The Manned Undersea Science and Technology Program: An Appraisal (1976)

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THE MANNED UNDERSEA SCIENCE AND TECHNOLOGY PROGRAM - AN APPRAISAL

MARINE BOARD
ASSEMBLY OF ENGINEERING
NATIONAL RESEARCH COUNCIL

THE MANNED UNDERSEA SCIENCE AND TECHNOLOGY PROGRAM - AN APPRAISAL

A report prepared by the Panel on Undersea Facilities of the Marine Board, Assembly of Engineering, National Research Council.

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C., 1976

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Panel responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by the Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

This report culminates a 12 month study of the Manned Undersea Science and Technology Office (MUS&T) of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). The study was conducted by the Panel on Undersea Facilities of the National Research Council's Marine Board.

Established in 1971, the MUS&T office was to "develop, promote, coordinate, and support a national civilian operational capability for man to work under the sea."[1] The direction and scope given the MUS&T office by NOAA have not confined MUS&T to any specific mission in support of this objective. Rather, MUS&T has been permitted, within the bounds of its budget, to support all types of scientific oceanic endeavors using divers, submersibles, and habitats.

Recognizing that the choice of programs conducted under this broad direction might not in fact meet the basic objective of the MUS&T office, NOAA requested the Marine Board of the National Research Council to conduct a study of the support provided by MUS&T for the civil manned undersea programs in relation to the present and future needs of the user community. The Marine Board constituted the Panel on Undersea Facilities to undertake the study which resulted in this report.

This study is an extension of an examination of the civil manned undersea activity in relation to national needs conducted in 1972 by the Marine Board and Ocean Affairs Board (now the Ocean Sciences Board) which resulted in the report, Civil Manned Undersea Activity: An Assessment.[2] The earlier study appraised the need for all civil manned undersea activities within the national ocean program, while this study addresses the need and proper scope for a civil manned undersea science and technology program within the federal government but with previous emphasis on the functioning of MUS&T within NOAA.

In conducting the study, the panel considered the following:

- The products and services provided by MUS&T;
- The need for and use of the capabilities and services provid-d by MUS&T to government agencies and other users;
- The need for engineering research and development to increase the capability and safety of existing and proposed undersea facilities;

- The program balance between service and research functions and between national and international agreements on MUS&T operations.

Little formal documentation exists as to MUS&T program guidance and achievements. As a result, the panel depended largely on interviews with MUS&T and NOAA officials, scientists and engineers who have participated in MUS&T programs, officials who have worked with MUS&T in such other government agencies as the Navy and Coast Guard, and scientists and engineers in industry, universities, and non-government institutions involved in undersea work. The panel also relied on its collective experience to evaluate a program that, although still young, is rapidly approaching maturity.

The panel wishes to thank those individuals listed on pages 19-20 who contributed their time and knowledge to help in this study.

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CONTENTS

I. INTRODUCTION

Interest in manned undersea activity increased rapidly in the U.S. during the 1960's. The Navy, in particular, initiated or sponsored a wide range of developmental work in deepsea manned submersibles and saturation diving techniques. A number of companies designed and built submersibles. These efforts were intensified after the loss of two nuclear submarines, Thresher and Scorpion.

During the decade, a rapidly expanding base of undersea technology, indications of continued federal support, and the perceived potential of the oceans, resulted in a surge of civil manned undersea activities. A multiplicity of submersibles and habitats were constructed for various purposes. Among these were the habitats Sealab I, II, and III, Tektite, and Aegir, and the deep submergence vehicles (DSV's) Deepstar, Deepquest, and Aluminaut.

After 1968 other priorities began absorbing an increasingly large share of the federal budget. It also became evident that while the potentials of the oceans are more promising than anticipated, the costs of working in the sea are exceedingly high. Lacking federal support, many existing undersea facilities around the country lay dormant. The trained marine engineers and technicians who designed, built, and operated them left the field to find other employment.

