

FIVE YEAR PLAN
for
NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

SPECIAL REPORT 89-3

Approved and Released by:

Claude A. Harvey

Claude A. Harvey, CAPT, MC, USN
Commanding Officer
July 1989

Table of Contents

I.	Work Unit Integration	1
	List of FY90 Work Units	8
II.	New Starts	
	FY91	
(A)	Auditory classification of sonar signals	9
(B)	Auditory detectability of signals subject to masking	11
(C)	Biochemistry of stress proteins: Toward prediction and protection from hazards of Navy operational and environmental stressors.	14
(D)	Biological effects of transmitting sonars.	17
(E)	Comparison of operability of different joy-sticks and track-balls to be considered for use the the visual displays being developed for the non-penetrating periscope.	22
(F)	Development of acoustic habitability standards for advanced design submarines	24
(G)	Effect of color-coded CRT Displays in the control room on the night vision of the periscope operator	28
(H)	EKG evaluation of arrhythmias.	30
(I)	Performance assessment for auditory sonar signals.	33
(J)	Scanning through the periscope	35
(K)	Suppression of immune system functioning in submariners	38
(L)	The role of atrial septal defects in susceptibility to decompression sickness in U.S. Navy divers	40
	FY92	
(M)	Cellular bioengineering: Concept development and application to problems of hazardous biological and chemical environments.	44
(N)	Effects of fire gases on decrement of crew mental acuity and performance.	49
(O)	Evaluation of HP-9000 computer sonar displays.	53
(P)	Fourier transforms of target stimuli for improved detectability.	55
(Q)	Three dimensional sonar and fire control displays.	57
	Summary Table For Additional Personnel.	59

III. Equipment and Facilities.	62
A. Equipment	62
B. Facilities.	62
C. Information Systems	63
IV. Management and Support	65
V. Laboratory Organization	66
VI. Fiscal Summary.	67
VII. Personnel Summary	68
A. Work Unit Personnel	68
B. Administrative Personnel.	68
VIII. Issues.	69
IS/FYP Annex	71

1. WORK UNIT INTEGRATION

The mission of the Naval Submarine Medical Research Laboratory (NSMRL) is to conduct research on problems affecting the U. S. Navy and Marine Corps with particular emphasis on the submarine fleet. The goal is to enhance the performance, health, safety and readiness of Naval and Marine Corps personnel.

In pursuit of this goal, NSMRL is conducting research in four areas; auditory and visual displays, hyperbaric physiology, improvement in patient management and medical problems in closed environments.

Charts 1, 1A-5 demonstrate program and work unit organization, flow and integration. Solid lines and boxes indicate currently active and funded work units. Broken line boxes indicate either newly proposed programs or the integration of new proposal in the current program areas.

AUDITORY AND VISUAL DISPLAYS (CHART 1)

This research thrust aims primarily at increasing the intelligibility of sonar displays. It is investigating the incorporation of the discriminatory, integrative, and detection abilities of the human auditory and visual systems in potentiating the interpretation of the physical information content of sonar signals. Research includes investigations on the effects of color coding, alteration on computer displays, alterations in the processing of sound signals, signal digitization, and analysis of the physical characteristics of the sonar signal.

The proposed program (CHART 1A) on periscopes is intended to increase the capability for visual periscope information processing.

HYPERBARIC PHYSIOLOGY (CHART 2)

A disabled submarine may well have air leaks, may deliberately pressurize a compartment or be partially flooded, thus increasing its atmospheric pressure. During rescue crewmen could be subjected to the effects of oxygen toxicity from the effects of breathing high pressure oxygen or decompression sickness resulting from a too rapid change from a hyperbaric to normobaric environment. Research in this program area is concerned with the establishment of optimized decompression tables for submarine rescue scenarios (operational saturation diving), establishment of no-decompression limits (NO-D) applicable to such operational diving activities as special warfare, salvage and hull repair. This research program includes a new work unit for FY90 on the development of hearing conservation standards for diving operations.

IMPROVEMENT IN PATIENT MANAGEMENT (CHART 3)

Most submarines carry no medical officer. Patient care is entirely in the hands of the independent duty hospital corpsman. NSMRL is currently involved in research which will enhance his ability to manage patients by providing computer programs which will improve his ability to diagnose and treat patients.

MEDICAL PROBLEMS IN CLOSED ENVIRONMENTS (CHART 4)

This research area is more a proposed research thrust rather than an entity in being. A strong case can be made for the need for such a program. Submarines have unique closed industrial atmospheres. Although outside review (NAS, DoD Live Fire Test Program) have highlighted extensive and perhaps critical knowledge gaps in this area, there is presently no full-time Navy medical responsibility for atmosphere research. A dedicated research program in this area could beneficially address recognized military operational problems relevant to both normal and abnormal atmospheres.

A particularly important subject requiring further research is the area of fire retardation and suppression in submarines. Submarines operating under ice would be unable to surface in the event of a fire emergency. Fire suppression techniques available for this scenario would include, atmospheric O₂ reduction, N₂ overpressure and atmosphere monitoring to achieve safe breathable levels after a fire. All of the above solutions would have effects on crew performance, mental acuity and decision making. No emergency standards currently exist which would relate crew performance capability with submarine atmospheres radically altered by emergency operational fire scenarios.

