineers and architects at Headquarters and throughout the field organizations -- the Engineering Field Divisions, Construction Battalion Centers, Public Works Centers, the staffs of Officers and Resident Officers in Charge of Construction and the Naval Civil Engineering Laboratory.

The success of the registration drive moved the Command in 1967 to address personal letters to all Engineering Field Divisions, Public Works Centers, and Construction Battalion Centers listing ten administrative actions directed toward raising the registration percentage. A Command statement of September 1967 summarized the policy.[2] It restricted important functions -- such as acting as a Command consultant, approving engineering plans or specifications, representing the Command officially at professional societies, and serving on certain boards -- to registered engineers and architects. The statement also noted that registration was a factor in selecting civilian and Civil Engineer Corps engineers for certain key positions.

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[2]RADM A. C. Husband, CEC, USN, Commander, NAVFAC, "Speaking from Topside," The Navy Civil Engineer (Sep 1967), p. 3.

This policy became official in 1968.[3] Professionalism is fully covered in Chapter 4 (Administration) of this history.

CRITERIA DEVELOPMENT

An important aspect of the Command's effort was the development and maintenance of design standards and criteria. Revising, updating, and supplementing the data embodied in design manuals, definitive drawings, standard drawings, guideline specifications, and design technical notes, was a continuous process.

Design Manuals and Publications

Because many of the Command's publications included material that was outdated when compared to that of private industry, it was decided in the early 1960s to combine all criteria and design data into a series of design manuals. These manuals were identified as the NAVFAC DM series. The material in this series was used for the design of facilities in the naval shore establishment.

Each manual included an index to the text in that particular manual. Furthermore, there was a cumulative index included which not only showed the data for the particular manual, but also included a cumulative subject reference that was an essential tool for the effective use of the whole series of design manuals.

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[3] NAVFAC Notice 12400 of 1 Mar 1968.

The criteria contained in the manuals, together with the definitive designs and guideline specificiations of the Command, constituted the Command's design guidance. These standards were based on functional requirements, engineering judgement, knowledge of materials and equipment, and the experience gained by the Naval Facilities Engineering Command and other commands and bureaus of the Navy in design, construction, operation and maintenance of naval shore facilities.

The design manual series presented criteria that were used in the design of facilities under the cognizance of the Command. These manuals were not textbooks but were for the use of experienced architects and engineers. Many criteria and standards appearing in technical texts issued by government agencies, professional architectural and engineering groups, and trade and industry groups were suitable for and thus were made an integral part of this series of manuals. These design manuals were revised and updated periodically to keep them abreast of new technical developments.

Another of the principal communications media used by the Command was the publications program. Publications were listed in the _NAVFAC Documentation Index_, NAVFAC P-349, and provided a ready reference to current technical and administrative data. In addition, several publications were developed in cooperation with the Army and Air Force.

For the development of these tri-service manuals the Department of Defense appointed one of the agencies as manager for a specific portion of the publication and a working group was formed to coordinate with the other agencies. Notable among the tri-service publications was Seismic Design for Buildings. The Command designation for this manual was NAVFAC P-355.

In 1964 it was decided that a tri-service manual for seismic design would be developed. A tri-service committee, with the Command representing the Navy, was formed and the Army Corps of Engineers was named to manage the manual. During 1965 and 1966, the Command participated in a review of draft chapters and at the end of 1966, the manual was issued. A general revision was issued in 1973. The changes in earthquake criteria resulted in an increase in the estimate of risk in some areas and pointed out past deficiencies in design. By the end of 1974, the Command had undertaken a series of engineering investigation projects for the purpose of examining and evaluating typical structures of the naval shore establishment.

Another noteworthy publication was titled, Structures to Resist the Effects of Accidental Explosions. The Command designation for this manual was NAVFAC P-397.

In 1968 the Armed Forces Explosives Board initiated development of a manual to be used for structures that might be subjected to internal or close-by explosion of either nuclear or conventional weapons. This manual was developed under contract and issued in 1969. The work consolidated the results of many field tests and adapted analysis techniques which had been developed for nuclear weapons effects at greater distances.

Between 1970 and 1973 three unique and significant publications were generated to support the engineering, design, and certification of hyperbaric facilities. They were entitled, _Hyperbaric Facilities, General Requirements for Material Certification_, NAVFAC P-422 (1970), _Hyperbaric Facilities_, NAVFAC Design Manual DM 39 (1972) and _System Certification Procedures and Criteria Manual for Deep Submergence Systems_, NAVMAT P-9290 (1973).

In 1974, the Command developed an engineering investigation proposal for the Naval Civil Engineering Laboratory to perform field investigations involving full scale tests on ammunition facilities being removed at Bangor, Washington, to make room for Trident facilities. The results of these studies led to modifications of the requirements for roof design. The Command also initiated an engineering investigation project to permit the laboratory to update the publication. At the end of 1974, it appeared that the project would receive tri-service support and go forward in the near future.

Definitive Designs

The Command published definitive designs for use as guidance in designing repetitive type facilities or as requested by sponsors to establish common practices for design of facilities. These designs were updated regularly and consisted of engineering drawings and criteria. The Command was responsible for approximately 700 definitive designs.[4] The designs were used to the greatest extent possible to reduce design costs. Deviations from them were made only when local conditions fully justified additional design and construction costs.

Standard Designs

Standard designs were those drawings and accompanying specifications that the Naval Facilities Engineering Command prepared for certain specialized structures to assure uniform construction that would meet the rigid operations requirements established by the commands and bureaus. They consisted of working drawings and were intended to be included with project specifications. These drawings and specifications formed a part of a contract.

There were mandatory standard designs as well as non-mandatory standard designs. Mandatory standard designs were those drawings and specifications which were not to be changed in any respect whatsoever, except by Command Headquarters. All modifications necessary to suit a specific project had to be shown on separate project drawings prepared for that purpose. In addition, when it was necessary to modify requirements of a standard specification, it was referenced and exceptions taken.

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[4] Definitive designs are contained in Definitive Designs for Naval Shore Facilities, NAVDOCKS P-272. This publication contains half-size reproducible drawings.

On the other hand, modifications to a non-mandatory drawing or specification could be made when it was deemed necessary in the light of current methods and techniques.

Command development of housing for bachelor enlisted personnel is an example of the use of standard designs. In the years preceding, during and immediately after the Second World War, housing for bachelor enlisted personnel was essentially unchanged. These quarters were usually two or three story structures. The interiors were austere open bay dormitories with central toilet facilities which offered no privacy and the very minimum in livability.[5]

After 1960 it bacame apparent that improvements in the housing of enlisted personnel were essential for maintaining a viable and effective Navy.

By 1966 the main emphasis in the design of bachelor enlisted quarters was flexibility and improved livability. Progress was slow, a few more square feet per man, less men per room, a private bath for each sleeping room, a living room for each twelve men, a refrigerator in each sleeping room.

In 1969 the Command began to use "multi-use" bachelor enlisted quarters designs. This involved the preparation of designs which were site adapted to various locations as the need arose for enlisted quarters. In the 1970s, the Command was using three multi-use designs -- two had been prepared by architectural and engineering firms and one had been prepared by Headquarters personnel.

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[5]W. C. Suite, "Bachelor Enlisted Quarters," point paper (31 Jan 1975), NAVFAC Engineering and Design, Code 0461A.

However, in fiscal year 1975, the Command developed a design for enlisted quarters which provided a flexible plan which could be used by grades E2 through E9. The basic layout for these grades consisted of a room for three men, with private bath and refrigerator, three separate cubicles with a window, desk with book shelf and light, chair, bed and wardrobe. The cubicles were divided by the placement of the wardrobes. Personnel in grades E5 and E6 were provided a room for two men with all the amenities listed above except that one of the three cubicles was used as an area for entertaining and was furnished with three lounge chairs, a coffee table, cabinets and bookshelves. The accomodations for grades E7 through E9 consisted of a similar room, but for single occupancy with the space of two cubicles furnished for entertaining. The basic room was 270 square feet. Each four room complex had a living room with an area of 155 square feet.

The core of these quarters was housed in a separate structure. In it was the lobby-lounge, office with information desk, linen issue room, men and women's toilet facilities, concession area, cleaning gear room, public telephones, laundry, bag storage space and a mechanical room. All rooms and areas in the structures had color coordinated furnishings and decor. The grounds were interestingly landscaped and spaces were provided for sitting, games, sports and parking.

Bachelor enlisted quarters at recruit facilities underwent little change. They were open bay dormitories with 72 square feet per man

CHART 9-1 BACHELOR ENLISTED QUARTERS

	Gross floor area per man	Net floor area per man	Cost per man	Cost per square foot
1956-70	125	72	$1,700-$2,750	
1971	145	90*	$3,200	
1972	145-150	90*	$3,200	
1973	150***	90**		$27.00
1974	150-155***	90**		$28.50
1975	160***	90**		$31.00
All recruits (E1)				
1956-75	125	72		Cost per man is the same as above.

* 3 man room with central toilet facilities.

** 90 square feet per man for grades E2 through E4 with private bath.
135 square feet per man for grades E5 and E6 with private bath.
270 square feet per man for grades E7 through E9 with private bath.

*** Based on 3 men per room.

net and 125 square feet gross areas. Included were spaces for central toilet facilities, bag storage, a laundry, an office, cleaning gear, storage, concessions and a mechanical room.

Chart 9-1 shows the net and gross floor area allowance per man in bachelor enlisted quarters for the years 1956 through 1975. The chart also shows the cost per man for the 1956-1972 period and the cost per square foot for 1973-1975.

Guideline Specifications

Specifications are technical descriptions of materials, equipment, workmanship, and quality assurance provisions which supplement the drawings and complete the design package.[6]

As the Command entered 1965 there was an inventory of 19 "Y" series specifications, 125 "TS" series specifications and 34 Department of Defense Family Housing guide specifications in the "GSH" series.

The "Y" specifications were a family of reference documents widely used and accepted in the construction industry. Their use reduced the volume in project specifications and assured the general contractors and the subcontractors that the Command's requirements for common work would be the same each time. During 1970, under pressure from some contractors and some elements of the Command, the "Y" series was cancelled and the data included in the "TS"

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[6] R. H. Welles, "How Better Design Relates to Specifications," _The Navy Civil Engineer_ (Jan 1963), p. 13.

series guide specifications as they were revised. Subsequently the data was included in the actual project specifications. Because of this, the size of a typical project specification was increased by 20 percent or more. This action made minor reductions in the number of reference specifications needed at the job site. Factory fabricated equipment and materials were covered by references in the project specification to industry, military and federal specifications.

During the period 1965-1974 the format of the "TS" series of specifications was redone and renumbered following generally the Construction Specifications Institute (CSI) guidelines. The specifications in this series were designed to set the technical policy for materials, equipment, workmanship and quality assurance. In 1974 these specifications were stored on a computer as the master specification for use (through a computerized system managed by Command Headquarters) by the Engineering Field Divisions located within the continental United States.

The "TSM" series of specifications were used for contract maintenance projects. These specifications grew obsolete because of reduction of resources at Command Headquarters at the end of 1974. However, because of increased need, efforts were being made to update these criteria using the resources of the Engineering Field Divisions.

The "GSH" series of specifications for family housing was used heavily until 1970. At that time, the method of procurement of family housing was changed. The new method of contracting for family housing was the "turn key" method.[7] This method used the data in the "GSH" series and Federal Housing Minimum Property Standards as the basis for contract award. At the end of 1974, there were eighty specifications in the "GSH" series.

