# Naval Submarine Medical Research Laboratory

**NSMRL Special Report 91-2** **1 OCTOBER 1991**

AD-A242 229

# FIVE YEAR PLAN
# FOR
# Fiscal Years 1992-1996

*S. D. Monty, Editor*

Released by:
R. G. Walter, CAPT, DC, USN
COMMANDING OFFICER
Naval Submarine Medical Research Laboratory

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91-14908

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# FIVE YEAR PLAN
# 1992-1996

for

## NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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S. D. Monty

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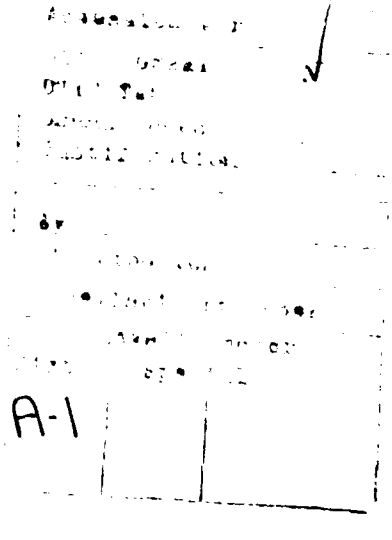


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CHART 1
AUDITORY AND VISUAL DISPLAYS

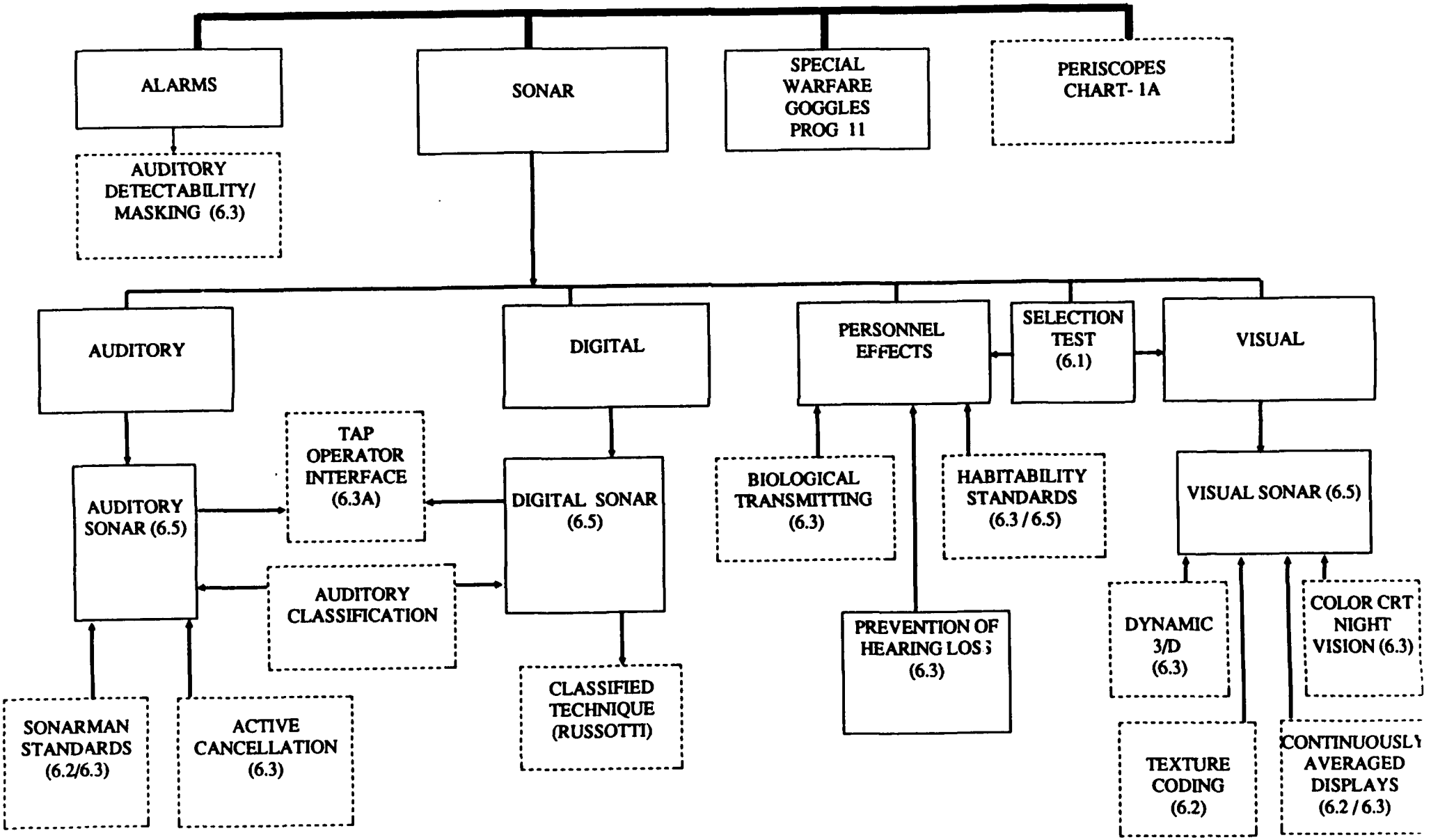


CHART 1A

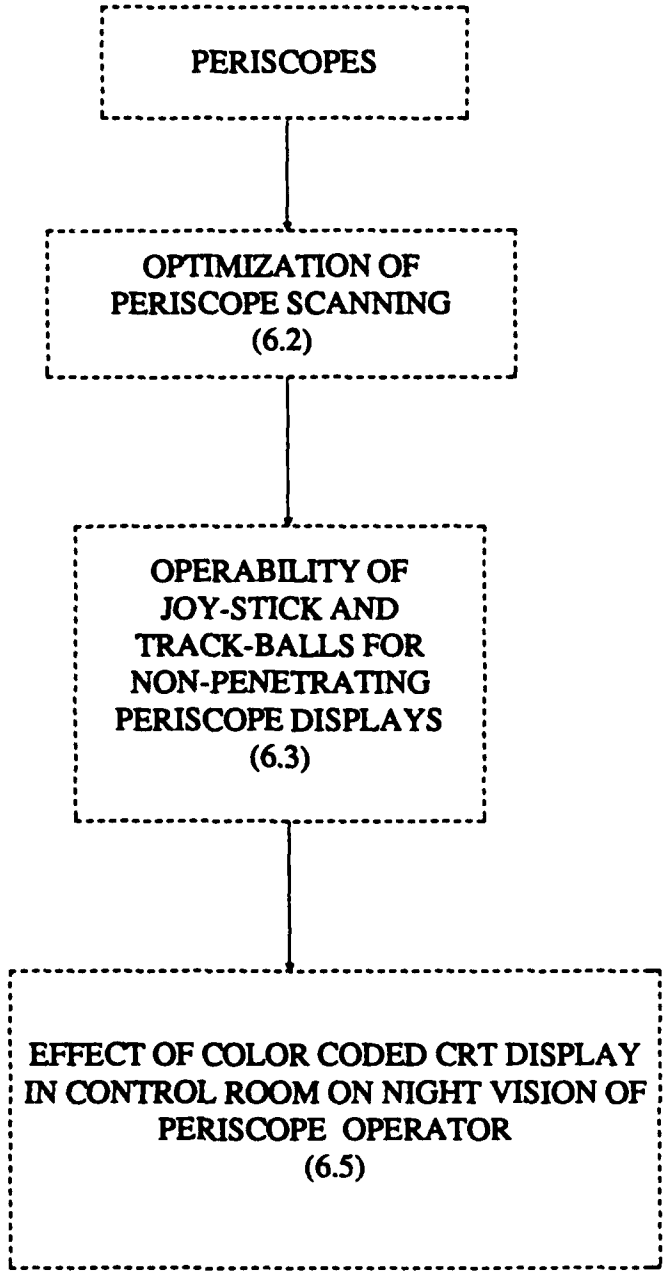
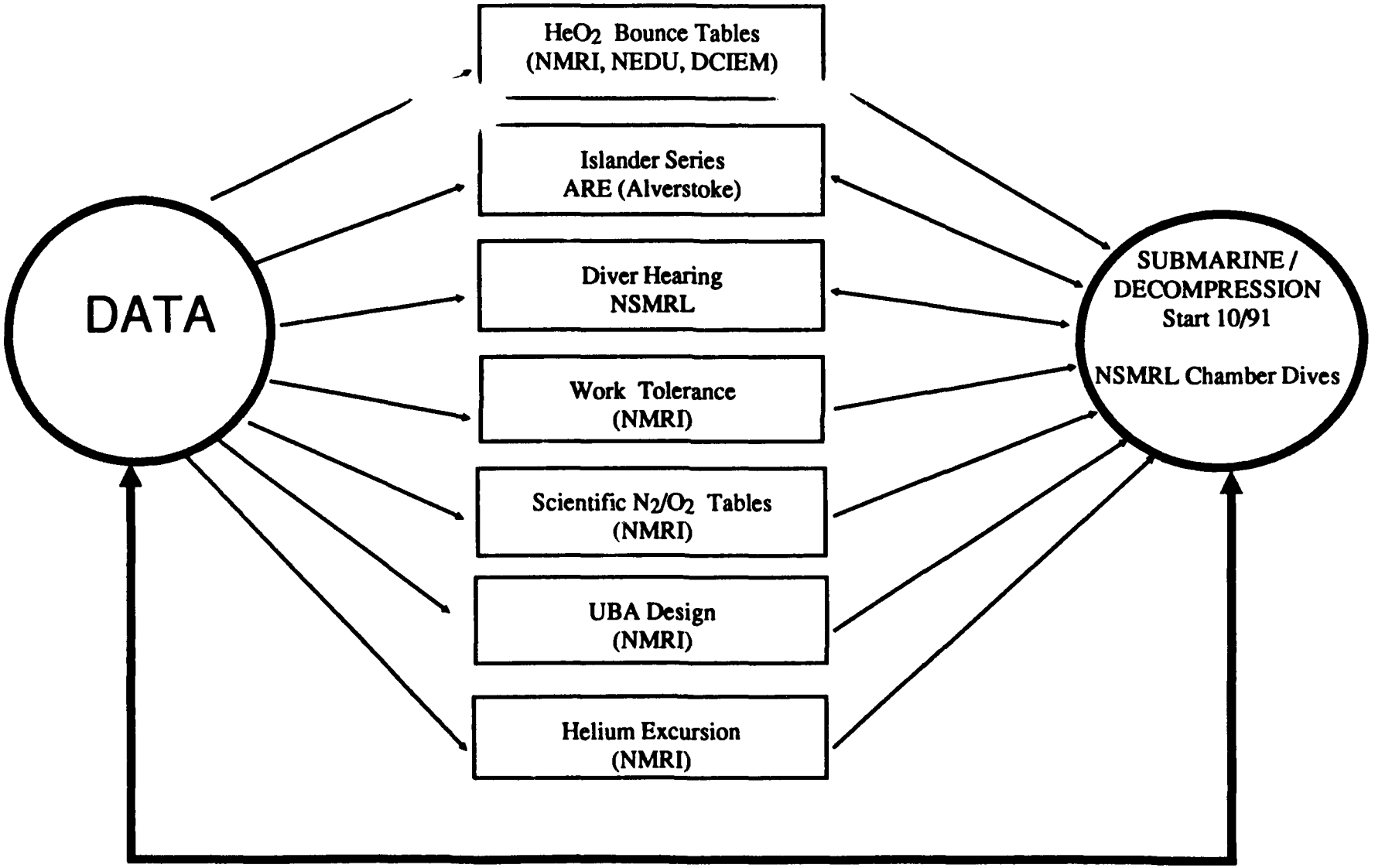

PERISCOPES
OPTIMIZATION OF PERISCOPE SCANNING (6.2)
OPERABILITY OF JOY-STICK AND TRACK-BALLS FOR NON-PENETRATING PERISCOPE DISPLAYS (6.3)
EFFECT OF COLOR CODED CRT DISPLAY IN CONTROL ROOM ON NIGHT VISION OF PERISCOPE OPERATOR (6.5)

CHART 2
HYPERBARICS




Note: Connections to NMRI efforts apply also to planned new starts / follow-on work units.

## FY 91 WORK UNIT LIST

| | |
|---|---|
| 61153N MR04101.001-5014 | Cell culture modeling of neurophysiological pathology and brain associative processes. |
| 62233N M3P30 .006-5101 | An evaluation of alternative symbolic designs for maritime tactical displays. |
| 63706N M0095.005-5010 | Submarine deployable computer based system for enhancing medical practice, performançe, and quality. |
| 63706N M0095.005-5102 | Evaluation of field clinical laboratory equipment for Fleet Marine Force. |
| 63706N M0095.005-5104 | Analysis of vision problems aboard submarines |
| 63706N M0095.005-5105 | Performance enhancement for submarine systems using human factors principles and techniques |
| 63706N M0096.002-5103 | The effects of operational stressors on team performance during continuous/sustained naval submarine operations. |
| 63713N M0099.01A-5012 | Medical problems associated with pressurized submarine rescue |
| 63713N M0099.01C-5050 | Development of a general hearing-conservation standard for diving operations |
| 64771N M00933.001-5106 | Evaluation of technology for the production of sterile pyrogen-free fluids for injection. |
| 65856N M0100.001-5001 | Auditory sonar. |
| 65856N M0100.001-5003 | Enhanced performance with visual sonar displays. |
| 65856N M0100.001-5051 | Digital signal processing for auditory sonar. |
| 65856N M0100.001-5110 | Human factors evaluation of non-penetrating periscope. |
| COAST GUARD (5202) | Investigation of the conspicuity of illuminated aids to navigation. |
| PMO 424 (5203) | Development of acoustic habitability standards for ship's spaces subjected to intense tones. |

II. NEW START (A)

1. Title: Comparison of Operability of Different Joysticks and Trackballs

2. Principal Investigator: S. M. Luria, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory,
Behavioral Sciences Department
Phone:
Autovon 241-2527
Commercial (203) 449-2527

4. Navy Need:

A large number and variety of joysticks and trackballs are commercially available. Eleven such joysticks were demonstrated to the committee set up to develop the new non-penetrating periscope. All have 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 diagnoal movement of the cursor, etc. Operators manipulate a joystick for long periods of time. Yet the accuracy of control and the amount of fatigue produced by each stick have not been measured.

5. Problem/Objective:

To compare the ease and accuracy of operation of a selection of joysticks and trackballs.

6. Technical Appraoch:

Subjects will view CRT displays requiring specific cursor adjustments such as would be required to lock on and track a target. Accuracy and speed will be measured, and subjects will rate the degree of fatigue at the end of each session.

Product: Determination of optimal joystick for various tasks

7. Assessment of Risk: None

8. Related Activities:

All human factors studies of speed and accuracy of eye-hand coordination are related.

9. Transition Approach:

The information would be available for designers incorporating joysticks in their equipment.

10. Resources Required:

| | FY92 |
|---|---|
| Funding required | 132.0 |
| Personnel required | |
| Military Officer | 0.0 |
| Military Enlisted | 0.0 |
| Civilian Professional | 0.6 |
| Civilian Supporting | 0.1 |
| Total | 0.7 |
| Additional personnel | |
| Military Officer | 0.0 |
| Military Enlisted | 0.0 |
| Civilian Professional | 0.0 |
| Civilian Supporting | 0.4 |
| Total | 0.4 |

11. Current References: NA

II. NEW START (B)

1. Title: Human Factors Evaluation of Non-penetrating Periscope

2. Principal Investigator: Thomas P. Santoro, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Behavioral Sciences Department
Phone numbers:
Autovon: 241-2445
Commercial: (203) 449-2445

4. Navy Need:

The Naval Sea Systems Command is developing a periscope (NHPP) which does not have an optical shaft penetrating the hull. Instead, information from the sensors mounted on an external mast is brought into the ship via fiber-optic cables and displayed on BSY-2 style CRT screens. The NHPP raises many human factors problems which must be resolved before optimal use can be achieved.

5. Problem/Objectives:

One problem is that of orientation with respect to own ship's course: the operator of a conventional periscope can tell in which direction, relative to the submarine, he is looking simply by noting in which direction he is facing in the control room. There is no similar way of orienting the line of sight of the NHPP from the CRT display (1). Another problem is that it is not known if the best way to scan with the periscope is continuously or in a stepwise scan. Another problem is to determine which sensor or combination of sensors is best for a given target detection or recognition task (2). The objectives of this research will be to find solutions to these types of problems.

6. Technical Approach:

Periscope scenes have been simulated on a high resolution display and observers perform typical search/surveillanace tasks as the line of sight is automatically scanned at different rates. To investigate the problem of orientation, the relative and/or true bearing of each target is indicated in several ways, and for each way, the maximum scan rate at which the operator can still detect both the target's presence and its bearing have been measured using a staircase threshold technique. Preliminary results show one class of bearing display allows performance to a significantly faster scan rate than the other types thus far examined. In a like manner, we plan to study continuous versus stepwise scanning with a wide field of view, virtual image display (3), explore various combinations of sensor video using a neural network model (4), and analyze the conceptual organization of target data by experienced operators (5).

Specific recommendations will be made as to the best method of indicating orientation, of scanning, of combining sensor video, and so on.

7. Assessment of Risk

There is the risk that the methods we identify to implement orientation, scanning, and other enhancements on the proposed periscope display will involve apparatus that requires too much space or for other technical reasons can not be adapted to the submarine environment. Also, it may turn out that, rather than improving things, some of the displays we try only add to the already significant problem of information overload on the human visual system.

8. Related Activities:

We have established an association with colleagues at the Air Force Armstrong Aerospace Medical Research Laboratory where extensive work has been done on helmet mounted virtual image displays with very wide field of view and head motion tracking. We believe there is a natural application for these devices in the NHPP evolution.

9. Transition Approach:

The development of the NHPP is being directed by NUSC/New London. Our results would be communicated to them for the purpose of incorporating our recommendations into the final design of the new periscope.

10. Resources Required (Funding category: first year 6.1, then 6.2)

| | FY92 | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|---|
| Funding Required | 308.0 | 465.0 | 309.0 | 298.0 | 288.0 |
| Personnel Required | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| Additional Personnel | | | | | |
| Consultant (AL, WPAFB) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

Cost includes 3-D helmet mounted projection system in FY94.

11. Current References:

1. Duff, J.M. (1987). A study for a low observable multi-sensor submarine mast system. Monterey, CA: Naval Postgraduate School.

2. McClumpha, A.J. , Baird, J. (1991). Viewing multiplexed sensor data: an experimental study. Digest of Society for Information Display, Vol 22, pp. 457-460.

3. Task, H.L. (1991). Optical and visual considerations in the specification and design of helmet-mounted displays. Digest of Society for Information Display, Vol 22, pp. 297-300.

4. Carpenter, G.A., Grossberg, S. (1987). A massively parallel architecture for a self-organizing neural pattern recognition machine, Computer Vision, Graphics, and Image Processing, Vol. 37, pp. 54-115.

5. Johnson, S.C. (1967). Hierarchical clustering schemes. Psychometrica 32: 241-254.

II. NEW START (C)

1. Title: Prevention of Hearing Loss in Navy Personnel

2. Principal Investigator: Lynne Marshall, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Submarine Systems Department
Phone Numbers:
Autovon: 241-2545
Commercial: (203) 449-2545

Other Laboratories Involved: NEHC

4. Navy Need:

To decrease the amount paid annually in compensation claims by the Navy for hearing loss.

