

NRAC 92-4



NAVAL
RESEARCH
ADVISORY
COMMITTEE
REPORT

SCIENCE AND TECHNOLOGY TECHBASE STRATEGY FOR THE YEAR 2010

NOVEMBER 1992



OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, DEVELOPMENT AND ACQUISITION)
WASHINGTON, D.C. 20350-1000

DISTRIBUTION OF THIS DOCUMENT IS AUTHORIZED TO THE DEPARTMENT OF DEFENSE AND DOD CONTRACTORS, ONLY, TO PROTECT TECHNICAL DATA FROM AUTOMATIC DISSEMINATION UNDER THE INTERNATIONAL EXCHANGE PROGRAM AS OF SEPTEMBER 1992. FURTHER DISSEMINATION OF THIS DOCUMENT IS AUTHORIZED ONLY AS DIRECTED BY THE NAVAL RESEARCH ADVISORY COMMITTEE.



**NAVAL RESEARCH
ADVISORY COMMITTEE**

**S&T
STRATEGY**

**SCIENCE AND TECHNOLOGY
TECHBASE STRATEGY FOR THE
YEAR 2010**

TABLE OF CONTENTS

SECTION	TITLE	PAGE
I.	EXECUTIVE SUMMARY	5
II.	TASKING	7
III.	PANEL MEMBERSHIP	9
IV.	BRIEFINGS/PRESENTATIONS	11
V.	INTRODUCTION	13
VI.	CORE RESEARCH AREAS	25
VII.	NEW S&T PRIORITIES	29
VIII.	S&T IN THE WARFARE CENTERS/NRL	47
IX.	S&T MANAGEMENT	59
X.	SUMMARY	75
XI.	APPENDIX A - GLOSSARY	79
XII.	APPENDIX B - FORMAL PRESENTATIONS	81

EXECUTIVE SUMMARY

The 1992 Naval Research Advisory Committee (NRAC) Summer Study on Science and Technology (S&T) was conducted in order to help the program be responsive to the profound changes in the world situation. These changes combined with the significant modifications of the Navy's S&T activities during the last two years, made a broad assessment valuable at this time. The most significant changes within Department of Navy (DoN) and Department of Defense (DoD) were (1) realignment of Navy's laboratories to become part of comprehensive Warfare Centers under the direction of the Systems Commands, (2) reassignment of the Office of Advanced Technology (OAT) from the Staff of the Chief of Naval Operations (OPNAV) to the Office of the Chief of Naval Research (OCNR), and (3) increased focus and direction from DoD on S&T strategy. All of these argued strongly for the NRAC to examine DoN S&T enterprise and assess its ability to serve effectively during the next two decades.

The Panel concluded that, while the defense production requirements will be markedly reduced and not demand an extensive S&T base, there is still a requirement for a strong DoN S&T base. Maintaining technological supremacy of our weapons systems provides the basis for an effective deterrent and warfighting capability, permits accurate assessment of the capability of others, and retains a cadre of defense oriented scientists and engineers that is difficult to reconstitute if the nation requires a defense program surge. However, the Panel recommends changes to the way the DoN S&T program is executed. Recommendations are made concerning areas of new or expanded investment, new and revised roles for the Navy's Warfare Centers, and the organization and management approach of OCNR.

The McNamara paradigm of an orderly serial transition of investment from Basic Research (6.1), to Exploratory Development (6.2), to Advanced Development (6.3), to procurement was created to bring financial accountability to a very large and complex acquisition process. In the future, with relatively few new platforms being built and a succession of prototype developments and product improvements being conducted at the subsystem and component level, it is more appropriate to have a new paradigm that blurs the line between 6.1 and 6.2 and eliminates the distinction between 6.2 and 6.3. The Defense Advanced Research Projects Agency (DARPA) has operated effectively in this manner for some time, and the CNR's present scope of responsibility permits the DoN to evolve toward this new paradigm.

The Panel highlights several technologies for new or increased emphasis. Affordability is a major S&T investment driver. The development of prototyping methodologies, simulation and modeling techniques, and the study and adaptation of commercial manufacturing methods focus on reducing the cost of operations and acquisition. Autonomous or remotely operated vehicles offer opportunities to reduce casualties. Navy should maintain experimental test beds for investigating platform improvements, e.g. modified hull shapes, propulsion systems, embedded sensors. Effectively generating, storing, and distributing electrical power will be a key enabler in future military systems. Continued strong investment in advanced materials is also recommended.

Some changes are recommended for the new Warfare Centers that exploit the breadth of the resident expertise and strengthen the S&T base. In-house laboratory/industry cooperation can be expanded by requiring a laboratory/industry partnership on every Advanced Technology Demonstration (ATD) program. The Warfare Centers have developed analysis capabilities primarily for their own marketing purposes. These should be harnessed by the CNR to perform trade-off studies, operations analyses, and the marginal utility evaluations for optimizing the allocation of resources for S&T. With limited resources and a more diverse set of suppliers of militarily relevant technology, the Warfare Centers and Naval Research Laboratory (NRL) should establish small cadres of scientists and engineers to monitor and exploit S&T worldwide. Finally, the Panel feels that approximately five percent of the DoN S&T resources should be allocated to the Warfare Centers to be used at their discretion.

The organizational structure and the management processes of OCNR were intensively reviewed. The Panel concludes that the present organization is not well suited to the new paradigm for S&T. The Panel recommends that the CNR create a nearly seamless organization that has an integrated Planning and Assessment staff (instead of ONR, Office of Naval Technology (ONT), and OAT each having their own) and a set of Program Directors, organized along the lines of the S&T customers, that manage funds from all three appropriations (6.1, 6.2, 6.3A). Within this new structure the CNR should use a management approach that is similar to that currently employed in ONR and DARPA, i.e. programs directed by a headquarters (HQ) group of highly talented, respected technical experts that champion the case for resources to conduct S&T programs and determine the people and facilities to execute them.

GENERAL:

- **Provide a broad-based independent assessment of the DoN S&T investment strategy and review its applicability to the future military mission.**

SPECIFIC:

- **Develop a List of Key Core Research Areas**
- **Identify Key Technologies**
- **Examine the Process by which the DoN Creates its S&T Investment Strategy**

NRAC was tasked to convene a Panel to conduct an independent evaluation of the DoN S&T investment strategy. The Panel was comprised of nationally recognized leaders from industry, academia and government. The membership included current and former senior officials from Departments of Commerce, Defense, and Energy, and active and retired military and civilian employees from the DoD.