In 1969 the ground work was laid for the Federal Construction Guide Specifications Program. Government construction agencies were under pressure to achieve uniformity in their respective specifications. The Federal Construction Council set up a task force to study the feasibility of preparing joint guide specifications to be used by all government agencies. The task force was made up of representatives from the Navy (the Naval Facilities Engineering Command), the Army, the Air Force, the General Services Administration and the Veterans Administration.

Federal Construction Council Technical Report Number 58 set forth the findings of the task force. The task force concluded that a degree of uniformity was feasible. The actual preparation of the Federal Construction Guide Specifications began in 1970. Since then, through 1974, the Command prepared eighteen of these specifications. All other agencies, during the same period, prepared a total of twenty-eight with input from the Command.

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[7] See Chapter 10 for a detailed discussion of the "turn key" method of contracting.

Computerized Specification System

In October 1974, the Command's Computerized Construction Specification System became an operational reality and was the culmination of years of work. The system was designed for rapid update of a master specification by Command Headquarters with input from the Engineering Field Divisions. Each field division then accessed the master file via terminals, edited the master for the specific project and then printed out a camera ready copy off their own high speed line printer terminal.

This computerized system was expected to improve design completion time without additional manpower by making a more responsive master specification available to the specification engineer. This was to result in less repetitive engineering effort on individual jobs as well as a reduction in the technical effort required for proofreading those portions extracted from the master.

Contractor Quality Control

The Contractor Quality Control Program was initiated by the Command in March 1970. The program implemented the Armed Forces Procurement Regulation which required a contractor inspection system. Contractor Quality Control was included in all facilities construction contracts over $10,000.

Under this program, the contractor was required to set up an organization whose responsibility was to inspect the materials and the work, and to run -- or have run in a laboratory -- all specified tests, and to certify on a day-to-day basis that all requirements of the contract were met. In addition, the Navy conducted surveillance of the adequacy of the contractor's quality control program and made inspections and tests as deemed necessary. The total quality control system for a construction project was made up of three parts; Contractor Quality Control, Navy surveillance, and Navy inspection and testing.

The introduction of Contractor Quality Control made it necessary to be more precise in the specifications as to the numbers and the frequencies of tests because they became both a cost item for the contractor and a critical factor in determining conformance.

Design Technical Notes

In September 1965 a direct and informal means of communications between designers was established through the medium of Design Technical Notes and Shop Talk. The notes and talks exchanged information on how to design and even what to design with tips on short cuts or improved methods of design.

Design Technical Notes were used to clarify and direct attention to criteria, give information on how to design with suggestions for better methods of design, advise on criteria undergoing revision and request background data as needed for new or revised criteria.

Shop Talk was used to exchange information on new products, materials, application and methods, direct attention to engineering studies and reports being undertaken or completed, describe test procedures or experiences and advise of errors in design and construction.

Standardization

Standardization is the end result of actions to reduce the number of items in the Department of Defense Supply which served a specific purpose. The Command's standardization effort was a part of the overall Department of Defense Standardization Program which was based on Public Law 436 of 1 July 1952, enacted by the 82nd Congress.

To accomplish the workload assigned to the Naval Facilities Engineering Command in the Defense Standardization Program during the period 1965 through late 1973, the Command had approximately forty-three people located at two field offices; one at the Naval Construction Battalion Center, Port Hueneme, California, and the second at the Naval Construction Battalion Center, Davisville, Rhode Island. These centers were assigned technical responsibility in a number of Federal Supply Classes for detailed standardization planning, and the preparation and maintenance of standardization documents and studies. Overall program management, guidance, and administrative support was provided by Command Headquarters personnel.

Characteristic of standardization study projects was a study completed in 1966. As a result of this study, 15 items were standardized, 7 items were assigned limited standards, and 119 were designated as non-standard. These 119 items were ultimately deleted.

In 1965 the Command had a prime interest in 4,207 standardization documents; of these the Command was the preparing activity for 792 documents. By the beginning of 1975, the Command had a prime interest in 5,682 standardization documents, and was the preparing activity for 989 documents out of the overall Department of Defense total of 40,000 documents. As the preparing activity for standardization documents, the Command had the responsibility for coordination with industry as well as with all of the Department of Defense and civil agencies. To do this, a document was circulated to a complete representative cross section of the affected segments of industry. Industry comments were solicited primarily to obtain information on the technical content of the document, and to determine which commercial items, assemblies, etc. were available.

It was the policy of the Department of Defense to make maximum use of industry standardization documents having a present or potential defense use. During the years 1972, 1973, and 1974, the Command adopted for Department of Defense use a total of thirty-one documents from the American Society for Testing and Materials. Adoption of these documents meant the cancellation of thirty-one NAVFAC documents. The Command utilized the savings that resulted from these cancellations, for the development of other criteria.

On 28 November 1973, the Davisville Center was advised that the Defense Standardization Program effort at the center would terminate on 30 March 1975. Thus, a gradual phase down of operations at Davisville began. After the formal announcement of this phase down, the Command assigned responsibility for all Davisville standardization projects to the Port Hueneme Center. In addition, the Port

Hueneme Center was assigned the responsibility for the control of all standardization projects under Command cognizance. There was an orderly transition from Davisville to Port Hueneme to accomplish the phase down.

Cost Engineering

Cost estimates were necessary to plan and design construction projects. These estimates were used to provide data for budgetary submittals for the military construction programs and for improvements, alteration and repair projects. In addition, they provided economic comparisons of design that involved the use of various types of materials in structures and they established economic controls over the planning and design of projects.[8]

Furthermore, cost estimates were used to control expenditures, to form parts of reports and correspondence relative to cost, to support cost calculations for change orders to construction contracts, and to provide a basis for any type of cost evaluation study.[9]

Military construction cost estimating was basically categorized as conceptual estimating for planning, program estimating for budgeting, and, detailed estimating based on plans and specifications for project estimating and cost control.[10]

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[8] Cost Data for Military Construction, NAVFAC P-448.

[9] Ibid.

[10] Jefferson L. Dean, "Building Systems Cost Guides Aids Estimating," The Navy Civil Engineer (Spring 1974).

Historically the conceptual estimate suffered from a lack of definition and accuracy. This type of estimate was normally lump sum and based on an estimated cost per square foot. The budget estimate though having greater definition, detail and accuracy than the conceptual estimate, also suffered from a lack of accuracy and sometimes continuity. The detailed estimate based on plans and specifications was the most accurate estimate. This estimate, however, could not be made without plans and specifications. If the estimate was made and the project cost was not in line with the budgeted amount, redesign to bring the project cost in line with the budgeted dollars was costly or impractical. The detailed estimate also suffered from a lack of continuity.[11]

In 1970, the Command initiated a historical construction cost file. This file contained a listing of frequently built types of military facilities grouped by Navy category codes. In 1971, a construction unit cost file was established. This file was used and maintained by a computerized data processing system. The unit cost was based on a geographical cost factor and was predicated upon such considerations as material and direct charges of labor, as well as the contractor's indirect charges.

In 1973, the Command's conceptual military construction cost engineering data file, originally Design Manual 10, now P-448, was

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[11] Jefferson L. Dean, "Building Systems Cost Guides Aids Estimating," The Navy Civil Engineer (Spring 1974).

converted to a computerized data file. The cost data was derived from many sources and was arranged according to facility classes and construction codes.

Furthermore, the Command is planning to publish, for the first time, a construction building systems cost book. This book will be based on building systems costs and will provide a new tool for cost control during design.

In addition, the Command continued to participate in the Tri-service Cost Committee. This committee established tri-service cost guidelines and made recommendations to the Department of Defense. Another committee on which the Command continued to be active was the Cost Committee of the Federal Construction Council of the Building Research Advisory Board. This committee was the medium through which the Command and other federal agencies exchanged cost information.

Cost estimating requires experience for which there is no substitute. However, this experience is significantly aided by the accuracy, uniformity, reliability, simplicity, flexibility and speed of the computer. The use of computers to reduce construction costs and to bring bids within the limits of available funds was an important step in the preparation of cost estimates.

Computer Aided Design

In 1964 the Command started using computers for design. Much of the early work was done by utilizing an IBM 1401 machine located in the old Yards and Docks Annex. A major accomplishment was the development of a program for the analysis of guyed towers.[12] Initial efforts were truly remarkable because of the limitations of the 1401 computer employed.

By 1966 the rapidly developing technology, characteristic of the computer field, had already led to vastly improved machines. Command engineers began to use the more powerful IBM 7094 located at the Pentagon. However, access to this machine was difficult and time consuming. Acquisition of a new computer for design was studied but the high cost was discouraging. For this reason the Command began looking at the then newly emerging time sharing services that permitted use of a computer at a remote site by the use of a teletype terminal.

In 1967 a trial contract with General Electric brought the first time sharing terminals to the Command. This service made the computer much more accessible to engineers and encouraged its use. One of the first programs developed in-house on the time sharing system was an air conditioning load program which allowed rotation of the building and a load calculation at any hour of the day. This program was designated M6701-COOLIT and modified forms of it are still used by NAVFAC and the Engineering Field Divisions.

In 1968 the Command initiated formation of an ad hoc computer aided design users group involving other government agencies. This group later became the building Research Advisory Board, Federal Construction Council Computer Committee.

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[12] Ezra G. Odley, "Analysis of High Guyed Towers," Journal of Structural Division, ASCE (Feb 1966), p. 169.

The time sharing system at once attracted a good deal of use for solving structural and mechanical problems, and interest spread rapidly throughout Headquarters. The success of time sharing computer aided design at Headquarters suggested that computer capacity would be useful to the Engineering Field Divisions. Therefore, in 1968 the Computer Aided Design System was demonstrated at the Southern Division by using a portable teletype terminal and a trial link was established on the COMNET system using a Burroughs 5500 computer. For a while, input and output were relayed through Headquarters, but in a short time arrangements were made for direct connection of Engineering Field Divisions to the computer. By 1969 all of the field divisions were able to establish a connection with the system and Headquarters personnel visited the divisions to provide training. About twelve programs developed in-house by Headquarters as well as a number provided by the time sharing service company comprise the Computer Aided Design Library.

The Computer Aided Design System was changed several times either to take advantage of improved capability, lower cost, or because the vendor made changes. At various times during the past ten years, the Command has had Computer Aided Design contracts with General Electric, COMNET, U. S. Time Sharing, and Control Data Corporation. In 1974 the Control Data Corporation service provided the basic capability for computer-aided design, however, many other systems were tested and evaluated and a trial of the General

Services Administration Remote Access Multiple User System was made. This system used the GE 440 computer. In addition, this system looked promising and facilitated exchange of programs with other government agencies.

Furthermore, in 1974 the Facilities System Office at Port Hueneme, California, began to develop a Computer Aided Design Time Sharing System using an IBM 360-50 computer. Because of the increased workload and computer usage, the Facilities System Office has now installed an IBM 370-165 computer which has a far greater memory and work capacity. In the future, the Facilities System Office may be able to provide for a significant portion of the Command's computer-aided design requirements.

DESIGN MANAGEMENT

Command management of design consisted not only of developing criteria, but also of reviewing, investigating, and to some extent coordinating the engineering and design product of the field divisions.

Review of the Program Cost Estimates and Line Item Data Sheets

Part of the Command's effort to maintain high design quality was the review for cost and technical criteria of program cost estimates submitted by the field divisions. Until 1968, the Command selected for review only a random sampling of the program cost estimates submitted by the field divisions. This number fluctuated from a low of 287 in 1971 to a high of 1,000 in 1968.