To protect the hearing of Navy personnel so that their hearing losses do not exceed Navy standards for their job classification.

To increase net productivity of Navy personnel by decreasing hearing-associated performance loss.

5. Problem/Objective:

In FY89 DOD lost more than $200 million in compensation claims for hearing loss. Amounts expended have been increasing steadily over the last 20 years. The situation may become worse in the future. In the Navy, personnel whose hearing exceeds the Navy standards typically are given medical waivers, allowing them to continue working in areas where they are potentially exposed to high levels of noise. The Navy also does not include all noise-exposed personnel in hearing-conservation programs. For example, Navy divers currently are exempt even though their hearing is at risk.

Hearing losses that exceed Navy standards also may affect job performance. Audition plays a large role in many jobs and includes the ability to communicate with ease, especially in noisy environments, as well as the ability to perform specific auditory tasks, such as submarine sonar detection and classification. Even clerical jobs like computer data entry requires auditory feedback (the "click" each keystroke) for optimum performance. Therefore, hearing losses not only are a problem for future compensation claims, but have the more immediate effect of decreasing safety, productivity, and competence (i.e., fitness for duty).

Improvements to current hearing-conservation programs would reduce the amount of hearing loss. By identifying categories of jobs in which excessive hearing loss is occurring, it often is possible to implement noise controls for specific situations (e.g., output limiting for sonar systems). Hearing-protection fitting and usage problems would also become apparent. At present there is no known way to predict which individuals are most susceptible to hearing loss from noise exposure even though many approaches have been tried. Evoked otacoustic emissions, which are acoustic echoes caused by external sounds, may have predictive value. They are generated from outer hair cells in the cochlea (inner ear). The outer hair cells are the primary site of damage from noise exposure, and otacoustic emissions are sensitive indicators of outer hair cell function. Individuals who are most susceptible to noise could be identified early in their careers and assigned to jobs where they would be minimally noise exposed.

Specific objectives are to:

i) document the prevalence of hearing loss in Navy personnel;

ii) document how quickly hearing loss is progressing;

iii) determine whether individual susceptibility to hearing loss from noise exposure can be predicted; and

iv) make recommendations for hearing-conservation program improvement.

6. Technical Approach:

Annual audiograms for both civilians and military personnel in the Navy's hearing conservation programs are entered into the Hearing Examination and Audiometric Reporting System (HEARS) data base. This data base offers a powerful way to monitor and improve hearing-conservation programs. However, there is no current way of querying the data base for specific answers, or to compile all the information at one site. The first step in this project is to improve storage of the records so that all are accessible, and to develop software such that the data base can be accessed in helpful ways.

Various analyses would use the data in the current HEARS data base. One important analysis would be to determine the prevalence of hearing loss in particular job categories (as done by Marshall and Carpenter (1988) for submarine sonar technicians). The rate of change in hearing levels would be determined by examining individual hearing levels from a three-year period. Collection of additional longitudinal data would allow application of the American National Standards Institute (ANSI) draft standard, "Evaluating the effectiveness of hearing conservation programs." Unlike hearing monitoring for individuals, which compares current hearing thresholds in each successive year with an original baseline audiogram and factors in the amount of loss expected from aging, the audiometric data-base analysis compares sequential audiograms of a group over a relatively short period of time (e.g., a few years). Because of the short time frame, aging effects are minimized. The ANSI procedure is a powerful way of

evaluating the effectiveness of hearing-conservation programs because it determines the percentage of people who have threshold shifts and the variability of the threshold estimates between sequential audiograms taken during the normal work-day. Control populations, who are not exposed to noise at work, can be compared to those who are. Problems relating to job categories, work place (e.g., a particular ship), or hearing-conservation center (e.g., improper fitting of ear-protection devices) can be detected and remedied.

Otacoustic emissions may be more sensitive to inner-ear damage than an audiogram. Input-output functions (i.e., emission amplitude as a function of stimulus level) will be obtained for Navy personnel with good hearing but noise-exposure histories. These data will be compared with normative data on a non-noise exposed population to determine whether noise exposure influences the I-O function beyond what is predicted from hearing levels alone. Also, otacoustic-emission amplitude decrements and behavioral pure-tone threshold shifts resulting from exposure to high-level acoustic stimuli will be compared to determine which of the two measures is most sensitive to inner-ear changes. On the basis of emerging research in the area of otacoustic emissions as well as a growing body of research on "toughening" (in which certain prior noise exposures lessen the damage of subsequent exposures), an inner-ear stressor test using otacoustic emissions will be developed to determine whether susceptibility to noise can be predicted.

7. Assessment of Risk:

Development of the HEARS query program for the Navy and improvement of hearing-conservation strategies is straightforward and low risk. The development of an otacoustic-emission test that will predict susceptibility to permanent hearing loss is high risk because there is more than one cause for short-term alterations in otacoustic-emission amplitudes.

8. Related Activities:

The ANSI draft standard was issued in January, 1990, for a three-year trial period. Dr. Marshall can effectively monitor the progress of the ANSI draft standard as she chairs two ANSI committees, is the Naval Medical Command's Alternate Representative to ANSI S-3 and S-12, and interacts with the chair and vice-chair of the ANSI working group responsible for this standard. Dr. Susan Norton, an internationally-recognized expert in the area of otacoustic emissions, is currently a consultant to Dr. Marshall for otacoustic emissions work at NSMRL and would continue in that capacity for this project.

9. Transition Approach:

The results will be immediately available to hearing-conservation programs and to BUMED and thence to NEHC for implementation.

10. Resources Required (Funding Category 6.3):

| | FY92 | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|---|
| Funding required | 420.0 | 380.0 | 360.0 | 360.0 | 310.0 |
| Personnel required | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Civilian Supporting | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Additional Personnel | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.4 | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Supporting | 1.7 | 3.0 | 2.6 | 2.6 | 1.8 |

Major Equipment: Computers and otacoustic-emission equipment in years 1 and 2.

11. Current References:


Marshall, L., and Carpenter, S. (1988). Hearing levels of 416 submarine sonar technicians. NSMRL Report No. 1123.

Norton, S.J., and Hayes, J.M. (1991). Effects of prior acoustic stimulation on evoked otacoustic emissions." Paper presented at the Midwinter Meeting of the Association for Research in Otolaryngology, February, 1991.

Probst, R., Lonsbury-Martin, B.L., and Martin, G.K. (1991). A review of otacoustic emissions. J. Acoust. Soc. Amer., 89, 2027-2067.

Royster, J.D., and Royster, L.H. (1991). Using audiometric database analysis results to prevent occupational hearing loss. J. Acoust. Soc. Amer., 89, 1880.

Subramaniam, M., Campo, P., and Henderson, D. (1991). The effect of exposure level on the development of progressive resistance to noise. Hearing Research (In Press)

II. NEW START (D)

1. Title: Situation/Fatigue Stress and Man-Machine Systems

2. Principal Investigator: Karl F. Van Orden, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Vision
Phone numbers:
Autovon: 241-3772
Comm: 203-449-3772

4. Navy Need:

Most complex weapon and information systems are designed for the human operator working at maximum efficiency; little regard is given to even the most basic tenets of arousal stress reaction, such as narrowing of attention and perseveration on nonessential information. The incompatibility of man under stress-machine systems has played a part in such accidents as the U.S.S. Vincennes, Three Mile Island, and numerous aircraft incidents.

5. Problem/Objective:

The effects of stress on decision makers who must interpret complex and confusing information and interact with intricate man-machine interfaces is poorly understood. Current efforts within the Navy's Tactical Decision Making Under Stress (TADMUS) have offered little to the human factors community in the way of recommendations for interface design.

Man-machine systems are typically conceived within sterile laboratory environments and tested with subjects under ideal conditions. When prototypes appear promising, they might be put to test in a simulator/training environment. These situations feature rather generic scenarios of predictable engagement level and duration. Unfortunately, the real test for these systems, in terms of operator usability, hardware performance and maintainability, is at sea, well after the most flexible RTD&E stage is complete. In terms of usability, it is clear that some systems are easier to operate under crisis than others.

The goal of this research is to determine how stress effects performance and decision making within the realm of complex systems, and ultimately derive interface design concepts that take the man-under-stress into account.

6. Technical Approach:

The project will be a joint NSMRL-NOSC venture. Dr. Glenn Osga (NOSC Code 441) will be the collaborating investigator. A series of experiments will examine performance on the NOSC Navy Advanced Information Management Evaluation System (NAIMES); a scripted, unfolding Aegis-like tactical scenario that requires the user to answer questions by seeking out information within the display and make decisions regarding tactical action. Performance will be assessed under conditions of task overload (induced by time stress, task complexity, imbedded frustraters) under fatigued and rested conditions. Initial psychophysiological metrics will include heart rate data, while blood pressure, EEG, and eye movement/pupil monitoring will be assessed as candidate metrics as well. For cross validity, heart rate data will be compared to similar measures collected by NHRC researchers on Aegis crew members in training and during drills at sea. The physiological data would indicate the relative stress level imposed by the task, while the recorded performance data would identify those interface input/output characteristics that are most troublesome to the user.

Outyear projects would include expanding the NAIMES system to include multiple users in a small team format, since most Navy systems are distributed in design, and communication between team members under stress may prove to be an area in need of improvement. The implementation of a 3-dimensional sound capable headphone system (under development within the NSMRL Submarine Systems Department) has been identified as a likely design improvement within the CIC environment, and could be evaluated with a distributed NAIMES laboratory.

7. Assessment of Risk:

The protocol has been designed and funded at a level which minimizes technical risk. The greatest risk involves the design of realistic CIC tasks. NOSC has had considerable success in this regard, while subjective and objective indices of workload exist at present and can be implemented by NSMRL investigators.

8. Related Activities:

A preliminary investigation of the issues noted above is underway in NMRDC Work Unit 62233N.MM33P30.008-5101 (An evaluation of alternative symbolic designs for maritime tactical displays), thus this new start can be considered a transition plan for an existing IED program.

9. Transition Approach:

Initially 6.2 or 6.3 as MMI guidelines are developed. Work could transition to 6.4 or 6.5 if NAIMES is configured to mimic existing or proposed systems explicitly (eg. AN/BSY-2).

10. Resources Required (6.2 or 6.3):

| | FY92 | FY93 | FY94 |
|---|---|---|---|
| Funding required | 285.0 | 320.0 | 335.0 |
| Personnel required | | | |
| Military Officer | 0.5 | 0.5 | 0.5 |
| Military Enlisted | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.3 | 1.3 | 1.3 |
| Civilian Support | 1.0 | 1.0 | 1.0 |

11. Current References:


Hancock, P.A., and Warm, J.S. A dynamic model of stress and sustained attention. Human Factors, 31, 519-538, 1989.

Klein, G.A., Thordsen, M.L., and Calderwood, R. Descriptive models of military decision making. ARI Research Note 90-93; U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA, 1990.

Kramer, A.F. Physiological metrics of mental workload: a review of recent progress. NPRDC-TN-90-23; Navy Personnel Research and Development Center, San Diego, CA, 1990.

Van Orden, K.F., Osga, G.A., and Lauben, J. An evaluation of alternative maritime tactical display formats I: visual search. NSMRL Technical Report in preparation: Naval Submarine Medical Research Laboratory, Groton, CT.

Wellens, A.R., Grant, B.S., and Brown, C.E. Effects of time stress upon human and machine operators of a simulated emergency response system. work in progress poster presented at the Human Factors Society Meeting, Orlando, FL, October 1990.

Wickens, C.D. Attention. In P.A. Hancock (Ed.), Human factors psychology, pp. 29-80, 1987, Amsterdam: North-Holland.

Wickens, C.D. The integration of complex information from auditory and visual channels under stress. HEL Technical Note 5-90; U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD, 1990.

II. NEW START (E)

1. Title: Validation of a Sonarman Selection Test.

2. Principal Investigators: Christine Schlichting, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory,
Department: Behavioral Sciences Department
Phone numbers:
Autovon: 241-2527
Commercial: (203) 449-2527

4. Navy Need:

When NSMRL was founded, its original goal was to develop a selection test for sonarmen. Fifty years later, the need still exists-- in view of the high costs of sonar school--to be able to select those men who will make the most competent sonarmen. Ten years ago NSMRL developed a sonarman selection test battery which was subjected to a preliminary validation. In 1984, a cross-validation study was begun. We now propose to conclude that study.

5. Problem/Objective:

To develop a selection test for sonar school candidates

6. Technical Approach:

1984 an entering class of about 100 men at the sonar school, San Diego, took the NSMRL Sonarman Selection Battery. Their scores on this test battery will be correlated with the ratings of sonarmen by their peers, supervisors, and officers and with the career milestones (promotions, medals, awards, etc.) of those men who are still in the Navy. If possible, the records of those men who have resigned from the Navy will also be considered.

Eventual Product: A selection test for sonar school candidates

7. Assessment of Risk: None

8. Related Activities:

Selection tests are a pervasive feature of the military scene.

9. Transition Approach:

If these results are positive, a definitive study should be carried out leading to a valid selection test.

10. Resources Required:

| | FY92 |
|---|---|
| Funding required: | 121.1 |
| Personnel required | |
| Military Officer | 0.0 |
| Military Enlisted | 0.0 |
| Civilian Professional | 0.6 |
| Civilian Supporting | 0.3 |
| Total | 0.9 |
| Additional personnel | |
| Military Officer | 0.0 |
| Military Enlisted | 0.0 |
| Civilian Professional | 0.0 |
| Civilian Supporting | 0.0 |
| Total | 0.0 |

11. Current References:

J.A.S. Kinney, D.F. Neri, A.P. Ryan, and C. L. Schlichting, Predicting proficiency on visual sonar displays: validation of a test battery. NSMRL Rep. No. 994, Jan. 1983.

II. NEW START (F)

1. Title: Abbreviations for Use in AN/BSY-2 Submarine Combat System Displays

2. Principal Investigator: Kevin V. Laxar, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Vision Department
Phone:
Autovon: 241-2522
Comm: 203-449-2522

4. Navy Need:

The AN/BSY-2 Submarine Combat Systems Display will use about 1400 abbreviations. Learning so large a number of abbreviations and responding quickly and accurately to them under operational conditions will place a considerable burden on the operators. The AN/BSY-2 System Standards and Conventions Technical Report specifies that each abbreviation must be submitted to the Prime Contractor's operability committee for approval, but the basis for this approval is not stated. The Report does concede that "operators may have difficulty." Research is required to ensure that the best abbreviations are used.

Requirements document: AN/BSY-2 Submarine Combat System Standards and Conventions Technical Report, General Electric Co., Syracuse, NY.

5. Problem/Objectives:

To enhance the performance of combat system operators by providing the optimum set of abbreviations for use in system displays.

This research will focus on finding the optimal abbreviation(s) for each word needed to be displayed on the AN/BSY-2 workstations. These new consoles use two large color CRTs in landscape orientation (long axis horizontal) rather than one or two CRTs in portrait mode (long axis vertical). This additional display area permits not only the presentation of ancillary information around it. With the greatly increased amount of information available, however, space on the display surfaces is still at a premium and the need to abbreviate text remains vital to minimizing clutter on the displays.

The AN/BSY-2 System Standards and Conventions Technical Report prepared by prime contractor General Electric Co. lists approximately 1400 abbreviations to be used in the system displays. According to the Report, the rule used to create the abbreviations was to eliminate the vowels and truncate. Examination of this list shows, however, that several methods have been used to generate abbreviations from the original words or phrases. For example, some abbreviations were created by the simple truncation rule,

in which letters are eliminated from the right end of the word until some given length abbreviation is arrived at. With this rule PROB is used to represent "probability," "probable," or "problem." With others, an acronym rule was used, where each letter stands for the first letter in the phrase to be abbreviated, such as RADAR. Still others were formed by the "conventional" method, whereby the abbreviation is chosen by experts in the given subject matter. PRPLN is listed to represent propulsion. It is generally agreed upon that no one method of abbreviating is best for all purposes, and that the abbreviations used should be appropriate for the users and the context in which the abbreviations are to be used (Hodge & Pennington, 1973). The Technical Report acknowledges both this and the possible need for even more abbreviations. Research has shown, however, that the rule stated in the report for creating the new abbreviations, eliminating vowels and then truncating, was one of the least preferred methods (Rogers & Moeller, 1984).

Clearly, then, the need exists for determining empirically the best abbreviations for at least the most important and frequently used terms in state-of-the-art combat systems. Results will enhance combat system performance by increasing the meaningfulness of abbreviations for the operators and making displays easier to read and understand.

6. Technical Approach:

Research will follow two principal approaches, consistent with previous studies of abbreviation adequacy (Moses & Potash, 1979; Rogers & Moeller, 1984). Both approaches will employ Naval personnel with expertise in operating submarine combat systems.

The first study will require the combat system operators, including available AN/BSY-1 operators, to review the 1400 AN/BSY-2 terms and their abbreviations. By means of a paper and pencil task, the operators will rank each term on a seven-point scale for its importance, or frequency of use, in the combat system. Similarly, the operators will rank each abbreviation for its meaningfulness, or how well it represents the encoded word or phrase. The results of these rankings will determine the selection of a subset of terms and their abbreviations for further study in the second phase of this research. The operators will then be asked to provide the abbreviation they would prefer most for each of those terms. Additional analyses of the meaningfulness scale will reveal which methods of forming abbreviations are the most preferred and which are least preferred, to help guide the creation of abbreviations in the future.

The second phase of the research will use a subset of the combat system terms determined in the first experiment. Four additional groups of combat system operators will be trained to a nominal low level of proficiency on associating system terms with their representative abbreviations. One group will be trained on the abbreviations as given in the Technical Report. A second group will be trained with a consensus of abbreviations created by the expert group from the first experiment. The third and fourth groups will be trained on abbreviations formed by the two most preferred methods as determined in the first experiment.

After training, the operators will be tested on a task that measures response time and accuracy. Using a computer-driven CRT, an abbreviation will appear on the screen and the subject must say aloud what he believes the term it represents is. A voice-actuated relay attached to the computer will be used to record the operator's response time, and the actual response will be recorded manually by the experimenter. Mean response times and accuracy will be computed for each group.

7. Assessment of Risk:

This research will use the methods of previous research in this area some of which have been conducted at this laboratory. The Principal Investigator is familiar with this work and has assisted with some of it. There are no particular risks which would inhibit the success of the work.

8. Related Activities: NA

9. Transition Approach:

The results would be communicated to PMO-418, the managers of the AN/BSY-2 System. Any changes in the proposed abbreviations would presumably be incorporated into specifications for the system as quickly as the experiments are completed.

10. Resources Required:

| | FY93 | FY94 |
|---|---|---|
| Funding Required | 208.0 | 180.5 |
| Personnel Required | | |
| Military Professional | 0.0 | 0.0 |
| Military Supporting | .5 | .5 |
| Civilian Professional | .8 | .8 |
| Civilian Supporting | .5 | .5 |
| Total Personnel | 1.8 | 1.8 |

11. Current References:

Hodge, M. H., & Pennington, F. M. (1973). Some studies of word abbreviation behavior. Journal of Experimental Psychology, 98, 350-361.