CHART 1

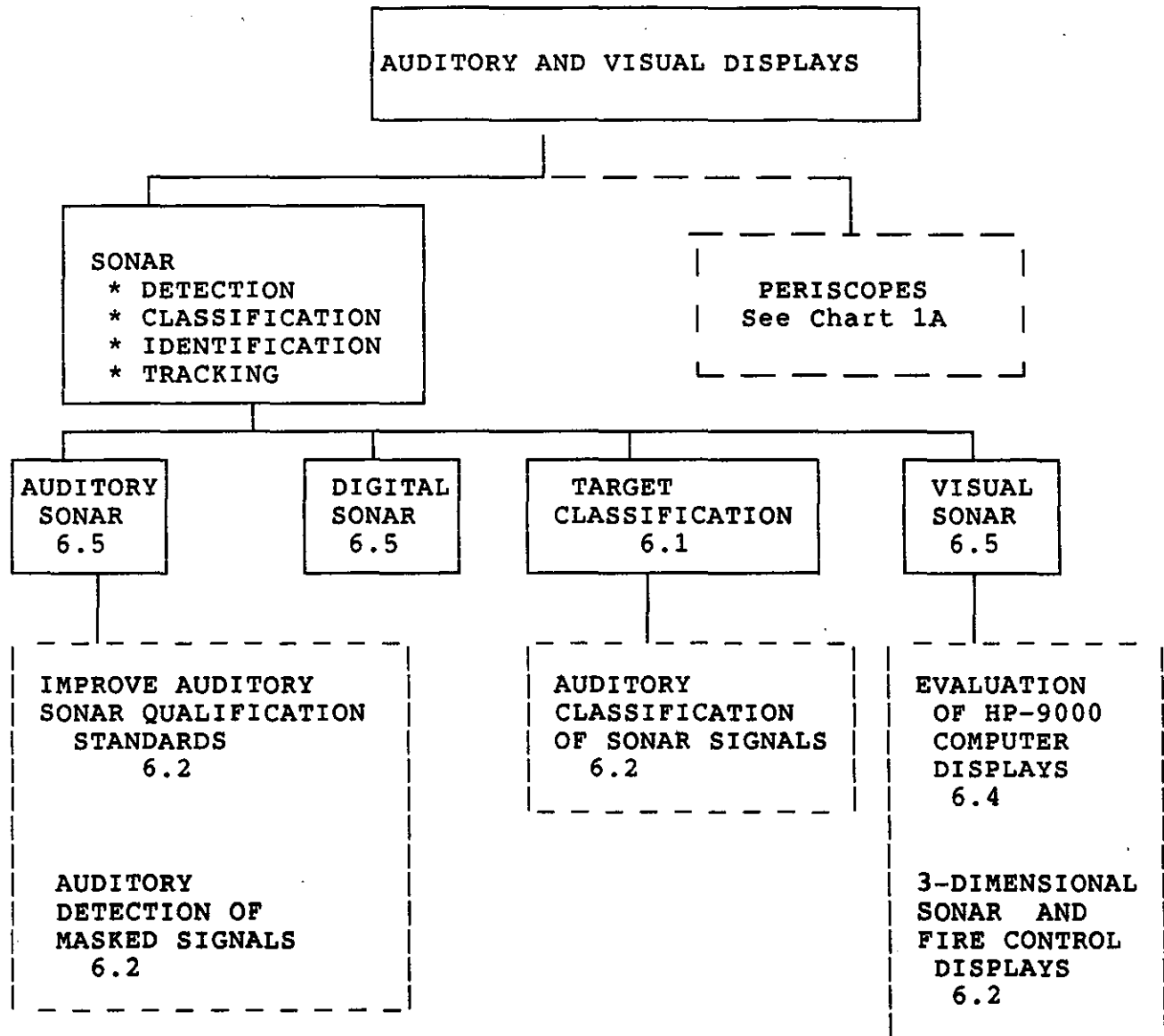


CHART 1A

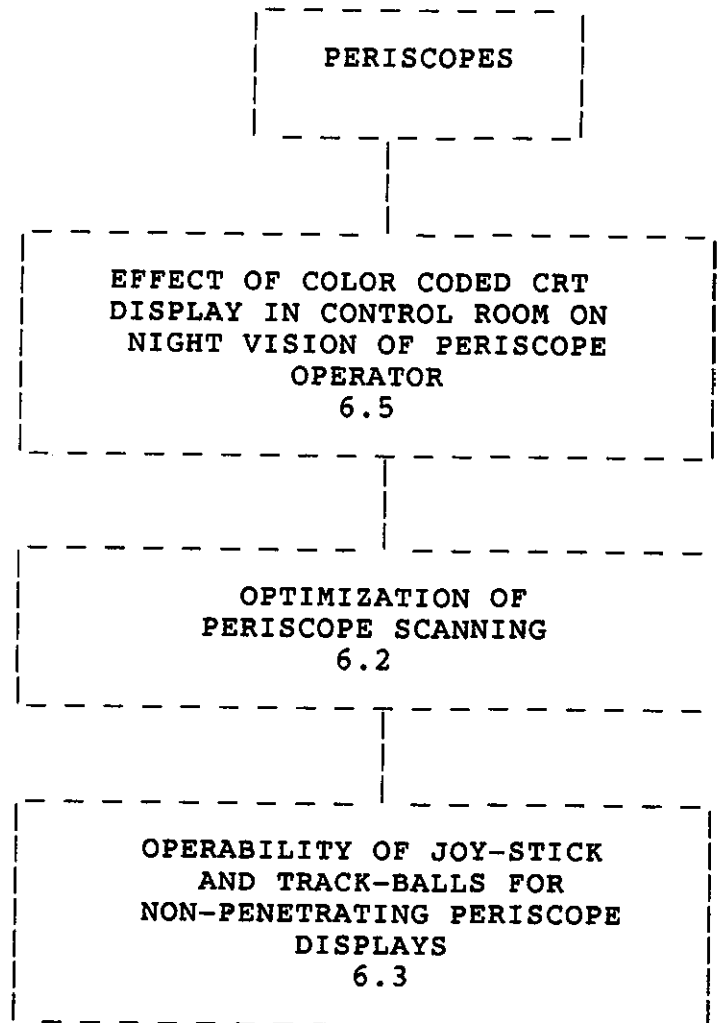


CHART 2

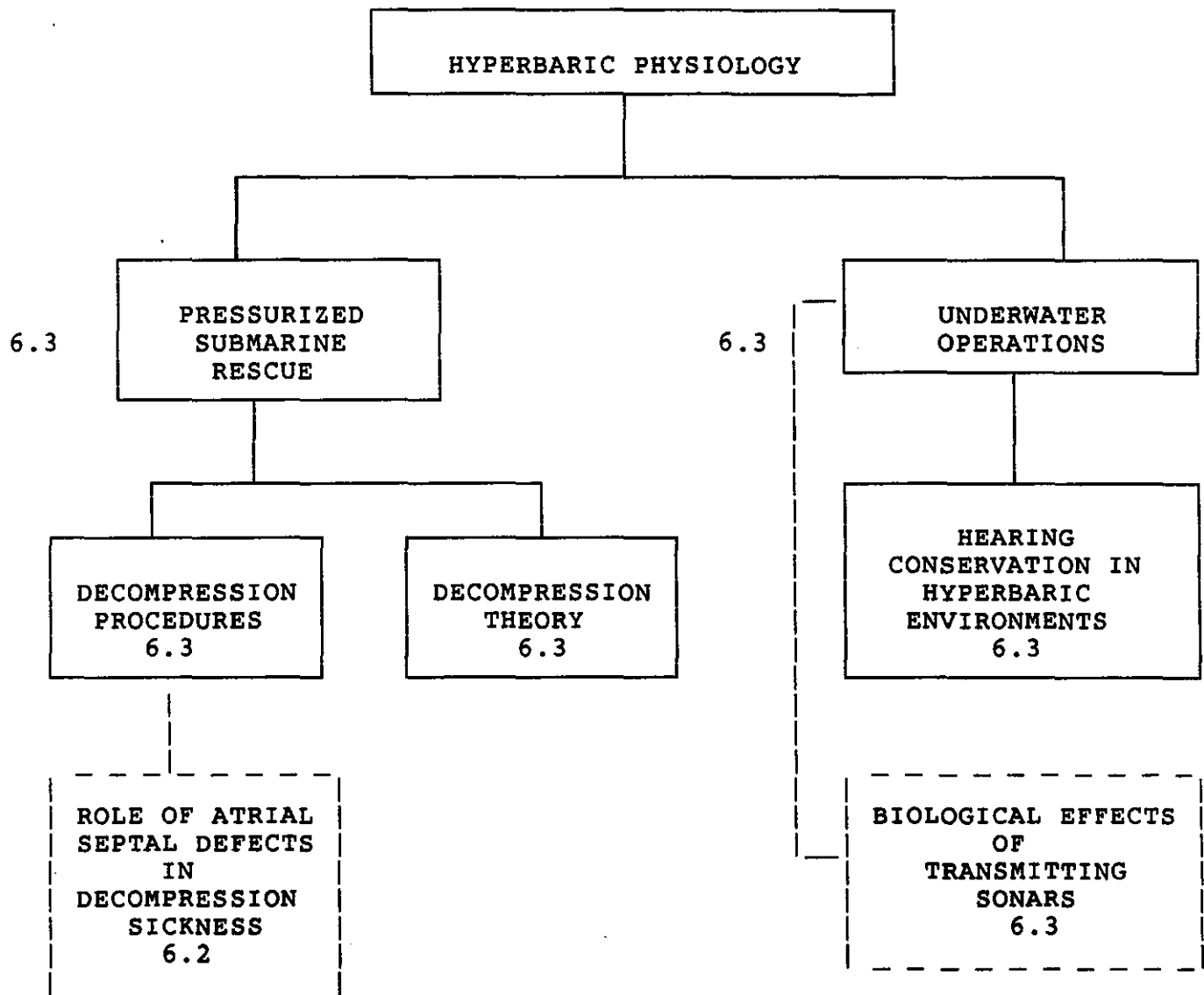
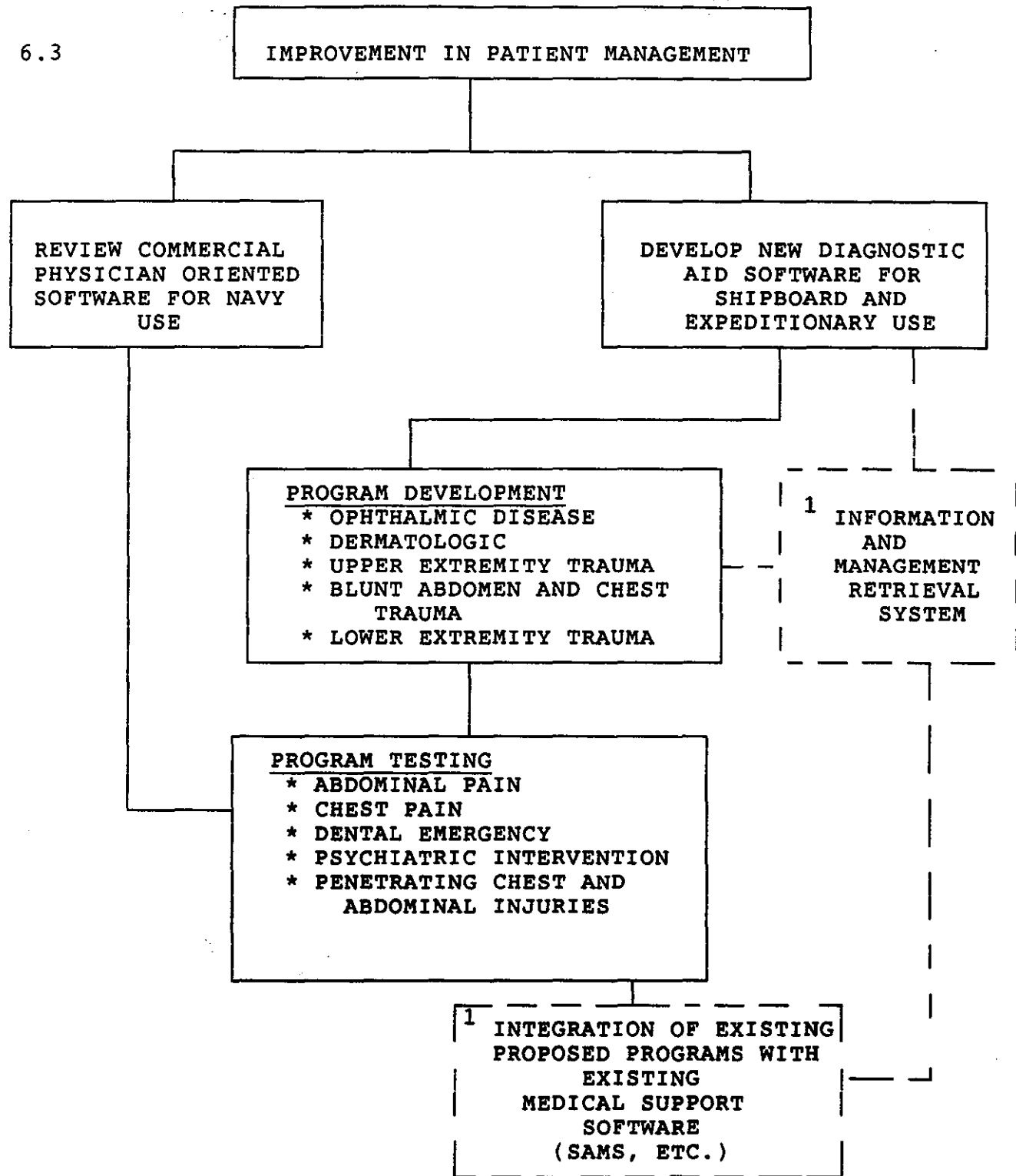


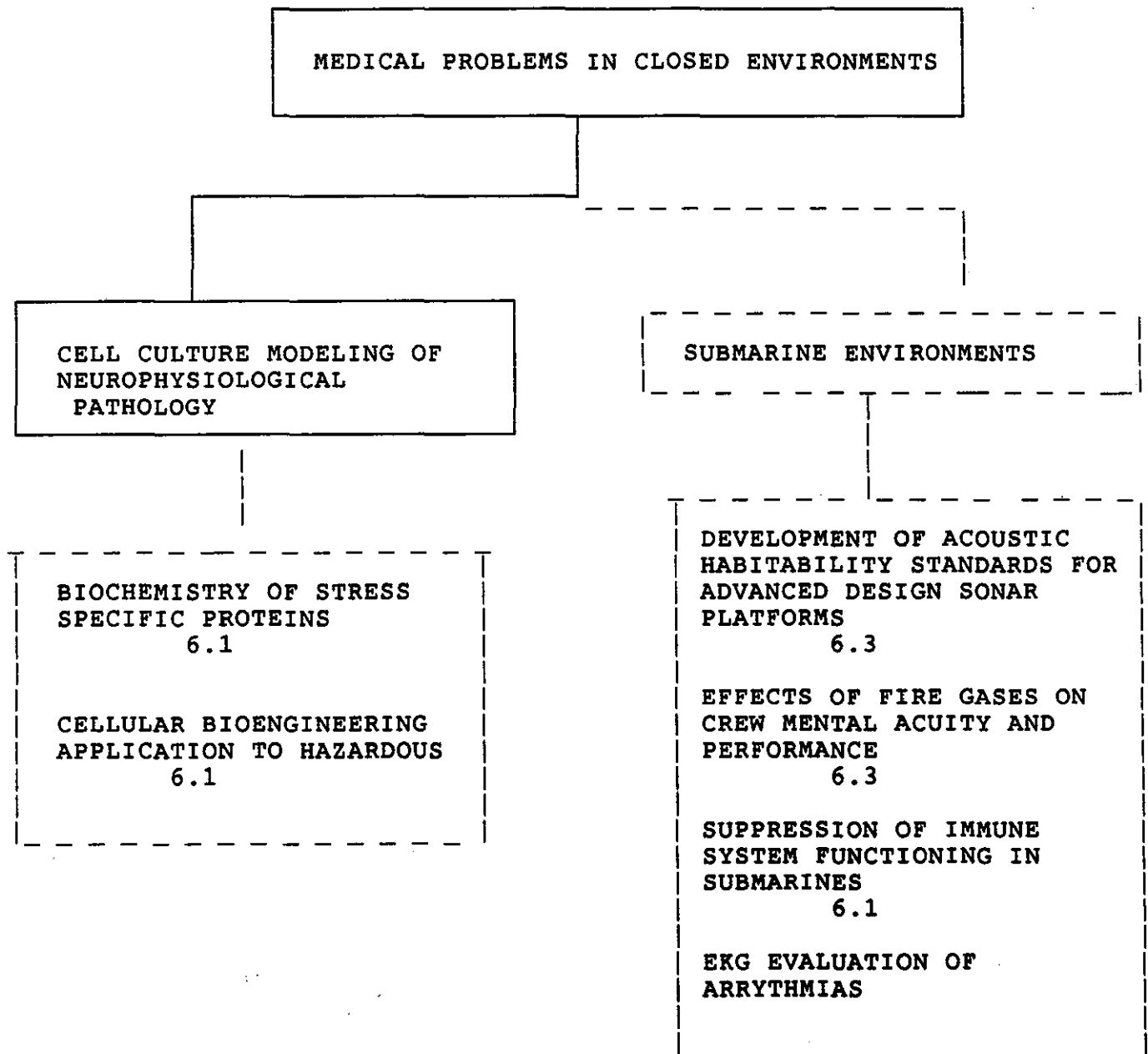
CHART 3

6.3



¹ Currently under discussion as cooperative effort with NHRC and APL

CHART 4



FY90 WORK UNIT LIST

1498	TITLE
61153N MR4101 001 5014	Cell culture modeling of brain associative
63706N M0095 005 5010	Sea trials for computer-based medical diagnostic/patient management system for use aboard SSN/SSBN submarines
63713N M0099 01A 5012	Medical problems associated with pressurized submarine rescue
65856N M0100 001 5003	Enhanced performance with visual sonar displays
65856N M0100 001 5001	Auditory sonar
63713N M0099 01C	Development of a general hearing-conservation standard for diving operations
65856N M0100 001	Digital signal processing for auditory sonar
REIMBURSABLES	
61153N RR4209 001 ONR 4424207	Auditory classification based on the identifiability of complex stimulus features
VA GAV600(90)5-88001	Psychophysical procedures for auditory measures with naive subjects

II. NEW START (A)

- A. TITLE: Auditory classification of sonar signals
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 6.2 Human Factors Technology Program
- C. STATUS: New Start (First proposed FY90)/Transition
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To enhance classification of transient sonar signals.
- F. RATIONALE: It is becoming increasingly important to classify transient sonar signals. Currently, this task is best performed by trained listeners. However, a trained listener is not able to attend simultaneously to the multiple sources of sonar information available at a given moment in time. A description of how trained listeners classify sonar signals could be used to develop algorithms for computer recognition of these sounds. This algorithm would allow a more complete analysis of sonar information than is currently possible. Moreover, the limited operator time available could be used for listening more carefully to the most important signals. Several methods of approaching this problem are under study, but none that attempt to model the mechanism that is best at the task - the human ear.

The proposed work would address three questions towards solving the problem of classifying sonar signals. First, what are the perceptual categories used by listeners and how reliably do listeners use these categories? Second, how do these categorizations compare with those used by algorithms; can those categories be used to train better algorithms? Third, which acoustic features define the perceptual categories?

- G. TECHNICAL APPROACH: NUSC has collected a library of transient signals. Trained sonar operators will be asked to listen to these signals and group them into categories of their own choosing. Reliability of each individual's judgments and consistency of categories across listeners will be used to define meaningful perceptual categories. Subjects will also rate each signal along a binary dimension which is currently being used to train a computer algorithm. The following questions will be answered: 1) can the perceptual categories be used to predict the rating judgments?, 2) is there information in human rating judgments that is not used by the computer algorithm?, 3) do the perceptual categories contain the information that the computer algorithm is missing?, and 4) can the computer

algorithm perform better by training to the perceptual categories?

Attempts will be made to identify specific acoustic features which define the perceptual categories and rating judgments. The features used by current algorithms will be tested as well as any features suggested by listening to the categories. Prior research suggests that the amplitude envelope may be important; classification data will be collected using stimuli with only the signals' envelopes preserved to determine which categorizations can be made using the envelope. A second possibility is to use an analysis/synthesis technique to generate a modified stimulus set for classification. This technique is known to produce perceptually similar stimuli, but with simpler stimuli. It would be easier to identify features from this alternate signal set. Moreover, these signals can be modified to provide tests of the importance of certain features.

H. EXPECTED PRODUCTS/USERS: These results would be used by NUSC to develop classification algorithms.

I. OTHER ORGANIZATION(S) INVOLVED: NUSC and SUBSCHOL

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92	FY93	FY94
In-House Personnel/Overhead	150	155	160	165
Contracts	20	20	10	5
Equipment	20	20	10	5
Supplies	7	7	7	7
Travel	3	3	3	3
Total	200	205	190	185

K. PERSONNEL REQUIRED BY FISCAL YEAR:

	FY91	FY92	FY93	FY94
Onboard Manpower Available				
Military Officers				
Military Enlisted	.2	.2	.2	.2
Civilian	.4	.4	.4	.4
Total	.6	.6	.6	.6
Additional Manpower Required				
Military Officers				
Military Enlisted	.2	.2	.2	.2
Civilian GS-180-11/12/13	.4	.4	.4	.4
GS-1550	.6	.6	.6	.6
GS-181-5/7/9	.6	.6	.6	.6
Total	1.8	1.8	1.8	1.8

II. NEW STARTS (B)

- A. TITLE: Auditory detectability of signals subject to masking
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 62758N Performance Assessment/Enhancer
- C. STATUS: New Start (First proposed FY87)
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To develop an algorithm to predict the detectability of sonar signals and auditory alarms.
- F. RATIONALE: A variety of tasks performed by naval personnel require that auditory signals be detectable in adverse acoustic environments. The proposed work will specify what signal-to-noise ratios are necessary to achieve detectability as influenced by the spectral properties of the signal and the extraneous interfering stimuli. The work will provide useful guidelines to system design engineers as to whether the signals they are dealing with are detectable by ear. The present proposal suggests applications to two problems of importance for the submarine forces. The first problem is that of accurately predicting the detectability of auditory sonar signals. The specification of such detectability levels, also known as NRD values, is of tactical value in determining operational limits of the sonar equipment. These NRD values are currently determined in at-sea trials and published for use by the submarine operational forces. Threshold values obtained from at-sea trials, however, are time-consuming and limited in their ability to recreate a variety of targets and background. An alternative is to use a predictive model, based on scientific data on auditory performance, that specifies how the detectability of auditory stimuli depends on spectral characteristics of the signal and the background. A validated model of detectability, one that is found to predict values obtained in at-sea trials, would provide an inexpensive and more accurate means to predict detectability in the variable tactical settings encountered during deployments. This application can also include the determination of the detectability of own ship. In addition, a model of detectability could be used during the design of sonar systems and hull shapes to explore efficiency of various proposals prior to prototyping.

A second application is for the design of alarm signals

in any of the submarine compartments. Depending on the acoustic environment in the compartment, certain alarm signals may be more or less effective. The work will provide guidance for constructing alarm signals at decreased levels relative to current levels. A decrease in alarm levels can increase the usage of these warning devices by operators since lower levels are less aversive and interfere less with other auditory tasks.

- G. TECHNICAL APPROACH: Dr. Roy Patterson from the MRC Applied Psychology Unit in Great Britain has developed an algorithm to predict the detectability of signals in the presence of interfering stimuli, and has developed numerous alarm signals based on the predictions of his algorithm. This work was conducted for military applications, primarily to address problems encountered by helicopter pilots. The approach has proved extremely valuable for improving pilots' performance in tactical settings and has also been extended to more general settings, such as hospitals. Other applications are being pursued in conjunction with several NATO countries, including Canada, the Netherlands, and West Germany. Dr. Patterson has expressed interest in working with our laboratory to explore applications of interest to us.

In consultation with Dr. Patterson, we will apply his algorithm to sonar signals to examine how well the algorithm estimates the threshold NRD values of sonar operators. Since it is not necessary for Dr. Patterson to know specifically the signal spectra, there will be no security concerns associated with his involvement in the project. Comparisons will be made between the predicted thresholds and those obtained in at-sea trials to determine the range of applicability of the model to sonar detection. Shore-based testing may be used to complement the at-sea data and to modify Patterson's algorithm if necessary. The primary goal will be to develop a more efficient and comprehensive method to obtain NRD values through the combination of an efficient detection estimation algorithm with supplemental shore-based testing. If successful, a secondary goal will be to implement a dynamic estimation method to be used on-line during deployments to provide the submarine commander with accurate current detection ranges.