The second feature of the Command's control of design was the review of military construction line item submissions, DD Form 1391, from the Engineering Field Divisions. These descriptive forms were used to support inclusion of line items in the Command's construction programs. This feature of design management began in 1967. That year 148 of the forms were reviewed. Thereafter, increases and decreases of the 1391s followed the same pattern as the program cost estimates except that the increase or decrease occurred a year earlier. Furthermore, the number of 1391s submitted was slightly larger than the number of cost estimates.

Engineering Investigation Program

The Command's Engineering Investigation program continued to be a useful tool throughout this period. The objective of the program was to resolve shore facilities engineering problems that were, by their nature, beyond the Command's in-house performance capabilities. Basically this program provided a centrally managed budgetary means of providing shore facilities engineering support of the fleet worldwide. The program was funded at the $1 million level annually.[13]

Engineering Investigation projects were solicited from all organizational components of the Command, both at Headquarters and in the field. Proposed projects were evaluated by a panel of

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[13]Thomas R. Rutherford, "Engineering Investigation Program," Blueprint (22 Apr 1975).

Command consultants, chaired by the Chief Engineer, Code 04B. This panel determined the benefit of a project to the Navy. The criterion used by the panel to determine the merit of a proposal was primarily the project's potential for broad Navy benefit and high return on investment, either in increased military readiness or economic savings.

Investigations were made leading to improvement and savings in planning studies and master plans, engineering studies and designs, real property management, and studies and surveys in the operations and maintenance field.

An important feature of the program was that it allowed the Command to provide an immediate response to unforeseen technical problems. Investigations covered a wide range of projects. These included: engineering studies of tri-service building materials, high temperature water systems, and underground gasoline hazards; planning studies of the Washington Navy Yard, the Philadelphia Naval Shipyard, and other naval facilities at Pearl Harbor, Hawaii and Okinawa and Bethesda, Maryland; pollution abatement studies at the Kodiak and Adak Naval Stations and at several naval air stations; several electrical generation and electrical distribution studies; and water surveys at several Marine Corps installations, and the development of criteria for energy conservation and pollution control.

Value Engineering

The basic objective of the Value Engineering Program was that of lowering the cost of an item without adversely affecting its performance or effectiveness. The program's methodology was to take a "second look" in order to obtain like quality with greater economy. Savings through value engineering were measured in terms of costs reduced (hard savings) and costs avoided.[14]

The Command's Value Engineering Program was inaugurated in fiscal year 1964.[15] Initially the program applied only to engineering. However, its similar applicability to construction soon became clear.

An important feature and key attraction of value engineering was a mechanism that provided incentive to contractors by sharing equally with them the savings that resulted from contractors cost reduction proposals. This incentive clause was applied to the construction field in October 1964 and from January 1965 contracting officers were required to review projects of $100,000 or more for application of the incentive provisions. Exceptions to the provisions might include cost-reimbursement type contracts and some architect-engineering services contracts. The first "Value Engineering Change Proposal" from a contractor was received on 2 February 1965.[16]

There was an early hesitancy on the part of contractors to participate in value engineering. Their reluctance was based on

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[14]The cost avoided category for reporting value engineering savings was discontinued after fiscal year 1966.

[15]BUDOCKS Instruction 4858.1 of 11 Sep 1963.

[16]Point paper by Mr. A. J. Dell'Isola, Special Assistant for Value Engineering, NAVFAC (May 1966). Record Group 2, NAVFAC Archives, CBC, Port Hueneme.

their assumption that approval of suggested changes would take too long. This hesitancy was overcome by accelerating approvals.[17] Thus, the program was extended to embrace both construction and engineering.

To carry out the objectives of the Value Engineering Program, one full time value engineer was assigned to each of the fourteen Engineering Field Divisions. (These fourteen divisions were later consolidated into six Engineering Field Divisions). In general, the source of savings from the Value Engineering Program were those military construction projects generated in-house and those generated by general contractors. Each accomplished saving was fully documented by the applicable Engineering Field Division value engineer and all reportable value engineering savings information was forwarded to Command Headquarters. At Headquarters the information was validated and reported to higher authority. The reporting system remained essentially the same throughout the ten year period.

Each Engineering Field Division was assigned an annual dollar savings goal in the Command Management Plan. Such assignments were based on the dollar volume of the Navy military construction projects that were the Engineering Field Division's responsibility. Headquarters was kept informed of all the progress made in augmenting organization, training, projects and other program elements for the purpose of achieving the dollar goals. From 1965 through 1974

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[17] A. J. Dell'Isola, "VE Expanded During FY 65," The Navy Civil Engineer (Nov-Dec 1965).

the Command exceeded its annual assigned value engineering dollar savings goals as shown in Chart 9-2.

CHART 9-2 VALUE ENGINEERING SAVINGS

Fiscal Year	Value Engineering Goal	Validated Savings
1965	$6,000,000	$8,100,000
1966	8,000,000	12,100,000
1967	4,000,000	6,750,000
1968	5,000,000	10,500,000
1969	6,750,000	18,500,000
1970	8,000,000	18,761,000
1971	10,600,000	25,137,000
1972	12,550,000	23,622,000
1973	10,000,000	20,807,000
1974	10,000,000	18,695,000

Awards

The Command had a continuing interest in promoting excellence in architectural design. To further this interest, the Naval Facilities Engineering Command in collaboration with the American Institute of Architects established a Biennial Awards Program in 1968.[18]

[18] NAVFAC Instruction 5061.2C of 11 Mar 1974.

First place honor awards and awards of merit were given to the best submissions. The jury was composed of three architects, all members of the American Institute of Architects, and a student observer. A certificate was given to the Engineering Field Division and another to the architectural firm which designed an award winning building. Additionally, a bronze plaque was installed in all buildings selected for an honor award. All entries had to be constructed architectural projects, either for the Navy or some other government agency. It was also necessary that the design and construction of the project be administered by the Command.

The various categories for entries in the NAVFAC-AIA Biennial Awards Program are shown in Chart 9-3. Also included in the chart are descriptions of the facilities included in each category.

Projects could be constructed anywhere in the United States or abroad and construction had to be completed at some point during the five years immediately preceding the year of the judgment.

The selection for awards was made from designs prepared by private architects or in-house Engineering Field Division architects. There was an average of fifty entries for each of the award programs in 1968, 1970, 1972 and 1974. This program promoted excellence in architectural design and provided motivation and recognition for architects who designed facilities for the Command.

In the late spring of 1972, a Department of Defense Design Awards Program was initiated. Each service was permitted a maximum of three entries in each of five specific categories -- medical facilities, architectural facilities, welfare and recreational facilities, engineering facilities, and family housing. In this competition, the Navy won first place in three of the five categories. All of the Navy's winning awards were submitted by the Command's Western Division. In addition to the first place awards, the Navy won the Defense Blue Seal Award for the best of all winning designs.

Although this awards program was well received by members of the engineering community, it was not held in 1973 or 1974.

CHART 9-3

CATEGORIES FOR ENTRIES IN THE NAVFAC-AIA BIENNIAL AWARDS PROGRAM

Category	Description
Medical Facilities	To include hospitals, dispensaries and clinics (medical and dental)
Family Housing	Married enlisted and officer housing construction with appropriated funds.
Bachelor Housing	Bachelor enlisted and officer housing constructed with appropriated funds.
Architectural Facilities	To include administration, operational, training, research, specialized, libraries and other similar appropriated fund facilities.
Welfare and Recreational Facilities	To include chapels, gymnasiums, exchange facilities of all types, hobby facilities, child care centers, clubs, etc., whether constructed from appropriated or non-appropriated funds.

In-house Design

While the field divisions executed the greater portion of shore facilities design, nevertheless Headquarters personnel designed a wide range of projects. Many of the in-house projects were selected to maintain an experienced engineering staff at Command Headquarters. Other projects such as the Ammi structures and certain classified projects demanded close control and were the logical preserve of the Headquarters staff.

Two general trends marked the Headquarters design program. First, because of the rising demands of the Vietnam conflict, the Command deferred several projects and completed little design between March and December 1966. Second, during 1967 the Command undertook several new, significant design projects that spectacularly raised the value level of in-house design.

Most Headquarters design projects consisted of construction drawings, but besides these standard drawings, procurement drawings, estimates and studies were also prepared.

Regular Projects: Many of the design projects completed in-house could be categorized only by their diversity. Notable were several barracks designs and barracks modernization designs. Other large construction projects included a 300-man brig at Camp Lejeune North Carolina; an aircraft maintenance hangar at the Naval Air Station in Oceana, Virginia; a dispensary at Charleston, North Carolina; and a dispensary and dental clinic at Moffett Field, California.

Unique and Complex Projects: The Command was responsible for the preparation of plans and specifications for the Recovery System support structures for the Poseidon Submarine Missile. This work was praised by President Lyndon B. Johnson. Another unique accomplishment was the selection of a design by NAVFAC architects for the Presidential Reviewing Pavilion used on Inauguration Day in 1969. This design was so well accepted that it was unanimously chosen by the District of Columbia Inaugural Planning Committee to be used again for the 1973 inauguration ceremonies.[19]

Ammi Projects:[20] No project of this period that had been designed by Command Headquarters had more immediate impact or promised greater long-term significance than did "Ammi" structures.

The Ammi pontoon prototype measured ninety feet by twenty-eight feet. it was used singly or in multiple units and could be mounted on steel piles or floated free. It lent itself to a multitude of uses and adaptations. The most apparent of these were floating and elevated piers and causeways, the self-propelled barge, the warping tug, and the floating tanker.

However, it was in response to an increased need for drydocking facilities in remote areas that the Command introduced a novel scheme in the form of the Ammi Lift Dock.

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[19] W. C. Suite, "Architectural Concept", point paper (1968) NAVFAC Engineering and Design, Code 0461A; Dr. M. Yachnis, "Structural Design", point paper (1972), NAVFAC Engineering and Design, Code 04B.

[20] The Ammi pontoon was named for the man who conceived the idea, Dr. Arsham Amirikan, Chief Engineering Advisor at NAVFAC.

The lift dock was essentially a floating platform accompanied by support and service piers. The entire facility was composed of a series of individual pontoons. A vessel was brought over the submerged platform and the platform was raised by forcing compressed air into the platform, thus, forcing out the ballast water.

In view of the apparent cost savings and operational benefits which preliminary studies revealed, the Chief of Naval Operations instructed the Command to proceed with a prototype test facility.

A site was selected at the Naval Construction Battalion Center at Davisville, Rhode Island. The lift dock was an experimental test facility. It was tested successfully with simulated vessel loads by filling pontoons with water and also by docking and lifting a destroyer six times. However, the phasing out of the Davisville Center wreaked havoc with Command plans for further evaluation of the system. As a result of the base closure, the test facility was dismantled and stored.

During the Vietnam war, the Command designed river patrol bases. These bases were composed of a number of Ammi pontoons and combined all necessary facilities. The Command developed and produced these Ammi mobile facilities to provide support to a squadron of river patrol boats engaged in riverine operations in Vietnam. Each base consisted of units for administration, berthing, galley and mess, and repair. The base was built on four oversized Ammi pontoons (110 feet long by 30 feet wide by 7 feet deep) with two standard Ammi pontoons moored adjacently to serve as fuel and water supply units. The first mobile river patrol boat base was deployed to

Vietnam in December 1967. Each base cost $2.5 million and required 120 days for construction and outfitting.

In addition, the Command designed and built six pontoon desalinization units for the production of potable water at isolated bases in Vietnam.