Moses, F. L., & Potash, L. M. (1979). Assessment of abbreviation methods for automated tactical systems (Tech Report No. 398). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (NTIS No. AD-A077-840)

Rogers, W. H., & Moeller, G. (1984). Comparison of abbreviation methods: Measures of preference and decoding performance. Human Factors, 26, 49-59.

II. NEW START (G)

1. Title: Auditory Classification of Sonar Signals

2. Principal Investigator: Thomas E. Hanna, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Submarine Systems Department
Phone Numbers:
Autovon: 241-2545
Commercial: (203) 449-2545

Other Laboratories involved: NUSC and SUBSCHOL

4. Navy Need:

To develop automated classification aids for passive sonar systems

Need identified in NAVSEA Technology Needs Guidance

5. Problem/Objective:

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?

These results would be used by NUSC to develop classification algorithms.

6. 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 do a binary categorization of each signal along a 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.

Finally, neural net algorithms will be developed that use models of auditory peripheral processing as input to the neural nets. The network will map input features onto perceptual judgments. This network would then serve as a preprocessor to identify important events to the sonar operator.

7. Assessment of Risk:

This proposal is high-risk but with potentially high payoffs for Navy application and scientific contribution. Auditory modeling and parallel processing capabilities are now sufficiently mature to study such a complex problem.

8. Related Activities:

The Battle-Management Technology Group, Code 5570, at the Naval Research Laboratory (NRL) is initiating a related project for passive sonar. The Advanced Resource Development Corporation has been granted a Phase II SBIR contract to use auditory features to classify active sonar returns. We would monitor their efforts and attempt collaboration, particularly with NRL, when feasible.

9. Transition Approach:

We would be doing this project in conjunction with a current NUSC 6.3 program. Some transition could be initiated prior to project completion so that a working prototype could be taken to sea in FY97.

10. Resources Required (Funding Category 6.2):

| | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|
| Funding Required | 250.0 | 255.0 | 240.0 | 235.0 |
| Personnel required | | | | |
| Military Officers | | | | |
| Military Enlisted | 0.2 | 0.2 | 0.2 | 0.2 |
| Civilian | 0.4 | 0.4 | 0.4 | 0.4 |
| Total | 0.6 | 0.6 | 0.6 | 0.6 |
| Additional personnel | | | | |
| Military Officers | | | | |
| Military Enlisted | 0.2 | 0.2 | 0.2 | 0.2 |
| Civilian Professional | 1.0 | 1.0 | 1.0 | 1.0 |
| Civilian Supporting | 0.6 | 0.6 | 0.6 | 0.6 |
| Total | 1.8 | 1.8 | 1.8 | 1.8 |

11. Current References:

Hanna, T.E. (1990) Contributions of envelope information to classification of brief sounds, NSMRL Report 1165.

Hanna, T.E. (1989) Auditory temporal features underlying sound source identification. Proposal to Office of Naval Research.

Shamma, S. (1988) Acoustic features of speech. Journal of Phonetics, Vol 16, pp 77.

Rumelhart, D. and McClelland, J. (1986). Parallel distributed processing: Exploration in the microstructure of cognition. Volumes 1 & 2. Cambridge, MA: Bradford Books/MIT Press.

SBIR Phase II proposal for signal feature analysis using neural networks and psychoacoustics by the Advanced Research Development Corporation.

II. NEW START (H)

1. Title: Cancellation of Active Sonar Transmissions From Auditory Sonar Signals

2. Principal Investigator: Thomas E. Hanna, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Submarine Systems
Phone Numbers:
Autovon: 241-2545
Commercial: (203) 449-2545

Other Organizations involved: NUSC, NAVSEA, Massachusetts Institute of Technology Lincoln Laboratory

4. Navy Need:

To cancel active surface sonar transmission from submarine sonar operator's headphones.

This need was identified at several meetings on low-frequency active sonar including one held at NSMRL 6 June 1990 and at ASN(RDA) 11 July 1990.

5. Problem/Objective:

To develop a prototype unit that eliminates active sonar transmissions from the sonar operators' audio signal.

Auditory sonar performance is expected to be impaired to an increasing extent due to the use of active sonar, particularly by surface ships (e.g., SURTASS, AN/SQY-2). It has already been reported that, due to the sound levels, submarine sonar operators have had to take off their headsets when their boat has operated in areas where these newer types of sonar are being used. The loss of auditory information is critical to operator performance. The proposed work would recover a high-quality audio signal by canceling the high-amplitude active transmission from the operator's audio signal. This problem is more difficult for auditory than for visual signals because the operator will be aurally more sensitive to any distortions introduced by the cancellation algorithm. Thus, simpler techniques that might work well visually would be inadequate, or even inapplicable. The techniques examined must be designed to reflect auditory sensitivity and perceptual capabilities.

6. Technical Approach:

Preliminary results suggest that an analysis/synthesis technique of signal modification developed at Massachusetts Institute of Technology's Lincoln Laboratory would provide a good method of eliminating active sonar transmissions. In the proposed work, Lincoln Laboratory would be primarily responsible for algorithm and hardware development. NSMRL would generate system requirements and evaluate the prototype in consultation with NUSC and NAVSEA. Approximately eight months would be required for the development of system requirements and the refinement of the analysis/synthesis (or alternative) technique to meet these requirements. Preliminary evaluations on sonar operators would be performed on synthesized and recorded signals. Six months would be required to develop hardware specifications and design that would implement selected algorithms for a programmable field prototype that could be used in at-sea evaluations with the capability to vary algorithm parameters for best performance. Hardware procurement, assembly, and software development would require twelve months. At-sea testing would be done in ten months.

7. Assessment of Risk:

There is only a low level of risk associated with this project. The Lincoln Laboratory technique is well suited to these signals. Pilot efforts have been fairly successful using a simplified version of their technique.

8. Related Activities:

The application is unique with no other similar efforts. Lincoln Laboratory has done some related work with speech interference, and is already discussing implementation on visual displays with the AN/BQQ-5 Upgrade office at NUSC.

9. Transition Approach:

The device could be added as a black box to current submarine systems.

10. Resources Required (Funding category 6.3):

| | FY93 | FY94 | FY95 |
|---|---|---|---|
| Funding required | 400.0 | 400.0 | 400.0 |
| Personnel Required | | | |
| Military Officer | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.2 | 0.2 | 0.2 |
| Civilian Professional | 0.5 | 0.5 | 0.5 |
| Civilian Supporting | 0.4 | 0.4 | 0.4 |
| Total | 1.1 | 1.1 | 1.1 |

Cost include: 1) contract with Lincoln Laboratory and 2) development workstation (FY94).

11. Current References:

An approach to co-channel talker interference suppression using a sinusoidal model for speech. IEEE Trans. on Acoustics, Speech, & Signal Processing (T. F. Quatieri & R. G. Danisewicz, 1990).

Speech transformation based on a sinusoidal representation. IEEE Trans. on Acoustics, Speech, & Signal Processing, Vol ASSP-34 p. 1449-64 (T. F. Quatieri & R. J. McAulay, 1986).

Speech analysis/synthesis based on a sinusoidal representation. IEEE Trans. on Acoustics, Speech, & Signal Processing, Vol ASSP-34, p. 744-54 (R. J. McAulay & T. F. Quatieri, 1986).

II. NEW START (I)

1. Title: Characterization of Visual Target Detection on Sonar Displays.

2. Principal Investigator: Joseph DiVita, Ph.D

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Vision Department
Phone numbers:
Autovon: 241-2528
Commercial: (203) 449-2528

4. Navy Need:

There are several generations of sonar systems currently deployed in the fleet. Each of these systems have "waterfall displays" which require an operator to visually detect a target, usually a broken vertical line embedded in a background of noise, on a CRT display. Typical examples are the Passive Broadband and Narrow Band displays. The physical characteristics of these displays are very different from one another. For example, the height and width of one bin of information varies across displays as does the range and number of brightness levels utilized to encode information. What is needed is a characterization of the human visual system's ability to detect targets in these displays. Such a characterization could be achieved by plotting the human visual system's contrast sensitivity function to simple stimuli such as vertical lines or "bars". The effect of adding noise to these simple stimuli on detection may then specified. Once these effects are known, each system may then be characterized in terms of human visual detection.

5. Problem/Objectives:

The Human visual system has been characterized in terms of its sensitivity to detect patterns whose luminance varies sinusoidally over space. This characterization is referred to as the Contrast Sensitivity Function of the visual system. The effects on detection of adding various types of noise to these gratings has also been studied. In an analogous fashion, the ability of the human visual system to detect vertical lines of various height, width, and contrast may be investigated. In addition, noise may be superimposed on these displays and the effect on vertical line detection investigated. In essence, a new contrast sensitivity function to vertical lines may be plotted. This contrast sensitivity function can then be utilized to evaluate human target detection on both new and old sonar systems. That is, how well the displayed information of each system is suited for human target detection may be specified. Thus each system may be evaluated and characterized against a common Navy-wide standard.

6. Technical Approach:

The research to construct the new contrast sensitivity function of the visual system will entail those experimental paradigms and techniques which were used to determine the contrast sensitivity function to sinusoidal gratings. These are standard psychophysical methods.

7. Assessment of Risk:

There is virtually no risk in this project since it entails measuring the human visual system's sensitivity to particular stimuli. Whatever the nature of this sensitivity proves to be, is in fact the product, or end result of this research endeavor. This work can be accomplished in a vision laboratory.

8. Related Activities: NA

9. Transition Approach

From the outset of this project there is a well defined product. Once the Contrast Sensitivity function to vertical lines is known, actual sonar systems may be tested. That is, simulated noise and targets may be presented to these system and the ability of operators to detect targets measured. The ability of operators to detect targets with these systems can then be compared with detection predicted by the contrast sensitivity function.

10. Resources Required (Funding category: 6.1 or 6.2)

| | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|
| Funding Required | 200.0 | 200.0 | 200.0 | 200.0 |
| Personnel Required | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 1.6 | 1.6 | 1.6 | 1.6 |
| *Additional Personnel* | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Supporting | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 0.8 | 0.8 | 0.8 | 0.8 |

11. Current References:


1) DeValois, R. L. and Devalois, K. K. (1990) Spatial Vision, Oxford University Press.

2) Stromeyer, C.F. and Julesz, B. (1972) Spatial-frequency masking in vision: critical bands and spread of masking. J. Opt. Soc. Am. Vol 62, No. 10, pgs. 1221-1232.

3) Kingdom, F. Moulden, B. and Hall, R. (1987) Model for the detection of line signals in visual noise. J. Opt. Soc. Am. Vol 4, No. 12, pgs. 2342-2354.

4) Kersten, D. (1987) Statistical efficiency for the detection of visual noise. Vision Res. Vol 27, No. 6 pgs. 1029-1040.

5) Legge, G. E., Kersten, D., Burgess, A. E. (1987) Contrast discrimination in noise. J. Opt. Soc. Am. Vol 4, No. 2, pgs 391-404.

6) Kersten, D. (1984) Spatial summation in visual noise. Vision Res. Vol 24, No. 12, pgs. 1977-1984.

II. NEW START (J)

1. Title: Continually Averaged Passive Broadband (CAPBB) Display

2. Principal Investigator: Joseph DiVita, Ph.D

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Vision Department
Phone numbers:
Autovon: 241-2528
Commercial: (203) 449-2528

4. Navy Need:

Currently there are three PBB displays each of which integrates data over a different time period: The STA display or Short Term Average display, ITA, the Intermediate Term Average display , and LTA, the Long term average display. In each of these displays a single piece of data represents information at a particular bearing averaged over one of three fixed time periods. Operator performance on the STA display is 3 to 5 dB below ideal performance (DiVita and Hanna, in press). Thus, ITA and LTA displays help the operator to integrate information. The problem with the current display system is that there is a temporal lag. That is, n number of lines of data must be presented on the STA Display before one line of data appears on the ITA Display. There are three problems with this current system: 1) Information on the STA display simply disappears from the screen and there is no record of it until ITA data appears. 2) Weak targets that are invisible on the STA display will eventually appear on the ITA display, but again the operator must wait until the ITA display updates. 3) Because each of the temporal update rates of the displays is fixed, none of the displays makes complete use of all of the information available at any given instant of time. What is needed is a Continually Averaged display that makes use of and presents all the information. In general, NAVSEA Technology Needs Guidance describes display issues.

5. Problem/Objectives:

The proposed new start will demonstrate the effectiveness of a Continually Averaged Display. The Continually Averaged Display will decrease the time it takes operators to detect a target. This new display will make use of all the information, where the term "information" is used here in the Statistical sense. Thus the first line of data of the CAPBB will be the same as that of the STA. However, the second line of data will be an average of two lines of STA data, the third line, of three lines of STA data, etc. Thus as time increases, a running average is kept. For each line of the display, if the cutoffs utilized to map amplitude of signal onto brightness levels remain unchanged, the false alarm rate will automatically decrease. Another way to state this is as follows: the probability that noise will map onto the brightest level utilized in the display will be made to decrease as the number of lines increases in the display. This feature is a simple con-

sequence of the standard error of the mean decreasing as the number of samples increases. In this scheme, targets appearing at the top of the display will have a lower false alarm rate than those appearing at the bottom of the display. Another consequence of this design is that a weak target will change from dim to bright as the operator looks from the bottom to the top of the display. This change in brightness is a direct analog of the change in false alarm rate as data from the contact accrues. This represents a major difference between current PBB displays, where within any given display, the probability that noise maps onto a given brightness level is constant.

6. Technical Approach:

The prototype CMA display will be constructed using a simple Statistical model of Gaussian noise and Gaussian signal. The Receiver Operating Characteristic Curves (ROC curves) for the Ideal Detector can thus be readily computed for such a display. The ability of operators to detect targets will be evaluated. In particular, the ability to detect targets using a combination of the STA and ITA displays will be compared to target detection with the new CAPBB display. The time to detection will be compared between the old displays and the new display.

7. Assessment of P[illegible]

Improvement in performance when measured in terms of time to detect is fairly well assured. Also, it is believed that the operator's ROC curve will improve since operators fail to visually integrate data over a large number of lines in the display (DiVita and Hanna, in press, Moulden and Kingdom, 1988). In essence, the CAPBB display will be accomplishing this integration for the operator.

8. Related Activities:

The CAPBB display will complement NSMRL's research efforts in visual sonar for FY92-94, entitled Enhanced Performance with Visual Sonar Displays (65856N M0100.001-5003). This research entails measuring operator performance on existing sonar displays and developing new visual sonar displays that will improve the sonar operator's performance.

9. Transition Approach:

Once the improvement in performance is quantified using simulated data, actual sonar data may be tested and presented in the CAPBB display. Operator performance will be measured and improvement in performance quantified.

10. Resources Required (Funding category: 6.2 or 6.3):

| | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|
| Funding Required | 300.0 | 325.0 | 350.0 | 400.0 |
| Personnel Required | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.6 | 1.6 | 1.6 | 1.6 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 2.4 | 2.4 | 2.4 | 2.4 |
| Additional Personnel | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 1.6 | 1.6 | 1.6 | 1.6 |

11. Current References:

1. DiVita, J. C. and Hanna, T. E. (in press) Human efficiency for visual detection of targets on CRT displays using a two level multiple channel time history format. J. Acoust. Soc. Amer.

2. Moulden, B. and Kingdom, F. (1987) Effects of pixel height and vertical resolution on detection of a simple vertical line signal in visual noise" Human Factors, 29 9(4), 433-445.

II. NEW START (K)

1. Title: Development of Revised Acoustic Habitability Standards for Active Sonar Platforms

2. Principal Investigator: Paul F. Smith

3. Laboratory: Naval submarine Medical Research Laboratory
Department: Submarine Systems
Phone Numbers:
Autovon: 241-2557/3201
Commercial: (203) 449-2557/3201

4. Navy Need:

Modern active sonars radiate intense tones into own-ships spaces. The Navy needs to prevent hearing loss in Naval crew members aboard vessels equipped with active sonars. Noise level criteria for berthing spaces are needed that will ensure recovery from auditory threshold shifts incurred while on duty in noisy spaces. Relevant official documents that support the Navy need are:

OPNAVINST 9640.1 Shipboard Habitability Program.

OPNAVINST 5100.23B CHAPTER 18. HEARING CONSERVATION AND NOISE ABATEMENT

CNO ltr 0191 ser 03/8C580210 of 2 May 88

COMNAVSEASYSCOM ltr 9073 OPR 55N2 ser 55N/334 of 22 Dec. 88

The research proposed herein addresses the Navy need by establishing, through experiment, the maximum ambient noise level for tones that does not interfere with recovery from noise-induced temporary auditory threshold shift.

5. Problem/Objective:

Many Naval vessels are equipped with active sonars that have the potential for insonifying shipboard spaces with tonals in frequency ranges that could interfere with human health. These developments raised 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 permit recovery from noise-induced temporary hearing loss incurred while on watch (as in the engineering spaces).

During experiments at NSMRL and NOSC that were done to establish present habitability standards for vessels equipped with active sonar, the sound of interest

(pings) 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 (TTS) 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 addition to engine rooms several other areas aboard submarines and warships are high noise level areas within which crew members may incur TTS.

In short, while the NSMRL and NOSC studies showed that TTS would not grow beyond insignificant levels from around-the-clock exposure to noise levels experienced in berthing spaces aboard a certain class boat, those experiments did not show that those levels were sufficiently low to permit crew members' ears to recover from other (non-sonar) noise exposure.

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. Although many experiments on asymptotic threshold shift have demonstrated that recovery of behavioral thresholds to pre-noise-exposure levels does occur even after many days of noise-induced threshold elevation, it is strongly suspected that chronic temporary threshold shifts eventuate in permanent hearing damage. Thus, if temporary threshold shifts which exist from noise exposure 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 infeasible for many shipboard spaces. Thus, one can not look to the existing literature for a solution to the present problem. Present berthing-space noise levels were established on the basis that recovery from temporary auditory threshold shift is not impaired by ambient broad-band noise as high as 75 dB(A).

6. Technical Approach:

A series of experiments will be conducted in which TTS will be induced by broad band noise (fifteen minutes at 104 dB(A)) and recovery will be measured under several levels of berthing-space pings up to an including present permissible level of 80 dB for 3.5 kHz tones at low duty cycles. Results will be compared with a control condition in which berthing-space noise will be less than 65 dB(A). Duty cycle of the pings will be the maximum expected to prevail aboard present vessels (about 5%).

7. Assessment of Risk:

Present berthing space noise (ping) levels may leave some of the crew at risk of incurring permanent noise-induced hearing loss. The failure to take recovery processes into account may leave the Navy open to claims from former members who happen to exhibit hearing deficits.

8. Related Activities:

This research is related to work being conducted at NSMRL to establish acoustic habitability standards for low-frequency active sonar platforms. There are a number DOD and civilian laboratories that conduct research on the effects of long-term noise exposure. Among these are the Aerospace Medical Research Laboratory at Wright-Patterson AFB, the U.S. Army Human Engineering Laboratory at Aberdeen Proving Ground, the Callier Center for Communications Disorders, U. Texas at Dallas, the Hearing Research laboratory, U. Minnesota, etc. Formal and informal relationships are maintained with such groups through the Acoustical Society of America and the NAS/NRC CHABA. Those resources may be called upon for consultation and for providing additional professional manpower when needed.