An additional goal is to develop better auditory alarm signals. First, submarine personnel will be interviewed to identify candidate alarm signals that are currently ineffective or annoying. Sonar operators have already indicated problems with the torpedo alarm, but additional information will be gathered on the use of alarms outside

the sonar shack. Second, background noise levels will be recorded in the areas in which the alarm is to be used, and a signal synthesized that is appropriate for that background. Finally, the resulting alarm signal will be compared to current alarm signals, and recommendations will be made based on both laboratory and operational evaluations.

- H. EXPECTED PRODUCTS/USERS: The validated model of auditory detectability in noise environments can be used by NUSC, COMSUBDEVRON-12, and the operational submarine forces as well as sonar system designers and engineers performing acoustic-quieting tasks.
- I. OTHER ORGANIZATIONS INVOLVED: MRC Applied Psychology Unit (Great Britain), COMSUBDEVRON-12, and SSEP.
- J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92	FY93	FY94
In-House Personnel/Overhead	150	165	180	195
Contracts	30	30	30	30
Automatic Data Processing	10	10	20	20
Equipment (task funded)	30	30	20	10
Miscellaneous	10	10	10	10
Equipment (general purpose)	10	10	10	10
Miscellaneous	10	10	10	10
Military Construction	0	0	0	0
Special Projects	0	0	0	0
Grand Total	250	265	280	285

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available
for this Work

Military Officer	0	0	0	0
Military Enlisted	0	0	0	0
Civilian (GS-	.8	.8	.8	.8

Additional Manpower Required
for this Work

Military Officer	0	0	0	0
Military Enlisted	.4	.4	.4	.4
Civilian				
GS-180/665-11/12/13	.8	.8	.8	.8
GS-181-5/7/9	.4	.4	.4	.4
Total	2.4	2.4	2.4	2.4

II. NEW STARTS (C)

- A. TITLE: Biochemistry of Stress Proteins: Toward Prediction and Protection from Hazards of Navy Operational and Environmental Stressors
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE:
61153N/MR04120/MR0412002 (Clinical Medical Sciences)
- C. STATUS: PROGRAM EXPANSION
- D. PROPOSED START DATE: FY91 FIRST PROPOSED FY88
- E. OBJECTIVE: Investigate the mechanism of action and biochemistry of stress proteins that are elaborated as a response to Navy operational and environmental stressors.
- F. RATIONALE: Current methods for the evaluation of the effects of environmental stressors are limited by the requirements for extensive animal and/or human studies, prolonged exposure periods, insensitivity of results, indefinite or multiple end points and large expense in laboratory costs. These experimental restrictions preclude any attempt at broad spectrum analysis, evaluation, and understanding of biological and chemical hazards faced in military environments. A new research technology which can provide a rapid, sensitive methodology for studying the basic cellular mechanism by which biochemical signals and toxic materials exert their effects is required to meet this need. At the present time, the U. S. Navy does not possess this capability.

Mammalian cells subjected to a variety of environmental stressors such as heat and cold shock, glucose, and oxygen deprivation respond to these stressors by inhibiting the synthesis of normal proteins and begin synthesizing a subset of proteins which are collectively called "stress proteins". These proteins are evolutionarily highly conserved and are found in low amounts in non-stressed cells. The principal stress proteins thus far elucidated are major heat shock proteins. These various proteins are primarily cytoplasmic and nuclear/nucleolar in location and their genotypic expression is considered to be a function of their cellular location. The principal stress proteins thus far described are observed at approximately 28, 34, 56, 70, 76, 89, 97, 110 and 170 KDa. A recent hypothesis has been proposed which postulates a specific physiological role for stress proteins and suggests that these proteins aid in the transport of globular proteins through cellular membrane barriers.

Additional studies have shown that when cells are "pre-stressed" and then reexposed a stress protein (hsp 70) may be produced to protect the cells from further damage. Consequently, understanding the mechanism of the cellular stress response will provide more specificity than current non-specific indicators of stress such as catecholamines and corticosteroids. No work has been done investigating the role of stress proteins in diving scenarios. Results of recent work at this laboratory in developing oxygen tolerant mammalian cell lines as a model of oxidative stress has led to the postulate that stress proteins may be elaborated under conditions of hyperoxic or decompression stress. The program proposed will establish the presence of these proteins and search for differences in patterns with different stressors. The identification of these markers could have application in screening stressed individuals, may be used in the prediction of sustained performance assessment, and may lead ultimately to production of therapeutic countermeasures of performance decrement.

- G. TECHNICAL APPROACH: The first two years of this three year program will be concerned with the validation of the concept of stress protein elaboration in stressful oxidative and decompression exposures by using NSMRL developed normal and oxygen resistant mammalian cell lines. Standard cell assays for viability, growth, DNA, and protein measures will be used. Two-dimensional gel electrophoresis will be used to demonstrate subsets of stress proteins. The third year will be designed to transition work to 6.2 Exploratory Development by using the techniques developed in the first two years. These tests will be applied to (1) human fibroblasts, which will be exposed to in vitro conditions of oxidative and decompression stress and (2) red blood cells obtained from Navy divers during simulated dives.

H. EXPECTED PRODUCT(S)/USER(S):

1. A new state of the art approach will be developed to predict, assess, and treat the response to stress in U. S. Navy operational environments.

USERS: Naval medical community to aid in diver and submariner health and safety, decompression procedures, and to maintain sustained operations in routine and special warfare operations.

- I. OTHER ORGANIZATIONS INVOLVED: This program will use the scientific resources of both Navy laboratories (NSMRL, NMRI) and outside contractors to focus on methods and

procedures to detect stress proteins in the Navy diving community. The results of this research has application in the mission of the Special Forces, Diving, and Medical communities.

J. Funding Required By Fiscal Year:	FY91	FY92	FY93
In-House Personnel/Overhead	140	145	180
Contracts	10	15	10
Automatic Data Processing	0	0	0
Equipment (Task Funded)			
GEL Electrophoresis	8	0	0
Subtotal	158	160	90
Equipment (General Purpose)			
Miscellaneous	10	10	10
Liquid Scintillation Counter	0	40	0
Subtotal	10	50	10
Military Construction	0	0	0
Special Projects	0	0	0
Grand Total	178	255	200

K. Personnel Required by Fiscal Years:

Onboard Manpower Available for This Work	FY91	FY92	FY93
Military Officers (total)	.2	.2	.2
Military Enlisted	.2	.2	.2
Civilian (total)	2	3	2
Additional Manpower Required for This Work			
Military Officer(s)			
Military Service Corps (2300/0840)	.8	.8	.8
Civilian Tech GS7-9	.8	.8	.8

II. NEW STARTS (D)

- A. TITLE: BIOLOGICAL EFFECTS OF TRANSMITTING SONARS
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 63713N M0099.01C
Diver Health and Safety
- C. STATUS: New Start
- D. PROPOSED START DATE: FY91 First proposed FY88
- E. Objective: The research effort will examine the effects of exposure to sonar transmissions emanating from all active sonars currently in use as well as those to be deployed in the near future by the U.S. Navy, in order to develop safe distance diving standards from the sonars. In addition, it will determine the nature of the bio-hazards which could be encountered when divers are exposed to the sonar transmissions.
- F. Rationale: Currently employed transmitting sonars aboard Naval vessels vary widely in their output characteristics and intended use. Ultrasonic sonars such as the AN/SQQ-14, AN/SQQ-30 and AN/SQQ-32 countermine series are used for mine detection and classification, whereas sonars with outputs in the audible frequency range such as AN/SQS-23, AN/SQS-26, AN/SQS-53 and AN/BQQ-5 are used for long range detection and classification of sub-surface vessel activities. The sonars also differ in their transmitting power capability as well as employing differing operational frequencies. Collectively, the transmitting sonars used by Naval vessels are capable of injecting signals composed of a myriad of combinations of amplitudes and frequency components into their aqueous environs. There has been little investigation of the possible hazardous effects of exposures of divers to these sonar transmissions.

The paucity of relevant information was recognized by NAVMINWAROOM, and NSAP was requested by them to fund a study aimed at providing guidelines concerning safe diving distances from mine hunting sonars, and the potential biohazards associated with underwater exposure of EOD divers to ultrasonic sonar transmissions. The NSAP tasking was given to NSMRL (NSAP Task CMWC-1-86, Safe Diving Distances). Research commenced 1 OCT 86 and a final report was submitted to the NSAP office, White Oak, MD, 27 SEP 87. Unfortunately, the data collected and extrapolated under the NSAP tasking only begins the process of elucidating the potential bio-hazards associated with underwater exposure to sonar transmissions.

The NSAP funded research concerned itself only with ultrasonic mine hunting sonars which operate at a much higher range of frequencies than those employed by more common subhunt sonars. Also, the tasking required that we determine conservative safe diving distance recommendations as they apply to EOD operations. These operations usually take place at considerable distances from the transmitting sonar transducers, with exposure time limited by the duration of the mine de-activation task. The ultrasonic nature of the countermine warfare sonars enabled prudent standards for exposure limits to be determined using predictive modeling techniques. These were derived from extrapolations from the vast library of information concerning the effects of exposure to clinical diagnostic and therapeutic ultrasound. The NSAP work provides little guidance directly applicable to the potentially hazardous effects of underwater exposures to high amplitude audible (low) frequency sonar transmissions. No corresponding data base of biomedical effects at these relatively low frequencies exists apart from that concerned with hearing conservation. Finally, even for ultrasonic sonars, our direct work yielded little information or predictive guidance concerning the possible bio-effects from an additive effect of repeated acute or continuous chronic high amplitude ensonification, or from possible interactions between ensonification and the changing levels of gas saturation which would be anticipated in ascending or descending divers.

As long as divers are presented in the water when active sonar is in use there is a cause for concern for their safety and well being. These concerns extend beyond EOD divers to other military divers working in areas where sonar is in use, or where tests are being conducted. Additionally, the Navy must also be concerned for the safety of civilian sport or salvage divers who may be inadvertently subjected to high power active sonar ensonification. The answers to the questions encompassing diver safety in waters where active sonar is in use are of such paramount and universal importance that it is surprising to find such a scarcity of relevant information.

- G. Technical Approach: In general, two main systematic approaches will be used. One approach, using human diver subjects, will focus on the effects of acute sonar ensonification and the ensuing degree of threat to Navy and civilian divers. This research will be primarily directed toward elucidation of the biological risks which are anticipated as a matter of standard operating

procedures and will answer questions that directly concern diver health and mission readiness. The second approach will focus on the assessment of bio-effects produced by acute, repeated acute and chronic high amplitude ensonification of laboratory specimens including animal-derived tissue and blood samples as well as cultured cell specimens. While the first approach will yield expedient answers to questions concerning safe diving practices in typical operating scenarios, the tissue and cellular experimentation will allow us to determine the predicted absolute limits at which hazardous bioeffects of sonar ensonification would be anticipated.

The technique to be used for assessing the damaging potential of sonar ensonification on human divers will employ standard hearing conservation methodology, and stress telemetric techniques. Because the cochlea is believed to be the most sensitive organ to high amplitude vibration, an assessment of the predictive indices of hearing loss by underwater sonar stimulation is probably the most sensitive and conservative measure of physiological damage possible. In the hearing conservation studies, divers will be exposed to sonar frequency stimulation at reversed-incremental distances from the source transducers at varying depths. Temporary auditory threshold shifts will be compared to those obtained at 1 ATM air to determine if damage risk criteria obtained at 1 ATM also hold true for submerged divers. In other experiments divers will be telemetrically monitored for changes in respiration, heart-rate, blood pressure and changes in blood oxygen saturation as a measure of stress as a function of distance from outputting sonar transducers. Additionally, blood and urine samples will be chemically analyzed for catecholamines and other stress related neurohumors. Finally, the results of these experiments will be analyzed and integrated in order to establish conservative safe diving guidelines for general operational use.

In order to develop an understanding of the relationships between underwater acoustic exposure conditions and the production of physiological damage it is necessary to use small, appropriate and easily maintained specimens which can be subjected to ensonification levels high enough to produce biological effects and damage. Biological effects will be assessed as a function of frequency and amplitude of the ensonifying stimulus as well as the degree of gas saturation induced by fluctuating atmospheric pressure. These studies will be conducted so as to

allow the investigation of both the primary effects of the frequency of the stimulation, its amplitude, and the equivalent atmospheric pressure of the medium as well as the interactions among the three variables. All ensonification exposures will be conducted using a portable ensonification bioeffects testing facility which will allow manipulation of stimulation frequency and amplitude, and which can be ported into a hyperbaric chamber for control of atmospheric pressure. Following the sonic exposures we will examine the preparations for disruptions or damage which may have been caused by acoustic stressors (e.g., transient cavitation, acoustic microstreaming, rectified diffusion, etc) using electron microscopic and other ultrastructural analysis techniques as well as tests of physiological functioning developed at this laboratory.

H. EXPECTED PRODUCT USERS: NAVSUPDIVE, NAVSPECWAR, NAVMINWARCOM, SUBLANT, SUBPAC, NWTGPAC, NAVSEA OOC, CNSP, and NAVMEDCOM.