It was in this climate that NOAA established the MUS&T Office in 1971 to "develop, promote, coordinate, and support a national civilian operational capability for man to work under the sea."[3] As with NOAA itself, the formation of the MUS&T program was largely an outgrowth of recommendations made by the Stratton Commission in its 1969 report, Our Nation and the Sea.[4]

II. NOAA MANNED UNDERSEA SCIENCE AND TECHNOLOGY PROGRAM OBJECTIVES

The scope and methods of implementing a formalized national ocean program have not as yet been clearly defined.[5] The role and functions for a civil manned undersea science and technology program in support of a national ocean program and the need for federal support of manned undersea science and technology are also incompletely understood. Shortly after the formation of MUS&T the objectives of MUS&T were defined, as stated in Manned Undersea Science and Technology FY 1972 Report:[6]

1. "Establish quantitative, scientific, and technical criteria for future civilian undersea facilities and platforms by using available technology, habitats, and submersibles."

2. "Foster and support civilian undersea technology and science projects in conjunction with other federal agencies, industry, and universities to obtain data and information for better understanding and use of marine resources. This includes providing scientific and diver support and sensor equipment."

3. "Develop a NOAA civilian diving program including rigorous physiological diving criteria to assure safe operations and diver efficiency over prolonged manned missions to continental shelf depths of 600 feet."

4. "Develop advanced ocean floor laboratories and submersible systems with relative independence from surface support and communication, navigation and life support systems. These would provide the advanced platforms from which man would be able to obtain the information on the oceans, required on a continuing basis, for contributing to such national goals as marine resources exploration."

Based on its experience during the first three years of operation, its perception of national needs, and direction from NOAA, the MUS&T office modified the scope of its activities and functions as expressed in these objectives. Its activities were narrowed to support of NOAA investigations involving manned underwater operations, support of undersea technology projects was de-emphasized, and an increased role in the dissemination of data assumed. These changes are reflected in a revised set of objectives, drawn up in 1975. Although the new objectives have not been formally approved by NOAA, they describe the MUS&T's current practice. They are:

1. "Provide manned underwater and operational support to NOAA investigations involving resources and environmental problems for which subsurface observations and data collection by man are required."

2. "Develop, support, and manage a NOAA diving program to assure safe diving and more efficient operations for prolonged manned missions on or near coastal regions and the continental shelf."

3. "Synthesize the data from MUS&T-supported investigations for dissemination to the user community in order to improve understanding of the nature and availability of marine resources."

4. "Foster and coordinate manned undersea science projects with other federal and state agencies, industry, institutes, and universities."

5. "Develop scientific and technical criteria for civilian undersea facilities through the experience gained by using available habitats and submersibles."

6. "Encourage and coordinate the transfer of undersea technology, including advances in diver technology, from other organizations including the U.S. Navy. Also, keep abreast of general scientific and technological developments both civilian and military, U.S. and foreign."

Both original and revised objectives are considered in this report.

III. FUNDING

The MUS&T budget, which was $1.5 million for its first year of operation (FY 1972), has been held constant at $1 million since FY 1973. Each year's budget includes support for the small headquarters staff within NOAA as well as for field operations. Over the years, if inflation is taken into account, the MUS&T budget has declined in "real dollars," as measured by the Consumer Price Index, by more than 45 percent. Beginning in 1975, NOAA committed $300,000 of the annual MUS&T budget to support the submersible Alvin for NOAA projects.

IV. ACTIVITIES, 1971-1975

During FY 1972, its first year of operation, MUS&T provided at least partial support for more than 130 investigators, enabling them to use 8 submersibles and 2 underwater habitats in their investigations. MUS&T also initiated various surveys of the national and international status of civil manned undersea science and technology.[7]

When funding was reduced by NOAA in FY 1973, MUS&T cut back its planned activities. As a consequence MUS&T's intention to support development of technological systems and equipment, such as underwater laboratories, submersibles, and supporting equipment was deferred indefinitely. Even so, in FY 1973, MUS&T supported four principal at-sea operations, involving 3 submersibles, 2 habitats, with more than 125 divers conducting research on marine fisheries and geology. In addition, several studies were undertaken to assess civil manned undersea activities, diving accidents, the requirements of the marine science community for seafloor laboratories, the status and use of civil manned underwater platforms, and the excursion limits for saturation diving in relatively shallow water.[8]