The Panel reviewed the Basis Research (6.1), Exploratory Development (6.2), and Advanced Technology Development (6.3A) efforts within the OCNR. Budget categories 6.1 and 6.2 are in Budget Activity 1 (BA-1) and are commonly referred to as the "Techbase." Basic Research is managed by the Director of Naval Research on the staff of the CNR; Exploratory Development, under the Director of Naval Technology was moved to the CNR Staff in the early 1980's. Advanced Technology Development in Budget Activity 2 (BA-2) was moved to the OCNR Staff in 1991 under the Director of Advanced Technology.

PANEL MEMBERSHIP

CHAIRMAN

Mr. W. Grover Coors

Adolph Coors Company

VADM Albert J. Baciocco, USN (Ret.)

Private Consultant

Dr. Marc H. Brodsky

Department of Commerce/IBM

Dr. Glen R. Otey

Sandia National Laboratories

Dr. Herbert Rabin

University of Maryland College Park

Dr. Martin H. Schultz

Scientific Computing Assoc.

Dr. Seymour L. Zeiberg

Private Consultant

EXECUTIVE SECRETARY

Dr. Eugene A. Silva

Office of Naval Research

VICE CHAIRMAN

Dr. Jerome A. Smith

Martin-Marietta Missile Systems

Dr. Ira Blatstein

Naval Surface Warfare Center

LTGEN Robert F. Milligan USMC (Ret.)

Private Consultant

Dr. Robert Porter

University of Washington - APL

Dr. William J. Schmitz, Jr.

Woods Hole Oceanographic Institute

Prof. William Forrest Weldon

University of Texas at Austin

ASN(RD&A) SPONSOR

Mr. Dave Rossi

ASST EXECUTIVE SECRETARY

Ms. Beverly Harris

Office of Naval Research



BRIEFINGS/PRESENTATIONS

S&T
STRATEGY

CNR	OP-091	NAVAIR
ONR	OP-80	NAVSEA
ONT	MCCDC	NCCOSC
OAT	PEO(CU)	NUWC
NRL		
ARMY	ONI	CNA
AIR FORCE	DIA	MIT

The Panel met three times. The first meeting, on May 21 and 22, 1992, at the CNR Headquarters in Arlington, VA was devoted to presentations on the DoN S&T organization from OCNR, OPNAV, HQ United States Marine Corps (USMC), and OCNR Staffs, respectively. The second meeting was also at OCNR on June 15, 16, and 17, 1992; presentations were made by the Systems Commands, intelligence communities and Department of Army and Air Force, respectively. The Panel completed their deliberations at NRAC Summer Study in Seattle, WA from July 13-23, 1992.

V. INTRODUCTION



- **The Cold War is over!**
- **The Arms Race Has Been Supplanted by Global Economic Competition**
- **The New DoD Science and Technology Strategy Now Sets the Context for S&T Strategies**

The Cold War is over. The political ramifications of this new reality are enormous, and the potential consequences on Defense S&T must not be overlooked. For more than forty years the United States has invested in a science and technology base geared to support a dynamic arms race with the Soviet Union for superpower military superiority. Now we have won this War, but we are not fully geared to adapt to this change. Significant realignment of the S&T base must be considered if the United States is to preserve its lead and improve its technological capabilities for the year 2010.

The arms race has been supplanted by global technology-based competition for economic leadership. Although the former Soviet Union no longer constitutes a credible threat to U.S. survival, regional powers will continue to threaten our national interests. This will be facilitated in the foreseeable future by the increasing availability of sophisticated weapons to potential adversaries resulting from proliferation of technology and foreign arms sales. Lethal weapons will be in the hands of a more widely dispersed and unpredictable threat. This will demand flexible and creative responses from our techbase. Interdependence among allied nations for critical military technology which may also be obtained by potential adversaries, and availability of advanced commercial technology for military "spin on" applications will threaten to erode the U.S. defense technology competitive advantage. All of these factors argue for a strong S&T base in the DoN.



TECHNOLOGY DRIVERS - IMPLICATIONS OF NEW REALITY ON S&T

**S&T
STRATEGY**

"The end of the Soviet threat ... [suggests] that we will be able to slow down our modernization efforts and still maintain our technological edge.... This enables us to cancel some modernization efforts and to emphasize longer periods for research and development and for testing and proving the value of systems before buying."

Secretary of Defense - 1992

DoD has recognized the "New Realities" with an over-arching Science and Technology Strategy published in May of this year, which sets the context for the service S&T strategies. Secretary of Defense, Richard Cheney, has captured the essence of the new strategy.

During the early 1980's, the Reagan Administration approved real growth in defense expenditures to rebuild our forces in response to the continuous growth of the USSR military structure. The modernization program embarked on by the U.S. was significant and crossed all elements of the DoD. The Strategic Defense Initiative added to the complexity of this build-up. Based on relatively large budgets and the need to modernize our forces rapidly, a major push of technology into fielded equipment was accomplished. At the same time, S&T was being pulled along by the momentum of greatly increased weapon system acquisition, further driving the technology development cycle.

In response to this technology-driven strategy, the DoN strengthened its Techbase structure by creating the (ONT) under the CNR to accelerate the transition of research results into applications, consolidate DoN S&T management, and facilitate transition of technology into the fleet in an expedited manner. The management of 6.1 and 6.2 efforts contributed to the DoN technical edge achieved

during this period, and resulted in a superior advantage in anti-submarine warfare (ASW), naval aviation, advanced sensor suites, surface ships, attack and strategic submarines, tactical combat vehicles and many other war fighting areas.

REALITIES OF 80's

- **Prepared for Soviets (Although Fought Others)**
- **Ample Defense Budgets**
- **S&T Structured for Support of Acquisition**

REALITIES OF 90's

- **No Soviets**
- **Regional Conflicts Likely**
- **Reduced Budgets**
- **Potential for Complacency**
- **S&T Still Important for Acquisition**
- **S&T Essential for Maintaining and Advancing Skills for Industrial Base**

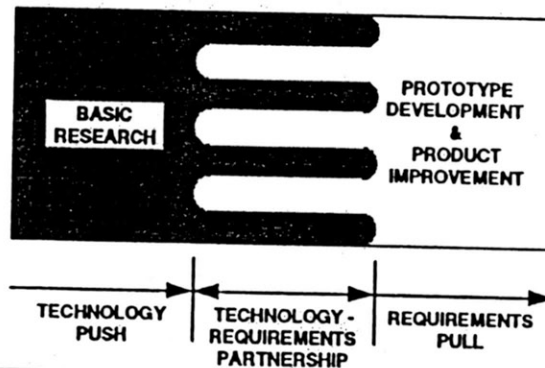
Having won the Cold War, the DoN S&T base is now challenged to be prepared for a diverse set of regional conflicts with reduced budgets. This challenge is compounded by the serious risk of complacency. Secretary Cheney has set the course for the U.S. Defense posture in the 1990's, pacing the modernization efforts to be in line with reduced budgets and emphasizing longer periods for research, development, and testing. Based on DoD guidance, the new acquisition strategy supports a level of government-supported R&D sufficient to maintain a healthy technology base and emphasizing prototyping and ATD. This latter emphasis is supported by incorporating the Office of Advanced Technology within OCNR. The realities of the 1990's dictate an additional role for S&T, namely to help support advanced skills needed in the industrial base.