Ammi pontoons were also used successfully on various other projects such as Port Tektile, Project AFAR and as part of a floating dispensary on Lake Titicaca in Bolivia.

Classified Projects: The Command was responsible for the construction of new facilities as well as for modifications at various classified sites in the Washington, D. C. area and other areas. The work included design of facilities to resist nuclear attack, security systems and other improvements for the Executive Branch, communications systems, reservoirs, and other facilities. During the ten year period ending in 1974, the Command provided design and analysis in support of many important classified projects.

Southeast Asia

The Office in Charge of Construction in Saigon was responsible for the design of facilities constructed in the Republic of Vietnam. Virtually all design required for Vietnam came under the supervision of his staff. This was because the requirements of design in Vietnam were few in comparison with those of construction to which the Command was compelled to direct its greater energies. Technical design problems were susceptible to technical solutions and were more commonly remediable in the field than in the Headquarters. Moreover, designs used in Vietnam construction, once tested, became like the design of the Second World War quonset hut, reliable constants. Non-technical design problems in Vietnam were of such a nature that they were manageable solely by the Officer in Charge of Construction in Saigon.

Coordinated by the Saigon office, three separate design forces produced the design of all Command sponsored facilities built by civilian construction firms in Vietnam.

Architectural-engineering firms with design staffs in Saigon and at construction sites throughout the country accounted for approximately sixty percent of the design work.[21] An average of thirteen firms from a pool of over twenty worked under lump sum contracts with the Officer in Charge of Construction after the Vietnam buildup began. This design force numbered over one thousand engineers, architects, and technical personnel. Major design firms were Frederic R. Harris, Inc.; Pacific Architects and Engineers; the Ralph M. Parsons Company; Pope, Evans, and Robbins International, Inc.; Trans-Asia Engineering Associates, Inc.; and Adrian Wilson Associates.[22]

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[21] LCDR P. H. Brandtmiller, CEC, USN, "Design in the War Theatre," The Navy Civil Engineer (Jan 1968).

[22] Ibid.

The staff of the Officer in Charge of Construction itself accounted for another 25 percent of the facilities designed in Vietnam; this proportion rose to between 30 and 40 percent in peak months. The Saigon staff numbered approximately 10 officers and 200 civilian employees, many of whom were "third-country" (principally Filipino) nationals, and engineers temporarily assigned from Command Headquarters for periods of three or four months. The construction contractor, RMK-BRJ, supplied the remainder of the design requirements.

The large pool of architectural-engineering firms in Vietnam assured adequate design in terms of quantity. There were indeed more firms than could be used much of the time. This surplus of designers helped alleviate workload problems resulting from the chronic understaffing of the Officer in Charge of Construction design staff to which the civil service could not attract sufficient engineers.[23]

Quantity of design staffing did not assure consistent quality of design. Although the quality of design work by most of the firms was high, performance by a few was borderline. All together the design staffs of the architectural and engineering firms were half as productive as the design staff of the Officer in Charge of Construction. Possibly, the large number of design firms with which the Officer in Charge of Construction was compelled to work was a factor detrimental to productiveness. The contracting of

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[23] NAVFAC Analysis of RVN Construction, (Draft: 13 Nov 1967).

design to a combine of fewer firms might have permitted firmer control and greater production.

The primary factor affecting design was time. Short deadlines were frequent because of the scope of the engineering task in Vietnam. The entire physical base from which the war would be waged and to be built. Therefore urgent projects were great in number. In addition, some of the most urgent, such as the Newport Harbor and the Long Binh complex, were extensive. However, deadlines were a question of months or weeks rather than years.

Design procedures had to adapt to the hurried pace. Early phases of the program involved largely original design work, but design standardization of a sort soon evolved. To meet the pressure of deadlines standard details were incorporated in projects by notation and to maximum use was made of advance base and other standard drawings that existed. Since time did not permit development of adequate standard designs to fit needs, it was necessary to waive or change many established standards.

The nature of the war and the press of events ruled out design of permanent structures for mass use such as housing for troops. An array of temporary structures -- quonset huts, butler buildings, inflatable structures, prepackaged steel structures, and pre-cast concrete structures -- were employed to a limited extent for personal use. However, it was the easily and more cheaply built wooden "hootch" that became the standard for troop housing design in Vietnam.

Troop housing design was amenable to relatively simple solution through standardization of the hootch design. But design problems posed by more sophisticated facilities were not so easily solved. Design of such facilities as air conditioning equipment, plumbing, and fueling equipment encountered problems of insufficiently updated criteria and specifications.

Success in any type of military action is greatly dependent upon the smooth flow of supplies. In Southeast Asia procurement was a major problem. The Command remedied the problem by developing the Southeast Asia Materials and Equipment Control Program (SEAMAT). The SEAMAT Program coupled identification of materials in designs and material take-offs with a means for rapid, accurate, abbreviated transmission of material requirements for procurement. The system used the Construction Specifications Institute's construction specification format as a basis. Each document contained a brief statement of the material's intended use and service life, a short specification suitable for competitive purchase and inspection, and a separate listing of proven sources of supply, including manufacturer's and model numbers. Under the Southeast Asia Materials and Equipment Control Program, the designer was provided with detailed characteristics of materials for appropriate cataloging system selection, using a minimum of catalog documentation. This significantly differed from the Department of Defense Supply System Catalog, which listed everything used by the Department of Defense, but which was not often pertinent to facilities design.

Although SEAMAT was developed for use in Vietnam, its development came too late to be of much value in executing the construction program there.

Antarctica

Following the completion of the International Geophysical Year in 1958, the decision was made to retain certain bases for permanent United States scientific activity in Antarctica. Because of this decision, replacement of the austere temporary two-year International Geophysical Year facilities with more livable permanent facilities was begun. In addition, as the scientific effort expanded, additional new permanent facilities and temporary stations were needed as well as additional scientific facilities at existing permanent stations. The design of these facilities was done exclusively by the Command Headquarters staff through the end of 1967. Beginning in 1968, Antarctic designs were prepared by architectural and engineering firms as well as by Headquarters personnel. The major portion of the design and construction program consisted of permanent facilities at McMurdo Station, the largest United States base and main port of entry to the inland stations, and included roads, buildings and utilities.[24]

At McMurdo, the largest and most complex building was the personnel building. It contained 68,600 square feet of floor area

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[24]See Chapter 10 for further information on Antarctic construction.

and was a split level structure with three different floor levels. The building contained berthing spaces for 250 men, a barber shop, and a Navy exchange in a two-story portion of the building. Messing facilities for 500 men at one sitting (250 in winter with the remainder of the areas closed) and a laundry and mechanical room were in one-story portions of the building at two different levels.

Other major facilities designed for and constructed at McMurdo were a science administration building with quarters, an equipment center, and a garage and storage building; Navy administration and operations building, communication transmitter building, frozen food storage, air operations shops and office building, utilities and grounds maintenance building, three warehouses, a petroleum, oil and lubricants system, and extensions to water, sewer, electrical and communications systems.

A new South Pole Station was designed to replace the 1958 International Geophysical Year station, which was buried under and slowly being crushed by snow. Concept studies began in December 1967. In these studies consideration was given to under-snow, on-snow and above snow (elevated) construction. The rigorous climatic and site consideration (elevation 9,184 feet, annual mean temperature -56.6 degrees F., extreme low 113.3 degrees F., construction season approximately sixty days with average temperature of -15 degrees F., and depth of snow some 9,000 feet) and limited accessibility (only by air) severely constrained the possible solution. The final design completed in June 1970 provided for a summer population of forty-eight and a winter population of sixteen. This design consisted of a 164 foot diameter aluminum geodesic dome containing three two-story prefabricated van-type buildings (a science-living building, a communications-library-ships store building, and a galley-post office-meeting hall building) and four forty-four foot diameter steel arches (fuel storage, bio-medical, power, and garage-storage).

Exterior structures consisted of a four-story fifty-four foot six inch high sky lab, a balloon inflation building and helium storage arch, and an emergency camp. Utilities were contained in an under snow utilidor. The station was completed and dedicated in January 1975.

An entirely new station, Palmer, was designed and constructed for marine biological research on the Antarctic Peninsula. The three-story main station building contained living quarters, messing facilities, science laboratories, a storage area, and a mechanical room. The two-story ancillary structure contained a power plant, garage and shop, storage and additional berthing for summer personnel. Also provided were a wharf for science research vessels, a helicopter pad, and all utilities including petroleum, oil and lubricants.

A temporary station utilizing air-lifted interconnected van-type structures was designed and built for the Polar Plateau Station. This station was located at an elevation of 11,890 feet on the polar icecap in Queen Maude Land, 1,350 miles from McMurdo and 600 miles beyond the South Pole Station. It contained all facilities for eight winter-over men including four scientists.

In addition to the foregoing, other facilities such as Siple Station (in the general area of the old Eights Station), a Byrd VLF Long Wire facility near Byrd Station, a deep core drill facility at Byrd Station, portable airfield lighting, and minor facilities in Hallett Station were designed and constructed.

SPECIALIZED PROGRAMS

During the ten year period under consideration, the Command instituted or continued several specialized programs. These programs dealt with the design of many distinct groups of facilities that for varying reasons required special attention.

Nuclear Engineering

The earliest concern of the Command in the field of nuclear engineering was the PM-3A nuclear power plant at McMurdo Station, Antarctica. Installation was begun in 1961 and the reactor became operational in 1962.

In 1966 and 1967, the Command's experience with the McMurdo plant led to expanded nuclear engineering responsibilities. On 19 August 1966, the Chief of Naval Operations assigned to the Command responsibility for management and technical direction of the development and use of nuclear shore power plants for naval application, including the design, operation, maintenance, safety, and technical training of personnel.[25]

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[25] OPNAV Instruction 11310.1 of 19 Aug 1966.

The Command's pioneering work in Antarctica led also to assignment of responsibilities embracing a second major field of nuclear engineering, radiosotope power devices. On 29 April 1966, the Chief of Naval Material assigned to the Command responsibility for coordinating all applications (other than Naval propulsion) of such devices.[26] In August 1966, the Chief of Naval Operations formally delegated to the Command the technical direction for the development and use of radiosotope power devices.[27]

PM-3A Nuclear Power Plant Operations and Removal

During congressional hearings in 1960, it was determined that the construction of nuclear power plants in Antarctica would cut the cost of operations, particularly in the logistical area, at United States stations there. As a result of these hearings, Congress authorized and made available funds to construct the PM-3A Nuclear Power Plant in Antarctica at McMurdo Station.

In August 1960, the U. S. Atomic Energy Commission initiated work by fixed-price contract for design, fabrication, preshipment testing, packaging, transportation, installation and on-site testing and initial operation of the first nuclear power plant for Antarctica. This was to be a pressurized water nuclear electric power facility generating electrical power and fresh water from its

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[26]CNM ltr, Ser. 3241 of 29 Apr 66.

[27]OPNAV Instruction 11310.2 of 30 Aug 1966.

desalinization plant. The design capacity of the plant was 1800 KWE at 0.8 power factors.[28]

The plant arrived at McMurdo Station aboard the USNS _Arneb_ on 12 December 1961. It was installed by Naval Mobile Conctruction Battalion 1 and the Navy startup crew under the supervision of the contractor.[29]

The first nuclear criticality was achieved on 3 March 1962 and the first usable electric power was supplied to McMurdo on 10 July 1962. Operation of the reactor was carried out by contract until mid-1964. On 27 May 1964 the Navy was authorized to operate the PM-3A. The operating crews, detachments of the Naval Nuclear Power Unit were selected and trained by that unit. After completion of the necessary testing, the first electrical energy supplied under Navy operation was produced on 10 June 1964.[30]

On 23 August 1971 the PM-3A broke its own previous endurance record and then on 11 September it broke the military shore power endurance record. On 24 September, when it finally shutdown for maintenance, more than 4,400 hours of continuous power generation were logged. The plant was back in operation on 1 October, only seven days after it was shutdown.