During the next year, FY 1974, MUS&T concentrated increasingly, but not exclusively, on coastal zone problems, particularly those related to ecology and the environment. The principal support provided was for submersible operations in a study of the ecology of the New York bight, habitat operations for coral reef studies, and submersible operations for geological investigations of the Mid-Atlantic Ridge (project FAMOUS). In addition, further studies of diver safety were conducted.[9]

The FY 1975 MUS&T Annual Report has not been issued. (Subsequent to the conclusion of the panel's deliberations, this report was issued.) However during this period MUS&T directed its efforts toward several projects. MUS&T published The NOAA Diving Manual: Diving for Science and Technology, which thoroughly reviews contemporary diving procedures, equipment, and decompression tables.[10] Although potentially useful for all diving activities, the diving manual is currently in force as an instruction only for NOAA activities.

Preparations were made for the use of the West German undersea habitat, Helgoland, for studying a spawning area off Rockport, Maine. One of a series of cooperative, international programs, this saturation diving operation included West German, Polish, and American participation and was completed in the fall of 1975. In addition, MUS&T personnel have been participating in the formulation of a national plan for diving health and safety in conjunction with other agencies.

V. FUNCTIONS

The functions supported by MUS&T are a mixture of scientific research and technology combined with diving, submersible, and habitat operations. These functions, as identified by the panel during the course of its study can be stated as:

1. Providing undersea facilities, including both submersibles and habitats;

2. Initiating and/or supporting manned undersea science and technology programs;

3. Developing diving safety standards for NOAA;

4. Fostering international cooperation in manned undersea science and technology projects;

5. Coordinating national undersea science and technology programs;

6. Establishing standards and criteria for manned undersea systems;

7. Funding key/limiting technical problems in manned undersea science and technology; and

8. Providing for information and data exchange in the foregoing areas.

The relative emphasis placed on these functions has varied with MUS&T's changing perception of needs and opportunities for the use of available undersea habitats and submersibles. In many instances, programs undertaken have been a combination of functions. Nevertheless, the list provides a useful basis for discussion.

As a generalization, MUS&T is primarily a service organization in the sense that it provides facilities and services for NOAA and other potential users. By providing these facilities and, to some extent, its other services and through its actions in catalyzing and initiating undersea programs, MUS&T fosters research although funding limitations have precluded sponsoring major research and technology programs.

Undersea Facilities

One of the major activities of MUS&T has been sponsorship of the use of undersea facilities. MUS&T has in recent years provided about one-third of the annual operating costs of the DSV Alvin* and has funded the leasing of the DSV Nekton Beta and other submersibles. It has also funded the use of habitats, beginning with Tektite II and continuing with other U.S.-designed warm-water installations. MUS&T also provided partial funding in 1975 for the use of the West German habitat Helgoland, which was used in a series of joint American/German/Polish experiments.

The nature and size of the federal ocean program (approximately $800 million in FY 1975) indicate a continuing need for deep diving submersibles. Among those currently available for scientific research are Alvin, the Johnson-Sea-Link I and II, Diaphus, and, for Navy purposes, the Turtle and Sea Cliff. Of these, today, only Alvin is nominally available through MUS&T. Normally, Alvin operates in the Atlantic or Caribbean.

* The program and schedule for the use of Alvin are controlled by an external scientific review committee whose meetings are participated in by representatives of NOAA, ONR, and NSF--the three funding agencies for Alvin.

As civil ocean research needs increase in the Pacific area, the use of a submersible and/or habitat located there may be required. Funding of submersible and habitat operations for selected projects has been one of the functions of the MUS&T office, although MUS&T is not the only federal agency that does this.

MUS&T is not currently funding any operations utilizing U.S.-built habitats; nor are any U.S.-built habitats currently in operation. While recent advances in U.S. habitat technology have been made largely because of MUS&T encouragement and support, there does not appear to be a valid need for further development of fixed habitat technology.