9. Transition Approach:

This research updates previous research. The results will be immediately implemented through appropriate guidance to the fleet (BUMED notice, etc.)

10. Resources Required (Funding Category 6.3):

| | FY93 | FY94 | FY95 |
|---|---|---|---|
| Funding required | 553.0 | 398.0 | 292.0 |
| Personel required | | | |
| Military Officer | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.0 | 1.0 | 1.0 |
| Civilian Supporting | 0.0 | 0.0 | 0.0 |
| Additional Manpower | | | |
| Military Officer | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.0 | 1.0 | 1.0 |
| Civilian Supporting | 2.0 | 2.0 | 2.0 |
| Total | 3.0 | 3.0 | 3.0 |

11. Current References:

1. Hamernik, R.P., Henderson, D., Salvi, R. eds. (1982) New perspectives on noise-induced hearing loss. Raven Press, New York.

2. Salvi, R.J., Henderson, D., Hamernik, R.P., and Colletti, V. eds. (1986) Basic and applied aspects of noise-induced hearing loss. Plenum Press, New York.

3. Kryter, K.D. (1984) PhysiologicaL, psychological, and social effects of noise. NASA Reference Publication 1115

4. Cantrell, R.W., (1974) Prolonged exposure to intermittent noise: audiometric, biochemical, motor, psychological, and sleep effects. Laryngoscope, suppl. 1, vol. LXXXIV no. 10, pt 2. 1-55.

II. NEW START (L)

1. Title: Dynamic Visual Sonar Displays

2. Principal Investigator: Dr. Joseph DiVita

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Behavioral Sciences Department
Phone numbers:
Autovon: 241-2528
Commercial: (203) 449-2528

4. Navy Need:

The sonar operator has too much disparate information which he must analyze and integrate into a coherent representation of the ocean world around him. Narrow band analysis offers the greatest resolution; however, there are simply too many bearings and too many frequencies which the operator must simultaneously monitor, in order to detect and identify contacts. The performance of the sonar operator may be greatly enhanced by a display that presents all the essential data simultaneously. The information must be presented in a denser but still complete format, that is, in a display that offers the operator a global view, yet still allows the operator the ability to analyze specific characteristics of the data.

5. Problem/Objectives:

The proposed new start will demonstrate the effectiveness of a 3-Dimensional data cube that contains all the sonar information. The x, y, and z axis of the 3-Dimensional space of the data cube are frequency, bearing, and time, respectively. Thus the x-z planes of the cube will contain the frequency-time data displays at each of the bearings, the x-y planes will contain the frequency-bearing displays at each segment in time, and the y-z planes will contain the bearing-time displays at each of the frequencies. A two dimensional projection of the cube is presented to the operator. There is static mode and a moving mode in which to display information. In the static mode, the average of all pixel intensities of one line of sight is presented. In the moving mode, the planes of data along one of three lines of sight-time, frequency, or bearing-are sequentially viewed so that a dynamic representation of the data is achieved. Targets changing with respect to the dimension sequenced will appear to move, whereas noise will appear as dynamic random dots with no particular coherent motion. The sonar operator controls, with a mouse, the perspective projection of the cube, and is able to window and clip data in the cube.

6. Technical Approach:

The human visual system is exquisitely sensitive to motion. No use is made of the visual system's motion. Currently, the way data is presented on sonar displays, detection of targets exploits the visual system's ability to detect patterns. No use is made of the visual's system motion detection mechanisms.

The psychophysical parameters of perceiving motion in dynamic noise must first be investigated. The conditions under which motion of targets may be perceived in a background of random dynamic noise must be specified. Once these parameters are specified, a dynamic display, as outlined in the objective section, can be built. For example, It is very difficult to obtain a frequency signature of contacts with high bearing rate, that is, contacts that are changing their bearing relatively quickly; hence their tracks do not appear in any one LOFAR DISPLAY. However, if the LOFAR DISPLAYS at each bearing are "flipped" through as in animation, the signature of the high bearing rate contact will emerge through the dynamic presentation of the data.

7. Assessment of Risk:

Advances in the world of computer graphic and animation are now making it feasible to achieve dynamic displays on desk top computers. Certainly the applicability of this technology to visual sonar displays needs to be exploited. Specifically, color CRT monitors now have refresh rates above the human flicker fusion threshold. This makes it possible to utilize the human visual system's motion detection capabilities in order to detect and classify contacts.

8. Related Activities:

Dynamic Visual Sonar displays will complement NSMRL's research efforts in visual sonar for FY92-94 entitled, Enhanced Performance with Visual Sonar Displays (65856N M100.001-5003). This research entails quantifying operator performance on existing displays and developing new displays that will improve performance.

9. Transition Approach:

From the onset of this project there is a well defined product, the creation of which is the goal of the project, i.e. the 3-D data cube. Once the psychophysical parameters of the visual system's capability to detect motion in dynamic noise are known, actual sonar data may be tested in the data cube.

10. Resources Required (Funding category: 6.1 or 6.2):

| | FY93 | FY94 | FY95 | FY96 |
|---|---|---|---|---|
| Funding Required | 300.0 | 325.0 | 350.0 | 450.0 |
| Personnel Required | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 1.6 | 1.6 | 1.6 | 1.6 |
| Civilian Supporting | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 1.6 | 1.6 | 1.6 | 1.6 |
| Additional Personnel | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.4 | 0.4 | 0.4 | 0.4 |
| Civilian Professional | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Supporting | 1.2 | 1.2 | 1.2 | 1.2 |
| Total | 1.6 | 1.6 | 1.6 | 1.6 |

11. Current References: NA

II. NEW START (M)

1. Title: Development of a Portable Test to Determine Fitness for Duty.

2. Principal Investigator: C. Schlichting, PhD.

3. Laboratory: Naval Submarine Medical research Laboratory
Behavioral Sciences Department
Phone numbers:
Commercial (203) 449-2529
Autovon 241-2529

4. Navy Need:

There are many internal and external factors that may affect performance to the point where individuals are no longer capable of safely and effectively performing their jobs. These include, but are not limited to, alcohol use, sleep deprivation, physical fatigue, heat stress, illicit drug use, and prescribed or over-the-counter pharmaceutical preparations. There are many circumstances in which missions could easily be jeopardized by inadequate performance on the part of one or more individuals.

Currently there is no objective means of determining whether an individual is capable of performing his/her job. There is a need for a test that could be rapidly and reliably administered in different environments. Such a test could greatly enhance the safety and effectiveness of personnel in critical positions. As required by the particular mission or job category, tests could be administered before duty commenced and also during performance of duty as conditions that might cause deterioration in performance worsened. Impaired persons could be removed from duty before personnel were injured or hardware damaged by faulty decisions or performance. This type of test could also be used to measure the effectiveness of protection against chemical or biological warfare.

Development of this form of testing has several advantages. It can provide an objective determination of an individual's fitness for duty. It does not require that the underlying cause of performance decrements be specified. Additionally results of the test would be immediately available. The test chosen however, must be reliable, valid, and sensitive; test results must be easily interpreted.

There are currently no performance, motor or physiological tests of fitness for duty testing available to the tri-services. Particularly there are no tests available for small handheld computers that could be used in multiple environments.

5. Problem/Objective:

To develop a test of fitness for duty to be used in various military environments that can be easily and rapidly administered using a lightweight battery operated hand held computer.

6. Technical Approach:

The proposed work will evaluate several computer administered tests of physiological, perceptual, cognitive, information processing and motor function for possible adoption. If necessary, new tests will be developed. Validity, reliability and specificity of the proposed test or tests for specific tasks will be determined. Ease of administration, time required for completion and interpretation will also be heavily weighted in the evaluation. Ideally one rapidly administered test will be sufficient for most situations.

Tests that have been shown to be sensitive to various neurotoxicological insults will be evaluated first. These include compensatory tracking, mathematical processing, digit symbol substitution, pattern comparison, Manikin and measures of heart rate and peripheral blood flow.

Initially dose-response curves will be assessed for two substances known to affect performance, alcohol ingestion and the use of antihistamines. Blood or urine tests will be performed to determine physiologically active levels of these substances. After selection of tests population means and standard deviations for unimpaired performance will be developed for each test on the appropriate military populations. The applicability of performance and physiological testing for other specific stressors such as chemical warfare or heat stress can be determined as the need develops.

Anticipated Product: Specific recommendations for tests to be used to determine fitness for duty under given conditions will be developed. As an end product portable, reliable and valid versions will be produced.

7. Assessment of Risk:

There are no known problems that would inhibit research success. Although the payoff would be high, this is not a high risk project.

8. Related Activities:

Research on the AGAARD-Stress and UTC-PAB batteries is related but these tests have not been evaluated or developed as measures of fitness for duty. Additionally standardized versions of these tests are not available nor are versions available for small handheld computers. These two batteries do not include compensatory tracking or measures of heart rate and peripheral blood flow. A commercial version of a tracking task implemented on an IBM compatible PC is currently being pilot tested in the transportation industry for personnel screening.

9. Transition Approach:

The research funding category is 6.2 with probable transition to 6.3 or 6.4 for development of the actual test device in outyears.

10. Resources Required (Funding Category 6.2):

| | FY93 | FY94 | FY95 |
|---|---|---|---|
| Funding Required | 250.0 | 250.0 | 250.0 |
| Personnel required | | | |
| Military Officers | 0.8 | 0.8 | 0.8 |
| Military Enlisted | 0.0 | 0.0 | 0.0 |
| Civilian professional | 0.8 | 0.8 | 0.8 |
| Civilian Support | 0.8 | 0.8 | 0.8 |
| Total | 2.4 | 2.4 | 2.4 |
| Additional personnel: | | | |
| Military Officers | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 |
| Civilian professional | 0.0 | 0.0 | 0.0 |
| Civilian Support | 0.8 | 0.8 | 0.8 |
| Total | 0.8 | 0.8 | 0.8 |

The commercial version of the tracking task will be purchased and evaluated. Clinical laboratory tests will be needed to measure blood or urine levels of related biochemical compounds.

Portable computers must be purchased to obtain performance and physiological data.

11. Current References: NA

II. NEW START (N)

1. Title: Effect of Caffeine on Cognitive Performance, Mood and Cardiovascular Reactivity in Habituated Users and Non-Users

2. Principal Investigator: Christine L. Schlichting, Ph.D.,

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Vision Department
Phone Numbers:
Autovon: 241-2529
Commercial: (203) 449-2529

4. Navy Need:

Military operations require that personnel maintain alertness and high performance levels for prolonged periods without rest, under atypical work/rest cycles or under conditions of physical fatigue such as divers in hyperbaric environments. The United States Navy and the Army are currently investigating the use of psychopharmacological agents to enhance performance. One of the more promising psychoactive agents for operational use to counter these fatigue effects is caffeine. One suggested use of caffeine is to reduce the effects of hangover drowsiness from the use of benzodiazepines and from physical fatigue.

Unfortunately many of these studies have neglected to consider the fact that many individuals use caffeine on a daily basis; some in fairly large quantities. To accurately be able to recommend the psychopharmacological use of caffeine one must be able to predict its effects in habituated users. The objective of this research is to determine the effect of habitual caffeine use on performance, mood and cardiovascular reactivity during subsequent caffeine challenge. It is hypothesized that habitual use of caffeine will reduce the effect of caffeine on performance, central nervous system arousal and cardiovascular reactivity normally found in nonusers. The effects of dosage level and habitual caffeine use on several aspects of performance (stimulus processing, response choice, motor programming, motor activation and response execution) will be evaluated. It is further hypothesized that habitual caffeine use will reduce cardiac reactivity to physiological stress.

This work is designed to complement current research investigating the efficacy of pharmacological agents in preventing or reducing performance decrements in adverse environments such as high terrestrial elevations (Army Research Institute of Environmental Medicine), radiation (Armed Forces Radiobiology Laboratory) hyperbaric diving (Naval Medical Research Institute) and sustained operations with concomitant sleep deprivation (Walter Reed Army Institute of Research, Naval Health Research Center). Information on changes in responsivity to caffeine in habitual users

will be important in framing specific recommendations for pharmacological use of caffeine in each of these research areas.

Military Requirements include SUSOPS JWG Ltr. Ser. 02 of Oct 87 and Medical Requirement Number 20 of 25 Jan 88.

5. Problem/Objective:

Military sustained operations require personnel to maintain the highest level of functioning despite prolonged sleep deprivation. In this context caffeine is being studied as one method of reducing the hangover drowsiness induced by benzodiazapines. Work in hyperbaric environments may produce extreme physical fatigue limiting work capacity. Psychopharmacologic agents have been suggested as one means of maintaining vigilance and performance under these conditions.

Caffeine (1,3,7-trimethylxanthine), in particular has been studied as one possible drug of choice. Caffeine is also being studied for its potential to improve soldier's performance at high terrestrial elevation.

Much is known about the physiological effects of caffeine. Plasma norepinephrine, epinephrine and renin are considerably elevated following ingestion of caffeine (Robertson, Frolich, Carr, Watson, Hollifield, Shand and Oates, 1978). Caffeine also has the advantage of complete and rapid absorption (30-120 min) and a half life that varies from 4 to 10 hours in healthy adults. The half life is shorter in smokers. (Benowitz, 1988).

Caffeine is also one of the most commonly used psychotropic agents in the world; epidemiological studies suggest that 80% of adults in the United States consume coffee, tea or caffeinated beverages daily (Benkowitz, 1990). As many as 10% consume 500 mg (approximately 6 cups of coffee) or more, a dose that puts them at risk of "caffeinism", which includes various behavioral psychophysiological and affective deleterious effects (Truitt, 1971; James, Paull, Cameron-Traub,Miners, Lelo and Birkett, 1988).

Despite this widespread use, a complicating factor in the potential military use of caffeine is that individuals may be asked to perform operational tasks during periods of stress. While a fair amount is known about the effects of caffeine on physiological systems, considerably less is known about the synergistic or additive effect of caffeine use combined with psychological or physical stress (Sawyer, Julia and Turin, 1982). The possibility that caffeine effects could interact with stress and intensify cardiovascular and hormonal effects has been suggested by several investigators (Lane, 1983). Caffeine is known to have an additive effect with drugs administered to protect against radiation effects in disrupting performance. In many of these applications, the effects in long term habitual users is unknown.

Investigations of the effects of caffeine and stress often do not provide adequate information and many are procedurally flawed. Practice effects in repeated measures designs are often not considered. Normal caffeine consumption by subjects is frequently not considered. Baseline performance measures may not be recorded. For instance, one study that did investigate the combined effect of caffeine and stress did not report performance scores without caffeine (France and Ditto, 1988). This study did show that caffeine and stress combine to produce additive effects in vascular functioning. Preliminary results (MacKinnon, 1991) suggest that caffeine may act as a buffer during stress to decrease cardiac reactivity (diastolic blood pressure and heart rate) compared to subjects without caffeine. Changes in the peripheral vasoconstriction and neurohormonal levels (cortisol, epinephrine, norepinephrine) were not measured so the mechanisms underlying the effects could not be determined.

If caffeine is to be used as a stimulant under sustained operations, its effect on performance and mood under stress must be known. Cardiovascular reactivity is of interest as perceived stress can influence performance and increases in heart rate can increase perceived stress. Studies of the effects of caffeine and mood show increased anxiety, anger, restlessness and helplessness following ingestion of caffeine compared to a placebo. High caffeine intake is associated with greater report of anxiety and depression (Greden, Fontaine, Lubetsky and Chamberlain, 1978). These effects are greater when a stressful task is performed (MacKinnon and Sullivan, 1991).

Finally, the effects of caffeine habituation and caffeine deprivation in habitual users have not been fully addressed. Individuals typically develop a high tolerance for caffeine, at least in regard to health symptoms. Many of the effects of caffeine, such as increased sleep latency, anxiety, tremors are reduced in habitual caffeine users as compared to light or occasional users ( Benowitz, 1988). Subsequent abstinence frequently leads to headache, fatigue, nausea, anxiety and impaired psychomotor performance (Griffiths and Woodson, 1988).

Effects on performance do not appear to have been tested in habitual users. It is uncertain therefore, what effect caffeine has on performance or the ability to maintain an alert state in habituated users. Many studies of caffeine do not screen their subjects for habitual levels of use and do not consider the effects of caffeine deprivation when requesting that volunteers abstain from caffeine use prior to performing an experimental protocol.

Before caffeine can be recommended as a pharmaceutical agent for use during sustained or other military operations questions concerning its effects in habitual users and under periods of stress must be answered.

6. Technical Approach:

EXPERIMENT 1. CARDIOVASCULAR, MOOD AND PERFORMANCE EFFECTS (FY93):

Two groups of volunteers will be recruited, habitual caffeine users and non-users. For this and all subsequent experiments , caffeine usage will be determined using a standard caffeine intake questionnaire. These questionnaires have been found to provide reliable estimates of caffeine intake (Sawyer, Julia and Turin, 1981). Subjects will also be asked to fill out a brief health questionnaire to determine potential health problems and participation will be screened by a medical officer. Individuals consuming more than the equivalent caffeine in two cups of coffee daily will be considered habitual users. A minimum of ten subjects per group will be used in each experiment.

For the first experiment each subject will participate in two sessions. Subjects will be told not to discontinue normal caffeine usage; they will not be caffeine deprived. During one session the subject will receive a placebo and during the second 250 mg of caffeine. Both dosages will be presented in grapefruit juice to mask the taste. This dosage has been employed in several recent studies of caffeine (Lane and Williams, 1988; France and Ditto, 1988; Sawyer, Julia and Turin, 1982). Caffeine approved for human use will be obtained from a pharmaceutical company. Both the subjects and the investigator will be blind to the experimental condition during testing.

Baseline cardiovascular, mood and performance measures will be taken before administration of the caffeine or placebo. Cardiovascular measures will include heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and vascular measures of pulse blood volume and/or pulse transit time. The latter two measure provide information on the state of peripheral circulatory system and peripheral pressure dynamics. Caffeine levels will be measured at the beginning and the end of performance testing using a salivary assay or in plasma using high pressure liquid chromatography. While salivary assays would be preferred because they are non-invasive the development of these assays is still in the experimental stages. Neurohormonal measures of caffeine's effect on the stress response will be determined by measuring levels of cortisol, norepinephrine and epinephrine in plasma. This will assist in determining the mechanism underlying elevated blood pressure after caffeine consumption. It is hypothesized that caffeine's primary cardiovascular effect is in the enhancement of vascular resistance rather than sympathoadrenal system activation.

The performance tests used will consist of paced mental arithmetic (Schlichting and Wray, 1986) and AGAARD Reaction Time measures which permits studying potential differential effects on separate stages of the reaction process; these include stimulus processing or encoding, response choice, motor programming, and motor activation. Mood will be measured following performance testing. This paradigm

will determine which information processing stages are affected by caffeine and the extent to which these changes are still present in the caffeine tolerant individual.