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[28] _Final Operating Report for PM-3A Nuclear Power Plant, McMurdo Station, Antarctica_, Report No. 69 (12 March 1964-20 October 1973).

[29] _Ibid_.

[30] _Ibid_.

On 18 September 1972, after 2,900 hours of continuous power operations, the PM-3A Nuclear Power Plant was again shutdown for routine maintenance. The next day, during a general inspection of the steam generator tank, water was discovered leaking through the normally watertight interconnect between the steam generator tank and the reactor tank.

In January and February of 1973, specialists performed a partial inspection of the pressure vessel and piping and found no evidence of corrosion cracking. However, because of the high cost of performing a full inspection, which would be necessary before operation could be resumed, and the unlikely probability of economical repair if the findings were negative, it was decided to dismantle and remove the PM-3A.[31]

On 16 February 1974, the first phase of the PM-3A dismantling project was completed. The work was accomplished during the austral summer, October 1973 to March 1974. The work included the removal of primary systems and associated piping and wiring and the secondary systems, including the turbine, generator, condensers and heat transfer apparatus. Approximately 40 percent of the preparation of the containment tank which was to be used as the reactor pressure vessel shipping container was completed. This included the removal of detector brackets, clips, and other components from the reactor pressure vessel, placement of a seventeen inch

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[31] CDR G. E. Krauter, CEC, USN, "McMurdo Nuclear Power Plant Closed," The Navy Civil Engineer (Winter 1973).

concrete base in the bottom of the containment tank, and installation of a steel shield around the reactor pressure vessel. The steel shield was used to verify the design and installation procedures for the depleted uranium shield which was to be installed during the Deep Freeze 75 season. Approximately eighty tons of radioactive waste was shipped from the PM-3A.[32]

During the 1974 austral winter the power plant crew successfully operated the water desalination plant and performed assigned dismantling projects which included the cleaning and decontamination of the radioactive waste disposal system tank and installation of shielding in the steam generator tank.[33]

On 15 October 1974 the second phase of the dismantling project began. Major projects completed through the end of the year included completion of the preparation of the containment tank as the reactor pressure vessel shipping container, removal of the primary building and primary building addition, removal of the crushed rock backfill from around the containment tanks, and removal of the reactor, steam generator, spent core, void and radioactive waste disposal system tanks. The depleted uranium shield was successfully installed around the reactor pressure vessel and the entire vessel was encased in reinforced concrete within its containment tank.[34]

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[32] History of the Naval Nuclear Power Unit, Fort Belvoir, Virginia, Calendar Year 1974.

[33] Ibid.

[34] Ibid.

During the time it was in operation the PM-3A supplied 60,938,800 KWHs of electrical energy to McMurdo Station. Furthermore, during the period of Navy operation ending 30 December 1972, the PM-3A was available to supply power to McMurdo Station for 54,182 hours 49 minutes out of possible 74,976 hours for an availability of 72,266 percent. During the period of 12 March 1964 through 30 September 1973, there were 438 malfunctions.

Although the PM-3A Nuclear Power Plant was shut down earlier than originally planned, the plant did represent the beginning of a recognition that nuclear power had potential for Navy applications in areas other than nuclear propulsion. The installation and operation of the plant demonstrated that it was possible to support complex and technically demanding facilities even in the most remote regions of the world.

Radioisotope Program

In 1964, it was recognized that there would ultimately be many requirements for fixed power sources beneath the sea and that there were no power systems suitable for operation in such an environment. Coincidentally, the U. S. Atomic Energy Commission had been working on developing small self-contained radioisotopic power generators and the Command realized that these systems had significant potential for Navy application. The Command discussed the feasibility of such application with the Atomic Energy Commission, ultimately borrowing several units for test and evaluation.

Since then the Command has continued to use the radioisotopic power generators in ever increasing numbers.[35]

Upon its designation as coordinator for development and use of radioisotope power devices in 1966, the Command assumed technical and administrative control over four such devices powering weather transmitters in Antarctica, the Gulf of Mexico, and off Bermuda and an oceanographic telemetry system in Alaska. These devices were:

1. Systems Nuclear Auxiliary Power (SNAP) 7C, powering a weather transmitter at Brockton Station, Antarctica.
2. SNAP 7D powering a Nomad Automatic weather station in the Gulf of Mexico.
3. SNAP 7E powering an underwater transmitter at the Bermuda Underwater Acoustic Range.
4. LCG-25A Nuclear generator powering an oceanographic telemetry system at Fairway Rock, Cape Prince of Wales, Alaska.

Use of radioisotope power devices on the ocean floor was a field to which the Command devoted much attention in 1967. The Command procured and delivered four radiosotope thermoelectric generators to the Naval Civil Engineering Laboratory for laboratory and shallow water testing, and one such device to the Naval Ship Research and Development Center, Annapolis, Maryland. In November

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[35] CDR Ronald P. Cope, CEC, USN, "PM-3A Operation Record and Radiosotope Power General Development Program," orientation brochure, NAVFAC Engineering and Design, Code 04.

1967, another radioisotope thermoelectric generator, an LCG-25C1, was procured and delivered to the Naval Oceanographic Office to power an experimental oceanographic "interrogation, recording, and location system." This generator was placed in a subsurface buoy near Puerto Rico on 19 May 1968.

Also in 1967, the Command drew up plans for a device for use by the Naval Undersea Warfare Center for an underwater sound propagation system. This system was installed on the San Juan Sea Mount near the California coast in June 1969.

While the initial systems were very low-powered, falling into the 1 watt, 10 watt, 25 watt region, in 1972 a 100 watt radioisotopic thermoelectric generator was procured. This was the first unit of this size built for ocean application. This generator was delivered by the contractor for acceptance testing on 31 April 1972 and was accepted on 21 July 1972. The unit was designated Sentinel-100F. In 1974, it was shipped to Eleuthera Island to provide no-break power for a University of Miami project located there.

A significant new undertaking in 1973 was in the area of plutonium fuel unit procurement. The Naval Electronics Command requested that the Naval Facilities Engineering Command initiate procurement of plutonium fueled two-watt radioisotopic powered generators for use in undersea surveillance. Contracts were subsequently let for the construction of several half-watt plutonium fueled generators for demonstration purposes. These units were delivered in the Fall of 1975.

Radioisotopic power devices had many advantages. They provided a source of constant reliable electrical power. Furthermore, personnel were not required to maintain, service, recharge or replace the radioisotopic power generators or their components These generators could be used in any location under any environmental conditions. Additionally, they conformed to all Department of Defense, Nuclear Regulatory Commission and Department of Transportation regulations and requirements.

In 1974 two radioisotopic powered generators completed their assigned missions and were returned from the Naval Underwater Research and Development Center, San Diego, to the East Coast Surveillance Facility for testing and storage. One of these generators, however, was sent to disposal at the Nuclear Engineering Corporation burial site at Morehead, Kentucky. This was the first Navy owned radioisotope powered generator to be disposed of.[36]

During the period 1965-1974, the radioisotope power generator program emerged from the test and evaluation stage and became a proven, reliable operational program. The number of generators in the Navy inventory increased to over fifty and the basis for continued program expansion was established.

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[36] History of the Naval Nuclear Power Unit, Fort Belvoir, Virginia (1974).

Radiological Affairs Support Program

During 1972 the Radiological Affairs Support Program was established by the Chief of Naval Material.[37] This program was established to assure the protection of Navy personnel, the public and the environment in the handling and use of nuclear materials.

The Command was assigned responsibility for the program as a result of the expertise which it had gained in this area through maintaining a viable radiological protection program of its own in connection with the PM-3A and radioisotope programs.[38]

The Command delegated responsibility for this program to the Naval Nuclear Power Unit at Fort Belvoir, Virginia. As a field activity of the Command, the unit's mission was officially augmented to provide technical advice and field assistance of a radiological affairs support nature to the Command.[39]

In 1974 the radiological support mission was expanded to include maintenance of a nuclear accident response capability within the guidelines as set forth by the Joint Nuclear Accident Coordinating Center Interagency Radiological Assistance Plans Program.[40] Also

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[37] NAVMAT Instruction 5100.8 of 18 Apr 1972.

[38] Glenn W. Zimmer, "Radiological Affairs Support Program," *The Navy Civil Engineer* (Summer 1973)

[39] NAVFAC Instruction 5450.62D of 1 Nov 1972.

[40] *History of the Naval Nuclear Power Unit, Fort Belvoir, Virginia*, (1974).

included in the expanding mission was responsibility for radiation shielding design assistance for new and modified radiography facilities.[41]

The support provided by this program covers all aspects of ionizing radiation from X-ray devices, accelerators, radiographic units, and from both licensed and unlicensed materials, including radioactive waste regardless of origin (the only exception being wastes from nuclear propulsion systems or their prototypes).[42]

Special and continuing projects of the program included the preparation of a Navy Radioactive Material Control Manual, evaluation and disposition of waste from two Navy radioactive waste burial sites, and radiological safety evaluations of various types of industrial X-ray machines being considered for use by Naval Air Systems Command activities.

Fire Protection Engineering

Fire protection engineering is essential in the planning, design, construction and maintenance of all facilities of the naval shore establishment. Modern large-scale operations and processes, upon which our economic welfare and national defense are dependent, present concentrations of facilities which are conducive to major losses of life and property by fire. In order to assure the safety of personnel and to protect critical and strategic operations, fire

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[41]NAVFAC Instruction 11080.4A of 2 Aug 1974.

[42]Glenn W. Zimmer, "Radiological Affairs Support Program."

protection engineering provisions must be incorporated as basic elements in design and construction consistent with the mission of the activity, the risk involved, and economic considerations.[43]

The problem of fire losses in the shore establishment was of sufficient magnitude to require special attention by the Command. Two basic methods were employed in the effort to reduce fire losses. These were fire protection engineering surveys, and compilation and development of data on fire losses throughout the shore establishment.

Surveys by Headquarters personnel and fire protection engineers of the field divisions took place throughout the period of 1965-1974. Surveys of major shore activities were conducted on a three-year cycle while surveys of minor activities were conducted on a six-year cycle.[44]

Fire loss reports were compiled throughout the period. However, in fiscal year 1970, the Navy Safety Center at Norfolk, Virginia, assumed responsibility for the Navy fire loss reporting system which had formerly been handled by the Command. These fire loss reports included summary data on types and locations of fire alarms answered, causes of fires and factors affecting their spread, types of property loss, methods of detection, alarm, extinguishment, and other data, together with abstracts of major fire reports.

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[43] Design Manual 8, <u>Fire Protection Engineering</u>.

[44] A major shore activity has a Class II plant account value of $2 million and a minor activity has a Class II plant account value of between $500,000 and $2 million.