There is, however, a need for continued research involving man-in-the-sea. Many biological and environmental studies can only be done by man in the environment. Associated with this is a need for further in situ evaluation of human behavior and physiology, in order to improve the safety of divers performing this research, or doing other useful work under the sea.

Mobile habitats could provide supporting facilities for the studies needed. Support of habitats, fixed or possibly mobile, is a logical function for the MUS&T program and therefore a candidate for appropriate funding, provided a national need for use of these facilities can be verified. Consideration should be given to support of one or more mobile habitats on a permanent basis.

One of the original objectives of the MUS&T office was the development of advanced ocean floor laboratories, as recommended by the National Commission on Marine Science, Engineering and Resources. Most recently this concept has taken the form of a system called Ocean Lab, a mobile underwater facility that can function at various depths and locations. The laboratory can be used to gather information for managing marine resources, supporting the establishment of safety requirements and standards, and evaluating advanced diving technology.*

Since the cost of operation of manned undersea facilities is significant, the rationale for the support of these facilities should be based on national needs rather than on needs peculiar to NOAA agencies. Utilization should be based on criteria of project merit and national priority. Some members of the panel believe that these criteria may not have been applied or documented adequately enough in all past activities to justify in hindsight, MUS&T facility support.

* In July 1976, after the panel's study, but before this report was issued, the Congress passed Public Law 94362, which included an appropriation of $1,500,000 for OceanLab.

Manned Undersea Science and Technology Programs

MUS&T fostered and coordinated manned undersea studies with other federal and state agencies, universities, and private institutes. These studies have included the environmental effects of ocean dumping, coral reef ecological measurements, and various projects on fisheries. In many instances, MUS&T identified applications of undersea facilities, organized the projects, and in some cases provided the overall field direction. In many cases, funding of these projects was provided by other agencies with MUS&T serving as a catalytic agent.

While MUS&T has initiated and/or supported a significant number of such projects, the absence of a well-defined objective and operative mechanism for evaluating and assigning priorities to the projects makes assessment of the individual programs difficult. Assessment of results is further complicated by the limited amount of published scientific and technical data resulting from the projects.

Of equal concern is that many of the projects initiated or otherwise supported on a short-term basis by MUS&T have not resulted in continuing support of an undersea facility by either the participating scientists' organizations or sponsoring government agencies. This is not to imply that the programs supported were unsound, but rather that their selection might have benefitted from external review. The credibility of MUS&T programs, as far as external organizations and scientists are concerned, would be enhanced by early determinations of, and working toward, the scientific and mission goals of the participating diver scientists. Too often, when MUS&T requests organizations to participate in a program, those organizations "loan" a junior person without support or without real concern as to what the organization will learn from the study, scientifically or technologically.

Diving Safety

Diving Safety, in the view of the panel, is an area where national and MUS&T needs are most similar. MUS&T funding of research on shallow saturation decompression tables, and tables for excursion dives from a saturation base, have produced useful decompression schedules for this type of diving. The

establishment of standards and operating criteria for the safety of NOAA divers, as set forth in the recently published NOAA diving manual, is considered timely and important. Unlike the manuals prepared by the Navy and others, the NOAA manual provides, in a single volume, complete and pertinent information concerning diving equipment, decompression tables, and safety procedures. Although many groups, within and outside of NOAA contributed to this effort, it was a MUS&T initiative. The manual is issued for the use of NOAA divers, however, government agencies and other agencies of the diving community may also adopt it. Individual sport divers, perhaps the group most deficient in this area, can in all probability more easily understand and afford to comply with its provisions than with its primary predecessor--the U.S. Navy Diving Manual.[11] The Navy manual addresses the unique needs of Navy divers, but does not address the broader aspects of the varied equipment, dress, and training needs of the civilian diving community.