EXPERIMENT 2. EFFECTS OF STRESS ON CARDIOVASCULAR REACTIVITY IN HABITUAL USERS AND NON-USERS OF CAFFEINE (FY93):

Habitual users and non-users will be given either placebo or a 250 mg dose of caffeine prior to a cold pressor test. Centrally mediated cardiovascular reactivity and peripheral vasculature effects will be measured before, during and after a 3 degree Celsius cold pressor test. This experiment will test the hypothesis that habitual caffeine users will show less cardiac system reactivity to stress and provide information on the mechanism of action (peripheral or central). It will also determine to what extent caffeine may act as a buffer against increased cardiac reactivity in non-users. Caffeine levels will be determined before and after the experiment using salivary assays or in plasma.

EXPERIMENT 3. HEMODYNAMIC AND NEUROENDOCRINE EFFECTS OF CAFFEINE IN CHRONIC USERS (FY94).

This experiment will examine tolerance effects in chronic users. Habituated users will be tested in four sessions. For two sessions the subjects will be asked to abstain from caffeine use for 24 hours and in the other two they will continue their normal pattern of consumption. Caffeine (250 mg) will be administered following abstinence and following normal consumption. A placebo will be administered in the other two sessions. A psychological stressor known to elevate blood pressure and heart rate, mental arithmetic, will be administered to determine the additive effects of caffeine and psychologic stress in chronic users. Cardiovascular measures will include systolic and diastolic blood pressure, heart rate and pulse volume. Caffeine, cortisol, epinephrine and norepinephrine levels will be measured in plasma before and after each session. It is hypothesized that due to the cyclic nature of daily caffeine consumption (no caffeine during sleep) habituated users will not show chronic tolerance to caffeine's pressor effect after abstaining from caffeine for 24 hours and that residual caffeine levels will influence responsivity in the non-abstaining sessions. The nature of the interaction of combined caffeine and psychologic stress effects will be determined. It is hypothesized that the effects will be additive.

7. Assessment of Risk:

With the exception of a system to quantify pulse volume/pulse amplitude, all equipment required is already on hand. Habitual caffeine users are also available. Preliminary data collected from 40 volunteers suggests high caffeine usage in young navsal personnel.

8. Related Activities:

NHRC and NMRI are currently performing caffeine related research. The P.I. will collaborate with the individuals involved with similar research at these institutions. The

P.I. has also consulted with local researchers in the New London area, in particular Dr. J. Mackinnon at Connecticut college. This relationship will continue.

9. Transition Approach:

This research will provide specific recommendations for caffeine use in habituated users. The test paradigms developed could easily transition to the study of other proposed stimulants including the interactions of these with chronic caffeine usage.

10. Resources Required (Funding Category 6.1):

| | FY 93 | FY 94 |
|---|---|---|
| Funding Requirement | 176.0 | 170.0 |
| Civilian Professional | .8 | .8 |
| Civilian Supporting | .4 | .4 |
| Total | 1.2 | 1.2 |

11. Current References:


Benowitz, N.L. (1990). Clinical pharmacology of caffeine. **Annual Review of Medicine**, 41, 277-88.

France, C. & Ditto, B. (1988). Caffeine effects on several indices of cardiovascular activity at rest and during stress. **Journal of Behavioral Medicine**, 11(5), 473-482.

Greden, J.F., Fontaine, P. Lubetsky, M., and Chamberlain, K. (1978). Anxiety and depression associated with caffeinism among psychiatric patients. **American Journal of Psychiatry**, 135, 963-966.

Griffiths, R.R., and Woodson, P.P. (1988). Caffeine physical dependence: A review of human and laboratory animal studies. **Psychopharmacology**, 94, 437-451.

James, J., Paull, I. Cameron-Traub, E., Miners, J.O., Lelo, A., Birkett, D.J. (1988). Biochemical validation of self reported caffeine consumption during caffeine fading. **Journal of Behavioral Medicine**, 11 (1), 15-30.

Lane, J. Caffeine and cardiovascular responses to stress (1983). **Psychosomatic Medicine**, 45, 447-451.

MacKinnon, J.R. Report in preparation, 1991.

MacKinnon, J.R. and Sullivan, E.R. (1991). The effects of caffeine and cognitive stress on mood. Paper presented at the 12th annual meeting of the Society of Behavioral Medicine, Washington, DC, March 20-23, 1991.

Robertson, D., Frolich, J., Carr, R.K., Watson, J.T., Hollifield, J.W., Shand, D.G., and Oates, J.W.A. (1978). Effects of caffeine on plasma renin activity, catecholamines and blood pressure. **New England Journal of Medicine**, 298, 181-186.

Sawyer, D.A., Julia, H.L., Turin, A.C. (1982). Caffeine and human behavior: Arousal, anxiety, and performance effects. **Journal of Behavioral Medicine**, 5(4), 415-439.

Schlichting, C.L. and Wray, D. (1986). Cognition: A program for the presentation of several tests of cognitive function using the Hewlett-Packard 85 computer. **Behavior Research Methods, Instruments, & Computers,** 18 (1), 65.

A DTIC Search , Report Number XMO58K, was conducted on 10 May 1991 to identify related research efforts.

12. Issues:

Potential issues involve the administration of caffeine to volunteers and medical monitoring to assure the safety of all procedures. Proposed research will meet all guidelines of SECNAVINST 3900.39B of 27 FEB 1984 and the requirements of the NSMRL Committee for the Protection of Human Subjects.

Management of out-of-house efforts:

Use of salivary assay for caffeine would require coordination with Naval Health Research Center. This assay has been developed under contract with NHRC under the auspices of Dr. P. Naitoh. Contract costs include funding for these assays and the development of a system to measure pulse amplitude.

II. NEW START (O):

1. Title: Effects of Multiple Stressors on Physical and Mental Performance in Fire Contaminated Compartments

2. Principal Investigator: A. Callahan, Ph.D
Co-Investigators: LT Dennis DLugos, MC, USNR and
C. Schlichting, Ph.D.

3 Laboratory: Naval Submarine Medical Research Laboratory
Department: Biomedical Sciences
Phone Numbers:
Autovon: 241-3410
Commercial: (203) 449-3410

4. Navy Need:

There are three major requirements to which this work is addressed. The first is established under the cognizance of ADDDRE(T&E). The U.S. Congress has passed legislation (Chapter 139 of Title 10, Section 910 of the United States Code) requiring vulnerability and lethality testing of selected major weapons systems prior to full scale production. The primary emphasis of the Live Fire Testing program is on realistic testing as a source of personnel casualty, vulnerability and lethality information which takes into account the susceptibility to attack and vulnerability of the combat system. The Assistant Deputy Director Defense Research and Engineering (Test and Evaluation) (ADDDRE(T&E)) has provided the funds for preliminary studies in this area at NSMRL. ADDDRE(T&E) also sponsored a work-shop on live fire Test-Crew Casualty Assessment at NSMRL on 18-19 Oct. 1988.

The second requirement for this program is established by the Ship Survivability Program with OP-03C2 as NAVOP Coordinator for Survivability. A specific goal of this program is to develop methods to deal with major interior ship conflagrations, to integrate newly developed items, including new fire retardant materials for damage control and firefighting. The final goal of this program is to provide for advanced damage control and firefighting concepts for new ship designs. OP-03 sponsored and funded a Workshop on the Effects of Combined Fire Products on Human Physiological and Psychological Performance at NSMRL on 16-18 Nov. 1987. A NAPDD for Active Firefighting Initiatives (NAPDD #218-03) has been approved and promulgated for this program.

The third requirement for information derived from this program is established under a Tentative Operational Requirement for Damage Control Management Systems (promulgated 9/14/88 by OP-098). Included among the capabilities derived by this TOR are the need to diagnose problems in order to minimize, localize, and limit casualties;

monitor and verify casualties; and monitor and verify casualty resolution. In the context of this TOR, a casualty refers to combat operational systems, e.g., missile launch, propulsion, communication as well as considering the crew component as a specialized combat operational system.

5. Problem/Objective:

The output of this study will document the dose thresholds at which several commonly encountered fire-produced stressors, alone and in combinations, produce decrements in mental and physical performance. Stressors include exposures to elevated carbon monoxide, low oxygen, elevated carbon dioxide, heat and work loads. Performance of unprotected individuals and individuals in survival or fire fighting equipment will be investigated selecting the appropriate stressors for the degree of protection.

This research seeks to assess the physiological and psychological (mental acuity) effects incurred by damage control and firefighting personnel when exposed to the multiple stressors expected in operational combat scenarios. It is intended that a quantitative assessment technique will be developed which will incorporate environmental stressors and physiological responses to these stressors into a predicted value for personnel response capability. There are a variety of potentially applicable modeling techniques which can be applied to this task. Among these are the Coburn-Foster-Kane model, the Fractional Effective Dose Model and the N-Gas Model. All of these models are suitable to accommodate a variety of environmental stressors and physiological responses. However, there is insufficient data in the literature on the physiological effects of multiple stressors with which to exercise the models.

6. Technical Approach:

The research program has been planned for three phases:

Phase 1 is concerned with the establishment of presumptive baseline values for performance decrement, as a function of dose for each stressor and the selection of proper performance tests to reflect decrements of decision-making and mental acuity. Literature searches provide much of this information. A parallel effort will develop models for predicting decrements in mental acuity and physical performance based on physiological responses to multiple stressors. After the determination of presumptive baseline values, human pilot studies will be performed for validation and refinement of the research protocol for each stressor.

Phase 2 will consist of full scale studies using human volunteers. The research protocol will use a "step-up" approach of 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.

This proposal does not include examination of additional fire gas products such as HCN and HCL but further experiments could be performed on animals and the results extrapolated to the human model.

Phase 3 is concerned with gathering data and the application and validation of the research results in 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 human performance and pertinent environmental parameters (fire gas concentration, smoke, heat, mass loss and rate of build-up) useful in predicting physiological responses and performance, particularly for individuals wearing protective equipment. 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.

7. Assessment of Risk:

Phase 1 and 2 of this proposed study have been previously supported with limited "seed" money by the Live Fire Test Office for a feasibility study. A computer program based on 11 physiological and environmental variable has been completed and successfully tested with 9 human volunteers in 92 exposures. A presentation on the results of this preliminary study were presented at the Live Fire Testing Second Crew Casualty Assessment Workshop sponsored by ODDR&E(T&E) and held at Brooks AFB, San Antonio TX. This work has substantially demonstrated the feasibility of the modeling approach to this research. The agreement between levels of carboxyhemoglobin predicted by the computer model and those measured directly from the blood had very strong correlation, $r = 0.9688$. These subjects were exposed to a single concentration of CO (7440 ppm). In a real fire scenario however, personnel would be subjected to a fire gas concentration which would vary with time. For future work it will be necessary to alter the current uptake model to accomodate a time varying concentration of multiple gases ( CO, $CO_2$, $O_2$ ). Such alterations do not pose any obstacles to the completion of this work.

The limits for ship survivability and combat systems operations during fires are obviously affected by human performance. The tolerable limits of fire by-products as they infiltrate into vital shipboard spaces affects several areas: combat systems design; sensor settings for new compartment monitoring systems; equipment for appropriate personnel protection; permissible flammable materials (fire loading) included on combat platforms; life support systems; fire sensor design; human tolerance standards; and damage control/firefighting protocols. Models to predict human physiological responses and performance are difficult but not impossible to develop and test. The investment of time, money and resources in this program seems fully justifiable within the goals of ADDDRE(T&E), OP-03C2, and OP-091.

8. Related Activities:

This area is not being addressed by civilian sector, which is more concerned with fire by-product lethality and time to escape, rather than with continuing or reestablishing operations as quickly as possible. Cooperative efforts with NRL are discussed under "Technical approach."

9. Transition Approach:

The information can be used immediately in evaluating the vulnerability of present and future combat systems. Stay times, protection requirements, sensor design/settings, and damage control techniques can incorporate pertinent information immediately for systems under design and within several months to a few years for operational systems.

10. Resources Required (6.3 category):

| | FY93 | FY94 | FY95 | FY96 | FY97 |
|---|---|---|---|---|---|
| Funding required | 356.0 | 373.0 | 390.0 | 377.0 | 153.0 |
| Military Officer | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| Military Enlisted | 0.4 | 0.4 | 0.4 | 0.4 | 0.0 |
| Civilian Professional | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| Civilian Supporting | 1.0 | 1.0 | 1.0 | 1.0 | 0.2 |
| Total | 2.4 | 2.4 | 2.4 | 2.4 | 1.0 |
| Additional personnel | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 2.0 | 2.0 | 2.0 | 2.0 | 0.0 |
| Civilian Professional | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Civilian Supporting | 1.5 | 1.5 | 1.5 | 0.5 | 0.5 |
| Total | 4.0 | 4.0 | 4.0 | 3.0 | 1.0 |

11. Current References:

1. Proceedings of the Live Fire Test Crew Casualty Assessment Workshop. Office of the Director, Defense Research and Engineering (LFT), Washington, D.C., 1988.

2. Fire and Smoke: Understanding the Hazards. Committee on Fire Toxicology, Commission on Life Sciences, NAS-NRC, National Academy Press, Washington, D.C., 1986.

3. Complex Mixtures: Methods for In Vivo Testing. Board on Environmental Studies, Commission on Life Sciences, NAS-NRC, National Academy Press, Washington, D.C., 1988.

4. Purser, DA. Modelling Toxic Fire Hazards in Fires. In "International Progress in Fire Safety." Proceedings of the Fire Retardant Chemicals Association Meetings, 101-130, 1987.

5. Tikuisis, P., Meatal, HD, Gell, BJ, Lewis, WF, Cox, KN, and Kane, DM. A Critical Analysis of the Use of the CFK Equation in Predicting COHb Formation. Am Ind Hyg Assoc J, 48(3): 208-218, 1987.

II. NEW START (P)

1. Title: Medical Consequences of Submarine Atmospheres.

2. Principal Investigator: CAPT P. K. Weathersby, MSC, USN

3. Laboratory: Naval Submarine Medical Research Laboratory
Biomedical Sciences Department
Phone numbers:
Commercial: (203)449-2540
Autovon: 241-2540

4. Navy Need:

Prolonged confinement in an enclosed submarine atmosphere is a Navy-unique environmental hazard. Intensive work in the 1950s and 60s developed a robust atmosphere control system that met all medical standards of the time. Since that time, concern for environmental hazards both in society at large and in the Navy have increased substantially. However, there is not a single Navy health professional who has full time responsibility for submarine atmosphere. An integrated program of research and increased atmospheric monitoring is now needed.

5. Problem/Objectives:

a) Bolster the submarine atmosphere monitoring program to document fleet levels of trace organic contaminants.

b) Provide a long-term health surveillance program in areas of atmosphere toxicity risk to personnel.

c) Develop improved chemical instrumentation capable of efficient submarine deployment.

d) Expand submarine operational capability by manipulation of atmosphere parameters.

6. Technical Approach:

a) Institute program of atmosphere monitoring by review and periodic air sampling in submarines on patrol with subsequent analysis ashore.

Major performer: Contractor; Monitor: NSMRL

b) Conduct a (low level) submarine health monitoring program with an occasional major epidemiological study (like Ostfeld report)

Performers: NSMRL and NUMI

c) Evaluate, and modify, if necessary, commercial instruments for aerosol analysis; for portable instruments to replace detector tubes. Develop a means to use CAMS-II data tapes.

Performers: NSMRL, NRL (Code 6110), contractors

d) Conduct human experiments to allow extension of submarine oxygen zone into more fire-retardant regions. Explore use of $N_2$ as a fire extinguisher. Study the interaction of CO and $CO_2$ (gases which will always be important contaminants) to remove unnecessary conservatism in setting toxic limits. Develop methods to purify submarine air bank gas for use by deployed divers.

Performers: NSMRL, NMRI -TD

7. Assessment of Risk:

Technical risk is low to moderate on the research issues, none on the monitoring functions.

8. Related Activities:

This field is Navy unique. Main outside interaction will be with UK and French Navy with contact with external chemical and epidemiological investigators as appropriate.

9. Transition Approach:

Product delivery is obvious but timeline depends on funding. Expect about one chemical instrument per year and one performance enhancing recommendation about every 3 years.

10. Resources Required (Could be 6.3, 6.4, 6.5 or OM&N)

Personnel: Need NEW: physiologist, 2 chemists (civilian) plus 1 Undersea Medical Officer, 1 Submarine Independent Duty Corpsman, 1 lab tech (military or civilian), 1 data entry clerk (military or civilian)

Annual Cost: 1.9M (1991$)

Duration: Until demise of submarine fleet

II. NEW START (Q)

1. Title: Naval Medical Informatics Center -- NAMIC

2. Principal Investigator: D. M. Stetson, CAPT, MC, USN

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Behavioral Sciences
Phone Numbers:
Autovon: 241-2523
Commercial: (203) 449-2523

4. Navy Need:

Improved patient care and reduced administrative burdens on providers within existing assets.

Centralized focus for medical informatics in the Navy.

Focus for medical software development and testing.

5. Problem/Objective:

Improve practice quality for providers, enhance patient care, reduce medico-legal risks, and improve patient understanding and compliance regarding their care by bringing state of the art computer capabilities to the service of medical professionals.

6. Technical Approach:

Through evaluation of existing medical software, management of contracts to create new software products meeting specific requirements and in-house development and testing of hardware/software systems, the project will create an integrated medical care provider oriented medical practice supports system. The approach will emphasize:

1) Gathering, refining and validating user requirements.

2) Formal, dynamic system specification.

3) Rapid prototyping with expert review and usability testing.

4) Formal hardware/software quality assurance techniques.

5) Modular programming and integration under uniform interface.

6) Mainstream language to facilitate transition and maintenance.

Expected products: Full featured, integrated, micro-computer based multi-media system which supports medical provider needs by intelligently evaluating user inputs and stored information to instantly offer the user access to a wealth of medical reference material, expert system based diagnostic assistance and patient care review, and complete medical record keeping. Features will include:

1) Utilization of artificial intelligence and plain language recognition permitting background operation to minimize system demands on the user and allowing a single system to serve users with different skill levels working in facilities with different capabilities and limitations.

2) Multi-media capabilities including high resolution still and animated graphics, TV images and simultaneous sound.

3) Extensive library of text, images and sound providing information on medical conditions and procedures.

4) Voice recognition for data input and spoken responses.

5) Dynamic, interactive continuing medical education.

6) Patient tailored output including interactive patient education.

7) Complete patient record documentation.

8) Data exchange capability with other federal medical computer systems.

A system featuring intelligent review of user input and offering tailored diagnostic assistance, patient care review and patient education material will be completed in 2-3 years; a fully functioning system with full voice and medical language recognition will be complete in 5 years.

7. Assessment of Risk:

With the exception of medical language and voice recognition the likelihood of success is very high. Much of the needed technology is available, requiring only focused integration and testing.

Intelligent recognition of medical language and of voice are greater risks, reduced somewhat by the widespread availability of microcomputers with enormous computing power and several academic centers and industrial concerns devoting effort to these areas.

8. Related Activities:

NSMRL: Subscreen psychologic testing program; usability testing program. Auditory sonar program (enhancing speech recognition).

NHRC: Cooperation in MEPSS development, DNBI database, NOHIMS database.

CONTRACTORS:

APL:Cooperation in MEPSS development, neural network expertise, experience in language and voice recognition.

OTHERS (involved in knowledge base development): NW Research Associates, Seattle; Medical College of Pennsylvania, Philadelphia; University of Missouri-Columbia School of Medicine, St. Louis; Cyometrics, Bel Air, MD; University of Leeds, Leeds, England; Southern Illinois University; Harvard University Medical School, Boston; and others.