I. OTHER ORGANIZATIONS INVOLVED: None

J. FUNDING REQUIRED BY FISCAL YEAR:

	FY91	FY92	FY93	FY94	FY95
In-House Personnel/Overhead	190	200	260	275	290
Contracts *	220	160	105	70	70
Automatic Data Processing	50	30	10	10	10
Equipment **	175	75	20	20	20
Supplies	10	15	15	15	15
Travel (Data Collection)	25	40	10	10	10
Travel (Consultants)	10	10	10	10	10
Travel (Subjects)	10	10	0	0	0
Ensonification Laboratory	50	25	10	10	10
GRAND TOTAL	740	565	440	420	435

* Contracts

Acoustic Attenuation Modeling	110				
Acoustic Attenuation Computer	0	50			
Transducer Development	80	40	35		
Electron Microscopy	10	20	20	20	20
External Pathology	0	10	20	20	20
Animal Services	20	20	20	20	20
Consultants	0	10	10	10	10

** Equipment

Telemetry Apparatus (5X)	100				
Ensonification Laboratory	50	50			

General Purpose	25	25	20	20	20
-----------------	----	----	----	----	----

K. PERSONNEL REQUIRED BY FISCAL YEAR

	FY91	FY92	FY93	FY94	FY95
Onboard Manpower Available for the work					
Military Officer Total	0	0	0	0	0
Military Enlisted Total	1.6	1.6	1.6	1.6	1.6
Civilian	1.2	1.2	1.2	1.2	1.2
Additional Manpower Resources					
Civilian Professional (GS13/14)	.8	.8	.8	.8	.8

II. NEW STARTS (E)

- A. TITLE: Comparison of operability of different joy-sticks and track-balls to be considered for use with the visual displays being developed for the non-penetrating periscope.
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 65856N M0100.001
Biomedical Support for Submarine Systems
- C. NEW START
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To compare the ease of operation of the large selection of joy-sticks and track-balls available for use in conjunction with the visual displays being considered for use with the non-penetrating periscope.
- F. RATIONALE: The new non-penetrating periscope will be operated by observing CRT displays rather than simply looking through the periscope optics. A wide variety of functions will be available to the periscope operator, many of which will involve manipulations with a joy-stick or track-ball. Eleven such joysticks were demonstrated to the committee set up to develop the periscope. The different joy-sticks have much different human factors characteristics -- the pressure required, the excursion of the cursor in response to a given movement of the stick, the movements required for diagonal movement of the cursor, etc. Operators will manipulate the control stick for long periods of time. Yet, the degree of control and the amount of fatigue produced by each stick has not been measured.
- G. TECHNICAL APPROACH: Subjects will view CRT displays requiring specific cursor adjustments such as would be required to lock on and track a target through a periscope. Their accuracy and error-rate will be measured for periods of time equivalent to that engaged in by operators on the submarine. Subjects will manipulate all the sticks being considered for use in counterbalanced order and will rate the degree of fatigue at the end of each session. Both their objective performance and ratings of fatigue will be compared for the different joy-sticks and trackballs.
- H. EXPECTED PRODUCTS/USERS: The optimal joy-stick could be incorporated by the periscope designers.
- I. OTHER ORGANIZATIONS INVOLVED: None

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91
In-House Personnel/Overhead	120
Contracts	0
Automatic Data Processing	0
Equipment	10
Miscellaneous	2
Military Construction	0
Special Projects	0
Total	132

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available

Military Officer	0
Military Enlisted	0
Civilian	.9

Additional Manpower Required

Civilian	.6
Total	1.5

II. NEW TASKS (F)

- A. TITLE: Development of acoustic habitability standards for advanced design active sonar platforms
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: New Start PE 63706N (Fleet Occupational Health Standards)
- C. STATUS: New Task First Proposed 1985
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: Prevention of hearing loss in Naval crewmembers aboard vessels equipped with active sonars through the development of noise level criteria for berthing spaces which will permit recovery from noise induced auditory threshold shifts incurred while on duty and prevent degraded performance on aural tasks.
- F. RATIONALE: The SSN-21 is being built and other advanced concepts in submarine warfare are being implemented. In addition, surface vessels are being equipped with advanced sonars that have the potential for ensonifying shipboard spaces. These developments raise concerns related to acoustic habitability of spaces aboard those platforms. Among the questions that have been raised are what ambient noise levels are appropriate for berthing spaces to 1) prevent noise-induced hearing loss due to ships' sonar operations, 2) to permit recovery from noise-induced temporary hearing loss incurred while on watch (as in the engineering spaces), and 3) to avoid degrading crew performance on auditory tasks (as sonar operation).

Past efforts to establish berthing-space noise criteria have been less than systematic. The major guidance formerly available was a NAVSEA document entitled "Specifications for Ships" which has since been withdrawn by NAVSEA several years ago, but has not, as yet, been replaced. That guide was assembled on the basis of reviews of the then extant literature and consultations with national experts including representatives of all major Naval Laboratories. Specifications for Ships did not envision more recent developments in submarine design and submarine tactics. These later developments produced higher than anticipated intermittent sound levels in berthing spaces aboard attack class submarines. In the early 1970s, NSMRL and NOSC were tasked to develop habitability standards for the 688 class and succeeded in establishing permissible exposure levels for around-the-clock exposure for periods of up to 30 days.

That work, however, did not take several important factors into consideration. For example, although the NSMRL experiments investigated the effects of such exposure on sonar operator performance (no decrements in performance were found), no control conditions were run. In fact, despite the presence of around-the-clock intermittent noise at sound pressure levels up to 85 dB (referenced to 20 microPascals), both naive sonar watch standers (trainees) and experienced sonar men continued to show improved performance on a simulated sonar listening task throughout the 30-day exposure period. However, without a non-noise-exposed control group, it remains uncertain that performance had improved to the maximum extent possible. Also, during that experiment, the sound of interest was the only intense noise to which the subjects were exposed. That is, the situation of an engineman who is exposed to much higher sound levels while on watch was not considered. If engine room watch standers had incurred temporary threshold shifts while on watch, it is questionable that they would have recovered if berthed in a space subject to intermittent around-the-clock noise levels of 85 dB.

In short, while the NSMRL and NOSC studies showed that temporary threshold shifts would not grow beyond insignificant levels from chronic exposure to noise levels experienced in berthing spaces aboard 688 class boats, those experiments did not show that those levels were sufficiently low to prevent interference with the ability of sonar operators to perform optimally or to permit enginemen to recover from other noise exposure. In addition, the results of those studies are not generalizable to other stimulus conditions (different spectra or higher duty cycles) than were employed in those experiments. The situation for SSN-21 and certain surface vessels equipped with advanced sonars will be sufficiently different from the 688 class, both in the frequencies and the duty cycles that are expected to exist, that predictions of acceptable levels cannot be made on the basis of prior research.

Despite many years of research on the topic, there remains considerable debate in the literature as to what constitutes effective quiet for purposes of recovery from noise-induced temporary threshold shifts. It is strongly suspected, however, that chronic temporary threshold shifts eventuate in permanent hearing damage. Thus, if temporary threshold shifts which exist from noise experienced while on duty are not permitted to dissipate because of excessive noise levels in off-duty spaces, some permanent hearing loss may be expected to

develop. Yet, there is no consensus among scientists concerning how quiet is quiet. From prior experience, it is known that ambient levels as low as 55 to 65 dB that are thought by many to constitute "quiet" are economically and operationally unfeasible for many shipboard spaces. Thus, one cannot look to the existing literature for a solution to the present problem.

- G. TECHNICAL APPROACH: Specifications will be drawn up for spectral and duty cycle conditions expected to prevail on SSN-21 boats and other sonar platforms in consultation with program managers within NAVSEA. Some of that information is classified, hence some of the research done under this task will also be classified. Of particular interest will be identification of machinery noise spectra to which enginemen are expected to be exposed, identification of auditory tasks which sonar watch standers will be expected to perform, and other parameters having a bearing on expected noise spectra within berthing spaces. This effort will result in definition of the parameters to be employed in the experiments described below. Series of experiments will then be done in which the effects of various levels of the ambient noise of interest will be measured.

Series I. Effects of ambient noise in non-duty spaces on recovery from noise-induced temporary hearing loss.

A. One-week simulated cruise, N=24 in four groups of N=6. Subjects will be exposed to broad band noise (simulated engine room noise) for six hours. Ambient noise levels during a twelve-hour recovery period will be varied across groups from 55 dB to 85 dB in ten dB steps. Spectra of the fatigue inducing and ambient (recovery space) noise will be as defined in consultation with NAVSEA. Throughout the experiment, subjects will perform other tasks in a simulation of a normal cruise.

B. One-month simulated cruise. This will be essentially an extended version of experiment I.A. Ambient noise levels will be the maximum level found not to interfere with recovery and/or an additional level from five to ten dB lower.

Series II. Effects of ambient noise in non-duty spaces on aural performance of sonar operators.

A. and B. These experiments will follow the paradigm above except that on-duty time will be spent on simulated sonar watches. Sonar operators of various skill levels will be the subjects.

H. EXPECTED END PRODUCTS/USERS: The end products will be specifications for off-duty ambient sound levels for enginemen and sonar operators. Users: NAVSEA 55N, NAVMEDCOM.

I. OTHER ORGANIZATIONS INVOLVED: None.

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92	FY93
In-House Personnel/Overhead	150	160	165
Contracts	0	0	0
Automatic Data Processing	0	10	15
Equipment (Task-funded):			
Sound generation system	80	40	0
Task simulation equipment	60	20	0
Subtotal	290	230	180
Equipment (General Purpose):			
Computer control apparatus	120	60	0
Subtotal	120	60	0
Military Construction:			
Modifications to Sound Suite	50	40	0
Special Projects	0	0	0
Grand Total	360	330	180

K. PERSONNEL REQUIRED BY FISCAL YEAR:

	FY91	FY92	FY93
Military Officer Total	1	1	1
Military Enlisted	3	3	3
Civilian	3	3	3
Additional Manpower Required for this Work			
Psychologist (GS-180-11)	1	1	1
Research Assistant (GS-181-5)	1	1	1
Total	2	2	2

II. NEW STARTS (G)

- A. TITLE: Effect of color-coded CRT displays in the control room on the night vision of the periscope operator.
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 65856N M0100.001
Biomedical Support for Submarine Systems
- C. NEW START
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To measure the degree of degradation of dark adaptation in the periscope operator caused by the presence of color-coded CRT displays in the control room and to test solutions to the problem.
- F. RATIONALE: An increasing number of color-coded CRT displays will soon be found on submarines. Those in the control room will be significantly brighter than the black-and-white displays they will replace. The latter can be dimmed to a considerable extent and still present their information to the operator. Color-coded displays cannot be dimmed too much without losing the color and with it the information that the colors convey. The brighter displays will produce considerably more light in the control room which is typically "rigged for black" when the submarine is at periscope depth at night. The extent to which such CRTs will affect the dark adaptation of the crew-- particularly the periscope operator--should be determined. We propose to measure the effects on night vision sensitivity of having to work in a compartment with various numbers of CRTs with colored simulated sonar displays. The extent to which they can be dimmed will be determined and then their effect on night vision will be measured as a function of the number and size of the displays. If, as expected, night-vision is degraded, solutions to this problem will be tested.
- G. TECHNICAL APPROACH: The night vision threshold will be determined for each subject. The subject will then be exposed to a compartment containing color-coded CRTs after which his night vision sensitivity will again be measured. On successive exposures the number, size, and brightness of the CRTs will be systematically varied, as will the duration of the exposure, and the subject's sensitivity will be compared to its initial state in each case.
- H. EXPECTED PRODUCTS/USERS: The lowest brightness of the various displays which still convey the necessary

information will be determined. The effect on night vision of these displays will be measured for the various exposure times and number and sizes of the displays. Designers and periscope operators will know the effects of placing color-coded displays in the control room.

I. OTHER ORGANIZATIONS INVOLVED: None.

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92	FY93
In-House Personnel/Overhead	148	152	158
Contracts	1	1	1
Automatic Data Processing	0	0	0
Equipment (task funded)	10	5	0
Miscellaneous	10	10	10
Military Construction	0	0	0
Special Projects	0	0	0
Total	169	168	169

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available
for this work

Military Officer	0	0	0
Military Enlisted	.8	.8	.8
Civilian (GS-180-13)	.2	.2	.2
(GS-0856-11)	.1	.1	.1
(WG-4714-14)	.1	.1	.1

Additional Manpower Required
for this work .

Civilian (GS-180-11)	.8	.8	.8
(GS-180-5)	.8	.8	.8
Total	2.8	2.8	2.8

II. NEW STARTS (H)

- A. TITLE: EKG Evaluation of Arrhythmias
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE:
- C. STATUS: New Start (First proposed FY88)
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To determine if high-resolution EKG will detect and effectively evaluate arrhythmias, atrio-ventricular dissociation, and syncope.
- F. RATIONALE: The occurrence of half a million cases of sudden cardiac deaths each year has stimulated the search for clinically significant information regarding the conduction system, electrical instability, and the effectiveness of therapy. However, Holter monitoring, exercise testing, and programmed electrical right ventricular stimulation do not reliably predict syncopal attacks or sudden arrhythmic cardiac death.

Histopathologic studies suggest that complete atrio-ventricular (AV) block usually reflects disease of the conduction system rather than the AV node. Various patterns of bundle branch block are known to precede the development of AV block. But, during the late 1970s there was disagreement as to whether or not a prolonged H-V interval correlated with a high risk of development of AV block, as proposed by several investigators. However, the consensus seems to be that a prolonged H-V interval in the setting of a new bundle branch following an acute myocardial infarction may help in identifying those patients who are at an increased risk of developing third degree AV block.

In the past, electrophysiologic studies have had to be performed in specially equipped laboratories. The studies required 2-4 hours to perform. Four trained technicians were often required. Intracardiac electrograms from the right atrium, His bundle region, and right ventricle might be required. Four or more simultaneous catheters may be required. The cost has been estimated at \$15,000 per patient. These electrophysiological studies, thus, are time-consuming, expensive, and not readily available.

Noninvasive alternatives would be very useful. New signal-averaging neuroelectric techniques are capable of measuring the microvoltage electrical activity of the

His-Purkinje system at the surface of the body. Although His-Purkinje EKGs are now detectable, the clinical significance of the detectable changes remains to be determined. But there is preliminary evidence that the duration of the QRS complex is significantly longer in patients with ventricular late potentials (VLP) than in those without VLP. Delayed depolarization may indicate an increased risk of arrhythmia, and the long QT syndrome may indicate a risk of torsades de pointes tachycardias and sudden death. An analysis of the EKG using signal averaging and spectrum analysis may detect microvolt changes that correlate with these risks. If so, this would constitute a quick, inexpensive, and non-invasive procedure for identifying individuals with these risks.

Finally, in future years, an attempt would be made to identify those individuals who have not had a cardiac event but who are at risk for electrical dissociation. This would be of importance in screening Naval recruits.