There will be a continuing need for research in diving physiology and underwater human behavior. While research is progressing, new problems appear, due to changes in the mode of diving or the discovery of heretofore unknown long term effects, such as aseptic bone necrosis. NOAA should ensure that the appropriate physiological research is being addressed to underpin the diving techniques being developed.

Basic underwater physiology is most properly conducted under very controlled conditions in hyperbaric research facilities. However, certain types of physiological research, which depend on the nature of work being performed, should be conducted under water. This is true for human behavioral studies as well. Thus, the sponsorship of supportive diving physiology research and when necessary, the associated undersea facilities, is considered a necessary adjunct to the MUS&T program. This would increase the body of knowledge on undersea operations and, at the same time, increase the capability of MUS&T.

International Coordination

MUS&T has been involved in several international manned undersea programs, with French, West German, Japanese and other foreign divers and submersible operators. For some of these programs, NOAA had lead responsibility. NOAA needs to continue to be aware of manned undersea programs in other countries and be responsive to areas where U.S. participation might achieve a mutually beneficial result. This does not imply that NOAA should take the initiative in sponsoring joint programs with other countries unless such programs are in the U.S. national interest and their costs are commensurate with

potential scientific and technical gains. In the early planning stages of undersea programs in other countries, NOAA can and should indicate a willingness to participate and possibly provide some support. Inter- and intra-agency assistance should be used to enhance quality control in project selection of international projects.

National Coordination

Even confined to the NOAA field activities, coordination can be difficult. This is especially true if coordination is seen in the broad context of (1) reviewing the activities of all concerned agencies and (2) redirecting efforts to avoid duplication and to fill scientific and technical gaps. In the case of manned undersea science and technology, coordination would likely be tenuous unless restricted to specific areas, such as technology and operational techniques of diving, the development and/or use of specialized diving equipment, and related safety. In establishing the coordination roles, it must be ensured that there is no overburden of bureaucratic effort, and that the mission capabilities of the participating organizations are enhanced rather than restricted.

MUS&T is limited in its role as the coordinator of civil undersea science and technology projects by the lack of a legal mandate acceptable to other federal agencies. The definition and bounds of the coordination must be clearly established. The extension of the intra-agency coordination roles can be logically extended to inter-agency coordination if enhancement of capabilities is achieved.

Coordination, if done properly and in a sensitive manner is time and staff intensive. A selection of staffing for the coordination of a particular task is a significant factor.

Currently, MUS&T coordination has been restricted, to a large extent, to project operations. However, there is a federal effort to initiate a national plan for the safety and health of divers. The management of this plan will require extensive coordination with other agencies as well as with industry and academia. Although the panel did not weigh the qualifications of the other agencies involved, it concluded that MUS&T, through its position, experience and present responsibilities, could be a principal focus for the coordination of the plan.

Standards and Criteria

One of the major stated objectives of MUS&T is the development of scientific and technical criteria for civilian undersea facilities. In diving, MUS&T has been quite active, particularly with the publication of the NOAA diving manual.

MUS&T, in conjunction with the Energy Research and Development Administration, the National Institute for Occupational Safety and Health, the U.S. Coast Guard, the U.S. Navy, and the National Heart and Lung Institute is developing a national plan for the safety and health of divers. This project seeks to identify safety standards and provide guidelines for operating procedures.

Safety standards and criteria for submersibles and habitats have not been established. These standards, in the form of guidelines for design, construction, and material selection related to operational safety and rescue, could provide those institutions and industries involved in undersea research and development with a valuable coordinated and technically sound document, for use in training and operational planning. Standardization of rescue features might be a desired result. In light of the immaturity of the technology, these standards should not at this time serve as legal regulations of design or operation.

The need for the establishment of criteria and standards in the undersea has also been highlighted by the National Advisory Committee on Oceans and Atmosphere (NACOA) in its 1974 report, Engineering in the Oceans.[12]

Funding Key Technical Problems in Undersea Science and Technology

MUS&T has not devoted a significant portion of its efforts to the function of funding key/limiting technical problems. At the time the MUS&T Program was initiated, the U.S. Navy was phasing down its program in manned undersea technology. The technical basis for constructing facilities to support manned operations was largely established. Since then, this base has been maintained largely through industrial efforts.