As can be seen in Chart 9-4, the monetary loss during these ten years varied from a low of $2.4 million in fiscal year 1971 to a high of $18.8 million in fiscal year 1970 with a ten-year average

CHART 9-4 NAVAL SHORE ESTABLISHMENT FIRE LOSS STATISTICS

Fiscal Year	Number of Incidents	Monetary Loss
1965	1,531	$1,871,347
1966	1,509	2,624,708
1967	1,673	4,070,422
1968	1,507	9,067,628
1969	1,619	4,657,659
1970	1,389	18,825,698
1971	1,478	2,354,136
1972	1,410	4,185,729
1973	1,566	5,231,979
1974	1,641	5,225,321

of $5.8 million. The high loss in fiscal year 1970 was mainly attributed to a single loss of $11.7 million resulting from an aircraft crash and to a $4.5 million loss involving ship construction and repair. The loss experience was considered extremely low in face of an estimated value at risk on the order of $50 billion, excluding ships and aircraft. The number of fires averaged 1,532 annually while fire deaths averaged eight per year. Two multiple death fires produced significant impacts on this average. One was at a communications facility in Japan and resulted in twelve deaths; the other at a Naval air facility in California and also resulted in twelve fire deaths.

Through the review process of projects and designs at the Engineering Field Division level, adequate fire protection engineering features were incorporated in most new facilities and the level of fire protection at shore activities improved slowly as older facilities were phased out or replaced.

Consultation

The Command engineering consultants maintained a capability for engineering consultation services on highly complex technical problems requiring an unusual degree of competence. These services were made available to the field, other commands, bureaus and offices and to higher authority. In their turn and within the limits of their capabilities, the Engineering Field Divisions provided professional engineering services to the shore activities which they supported.[45]

As the facilities engineer for the Department of the Navy, the Command strove to attain and maintain a resources base sufficient to provide non-reimbursable facilities engineering and design consultation as requested by Navy customers. Realizing that sufficient

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[45] Policy Reference Book, NAVFAC P-329 (January 1972).

resources may never be attained, consultation with expectation of maximum return to the total Navy was emphasized.[46]

The consultant specialties included: electrical engineering systems, petroleum fuels-energy, soil mechanics and paving, waterfront structures, deep water structures, and metallurgical engineering.[47]

An example of significant consultation services provided to Engineering Field Divisions and to other commands included consultation on internal waves. The Command's findings on internal waves in the ocean were recognized by submarine experts. The submersible Ben Franklin experienced rapid accelerations upward and/or downward from its natural position during its free drift from Florida northward 1,500 miles to a point offshore Newfoundland. This erratic behavior was attributed to the existence of internal waves.[48]

Another example of the Command's consultation service involved repair operations on the 1,200-foot Tower #10, VLF Antenna at the Naval Radio Station, Annapolis, Maryland. On 7 and 8 May 1974, the Command completed repairs unique in the history of tower construction. These repairs included the detensioning of guy wires, welding repairs, and the jacking-up of the 1,200 foot tower so that a new insulator system could be installed.[49]

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[46] Policy Reference Book, NAVFAC P-329 (Jan 1972).

[47] Headquarters Organizational Manual, NAVFAC P-313 (1 Dec 1969).

[48] Dr. M. Yachnis, "Theoretical and Experimental Study of Internal Waves Generated by a Density Current Down a Sloping Bottom," International Offshore Exploration Conference, Athens, Greece, (1968), p. 371.

[49] See Chapter 10 for a complete discussion of VLF, Annapolis repairs.

Furthermore, the Naval Facilities Engineering Command, at the request of the Naval Sea Systems Command and the Pascagoula Supervisor of Shipbuilding, investigated and subsequently approved the unique, simultaneous drydocking of two nuclear submarines in one drydock. The submarines were the USS Haddo (SSN 604) and the USS Tunny (SSN 682). They were successfully drydocked in the Ingalls graving dock at Pascagoula, Mississippi.

During the summer of 1974 the Chesapeake Division discovered that the landfill under and adjacent to Nimitz Library at the U. S. Naval Academy, was moving laterally at the rate of more than one foot per year. This movement represented a serious threat to the foundation of the library. With Command consultation the movement was reduced to a very slow rate by removing approximately three feet of fill and restricting adjacent traffic and storage. At the end of 1974, permanent solutions were under study.

Medical Facilities

The Command was responsible for the development of medical and dental facilities design. This included the preparation of drawings, criteria, concept designs, specifications and related technical data for the complete spectrum of health service facilities required to support the Bureau of Medicine and Surgery in its projects for the military construction program.

During the years 1965 through 1974, the medical facilities program grew quickly. In fiscal year 1966 funds for the program totaled $13.7 million. By fiscal year 1976, approximately $134 million was budgeted.

In February 1972 the Secretary of Defense expressed disatisfaction with the rate of replacement of old, outmoded and inefficient military hospitals. These hospitals had been built during the Second World War, and in some cases earlier. The secretary directed that the program be accelerated and that a plan be prepared spreading the projects over a five-year period, from fiscal year 1974 through fiscal year 1978.[50]

In order to obtain the most construction and the best construction for the money, the Command and the Bureau of Medicine and Surgery undertook a joint review of completed medical construction. This review covered the broad spectrum of planning, programming, engineering, design, construction, maintenance, and operation of medical facilities including the provision of collateral equipment. Particular items were identified so those having special merit would be included in future work while those that proved undesirable would not be repeated.[51]

Evaluations were accomplished mainly by performing an in-depth analysis of completed hospitals. Hospitals inspected and evaluated

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[50] SECDEF Memo to Secretaries of the Military Department of 19 Feb 1972.

[51] C. A. O'Connor, "Evaluating Medical Facility Construction," The Navy Civil Engineer (Summer 1973).

included the Naval Hospital, Memphis, Tennessee; the Naval Hospital, Oakland, California; the Naval Hospital, Jacksonville, Florida; and the Naval Regional Medical Center Hospital at Charleston, South Carolina.[52]

An evaluation group composed of personnel from the Bureau of Medicine and Surgery and from the Naval Facilities Engineering Command inspected the hospitals and interviewed the staffs. This led to the identification of items requiring detailed investigation and analysis. These were organized into specific task assignments for action by specialty teams covering architectural, structural, siting, mechanical, electrical, equipment and public works management. These teams applied themselves to all assigned issues, developed check lists and performed on-site reviews. A report and recommendations were submitted to an executive committee for follow-up action by all interested parties. Individual committee members initiated appropriate action within their own commands, working cooperatively toward improving criteria, standards and procedures.

During the period covered by this history, the Command was tasked with the development of plans and specifications for many major medical facilities as well as smaller facilities that were considered unusual.

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[52] C. A. O'Connor, "Evaluating Medical Facility Construction," The Navy Civil Engineer, (Summer 1973).

Among the major medical facilities was the New Generation Hospital at Travis Air Force Base in California. This was a prototype of a new generation of military hospitals. While the Deputy Assistant Secretary of the Air Force (Installations) was designated as the overall program manager, the Command was assigned as the design and construction agent.[53]

The project was the result of studies began in 1969 by the Department of Defense to improve the efficiency of military health care delivery. The study resulted in a number of key concepts which were to be incorporated into the design of this prototype facility.

The basic concept for the new generation hospital employed a systems approach which considered the hospital and its operation in one package. This concept was brought about as the result of a detailed systems analysis of military hospitals, outpatient clinics and dispensaries to determine concepts and procedures which might improve the efficeincy of health care delivery systems.[54] As a result, the New Generation Military Hospital was to be so automated that labor costs would be drastically cut and routine services transferred from over-worked doctors and nurses to sophisticated machines. This was to be done through the use of

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[53]Ltr from COMNAVFAC to Special Projects Officer, Headquarters, U. S. Air Force of 14 Sep 1972, enclosure 1, "New Generation of Military Hospitals."

[54]Ibid.

convenience foods, automated laboratory procedures, computerized patient records and monitoring systems, a computerized appointments system, and automated material handling systems.[55]

Another important project for which the Command was designated construction agent was the modernization and new construction at the National Naval Medical Center, Bethesda, Maryland. This included modernization of the Naval Hospital and construction of the Uniformed Services University of the Health Sciences at the health center. The proposed redevelopment included a teaching hospital with an 850-bed capacity to replace the existing hospital facilities. The University was to have an ultimate capacity for graduating 300 students per year. The Command was responsible for the general site planning, the environmental impact statement, concept studies and the final plans and specifications.[56] The first building of the University was expected to be completed in December 1976. This building was to be a three-story structure that would house administrative offices and student facilities in addition to classrooms and laboratories.

One of the unusual design projects developed by Headquarters personnel was a hospital barge used on Lake Titicaca, Bolivia. The barge was designed to provide medical assistance to some 200,000 Aymara Indians who inhabited the shores of Lake Titicaca. The

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[55] R. L. Johnson, "NAVFAC to Assist in Design Development of New Generation Military Hospital," The Blueprint (29 Nov 1972).

[56] Architect-Engineering Services for the Development of a Uniformed Services University of the Health Sciences and the Redevelopment of the National Naval Medical Center," Commerce Business Daily (5 Dec 1973).

barge was assembled by Seabee Team 7412 using Bolivian sailors as construction assistants and trainees. The team was tasked with the field construction and launch of an Ammi pontoon, erection of a prefabricated Lewis building on the pontoon and installations of auxiliary equipment. The barge was put in operation in January 1973. All reports have indicated that the project was a complete success.[57]

Interior Design

Interior design is a professional design discipline devoted to developing functional, attractive interiors for all of the places where people live, work and spend leisure time. Interior design is divided into two major areas: structure related aspects, and furniture and furnishings.[58]

In 1964 a multi-disciplinary design task force was formed at Command Headquarters to study bachelor housing and to direct efforts to improve these facilities. Interior design was involved in this study from the outset. The study documented the impact of interior design on the quality perception of facilities by occupants. The growing awareness, at Command Headquarters and on the part of customer activities, of the important role interior design plays

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[57] "Seabees Build Floating Hospital in Bolivia," The Navy Civil Engineer (Summer 1973).

[58] George Baer, "The 'Inside' Story," The Blueprint (1 May 1972)

in the success or failure of the personnel support facility design mission prompted two important actions. First, the assignment of responsibility for initial furnishing to the Command. This gave the Command total design control to create a total environmental package. For the first time, control of both architecture and the interior was in the same hands. Secondly, the Command's integrated design policy was issued. This addressed the importance of total design, and required facility design which represented the coordinated input of all design and engineering disciplines.

The importance of quality interior design was emphasized, and basic interior design criteria were provided for the first time. An initial lack of adequate design staffing to meet this responsibility necessitated a limited scope at the outset, with the primary focus on bacehlor housing.

Continuing contributions made by the Interior Design Program pointed up the need for more intensive and broader coverage. To meet this need, interior design was formally established as a design discipline at Command Headquarters in July, 1970. The Command's Engineering Field Divisions were directed to staff full time interior design programs, with overall technical direction and criteria to be provided by Headquarters.

Interior design was an ongoing Command design program, executed on a decentralized basis through the Engineering Field Divisions. A complete interior design service was provided for all new projects in eighty facility categories ranging from bachelor housing and medical facilities to clubs, offices and educational resources.[59]

Interior design often provides the more immediate, most visible and most lasting impression of Navy buildings. If the interior fails to function well, is unattractive or uncomfortable, the best engineering structure loses much of its value.

Neglect of interior design diminishes the value of the construction investment and has a negative effect on all Navy personnel. Properly integrated in the total design effort, interior design is a direct, people-oriented service to men and women of the fleet.[60]

Systems Engineering

The systems method of designing buildings permitted the grouping of any desired number of standard modular units for each component -- such as heating, air-conditioning, plumbing and walls -- into a final integrated structure of the desired size.

The systems building approach also involved changes in bidding and procurement procedures, so that the different components or elements making up the building could be let out as individual bid packages.

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[59] G. E. Baer, "Establishment of a Professional Interior Design Program," undated point paper, NAVFAC Engineering and Design, Code 0463.