Anticipated Interaction. None of the other people in this field are developing products aimed at assisting the physician or non-physician medical provider practicing in isolated situations, small clinics or the general outpatient setting of hospitals. However, each of them is a useful resource for specific products and expertise. The availability of these related activities substantially lowers the risk of this effort.

9. Transition Approach:

Everything envisioned under this proposal can be immediately applied to physician and non-physician providers in the fleet, isolated practice and general outpatient practice. Everything envisioned under this proposal has immediate industrial applicability (at the medical clinic level). Transition for cooperative development will be easy, and licensing opportunities are very real.

10. Resources Required (Category: 6.3)

| | FY93 | FY94 | FY95 | FY96 | FY97 |
|---|---|---|---|---|---|
| Funding Required | 802.5 | 802.5 | 802.5 | 802.5 | 802.5 |
| Personnel required | | | | | |
| Military Officers | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Military Enlisted | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Civilian Professional | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Civilian Supporting | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Total | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Additional personnel | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Equipment: computer equipment/software/maintenance

11. Current References:


Lee K., Hauptmann A., Rudnicky A., "The Spoken Word", in BYTE, July 1990.

Kowarski D., "A Low-Cost Personal Computer-Based Radiology Diagnostic Expert Wywtem and Image and Text Database", Proceedings of the Third Annual IEEE Symposium on Computer-Based Medical Systems, June 1990.

Morelli R.A., Bronzino J.D., Goethe J.W., Hartmann-Voss K., "Incorporating a Language/Action Design Perspective into a Computer-Based Psychiatric Alerting System", Proceedings of Thirteenth Annual Symposium on Computer Applications in Medical Care, November 1989.

Mahon M.J., "The PC: A Tool for Integrated Information Management", in Proceedings of the American Society for Information Science Mid-Year Meeting, May 1990.

Kelly-Bootle S., "The human-appliance interface", *in Computer Language* 7:117-22, January 1990.

II. NEW START (R)

1. Title: Prevention of Coronary Heart Disease (CHD) Among Submariners With Nutrition Education and Modification.

2. Principal Investigator: LT Caron L. Shake, MSC, USNR

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Biological Sciences
Phone numbers:
Commercial: 203-449-3471
Autovon: 241-3471

4. Navy Need:

In 1981, the Department of Defense (DOD) updated DOD policy requiring all Navy members to meet percent body fat standards as a condition of military service. The DOD believes that an overfat or obese service member presents a health risk because excess body fat has been shown to be associated with high blood pressure, diabetes, and heart disease as described by the National Institutes of Health Conference on Obesity (1,2).

National interest in high cholesterol levels was created by the Surgeon General's Report on Nutrition and Health and the National Cholesterol Education Program. Lifestyle changes which include a healthy diet may reduce the incidence of chronic diseases such as heart disease, obesity, diabetes, and cancer (1).

The Navy supports the idea that members need to be aware of the importance of nutrition and its relationship to good health and encourages commands to provide nutrition information for such things as base papers, cafeterias, general mess and bulletin boards. However, no Navy requirements exist which formally address the issue of nutrition education for every member. Limited information is provided to the mess specialists (during their schooling) whose job it is to provide meals for Navy personnel. Although excellent nutrition information is available to Command Fitness Coordinators and Food Service Officers, this information is not fully promulgated down the line, and it is not always implemented. The mess specialists have less opportunities today to attend schools that offer nutrition information as they did in the past and the nutrition information they do receive during school is limited.

The relationship between risk factors (elevated serum cholesterol, and obesity) and CHD appears to, and should be of importance to the DOD and the U.S. Navy from both a health and financial standpoint. It has been estimated that the reduction of serum

cholesterol levels alone can increase health and life expectancy (3) and save thousands of dollars in lifetime medical expenditures per individual (4). According to the American Heart Association, the economic costs of cardiovascular disease totalled $85.2 billion in 1987 and continues to rise. They also report that an estimated 32 million work days and $8.6 billion in wages are lost annually to heart related disease (5). The cost of replacing, training, and recruiting higher level employees felled by heart disease is about $70 million a year (5).

It has been suggested that an individuals dietary habits are in part affected by the food choices available and the amount of nutrition knowledge attained (6). Research also suggests that nutrition knowledge is positively correlated with lifestyle factors associated with reduced cardiovascular disease risk (7). Therefore, the purpose of this research is to address how formal, required nutrition education of mess specialist aboard submarines, followed by nutritionally sound food preparation and meal planning, can provide submarine crew members with a variety of proper nutritional choices thus decreasing CHD risk factors.

5. Problem/Objective:

Hypothesis: There will be significant differences found between pre and post-submarine deployment measurements of total cholesterol (TC), high density lipoprotein cholesterol (HDLC), low density lipoprotein cholesterol (LDLC), triglycerides (TG), and percent body fat (%BF) in two groups of submariners.

The objective of this proposal is to demonstrate that a nutrition education program for mess specialists followed up by dietary/menu modification during submarine deployment can have a beneficial effect on the CHD risk factors in submarine crew members by reducing serum cholesterol, other lipid fractions, and body fat percentages (8). The reduction of CHD risk factors may lead to improved cardiovascular health, physical readiness and job performance.

6. Technical Approach:

This research will be carried out in the field. Subjects will include male U.S. Navy submarine volunteers from several Trident submarine Boommer crews stationed at either of the two Naval Submarine Bases (Kingsbay, GA or Bremerton, WA). Only individuals who are on medication for the treatment of hypercholesterolemia will be omitted. Research will be conducted during deployments of at least 60 days. The submarine crews will be randomly assigned to either the treatment group or control group. The control crew will be provided a diet consisting of menus prepared as usual by the

mess management specialist who will not be given any additional nutrition education. The treatment crew will be served a modified diet which will be prepared by mess specialist who have received specific instructions on how to order foods, prepare cycle menus, and prepare foods. They will also have attended nutrition education lectures. The modified submarine diet will be planned under the supervision of a registered dietician from NAVHOSP Groton.

This experimental diet will be designed to include many nutritionally sound recommendations. Following are some of the recommendations.

a. Use whole grains in bread products when possible.

b. When feasible use high fiber, low fat, low cholesterol foods.

c. Provide alternate choices of fish, chicken and pork versus beef when possible.

d. Boil, bake, and broil foods instead of frying or deep fat frying.

e. Use skim milk in cooking and for drinking.

f. Replace usual high fat main courses with low fat alternatives.

k. Keep fats, fatty foods and sugar to a minimum.

f. Cook vegetables without butter or sauces and spice appropriately.

Measurements of total cholesterol (TC), high density lipoprotein cholesterol (HDLC), low density lipoprotein cholesterol (LDLC), triglycerides (TG), and percent body fat (%BF) will be made immediately pre and post deployment. Blood will be drawn in the morning after a 12 hour fast with the subject in a sitting position (9) and analyzed at the appropriate Naval Submarine Base Hospital for TC, HDLC, LDLC, TG. Percent body fat will be determined by hydrostatic weighing at the nearest research laboratory.

The data will be analyzed with the SPSSX Manova procedure using the between groups multivariate model. Statistical and clinical significance of the data will be analyzed and appropriate recommendations will be made concerning the results.

This research was chosen to take place aboard submarines. The issue of weight gain and meal/food choices has been an ongoing and increasing concern of submarine crew members and medical officers. The Trident missile submarines offer the most ideal setting for research designed to last no less than 60 days. The Trident missile submarines usually have a more regular schedule of deployment and the submarine itself offers a relatively confined and controlled situation with respect to meal planning and preparation.

7. Assessment of Risk:

The technical risk is extremely low with respect to the research issues.

Any time research is conducted on board a submarine during deployment, there always exists the possibility that the military mission may take precedence over any such research, thus inhibiting or interrupting such studies. We do not expect any problems once the nutrition education has been provided, the menu planned and the submarine is underway.

8. Related Activities:

There have been many groups of individuals (government and civilian) who have conducted and are conducting research which studies the effect of diet on CHD and related risk factors. There is one group of civilian scientists (School of Nutrition, Tufts University, Medford, MA) who has just recently studied the correlations between nutrition knowledge and risk of cardiovascular disease (Blumberg JB, Rasmussen H, Dallal G et al., Unpublished). However, this is the only research that is designed specifically to document changes (during a submarine deployment) in CHD risk factors, with the intent of modifying such changes by implementing a nutrition education program along with altering the diet/menu of submariners.

Interaction with groups who are working in the area of CHD and nutrition knowledge have as of this date already been established (Blumberg JG, Rasmussen H, Dallal G et al.). Collaboration/consultation efforts with other scientists (civilian and military (NMRI)) is a priority with this study and again has been established.

9. Transition Approach:

Transition of the research product(s) into use by the Fleet would be simple and fairly inexpensive in dollars and time. Should the results indicate that formal nutrition education and slight diet/menu modification lowers risk factors for CHD, then the nutrition information could be implemented into the curriculum of the mess specialist texts at all levels. Review and revision of existing menu cards could also be easily accomplished. The intent would not be to alter every menu card but instead provide low fat, low cholesterol, low calorie alternatives when possible. The time needed for these transitions would be no more than two years assuming there is sufficient military support.

10. Resources Required (6.3):

| | FY93 | FY94 |
|---|---|---|
| Funding required | 102.0 | 102.0 |
| Personnel required | | |
| Military Officer | .3 | .3 |
| Military Enlisted | .5 | .5 |
| Civilian Professional | .2 | .2 |
| Civilian Supporting | .1 | .1 |
| Additional personnel | 0.0 | 0.0 |

11. Current references:


1. Weber D. Navy nutrition and weight control guide (NAVPERS 15602). Washington, DC: Naval Military Personnel Command: 1989.

2. National Institutes of Health Consensus Development Panel on the Health Implications of Obesity. Health implications of obesity. Ann Intern Med. 1985: 103: 1073-7.

3. Taylor WC, Pass TM, Shepard DS, et al. Cholesterol reduction and life expectancy: a model incorporating multiple risk factors. Ann Intern Med. 1987: 106-14.

4. Oster G, Epstein AM. Primary prevention of coronary heart disease: the economic benefits of lowering serum cholesterol. Am J Public Health. 1986: 76: 647-56.

5. American Heart Association. Heart at Work Trainer's Manual. Volume II. Edited by Donatelle, RJ. Portland, OR: American Heart Association, Oregon Affiliate, Inc. 1987.

6. Graham C, Good D. Nutrition. In: Donatelle RJ, ed. Heart at work trainer's manual. Portland, OR: American Heart Association, Oregon Affiliate: 1987.

7. Blumber JG, Rasmussen H, Dallal G, et al. Analysis of the Promise Indes (TM) Survey: correlations between nutrition knowledge and risk of cardiovascular disease. Unpublished. (As of Aug 1991).

8. National cholesterol education program. Highlights of the expert panel on dectection, evaluation, and treatment of high blood cholesterol in adults. Bethesda, MD: National Heart, Lung, and Blood Institute, 1987: National Institutes of Health, Publication No. 88-2926.

9. Segal P, Bachorik PS, Rifkind BM, et al. Lipids and dislipoproteinemias. In: Henry JB, ed. Clinical diagnosis and management by laboratory methods. Philadelphia: W.B. Saunders: 1984: 180-203.

II. NEW START (S)

1. Title: Role of Carbon Monoxide in Potentiating Lung Damage Due to Toxic Smoke Inhalation

2. Principal Investigator: Arthur Messier, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Biomedical Sciences
Phone Numbers:
Autovon: 241-2537
Commercial: (203) 449-2537

4. Navy Need:

Fire is an ever present danger aboard U.S. Navy ships exposed to combat damage as well as to routine accidents. The presence of smoke and fire gases can cause severe personnel casualties even at levels of smoke and fire gases which would normally be considered to be non-lethal. The mechanism by which this lung damage occurs is not fully understood and consequently, therapeutic measures for the treatment of this lung injury are somewhat empirical. A fuller understanding of the mechanism of lung injury due to inhalation of smoke and fire gases would provide the basis for improved methods for treatment.

5. Problem/Objective:

The processes by which toxic smoke and fire gases produce lung tissue damage have been intensively studied [1,2]. There is still much uncertainty as to the molecular events which trigger and sustain this pathophysiological process. A wide variety of interacting biological molecules have been implicated, e.g. biogenic amines, kinins, prostaglandins, leucotrienes and activated complement factors[3,4]. One of the most prominent events in the damage syndrome is the infiltration of the tissue by polymorphonuclear leucocytes, macrophages and monocytes which have been associated with much of the tissue damage. Phagocytic activity of these cells is accompanied by an extra consumption of oxygen ("respiratory burst") which results in the production of several species of tissue damaging free radicals, superoxide($O_2$.-), hydroxyl($OH^{\cdot}$) and peroxyl ($^{\cdot}HO_2$) as well as singlet oxygen($^1O_2$) and peroxide ($H_2O_2$).Although the purpose of the radicals is to generate bacteriocidal compounds e.g.hydrogen peroxide, they can be equally damaging to the tissue cells as to the infectious bacteria[3]. Superoxide radicals are also produced normally in the mitochondria at the cytochrome $a_3$ site of the electron transport system as part of the process of reduction of $O_2$ to $H_2O$[6]. Normal protection from the excess accumulation of the radicals is provided by the superoxide dismutases produced in the nucleus, mitochondria and cytosol. The superoxide dismutase converts the superoxide radical into molecular $O_2$ and hydrogen peroxide which is further decomposed to $H_2O$ and $O_2$ by catalase and glutathione peroxidase.

Cytochrome $a_3$ is the only cytochrome which can bind with ligands like $O_2$ and can be inhibited by carbon monoxide[6]. Inhibition at this level could prevent the final reduction of the superoxide radical to $O_2$ and lead to an excess of cell damaging free radicals which could overwhelm the dismutase system in the mitochondria[5]. Such an excess of free radicals could also cause damage to the mitochondrial membrane and leakage of additional mitochondrial free radicals into the cytosol potentiating further damage to cells and tissue caused by macrophage infiltration and function.

Although the scientific basis for a potentiation of lung tissue damage by carbon monoxide as a result of breathing toxic smoke and gases is soundly based, this aspect of the total damage syndrome has not been fully examined. It is the objective of this proposal to evaluate the contribution of this potentiating effect in the lung damage process.

6. Technical Approach:

The technical approach to this research will be implemented in three phases which would insure proper consideration of risk assessment.

1. Demonstration of mitochondrial free radical effect in pulmonary cells due to carbon monoxide exposure.

2. Quantitation of mitochondrial free radical effect under increasing concentrations of carbon monoxide.

3. Quantitation of mitochondrial free radical effect in total smoke damage syndrome.

In order to investigate the role of carbon monoxide in potentiating lung damage due to toxic smoke inhalation, human lung cells will be obtained from bronchoalveolar lavage and from surgically excised tissue. Arrangements for obtaining these human cells have been discussed with CDR H. Newball at NMRI. Four cell types will be prepared by density centrifugation into pneumocyte, monocyte, macrophage, and neutrophil fractions; placed in a biological oxygen consumption monitor, and a superoxide respiratory burst will be stimulated by both particulate and soluble agonists. The respiratory burst will be assayed by cellular oxygen consumption, chemiluminescence, cytochrome c reduction, and ATP production. Metabolic blocks of the mitochondrial electron transport chain such as rotenone, cyanide, and azide as well as the effect of carbon monoxide will be tested. A number of possible protective agents (free radical scavengers) will be used to test the concept of therapeutic amelioration of the effects of CO upon the lung inflammatory response. This approach will provide information about the intracellular mechanisms of CO toxicity in potentiating the effects of lung damage and lead to development of possible protective and therapeutic approaches.

7. Assessment of Risks:

The effort proposed in this submission is based on fairly recent scientific concepts of free radical action which have only been developed within the past ten years. Definitive reviews of free radical action and their role in cellular function and injury date only since 1984[3,4]. The advancing state of knowledge in the physical chemistry of free radical reactions in biological tissue presents an opportunity to apply this knowledge and make a significant contribution to the increased understanding of the lung damage syndrome. The fact that the inhibitory site for CO which can produce an excess of cell damaging free radicals can be localized to a single, experimentally accessible enzyme offers several important research advantages. It presents the opportunity to study and quantitate the effects of this single aspect of the lung damage syndrome independently from the many other damage processes which normally occur concurrently. It clarifies and makes possible the assessment of the relative importance of this mechanism in consideration and application of therapeutic measures. It permits the research to be done most optimally at the isolated cellular level rather than at the more complicated tissue level and provides the opportunity to use a variety of human pulmonary cell types. The use of a cellular approach in this study will permit studies of a much wider range of exposure levels and pulmonary cell types at a far lower cost in time and dollars than would be possible using more expensive and time consuming whole lung tissue preparations. The use of human pulmonary cell types will also optimize the credibility of these findings when applied to humans.

The research protocol has been developed with "go-no go" milestones, i.e., successive phases of the research and continuation of the effort depend on the success of the previous phase.

Performers: Human lung samples will be obtained in collaboration with CDR Newbold, NMRI. Dr. Fisher of the University of Rhode Island will provide essential in vitro primary human cell isolation expertise. Initial experiments will be conducted at NSMRL and later experimental collaboration with Dr. Newball at NMRI. Collaborative efforts have also been discussed with Dr. Vernon Benignus of the Human Research Division of the EPA Health Effects Laboratory, Research Triangle, N.C. This proposed effort will continue on-going research at this laboratory on the oxidative stress in mammalian cells. Specifically this work is concerned with cellular adaptation to oxidative stress[7] and its effect on the ATP mechanism in the mitochondria.

Other Approaches: In vivo approaches utilizing human subjects are not feasible. The in vitro approach can best isolate the critical sites in the electron transport chain and isolate the mitochondrial effects from cell membrane and cytosolic tissue effects in the damage process.

8. Related Activities:

There are other groups separately looking at the inflammatory response of human pulmonary cells and the mitochondrial electron transport chain. However, at present we

are the only group investigating the role of carbon monoxide in potentiating lung damage in the context as presented in this proposal.

9. Transition Approach:

Understanding the pathophysiological role of CO in potentiating lung damage will lead to advances in clinical management of smoke inhalation in Naval personnel. Countermeasures for enhancement and maintenance of critical performance during sustained operations will be developed as a ressult of these studies. A period of three years will be required for testing of the hypothesis in this project. It is intended that upon the establishment of the potentiating effect of CO in cellular lung damage this work will transition into an investigation of the efficacy of known scavenger compounds, catalase, dismutase, *a*-tocopherol, etc., in antagonizing free radical damaging effects of toxic smoke inhalation in pulmonary cells. Preliminary discussions have been held with CDR Newball of NMRI about a cooperative effort on the assessment of therapeutic measures.

10. Resources Required(6.1 Funds):

| | FY93 | FY94 | FY95 |
|---|---|---|---|
| Funding Required | 248.0 | 220.0 | 215.0 |
| Personnel Required | | | |
| Military Officer | 0.0 | 0.0 | 0.0 |
| Military Enlisted | .6 | .6 | .6 |
| Civilian Professional | 1.5 | 1.5 | 1.5 |
| Civilian Support | .6 | .6 | .6 |
| Additional Personnel | | | |
| Civilian Professional (GS9/11) | .8 | .8 | .8 |

11. Current References:

1. Peters, S.P., K.H. Albertine, M.H.Gee and J.E. Gottlieb. A structure-function approach to investigate the role of inflammatory cells and mediators in the production of acute lung injury. Ann. N. Y. Acad. Sci. 524:271-281, 1988.