"McNamara Paradigm" for Cold War S&T

- Serial 6.1 → 6.2 → 6.3 → Acquisition
- Technology Carried by Acquisition
- Budget Categories Promoted "Stove Piping"

"Cheney Paradigm" for Post-Cold War S&T

- Sufficient Time to Mitigate Risk
- Technology an Integral Part of Acquisition Enterprise
- Integrated S&T Base



The 1980's were dominated by the "McNamara Paradigm" for Cold War S&T where the arms race required a serial S&T process from basic research all the way to acquisition. During this period the "category 6.x" budget nomenclature was instituted in an attempt to improve Research and Development (R&D) management and accountability. The consequence of this system was to promote a series of organizational "stovepipes." While acquisition for the arms race was strong, the problems of this structure did not manifest themselves. The problems were there, but the regular acquisition of systems allowed S&T developments to be injected in spite of the serial process. Now that the momentum of acquisition has slowed, a new S&T paradigm is needed. This new paradigm will be called the "Cheney Paradigm" for Post-Cold War S&T which stresses sufficient time to mitigate risk. In this new era, technology must become an integral part of the acquisition enterprise which now can be characterized by a balanced partnership between technology push and requirements pull. The optimum S&T structure for accomplishing this is an integrated S&T base where the artificial barriers between 6.1, 6.2, and 6.3A are removed and technology can freely flow throughout the S&T base.



S&T BASELINE ASSUMPTIONS FOR THE 90's

**S&T
STRATEGY**

- **The U.S. Will Preserve its S&T Base**
- **The Ratio of S&T to Acquisition Will Increase**
- **S&T Will Not Be Reduced Proportionally to Overall Force**
- **Today's Investment in S&T Will Enable the United States to More Effectively Respond to Future Threats**
- **The S&T Base is Difficult to Reconstitute Due to the Long Term Investment in Human Resources**
- **The Navy and Marine Corps Must Retain Their Capability to Be Smart Buyers**
- **Private Industry Cannot Be Expected to Invest in Unique Military S&T Without Follow-on Production Programs**

Certain baseline assumptions must be made for the 1990's, without which, a superior level of S&T competency may be placed in jeopardy. Foremost among these is the assumption that DoN will continue to value S&T above other activities in the face of intense budget scrutiny. This means that the S&T budget will be maintained at least at the 1992 level, regardless of the trend in acquisition and overall force levels. The S&T base must be viewed as vital because the long term investment in human resources will be difficult to reconstitute at a later time. It is also assumed that the Navy and USMC will retain their capability to be "smart buyers" by retaining the technical excellence needed to design and manage weapons programs. It is also recognized that in times of dramatically reduced procurements, private industry cannot be expected to invest in unique military S&T for the long term benefit of DoN. This means that the burden of S&T investment will increasingly fall to the Navy and USMC.

VI. CORE RESEARCH AREAS



- **OBSERVATIONS**
 - **ONR Has Three Core DoN-Critical Research Areas**
 - **Ocean Sciences**
 - **Advanced Materials**
 - **Information Sciences**
- **CONCLUSIONS**
 - **Core Areas Are Still the Most Relevant**
- **RECOMMENDATIONS**
 - **Maintain Present Core**

ONR has identified a core of three DoN-critical research areas. The core areas are: ocean sciences, advanced materials, and information sciences. The recognized success of the core research program is built upon a management approach that utilizes highly technical, discipline-oriented scientific officers that argue for resources and then employ the best scientists and engineers to conduct DoN relevant research.

We conclude that these core areas are broad enough yet concrete enough to still be vital to the needs of DoN capabilities and systems. They encompass the activities and disciplines that appropriately address and advance the fields of science and technology upon which the DoN depends.

We recommend the present core areas be maintained.

VII. NEW S&T PRIORITIES

- **Cost Reduction**
 - **Simulation and Modeling**
 - **Prototyping**
 - **Utilization of Commercially-based Manufacturing**
- **Casualty Reduction**
 - **Autonomous/Remote Vehicles**
- **Platform Superiority**
 - **Test Bed Platform Technologies**
- **Emerging Technologies**
 - **Energy Supply and Allocation**
 - **Smart Materials**

As a result of the changing military threat, reduced budgets, and strong economic competition, some new key technology priorities are recommended. We view these as having high payoff and as being candidates for increased S&T investment. During the Cold War, affordability of weapon systems was rarely a concern, but in the decades ahead, affordability may well be the principal driver of weapons for military superiority. Simulation and modeling, prototyping, and utilization of commercially-based technology can significantly reduce the costs associated with developing and building new systems. America has become increasingly intolerant of casualties suffered in combat; therefore, autonomous or remotely operated vehicles offer potential for reducing casualties across a broad spectrum of naval missions and operations. In order to maintain technical superiority of major platforms, platform design teams and test bed platforms focused on new technologies, should be assembled and tested periodically. Additionally, increased requirements for energy supply and allocation and emerging capabilities in smart materials offer new opportunities for S&T contribution.

These key technology areas inherently require integrated activity across the S&T budget and management categories, and strong coupling to the customer. For each of the seven recommended S&T priorities, observations are made addressing newly recognized Navy and Marine needs or newly emerging technological

opportunities for future fleet operating and support forces. Particular attention has been paid to the shift in S&T focus from the global Soviet threat to a variety of potential littoral operations. For each S&T priority, conclusions are drawn assessing their potential impact on DoN problems or opportunities. Recommendations to implement the S&T priorities include integrated activities as well as specific disciplines and programs.