At the phase out of the Navy program, many scientists and engineers believed that there was a national need to continue the Navy work funded by and for the benefit of the civil federal agencies. However, funds

for the use of available submersibles and habitats by the scientific community were not forthcoming, and consequently the additional support of undersea technology development in vehicles, equipment, and systems proved to be negligible. Submersibles and habitats are costly not only to design and build, but also to maintain and operate. Since 1971, the NOAA budget for MUS&T has been inadequate to develop complex operational habitats or submersibles that meet the certification requirements for manned operations. Thus, except for a few isolated projects, such as assistance in the development of a portable recompression chamber, MUS&T has not been deeply involved in fostering undersea technology.

From discussions with the builders and users of undersea facilities, the panel has concluded that the needs for development of undersea technology as now perceived, in submersibles, diving systems, habitats, and other underwater systems and structures can be met for the most part by industry, private foundations, and other government agencies. Thus, no clear present need was identified for additional government support of technology development in this area. However, NOAA should continue to support specific developments which ensure and promote safety in undersea activities.

Moreover, the U.S. has no habitats structured or equipped for extended cold water operations, nor do any habitats have the ocean floor mobility and endurance required to support extensive investigations. Should future scientific and engineering operations require such habitats, government support will be required.

Information and Data Exchange

MUS&T seeks to foster information and data exchange through the publication and dissemination of reports and journal articles on manned submersibles/habitats and diving statistics.

Dissemination of such information, while not extensive in volume, is difficult because the activities are widely dispersed both geographically and in a management sense. Since the community concerned, is relatively small, professional journals and magazines provide much of the necessary general information exchange. Unfortunately, information on many of the projects sponsored by MUS&T and the resulting data have not been published. MUS&T if often only a secondary sponsor of many projects. Responsibility for encouraging pub-

lication of the results rests with the primary sponsor. There is no compendium of the results of the data gathering techniques used in undersea facilities. Such a compendium would not only point out the successful use of manned facilities, but also the failures and limitations of these facilities in meeting scientific and engineering needs. MUS&T should encourage the scientists and engineers operating with total or partial MUS&T funding to publish the results of their work promptly.

VI. ACHIEVEMENT OF OBJECTIVES

The objectives established in FY 1972, as listed in Section I, have been accomplished to a limited extent.

Objective Number 1 (Establish Criteria for Future Civilian Undersea Facilities and Platforms): MUS&T has supported programs which have used many habitats and submersibles during its four years of operation. From this, MUS&T and participating scientists and engineers have gained considerable insight into the advantages and disadvantages resulting from their use as well as their costs. However, documentation was meager.

Objective Number 2 (Foster and Support Civilian Undersea Technology and Science Projects): During the past four years, MUS&T has fostered and supported a considerable number of projects in which the participating scientists felt that habitats or submersibles significantly increased their capability to accomplish their tasks. However, fostering alone does not necessarily result in the leverage effect where the requirements for continued use of habitats and submersibles become visible and evident. Increased use of facilities is limited by several factors: a scarcity of funds, programs that require such facilities to gather significant information, and scientists and engineers who are willing to devote their careers to high risk programs which may not come to fruition, resulting in loss of professional achievement for the involved scientist.

Furthermore, fostering the increased use of undersea facilities is not considered likely when the job is given to an office with an inadequate budget.

Objective Number 3 (Develop a NOAA Civilian Diving Program): MUS&T has expanded the NOAA civilian diving program to include techniques using saturation diving principles. MUS&T has developed a broadly conceived diving manual which provides excellent guidance for civilian divers and scientists.