[60] G. E. Baer, "Interior Design Program," point paper (16 Dec 1974), NAVFAC Engineering and Design, Code 0463.

One of the advantages of the systems building approach was that all the major elements of a building could be prefabricated in a shop and then brought to the building site and erected. Another was that less time was needed to complete the building, for each contractor could order materials and begin work before the final, overall plans were completed. In addition, the designer had a greater degree of control over the quality of the materials that went into a structure.

The systems building approach was used on such projects as concrete modules fabricated in Seattle, Washington, and then barged to Alaska for erection as barracks facilities; the purchase, removal and re-erection of Air Force family housing units at a permanent Navy base; factory fabricated modulars used for the construction of Navy lodges; and in the Tactical Container Shelter System (TACOSS).

Structures were designed and fabricated for this system under a contract at the Tulsa, Oklahoma plant of North American Rockwell. These structures were designed to be used in contingency operations. A prime requisite was that the units be readily shipped by land, sea or air in civilian or military transports, and that they should be able to withstand rapid local transfer from the point of arrival to the construction site.

Equally important was that the units be designed to permit relatively unskilled personnel to assemble them without the need for tools and equipment. In addition, it was necessary that the units be easily and economically recoverable and relocatable through several moves.[61]

During the period under study Command Headquarters personnel as well as personnel from the Engineering Field Divisions were indoctrinated and briefed on systems building. Headquarters personnel attended various workshops and conferences. In addition, Headquarters personnel served on a committee of the Building Research Advisory Board. This committee prepared the technical report, "Promotion of the Development and Use of the Subsystem Concept of Building Construction." The results of the work accomplished were encouraging and promised to save design effort and funds and improve technical quality and readiness.

Facilities Certification[62]

In 1969 the Chief of Naval Operations assigned to the Command the responsibility for material certification of shore-based, manned hyperbaric and deep ocean simulation pressure chamber complexes. This included all decompression and recompression chambers, diving pressure tanks and pressure vessels (used for testing equipment) which were part of a shore facility.[63]

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[61] LCDR John P. Brennan, CEC, USN, "TACOSS. . . Off the Drawing Board," The Navy Civil Engineer (Summer 1973).

[62] Dr. M. Yachnis, "Fifty-Year Development of Naval Facilities Construction," Journal of the Construction Division (March 1975), p. 24.

[63] NAVFAC Instruction 11012.122 of 23 Feb 1971.

CHART 9-5 SYSTEM CERTIFICATION STATUS/PRIORITY LIST

Priority	Activity/Sponsor	System Description	Use Date	Certification Dates					Cert. Depths		Notes
				Cert. Initiated	On Site Inspection	Certified	Waiver Issued	Recert. Due	Planned	Present	
1	Environmental Health Effects Lab/BUMED	Hyperbaric Research Fac. 1000 & 1500		3 Jan 71	N/A	-	-	-	2250 & 3375	0	In the Design and Construction stage
2	Experimental Diving Facility/EDU	Hyperbaric Research Facility 600 ft.		11 Oct 73	N/A	-	-	-	600	0	In the Design and Construction stage.
3	Westinghouse Hyperbaric Facility	Saturation Diving Research Chamber	in use	21 Apr 72	4 Aug 75	-	-	-	1500	1500	Will be certified in 1975
4	Naval School Explosive Ord. Disposal Indian Head, MD	Double Lock w/Med Lock Riveted Steel Std. Recompression	in use	20 Mar 74	2 visits 16 May 74 23 Jun 75	-	-	-	165	165	Will be certified in 1975
5	Naval Ord. Lab. Solomon's Field Br. Solomons, MD	Double Lock Welded Aluminum Std. Recompression Chamber	in use	20 Dec 73	28 Aug 74	-	-	-	165	165	
6	Naval Underwater Sys. Center, AUTEC Det. Andros Is., Bahamas	Double Lock Welded Aluminum Std.Recompression Chamber	in use	23 Jan 75	19 Aug 75	-	-	-	165	165	On-site inspection scheduled for 26 Aug 1975
7	Naval Undersea Center Long Beach Det., San Clemente Is., CA	Double Lock, Alum. Std. Recompression Ch. Existing Cham.	in use	3 Sep 74	2 & 3 Apr 75	-	-	-	165	165	

CHART 9-5 (continued)

SYSTEM CERTIFICATION STATUS/PRIORITY LIST

Priority	Activity/Sponsor	System Description	Use Date	Certification Dates					Cert. Depths		Notes
				Cert. Initiated	On-Site Inspection	Certified	Waiver Issued	Recert. Due	Planned	Present	
8	Naval Undersea Center Long Beach Det., San Clemente, Is., CA	Double Lock, Steel Std. Recompression Cham., New Chamber	1976	3 Sep 74	2 & 3 Apr 75	-	-	-	165	165	Facility being assembled
9	Naval Undersea Center Long Beach Det. (Morris Dam)	Single Lock Alum. Std. Recompression Chamber	1976	28 Feb 75	1 Apr 75	-	-	-	165	165	
10	Civil Engineering Lab., Port Hueneme, CA	Unmanned Deep Ocean Simulation Facilities	1976	6 Aug 72	28 & 27 Mar 75	-	-	-	Varies	Varies	
11	Naval Special Inshore WesPAC NavPhiBase, Coronado, CA	Double Lock Steel Std. Recompression Chambers	1976	5 Mar 75	21 Mar 75	-	-	-	165	165	
12	Portsmouth Naval Shipyard, Portsmouth, N.H.	Double Lock Steel Std. Recompression Chamber	1976	3 Mar 73	16 Apr 73	-	-	-	165	165	
13	Naval Underwater Sys. Center, Newport, R.I.	Double Lock Riveted Steel Std. Recompression Chamber	1976	30 Jan 73	22 Feb 73	-	-	-	165	165	
14	Submarine Ballast Blow Test Fac., NSRDC Annapolis, MD.	Unmanned Test Fac.	in use	14 Nov 72	4 visits 10 Apr 71	-	-	-	1000	1000	

CHART 9-5 (continued)

SYSTEM CERTIFICATION STATUS/PRIORITY LIST

Priority	Activity/Sponsor	System Description	Use Date	Certification Dates					Cert. Depths		Notes
				Cert. Initiated	On-Site Inspection	Certified	Waiver Issued	Recert. Due	Planned	Present	
15	Two Antenna Test Tanks, Phila. Naval Shipyard, Phila, PA	Unmanned Test Fac.	Delivery Oct 75	29 Jul 74	N/A	N/A	N/A	N/A	2250	0	In the Design and Construction stage
16	Naval Ship Research and Development Center, Carderock, MD	13 ft. Diameter Test Tank	Deliv. Dec 75	2 Sep 72	-	-	-	-	6750	0	In the Design and Construction stage
17	University of PA Bureau of Medicine and Surgery	Manned Hyperbaric Facility, 18 ft.	in use	9 Nov 73	9 visits 8 Oct 72 22 May 75	1 Jul 75	N/A	1 Jul 76	1800	1800	Certification applicable only for dry chambers
18	Exploratory Development Unit/Naval Coastal Sys. Lab.	Ocean Simulation Facility (Hyperbaric Research 2250)	in use	17 Feb 69	14 visits 12 Jun 72 Jan 75	10 Feb 75	N/A	10 Feb 77	2250	2250	
19	Explosive Ordnance Disposal Group II, Port Story, VA	Two Lock Welded Steel Diver Recompression Chamber	in use	21 Dec 72	24 Sep 73	10 Dec 73	N/A	10 Dec 75	165	165	
20	Naval Amphib. School NavAmpBase, Coronado, CA	Double Lock	in use	8 Jun 72	5 Mar 73	1 Aug 74	N/A	1 Aug 76	165	165	
21	Naval Air Development Center, Naval Air Engineering Center	Hyperbaric Facility	in use	20 Nov 72	14 Dec 72	15 Jun 73	N/A	15 Jun 75	Max Alt 90,000	Max.Alt 90,000	

CHART 9-5 (continued) SYSTEM CERTIFICATION STATUS/PRIORITY LIST

Priority	Activity/Sponsor	System Description	Use Date	Certification Dates					Cert. Depths		Notes
				Cert. Initiated	On-Site Inspection	Certified	Waiver Issued	Recert. Due	Planned	Present	
22	U.S. Naval Station Adak, Alaska	Single Lock, Welded Steel Std. Recompression Chamber	in use	14 Jan 71	1 Nov 72	1 Jan 74	N/A	1 Jan 76	165	165	
23	Naval Coastal Systems Lab., Panama City, FL	Single Lock w/Med Lock Welded Steel Std Recompression Chamber	in use	15 Aug 73	15 Aug 73	N/A	23 Aug 73	23 Aug 75	165	165	
24	Long Beach Naval Shipyard, Long Beach	Double Lock w/Med Lock Steel Std. Recompression Chamber	in use	9 Dec 71	7 Mar 73	1 Mar 75	N/A	1 Mar 77	165	165	
25	EDU/Taylor Diving Salvage	Research Chamber	in use	14 Dec 71	29 Nov 72	16 Apr 73	N/A	16 Apr 74	1600 ft	1600 ft	Certified only for the one time, 1600 ft dive by EDU
26	Naval Air Development Center	Underwater Observation Tower	in use	1 Oct 69	17 Jun 73	15 Jun 75	N/A	15 Jun 76	60	60	
27	Naval Diving and Salvage School, Wash. Navy Yard	Training Facility	in use	2 Jul 69	-	N/A	-	N/A	337	337	
28	Naval Diving and Salvage School, Wash. Navy Yard	Training Facility	in use	2 Jul 69	-	N/A	-	N/A	150	150	

CHART 9-5 (continued) SYSTEM CERTIFICATION STATUS/PRIORITY LIST

Priority	Activity/Sponsor	System Description	Use Date	Certification Dates					Cert. Depths		Notes
				Cert. Initiated	On-Site Inspection	Certified	Waiver Issued	Recert. Due	Planned	Present	
29	Exploratory Development Unit	Complex No. 5	not in service	29 Jun 71	9 visits 1972-1973	22 Jan 73	N/A	N/A	1000	0	Complex discontinued from service
30	Exploratory Development Unit	Complex No. 6	not in service	29 Jun 71	9 visits 1972 - 1973	22 Jan 73	N/A	N/A	1000	0	Complex discontinued from service
31	University of New York Buffalo, N.Y.	Research Facility		24 Nov 72	31 Jan 73	N/A	N/A	N/A	2500		Discontinued - certification efforts on advice of NAVMAT

During the material certification process an independent review was made to insure, within the existing state of the art, that design, fabrication, testing, construction, inspection, maintenance, and operation of the various systems, subsystems, components, and portions of the facility were in accordance with sound and acceptable engineering principles. The material certification process had a dual purpose. The first was to safeguard the life of the individuals in the chamber during simulated dive conditions and the second was to provide for casualty recovery during an accident.[64]

Since the start of the program, many hyperbaric and deep ocean simulation facilities were certified by the Command.[65] A system certification status is shown in Chart 9-7.

SPECIALIZED PROJECTS

In addition to the regular projects assigned to the Command, there were many specialized projects. Such projects were termed "special" because they were either new or very complex.

Pollution Control

The development and updating of design criteria for land and water pollution control was the responsibility of the Naval Facilities Engineering Command. The Command was called upon repeatedly

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[64] Dr. Michael Yachnis, Chief Engineer, "Material Safety Requirements of Hyperbaric Facilities" ASCE National Structural Engineering Meeting, Baltimore, MD (April 1971) Preprint #1357.