- G. TECHNICAL APPROACH: EKGs would be obtained from one to two-hundred patients in cardiac care units. The tapes of these recordings would be subjected to a spectrum analysis to determine who exhibits an after-potential and who does not. After six months to a year, a follow-up of the patients would be conducted to determine morbidity and mortality rates of the two groups. This would determine whether or not the presence of the after-potential correlates with additional risk.
- H. EXPECTED PRODUCTS/USERS: A non-invasive method of predicting which patients are susceptible to atrio-ventricular block which could be used by all Naval Hospitals, and would have high civilian application.
- I. OTHER ORGANIZATIONS INVOLVED: This proposal is feasible if conducted as a joint laboratory and clinical investigative program at Naval and civilian hospitals.
- J. FUNDINGS REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92	FY93
In-house personnel/overhead	53	54	55
Contracts	50	50	50
Automatic Data Processing	0	0	0
Equipment	0	0	0
Miscellaneous	10	10	2

Military Construction	0	0	0
Total	113	114	107

K. PERSONNEL REQUIRED BY FISCAL YEAR

	FY91	FY92	FY93
Onboard Manpower available			
Military Officers	.1	.1	.1
Military Enlisted	.4	.4	.4
Civilian (GS-180-13)	.4	.4	.4
Additional Manpower Required			
Civilian	0	0	0
Total	.9	.9	.9

II. NEW STARTS (I)

- A. TITLE: Performance Assessment for Auditory Sonar Signals
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 62758N MM58 528.01 Performance Assessment/Enhancement
- C. STATUS: New Start - First proposed FY87
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: Improvement of auditory-qualification standards for submarine sonar operators in order to improve performance during naval operations.
- F. RATIONALE: Traditional pure-tone audiograms do not adequately assess the auditory skills required by submarine sonar operators. Once a sonar technician's hearing loss has reached levels that may disqualify him according to today's standards, suprathreshold auditory tests (currently not available) should be administered to determine whether he should be retained or disqualified. This work unit is intended to develop tests to evaluate auditory sonar performance test abilities. Some of the test may also be useful for sonar selection.
- G. TECHNICAL APPROACH: This work will focus on the development of a group of tests that measure the ability to extract auditory patterns from a background noise. The patterns or complexes involved will constitute simulations of actual auditory-sonar contacts but may be modified to allow measurement of discrete spectral and temporal characteristics. Unlike traditional pure-tone audiometry, signals will be complex, will be imbedded in a background of noise, and will be at levels above those used for pure-tone noise, and will be at levels above those used for pure-tone audiometry. Discrimination and identification tasks will be included along with detection tasks. Since sonar-pattern perception and speech-pattern perception share many characteristics, techniques that have been effective in speech-perception research will be used to segment complex sonar contacts into discrete elements or features. Much of this work will use digitally synthesized signals.
- H. EXPECTED USERS: NAVSEA, SUBSCHOOL, MEDCOM, design engineers for sonar systems and for machine-recognition systems.
- I. OTHER ORGANIZATIONS INVOLVED: SUBSCHOOL

J. FISCAL RESOURCE REQUIREMENTS: (\$000)

	FY91	FY92	FY93	FY94	FY95
In-House Personnel/O'hd	170	218	289	317	348
Contractor	50	50	50	50	50
ADP	20	20	25	25	25
Equipment (task funded)	25	25	15	10	10
Miscellaneous	5	5	5	5	5
Total	270	318	384	407	438
purpose)	1	1	1	1	1
Miscellaneous	5	5	5	5	5
Subtotal	6	6	6	6	6
Grand Total	282	330	396	419	450

K. Personnel Required by Fiscal Year:

Onboard Manpower Available
for this Work

	FY91	FY92	FY93	FY94	FY95
Military Officer:					
Total	0	0	0	0	0
Military Enlisted:					
Total	0	0	0	0	0
Civilian Professional:					
Total	0.2	0.4	0.4	0.4	0.4
Civilian Supporting:					
Total	0	0	0	0	0

Additional Manpower Required
for this Work

	FY91	FY92	FY93	FY94	FY95
Military Professional	0	0	0	0	0
Military Supporting	0.4	0.4	0.4	0.4	0.4
Civilian Professional					
GS-665-11	0	0	0.8	0.8	0.8
GS-1550-12	0.4	0.8	0.8	0.8	0.8
Civilian Supporting	0.8	0.8	0.8	0.8	0.8
Total Required	2.2	2.4	2.4	2.4	2.4

II. NEW STARTS (J)

- A. TITLE: Scanning through the periscope
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 62758N MM58 528.01
Performance Assessment/Enhancement
- C. STATUS: New Start- First proposed FY88
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To determine the optimal method of scanning through the periscope.
- F. RATIONALE: It has been brought to our attention by a submarine officer that it is not clear what is the most effective method of scanning through the periscope. Periscope operators disagree on whether a target is more likely to be seen if the operator traverses the periscope smoothly and continuously or if he traverses in discrete jumps and scans the field of view with the periscope held motionless.
- G. TECHNICAL APPROACH: Subjects will search for targets of varying size and contrast through a simulated periscope eyepiece. On half the trials, they will be instructed to traverse continuously through a 180 degree angle; on the other trials, they will move the eyepiece in discrete jumps, then pause and scan. The time taken to locate targets of various sizes and contrast and the number of times a target is missed will be recorded. Both photopic and scotopic vision will be investigated. Observer preferences will be ascertained and correlated with performance.
- H. EXPECTED PRODUCTS/USERS: The results will be important for all periscope operators.
- I. OTHER ORGANIZATIONS INVOLVED: None.
- J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92
In-House Personnel/Overhead	110	12
Contracts	1	0
Automatic Data Processing	0	0
Equipment (task funded)	5	0
Miscellaneous	5	1
Military Construction	0	0
Special Projects	0	0

Total	121	13
-------	-----	----

K. PERSONNEL REQUIRED BY FISCAL YEAR:

	FY91	FY92
Onboard Manpower Available		
Military Officer	0	0
Military Enlisted	.8	0
Civilian (GS-180-12)	.2	.1
(WG-4714-14)	.2	0
(GS-0856-11)	.2	0
Subtotal	1.4	.1
Additional Manpower Required		
Civilian (GS-180-11)	.8	.2
(GS0180-5)	.8	0
Subtotal	1.6	.2
Total	3.0	.3

II. NEW STARTS (K)

- A. TITLE: Suppression of Immune System Functioning in Submariners
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 61153N
(Clinical Medical Sciences)
- C. STATUS: New Start (First proposed 1988)
- D. PROPOSED START DATE: FY91
- E. OBJECTIVE: To describe psychological and biological processes that influence onset of illness in predisposed individuals when exposed to training or operational environments and to test therapies to modify biologic responses for their effectiveness in overcoming immunosuppression. This objective was identified at the CO's Conference November 1987.
- F. RATIONALE: Acute stress has been associated with transient immunosuppression. Immunosuppression leads to persistent alterations in cellular immunity and a higher susceptibility to disease. This leads to a reduction in available manpower and reduced performance in affected individuals. The effects of more prolonged stress have been shown to severely depress immune system functioning in several populations. Chronically stressed individuals do not show immunologic or psychologic adaptation to the stress; that is, immune system functioning remains suppressed throughout prolonged exposure to stress.

Submariners suffer from both physical and psychological stresses. They work in an environment that includes many mentally demanding tasks. Their normal sleep patterns are disrupted, and they are confined in a relatively crowded space for prolonged periods. They are separated from their families, and many show signs of acute depression prior to deployment. Crowding, marital disruption, and depression have all been linked to reduced immune function. Studies of Space Shuttle astronauts have reported changes in immunological responsiveness that the investigators attribute to physical and emotional stress. Other studies show that negative life events are related to reports of illness in Navy Submarine School students.

Submariners are at additional risk of depressed immune system functioning from the marginal deficiencies in vitamins B6, C, and D that occur during patrols. Finally, smoking is linked to reductions in immune

function.

Various biologic and psychological immune response modifier therapies are available. None of these have been studied in an operational environment. There is no information as to whether or not reductions in immune function lead to lower performance of duties and whether or not therapy which modifies these biologic changes will also reduce sick calls and improve performance. The purpose of this investigation is to determine if they would prove useful in improving performance or decreasing stress related illness. It is important that we first determine the extent of immune system depression in submariners and further evaluate methods to eliminate or reduce it.

- G. TECHNICAL APPROACH. Various biomedical, physiological and psychological variables will be studied in a submarine crew before during and after a patrol:
1. Immunologic Assays will be performed to determine the level of immune system function. These will include:
 - a. blastogenesis
 - b. antibody to Epstein-Barr virus
 - c. monoclonal antibodies
 - 1) natural killer cell percentages
 - 2) relative % of helper and suppressor T lymphocytes
 2. The nutritional status of the submariners will be determined by measuring the following:
 - a. albumin
 - b. transferrin
 3. A record of sick call visits during patrol will be obtained for each subject.
 4. Background history of information known to effect immune system functioning will be requested including:
 - a. demographic
 - b. marital history
 - c. health history (include weight and smoking)
 - d. "Life Changes"
 5. Each subject will complete a distress/depression inventory to measure the level of perceived

stress. All this data will be collected prepatrol. Several could also be collected at the end of refit (a high stress situation), during and after the patrol (the number of times determined by the difficulty of the assays). A regression analysis would be performed to determine which variables predict reductions in immune system functioning. Once the variables that influence immune system functioning are determined, means of reducing or eliminating critical variables can be developed.

H. EXPECTED PRODUCT/USERS: Product would be the identification of those factors that lead to reduced immune function and an equation relating those variables that would predict an individual's susceptibility to decreased immune function during training or in the operational environment.

I. OTHER ORGANIZATIONS INVOLVED: None

J. FUNDING BY FISCAL YEAR:

	FY91	FY92	FY93
In House Personnel/Overhead	150	200	150
Contracts	30	30	
ADP			
Equipment	50		
Miscellaneous			
Military Construction			
Special Projects			
Total	230	230	150

K. PERSONNEL BY FISCAL YEAR:

Onboard Manpower Available for this Work			
Military Officer			
Military Enlisted	.8	.8	.8
Civilian (GS-180-13)	.4	.4	.4
Additional manpower required for this work			
Civilian (GS-180-12)	.8	.8	.8
Total	2.0	2.0	2.0

II. NEW TASK (I)

A. TITLE: (U) The role of atrial septal defects in susceptibility to decompression sickness in U.S. Navy divers

B. PROPOSED PROGRAM ELEMENT:

C. STATUS: New Start

D. PROPOSED START DATE: FY91

E. OBJECTIVES:

To determine if the existence of particular atrial septal heart defects, including patent foramen ovale, is significantly associated with the incidence of decompression sickness in U.S. Navy divers, and to determine if echocardiography can be used to screen Navy diver candidates or assist the diving community to develop standards for the physical qualifications for divers.

F. RATIONALE:

As of January 1989 there were 4284 working U.S. Navy divers. Those divers participating in research or working dives are frequently at risk for the development of decompression sickness. Decompression sickness (DCS) occurs when nitrogen gas bubbles formed in the body cannot be eliminated and expand in the bloodstream during decompression after a dive or exposure to high pressure. In most cases, this DCS consists only of joint pain and resolves rapidly with treatment. The potential exists, however, to inadvertently cause more serious neurological damage. More severe decompression sickness includes neurological symptoms such as numbness, paralysis, tingling, and decreased sensitivity to touch, muscular weakness, and tremors. Amnesia, excessive fatigue, personality changes, irritability, and even death may occur.

Recent research suggests that certain individuals may be at considerably higher risk of developing these symptoms. These individuals are born with a minor defect in the heart called patent foramen ovale. In this condition, a small hole in the wall separating the upper chambers of the heart (the left and right atria) present during the development of the fetus fails to close at birth. Bubbles formed in venous blood ordinarily travel through the right atrium to the right ventricle and into the pulmonary circulation where they

are filtered out by the lungs. With patent foramen ovale and other atrial septal defects, bubbles can pass directly from the right atrium to the left atrium then to the left ventricle and into systemic arterial circulation where they may produce symptoms of DCS.

Under many diving conditions, small gas bubbles are formed in the venous blood but are filtered out in the lungs before they can escape into the bloodstream and other tissues. In a person with this atrial defect, the bubbles may be able to circumvent this filtering process and, therefore, pass directly into the bloodstream. This condition and similar atrial septal defects would put the individual at considerably greater risk of developing decompression sickness.

Although this defect occurs in approximately ten percent of the adult population, recent data from R. E. Moon and his colleagues at Duke University suggest that the defect shows up in 37% of divers with a history of decompression sickness and in 61% of divers with the most serious decompression symptoms.

The defect can easily be determined with echocardiography. Echocardiography is not expensive, is easily interpreted, and widely available at Naval Hospitals. Determinations would be needed only once in a diver's career.

If the relationship between this defect and the incidence of decompression sickness can be substantiated in a large group of U.S. Navy divers, it would be possible not only to screen diver candidates, but also for the diving community to establish physical qualifications for divers participating in dives where the risk of decompression sickness was highest. Presently, over 600 individuals attend U.S. Navy dive schools each year. Approximately 60 of these individuals will have atrial septal defects that have not been diagnosed. In the U.S. Navy diving community at large over 400 divers would have these defects.

By eliminating those individuals with increased risk of decompression sickness from possible exposure, diver safety would be improved. This could result in a substantial decrease in the incidence of decompression sickness in the U.S. Navy diver population and the possible extension of recommendations to the civilian diving community as well.

G. TECHNICAL APPROACH:

Navy Safety Center, Norfolk, VA, has the computerized information for every U.S. Navy diver. It has recorded every case of decompression sickness that has occurred in the diving population. This study will categorize divers into two groups from the Navy Safety Center. The first group will consist of divers with no history of decompression sickness. The second group, matched in age, number of dives, health history, etc., will consist of those divers with the highest incidence of decompression sickness. Each individual will be asked to participate in a two dimensional echocardiography session during which his or her heart will be examined for evidence of a small hole in the wall separating the right and left atria (patent foramen ovale or other related defects). A cardiologist will review the records to determine presence or absence of the defect. The cardiologist will not be told to which group a given diver belongs. Each session will last less than one hour and can be performed at any medical center with echocardiography equipment.

Data will be analyzed to determine the incidence of these defects in the two populations and, additionally, whether those individuals with the defect also experience more severe decompression sickness.

H. EXPECTED END PRODUCTS/USERS: Recommendations for the physical qualifications for prospective U.S. Navy diver candidates and guidelines for the U.S. Navy diving community for physical standards for participants in operations that involve increased risk of decompression sickness. NAVSEA, MEDCOM

I. OTHER ORGANIZATIONS INVOLVED: NONE

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY91	FY92
In-House Personnel/Overhead	66.7	66.7
Contracts	30.0	30.0
Automatic Data Processing		
Equipment (Task funded):		
Equipment (General Purpose):		
Military Construction	0	0
Grand Total	96.7	96.7

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Military Officer	.2	.2
Military Enlisted	.8	.8
Civilian	.8	.8
Total	1.8	1.8

II. NEW TASK (M)

- A. TITLE: Cellular Bioengineering: Concept Development and Application to Problems of Hazardous Biological and Chemical Environments
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE:
61153N/MR04120/MR0412002
(Clinical Medical Sciences)
- C. STATUS: New Program
- D. PROPOSED START DATE: FY92
- E. OBJECTIVE:
 - a. Develop research for a new, technological approach which will integrate biochemical, biophysical, genetic and cell culture techniques into an advanced analytical procedure for the rapid detection and evaluation of the mechanism of the cellular response to environmental contaminants and hazards.
 - b. Demonstrate the capabilities of this new technological approach to provide a more rapid, cost effective solution to identified U.S. Navy operational problems.
- F. RATIONALE: The CNO has reviewed recommendations concerning submarine atmosphere contamination and has determined that significant problem areas exist in submarine atmosphere control. NMRDC, CHNAVMAT and ONR were requested to provide available support for this program. CNR, in Key Naval Needs for Research and Technological Planning, 14 Jan 1985, 1706(U) recommended research to support biomedical standards for more effective performance in critical occupations, e.g. aviation and submarine duty.

Current methods for the evaluation of the effects of environmental contaminants are limited by the requirements for extensive animal studies, prolonged exposure periods, insensitivity of results, indefinite or multiple end points and large expense in laboratory costs. These experimental restrictions preclude any attempt at broad spectrum analysis, evaluation, and understanding of biological and chemical hazards faced in military environments. A new research technology which can provide a rapid, sensitive methodology for studying the basic cellular mechanism by which biochemical signals and toxic materials exert their effects is required to meet this need. At the present

time, the U.S. Navy does not possess this capability.