2. Demling, R.H. Current concepts on the adult respiratory distress syndrome. Circ-Shock 30(4): 297-309, 1990.

3. Flohe, L., Beckmann, R., Giertz, H., and Loschen, G. Oxygen-centered free radicals as mediators of inflammation. In: Oxidative Stress. H. Sies, Ed., Academic Press, London, England, 1985.

4. Piantadosi, C.A. Carbon monoxide, oxygen transport, and oxygen metabolism. J. Hyper. Med. 2: 27-44, 1987.

5. Mehrotra, S., Kakkar, P., and Viswanathan, P. Mitochondrial damage by active oxygen species in vitro. Free Rad. Biol. Med., 10: 277-285, 1991.

6. Copeland, R.A., Conformational switching at cytochrome *a* during steady-state turnover of cytochrome *c* oxidase. Proc. Natl. Acad. Sci. 88: 7281-7283, 1991.

7. Messier, A.A. and H. W. Fisher. Sensitivity of cultured mammalian cells to oxidative stress: adaptation to repeated exposures of hyperbaric oxygen. Undersea Biomedical Research. 17: 305-322, 1990.

II. NEW START (T)

1. TITLE: Evaluation of the Ability of Low-Frequency Active Sonar Transmissions to Deter Swimmers and Divers.

2. Principal Investigator: Paul F. Smith

This new start is classified.

II. NEW START (U)

1. Title: Texture as a Channel for Information Coding

2. Principal Investigator: Thomas P. Santoro, Ph.D

3. Laboratory: Naval Submarine Medical research Laboratory
Department: Vision Department
Phone numbers:
Autovon: 241-2445
Commercial:(203) 449-2445

4. Navy Need:

Information overload on sonar, radar, fire control, and other visual displays continues to be an increasingly significant bottleneck for the transfer of time-critical, complex tactical information to the operator via the human visual system. Designers of visual displays are therefore attempting to utilize every possible visual coding procedure. In the new AN/BSY-2 Submarine Combat System (1) eight methods are used to present visual information on the screen: position, alphanumerics, size, brightness, orientation, blink, shape, and color. One fundamental aspect of visual perception has not received adequate consideration by vendors of new display systems. That aspect is texture. We propose to thoroughly evaluate the use of texture to encode and enhance the transfer of information through visual displays.

5. Problem/Objectives:

Like color, texture is defined as a global attribute that is perceived apart from all specific, 'enumerable' (2) components of the visual environment. It has long been known (3) to play an important role in the detection and recognition of objects in the everyday world. Moreover, by their very nature, various sonar displays have texture as their primary visual feature. The Bearing Time Recording (BTR), and Low Frequency Analysis and Recording (LOFAR) displays present a classic texture detection and recognition problem to the operator. Early work (4) at NSMRL has suggested the existence of fundamental textures, possibly similar to fundamental colors, that are perceived equally well by most observers. Our first objective is to extend those preliminary findings and establish a solid characterization of normal texture vision and the nature of primary textures. This basic study will lead directly to the representation of complex sonar displays in terms of their underlying primary texture components thus contributing to more applied work in progress on visual sonar. If, for example, vertical line detection is important, background noise could be manipulated to enhance its horizontal connectedness thereby taking advantage of the known vertical/horizontal primary texture relationship (5). Finally, we will be able to recommend enhancements for sonar and other displays where texture is either an existing critical feature or could be used as an alternative information coding mechanism. Texture should prove to be an effective addi-

tion to the set of visual codes already in use. Moreover, detection and recognition of targets in noisy backgrounds could improve significantly through manipulation of the fundamental nature of background textures.

6. Technical Approach:

The texture vision test designed in the 76-77 study will be transferred to a state of the art high resolution CRT and re-run on a new group of sonar school subjects. The statistical representations of the basic textures will be redefined in the terms of current texture analysis theories (6). Typical sonar displays will next be examined to measure the distribution of fundamental texture properties and their dependence on the various signal processing stages and techniques applied to the original acoustic data. Once a link is made between the basic features critical to human texture perception and the parameters involved in modern sonar such as sample rate, quantization, adaptive filtering, quadrature detection, spectral density estimation and scaling, etc., recommendations can be formulated for the enhancement of sonar displays. Principles similar to those governing the use of color in information coding will be developed for the texture channel so that it can be fully exploited in the solution to the CRT information overload problem.

7. Assessment of Risk:

The basic theory for this work was established by Julesz (7) and extensively tested in subsequent work by other scientists (8). The fundamental texture properties originally described in terms of nth order Markov statistics have not changed and we have high confidence they will be the same when cast into the current "texton", orientation/contrast gradient usage (9). While there is now a significant established capability at NSMRL with regard to the principles of sonar signal processing, there is the risk that the methods we identify to implement texture enhancements on existing or proposed sonar displays will be costly or otherwise technically prohibitive. That and the risk of texture, like color, being over-used and only adding to confusion and clutter on visual displays, are the major foreseeable failures for this work.

8. Related Activities:

Ongoing auditory and visual sonar work units at NSMRL provide critical background on sonar signal processing for this study. Work on the use of color in visual displays for information coding may also be applicable to textures.

9. Transition Approach:

General suitability of the approach will be established by year 2. Subsequent applied work will be focused on submarine (AN/BSY-2) and surface combatant displays.

10.Resources Required (Funding Category: 6.1 then 6.2):

| | FY93 | FY94 | FY95 | FY96 | FY97 |
|---|---|---|---|---|---|
| Funding Required | 165.0 | 118.0 | 170.0 | 180.0 | 230.0 |
| Onboard Personnel | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.8 | 0.8 | 1.6 | 1.6 | 2.4 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 1.6 | 1.6 | 2.4 | 2.4 | 3.2 |
| Additional Personnel | 0.0 | 0.0 | 1.0 | 0.0 | 1.0 |

Cost includes high resolution graphics display station in FY93
FY95: 1 GS/180 res psych; FY97: 1 GS/855 elec engr

11. Current References:


1. AN/BSY-2 Submarine combat systems technical report General Electric CDRL: B001-06 review copy of Sept. 1990.

2. Richards, W. Texture matching. Kybernetik 16. 155-162, 1974.

3. Nothdurft, H. Texture segmentation and pop-out from orientation contrast. Vision Res. 31, 1073-1078, 1991.

4. Santoro, T. The basis for pattern perception in complex visual sonar displays. Work unit no. DD-DR&E(AR) 636(3900), 30 Sept. 1977.

5. Santoro, T. and Fender, D. Rules for the perception of connectivity in random dot patterns. Vision Res. 16, 937-981, 1976.

6. Nothdurft, H. Different effects from spatial frequency masking in texture segregation and texton detection tasks. Vision Res. 31, 299-320, 1991.

7. Julesz, B. Visual pattern discrimination. IRE Trans. of the Prof. Group on Information Theory. IT-8 (No. 2), 84-92, 1962.

8. Beck, J. Similarity grouping and peripheral discriminability under uncertainty. Am. J. Psychol. 85 (N0. 1), 1-19, 1972.

9. Landy, M. and James, R. Texture segregation and orientation gradient. Vision Res. 31, 679-691, 1991.

II. NEW START (V)

1. Title: The Effects of Smoking and Tobacco Deprivation on Visual Functions: Implications for Military Operations

2. Principal Investigator: C. Schlichting, PhD.

3. Laboratory: Naval Submarine Medical research Laboratory
Department: Behavioral Sciences Department
Phone Numbers:
Autovon 241-2529
Commercial: (203) 449-2529

4. Navy Need:

Naval operations are performed in a variety of different environments. These frequently include darkness or other low visibility situations that place extreme demands on the visual system. Piloting a plane, scanning the horizon for ships or planes at night and monitoring visual displays in lowlight conditions are three examples. Current Navy statistics show that 43% of Naval personnel are smokers and that the percentage of smokers is even higher on surface ships (50%). Together with the reduced capacity to perform physical work and other health effects, smoking may have both short and long term effects on several aspects of visual perception critical to navy operations. The literature however, reveals contradictory results which may be due to whether or not individuals were permitted to continue to use tobacco during testing. A recent Army sponsored review suggests that the tests of smoker, nonsmoker and deprived smoker differences on dark adaptation, ocular accommodation and convergence "could provide major payoffs of improved soldier and unit performance" (Dyer, 1986, p. 159).

The effects on visual functions appear to be the result of nicotine, and/or increased levels of carbon monoxide in the blood of smokers. Macular changes may also be induced. Night vision and accomodation are two functions that appear to be most affected. A less common, but equally important effect of extreme use of tobacco is the development of tobacco amblyopia. With this disorder individuals show demonstrable loss of central visual acuity and ability to discriminate colors. This major loss of visual function has additional implications for performance of military tasks requiring normal visual acuity. With cessation of the use of tobacco some recovery is found.

The results for the immediate effects of smoking on dark adaptation yield diverse effects. Sheard (1946) and McFarland (1970) both found poorer ability to dark adapt immediately following smoking. Several other authors have reported improved dark adaptation following smoking while still others found no effect. It is conceivable that in certain types of tasks tobacco users may actually show better performance.

The differences that are reported between smokers and nonsmokers occur even in young smokers. Such an effect was found by Luria and McKay (1979). Young smokers showed significantly worse dark adaptation than either young or older non smokers. One possible explanation for this result is ocular accommodation. At the close viewing distance used in this study it is conceivable that younger smokers were unable to accomodate for the viewing distance and therefore their performance was worse. This possible explanation is supported by work of Roberts and Adams (1980) who found smoking reduced the ability to accommodate for close viewing. Young and Erickson (1980) however, found that smokers take twice as long to dark adapt as nonsmokers. These differences in both absolute level of dark adaptation obtained and speed of dark adaptation are large enough to be important for any military operation in which dark adaptation or ability to focus are critical.

It remains to be determined however, whether many effects are the result of immediately preceeding smoking, smoking deprivation, or a longterm effect of smoking. Similarly if these effects are due to short term effects the time course of these effects is important; how long must an individual refrain from smoking for performance to improve becomes a critical question. If these effects are the result of long term smoking it would become important to select only nonsmokers for visual based tasks in lowlight or redlight conditions.

5. Problem/Objective:

The proposed work will determine whether effects on dark adaptation and other visual functions reported in previous studies are due to immediate preceding smoking or smoking deprivation, or are the result of long term and possibly irreversible changes in the the visual system. The implications of these findings for personnel selection and operational procedures will be determined.

6. Technical Approach:

Tobacco deprived and non-deprived users and nonusers will perform ocular accommodation, vigilance, visual acuity, contrast sensitivity, color discrimination and dark adaptation tasks. Aged matched user and nonuser populations will be employed. The data will be analyzed to determine what performance differences occur in ocular accommodation and visual functions in young smokers as a result of smoking and smoking deprivation and whether performance on specific tasks is better or worse than that of tobacco nonusers.

Anticipated Product: Specific recommendations for use of tobacco products during military operations; selection criteria for critical personnel performing demanding visual tasks.

7. Assessment of Risk:

There are no known problems that would inhibit research success. This is not a high risk project.

8. Related Activities:

This Laboratory has recently performed related work for the US Coast Guard pertinent to the design of new beacons.

9. Transition Approach:

Guidelines for tobacco use/nonuse could be promulgated to the Fleet immediately.

10. Resources required (Funding Category 6.2)

| | FY93 | FY94 |
|---|---|---|
| Funding Required | 115.0 | 115.0 |
| Personnel required | | |
| Military Officers | 0.2 | 0.2 |
| Military Enlisted | 0.0 | 0.0 |
| Civilian professional | 0.8 | 0.8 |
| Civilian Support | 0.8 | 0.8 |
| Total | 1.8 | 1.8 |

* No major equipment will be purchased.

11. Current References:

Dyer, F. Smoking and soldier performance: a literature review. USAARL Report No. 86-13.

Luria, S. and McKay, C.L. 1979. Visual processes of smokers and nonsmokers. Archives of Environmental Health. 34:449-454.

McFarland, R.A. 1970. The effects of small quantities of carbon monoxide on vision. Annals of the New York Academy of Sciences. 174: 301-312.

Roberts, J.D. and Adams, A.J. 1969. The short term effects of smoking on ocular accomodation and pupil size. Journal of the American Optometric Association. 40:528-530.

Sheard, C. 1946. The effects of smoking on dark adaptation of rods and cones. Federation Proceedings. 5:94.

Young, H.R. and Erickson, J.A. 1980. Effects of combat vehicle interior light colors on dark adaptation and detection by night vision devices. US Army Tank-Automotive Research and Development Command Laboratory Technical Report No. 12485. 1-24. Warren MI.

II. NEW START (W)

1. Title: Auditory Detectability of Signals Subject to Masking

2. Principal Investigator: Lynne Marshall, Ph.D.

3. Naval Submarine Medical Research Laboratory
Department: Submarine Systems Department
Phone Numbers:
Autovon: 241-2545
Commercial: (203) 449-2545

Other Organizations involved: MRC Applied Psychology Unit (Great Britain), COMSUBDEVRON-12, and SSEP.

4. Navy Need:

A variety of tasks performed by naval personnel require that auditory alarm 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.

5. Problem/Objective:

To apply an algorithm for auditory alarm detectability to the design of alarm signals for submarines. Depending on the acoustic environment in a particular compartment, certain alarm signal spectra may be more or less effective. The work will provide guidance for constructing alarm signals that are detectable at lower levels than current alarms. 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.

6. 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.

First, submarine personnel will be interviewed to identify candidate auditory alarm signals that are currently ineffective or annoying. Sonar operators have already indicated problems with alarms in sonar as well as ship's alarms; 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.

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.

7. Assessment of Risk:

Improving alarms onboard submarines is a low-risk project.

8. Related Activities:

As stated above, we would be interacting with Dr. Roy Patterson in Great Britain on this project.

9. Transition Approach:

Results of this research would be used for specifications of alarms on submarines. The length of time before the new design reached the fleet would depend on when new equipment was designed and contracted. NAVSEA might also decide to modify the design specifications for equipment that is already in production, or even to retrofit some of the alarms on existing equipment.

10. Resources Required (Funding Category 6.2):

| | FY94 | FY95 | FY96 | FY97 |
|---|---|---|---|---|
| Funding Required | 275 | 290 | 290 | 290 |
| Personnel Required | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Supporting | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTAL | 0.8 | 0.8 | 0.8 | 0.8 |

| | FY94 | FY95 | FY96 | FY97 |
|---|---|---|---|---|
| Additional personnel | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.8 | 0.8 | 0.8 | 0.8 |
| Civilian Professional | 0.4 | 0.4 | 0.4 | 0.4 |
| Civilian Supporting | 0.4 | 0.4 | 0.4 | 0.4 |
| TOTAL | 1.6 | 1.6 | 1.6 | 1.6 |
| GRAND TOTAL | 2.4 | 2.4 | 2.4 | 2.4 |

11. Current References:


Marshall, L., & Nash, M. (1989). Analog audio, digital audio, and alarms on the AN/BQQ-5 sonar system: Sonar technicians' ratings. NSMRL Report 1152 (Confidential).

Nash, M., & Marshall, L. (1990). Sonar technicians' ratings of shipboard and sonar alarms. NSMRL Report 1169 (Confidential).

Patterson, R. D. (1982). Guidelines for auditory warning signals on civil aircraft. Civil Aviation Authority. Paper 82017. London; Civil Aviation Authority.

Patterson, R. D. (1989). Guidelines for the design of auditory warning sounds. Proceedings of the British Institute of Acoustics 1989 Spring Conference, Vol II, Part 5, 17-24.

Patterson, R. D. (1990). Auditory warning sounds in the work environment. Phil. Trans. R. Soc. Lond.

II. NEW START (X)

1. Title: This new start is classified.

2. Principal Investigator: J. S. Russotti

II. NEW START (Y)

1. Title: Biological Effects of Transmitting Sonars.

2. Principal Investigator: A. B. Callahan, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Biomedical Sciences Department
Phone Numbers:
Commercial: (203)449-2539
Autovon: 241-2539

Other Organizations involved: None

4. Navy Need:

Currently employed transmitting sonars aboard Naval vessels vary widely in their output characteristics and intended use. Ultra-sonic 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.

5. Problem/Objective:

The paucity of relevant information was recognized by NAVMINEWARCOM, 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.

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.

6. 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 un-

derwater 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 outputing 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.

7. Assessment of Risk: None

8. Related Activities: None

9. Transition Approach:

Results of the research should be directly applicable to the evaluation of the biological risk associated with exposure to high amplitude sonar ensonification. The results will also have carryover implications for other operational questions concerning diving suit and equipment design and applicability of high amplitude acoustic fields for defense against swimmer attack.

10. Resources Required: (6.3)

| | FY95 | FY96 | FY97 | FY98 | FY99 |
|---|---|---|---|---|---|
| Funding Required | 740.0 | 565.0 | 440.0 | 420.0 | 435.0 |
| Personnel Required | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| Civilian | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Additional Personnel | | | | | |
| Civilian Professional (GS13/14) | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |

11. Current References:

1. NAVSEA INSTRUCTION 3150.2, OPR OOC32 dtd 10 Mar 1989

2. LTR CDR, NAVSEA to Distribution, 10560, OPR: OOC31A, Ser OOC/3247 dtd 4 May 1989

3. LTR CO, NMRDC/CO, NSMRL, 3900, NMRDC-401, dtd 28 Aug 1984.

II. NEW START (Z)

1. Title: Performance Assessment for Auditory Sonar Signals

2. Principal Investigator: Lynne Marshall, Ph.D.

3. Laboratory: Naval Submarine Medical Research Laboratory
Department: Submarine Systems Department
Phone Numbers:
Autovon: 241- 2545
Commercial: (203) 449-2545

Other Organizations involved: SUBSCHOL

4. Navy Need:

There is currently no objective means to determine whether waivers should be given to sonar technicians whose hearing loss exceeds the standards for their rate.

5. Problem/Objective:

Traditional pure-tone audiograms do not adequately assess the auditory skills required by submarine sonar operators. Once a sonar technicians'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 tests may also be useful for sonar operator selection. The tests could be useful for some aspects of sonar system evaluation.

Expected users will be NAVSEA, SUBSCHOOL, MEDCOM, design engineers for sonar systems and for machine-recognition systems.

Technical Approach:

The work related to sonar retention 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 audiometry. Discrimination and identification tasks will be included along with detection tasks. Because 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.

In order to determine to what extent auditory skills can be predicted a priori (for sonar selection), standard psychoacoustic and speech-perception tasks will be included. If performance on a non-sonar psychoacoustic task is highly correlated with a learned sonar task, the non-sonar task may be used to predict future sonar skills, e.g., performance on a temporal modulation transfer function (TMTF) task (which measures detection of noise modulation depth as a function of modulation frequency) can be compared with the ability to accurately perform turn counts.