Objective Number 4 (Develop Advanced Ocean Floor Facilities): The funding for MUS&T has decreased rather than increased, as originally envisaged, resulting in the deferral of plans to develop advanced ocean floor laboratories or submersible systems.*

The revised objectives, as drafted in 1975 (pages 2-3) significantly alter the role of MUS&T. These changes:

a) Limit MUS&T support for underwater operations to NOAA investigations;

b) Give MUS&T the role of synthesizing data gathered by scientists working in specialized fields of ocean science and engineering;

c) Provide a coordinating rather than supporting role for projects involving non-NOAA activities; and

d) Vest in MUS&T the responsibility for the transfer of undersea technology from other organizations.

Thus, the first of the changes would officially constrain the MUS&T program. The second change will require an increased staff in the MUS&T office to satisfy the need for specialists required to synthesize the data of participants. While it is quite understandable that the objective of this change may be to give a faster visibility to data obtained through MUS&T facilities support, it may not be acceptable to participating scientists or have long-term merit when participation by a non-NOAA investigator is involved. An alternative for NOAA would be to allocate funds for a preliminary quick-look data report provided by the organization of the participating scientist.

The final two changes may also require an increase in the MUS&T staff depending on the meanings given "coordinating" and "technology transfer" and the organizations involved.

VII. ALTERNATIVES FOR THE FUTURE

Although the use of submersibles in support of scientific research has been relatively small, there are about 100 manned undersea vehicles (excluding combatant submarines) around the

* The recent passage of legislation authorizing OceanLab will permit further work on this objective.

world that are in commercial operation or under construction. This represents an increase of more than 30 percent in one year (1974-1975). According to NOAA, the U.S. is the leading builder and operator of submersibles, followed by France and the Soviet Union.[13]

Most of these mobile underwater vehicles support the offshore oil industry, especially in the North Sea. Undersea vehicles are also used for inspection, cable laying, salvage, and geological, fishery, and environmental missions.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Throughout the body of this report the panel has rendered judgments concerning various aspects of the MUS&T program which are reiterated here in the form of conclusions and recommendations.

During its deliberations, the panel considered many alternatives for future federal support of the MUS&T. These alternatives call for:

- Eliminating MUS&T and transferring its functions to other units within NOAA or to other appropriate federal agencies;
- Maintaining the MUS&T status quo; or
- Strengthening selected functions of the MUS&T program, with commensurate funding, and with possible consolidation into an Institute for Engineering Research in the Oceans, along the lines recommended by NACOA in its report published in 1974.[14]

The first two alternatives were rejected by the panel.

The panel became convinced in the course of its investigations that a valid need exists for MUS&T functions. While each of these functions could be provided by a user or research sponsoring agency, for this to be economically effective there would be a need to coordinate the requirements for undersea facilities in every single agency. Otherwise, costs of the facilities per investigator would be prohibitive, particularly in agencies with infrequent need for manned undersea work. Moreover, there is a well-recognized need for concentration of efforts by inter-organization investigators to maximize scientific utilization of unique facilities. In its function of providing support facilities, MUS&T functions in some respects like an interagency motorpool.

Certain functions now exercised by MUS&T, notably supported for underseas facilities used in research, could be exercised instead by the National Science Foundation through the University National Oceanographic Laboratory (UNOLS),

should adequate funding be made available. Nevertheless, combining these functions with the other functions of MUS&T, which are not within the responsibilities of NSF, is a logical and mutually-supporting arrangement.

Maintenance of the status quo is an obvious alternative. However, the panel is convinced that MUS&T cannot operate effectively as now constructed and funded. MUS&T is a small office in both relative and absolute terms and may be below a "critical mass." MUS&T's current funding is insufficient to accomplish its functions. This low funding level could have an adverse impact on the quality and safety of its projects, particularly those concerned with the use of submersibles and habitats, unless the office continues to maintain vigilance in their direction.

The third alternative is believed to be the best to achieve the goals and carry out the functions currently assigned to MUS&T. This alternative requires that MUS&T be given the authority, funding, and visibility within NOAA to enable it to accomplish its stated functions. These conclusions and recommendations, however, are independent of the organizational location of the program within NOAA.