Cellular Bioengineering is a newly developed research concept based on the theory of cellular communications in intact organisms. The theory states that cellular systems communicate functional information to other cells by creating biochemical signals in extracellular fluid. The biochemical signal initiate such cellular response as growth, division, secretion and transformation. The underlying principle of Cellular Bioengineering is that the behavior of a cell not only depends on the presence or absence of specific effector molecules in its natural environment, but also on the temporal patterns of change in the concentration of the effector molecules i.e. rate of change, amplitude, and frequency of change. Most current techniques for evaluating biochemical effects on cultured cells and tissues are concerned with measuring the response of the cells to the total amount of chemical presented (dose/response curves) and not the actual chemical signal patterns. These older approaches provide only information on the response of cells to a static challenge rather than to a dynamic, time-varying delivery of effector molecules. Cellular Bioengineering of cultured cells and tissues offers the potential to be a sensitive, rapid, interactive method for studying the natural delivery pattern or wave-form of a single or multiple signal substance which elicits a detectable, desired response. By manipulating the delivery pattern, certain reproducible cellular responses such as secretion or overproduction of desired substances, e.g. mammalian gene products and monoclonal antibodies may be produced. In addition, this new approach provides the possibility for an accurate, sensitive, cost effective technology not only for the screening of large numbers of toxicants but also to provide basic information on the primary site and mechanism of action.

- G. TECHNICAL APPROACH: The technical approach for the concept development of Cellular Bioengineering is based on two main phases which can be described as the (1) Challenge Phase and (2) Detector Phase.

The Challenge Phase will consist of research to establish the critical parameters involved in the delivery of specific effector molecules, e.g. growth hormone, peptides, sugars, electrolytes, toxicants, and other agents which have direct effects on cellular function. These critical parameters will include flow rate, amplitude, volume, and time phasing of selected effector molecules which are responsible for the control of cell response and communication. Additional research

effort will be directed toward the establishment of a unique flow-through cell culture system which will precisely program and regulate delivery of specific biological effector molecules to the cell or tissue culture. The system will incorporate process control technology and will be based on a mathematical model of a flow-through culture system. It will permit the time-phased delivery of as many as five different biological or chemical effectors under precise interactive computer control.

In the Detector Phase, the responses of cells to effector molecules, including pollutants, falls into five major categories: genetic, biochemical, biophysical, functional and ultrastructural effects. The use of only a single, or a few detector end-points increases the probability of selecting the wrong end-point and results in failure to demonstrate a cellular response to an effector substance. The Detector Phase will be concerned with research to establish an appropriate multivariant detector matrix will include such detector diagnostics as immunofluorescent techniques, activity of membrane surface, electron micrography, sister chromatic exchange, DNA synthesis and repair, radioimmunoassay, labeled antibodies, etc.

A second major aspect of the Detector Phase will be concerned with the validation of the concept of Cellular Bioengineering and demonstration of the advantages of this research approach for providing new techniques and insights into research on mechanisms of cellular action. A selected group of tissue culture cells, initially, primary culture liver cells, Type II pneumocytes, neuroblastoma, Chinese Hamster Ovary (CHO) and monocytes will be evaluated.

An additional validation effort will be directed toward the demonstration of the capability of the cellular bioengineering techniques to provide a broad range of cell response information as a result of toxic challenge. This validation effort will demonstrate the capability of the multivariant detector diagnostic matrix to provide a greatly increased level of cell response information in a single experiment. Additional comparisons of cell culture challenge with known toxic substances will be compared with similar challenged whole animal models to evaluate the extent to which this technique will function as an alternative to whole animal testing.

H. EXPECTED END PRODUCTS/USERS:

1. A new basic research approach of cellular functions will provide far greater information content in individual experiments, and introduce new experimental approaches to research on cell mechanisms. Users: General scientific community.
2. A new approach to toxicological screening of hazardous biological and chemical substances in U.S. Navy occupational and operational environments. The approach will provide the capability for more rapid and sensitive hazard evaluation which is better adapted to the screening of the large number of potentially toxic industrial materials which are continually being introduced into the U.S. navy. Users: NSMRL, NAVSEA, NRL, and MEDCOM.

I. OTHER ORGANIZATIONS INVOLVED:
 Contractor: University of Rhode Island
 Naval Toxicology Unit - Wright Patterson

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY92	FY93	FY94	FY95	FY96
In-House Personnel/Overhead	195	278	278	250	210
Contracts	85	90	90	80	—
Automatic Data Processing	—	—	—	—	—
Equipment (Task-funded):					
Acusyst-P Perifusion Syst.	77	—	—	—	—
Fluorescent Act. Cell Sorter	—	150	—	—	—
Gel Electrophoresis	—	—	15	—	—
Liquid Scintillation Cntr	—	—	40	—	—
Miscellaneous	35	30	30	30	20
Subtotal	392	548	453	360	230
Equipment (General Purpose):	15	15	10	10	—
Miscellaneous	35	45	40	30	25
Subtotal	50	60	50	40	25
Military Construction:	0	0	0	0	0
Special Projects	0	0	0	0	0
Grand Total	442	603	503	400	255

K. PERSONNEL REQUIRED BY FISCAL YEAR:
 Onboard manpower available

Military Officer Total	.5	.5	.5	.5
Military Enlisted	.8	.8	.8	.8
Civilian	.8	.8	.8	.8

Additional Manpower Required for this Work				
Military Officer	—	—	—	—
Military Service Corps				
(2300/0840)	.8	.8	.8	.8
Civilian Technician GS7/9	.8	.8	.8	.8

II. NEW STARTS (N)

- A. Effects of fire gases on decrement of crew mental acuity and performance
- B. PROPOSED PROGRAM ELEMENT/TASK AREA/TASK TITLE:
6.3/Biomedical support for submarine systems
- C. NEW START
- D. PROPOSED START DATE: FY92 FIRST PROPOSED FY88
- E. OBJECTIVES: Establish standards and a predictive model for assessing decrement in human performance, mental acuity and decision making associated with an atmosphere contaminated with fire gases, from burning material, used aboard U.S. Navy submarines and surface ships. The performance assessment will be incorporated by NAVSEA into specifications for materials to be used aboard U. S. Navy ships, specifications for shipboard fire sensors, and fire damage control protocols.
- F. RATIONALE: In a military operational environment, the ability to make correct decisions about ship operations, under vary adverse damage and fire situations, is critical. The effects of combustion products is a serious problem, with an immediate negative physical and psychological impact. Peak performance is desirable but unattainable under these conditions. Under conditions of high levels of CO, CO2, heat, reduced oxygen and strenuous physical exertion, mental acuity is affected and the ability to make correct decisions becomes questionable. The concentration levels of fire by products, that produce impairment of mental abilities, are not well defined and the interactive effects of multiple fire by products, resulting from shipboard fires, are not known. At some level below lethality, or obvious impairment, the ability to make consistent sound rational judgments may be seriously degraded due to the inhalation of fire by-products. This area is not being addressed by the civilian sector, which is more concerned with fire by-product lethality and time to escape, rather than with continuing operations. Of additional concern to Navy-unique operations is rapid infiltration of fire by-products into vital shipboard spaces. Consequently, the Navy must determine the levels of combined fire by-products that can be present and tolerated without seriously affecting the judgmental abilities of operating personnel in shipboard environments, in order that appropriate standards for personnel protection can be established.

In view of the extreme hazards of a ship fire, a Ship Survivability Program (Ship Damage Control Program, Program Summary March 1985, Naval Sea Systems Command 05R23) has been established under the cognizance of CNO (Surface Warfare) OP-03. Under this program a supporting effort in Passive Fire Protection has been implemented. (Passive Fire Protection Symposium 16 OCT 1984, Naval Sea Systems Command, Naval Material Command, Naval Research Laboratory). The objective of this Passive Fire Protection Program is to propose and evaluate experimental passive fire protection systems to increase the survivability of both surface ships and submarines. In addition, a Live Fire Test Program has been initiated by the Office of Secretary of Defense (OSD). This program was mandated by Congress by the FY87 Defense Authorization Act, which was further amended by the FY88-89 Defense Authorization Act. The mission of Live Fire Test and Evaluation is the assessment of vulnerability and/or lethality of a system under realistic conditions.

NAVSEA (05R23) funded two workshops at NSMRL, in FY85 and FY87. The first of these workshops reviewed current knowledge on effects of fire gases on mental acuity and decision-making. The second workshop assembled an interdisciplinary panel of physicians, physiologists, psychologists, toxicologists, and statisticians to consider requirements for an optimal research protocol. The workshop results have demonstrated the experimental feasibility of recommendations for an achievable research protocol.

- G. APPROACH: The research program has been planned for three phases, with each phase constituting a "go-no go" decision point, based on progress and feasibility.

Phase 1 will be concerned with the establishment of presumptive baseline values for performance decrement, as a function of carboxyhemoglobin (HbCO) levels, and the selection of proper performance tests to reflect decrements of decision-making and mental acuity. There is a large amount of scientific literature on the effects of HbCO levels on human performance, and a review of this literature will provide an adequate, initial estimate of COHb levels which affect mental acuity and decision-making. Candidate testing systems for cognitive performance determination, which were recommended at the 1987 Workshop held at NAMRL, include the Unified Tri-Service Cognitive Performance Assessment Battery (UTC-PAB) and the Automated Performance Test Battery (APTS), and the

Neurobehavioral Test Battery.

A parallel effort will be initiated to develop a mathematical model to predict physiological and psychological performance decrement due to specific fire gas stressors, i.e., CO, CO₂, heat and exercise. The model will be based on established Fractional Dose Equations (FDE) for combined stressors. Current fractional dose models are concerned with incapacitation rather than decrement. Therefore, the FDE equations must be established for decrement in mental acuity and decision-making rather than incapacitation. After the determination of presumptive baseline values, human pilot studies will be performed for validation and refinement of the research protocol. Completion of Phase 1 will establish an initial decision point for the program.

Phase 2 will consist of full scale studies using human volunteers. The research protocol will use a "step-up" approach to exposure to mixed stressors, as recommended by the 1988 Workshop scientific panel. In this approach, exposure to an additional stressor will be administered additively in an ascending concentration to the previously determined concentration of stressor (or stressors), which produced minimal performance decrement.

Based on the results of Phase 2, a decision will be made as to whether the effects of additional fire gas products should be determined for the model e.g., HCN, HCl. Should this be desirable, further experiments will be performed on animal test subjects, and the animal results extrapolated to the human model.

Phase 3 will be concerned with the application and validation of the research results to operational scenarios. This will be accomplished through a joint effort with the Naval Research Laboratory (NRL). These studies will be performed at the large-scale fire test facility at Mobile, Alabama, where the capability exists for monitoring the pertinent parameters, i.e., fire gas concentration, smoke, heat, mass loss and rate of build-up. This phase of the work will be primarily under the direction of NRL. A joint report on the final results of this research program will be made with NRL.

- H. EXPECTED PRODUCTS/USER: Human performance standard for fire sensor design, test protocols and atmosphere limits for fire involvement aboard Navy platforms, and recommendations for fire damage control protocols and

equipment. USERS: NRL, NAVSEA, OPNAV, USARIEM.

I. OTHER LABORATORIES INVOLVED:
NRL, NMRI Toxicology Detachment, USARIEM

J. FUNDING REQUIRED BY FISCAL YEAR:	FY92	FY93	FY94
In-house personnel/overhead	125	125	61
Contracts	20	0	0
Equipment	11	5	0
Supplies	17	10	2
Travel	4	3	2
Misc	3	2	0
TOTAL	180	145	65

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available for this work	FY92	FY93	FY94
Military Officers (total)	.5	.5	.4
Military Enlisted	.4	.4	.4
Civilian (total)	1.1	1.1	1.1
TOTAL	2.0	2.0	1.9

Additional Manpower Required
for this work

Military Officers	0	.5	.5
Military Enlisted	0	0	0
Civilian GS-645-7/9	.8	.8	.8
TOTAL	.8	1.3	1.3

II. NEW STARTS (0)

- A. ~~PROJECT~~ TITLE: Evaluation of HP-9000 computer sonar displays
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 64
- C. STATUS: New Start (First Proposed FY88)
- D. PROPOSED START DATE: FY92
- E. OBJECTIVE: To evaluate all the display categories available on the HP-9000 computer and to recommend the most effective use of color- and symbol-coding for each.
- F. RATIONALE: The submarine force is deploying HP-9000 micro-computers throughout the fleet. These will present various visual displays which will be used for a variety of purposes. The displays, unlike previous CRT displays, will be color-coded in addition to the use of symbol codes. To get the most benefit from these displays, each should be analyzed to ensure the color-coding and use of symbols conforms with human factors principles. On the GEOSIT display, for example, we can test the degree to which symbols are confused with other symbols; alternate symbols can be recommended. Previous work at NSMRL has developed techniques for analyzing quantitatively the effectiveness of color coding in visual displays.
- G. TECHNICAL APPROACH: The response times and errors of observers attempting to extract information from each display will be measured as a function of changes in the color- and symbol-coding.
- H. EXPECTED PRODUCTS/USERS: The specification for optimal color- and symbol-coding will be used by systems designers and the operators.
- I. OTHER ORGANIZATIONS INVOLVED: None.
- J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY92	FY93	FY94
In-House Personnel/Overhead	100	110	120
Contracts	0	0	0
Automatic Data Processing	10	10	10
Equipment (task funded)	30	0	0
Miscellaneous	10	10	10
Military Construction	0	0	0
Special Projects	0	0	0

Total	150	130	140
-------	-----	-----	-----

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available for this Work			
Military Officer	.4	0	0
Military Enlisted	.4	.4	.4
Civilian (GS-180-13)	.3	.3	.3
Subtotal	1.1	1.1	1.1
Additional Manpower Required for this Work			
Civilian (GS-180-11)	.8	1.2	1.2
(GS-180-5)	.5	.5	.5
Total	2.4	2.4	2.4

II. NEW STARTS (P)

- A. TITLE: Fourier Transforms of Target Stimuli for Improved Detectability
- B. PROPOSED PROGRAM ELEMENT/TASK TITLE: 61
- C. STATUS: New Start (First proposed FY88)
- D. PROPOSED START DATE: FY92
- E. OBJECTIVE: To improve sonar target detection by transforming the target signal into a perceptually more salient signal.
- F. RATIONALE: Modern signal-processing techniques enhance sonar operator performance by computer manipulation of the target's auditory signal into a visual display. Every visual stimulus can be broken down into a set of component sinusoidal gratings of various frequencies, amplitudes, and orientations. These can be transformed into different waveforms and then resynthesized into a visual image. The aim of this research would be to determine if such transformations result in a more salient visual image — that is, in a more detectable target for the sonar operator. If so, we would investigate whether there are any general principles which govern the transformation of any sonar signal into a more detectable visual target.
- G. TECHNICAL APPROACH: High-quality analog signals taken from recordings made at sea will be presented to observers both in their original form and filtered versions. Target detectability will be compared for the various presentations. Results with laboratory observers will be confirmed with experienced sonarmen.
- H. EXPECTED PRODUCTS/USERS: This research should produce specifications for computer transformations of sonar signals which will result in greater visual saliency and target detectability. The results will be used by system designers and ultimately by sonarmen.
- I. OTHER ORGANIZATIONS INVOLVED: NUSC and the submarine operational forces.