NEW S&T PRIORITY SIMULATION AND MODELING

S&T STRATEGY

- **OBSERVATIONS**
 - **Simulation Can Work Well**
 - **Simulated System Performance Impacts Strategy, Tactics, and Costs**
- **CONCLUSIONS**
 - **Simulation and Modeling is the Wave of the Future -- Integrated With Prototyping and Manufacturing**
 - **Benefits to DoN**
 - **Performance Comparisons for S&T and Acquisition**
 - **Training, Tactics, and Strategy**
 - **Logistics and Fleet Support**
- **RECOMMENDATIONS**
 - **Research New Simulation Methodology and Innovative Models**
 - **Innovate and Test Technology Concepts Through Simulation**
 - **Validate and Improve ATD's Through Simulation**
 - **Strengthen Connectivity of DoN to DoD Activity**

Simulation and modeling has worked well for the military; successful examples are Army SIMNET, Oceanographic Prediction Systems for the Persian Gulf and Gulf Shear, and aircraft simulators. Simulated system performance can positively impact strategy, tactics, and costs. We conclude that over the next two decades, computer simulation will become a standard mode of doing activities which are fundamental to DoN's technological base and an understanding of Navy and Marine Corps' operational environment. More powerful computers along with more efficient algorithms will allow DoN researchers to solve physical problems of increasing size and complexity, drop simplifications from mathematical and computational models, simulate new types of phenomena, and study coupled different phenomena.

The intensive use of computer simulation will also be of fundamental importance in the engineering design process. Engineers will be increasingly capable of optimizing designs for performance and cost of production and lifelong maintenance, particularly when integrated with prototyping and innovative manufacturing methods. The intensive use of computer simulation will allow a significant and cost effective enhancement of the realism and availability of war gaming. Through the use of the rapidly developing techniques of "virtual reality," DoN will be able to mobilize this technology to routinely provide intensive training of the majority of its personnel much in the way that pilots currently use flight

simulators. The success of using these methods depends on having good models to simulate systems, processes, or the environment. The development of new models and the testing and improvement of these models is part of the basic research required. Associated exploratory technology is involved with prediction, display, and parameter optimization.

We recommend S&T programs for simulation and modeling that include developing new methodologies and major innovation. Simulation applications should be an integral part of the technology innovation and concept testing process. Simulation should be used before, during, and after demonstrations to validate and improve ATDs. DoN should strengthen its connection to the high priority DoD activity in simulation and synthetic environments:



NEW S&T PRIORITY PROTOTYPING METHODOLOGY

**S&T
STRATEGY**

- **OBSERVATIONS**
 - **OSD Focus**
 - **Methodology Not Well Established (When? What? How?)**
 - **Prototyping Critical in Low Production Environment**
- **CONCLUSIONS**
 - **Need to Evaluate Technology Options at Earliest Opportunity**
 - **Need Methodology for How, When, and What to Prototype**
 - **Iterative Prototyping Beneficial and Maintains Technical Competence**
 - **Reduces Life Cycle Costs**
- **RECOMMENDATIONS**
 - **Develop Prototyping Methodology**
 - **Implement Iterative Prototyping in Lieu of Acquisition**

The combination of changing threats and reduced budgets will result in increased emphasis on prototypes for validation and demonstration of S&T results as well as a means of capturing technology status for future use. Since prototyping typically has been ancillary to a major S&T programs, the engineering discipline and methodology of prototyping has not received adequate attention. This becomes even more critical with reduced transition to production.

Budget limitations make it essential to sort technology options as early as possible in the S&T process. In concert with improved simulation and modeling, a methodology is needed to decide when prototypes are needed, what aspects should be prototyped, and how the prototypes should be developed. In the absence of transition to production, the opportunity exists to iteratively prototype, which means producing successive generations of prototype systems, each incorporating incremental improvement, without necessarily moving to full scale development. Iterative prototyping can serve to refine technology, adapt to evolving requirements, and maintain critical technical competence. Properly focused, the prototyping process can reduce development and life cycle costs, facilitate the transition to production when needed, and in certain cases provide limited operational capability. Development of a vigorous prototyping methodology could enhance commercial competitiveness as well, at least partially offsetting the loss of the defense production incentive.

We recommend that the Navy S&T program pursue the development of a prototyping methodology, integrated with simulation and modeling techniques to optimize the return from the S&T investment, and support iterative prototyping cycles to keep current technology "on the shelf" for critical needs.



NEW S&T PRIORITY UTILIZATION OF COMMERCIAL BASED MANUFACTURING

**S&T
STRATEGY**

- **OBSERVATIONS**
 - **Reduced Defense Manufacturing Base**
 - **Fewer New Platforms**
 - **Test Beds Still Needed**
 - **Growing Hi-tech Commercial Manufacturing Capability**
- **CONCLUSIONS**
 - **Need to Leverage Commercial Technology and Manufacturing**
 - **Need to Manufacture and Field Technology Prototypes**
- **RECOMMENDATIONS**
 - **Investigate Manufacturing Research as a Discipline**
 - **Target Exploratory Technology for ATD's and Existing Platforms Utilizing Commercial Technology**
 - **Design ATD's to Capitalize on Commercial Manufacturing Technology**

The reduced defense manufacturing base resulting from producing fewer new systems and platforms does not eliminate the continued need for S&T test beds and demonstrations. It will be necessary to take advantage of the growing commercial capability in high-technology manufacturing in order to realize these prototypes. Furthermore, DoN must ensure that it makes production affordable to enable reconstitution if necessary. An example is utilization of advanced packaging of chips, inter-connects, and boards made for consumer electronics where appropriate versus full MILSPEC hardware as a matter of course.

DoN must incorporate consideration of commercial technology and manufacturing capabilities into the development of new technologies and platform concepts. In order to establish the necessary framework, manufacturing research should be investigated as a science and engineering discipline. Every effort should be made to exploit commercial capabilities in developing technology for ATDs and upgrading existing platforms.