7. Assessment of Risk:

Development of a test that gives a more valid assessment of auditory performance on sonar tasks than do pure tones is not high risk. However, the test development is time-consuming, requiring fairly lengthy testing time on a large number of subjects, so the greatest risk is that it could be difficult to get enough volunteer subjects to complete the project quickly.

Development of a test for selection of sonar operators who will have good auditory skills is much higher risk. If none of the non-sonar tasks correlate very highly with sonar performance (which is a possible outcome), then sonar retention criteria will not be improved.

8. Related Activities:

Auditory assessment using the auditory skills required for a particular job has been implemented for tasks requiring auditory understanding of speech. Military applications are primarily for pilots. Assessment of non-speech auditory skills to our knowledge is not currently being systematically investigated by any other group.

9. Transition Approach:

The sonar-retention test could be used by audiologists to provide objective data to physicians on whether a sonar technician should be given a medical waiver. There are two different approaches that could be used to implement the test into audiology clinics. The first would be simplest and less expensive from the audiologist's standpoint, but would require further development from us. It would involve transforming the laboratory psychoacoustic tasks into comparable clinical ones that could be administered using the equipment already present in audiology clinics. The second approach would be more expensive for audiology clinics, but would require no additional research from us. In this approach, miniature psychoacoustic test stations would be set up in each clinic.

In either case, the implementation, including training of Navy audiologists and the physicians, would take approximately three years.

10.Resources Required (Funding Category 6.2):

| | FY95 | FY96 | FY97 | FY98 | FY99 |
|---|---|---|---|---|---|
| Funding required | 306.0 | 366.0 | 431.0 | 446.0 | 466.0 |
| Personnel required | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Civilian Professional | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 |
| Civilian Supporting | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 |
| Additional personnel | | | | | |
| Military Officer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Military Enlisted | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Civilian Professional | 0.4 | 0.8 | 1.6 | 1.6 | 1.6 |
| Civilian Supporting | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Total | 1.6 | 2.0 | 2.8 | 2.8 | 2.8 |

11. Current References:


Hanna, E.T., Russotti, J., and Marshall, L. (1988). Auditory sonar: the importance of high-quality channels in system design. NSMRL Report 1109.

Marshall, L. (1990). Identification of the bandwidth needed for auditory sonar. NSMRL Report 1159 (SECRET).

Marshall, L. and Carpenter, S. (1988). Hearing levels of 416 submarine sonar technicians. NSMRL Report 1123.

Van Rooij, J.C.G.M., Plomp, R., and Orlebeke, J.F. (1989). Auditive and cognitive factors in speech perception by elderly listeners. I: Development of a test battery. J. Acoust. Soc. Am., 86, 1294-1309.

Van Rooij, J.C.G.M. and Plomp, R. (1990). Auditive and cognitive factors in speech perception by elderly listeners. II: Multivariate analysis . J. Acoust. Soc. Amer., 88, 2611-2624..

III. EQUIPMENT, FACILITIES, AND INFORMATION SYSTEMS:

A. Equipment ($000)

| | FY92 |
|---|---|
| Work Unit Equipment<br>New (over 15K) | 73.0 |
| General Purpose Equipment<br>New | 106.2 |
| Replacement Equipment | |

Identification and Justification of Work Unit Equipment over 15K

| | | |
|---|---|---|
| FY92 | Real ear probe-tube measurement system | 15.0 |
| | Convolvotron | 40.0 |
| | Audiometer | 18.0 |
| | TOTAL | 73.0 |

Identification and Justification of General Purpose Equipment over 15K

| | | |
|---|---|---|
| FY92 | High pressure gas cylinder | 56.2 |
| | SUN workstations | 50.0 |
| | TOTAL | 106.2 |

B. Facilities:

1. Military Construction (MILCON): N/A

2. Special Projects: As outlined below, the proposed special projects are aimed at increasing building usability and functionality, and increasing the life expectancy of the facilities. Projects listed below are prioritized within each fiscal year.

FY92

(1) CR40-87 Non-electrical Improvements - Bldg 156: $160K const. 9305-9310.

(2) CR2-90 Replace Windows - Bldg 156: $104K const. 9204-9208.

(3) CR1-90 Electrical Upgrade - Bldg 148: $47K const. 9112-9203.

(4) CR1-91 Replace Windows Phase I (Bldg 148): $70K const. backlog. 9111-9205.

(5) CR1-92 Modify Storage Areas - Bldg 141: $12K A/E. 9111-9205.

FY93

(1) CR1-91 Replace Windows Phase I (Bldg 148): $75K const. 9304-9307.

(2) AC1-93 Central AC/Ceilings - Bldg 148: $11K A/E. 9211-9305.

(3) CR1-92 Modify Storage Areas - Bldg 141: $80K const. 9212-9305.

(4) CR2-92 Replace Carpet/Flooring - Bldg 156: $35K A/E-const. 9111-9208.

FY94

(1) CR1-91 Replace Windows Phase II (Bldgs 141): $140K const. 9403-9408.

(2) CR2-92 Replace Carpet/Flooring - Bldg 141: $47K A/E-const. 9312-9404.

(3) AC1-93 Central AC/Ceilings - Bldg 148: $110K const. 9403-9408.

(4) AC1-94 Central AC - Bldg 141: $15K A/E. 9312-9407.

(3) CR2-92 Replace Carpet/Flooring - Bldg 141: $47K const. Backlog.

FY95

(1) AC1-93 Central AC/Ceilings - Bldg 148: $150K const. 9412-9507.

(2) AC1-94 Central AC - Bldg 141: $150K const. 9502-9509.

(3) CR1-95 Renovate Material Shop Spaces - Bldg 156: $8K A/E. 9411-9504

FY96

(1) CR1-95 Renovate Material Shop Spaces - Bldg 156: $80K const. 9512-9606.

(2) Renovate Lab Spaces Bldg 141: $8K A/E. 9512-9606.

Issues:

a) Upon completion of some facilities improvement project A/E designs (ie. window replacement projects), it may be determined that funding will be provided by the host activity (SUBASE-NLON). This would permit earlier funding of projects in backlog status, as noted above.

C. Information Systems (IS):

The Information Systems Management Plan (ISMP) will be prepared and submitted to NMRDC by Dec. 31, 1991.

## IV. MANAGEMENT AND SUPPORT

This section does not apply to this Laboratory.

## V. LABORATORY ORGANIZATION

A. Mission: The mission of this laboratory is to conduct quality research, development, test, and evaluation in submarine, shipboard, and diving medicine to enhance the health, safety, and readiness of Navy and Marine Corps personnel, in the performance of peacetime and contingency missions, and to perform such other functions or tasks as directed by higher authority.

B. Organization: The Research Departments of this command include Biomedical Sciences, Vision, Human Factors, and Submarine Systems. The Support Departments of this command include the Bioengineering Department, the Research Support Department, and the Fiscal and Supply Department. Department Heads are directly accountable to the Commanding Officer for the execution of their mission, but report to the Executive Officer as their line supervisor. Each department is under the direction of a Department Head, who is responsible for the proper and effective utilization of resources (manpower, facilities, equipment, and financial) in the execution of their assigned program components, and for the exploration and development of new projects. The Assistant Department Head will assist the Department Head and assume responsibility when the latter is absent.

C. Vision Department: This department studies the visual and perceptual problems of submariners, divers, Marines, and other shipboard personnel. It investigates the effects of environmental conditions, equipment design, and individual characteristics on visual performance. Current work deals with pattern and color perception on visual displays, sonar target detection and classification, the display of periscope information, the human limits for absorbing visual and cognitive information, effects of lighting on performance, and the effectiveness of navigation beacons. The department consists of these divisions: Cognitive Displays Division, Performance Division, and Optometry Division.

Cognitive Displays Division: Investigates the effects on performance of the design characteristics of sonar and other visual displays and attempts to improve operator performance through redesign of the displays or changes in procedure. Studies the effects of information coding and display formatting on performance; investigates the limits of operators for absorbing visual and cognitive information and seeks to expand those limits and improve performance.

Performance Division: Uses modern electrophysiological techniques and performance tests to evaluate sensory and attentional processes. The effects of different breathing mixtures and various stressors are studied. These methods permit the detection of subtle performance changes and central nervous system effects. Investigates the ability of individuals to see under various operational conditions, compares different visual signalling devices, and evaluates the effectiveness of new visual devices both in the laboratory and in the operational environment.

Optometry Division: Studies the frequency and extent of visual diseases and problems encountered on submarines and surface ships.

D. Human Factors Department: This Department uses human factors principles to enhance performance of human operators in submarine systems and other operational settings. The department explores man/machine interaction with consideration of psychological, physical, and physiological requirements for maximum sustained performance of personnel in operational settings.

E. Submarine Systems Department: This Department provides consultation, information, assistance, and research to the Navy and to the Department of Defense, in all areas of psychological measurement, sensory psychology, experimental audiology, human information processing, decision-making and human performance. The emphasis and focus of current work are on auditory and human performance measurement and on physical, physiological, and psychological acoustics, including speech communication. Areas of operational importance include sonar and sonar systems; sonar-target synthesis for measurements of field-system validity; pattern recognition and classification of targets; performance limits for human receivers of auditory and cognitive information; weapons and combat systems; electroacoustic measurements; effects of sonar signals on human and marine life; speech communication; signal detection, classification, and selection in normal and combat-noise environmental conditions; selection, effectiveness and interference of alarm signals; hearing conservation; occupational standards for noise; and effects of noise and of mixed stressors including annoyance effects, effects on sleep, and effects on speech communication.

F. Biomedical Sciences Department: This Department provides support to and performs liaison with the operational community, and conducts biomedical and epidemiological studies of a direct operational nature or requirement within the mission and tasks of this laboratory. The functional components of the Biomedical Sciences Department consist of the Hyperbaric Research Division, the Environmental Physiology Division, and the Submarine Operational Medicine Division.

Hyperbaric Research Division: This Division conducts research in diving medicine and hyperbaric physiology; conducts tests and evaluations of various items of health and safety equipment and supplies for diving use; applies diving technology and techniques to the submarine environment, e.g. submarine escape and rescue; and conducts investigations in the area of submarine medicine and submarine escape and survival techniques.

Environmental Physiology Division: This Division conducts studies on the physiological functioning of the human body in the unique context of the operational environment; evaluates the effects of the submarine atmosphere and life style on both the acute and long-term health of submariners; and recommends habitability improvements as they are developed in the research program.

Operational Medicine Division: This Division conducts research on the chemical and biochemical relationships of any aspect of Navy and Marine Corps operations that may influence Naval personnel, and provides clinical chemical and biochemical support for monitoring the health of subjects exposed to experimental submarine environments.

G. Bioengineering Department: This Department provides a variety of professional expertise, facilities, and specialized equipment to be utilized by the various research projects and investigators. The department is a unique resource for consultation on instrumentation selection, utilization, and acquisition, as well as high gas pressure utilization and wet or dry diving operations. The Computer Applications Service coordinates and supports the utilization of computer hardware and software systems within the command. It manages centralized processors and networks; consults on hardware/software selection, utilization, and planning; and provides specialized programming support and minor hardware installation and maintenance. The Environmental Simulation Service is responsible for the operation, maintenance, and developmental improvements of the command's hyperbaric facilities and related systems. It maintains all critical systems to man-rating certification standards and provides planning, coordination, and supervision throughout all operations. It establishes operational and emergency procedures, personnel qualification procedures and criteria, and provides logistical planning for research dives. It provides similar support for occasional non-diving operations simulating other nonstandard environments (altitude, cold, heat, etc.). The Apparatus Design Service designs and fabricates mechanical or electromechanical apparatuses or customized parts required in support of research throughout the laboratory, and provides routine minor maintenance functions within the capabilities of the staff. The Electronic Instrumentation Service designs, develops, modifies, and repairs electronic instruments utilized in research at this command. It coordinates the command preventive maintenance and calibration program.

H. Research Support Department: This Department provides mission area support to the office of the Commanding Officer and to the other departments. These services include administrative and the Fiscal and Supply functions. The Personnel and Facility Service provides various office services including the maintenance of the central correspondence files, archives, mail, and messenger services. It maintains a tickler file on action correspondence and messages; administers the activity's instruction and notice program, receives, distributes, and ensures the proper custody and security of classified material; and provides qualified motor vehicle operators for the operation and control of command vehicles. It is responsible for the internal security and the maintenance of good order and discipline throughout the command. It is responsible for correspondence and reports applicable to personnel matters, processes personnel requests, performs limited personnel services, and acts as liaison with the servicing military and civilian personnel offices. It oversees an enlisted training program, the preparation of watch bills and the plan-of-the-week, and provides janitorial, cleaning, and related services. The Graphic Arts Service prepares photographs, projection slides, and other display material for scientific and information purposes, and prepares mock-ups and exhibits. The Library maintains a collection of medical, scientific, and technical books

and other such texts deemed essential; it conducts abstracting and reference services for the staff; it prepares bibliographies and arranges interlibrary borrowing and lending. The Publications Office coordinates, edits, and prepares final manuscripts, scientific papers, project reports, and summaries for publication; it assists principle investigators in editing research work-unit summaries; and it compiles and publishes the annual command history.

I. Fiscal and Supply Department: The Fiscal and Supply Department is responsible for all matters concerning the financial and material condition of the laboratory. The Fiscal Officer (FO) is assigned as Department Head and provides guidance and direction on financial matters throughout the organization, as a staff service to the Commanding Officer. The FO reviews and analyzes new and proposed legislation, regulations, or policies issued by higher authority, and takes appropriate actions to implement such policies or makes recommendations as required. The FO certifies that funds are available before obligations are made against allotments. The FO implements accounting policy and corresponding procedures for the command per the Authorized Accounting Activity. The FO conducts a continuous review of accounting reports to ensure responsiveness to management needs. The FO conducts special studies, analyses, and investigations to detect and correct troublesome and unsatisfactory conditions which do not comply with established financial practices or procedures. The department coordinates budget planning, submission, and execution; receives and distributes fund resources; documents accounting transactions; and is responsible for property control. It is further responsible for receipt, issue, accountability, and disposal of laboratory material and equipment. It coordinates procurement of all materials and services; performs liaison functions between this command and procurement activity contracting personnel; advises departmental components of status of materials ordered, initiates follow-up actions as necessary; screens and classifies all work requests prior to submission to the Public Works Department of the host activity, and maintains liaison with the Public Works Officer on the status of all work requests submitted.

VI. FISCAL SUMMARY: ($000)

| Program Element | Task Title | FY91 | FY92 | FY93 | FY94 | FY95 |
|---|---|---|---|---|---|---|
| 61153N | Cell Culture Modeling | 136 | 148 | 0 | 0 | 0 |
| 62233N | Tactical Displays | 96 | 85 | 0 | 0 | 0 |
| 63706N | Computerized Diagnosis | 275 | 300 | 0 | 0 | 0 |
| | Contact Lenses | 58 | 0 | 0 | 0 | 0 |
| | Human Performance | 97 | 0 | 0 | 0 | 0 |
| | Clinical Laboratory | 120 | 144 | 144 | 144 | 0 |
| | SUSOPS | 150 | 314 | 338 | 321 | 350 |
| 63713N | Submarine Rescue | 434 | 0 | 0 | 0 | 0 |
| | Submarine Decompression | 0 | 501 | 522 | 552 | 542 |
| | Hearing Conservation | 211 | 336 | 457 | 441 | 0 |
| 64771N | REFLUPS | 25 | 40 | 40 | 40 | |
| 65856N | Auditory Sonar | 481 | 480 | 610 | 640 | 670 |
| | Visual Sonar | 471 | 470 | 570 | 375 | 375 |
| | Digital Sonar | 251 | 251 | 220 | 220 | 231 |
| | Periscope Study | 22 | 308 | 465 | 309 | 298 |
| | TOTAL DIRECT | 2827 | 3377 | 3366 | 3042 | 2791 |
| 1GAV60 | VA: Psycho. Proc. | 26 | 0 | 0 | 0 | 0 |
| USCG | Navigation Lights | 12 | 115 | 0 | 0 | 0 |
| NMRI | Diving | 40 | 30 | 0 | 0 | 0 |
| NAVSEA | Low Frequency Active Sonar | 1300 | 1000 | 0 | 0 | 0 |
| | TOTAL REIMBURSABLES | 1378 | 1145 | 0 | 0 | 0 |
| | GRAND TOTAL | 4205 | 4522 | 3366 | 3042 | 2791 |

## VII. PERSONNEL SUMMARY

| | FY91 | FY92 | FY93 | FY94 | FY95 |
|---|---|---|---|---|---|
| Direct Tasks | | | | | |
| Military Officer | 08 | 10 | 10 | 10 | 10 |
| Military Enlisted | 10 | 11 | 12 | 12 | 12 |
| Civilian Professional | 19 | 21 | 23 | 25 | 25 |
| Civilian Supporting | 10 | 13 | 16 | 19 | 19 |
| Subtotal | 47 | 55 | 61 | 66 | 66 |
| Administrative | | | | | |
| Military Officer | 04 | 04 | 04 | 04 | 04 |
| Military Enlisted | 04 | 04 | 03 | 03 | 03 |
| Civilian Professional | 01 | 01 | 01 | 01 | 01 |
| Civilian Supporting | 15 | 15 | 15 | 15 | 15 |
| Subtotal | 24 | 24 | 23 | 23 | 23 |
| TOTAL (Note 1) | 71 | 79 | 84 | 89 | 89 |

Note 1: Personnel onboard. Increases in military personnel reflect anticipated filling of vacant billets.

VIII. ISSUES:

The most important issues at NSMRL are generally the same as those at other laboratories:

(1) Lack of adequate programmatic core resources.

(2) Lack of flexibility in obtaining resources for new topical research ideas. The system does not respond quickly to opportunities to conduct research.

(3) Detrimental effects of hiring freeze. Inability to obtain professional, technical, and administrative personnel.

(4) Continuous need to repair facilities.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF THE REPORT
Approved for public release, distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
NSMRL SPECIAL REPORT SP91-2

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 & Development Command

6c. ADDRESS (City, State, Zip Code)
Box 900, Naval Submarine Base NLON, Groton, CT 06349-5900

7b. ADDRESS (City, State, Zip Code)
National Naval Medical Center, Bldg 1, Tower 12, 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, Zip Code)
Same as 7b

10. SOURCE OF FUNDING NUMBERS

| PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. | WORK UNIT ACCESSION NO. |
|---|---|---|---|
| | | | |

11. TITLE (Include Security Classification)
FIVE YEAR PLAN FOR Fiscal Years 1992-1996

12. PERSONAL AUTHOR(S)
S. Monty, Editor

| 13a. TYPE OF REPORT | 13b. TIME COVERED FROM ____ TO ____ | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| | | 1991 October 1 | 104 |

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 report is the Five Year Plan, Fiscal Years 1992-1996, for the Naval Submarine Medical Research Laboratory.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[X] UNCLASSIFIED/UNLIMITED [ ] SAME AS REPORT [ ] DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

| 22a. NAME OF RESPONSIBLE INDIVIDUAL | 22b. TELEPHONE (Include Area Code) | 22c. OFFICE SYMBOL |
|---|---|---|
| S. Monty, Publications Office | (203) 449-3967 | |

DD Form 1473, JUN 86 Previous editions are obsolete. S/N 0102-LF-014-6603

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED