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ABSTRACT

During the next two decades, changes in underseas technology will profoundly affect Navy personnel and training requirements. Both Navy and national programs in ocean science and engineering will require operational commitments from the Navy which are far beyond present personnel capabilities. In the near future, Navy personnel will routinely work as free divers at depths of 1,000 feet and at even greater depths within 20 years. In future exploration the problems of deep-ocean visibility, heating, communications, navigation, and psychophysiology will be examined. There is a need for more detailed study of oceanic programs, undersea technological trends, and projected effects on future Navy personnel capabilities. Diving training facilities and methods also should be improved as soon as possible. (BC)

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SAN DIEGO, CALIFORNIA 92152

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PERSONNEL IMPLICATIONS OF NEW TECHNOLOGICAL DEVELOPMENTS: UNDERSEA TECHNOLOGIES

David A. Wilson

AN ACTIVITY OF THE BUREAU OF NAVAL PERSONNEL

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PERSONNEL IMPLICATIONS OF NEW TECHNOLOGICAL DEVELOPMENTS: UNDERSEA TECHNOLOGIES

by

David A. Wilson

July 1969

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SUMMARY AND CONCLUSIONS

Problem

The purpose of this exploratory investigation is to develop and employ valid bases in forecasting the most likely effects of new technology on future Navy personnel and training requirements. This preliminary report projects long-range personnel implications of advances in undersea technologies. The research is not directed at developing a personnel plan, but at providing the Navy with information upon which to base long-range personnel planning.

Background and Requirements

This continuing investigation was initiated in Fiscal Year 1963 to examine the potential effects of microelectronics on future Navy personnel requirements. The first report (19) proved quite controversial, and led to a continuation of the investigation. A critique of the original report was published in 1965 (20) and a projection of the personnel effects of automation in 1966 (18). An updated report on personnel implications of developments in microelectronics and automation was published in 1967 (49) and a paper based on that report was presented at the 1968 Government Microcircuit Applications Conference (GOMAC) (48). The present effort was begun in 1967 as a limited investigation on the potential implications of oceanography, but was soon expanded to consider the broad spectrum of undersea technologies now under study.

Approach

This preliminary report includes a brief historical summary of important undersea technologies, a projection of future trends, and an examination of major sources of future Navy commitment. Personnel and training implications are then derived, and forecasts and recommendations stated. Content is based on a review of technical journals, study of recent technical and policy documentation, on-site interviews with numerous scientists, technicians, planners, and managers both in and out of the military establishment. This review was completed in January 1969. An attempt is made to isolate a manageable set of specimen benchmarks indicative of the most likely trends in technology, policy and philosophy, and to project the resultant personnel and training requirements for consideration.

Findings, Conclusions, and Recommendations

This report forecasts that future developments in undersea technologies will profoundly affect Navy personnel and training requirements during the next two decades. Both Navy and national programs in ocean science and ocean engineering will soon impose operational commitments on the Navy far beyond present personnel capabilities. (pp. 2, 3, 13-19) It is further predicted that Navy personnel will routinely work as free divers at depths of 1,000 feet within the next decade and at greater depths within the next two decades. (p. 6) Navy personnel will also operate vehicles and occupy and maintain habitats and operational facilities in the deepest ocean depths within two decades. (pp. 8, 9) Parametric technologies are forecast to be deep-ocean visibility, heating, communications, navigation, and psychophysiology. (pp. 10-11)

This report recommends more detailed study of Navy and national oceanic programs and undersea technological trends and more comprehensive reporting of projected effects on future Navy personnel capabilities and commitments. It is also recommended that diving training facilities and methods be improved on an urgent basis, and that greater Navy effort be directed to the long-range support of production of more and better deep-ocean scientists and engineers.

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I. INTRODUCTION

A. PURPOSE, SCOPE, AND METHOD

1. Purpose.

The purpose of this exploratory investigation is to develop and employ valid bases for forecasting the most likely long-range effects of technological advances on future Navy personnel and training requirements. Studies conducted during Fiscal Years 1962-1967, covering the technologies of microelectronics and automation, have been reported (18, 19, 20, 48).

Undersea technologies were selected for the present study because of the recent increase in military, commercial and governmental emphasis, with the Navy in a dominant role. This research is not directed at developing a personnel plan, but at providing the Navy with information for long-range personnel planning.

2. Scope.

This preliminary report, addressed to personnel researchers, planners, and managers, avoids the highly technical language of oceanographic sciences, and omits those details of a classified or proprietary nature which would limit its distribution as an informational document. No attempt is made to digest the large volume of literature accumulating on undersea technological developments. Rather, an attempt is made to isolate a set of pertinent benchmarks indicative of the most probable trends in technology, policy, and philosophy, and to project the most likely long-range Navy personnel implications for consideration.

3. Method.

Content of this report is based on (a) review of recent technical journals, (b) study of recent technical and policy documentation, and (c) on-site interviews with numerous scientists, technicians, planners, and managers both in and out of the military establishment. In forecasting the future of any technology, it is assumed that neither invention nor the rapidity of exploitation of invention can be predicted with complete accuracy. This research is therefore directed at (a) study of the state-of-the-art of undersea technologies, (b) identification of the most probable direction and rate of developments, (c) isolation of those trends most likely to be furthered and accelerated by oceanographic and undersea technological advances, and (d) consideration of related developments in both foreign and domestic policy and economics. Apparent implications for future Navy personnel and training requirements are then derived.

B. HISTORY OF THE INVESTIGATION

Investigation of personnel implications of new technological developments was begun in the New Developments Research Department of the Naval Personnel Research Activity, San Diego, California, in September 1962. The first report was published as Research Memorandum ND 64-12 (19) in August 1963. The Principal Investigator, Mr. I. E. Kaplan, developed a projection of electronic developments during the period 1965-1980, based on estimates by a number of scientists and engineers actively working in the microelectronics area. From this projection were derived implications for future Navy personnel and training requirements. Comments on the initial report by workers, both in electronics and in personnel management, were collected in late 1963 and early 1964. In addition, critical review was obtained from personnel and human factors contractors. A critique of the original report, in which even later electronic developments were considered, was published in January 1965 as ND 65-20 (20). In this report the author recommended that "deep forecasting" of the effects of changing technology on Navy personnel planning be made a continuous personnel research effort.

During 1965 and early 1966, the rapid increase in automation brought about by technological progress was studied, and a two-part projection of effects on future Navy personnel and training requirements published as SRM 67-3 (18) in August 1966. The author, Mr. Kaplan, concluded that increased automation of military work will soon necessitate reconsideration of the performance by humans of most Naval functions. This report included a tabulation of Navy ratings and Naval Officers Billet Classifications, listed according to the susceptibility of the work to automation. A further study of the personnel implications of microelectronics and attendant automation was made by the author of the present report during 1966 and early 1967. The report of this investigation was published as SRM 67-29 (49) in June 1967 and a paper based on the report delivered at the 1968 Government Microcircuit Applications Conference (GOMAC) (48).

C. IMPORTANCE OF UNDERSEA TECHNOLOGIES

The present study was begun in 1967 primarily as an investigation of trends in oceanographic research. It was soon apparent, however, that the entire realm of undersea technological research and development would operate to affect Navy personnel and training requirements profoundly during the next two decades. Research was therefore broadened to embrace the same variety of technologies whose development must be contemplated under the program recently proposed by the Deep Submergence/Ocean Engineering (DS/OE) Planning Group to the Deputy Chief of Naval Operations (Fleet Operations and Readiness) (46).