- **OBSERVATIONS**
Several Navy and Marine Corps Critical Applications Will Benefit From Using Unmanned Vehicles
 - **Mine Countermeasures**
 - **Environmental Characterization**
 - **Shallow Water ASW**
 - **Near-Horizon Detection of Sea Skimming Missiles and Fast Patrol Boats**
 - **High Resolution Imagery and Long Loiter Time**
 - **Forward Warning of SCUDs and Air-to-Surface Missiles**
 - **Battle Damage Assessment and Target Acquisition**
 - **Decoys and Deception**
- **CONCLUSIONS**
 - **Force Enhancement**
 - **Reduce Casualties**
- **RECOMMENDATION**
 - **Demonstrate Application-Specific Prototypes**

Critical Navy and Marine Corps missions include mine countermeasures where specialized vehicles equipped with electro-optic (EO) sensors may be used to locate, and characterize mine fields. A previous NRAC study has proposed the use of remotely operated vehicles on a defended beach. These vehicles can be specifically designed to neutralize surf zone and very shallow water mines. Autonomous vehicles could also be developed to locate and neutralize shallow water mines in the projected area of operations of an amphibious force. Determination of environmental characteristics using Unmanned Underwater Vehicles (UUVs) would permit oceanographic measurements in forward areas. Identified missions include area reconnaissance and feature inspection. Area reconnaissance is used for quick-look surveys using conductivity, temperature, depth, wave, and current sensors. Features such as river outflows or other fronts can be precisely resolved. Detailed bathymetry can be collected, and other data can be collected to update prediction models.

Shallow water ASW is a more tractable problem if UUV's are used. For example, a sound source can be remotely deployed and used to calibrate tactically important propagation paths. Management of the fleet battle operations can be improved by using autonomous vehicles to augment aircraft surveillance for the battle group. Early detection of sea skimming missiles and patrol boats might be enhanced by vehicles equipped with radar, EO, or infrared (IR) sensors. Additionally,

early and accurate battle damage assessment becomes possible. Autonomous and remotely operated vehicles can be used to loiter in the vicinity of suspected Tactical Ballistic Missile (TBM) or air-to-ground missile launchers. High resolution imagery [EO or IR] can provide a search or early warning capability.

Autonomous and remotely operated vehicles may be used to reduce the number of manned missions, leading to fewer casualties. Critical gains include force enhancement through reduced cost by trading off weapons and sensor payloads against manned support. Reduced casualties, especially when defenses are still not completely suppressed, will permit high risk missions to be carried out. The most direct approach to exploiting these potential benefits is to demonstrate autonomous prototype and/or remotely operated vehicles for specific applications.



- **OBSERVATIONS**
 - **Fewer New Platforms**
 - **Long Incubation Time for Design Teams**
 - **New Technologies May Drive Platform Configurations**
- **CONCLUSIONS**
 - **Need to Maintain Competent Platform Design Teams**
 - **Need S&T Investment Strategy for Platform as well as Subsystem Improvements**
- **RECOMMENDATIONS**
 - **Establish and Maintain Platform Design Teams**
 - **Periodically Institute Technology Specific Platform Demonstrations**

Although both S&T and acquisition activities in the foreseeable future may emphasize system and sub-system improvements in lieu of new platforms, a continuing healthy level of platform-oriented R&D activity is considered essential. We feel strongly that a continuing investment in advancing the state-of-the-art of naval platforms (aircraft, submarines, and surface ships) is necessary to ensure that the most modern and capable technologies are proven and available for incorporation into new production design.

An attractive mechanism for consideration as a means to ensure the continuing advancement of platform technologies is the periodic design, construction, and operations of what might be characterized as "platform test beds," optimized to address specific technical advances. Commitment to such an endeavor, perhaps on a cycle of every 3-4 years per major platform category, would serve to keep design teams intact, keep components of the industrial base minimally active, and keep a focus on R&D efforts and resources. The platform should not be considered a prototype or a forerunner to a series production of a design. Normally, only one would be built. A limited warfighting capability would be desirable but is not mandatory.

Initial R&D test platforms might be optimized as follows:

- **Aircraft: Survivability and Mission Endurance**
- **Submarines: Hydrodynamics and Automation**
- **Surface Ships: Survivability and Hydrodynamics.**



NEW S&T PRIORITY ENERGY SUPPLY AND ALLOCATION

**S&T
STRATEGY**

- **OBSERVATIONS**
 - **Increased Dependence on Electric Power for Individual Warrior to Major Combatants**
 - **Load Management Essential to Graceful Degradation**
 - **Traditional Power Generation Hot and Noisy**
- **CONCLUSIONS**
 - **Need Low Signature Power Technologies**
 - **High Energy and Power Density Critical for Many Applications**
 - **Integration of Generation/Storage/Conditioning/Distribution Allows Effective Management and Efficiency of Scale**
- **RECOMMENDATIONS**
 - **Explore Stealthy Power Technologies**
 - **Integrate Energy Management Into Requirements**
 - **Develop Integrated Power Systems**

Electric propulsion, electric weapons (lasers, guns, particle beam weapons), electromagnetic weapon launch, electrically powered sensors and countermeasures, autonomous and remotely operated vehicles, and the desire to equip individuals with enhanced sensing, computing, communications, power projection, and life support all reflect increased dependence upon availability of suitable electric power. The feasibility of many applications -- particularly mobile or remote functions -- is constrained by power generation densities or energy storage density. Since functional priorities vary with conditions, the ability to shift energy resources between functions can substantially increase mission capability and reduce overall energy requirements. Applicability of traditional combustion-based power generation technologies will be increasingly limited by acoustic and IR signature considerations.

This clearly leads to a need for high energy density, low signature power technologies for generation and energy storage. Where practical, integration of power generation, energy storage, power conditioning, and distribution systems for various applications benefits from increased capabilities through efficiency of scale and the opportunity to intelligently manage load requirements. This is particularly important for maintaining critical functions in the event of battle damage and/or declining energy reserves.

We recommend that the Navy and Marine Corps S&T programs explore stealthy power technologies, integrate energy management into requirements for future systems, and where applicable, develop integrated power systems to achieve the benefits discussed here.



NEW S&T PRIORITY SMART MATERIALS

S&T STRATEGY

- **OBSERVATIONS**
 - **Material Advances Continue to Impact Navy Technology**
 - **Embedded or Inherent Functions Can**
 - **Modify Surface Characteristics**
 - **Sense Environment or Material State**
 - **Damp Vibrations**
- **CONCLUSIONS**
 - **Opportunities Exist for Incorporating New Functionalities**
- **RECOMMENDATIONS**
 - **Materials Research Should Encompass "Intelligence"**
 - **Pursue Exploratory Technology and Demonstrations Incorporating Smart Materials**