On balance, the MUS&T program has exhibited strengths and weaknesses. It has provided useful support and facilities for scientific research in the undersea, and has done excellent work in the establishment of diving standards and operating procedures. However, the panel concluded that, in general, the MUS&T program suffers from the absence of a definitive charter, adequate funding, advance planning, and an external review of projects. This has resulted in a limited acceptance of and support for the program by the user community.

The increase, both current and projected, in the level of civil undersea activity, together with the limited program results, indicate a need to continue and strengthen the coordination of federally sponsored civil manned undersea activity.

Therefore, the panel recommends that NOAA revise the MUS&T objectives and issue a formal, definitive charter for MUS&T, seeking legislative approval if required. In revising the charter, the panel recommends that NOAA consider the following:

1. Program Scope: Fundamental to the charter is a decision as to whether the program should function in support of NOAA, in support of federal civil agencies, or become national in scope and support both the civil federal and non-federal users. The panel recognizes that current guidance restricts MUS&T to supporting only NOAA missions. Budget levels have been inadequate for MUS&T to handle its functions.

It is remarkable that as many different projects have been supported. The panel believes that strengthening the program and providing commensurate funding is preferable to narrowing MUS&T's focus. The MUS&T program should be national in scope and should support civil federal and non-federal users.

2. Program Objectives: The results of the present program tend to be judged in terms of the scientific and technical products of the experiments with which MUS&T is associated, rather than the services it provides. The panel believes that the principal thrust should be one of coordination and overall management rather than operational control. In this context, the objectives should emphasize:

    - Providing a national focus in the area of civil manned undersea programs through a long-range planning effort, both nationally and internationally;

    - Providing information and services on a national basis to include diving tables, statistics, and initiation of standards;

    - Transfer of research results and technology between government agencies, industrial organizations, and academic institutions; and

    - Providing funding grants, within specified guidelines, for the development, application, testing, and support of undersea activities.

3. Technology Development: Although the panel believes that a continuing need exists for the development of undersea technology for manned activity, other federal agencies, specifically the U.S. Navy, as well as the petroleum industry appear capable of meeting the principal needs. Therefore the program should be oriented to the proposed program objectives of item 2 above.

4. External Review: The program can provide a useful service as a catalytic agent, coordinating and providing partial support for projects that might individually be unsupported. However, the current mechanism by which projects are selected for support is not well defined or generally understood within the user community or by other federal agencies.

These MUS&T-supported projects are a mixture of scientific investigation, engineering research and technology development, habitat and submersible operations, and documentation. While many of these are subjected to some type of review process, it is not clear that all were, or that there is a systematic interagency review or input to the program.

Support of mission-oriented programs or projects should undergo inter- or intra-agency planning review. Programs of individual participants should be reviewed from a standpoint of scientific merit by a peer review process as well as by MUS&T personnel for compatibility and adequacy of the projected available operational support.

If the charter of the MUS&T office is to include support for scientists and engineers from non-NOAA organizations, then close liaison should be established with NSF, UNOLS, ONR, and other funding agencies. A clear understanding should be reached, with documentation provided, as to the MUS&T support policy.

5. Safety Aspects: The increase in the amount of manned undersea activity indicates the need for an increased emphasis by the government in support of civil diving and submersible safety. Although the regulatory responsibility in this lies, in all probability, with the U.S. Coast Guard, support to the user community in the form of safety related documentation and supporting research might well be an integral part of the MUS&T program. The work accomplished in support of NOAA diving safety is an excellent first step in this direction. The panel believes that the NOAA diving manual should be adopted as a guide by the civil agencies and that the manual should be updated as required. Additional tasks which could be undertaken include the cataloging of available information on civil submersibles and diver safety and rescue equipment. A corollary function would include identifying and funding problem areas, such as research on human responses to hyperbaric pressure, various mixtures of gas, saturation exposures and decompression schedules in the oceans related to the accomplishment of the MUS&T charter. A comprehensive study, jointly conducted by NOAA, the Coast Guard, and the Navy is needed to consider the areas of safety, rescue, and recovery of submersibles and habitats. This study should take into consideration the design and construction guidelines as well as operational factors related to safety.

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