Implications for future Navy personnel and training requirements ranging from the potential availability of scientific and professional personnel to the utilization of readily available lower-aptitude seamen and civilians must be projected if the Navy is to minimize personnel limitations to its future commitments. Continuing investigation indicates that progress in undersea technological development is at the beginning of an up-curve which, within the next decade, will not only increase many familiar Navy activities, but will add new commitments for which there is no precedent.

This report based on research ending on 15 January 1969, was intended to serve as a preliminary statement of apparent implications and as a basis for more detailed and comprehensive reports. The assignment of higher priority projects, however, necessitated termination of the investigation, at least for the time being. The report was subsequently submitted for technical review to several cognizant Navy authorities, and their comments have been considered in this final revision.

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II. TECHNOLOGICAL DEVELOPMENT TRENDS

A. DIVING

1. Past Developments. (5, 33, 37)

For more than twenty centuries prior to about 1800, the diving bell or kettle was the only practical apparatus available to assist man in entering the sea. Shortly after 1800, the use of compressed air supplied from a pump on the surface was introduced, and in 1837, the "closed" diving dress invented by Augustus Seible provided the diver a limited mobility on the ocean floor. This "hard-hat" dress, consisting of a heavy metal helmet and waterproofed canvas suit, with air supplied through an "air umbilical" by surface pumps and exhausted into the sea, has not been basically changed in 132 years.

Numerous improvements in design, materials, and procedures have of course been developed. Research into the use of inert gas mixed with oxygen was begun in 1924, in an effort to solve the problems of oxygen toxicity and nitrogen narcosis. A Naval Experimental Diving Unit was formed to support such research and was transferred to the Washington Navy Yard, adjacent to the diving school, in 1927. Through experimentation and experience, the first accurate set of gas mixtures and diving tables satisfactory to 500 foot depths were developed by 1939.

By 1940, the self-contained underwater breathing apparatus (SCUBA) had been developed to a practicial stage, and the first American SCUBA divers started training in 1942 for duty with the Office of Strategic Services (OSS). Free diving was further advanced in 1943 with the introduction of the Cousteau Aqua Lung, which provided both a back-packed air supply and a demand regulator. By 1947, SCUBA diving was included in the training of underwater demolition teams (UDT), and in 1954 the Navy Underwater Swimmers School was established at Key West, Florida. Currently Navy SCUBA Diver (NEC 5345) training is accomplished at five different schools.

Hard-hat and SCUBA divers breathing either air or mixed gasses during relatively brief excursions into the sea are now known as "conventional" divers. This term became necessary upon the introduction of "saturation" diving in 1957. This form of diving, in which the diver's body tissue is saturated to capacity with a pressurized mixture of helium, nitrogen, and oxygen, permits long periods of submergence.

The initial research project, called "Genesis", was conducted by Navy CAPTAINS George Bond, Walter Mazzone, and Robert Workman at the New London Naval Medical Research Laboratory. This early research was expanded into Sealab I (1964) and Sealab II (1965), open-sea projects in which aquanauts lived in a pressurized habitat at 200 foot depths for periods up to 30 days, and left the habitat as free swimmers for as long as 3 hours at a time. Extended periods of compression and decompression are necessary before and after saturation diving. This disadvantage is more than offset by the long work periods and repeated excursions possible at the greater depths. In Sealab III, the habitat is to be placed at a depth of 600 feet, with some personnel remaining in a saturated condition for as long as 12 days at a time.

Saturation divers who live and work for such extended periods without returning to the surface are now known as "Aquanauts".

2. Future Trends.

Advances in diving technology will apparently permit divers to routinely do useful work at depths down to 1,000 feet within the next few years (32). This will be due largely to continued research and experimentation leading to greater understanding of gas mixtures and compression/decompression schedules. Some scientists believe that within the next decade, depths of down to 2,000 feet or deeper may be achieved (5, 8, 24). Depths reached by free divers may be further increased if "flooded lung" techniques now under study prove feasible. Research conducted to date indicates that the transfer of sufficient oxygen to the surface tissue of the lungs through a saline solution is entirely possible, but that the removal of sufficient quantities of waste gasses through the same medium remains an unsolved problem. Should this problem be solved, the body of a diver with liquid-filled lungs and oral and nasal cavities could theoretically withstand much greater ambient pressures than that of a gas-breathing diver (24).

For man to dive deeper and work longer and more efficiently, several related technologies must be further developed. Among these are heating, lighting, navigation, communication, tool design, power supply, delivery and recovery systems, and habitats. At present, research and development programs in such technologies are at best modestly funded, yet very considerable progress is being made. Thus there are valid grounds for the prevalent optimism among members of the diving community that continued and more rapid progress is likely throughout the next two decades.

B. VEHICLES

1. Past Developments. (4, 8, 39, 46)

The self-propelled undersea vehicle originally conceived during the American Revolution became operationally effective by the end of the nineteenth century. From the small early submersibles such as those of Simon Lake (1895) and John Holland (1899) have emerged three basic types of undersea vehicles capable of self-propulsion: (a) the bathyscaph, (b) the submarine constructed with a ring-stiffened metal hull, and (c) the pressure-capsule undersea vehicle.

Examples of the bathyscaph type are the Trieste, and her French counterpart, the Archimede, both designed for oceanographic observation. Each of these vehicles consist basically of a negatively buoyant hull and a float large enough to provide the necessary reserve buoyancy. Aviation gasoline was originally used for floatation, but, due to the serious safety hazard, better materials, such as syntatic foam, are being developed. The latter material consists of small, hollow glass spheres bonded together by epoxy resin, producing a rigid material even more buoyant than gasoline.

This type of vehicle, though limited in crew space, has the ability to support large payloads of power supply, life support, research, and working equipment, and to move about the floor of the deepest oceans. This combination of capacity for deep-diving and self-propelled mobility with a heavy payload indicates that the bathyscaph type vehicle will be useful for years to come. The type is, however, slow and limited in cruise range, and therefore does not satisfy the Navy's need for higher performance vehicles.

The advent of the German U-Boat of World War I brought about rapid development of ocean-going high-performance submersibles. Despite the introduction of improvements such as diesel-electric propulsion and the breathing snorkel, however, these remain basically surface boats which can completely submerge for only brief operational missions. The nuclear-powered SSN types were the first true submarines capable of living in the deep ocean throughout an extended operational cruise. Nuclear power eliminates the need for refueling at sea, and also provides the crew with ample breathing air and fresh water. The technology is now such that cruise duration is personnel-limited; that is, human psychophysiological limits can be exceeded by the performance of the vehicle. Depth capabilities however are constrained by a combination of the nature of the design and the strength of available materials. The large, ring-stiffened streamlined metal hull can not withstand pressures found in the deepest oceans.

The third basic type of vehicle combines some of the capabilities of both the bathyscaph and the submarine. Vehicles of this type generally have a positively buoyant spherical pressure hull for the crew, supported and protected by an outer unpressurized shell containing the propulsion system and all possible life support and operational equipment. The forerunner of such vehicles, the French Soucoupe, is limited to depths of 1,000 feet, due to the quite conventional steel used to fabricate the pressure hull. Later vehicles, such as the Alvin, Deepstar, Moray, Deepquest, and Ashera have better depth capabilities, resulting from the improved material used. The Alvin, for example, achieved depths of down to 6,000 feet before her accidental loss in 1968. Their pressure hulls are all constructed of special high strength steels except for the Moray, in which aluminum was used. A great deal of research and experimentation has been done with glass and plastics, but they are not yet in general use for deep-diving pressure capsules.

All vehicles in this category are small and limited in crew size, payload, and cruising range. Unlike the submarine, they are dependent on special surface vessels for delivery to an operating site as well as for support during a mission. Their use is thereby limited by weather, sea state, and time constraints.

Other manned undersea vehicles include those which are designed to transfer personnel from the surface to an undersea vehicle or habitat and back. These are basically diving bells with a diver lock-out capability. They may be self-propelled, or may be winched up and down and positioned from a surface support vessel.

Unmanned vehicles include surface and sub-surface buoys, bottom-sitting stations, surface-controlled robots, and orbital satellites. Unmanned buoys and stations have been developed for oceanographic research (primarily data collection) and for monitoring the passage of surface and sub-surface vessels. Orbital satellites have been employed recently to record and report oceanographic meteorological data, collected over much larger areas of the oceans than could be covered by other means.

2. Future Trends.

There is ample evidence that all the types of undersea and oceanographic vehicles described above will be further developed during the next two decades. Each type has characteristics and capabilities not shared by other types. Some experts foresee a great proliferation of small manned research and work submersibles (8, 11), due to future demands of industry, oceanography, and security. Others feel that the performance limitations of this type will instead bring on a proliferation of larger, higher performance submarines, of which the nuclear-powered NR-1 research submarine is merely the predecessor (39).

In either case, the considerable progress made by both government and industry within very modest budgets indicate that a continuing succession of both specialized and general purpose vehicles will appear. Future government support and commercial investment seem certain to increase greatly as noted in Part III below. Such increases will result in correspondingly heavier demands on Navy manpower resources.

C. HABITATS

1. Past Developments. (2, 8, 16, 17, 32, 35, 37)

The concept of ocean-floor habitation first became feasible with the development of saturation diving in the "Genesis" project. The succeeding Sealab program and, more recently, other similar efforts, have resulted in considerable advances despite very nominal funding support. Another concept of excavating habitats within the ocean floor has elicited little active support, but is considered to have future potential. Basically, the following three types of habitat are under study:

a. Bottom-sitting. This type of habitat is carried or towed to an operational site, and lowered to the ocean floor. It is then occupied by personnel who have undergone saturation compression in a chamber aboard a surface support vessel and lowered to the habitat in a pressurized personnel transfer capsule. The most advanced experiment to date was the Sealab II project conducted in 1965 by ONR as part of DSSPs Man-in-the-Sea program. During this multidisciplinary investigation 28 Navy divers and civilian scientists performed ocean floor tasks including studies of human physiology and performance, salvage techniques, biological and physical oceanography, mining techniques, and evaluation of the prototype habitat, diving equipment, and compression/decompression system.

b. Mobile. A considerable interest has also developed in the concept of a mobile habitat. Similar in capabilities and uses to the bottom-sitting type, a mobile habitat could propel itself from site to site without the necessity of surfacing. With a nuclear power source, such a habitat could produce potable water and breathing air as does a nuclear submarine, with personnel and provisions delivered and recovered by means of personnel transfer capsules and/or small submersibles. Such a habitat would be capable of supporting exploration and work parties for a long period of time over a large area of ocean floor with only occasional regard for weather conditions and sea state. Although no such operational mobile habitat has been produced, it is considered feasible without great technological advancement, and an operational moveable habitat, without self-propulsion, is now planned.

c. Manned-in-Bottom. The concept of a Manned-in-Bottom Base, that is, a habitat under the sea floor, has been the basis of considerable research and exploratory work for many years. The first comprehensive Navy study resulted in the "Rock-Site" concept of large under-the-sea-floor installations with a shirt-sleeve, one-atmosphere environment. Such a habitat appears to be within existing technological capabilities, and a great deal of experience has been accumulated in off-shore mining operations. Such a habitat could be constructed either with "air umbilicals" to the atmosphere, or with breathing air produced by a nuclear power plant, as in the submarine. Access for swimmers, personnel transfer capsules, and/or submersible vehicles would be possible through air locks. By tunnelling, habitat capability could be expanded to such a size that large colonies and a variety of operations could be accommodated on a permanent basis.

2. Future Trends. (16, 17, 46)

Research and experimentation, although severely constrained by budget limitations, are progressing on a wide variety of manned habitat concepts. The need for program expansion with more adequate support is illustrated both by the problems experienced during the current Sealab III project and the limited work possible on other types of habitat. A large variety of technologies ranging from basic metalurgy and welding methods to basic medicine and psychology are involved, and only a broad multidisciplinary program is likely to produce satisfactory results.

Such broad programs have been developed and proposed, and increasing national interest seems certain to result in gradual implementation within the next few years. During the next two decades a variety of fixed, portable, and mobile habitats will surely result.

D. CONTRIBUTING TECHNOLOGIES

1. Parametric Technologies.

This preliminary investigation indicates that certain constraints on undersea activities are already imposed or will soon be encountered unless technological research and development is more vigorously pursued. In considering personnel and training requirements, emphasis and progress in selected areas should prove useful indicators of future trends. Additional parametric technological areas should also be identified and considered as their importance as useful indicators becomes apparent. The author finds little agreement among experts of various disciplines as to which technologies will rapidly advance and thus ensure continued progress, but those listed below seem to be generally recognized as critical benchmarks:

a. Visibility. The deep ocean is completely dark. In addition, the presence of microorganisms and floating particles result in such turbidity that ordinary light is scattered and its range thus shortened. Increasing the candlepower of conventional lighting results in relatively little improvement in visibility. Several new approaches to increased range and clarity of visibility include the use of coherent light, light amplification, and acoustics (including acoustic holography). (5, 11, 12, 31)

b. Heating. The deep ocean is so cold that man can not survive or work efficiently without artificial heating of his vehicles, habitats, and dress. This is particularly true of saturated divers living in a helium-rich atmosphere, since helium transmits body heat much more rapidly than air. Small, light, portable, dependable heat sources, including man-packed nuclear suit heaters, are being developed. Nuclear power sources are also considered as heat sources for vehicles and habitats. A habitat deep under the sea floor, on the other hand, would have to be cooled, using circulating sea water to carry off the earth's heat. (2, 5, 16, 31, 32, 37)

c. Communication. In a high-pressure helium-rich atmosphere, the human voice rises to such a high pitch as to be unintelligible. Electronic equipment to restore the pitch to normal has been developed, and improvements promise to solve this problem soon. Long-range, dependable communications between divers, vehicles, and habitats, however, have not yet been developed. Much research and experimentation on electronic, laser, and acoustic communications methods are necessary. (5, 32, 37)

d. Navigation. The operator of swimmer transport vehicles, as well as the free swimmer, faces serious navigational problems. A great deal of research and human engineering work is needed to obviate the danger of disorientation at all depths. A variety of man-packed and small-vehicular navigational aids combining accuracy, simplicity, and reliability, must be developed, and the use of sea animals in guiding and rescue must be further explored. (5, 31, 37)

e. Psychophysiology. The limits of man's ability to operate as a free swimmer, at depths at least as great as those on the floor of the continental shelves, and of his behavioral efficiency during and after prolonged confinement in undersea vehicles and habitats are not known. Present evidence indicates that psychophysiological limitations may soon prove a barrier to full exploitation of vehicular and habitat capabilties. This is particularly apparent when the prospect of prolonged excursions by mature, experienced scientists and technicians is considered. In the near future, lack of sufficient knowledge of psychophysiological parameters may deter such personnel from venturing into environments presently reserved for young men characterized by unusual physical stamina and personal bravery. (5, 11, 17, 24)

f. Facilities Construction and Maintenance. The construction and maintenance of undersea operational facilities will require adaptation of existing engineering techniques and the invention of new methods, materials, machines, and structural forms. (2, 16, 35, 39)

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III. SOURCES OF NAVY COMMITMENT

A. OPERATIONAL REQUIREMENTS

Future operational capabilities to which the Navy is committed are stated in the recent landmark report of the Deep Submergence/Ocean Engineering Planning Group (46). Detailed description and discussion of operational capabilities and plans to achieve them are classified, and so are not repeated here. The following extracts from an unclassified summary, however, disclose ample evidence of the nature and extent of this Group's proposed program for the 1970 decade.

1. Objectives.

Stated objectives include development of the ability to:

a. Use more efficiently the inherent characteristics of the sea, and in particular those of the sea floor, to achieve increased operational capabilities in performing offensive and defensive military missions.

b. Deny the effective use of the sea and the sea floor to those nations whose interests are hostile to those of the United States.

c. Provide systems and a spectrum of reasonable technological options for deep submergence activities from which to draw operational capabilities responsive to the threats and needs facing the United States and its allies.

d. Insure, through development of effective and demonstrable capabilities, that the United States can exert an authoritative and credible influence on international deliberations regarding the exploration, exploitation, and ownership of the sea floor.

2. Operational Capabilities.

The Planning Group defined and discussed necessary operational capabilities in ten primary mission areas:

a. Surveillance

b. Reconnaissance

c. Small Object Recovery

d. Rescue and Undersea Transfer of Personnel and Cargo

e. Explore and Chart the Ocean Bed

f. Construct and Support Installations on the Sea Floor

g. Police/Protect Bottom Installations

h. Neutralize Enemy Undersea Installations

i. Support Amphibious Operations

j. Salvage

3. Specific Projects.

In the report, the current Navy DS/OE program was divided into 21 identifiable projects, ranging from basic research and exploratory development to operational systems development. Continuation of most of them on a modified and expanded basis, was proposed as follows: (Current project document numbers are included where available.)

a. Technology.

(1) Ocean Engineering

(2) Biochemical Research

(3) Biochemical Development (AD043-06X)

(4) Deep Ocean Technology (AD046-36X)

(5) Man-in-the-Sea, Deep Ocean (AD046-20X)

(6) Extended Depth Salvage (AD046-18X)

b. Development.

(1) Vehicle

(2) Submarine Location and Rescue Systems (Deep Submergence Rescue Vehicle - DSRV) (SOR46-15R2)

(3) Submarine Escape (SOR46-15R2)

(4) Object Location and Small Object Recovery System (Deep Submergence Search Vehicle - DSSV) (SOR46-16)

(5) Nuclear Powered Ocean Engineering and Research Vehicle (NR-1) (SCB Project No. 301.65)

c. Man-in-the-Sea.

(1) Man-in-the-Sea, Continental Shelf (SOR46-19)

(2) Large Objects Salvage System (LOSS) (SOR46-17)

d. Support.

(1) Facilities

(2) Training

4. Scope and Priorities.

The Planning Group considered almost all of these technology and support objectives of the Navy to be synonymous with national objectives. In other words, the Navy, in accomplishing its own ends, would be carrying out a large part of the national oceanographic program. They therefore recommended implementation of what has been publicly described as a 12-year, $3.5 billion effort (29). Of particular interest here was their recommendation of greatly increased emphasis on biomedical and Man-in-the-Sea research and development. They concluded that "unless greater support is given in this area, use of the sea floor for military purposes will not be possible". Another conclusion of importance to future personnel considerations was that present and currently planned facilities for testing vehicles and other systems will soon prove inadequate. In addition to increases in physical testing and simulation facilities, they indicated that "training of personnel for operating and maintaining DS/OE systems will require courses of instruction and facilities not presently in existence".

B. NATIONAL POLICY

1. Increasing Emphasis.

Evidence of the rapidly increasing national emphasis on oceanographic research and undersea technological development abounds (10, 11, 13, 14, 25, 27, 44, 47). In 1963, an Interagency Committee on Oceanography released a report entitled "A Long Range National Oceanographic Plan 1963 - 1972". The plan recommended the expenditure of $2.3 billion over the ten-year period (44). By comparison, the Navy's recommended DS/OE program, much more limited in the areas of basic science, calls for an expenditure of $3.5 billion during the next 12 years (29). The most recent proposal, developed by a Congressional Commission on Marine Science, Engineering, and Resources recommended programs variously estimated to cost between $8 billion and $16 billion over the next ten years. This report is not yet available to the author, but public disclosures indicate that the programs are much broader than previously contemplated. Implementation of this commission's proposal would result in the establishment of a "wet NASA"; that is, a single National Oceanic and Atmospheric Agency to coordinate and manage a total national oceanic program. Such a program, rather than relieving the Navy of its future commitments, would utilize Navy development capabilities for fundamental technology, and, as the uses of the sea multiply, complicate the Navy's defense mission by the presence of additional structures, vehicles, and men employed in new activities in the oceans of the world (27, 46, 47).

Another recent proposal developed at the direction of President Johnson by the National Council on Marine Resources and Engineering Development, calls for an International Decade of Ocean Exploration, with the United States and the Soviet Union each contributing some $3 billion, and other participating nations a similar amount. Although this proposal may not be implemented for reasons of international politics, it is indicative of the United States' determination to keep the ocean floor and the water above free from national or international control (25). Proposals that the United Nations be given jurisdiction over the sea floor beyond the continental shelves have been categorically rejected by the United States government (6). The Congress has, however, ratified four United Nations conventions aimed at establishing international law pertinent to the age of exploiting the resources of three-dimensional oceans. These are:

a. Convention on the High Seas

b. Convention on the Territorial Sea and the Contiguous Zone

c. Convention on Fishing and Conservation of the Living Resources of the High Seas

d. Convention on the Continental Shelf

Our own laws permit, and our national policy supports, the unrestricted exploration and exploitation of the ocean depths and the ocean floors not specifically covered by convention. Thus, our national policies commit the Navy to the development of proven ability to secure such operations in all the oceans and at any depth (36).

C. COMMERCIAL POTENTIAL

1. Material Resources.

The author finds little agreement as to the future development of fishing, undersea mining, and the recovery of metals and chemicals from sea water. Although the potential is admittedly huge, the need for such resources has not yet been sufficient to elicit the commitment of large capital investments (3, 7, 9, 11, 40, 42, 47, 50). In the near future it appears that oil and gas exploration and recovery will dominate commercial undersea developments. It has been estimated that 16% of the world's oil production and 6% of its natural gas is now obtained from offshore wells. Other estimates indicate that the oil industry will invest some $25 billion during the next ten years on further offshore enterprises in at least 100 countries.

Unlike certain undeveloped countries, whose governments derive a large proportion of their total revenues from oil, the United States has not yet felt the full economic impact of offshore oil and gas leasehold operations. Only the shallow areas off Louisiana, Texas, and California have been extensively exploited. Yet these areas alone are estimated by the Geological Survey to contain proved reserves of 2.9 billion barrels of oil liquids and 30.3 trillion cubic feet of natural gas. As oil reserves are depleted and deep-ocean exploration and recovery technologies are developed, recoverable resources estimated at 35 to 220 billion barrels of oil and 170 to 1100 trillion cubic feet of gas will become available and economically exploitable along the United States coastlines (11, 21, 41, 50).

When these and other recovery operations are extended beyond adjacent waters, the Navy's commitment to providing security will further increase.