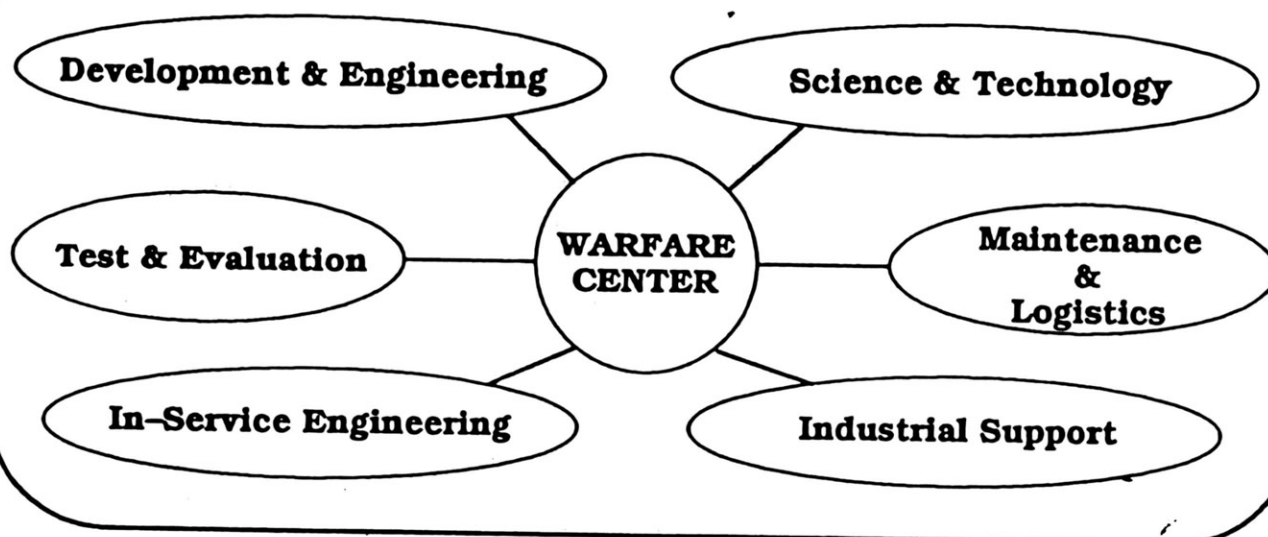
Since most DoN systems emphasize specific performance, they will continue to be driven by advances in materials technology. An emerging capability in this area is the incorporation of inherent or imbedded intelligent functions in the materials themselves. Today, this capability is based upon large-scale microelectronic fabrication techniques and materials. Examples include: 1) electromechanical or piezoelectric modification of surface roughness or contours; 2) sensing of environmental conditions (pressure, temperature, radiation) or material state (strain, fatigue); and 3) active or passive vibration damping.

Challenges include distributing and imbedding the logic as well as the sensing and actuation functions to eliminate the requirement for centralized data processing and providing and distributing the required power.

These capabilities will continue to develop in the commercial sector and will offer many opportunities for incorporating additional functionality. DoN materials research efforts should encompass these inherent intelligent capabilities, and exploratory technologies and demonstrations should incorporate them.

VIII. S&T IN THE WARFARE CENTERS/NRL

- **Institutional integration of the Warfare Centers provides an opportunity to influence the S&T process more comprehensively.**



The Warfare Centers have been reconfigured in the recent Navy R&D consolidation process to provide integrated, full spectrum centers for science and technology, development and engineering, test and evaluation, in-service engineering, maintenance and logistics, and industrial support. This expanded capability provides the means to participate in the S&T process in a much more comprehensive manner. The centers are now uniquely positioned to take advantage of insights gained through fleet support and user interfaces in conducting a more effective S&T program.

The combined knowledge of customer needs and first hand experience with equipment in the field should result in a much more vital in-house S&T program, and also serve as an important adjunct to the CNR in formulating plans and assessing the entire Navy S&T program. It is, therefore, incumbent on each Warfare Center to establish an appropriate mechanism for capturing the knowledge base across their expanded operations to derive the full benefits of cross-fertilization for Navy S&T.



CONCLUSION

- **Industry/In-house Laboratory Cooperation
Should Be Expanded**

RECOMMENDATION

- **Require Warfare Center/Industry Partnerships
For All ATD's/EATD's**

This NRAC panel concluded that there are several areas in which S&T in the Warfare Centers/NRL should be enhanced. These deal with the subjects of in-house/industry relationships, technical analyses at the Warfare Centers/NRL, discretionary S&T funds, and monitoring and exploiting worldwide S&T.

IN-HOUSE/INDUSTRY RELATIONSHIPS

The Defense establishment is being downsized in response to the massive changes occurring in the former Soviet Union. In this period of draw-down, management attention is needed to reduce tensions between industry and in-house activities and preserve the strengths of each.

There are several approaches available to address the problem. First, S&T can be managed with fixed in-house/out-of-house ratios. Second, specific levels of in-house S&T institutional funding can be established instead of current industrial funding practice. A third approach is to construct true R&D partnership arrangements. This affords the opportunity for cementing productive relationships between the in-house labs and industry with considerable advantage to the DoN. Although the partnership concept may be applicable to some extent for 6.2, its applicability to 6.3A appears to be the most attractive. It is in fact the 6.3A activity

of demonstrations and prototypes which intersects industry the most, both because of the shift in focus from less procurement to more 6.3A demonstrations and because demonstrations and prototypes are the entry point of downstream procurements to be conducted by industry.

RECOMMENDATION:

Industry/in-house laboratory cooperation in S&T should be pursued as a high priority matter. There are several approaches to address this subject; a study should be commissioned to explore the pros and cons of the various options available and to define their relationship with the S&T management process at OCNR. This study should solicit industry input. Further, the Panel specifically recommends that the ASN/CNR require Warfare Center/Industry partnerships for all ATDs and Enhanced Advanced Technology Demonstrations (EATDs).

CONCLUSION

- **Warfare Centers Capability Exists for More Detailed/Careful/Robust Technical Analyses**

RECOMMENDATION

- **CNR Should Capitalize on Warfare Centers Analysis Assets to Optimize S&T for Operational Capability**

TECHNICAL ANALYSES AT THE WARFARE CENTERS

The Panel concluded that there was both a need and the capacity for more detailed and robust technical analyses to be conducted on a continuing basis. This function is consistent with the broader technical responsibility mandated in the new Warfare Center configurations and on exploration of a broader range of technical options before entering into procurement. The Warfare Centers are positioned to draw from their full range of resident capabilities, e.g. technologists who are up to date and working at the state-of-the-art and have Fleet related experience that is both current and authoritative. This technical analysis capability should supplement the CNR's Planning and Analysis activity. It would also augment other DoN analysis activities such as those at the War College, Center for Naval Analyses (CNA) and Office of the Chief of Naval Operations (OPNAV).

RECOMMENDATION:

CNR should capitalize on the Warfare Center's technical analysis assets to optimize S&T for operational capabilities.