J. FUNDING REQUIRED BY FISCAL YEAR: (\$000)

	FY92	FY93	FY94
In-House Personnel/Overhead	120	110	115
Contracts	0	0	0
Automatic Data Processing	20	10	10
Equipment	60	5	0
Miscellaneous	5	5	5
Military Construction	0	0	0
Special Projects	0	0	0
Total	205	130	130

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available for
this Work

Military Officer	0	0	0
Military Enlisted	.2	.2	.2
Civilian (GS-180-12)	.4	.4	.4

Additional Manpower Required
for this Work

Civilian (GS-180-11)	.4	.4	.4
(GS-180-05)	.4	.4	.4
Total Requirement	1.4	1.4	1.4

II. NEW STARTS (Q)

- A. TITLE: Three dimensional sonar and fire control displays
- B. PROPOSED PROGRAM ELEMENTS:
- C. STATUS: New start
- D. PROPOSED START DATE: FY92
- E. OBJECTIVE: To improve the localization of sonar contacts through the use of three dimensional and perspective visual displays.
- F. RATIONALE: Certain sonar and fire control visual displays locate own ship relative to external landmarks or contacts. This information is currently displayed in a two dimensional visual representation that is frequently difficult for the operator to interpret. With new computer imaging techniques it is now possible to present this same information as a three dimensional display with the position of own ship clearly depicted. This added dimension improves the ability of the user to detect the targets presented on the display and to locate them relative to own ships heading in both distance and relative depth. This research will evaluate the use of three dimensional and perspective displays for possible adoption for use on critical US Navy submarine displays such as sonar or fire control. The role of color coding in improving performance will be also evaluated.
- G. TECHNICAL APPROACH: Different visual displays will be generated on the RAMTEK visual display monitor. These displays will be either two or three dimensional. Volunteers will be asked to detect contacts and to locate them in space on several different displays. Response times and number of errors will be measured. Both conventional and three dimensional (perspective) displays will be evaluated. Performance in multicontact scenarios will be included in the evaluation. In a second phase color coding of different types of contacts will be employed in conjunction with perspection.
- H. EXPECTED PRODUCTS: This research would result in greatly improved design of visual displays with subsequent improvement in the ability of the submarine to detect, locate and evade or attack contacts.

I. OTHER ORGANIZATIONS: None

J. FUNDING BY FISCAL YEAR: (\$000)

	FY92	FY93	FY94
In-House Personnel/Overhead	134	138	142
Contracts	0	0	0
Automatic Data Processing	10	10	10
Equipment (task funded)	20	0	0
Miscellaneous	10	10	10
Military Construction	0	0	0
Special Projects	0	0	0
Total	174	158	162

K. PERSONNEL REQUIRED BY FISCAL YEAR:

Onboard Manpower Available for this Work	FY92	FY93	FY94
Military Officer	0	0	0
Military Enlisted	.5	.5	.5
Civilian (GS-180-13)	.4	.4	.4
Subtotal	.9	.9	.9
Additional Manpower Required for this Work			
Civilian (GS-180-11)	.8	.8	.8
(GS-180-5)	.8	.8	.8
Total	2.5	2.5	2.5

SUMMARY TABLE FOR ADDITIONAL PERSONNEL

	FY91	FY92	FY93	FY94	FY95
Auditory classification					
Military Officer	0	0	0	0	
Military Support	.2	.2	.2	.2	
Civilian Professional	1.0	1.0	1.0	1.0	
Civilian Support	.6	.6	.6	.6	
Total	1.8	1.8	1.8	1.8	
Auditory detectability					
Military Officer	0	0	0	0	
Military Support	.4	.4	.4	.4	
Civilian Professional	.8	.8	.8	.8	
Civilian Support	.4	.4	.4	.4	
Total	1.6	1.6	1.6	1.6	
Stress proteins					
Military Officer	.8	.8	.8		
Military Support	0	0	0		
Civilian Professional	0	0	0		
Civilian Support	.8	.8	.8		
Total	1.6	1.6	1.6		
Transmitting sonars					
Military Officer	0	0	0	0	0
Military Support	0	0	0	0	0
Civilian Professional	.8	.8	.8	.8	.8
Civilian Support	0	0	0	0	0
Total	.8	.8	.8	.8	.8
Joysticks					
Military Officer	0				
Military Support	0				
Civilian Professional	.6				
Civilian Support	0				
Total	.6				
Acoustic habitability					
Military Officer	0	0	0		
Military Support	0	0	0		
Civilian Professional	.1	.1	.1		
Civilian Support	.2	.2	.2		
Total	.3	.3	.3		
CRT displays					
Military Officer	0	0	0		
Military Support	0	0	0		
Civilian Professional	.8	.8	.8		
Civilian Support	.8	.8	.8		

Total	1.6	1.6	1.6		
	FY91	FY92	FY93	FY94	FY95
EKG evaluation of arrhythmias					
Military Officer	0	0	0		
Military Support	0	0	0		
Civilian Professional	0	0	0		
Civilian Support	0	0	0		
Total	0	0	0		
Performance assessment					
Military Officer	0	0	0	0	0
Military Support	.4	.4	.4	.4	.4
Civilian Professional	.4	.8	1.6	1.6	1.6
Civilian Support	.8	.8	.8	.8	.8
Total	1.6	2.0	2.8	2.8	2.8
Periscope scanning					
Military Officer	0	0			
Military Support	0	0			
Civilian Professional	.8	.2			
Civilian Support	1.6	.2			
Total	2.4	.4			
Immune system					
Military Officer	0	0	0		
Military Support	0	0	0		
Civilian Professional	.8	.8	.8		
Civilian Support	0	0	0		
Total	.8	.8	.8		
Atrial septal defects					
Military Officer	0	0			
Military Support	0	0			
Civilian Professional	0	0			
Civilian Support	0	0			
Total	0	0			
Cellular bioengineering					
Military Officer			.8	.8	.8
Military Support			0	0	0
Civilian Professional			0	0	0
Civilian Support			.8	.8	.8
Total			1.6	1.6	1.6
Fire gases					
Military Officer		0	.5	.5	
Military Support		0	0	0	
Civilian Professional		0	0	0	
Civilian Support		.8	.8	.8	
Total		.8	1.3	1.3	

FY91 FY92 FY93 FY94 FY95

Evaluation of HP9000

Military Officer	0	0	0
Military Support	0	0	0
Civilian Professional	.8	1.2	1.2
Civilian Support	.5	.5	.5
Total	1.3	1.7	1.7

Fourier transforms

Military Officer	0	0	0
Military Support	0	0	0
Civilian Professional	.4	.4	.4
Civilian Support	.4	.4	.4
Total	.8	.8	.8

3-D sonar displays

Military Officer	0	0	0
Military Support	0	0	0
Civilian Professional	.8	.8	.8
Civilian Support	.8	.8	.8
Total	1.6	1.6	1.6

III. EQUIPMENT AND FACILITIES:

A. Equipment: (\$000)

	FY90	FY91	FY92	FY93
Work Unit Equipment				
New (over 5K)	62	104	110	0
Replacement				
General Purpose Equipment				
New	100.7			
Replacement				
GRAND TOTAL	162.7	104	110	0

Identification and Justifications for items over 5K

FY90: New Work Unit Equipment.
Hearing conservation:
 Dual channel real time frequency analyzer 32,200
 Multiprogrammer 16,000
 Head and torso simulators 14,000
 subtotal 62,200

FY90: New General Purpose Equipment.
Graphics plotting system 16,000
Microvax II interface 25,200
Programmable array processor 38,200
Medical diagnosis computer support 21,300
 subtotal 100,700

FY91: New Work Unit Equipment
Hearing conservation:
 MK 12 helmet 6,000
 10 kW amplifier and ancillary equipment 21,000
Underwater projectors 26,000
Signal generator, 2 Hz to 200 kHz 23,000
Graphics recorder 28,000
 subtotal 104,000

B. Facilities:

	FY89	FY90	FY91	FY92	FY93
1. Military Construction	0	80	190	0	0

(\$000)

Military Construction (MILCON):

FY91-92 NSMRL requested funding to replace the current laboratory spaces with a new building, in the Long-Range Military Construction Plan submitted in March 1989. This new facility will replace the current three laboratory buildings, which are inadequate for some current and much of the lab's projected research. The new building will allow for improved sonar research, using an improved Sonar Simulation Suite and more realistic submarine environmental simulations, through the use of a highly-sophisticated Crew Performance (Physiological and Psychological) Facility. In addition, an improved anechoic chamber area will allow for more comprehensive research in hearing conservation and headphone development for sonar operators, and a larger Diving Simulation Facility will enable more complex long-term research to be conducted in the areas of submarine escape and rescue. Also, significantly larger laboratory spaces and computer facilities will provide much-improved data collection and analysis opportunities. The new facility will encompass approximately 65,000 square feet of space and construction is scheduled to begin (according to NMRC's Synopsis of RDT&E Strategic (Long Range) Construction Plan submitted in May 1989) in 2003 at a cost of \$25M.

	FY89	FY90	FY91	FY92	FY93
2. Special Projects	637K	432K	20K	175K	25K

FY89: Building 156 Non-electrical improvements. Building 156 is the only building at NSMRL that has not had extensive renovation. Much of the interior is over 40 years old. The windows, in particular, are in very poor condition, and many of them do not close properly. In addition, space must be set aside and renovated especially for subjects, so experiments can be carried out on multiple subjects simultaneously and in privacy. This, as well as other identified changes, will require renovation and movement of partitions. The work was scheduled to begin in FY89, but other work in the building, specifically electrical renovations, precluded us from getting this work underway. We are currently waiting for the A&E to be conducted, so the actual work can begin in FY90, at an estimated cost of \$15K for the A&E and \$150K for the renovation work.

Building 141 Renovation of the Anechoic Chamber. This complex has not been used heavily for several years, mainly because of leakage of water through the roof and the possible presence of fiberglass particles in the air. Now, however, there is project work that will require, at some time, the use of this facility. The initial A&E for dismantling the facility has been completed and the A&E for rebuilding the chamber is partially completed. The latest figures available are approximately \$440K to complete both phases of the project (rip-out and re-build) in FY90.

Building 141 Installation of HVAC in Animal Facility. This project was to be completed in FY89, but the change in Public Works' contracting procedures precluded our getting a contract let this FY. The command went back to NMRDC and requested that the money for this work be reprogrammed for next FY. Currently, Public Works is waiting for the laboratory to notify them of the availability of funding for next year, so they can begin the contracting process. The project is scheduled to be completed in FY90; at an estimated cost of \$85K.

Building 148 Renovation of Library Spaces. The laboratory's library is in need of considerable renovation. The floor supports need checking, new lighting installed, and additional space is desperately needed, both for periodicals and books, as well as for study and writing space. The A&E process is underway, and the project should be completed in FY90, at an estimated cost of \$80K.

Building 141 Miscellaneous Improvements. A variety of improvements need to be carried out. Old windows need to be replaced, the electrical system needs to be upgraded, some new office spaces are required, the entrance ramp must be modified to allow entry by handicapped personnel, and the existing dumbwaiter facility needs to be repaired and modified. We are in the process of specifically identifying the tasks to be completed, so the A&E process can begin. The job is scheduled to be completed in FY90, at the estimated cost of \$8K for the A&E and \$45K for the renovations.

Building 148 Renovation of Head Facilities. The head facilities in building 148 are totally inadequate. There is a ladies' facility on the second deck and a men's facility on the first deck. Neither of these contains a shower. The only shower facilities in the building are located in the basement, and are under the cognizance of the Dental Clinic, and cannot be reached without going outside of Building 148. In the existing

heads, the plumbing is old and requires frequent repairs, and there are no handicapped facilities in the building. The A&E process is slated to begin soon, at an estimated cost of \$4K, with renovations to be completed in FY90, at an estimated cost of \$50K.

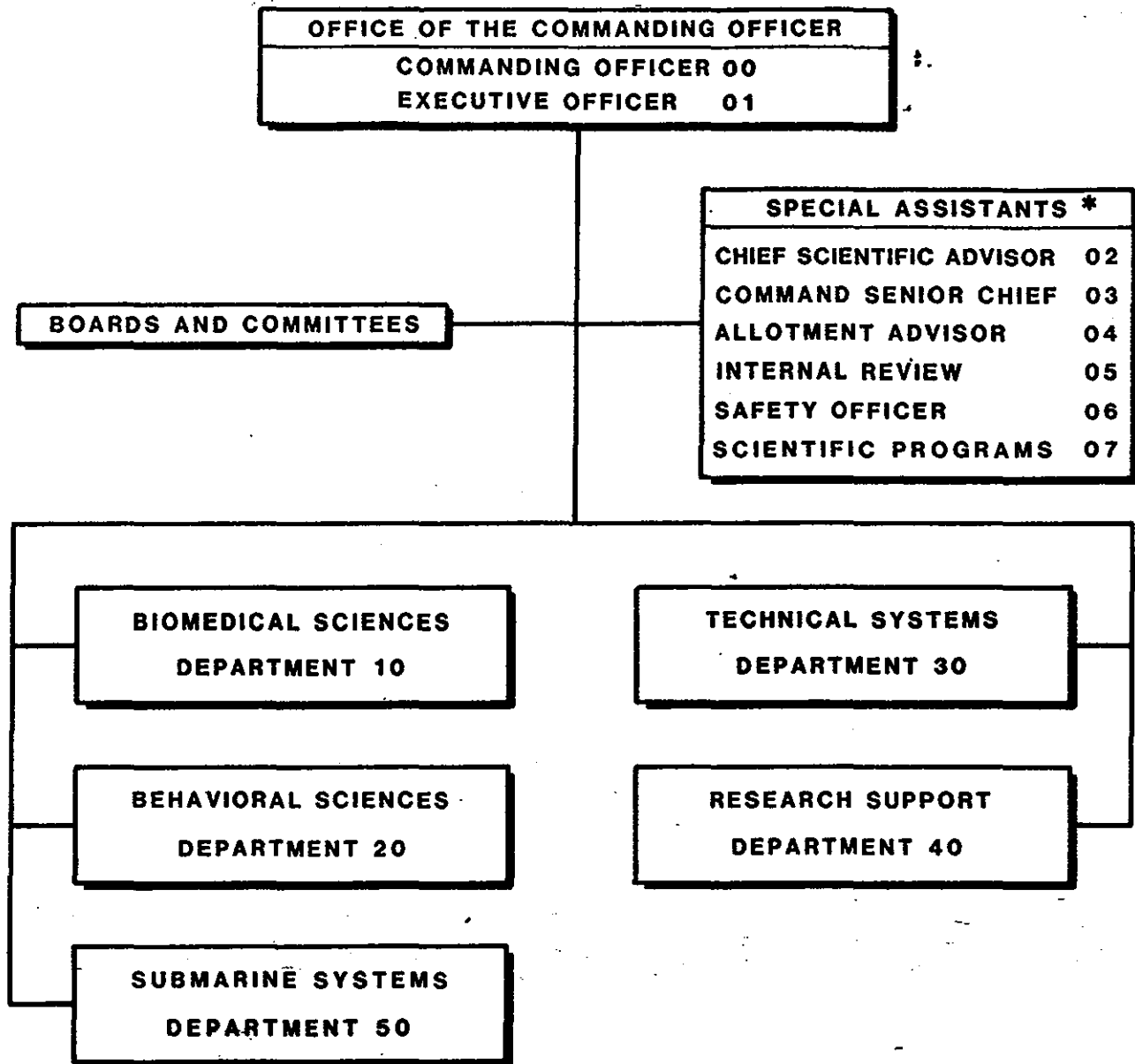
FY90: Building 148 Upgrading of Electrical Wiring. The current wiring in this building is inadequate for the amount of electrical equipment being utilized. This is especially true since personal computer workstations have been introduced, as part of the laboratory's addition of an ETHERNET Local Network. When more than a minimum of equipment is turned on, the circuit breakers begin blowing, shutting everything down, until they are reset. This removes everything that has been put on a computer, that has not been saved, as well as causing electrical problems with the printers. This work is scheduled to begin in FY90, with the work being completed during that FY or in early FY91. The estimated A&E cost is \$20K.