2. Market Opportunities.

Aside from the wealth available in and under the oceans, profits from the very research and development of growing oceanic programs are providing a powerful incentive to progress. One survey (3), for example, resulted in the following listing of market opportunities:

"ASW - Anti-submarine warfare

PSW - Pro-submarine warfare

Mine warfare

NOP - National Oceanographic Program

Other Military Oceanography

Deep Submergence Systems Project

Undersea Weapon Ranges

Deep Sea Seismic Arrays

Tsunami Warning Networks

Storm Surge Warning Networks

Remote Ocean Weather Stations

Tide Gages and Other Fixed Ocean Stations

Fixed Ocean Navigation Tower

International Ice Patrol

Federal Fisheries Research

State Fisheries and Oceanography Programs

Water Polution Study and Control

Shellfish Purification

Commerical Fisheries

Aquaculture

Desalination

Coastal Engineering

Undersea Civil Engineering

Port and Harbor Engineering

Offshore Petroleum

Offshore Hard Minerals

Direct Mineral Extraction

Tidal Electricity

Private Weather/Sea Forecasts

Commercial DR/Vs

Surface Work Ships and R/Vs

Salvage

Undersea Recreation

SCUBA, Hard-Hat Diving

Undersea TV and Movies

Individual Exploration

Industry Programs

Underseas Transport

Underseas Storage

Undersea Cables

Undersea Archeology

Oceanologic Activities of DASA (Defense Atomic Support Agency) in Connection with Nuclear Tests at Sea and the Protection of Naval Ships from Nuclear Attack

Detecting and Localizing Distant Underground Nuclear Tests

Field Oceanographic Support (sea state and swell monitoring and forecasts for amphibious landings, etc.)

Secret Underwater Activities of the CIA

Providing Goods and Services to those who are doing Specific Things in the Ocean."

Potential profits from research and development work and from the recovery of the ocean's riches combine to form a powerful incentive to technological progress. Such progress will at once contribute to the Navy's capabilities and impose new and greater burdens upon them.

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IV. PERSONNEL IMPLICATIONS

To meet its new and increasing commitments, the Navy must explore available sources of personnel ranging from top-flight oceanographers and engineers to support personnel whose work will be largely manual. This need results from the fact that a bewildering variety of tasks must be performed as undersea technologies develop. Such tasks will range from design and construction of unique vehicles and structures to the use and maintenance of tools and equipment not yet invented (30, 33, 45, 46).

A. RESOURCES

1. Professional Personnel.

The supply of scientists and engineers needed to staff present national programs of oceanography and ocean technological development is already critical, and promises to become more so as these programs are expanded. It has been estimated that the United States has fewer than a thousand oceanographers, with fewer than three thousand full-time technicians supporting them. The Soviet Union, by comparison, claims approximately twice these numbers (45). Although our ocean engineering and Man-in-the-Sea projects are in general well ahead of those of other nations, a great increase in the training of competent professionals is needed to maintain this lead. Many colleges and universities have initiated, expanded, and modified their educational offerings in an effort to produce larger numbers of oceanographers and ocean engineers. So far, however, this very emphasis has caused the schools to consume a large proportion of their own graduates as teachers (22, 23, 43). A National Sea Grant Program, through which federal funds are made available to colleges and industry, has yet to show a strong effect. Under this program, both education and on-the-job training are supported by channeling revenues from offshore leaseholds to both colleges and industry. Industrial firms and academic institutions are able to form working partnerships of several types:

a. Fellowships and scholarships which industrial organizations may furnish to institutions enjoying Sea Grant sponsorship.

b. Cooperative eduction/on-the-job training programs between Sea Grant institutions and industrial organizations, whereby the student may take a year longer to obtain his degree, but enjoy on-the-job training interspersed among the semesters -- the schedule to be negotiated between the school and the industry for maximum benefit to both.

c. Industrial organizations acting as subcontractors to institutions carrying out applied research projects under the Sea Grant programs.

d. Industrial organizations that wish to explore the possibilities of development in the ocean but which are uncertain of their rights (including patent rights, leasehold and royalty requirements; ownership rights for water column and/or bottom exploration, and re-entry rights, etc.) may utilize the services of social science departments of institutions which can be supported under the Sea Grant program.

e. Alliances between industrial firms and institutions to carry out applied research programs under sea Grant support.

The Sea Grant program is expected eventually to help keep the shortage of professional personnel and supporting technicians from becoming a major barrier to future progress (1, 14, 23). Aggressive Navy recruitment of both uniformed personnel and civilians from among professionals trained under the program would seem in order. In addition, the Navy must lead the way toward developing engineering curricula specifically aimed at producing new generations of ocean engineers.

2. Uniformed Personnel.

In addition to officers with educational backgrounds in oceanography and ocean engineering, an increasing number of both officer and enlisted personnel will have to be trained within the Navy in skills ranging from unfamiliar ones such as saturated diving, vehicle piloting, and undersea construction, to mundane ones such as tool maintenance, instrument surveillance, and line handling (33, 45, 46). In addition to competing with commercial enterprises and government for personnel of the highest technical aptitude, therefore, the Navy will need to tap the large reservoir of lower-aptitude manpower as represented in Project 100,000. There is already precedence for the latter approach in a new experimental training program initiated by the Office of Education. Detailed information has not yet been received, but according to a recent public announcement, this Office has obtained the decommissioned Coast and Geodetic Survey vessel Explorer and berthed it in the Anacostia River for the training of jobless men as "oceanographic aides" (38, 47).

B. PERSONNEL AND TRAINING REQUIREMENTS

1. Divers.

Requirements for the selection and training of Navy divers during the next two decades will apparently be dictated by the characteristics of systems now conceived and/or under development. Training methods and facilities for producing sufficient divers to meet these requirements have already been found to be wholly inadequate. After a recent BUPERS supported contractor study of diving training facilities (33), the contractor disclosed current inadequacies and recommended methods and facilities to correct them. The following extracts of this report will serve to indicate the need for prompt expansion to prevent Navy undersea programs from becoming personnel limited for want of sufficient divers. According to the BUPERS study, diving training requirements are as follows:

a. Types of Personnel Who Must be Trained.

ENLISTED	NEC	OFFICER	NOC/NOBC
SCUBA Diver	5345	Ship Salvage Diving Officer	9314
SALVOR Diver	5344	Deep Sea HeO_2 Diving Officer	9313
Diver Second Class	5343	Ship Salvage Operations Officer	9375
Master Diver	5341	Submarine Medical Officer	0090
Med. Deep Sea Diving Technician	8493	Aquanaut Officer	----
Aquanaut	5311		

b. Numbers Requiring Training. An example of a recent training requirements projection is shown in Figure 1, in which training billet allowances are shown at five-year intervals.

c. Numbers Available for Training. The mere allocation of diver training billet allowances evidently will not be sufficient to ensure the production of adequate numbers of trained divers. At the Navy School, Diving and Salvage (NSDS), at Washington Navy Yard, only 390 trainees were enrolled during Fiscal Year 1968, although 647 training billets were allocated. Even so, some facilities were overcrowded.

d. Additional Facility Requirements. The BUPERS contractor doing this study presented two optional facility proposals. In one, the present NSDS facility would be abandoned, and a new school established at San Diego, California. In the other, the present school would be renovated and a second facility constructed at San Diego. Both plans allow for considerable expansion, and include both dockside facilities and numerous craft to be used for at sea diving training.

2. DS/OE Personnel Requirements.

Manning of undersea and related systems now conceived and/or under development will require personnel in a great variety of categories. The most comprehensive current picture of these requirements is found in the recent report of the Deep Submergence/Ocean Engineering (DS/OE) Planning Group of the DCNO (OP-03) (46). Although most of the report is classified, the following list extracted from the unclassified Appendix H (Military Personnel and Training) will serve to indicate the variety of ratings which will require special training necessary for operating and maintaining DS/OE systems already programmed:

- Vehicle Pilot
- Sonar Technician
- Electronics Technician
- Interior Communication Electrician
- Machinist Mate
- Engineman
- Data Systems Technician
- Data Processing Technician
- Boatswain Mate
- Yoeman
- Quartermaster
- Radioman
- Patternmaker
- Photographers Mate

NEC, NOC, NOBC	BUPERS DIVER CURRICULA BUPERS DIVER CURRICULA	1969 (1)	1973	1978	1983	1988	1993
	SATURATION DIVERS						
- - -	MEDICAL OFFICER	-	10	13	13	14	14
- - -	DIVING OFFICER	-	12	18	19	20	20
- - -	ENLISTED DIVERS	-	39	50	37	39	39
- - -	MEDICAL TECHNICIAN	-	5	5	5	4	5
	CONVENTIONAL DIVERS						
- - -	PCO/PXO	15	17	18	20	22	24
9375	SHIP SALVAGE OPERATIONS OFFICER	10	11	12	13	14	15
9313	DEEP SEA (HeO_2) DIVING OFF. (C/T)	34	32	29	31	34	37
9314	SHIP SALVAGE DIVING OFFICER	103	112	122	135	148	163
0090	SUBMARINE MEDICAL OFFICER	56	62	68	73	79	86
- - -	MEDICAL DEPARTMENT OFFICER	20	22	24	27	29	32
8493	MEDICAL DEEP SEA DIVING TECH.	30	18	20	21	23	24
5341	MASTER DIVER	20	20	15	16	18	19
5342	DIVER FIRST CLASS (C/T)	225	119	129	139	149	161
5343	DIVER SECOND CLASS	240	240	240	240	240	240
5345	SCUBA DIVER	160	160	160	160	160	160
- - -	REQUALIFICATIONS	40	44	48	53	58	64

NOTES:

(1) Reflects training load increase to make up current inventory shortages.

Figure 1. Projected U. S. Navy Diver Training Billet Allowances (from Fig. D1, (33), page D2)

Equipment Operator
Builder
Steel Worker
Hospital Corpsman
Storekeeper
Radarman
Damage Controlman
Shipfitter
Machinery Repairman
Commissaryman
Steward
Gunners Mate
Signalman

Numbers of personnel required and manning structure is shown in the extracts included as Appendix A to this report.

3. Training Methods and Facilities.

Adequate facilities for teaching the necessary new knowledges and skills do not exist. Furthermore, new methods must be developed, including means of simulating the undersea living and operational environment. An indication of the magnitude of the immediate and near future problem may be found in the DS/OE Planning Group's summary statement of facilities requirements, which is quoted below (46):

"New training facilities will be required to support the proposed DS/OE program. For submersible vehicle training, a simulator facility is included in the FY 68 MILCON program. The facility will be located at Ballast Point, San Diego, California. The structure is costed at $106 K and the simulator, which is funded in FY 69, at $3.5 million. Planned also at this site is the Deep Submergence Applied Training Facility which will provide classroom and maintenance training work areas for vehicle crews needed to man DSSP managed submersible systems. This facility will consist of a three (3) story office/laboratory building and is estimated to cost $885 K. The facility will support DSRV [Deep Submergence Reserve Vehicle], DSSV [Deep Submergence Support Vehicle], Trieste and NR-1 crew training and could presumably, with only very minor expansion, support total Argonaut crew training, UIP/URV [Unmanned Instrument Platform/Unmanned Recovery Vehicle] training, and Diver Transport Vehicle training. The facility is expected to be operational in FY 72 and require an initial instructor staff of 7 officers, 42 enlisted personnel and 5 civilians (instruction capacity: 18 officers and 70 enlisted at one time).

"In the Man-In-The-Sea Project area, training facilities are required for fleet deep diving indoctrination, including the use of the MK 1 and MK 2 DDS [Deep Diving System]. Additional facilities are required to support the SEALAB portion of the Planning Group's proposed Man-In-The-Sea Project. The Bureau of Naval Personnel (BUPERS) has currently under study the requirements for a new Deep Diving School. Any proposed new facilities should include the capability of supporting MK 1 and MK 2 DDS training. As the BUPERS study is scheduled for completion in September 1968[1], the Planning Group makes no recommendations in this area.

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[1] Report of results is listed as reference 33. Results are summarized in Part IV, B, 1 of this report.

"To support the remainder of the Planning Group's Man-In-The-Sea Project, namely the Sealab in situ experiments, Prototype Underwater Work Unit, and the Manned Underwater Laboratories, new facilities are deemed necessary. The Planning Group proposes that a Diver Training Facility be built in FY 1972 for project support. The facility would provide office space, classroom and maintenance laboratory areas for training of the surface and aquanaut personnel required to man and operate the proposed equipment. It is expected that diver training in saturated diving techniques and in use of deep diving systems would be done at BUPERS planned facilities (which are not included as a direct DS/OE program charge). The facility proposed here assumes this prior training capability and indoctrination provides only for the specific training directly in support of the Planning Group's proposed project. Neither would the facility provide experimental tank simulators for man or equipment evaluations since it is expected that already existing or planned Navy facilities could support such needs. These latter facilities include chambers and tanks planned at NSRDC-Panama City, Florida, and NMRI.

"The facility is estimated to cost $1 million in MILCON exclusive of GFE. Tied to the facility would be the capabilities of the present Deep Submergence Systems Project Technical Office (DSSPTO) at Ballast Point, San Diego, California, which is the site for current Aquanaut training. To be located at the DSSPTO is the YFU-53 with a Mark I DDS, and in the general vicinity, specifically at San Clemente Island, the IX-501 with a Mark 2 Mod 0 DDS. These ships can provide the at-sea training required to support the project. The facility is scheduled, by the Planning Group, for operational use in FY 73, with an expansion of the base facility scheduled for completion in FY 75 to support MUL [Manned Underwater Laboratory] personnel training. Instructor staff is estimated to consist of 5 officers and 30 enlisted personnel.

"The Planning Group has not factored into its plans any changes in submarine excape training procedures and recommends that BUPERS, CNO, and DSSP review the adequacy of present training, note whether interim improvements are desirable and develop required training plans in coincidence with the development of the new proposed submarine escape system."

V. FORECASTS AND RECOMMENDATIONS

A. FORECASTS

On the basis of this preliminary research, the following forecasts are projected:

1. Future developments in undersea technologies will profoundly affect Navy personnel and training requirements during the next two decades.

2. Both Navy and national programs in ocean sciences and ocean engineering will soon impose operational commitments on the Navy which far exceed the present capabilities for providing personnel.

3. Navy personnel will routinely work as free divers at 1,000 foot depths within the next decade and at all depths on the continental shelves within the next two decades.

4. The Navy will operate vehicles and occupy and maintain habitats and operational facilities in the deepest ocean depths within two decades.

5. Parametric technologies will prove to be those related to deep-ocean visibility, heating, communications, navigation, and psychophysiology.

B. RECOMMENDATIONS

The following recommendations are made:

1. Study in detail all current and future Navy and national oceanic and deep-ocean programs, and develop updated long-range personnel and training implications.

2. Continue to study technological developments in deep-ocean diving, vehicles, habitats, visibility, heating, communication, navigation, and psychophysiology, and project the effects of any changes in their technological status on future Navy capabilities and commitments.

3. Improve Navy diving training facilities and methods on an urgent basis.

4. Increase Navy efforts related to the production of more and better qualified deep-ocean scientists and engineers.

5. Review and update both technological forecasts related to deep-ocean technologies, and exploratory development goals and programs, to ensure currency and relevance.

APPENDIX A

PROPOSED MANNING OF DEEP SUBMERGENCE SYSTEMS

(Extracted from Appendix H, (46))

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APPENDIX A

PROPOSED MANNING OF DEEP SUBMERGENCE SYSTEMS

(Extracted from Appendix H, (46))

1. Rescue and Work Systems

a. Deep Submergence Rescue Vehicle (DSRV)

The DSRV is a small self-propelled submersible capable of accomplishing a personnel rescue mission down to the collapse depth of U. S. Submarines and of secondary missions down to design depths.

Each DSRV unit will be assigned a crew of 30 depending upon mission requirements. The crew of each vehicle will consist of the following:

OPERATOR AND MAINTENANCE CREW	Grade & Number				
	03	E7	E6	E5	E4
Pilots	2				
Sonar Technicians (Co-Pilot)		1	2		
Electronics Technicians			2	2	
Electrician Mates			1	1	
Interior Communication Electrician				1	
Machinist Mates or Enginemen			1	2	
TOTAL OFFICERS 2 TOTAL ENLISTED 13					

The crew will operate, maintain (to a level to be determined) and assist in transporting the vehicle.

All crew members will be qualified as mid-sphere/manipulator operators.

The Officers and Sonar Technicians will be qualified vehicle operators. (Total of 5 Pilot Type Operators)

During a mission cycle, three men will be required aboard the vehicle; Pilot, Co-pilot and mid-sphere operator. The other crew members will be engaged in mission support activities aboard the support ship or submarine.

The operational crew of the DSRV will be changed during each life support system replenishment period.

In addition to the vehicle operator/maintenance crew, the following personnel will be required aboard the ASR support ship to track the vehicle, operate and maintain precise location equipment, and recording and analyzing data:

RESCUE CONTROL CENTER CREW	Grade & Number				
	03	E7	E6	E5	E4
Officer	2				
Sonar Technicians			1	2	3
Data Systems Technicians			1	1	1
Electronic Technicians			1		1
TOTAL OFFICERS 2 TOTAL ENLISTED 11					

Because of the inherent capabilities of a mother submarine (SSN) to provide the support control services stated above, no augmentation of a mother submarine crew for rescue system control is planned, though a portion of the DSRV unit personnel would be deployed on the SSN when it acts as mother ship.

Amplification of personnel and training requirements, as well as an outline of personnel research studies needed, are set forth in the training section of TDP 46-15R1, Submarine Location, Escape and Rescue.

b. UNMANNED INSTRUMENT PLATFORM (UIP)
(First Prototype Unit - 3 UIPs/unit)

The UIP will be an unmanned towed submersible instrument platform equipped with sonars and sensors. TV and film cameras for optical search and identification, lights, and radiation detectors will be included. It will be powered through a cable from an external source and will be substantially less complex than a manned vehicle.

The prototype unit, planned under the Rescue and Work System will be portable and operable from any of the new ASR ships. Two additional units are planned for Project ARGONAUT, however, these UIPs would be, in effect, Government Furnished Equipment to the Submerged Support Vehicle (SSV) and integral to its capabilities.

OPERATOR AND MAINTENANCE CREW	Grade & Number				
	03	E7	E6	E5	E4
Officer	1				
Sonar Technicians			1	2	
Electronics Technicians		1	1	1	1
Electrician Mates or IC's			1	1	
Data Systems Technicians			1	1	
Data Processing Technicians			1		
Machinist Mates or Enginemen			1		
TOTAL OFFICERS 1 TOTAL ENLISTED 13					

c. UNMANNED RECOVERY VEHICLE (URV)
(First Prototype Unit - 2 URVs/unit)

The URV is planned to provide the capability for attachment to and recovery of small or medium sized objects. It is a tethered unmanned vehicle equipped with sonar, optical, propulsion and hydraulic systems. The planned URV includes detachable work devices which will allow the vehicle to free itself of an attached object and permit independent lift or recovery of the work device with its recovered object. An economy in crew manning may be achieved by combining UIP and URV unit personnel; however, in order to provide for maximum operational flexibility these units have been considered separately.

The prototype unit, planned under the Rescue and Work Systems, will be portable and operable from any of the new ASR ships. Two additional units are planned for Project ARGONAUT, however, these URVs would be GFE to the SSV and integral to its capabilities.

The URV should have an operating/maintenance crew of the following personnel:

OPERATOR AND MAINTENANCE CREW	Grade & Number				
	03	E7	E6	E5	E4
Officer	1				
Sonar Technicians				1	1
Electronics Technicians		1	1	1	1
Boatswain Mates			1	1	1
Machinist Mates or Enginemen			1	2	
Electrician Mates or IC's			1	1	1
TOTAL OFFICERS 1 TOTAL ENLISTED 15					

2. PROJECT ARGONAUT

Each Project ARGONAUT unit will consist of:

2 Deep Submergence Search Vehicles (DSSV)
1 Submerged Support Vehicle (SSV)
3 Unmanned Instrument Platforms (UIP)
2 Unmanned Recovery Vehicles (URV)

As opposed to the operational concept of the rescue units, which dictates a per equipment manning philosophy, the ARGONAUT equipments together comprise an integrated operational unit intended to be employed as such at all times. Therefore, the proposed manning for ARGONAUT is treated below on a total unit bases. [sic]

The DSSV will be a manned, fuel cell powered submersible capable of extended time on the sea floor during deployment from the SSV. The DSSV would carry a crew of 3 or 4 men. It is desirable that each member of the crew be trained for pilot duties. Members of the DSSV support team not actually aboard the DSSV would be engaged in support activities or in standby relief status aboard the SSV.

The UIPs and URVs stationed aboard the SSV would be quite similar in operations to those used in the Rescue and Work System. However, where the Rescue and Work System equipment are portable and manned on a per equipment philosophy, the UIPs and URVs of ARGONAUT would be integral to the SSV, and only usable from another support ship in emergency situations.

The SSV will be a nuclear submarine capable of achieving at least 1,000 foot operational depth. It would be designed to transport, maintain, launch, recover and exercise command and control over DSSVs, UIPs and URVs. It will also possess its own capabilities to conduct search, recovery, and ocean exploration missions and to assist its deployed craft in the performance of their missions. The SSV will also be capable of locking out swimmers or divers as required. This capability requires a decompression facility, qualified divers, and equipment maintenance and operating personnel. These personnel would be cross-trained and assigned duties in the SSV's Operations Department. As there is no rating restrictions for diver training, desirably at least 20 of the ships crew would be qualified as divers.

It is expected that an ARGONAUT unit will require 18 officers and 139 enlisted personnel as follows:

ARGONAUT UNIT*

Department/Division		Officers				Enlisted						T
		05	04	03	02	E8	E7	E6	E5	E4	E3	
Supervisors/Dept. Head		1	1	10	6							18
Executive Dept.	(YN)						1		1			2
Navigation Dept.	(QM)						1	1	1	1	2	6
Operations Dept.	(ST)					1	2	3	2	2	2	12
	(ET)						2	3	5	3	2	15
	(DP)							1	1			2
	(PM)							2				2
	(DS)							1	1			2
	(RM)					1		1	1	1	2	6
	(BM)						1	1				2
Engineering Dept.	(MM)					1	2	5	7	4	1	20
	(EM)					1	1	2	4	4	1	13
	(IC)							3	3	3	3	12
	(DC)					1	1	1	1			4
	(SF)					1	1					2
	(MR)								2			2
Reactor Div.	(ET)					1		2	2	2		7
Aux. Machinery Div.	(EN)						1	2	4	4	2	13
Supply Dept.	(SK)							1				1
	(CS)					1		1	2	1	3	8
	(SD)							1	1	1		3
Medical Dept.	(HM)						1	2	1	1		5

* Includes personnel for DSSVs, UIPs and URVs Support.