CONCLUSION

- **Maintenance of a Healthy Level of Discretionary R&D at the Warfare Center Level Contributes to S&T Vitality**

RECOMMENDATION

- **Establish at the Warfare Centers/Director Level About 5% of S&T Funds for Innovative Projects**

DISCRETIONARY S&T FUNDS

There has been long standing recognition of the desirability for discretionary S&T funds at the laboratory level. Discretionary resources can also be employed to capitalize on unexpected research results, stimulate innovation, seed high-risk, high-payoff efforts, initiate cross disciplinary activities, and fill critical technology gaps. The Panel concludes that a healthy level of discretionary S&T at the Warfare Centers contributes to overall S&T vitality.

RECOMMENDATION:

The Panel recommends that five percent of the S&T funds which accrue to the Warfare Centers be made available for innovative projects at the Director's discretion. The CNR should establish the criteria for employment of these funds, should be made aware of their use, and should evaluate their contribution as part of the S&T assessment process.

CONCLUSION

- **Warfare Centers and NRL Should Seek New and Innovative Ways to Take Advantage of Worldwide S&T**

RECOMMENDATION

- **Warfare Centers/NRL Directors Create Small Groups to Monitor/Exploit Worldwide S&T**

MONITORING AND EXPLOITING WORLDWIDE S&T

The Panel considered the importance of accessing non-Navy funded S&T by the Warfare Centers/NRL. The nominal one billion-dollar Navy S&T program is a small fraction of worldwide S&T. Worldwide S&T includes both commercial and military S&T, conducted both in the U.S. and abroad. The totality of this enterprise is a potentially rich resource for the Navy to draw upon, especially in a declining DoD budget environment.

Access to worldwide S&T has been a part of the DoN S&T strategy for some time, e.g. the activities of ONR Europe and Asia, and through OCNR staff functions dealing with foreign military technology. The Panel concluded that this task will be of continuing importance, and that the Warfare Centers should seek new and innovative ways to take advantage of worldwide S&T in their assigned areas of responsibility. The Panel also took note of the congressionally mandated changes whereby industry R&D will soon become fully funded. Also, OCNR should continue to review the IR&D program as they have done in the past.

RECOMMENDATION:

The Panel recommends that the Warfare Centers/NRL initiate activities to monitor worldwide S&T to provide options beyond those derived solely from DoN funding. DoN should ensure continued access to industry R&D.

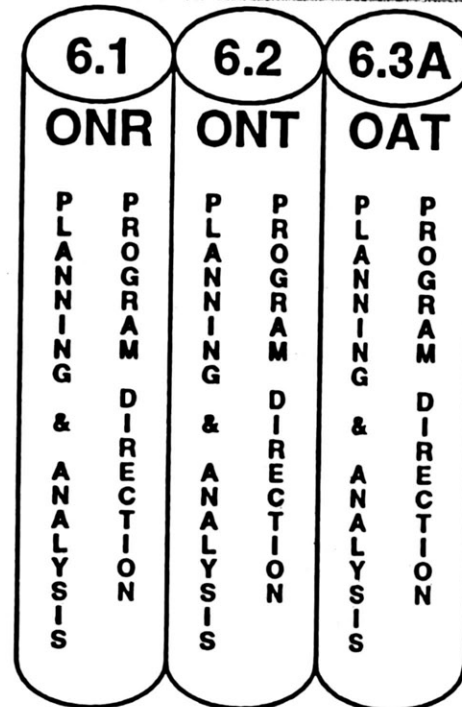
IX. S&T MANAGEMENT



S&T MANAGEMENT OBSERVATIONS

S&T STRATEGY

- **Present S&T Enterprise is a Set of Stovepipes**
- **Resource Allocation Process is Incomplete**
- **Role of OAT is Unclear**
- **Weak Customer Coupling**



The present S&T organization consists of three distinct entities (ONR, ONT and OAT) which have their roots in different time periods and environments. This history contributes to the differing operating processes and procedures and, most importantly, to the functioning of the composite organization as three "stovepipes." The lack of an integrated planning and analysis (P&A) activity is telling; as a result, there are impediments to the transition of technology to the next level of maturity and subsequently to the Fleet. In fact, the P&A is conducted within the stovepipes with the personnel resources being loaded towards the 6.1 and 6.2 areas (12 and 14 P&A staff, respectively) and the 6.3A area having a staff of only one. The lack of an integrated P&A activity for all of S&T means broad perspectives which should guide the total program are not visible.

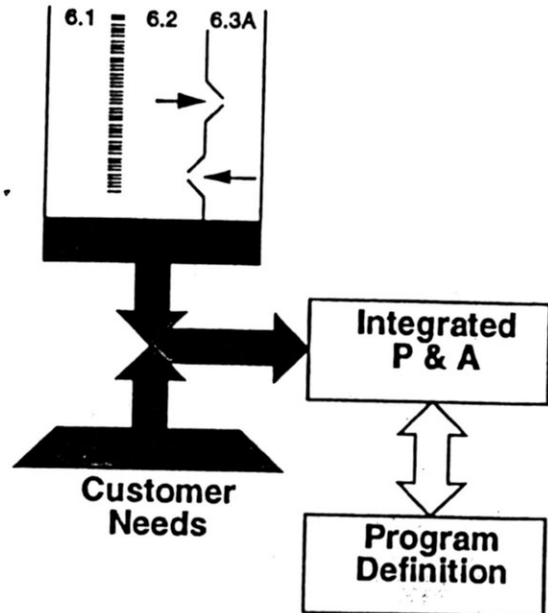
There is also a need for analysis that covers operational needs, technical alternatives, risk assessments, utility to the Fleet, and so forth on an end-to-end basis in order to develop definition of the program in total and in detail. Such an effort would allow the evolution of a return on investment strategy, i.e. description of the process of how and why to pick individual tasks and how to use the return on individual tasks in aggregation to achieve the DoN objectives. The latter is not simply a roadmap. It is a factual, evidenced-based set of analyses tracing proposed S&T programs all the way through Fleet-level operational utility assessments.

The weak involvement of Program Executive Officers (PEOs) and Direct Reporting Program Managers (DRPMs) in S&T work is a glaring deficiency. This, in effect, wastes resources because these organizations have to develop technology on their own if they are not serviced by the S&T community. The problem is two-sided since many PEO and DRPM organizations have interpreted their charters to be independent and autonomous. In the present and expected future budget environments this luxury is not affordable. There has to be coupling.