Building 148 Installation of a Handicapped Ramp. As it now stands, handicapped personnel cannot easily enter this building. Since the building already has a catwalk leading into it from the rear, it would be a simple matter to add sloping ramps to the ends of the catwalk. This work will be completed during FY90, with the A&E costs estimated at \$2K.

FY91: Building 148 Storeroom Renovation. The storeroom in the basement of Building 148 leaks when it rains, endangering our stored files and equipment. This work is scheduled to begin in FY91, with work completed in FY92. The estimated cost is \$60K for the A&E and the renovations.

IV. MANAGEMENT AND SUPPORT NA

V. LABORATORY ORGANIZATION



* COLLATERAL DUTY

DATE: 17 May 1989	APPROVED: <i>Clarence A. Harvey</i> COMMANDING OFFICER C.A. HARVEY, CAPT. MC USN
NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND	NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

VI. FISCAL SUMMARY: (\$000)

Program Element	Task Title	FY89	FY90	FY91	FY92	FY93
61152N	Independent Research					
	Event related potentials	50	77	0	0	0
	Analysis of problems	0	141	138	138	0
	[Directors Fund submission]					
	Subtotal	50	218	138	138	0
	Cell culture modeling	114	126	136	148	0
	Subtotal	114	126	136	148	0
63706N	Sea trials	375	400	400	0	0
	Digital sonar*	200	0	0	0	0
	[*transitioned to 6.5 in FY90]					
	Subtotal	575	400	400	0	0
63713N	Submarine rescue	420	428	434	452	484
	Hearing conservation	0	204	398	418	411
	Subtotal	420	632	832	870	895
65856N	Auditory sonar	410	480	480	480	610
	Visual sonar	290	468	470	470	570
	Digital sonar	0	251	250	251	220
	Subtotal	700	1199	1200	1201	1400
TOTAL DIRECT		1859	2575	2706	2357	2295
61153N	ONR - Auditory classification	119	59	0	0	0
1GAV600	VA - Psychophysical procedures	48	52	24	0	0
TOTAL REIMBURSABLES		167	111	24	0	0
GRAND TOTAL		2026	2686	2730	2357	2295

VII. PERSONNEL SUMMARY FY90 - FY93

A. Task related: (Work years)

	FY89	FY90	FY91	FY92	FY93
Military Officer:	6.3	7.0	7.6	7.6	7.6
Military Enlisted	7.2	9.1	9.1	9.1	9.1
Civilian Professional	10.9	14.7	15.5	17.1	17.5
Civilian Support	9.1	11.5	15.5	15.5	15.9
Sub-Total	33.5	42.3	47.7	49.3	50.1

B. Administrative Services (Work Years)

	FY89	FY90	FY91	FY92	FY93
Military Officer	3.6	3.4	3.6	3.6	3.6
Military Enlisted	4.5	4.5	4.5	4.5	4.5
Civilian Professional	1.7	1.7	1.7	1.7	1.7
Civilian Support	7.3	8.9	9.7	10.5	10.5
Sub-Total	17.1	18.5	19.5	20.3	20.3
TOTAL COMPLEMENT	68.0	76.0	84.0	87.0	88.0

VIII. ISSUES

CIVILIAN STAFFING - The civilian work force at the Naval Submarine Medical Research Laboratory has shrunk in size over the past eight years from an average of 85 employees, with a peak staff of 91 in FY85 and FY86, to a current level of 69 individuals. Present staffing levels, research programs, and funding are lower than we consider necessary to conduct the best research and to justify the administrative support necessary to accomplish our mission. Multiple factors have contributed to this shrinkage. Several core programs have been terminated or transferred from this laboratory without replacement by other programs. Attendant funding cuts and hiring restrictions, imposed by our parent command, have made it impossible to replace personnel lost by natural attrition. The laboratory has also lost several senior scientists through retirement and death. These leadership positions must be filled as soon as the restrictions are lifted and funding is assured. The laboratory has temporarily assigned several staff members to research projects outside of their primary area of expertise, in an effort to redress the imbalances and to maintain our broad spectrum of expertise. We have also proposed several research programs which would produce worthwhile products and more appropriately use these scientists. However, selected reductions in force may be necessary if proposed work units are not approved for FY90 and mismatches of expertise continue.

MILITARY STAFFING - During FY89, three of the five Medical Corps Officers have or will be transferring or retiring without projected replacements. The Medical Corps Officer, serving as Commanding Officer, will be replaced by a Dental Corps Officer. In FY90, both the Fiscal Officer and the Administrative Officer are scheduled for rotation. With the shortage of senior civilian staff members, the experience of the staff is becoming critically low. As this situation declines, the impact is a severe loss of corporate memory and a furtherance of the critical imbalance between scientific and support staffs.

The saturation diving program utilizes all staff enlisted members as watchstanders for chamber operations. This demands an extensive training and qualification program in chamber operations. Such a program is man-hour intensive. To allow for maximum efficiency of operation and ultimately, program expansion, staffing the laboratory with a cadre of well-trained divers would appear to be in order. The laboratory had requested 10 such billets but there is little hope of their creation without support of higher echelons.

FUNDING - Funding levels have fluctuated and the full utilization of these monies has been possible only late in the fiscal year. Thus, the laboratory has had to function with a great deal of command-directed work unit expenditures and staffing. Timely

commitments and obligations have been extremely difficult. It would be highly desirable to receive funding in each work unit at the beginning of the fiscal year, to allow cost center management by investigators and departments. In addition, 70% of the equipment and supplies purchased this year have been ordered using prior year funds. FY89 fund balances are projected to be small and use of prior year funds available during FY90 will be minimal. This will result in a very restricted FY90 funding year with substantial shortfalls in manpower, equipment, material, travel, training needs, and potentially, severe slippage in research milestones.

SUBASE SUPPORT - Support by FWC on the submarine base has been marginal due to their shortage of funds and staff. An additional problem is poor contract preparation and supervision of contractor performance. We will continue to work as closely as possible with them, but there seems to be little hope of significant improvement in their support, in view of the obvious necessity to support the operational submarine force as their top priority.

NEW RESEARCH - We have proposed several new starts for FY90 and FY91. We would welcome additional or alternative suggestions by program managers, in terms of research needs perceived for the operational forces and within the laboratory's capabilities.

READINESS - Mobilization planning for our military staff and for logistic support of our programs is very ill-defined. Efforts to correct this problem have been stalled by the lack of a war-time mission for this command. In the event of a war-time scenario, we anticipate that our resources (personnel, property and funding) will be redistributed, but the extent of redistribution has not been identified. Until this is done, the subsequent impact cannot be evaluated nor can contingency plans be developed. We have been directed by NMRDC to hold the updating of our laboratory mobilization instruction in abeyance, until NMRDC has completed the update of their own instruction.

ANNEX A. Information Systems Five-Year Plan

1. ADP Environment

The contracting process initiated in FY88 for the installation of a CODENOLL passive fiber optic star network connecting the three buildings that house NSMRL has resulted in a contract with the FUSION DATA COMM company of Norwalk, CT. Work on the project began the week of May 22 with all hardware line items delivered at that time. Assurances notwithstanding, the anticipated network bridge from NUSC has not materialized at this time and meetings are scheduled between NUSC and FUSION to identify possible alternative links between the two LANs. A minor modification or engineering change order to the contract may be required to detail the final configuration. Completion of the first year installation is scheduled for June, '89 with additional expansion for more PC nodes planned before the end of FY89.

The VAX 11/750 and the 11/730 will be the primary hosts for general purpose computing on the network. the 750 will continue to provide SPSSX, INFOCEN, CTOS and the recently installed WORDPERFECT. The 730's new availability will make it a viable alternative to the 750 for similar functions and file service. Each VAX will be an ideal backup for the other as the network terminal servers will route users to either independently. Both are on the 15KVA uninterruptable power supply (UPS) so they will remain running during power outages.

With the network structure established, adding appropriate host nodes to perform specialized operations that can be off-loaded from the existing two VAXes has begun. After extensive revision, NMRDC approved ASDP # 89-01 in March of '89. This proposal called for procurement of a new node with the highest CPU numerical processing power available for the funds allocated. In this case, the delayed approval worked to our advantage as it placed us in the thick of a major performance and price war among the industry's top players. Digital Equipment Corp, for example, announced the DECSYSTEM RISC (reduced instruction set computer) family of processors in early '89. SUN MICROSYSTEMS then countered with an equally attractive line of processing servers, the SPARC SYSTEM family. Unfortunately neither vendor will allow running of customer benchmarks, so careful evaluation of published industry-standard benchmarks is necessary to identify the best price performance offering. Final procurement will begin in June, 89 off new GSA contract listings.

With all the activity in networking and scientific processing, the area of desktop publishing and office automation lost attention in 1988-89 and the planned acquisition of a publishing station did not occur. Failure to replace a critical position in the Computer Applications Division for the second year running was the reason

Laser printer (2) A90605A word processing applications
A90621B

VAX node replacement

The most constant need that shows no signs of changing into the future is for skilled programming and systems people. Estimations of the scientific programming load alone for FY90 run to twice the available staff and beyond. As hardware proliferates throughout the Laboratory, requests for assistance, instructions, maintenance, security, and training escalate far above the available capacity. Reorganizing the Computer Applications Division does no good, if new individuals are not hired to fill the created slots.

a) Systems costing greater than \$5000:

A programmable array processor with numerical functions built in for general two-dimensional image processing: FFT, 16 color planes, edge enhancement. Capable of 1200x1200 16-bit pixel computations at minimum double precision floating point benchmark (LINPAK double precision

MFLOPS) of 15. Standard function subroutine library callable from Fortran or C languages.

A90605B 25.2 (general purpose) data storage, digital IO

Dual 150 Mbyte fixed disk storage drives compatible with existing microVAX disk controller unit and chassis, installation included. Sixteen-bit digital input/output ports, real time clock, software library compatible with VAX/VMS operating system and Fortran language.

A90605J 22.9 (general purpose) medical diagnosis, computer support

Three program development workstations for support of in-fleet software during seatrials. Compatible data storage media with that available aboard ship, tape backup system, 2400 baud modem for communications/data exchange when ships are in port.

A90605I 16.0 (general purpose funds) SPSSXGRAPHICS plotting

PC/AT or compatible with 91-mbyte hard disk, high resolution color display, VGA graphics controller, Ethernet, HP Laserjet II plotter. To support SPSSXGRAPHICS software now running on VAX11/750 at cost of 7.0k per year.

A90605H 11.1 (overhead funds) Enet PAL PDP11 machines interface

The Psychoacoustics Lab (PAL) PDP 11 computers control experiments and collect data that must be send to other processors in the network. A TCP/IP compatible ethernet interface device with appropriate software compatible with the RT11 operating system of the PAL machines and the VAX/VMS OS on the VAX's is required.

A90605D 12.2 (overhead funds) PC's for Computer Applications

PC/AT compatible systems (2) with appropriate MSDOS applications for fiscal, administrative, and scientific office automation. For use by Computer Applications Division personnel.

A90605E 7.2 (overhead funds) Enet expansion, yr 3

TCP/IP Ethernet hardware interfaces for existing PC/AT machines with MSDOS software compatible with VAX/VMS. File server software to run on VAX and provide transparent disk/backup services to PC's.

A90605C 14.2 (overhead funds) Desk top publishing

Single user workstation with Postscript laser printer compatible with NSMRL/NMRDC standard word processing package, Word Perfect, and standard publishing package, Ventura Publishing.

b) Systems or enhancements costing less than \$5,000:

A90424A	2.5 (work unit funds)	data storage, backup
A90424B	4.6 (work unit funds)	real time experiment control
A90605A	1.8 (overhead funds)	laser printer
A90424C	0.9 (overhead funds)	dot matrix printer
A90605F	0.6 (work unit funds)	graphics terminal
A90621A	2.7 (overhead funds)	laser printer
A90621B	4.9 (work unit funds)	program development workstation
A90621C	3.2 (work unit funds)	program development workstation

6. Summary of Total IS-Related Costs (\$000)

	FY90	FY91	FY92	FY93	FY94
NEW ADP	45.4	30	35	40	45
EXP/RPL ADP	36.5	30	32.5	35	37.5
OTHER EQ/SOFT	45.0	45	47.5	50	52.5
SUPPLIES	14	14	14	15	16
CONTRACTS	66.4	70	72.5	75	77.5
TRAVEL	6	6.5	7	7.5	7.5
ADP STUDIES	11	12	13	14	15
SALARIES	245	249	252	255	258
TOTAL	469.1	456.5	473.5	491.5	509.0

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NSMRL Special Report 89-3			5. MONITORING ORGANIZATION REPORT NUMBER(S) NA		
6a. NAME OF PERFORMING ORGANIZATION Naval Submarine Medical Research Laboratory		6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Naval Medical Research and Development Command		
6c. ADDRESS (City, State, and ZIP Code) Box 900, Naval Submarine Base NLON Groton, CT 06349-5900			7b. ADDRESS (City, State, and ZIP Code) NMC NCR, Bethesda, MD 20814-5044		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Same as 7a.		8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) Same as 7b.			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO. NA	PROJECT NO.	TASK NO.
					WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) Five Year Plan					
12. PERSONAL AUTHOR(S) Naval Submarine Medical Research Laboratory Staff					
13a. TYPE OF REPORT Special		13b. TIME COVERED FROM 1990 TO 1994		14. DATE OF REPORT (Year, Month, Day) 15 July 1989	
15. PAGE COUNT 79					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Five Year Plan		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This publication is the Command Five Year Plan for fiscal years 1990-1994.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION		
22a. NAME OF RESPONSIBLE INDIVIDUAL S. D. Monty, Publications Office			22b. TELEPHONE (Include Area Code) (203) 449-3967		22c. OFFICE SYMBOL 421