3. MAN-IN-THE-SEA

a. Deep Diving System (DDS)

A MK 2 Mod 0 DDS will be installed on each of the ten planned new ASR ships. The system is composed of:

- Personnel Transfer Capsule
- Main Control Consoles
- Deck Decompression Complex
- Winches, Strength - Power - Communication Cable and Ancillary Support Equipment
- Qualified Divers
- Aquanaut Equipments and Tools
- Maintenance/Operating Personnel

In addition to the DDS complexes aboard the new ASR, one MK 2 Mod 0 DDS will be aboard the IX-501 test range ship and another aboard the proposed additional test range ship. The proposed new construction Deep Ocean Diving and Engineering Support Ship (DODESS) will also be outfitted with a DDS.

Since the new ASRs are not considered, in this report, as part of the 1970-1980 DS/OE Program, their manning requirements are not discussed. However, these ships manning plans do include the personnel required for DDS operations. The manning requirements for the new test range ship and DODESS are discussed below under their respective headings.

b. Project SEALAB

Proposed are two distinct sub-programs. The first develops a prototype underwater work unit composed of:

- Aquanaut Work Tools and Equipments
- 2 Diver Transport Vehicles
- 1 Movable Habitat
- 1 Deep Ocean Diving and Engineering Support Ship (DODESS)
- In Situ Experiment (SEALAB Test Series)

The second sub-program is the application of the above unit to the task of building two Manned Underwater Laboratories (MUL). Once concluded these MULs will represent a research complex consisting of a basic habitat, an instrumented sea floor area adjacent to the MUL, satellite stations, and 2 Diver Transport Vehicles. For manning and training purposes the above systems will be considered in the following groups:

- Deep Ocean Diving and Engineering Support Ship Includes:

  DDS
  2 Diver Transport Vehicles

- Movable Habitat

- Manned Underwater Laboratories

(1) Deep Ocean Diving and Engineering Support Ship

The Planning Group envisions that this ship will be in size similar to a 21 Class ASR. Its primary function will be to support and assist in the operations of divers in the ocean as deep as 1,000 feet. Additionally, it will support the Movable Habitat from which extended time underwater missions will be performed by aquanauts.

The capabilities of this ship are described in Chapter IV of this report. Major support functions will include the maintaining, launching, and recovery of 2 Diver transport vehicles, the operation of a DDS, and the towing and servicing of the Movable Habitat.

The Diver Transport Vehicle will be a small, ambient pressure submersible capable of transporting 2 or 3 divers to various work sites on the sea floor. During work operations the vehicle would operate out of a "garage" in the Movable Habitat. Emergency provisions for mating to the DODESS deck decompression chamber will be required.

The DDS contained on the DODESS would be the latest version of the MK 2. At least 16 members of the support ship crew should be qualified divers (2 - 5341s and 14 - 5342s). These divers could also support the Movable Habitat operations and would provide a trained cadre of workers usable for short duration missions not requiring the emplacement of the Movable Habitat.

Berthing and messing provisions will be required for the Movable Habitat crew while embarked on the support ship during transit to the site of operations.

High emphasis on line handling skills will be required for the launch and recovery of the Diver Transport Vehicles, the operations of the DDS, and the towing, lowering and raising of the Movable Habitat.

The DODESS crew is expected to require 8 officers and 111 enlisted personnel as follows:

Deep Ocean Diving and Engineering Support Ship

Department		Officers				Enlisted						T
		05	04	03	02	E8	E7	E6	E5	E4	E3	
Department Head		1	1	4	2							8
Executive	(YN)							1		1		2
Operations	(GM)						1	3			1	5
	(SM)								2		1	3
	(RD)							1	2			3
	(RM)						2	1	2	1	2	8
	(ST)							2	3	1		6
	(ET)					1	2	2	4	1		10
	(DP)							1	1			2
	(DS)							3	1			4
Engineering	(EN)					1	1	4	4	6	6	22
	(EM)					1	1	2	2	4	2	12
	(IC)								4	1		5
	(MM)								1	1		2
	(DC)								2		1	3
	(SF)								3	1		4
Supply	(SK)							1		2	3	6
	(CS)						1	1	2		2	6
	(SD)							1	1	2	1	5
Medical	(HM)						1		2			3

(2) Movable Habitat

One movable habitat is proposed. It is envisaged that the habitat would be large enough to support a 50 man working force including habitat operators, maintenance, and watch personnel. Throughout the duration of a mission, the habitat would rest on the ocean floor with the aquanauts operating from its shelter and returning to it for rest periods. It would also serve as the on-site command center for the underwater operation and monitor activity in its vicinity. The ambient pressure Diver Transport Vehicles would be "garaged" at the habitat when not engaged in actual support tasks. Various diver tools and equipment required for frequent use would be stored and maintained in the habitat. As required, power for equipments situated at the work site would be supplied via a cable connection from the habitat or via portable power packs.

The needs for data gathering, analyzing and recording, oceanographic sensors and monitoring equipments, and underwater work and power equipments will require a large crew of operator/maintenance trained personnel.

In addition to the specialized training required for the operator/maintenance crew of the habitat, officer personnel as a minimum would have to qualify in one or more of the following areas: scientific observation, oceanography, engineering, or chemistry. All personnel must be qualified Man-In-The-Sea divers (NEC 5311).

Personnel manning the habitat will require cross-training in multiple rating skills to maximize the effectiveness and capabilities of the work team. As mission needs dictate, civilian or military technical personnel will be required in addition to the basic crew. Proposed manning would consist of ten officers and thirty-four enlisted personnel with a remaining capability of supporting up to six additional personnel as needs require. Manning would be as follows:

Movable Habitat

Personnel	Officer			Enlisted				
	05	04	03	E8	E7	E6	E5	T
Officers	1	3	6					10
Sonar Technicians					1	1		2
Electronics Technicians						1	1	2
Radiomen						1	1	2
Photographers Mates						1	1	2
Machinest Mates					1	1	1	3
Enginemen					1	1		2
Electricians Mate or IC					1	1		2
Ship Fitter						1		1
Boatswain Mates				1		1	2	4
Equipment Operators					1	2		3
Builders				1	1	2		4
Steel Workers					1	1	1	3
Hospital Corpsmen				1		1	2	4

(3) Manned Underwater Laboratory (MUL)

The MUL would be a fixed underwater research and development complex designed to support test and evaluation programs. Two such laboratories are proposed by the Planning Group. A description of these complexes, and their anticipated usages, is contained in Chapter IV, Volume 1. The MULS would have a variety of research facilities, docking capabilities for Diver Transport Vehicles (two such vehicles are included in each MUL complex), and the capability of simultaneously supporting personnel working at one atmosphere and at ambient pressures. The MUL would require military personnel for direct operation and support functions. However, research personnel could come from the scientific and academic communities. Thus, though the MUL could support over fifty persons at a time only a small percent of them would be military. Depending on the final characteristics, utilization analysis and site location of the MULs, substantial variation in the proposed manning plan can be anticipated. Indeed, experience may indicate that many functions now thought of as requiring military personnel in the MUL, might be performed by civilians. The means of access to the MUL could also lead to significant variations in military personnel needs, depending on whether a tunnel, marine railway, or elevator structure were to be employed. Therefore, the following manning plan, composed of 5 officers and 22 enlisted personnel is considered only as suggestive of what might be necessary to serve as a reference point for long range planning:

Manned Underwater Laboratory

Personnel	Officer			Enlisted				T
	04	03	02	E8	E7	E6	E5	
Officers	1	2	2					5
Sonar Technicians				1		1		2
Electronic Technicians					1	1		2
Radiomen					1			1
Electricians Mates/IC					1	1		2
Ship Fitter						1		1
Machinery Repairman						1	1	2
Boatswain Mate					1	1	3	5
Data Systems Technician						1		1
Hospital Corpsmen					1		2	3
Machinist Mates/Enginemen						2	1	3

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