[65] Ibid.

during the years 1965 through 1974 to fulfill this responsibility. Because of Department of Defense worldwide involvement, pollution had to be controlled. Therefore, some design criteria had to be developed while other criteria had to be updated to meet the requirements created by increased public concern for the environment. This resulted in even stricter pollution control regulations. Indications were that these regulations had a greater impact on the Navy than on any other department of the government.

In the early 1960s, Command Headquarters assisted the Engineering Field Divisions with a program for eliminating combined sewers at U. S. Navy shore facilities such as those at Charleston, South Carolina; Bremerton, Washington; and Pearl Harbor, Hawaii. Major projects for overseas application included the development of standard designs for small sewage treatment plants suitable for use in Southeast Asia and the in-house design of wastewater collection and disposal facilities in Antarctica.

The Antarctica designs were unique because of the locale's extremely cold climate. Because of the inimical climate, special materials were required for pipes and for heat tracings of sewers. Unusual soil conditions included such items as permafrost at the McMurdo Station, and a 10,000-foot high snow plateau at the South Pole Station. The pole station design included the use of a utilidor several feet below the snow surface for the distribution of steam, water, and electricity and for the collection and disposal of wastewater.

Early in the program the Command let contracts to update domestic wastewater, oily waste, industrial waste and solid waste pollution control criteria. It also developed criteria for sewer lines on piers and sewer transfer systems in graving docks. The new criteria described typical composition of wastes originating from domestic and industrial sources, recommended the cost effective method of treatment with alternatives to suit local conditions, and provided disposal methods for residues.

Because the testing of prototype equipment installed on ships indicated that shipboard wastewater treatment units were incapable of meeting pollution control criteria, the Command was tasked with the responsibility of transferring ship's waste to shoreside collection, treatment and disposal facilities. The various waste streams included sanitary, hotel, oily, industrial, and solid waste. Consultants were hired to provide information on waste quantities and all feasible methods of ship-to-shore transfer of waste streams and to recommend the optimum methods for further development. The consultants submitted their reports on the first conceptual phase of the Ships Waste Offload Systems Study and on an associated sensitivity study, conducted to test the recommended methods. It was proven that the collection, treatment, and disposal of ship's sewage was uniquely different from that of conventional sewage. The unique qualities included:

1. The high variability in locations, quantity, and discharge rate of ship's waste.

2. The location and access for sewage collection lines and appurtences on most piers and wharves was both congested and difficult with resulting high unit construction costs.

The Command developed a set of guide specifications for wastewater plant facilities and equipment to assist the designer. Special specifications described small prefabricated, so-called "package" sewage treatment plants. Environmental protection specifications were developed to define a contractor's responsibility for pollution control and environmental protection during normal construction operations.

Energy Conservation

The Command has been in the energy conservation business for many years and made several significant efforts long before the critical energy situation of the 1970s developed. For example, in the 1950s, the Command's Utilities Conservation Program was started. This program required comprehensive energy surveys of utilities and the establishment of local energy conservation programs.

However, it was in the 1960s that the Command established an Energy Resources Group. This was the result of a growing realization that limits existed on the availability of various energy resources throughout the country and that these limits needed to be understood and plans made to account for their impact upon the naval shore establishment. The Energy Resources Group examined the impact of limited energy resources upon the naval shore establishment and recommended courses of action to be taken by the Command.

The Energy Resources Group was not responsible for ongoing operational matters but for examining at the broad energy issues affecting shore facilities and related fleet support missions in order to identify new initiatives and future policies.

Recommendations made by this group were implemented by the appropriate administrative and operating element of the Command. These recommendations covered five categories: short range impact, intermediate range impact, long range impact, administrative, and investigations and demonstrations. Short range impact dealt primarily with operations and maintenance. Intermediate range impact was concerned with modifications to existing facilities. Long range impact dealt with the design of new facilities. Administrative dealt with information coordination, energy accounts and so forth. Finally, investigations and demonstrations was concerned with engineering studies, research and development, and demonstration projects to support innovative designs for energy conservation.

In early 1974, the Command was assigned additional responsibilities for direct energy coordination of all Navy Material Command activities and for increased technical support to the Chief of Naval Operations. As a result, the Command coordinated all aspects of energy plans, programs, and actions, established priorities and formulated policies and procedures. At the same time, the Energy

Resources Group was reconstituted as an Energy Review Group. This review group acted as a forum for review of policies, program status, and interchange of ideas with particular emphasis on future courses of research, development and engineering to reduce energy use and to increase energy utilization efficiency.

Some of the more significant things done by the Command to implement the recommendations of the Energy Resources Group were as follows.

In the short range impact area, the Command conducted energy conservation surveys at all shore based activities and provided each activity with specific action plans for conserving energy. In addition, the Command improved the efficiency of all boiler plants, and made surveys to determine where it was possible to convert to coal firing.

In the intermediate range area, the Command developed a five-year, $400 million Energy Conservation Investment Program to upgrade existing buildings and utilities. This program was the result of an extensive statistical and design analysis of existing facilities based on energy savings and investment cost payback.

In the long range area, the Command developed energy conservation design criteria for new facilities which were expected to save up to 40 percent of the energy presently required. The Command also prepared an energy analysis computer program, developed solar heating design criteria, revised specifications to require the highest practicable operation efficiencies for all equipment, and studied the technical and economic feasibility of reclaiming energy from solid wastes at twelve major naval activities. The first waterwall incinerator in the United States producing steam from solid wastes has been in operation at the Norfolk Public Works Center since 1967. A second waterwall incinerator is under construction at the Norfolk Naval Shipyard.

In the current demonstration project area, two new solid waste energy recovery plants are being designed for construction at the Mayport Naval Station, Florida, and Puget Sound Shipyard, Bremerton, Washington; and a third solid waste energy recovery plant is planned at the Philadelphia Naval Shipyard. When completed, the Philadelphia Naval Shipyard project is expected to save over 20 million gallons of oil a year. Also planned was the installation of a prototype fluidized bed oiler in the 50-100 thousand pound per hour class at the Great Lakes Naval Station. This boiler would be capable of burning low grade, high sulphur coal without slagging or exceeding air pollution limits.

The Command's research and development program included projects pertaining to the evaluation of new energy criteria, infrared analysis of heat losses, improved combustion processes, solar energy systems, wind power, ocean thermal power, geothermal energy, energy storage systems, and many other areas of energy research.

Construction Engineering Handbook

The Construction Engineering Handbook was a complete revision of the engineering portion of the 1954 edition of the technical publication entitled Inspection of Construction Contracts, TP-Ad-5. In 1969 the Command decided to replace the outdated and inadequate 1954 publication with three separate documents. As a result of this decision, the Construction Engineering Handbook, identified as NAVFAC P-455, became the second document. The first document dealt solely with contract administration and the third was a reprint of an existing Army Corps of Engineers checklist of facilities construction for use by Navy inspection personnel.

The Construction Engineering Handbook was to provide the basic engineering principles pertinent to all Navy faciliites construction, in order to provide a basis for judgement of contractor conformance to contract requirements, and to point out the critical parts of the construction or installation process.

The effort necessary for the preparation of a document of this scope precluded complete preparation by Headquarters personnel. For this reason, the Western Division was tasked with developing the content under the direction of Headquarters personnel. Drafts of the Handbook were sent to the other Engineering Field Divisions for comment and input. The final editing of the Handbook was done by Headquarters personnel.

The Handbook was organized to reflect fifteen of the sixteen widely accepted divisions of the Construction Specifications Institute for facilities construction contracts. However, no material was included for the Institute's division dealing with equipment. The Handbook has over 700 pages of text and illustrations and bears the publication date of July 1974.

Trident Program

The Trident System is the third generation of the nation's sea-going strategic deterrent weapon systems. The Trident System was preceded by the Polaris and the Poseidon Systems.[66]

The word Trident, as used in the Trident Weapon System, came from Greek mythology. It was the name of the three-pronged spear, held by King Neptune. The three prongs of the Trident spear are symbolic of the three major prongs, or aspects, of the Trident Weapon System. These are, the new submarine, the new missile, and the new support site.[67]

The Trident Weapon System was designed to operate from a single support site, a submarine base. Facilities to be constructed at the site were to provide all necessary support for a fleet of ten Trident submarines, including their crews and their armament of Trident missiles.[68]

Preliminary planning and design for the facilities to be located at Bangor, Washington began immediately upon the announcement of the selection of the site in March 1973. The first construction project, which was for the site clearing and foundation

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[66] Kenneth C. Perri, "The TRIDENT Support Site," The Blueprint, (17 Jan 1974).

[67] Joseph White, "Trident Program," in "Fifty-Year Development in Naval Facilities Construction," Dr. M. Yachnis, Journal of the Construction Division (Mar 1974), pp. 20-22.

[68] Joseph White, "Trident Program."

construction of a major training facility, was awarded in October 1974. The tempo of construction activity at the site was expected to increase rapidly and was projected to peak at about 3,600 workers.[69]

Because of the magnitude, complexity and strategic importance of the Trident Program, the Office in Charge of Construction, Trident, was established in March 1973. This office was established to execute the planning, design and construction of the shore facilities for the Trident Program, and to award and administer the associated contracts.[70]

Sanguine

Sanguine was a one-way radio communication system intended for use in sending critical messages to our submerged missile-launching nuclear submarines at great depths almost anywhere in the world. Operating from one transmitter complex within the continental United States, the buried Sanguine system would assure our ability to transmit to our submarines under any conditions, including nuclear attack on the United States or radio jamming.[71]

Sanguine system installation plans were carefully prepared to minimize environmental impact in the area of its location. Since

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[69] Mary Anne Ezzell, "The Trident System Support Site," The Navy Civil Engineer (Fall 1974).

[70] See Chapter 10 for a more detailed discussion of the Trident Program.

[71] "Project Sanguine - A perspective," point paper, NAVFAC Engineering and Design, Code 04.

local condition varied, a construction technique preferable in one region was incompatible in another.

A decision on the Sanguine site was not expected until 1976. However, in late 1974, the Navy began a study of all federally owned land within the continental United States. The final site selection decision would be made by the Secretary of Defense and would be subject to Congressional approval through the normal budgetary process.

The Navy realized that Sanguine had to be compatible with its environment. For this reason, a research and development program was initiated in 1967 to study the problems and answer the questions which were anticipated concerning Sanguine's environmental impact. The research and development effort addressed all environmental areas including elimination of interference on telephone lines, power lines, and wire fences; laboratory and field experiments to answer the biological and ecological questions; and detailed land-use planning and joint-use methods. The research program also included the construction of the Sanguine Wisconsin Test Facility which became operational in 1969.

During the later part of this period, there were many studies conducted by the Navy and independent research teams. Results of these studies at the end of 1974 showed that there were no effects from Sanguine on humans, animals, plants, or micro-organisms. In addition, these studies concluded that even hundreds of times more energy than Sanguine radiated would produce no noticeable biological effects.[72]

The long-term plans for Project Sanguine anticipated a production decision for system acquisition in fiscal year 1977. It was this activity that required the greatest study and planning to insure environmental protection. The evaluation of total environmental impact during construction and operation of a Sanguine System would be updated in an additional environmental impact statement prior to requesting authorization for construction of an operational Sanguine System.[73]

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[72]"Project Sanguine - A perspective."

[73]"Fact Sheet for the Sanguine System Final Environmental Impact Statement for Research, Development, Test and Evaluation (Validation and Full-Scale Development)" (Apr 1972). For additional information on Project Sanguine, see Chapter 10, Construction, in this history.