The role of OAT is still unclear eighteen months after its creation. The process of selection of ATD's seems divorced from the process of evolution and maturation of technology into a prototype product configuration. OAT seems to be a bystander to a bureaucratic voting process (and it does not vote!) and is relegated to being a helper to the implementer. OAT ought to be a leader in the process, making the learned technical decisions on matters such as what is ready to be an ATD, the approach to be followed, how much simulation should be done in preparation for hardware development, and even how much simulation should be done in lieu of hardware.

The S&T coupling to the customer community needs strengthening. Here "customer" means the operators of combat systems, the support forces, and the system developers. All of these groups should have input at the appropriate times since they eventually inherit the legacies left by S&T and have no choice but to insert them into the DoN weapon system configurations and operations or deal with the deficiencies resulting from an unresponsive S&T Program.

- **Integrated, Coherent, End-to-End Planning and Analysis for S&T**
- **6.1 to 6.2 Cooperation and Eliminate 6.2 to 6.3 Barriers**
- **Concentrate CNR Attention on Linkages with Customers in Definition of Program**
- **Strengthened Coupling and Interactions with Customers**



The S&T activities would be enhanced if there existed an end-to-end planning and analysis (P&A) function for the total effort, both through various technologies as well as from research through the employment life-cycle. All aspects of technology development need to be included in a fully integrated sense -- handover, transition, rapid exploitation, etc.

The customers' objectives and needs form the starting point for a thorough P&A effort. In conjunction with staff representing the customers, these inputs have to be translated, via technology and design oriented trade-offs, and combined with functional utility analysis into candidate concepts for solutions to the problems which, in turn, generally have a system level impact. Operational analyses and affordability assessments are necessary overlays in order to fully frame the picture of the usefulness of a particular venture to the DoN. Execution of this full spectrum allows the P&A effort to define the appropriate technology programs that meet the needs of the customers and also capitalize on technological opportunities.

A comprehensive P&A effort will also facilitate cooperation between 6.1 and 6.2 work and help eliminate barriers between 6.2 and 6.3A. Inability to achieve timely transition of items from one category to another and, apparently, disagreement on the selection of items are serious matters which could be obviated by having an

end-to-end S&T plan in which all the participants have a sense of ownership. All of the players would have to participate, couple their work and interests, integrate their plans into an omnibus plan and join resources to implement it. All of these steps should create unanimity of purpose and actions from the researcher all the way through the operators of combat systems.

The coupling of the OCNR and its components to the customers and the need for more extensive P&A represent the two important items for the CNR's attention. The new requirements placed on the DoD as a whole argue for concentrated dedication of the key leadership on deciding what to do and creating the architecture of how to do it.

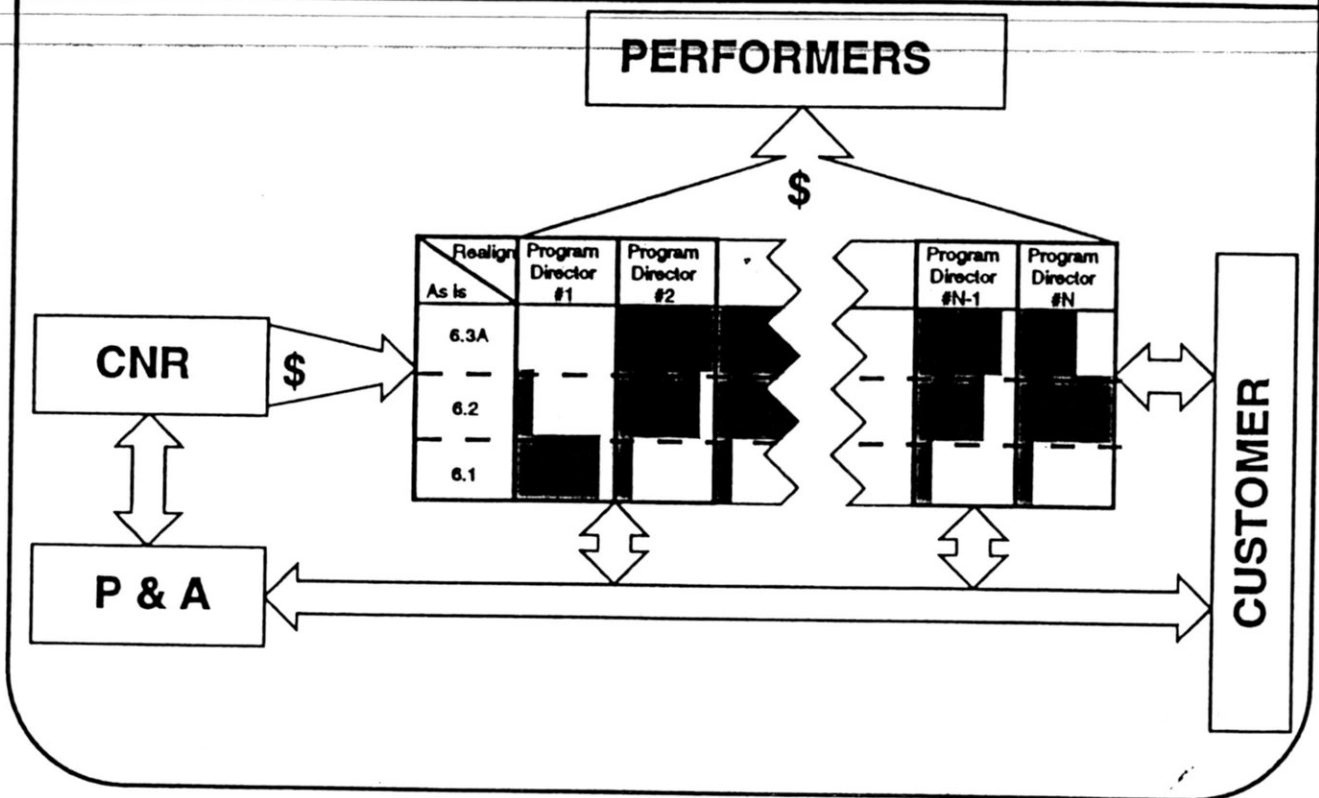
S&T management must perform the four basic functions of program management. These are as follows:

- The Planning and Programming function which combines the development of an understanding of customer needs with analyses of options for investment and results in an allocation of resources among a variety of claimants for funds.
- The Program Direction function, which is a resource management activity that encompasses the definition of statements of work and requests for proposals and selection of performers to initiate S&T activity. It also involves assessing the performance of the work.
- The Program Execution function organizes the effort, selects the people to do the work, provides day-to-day management of the effort, and keeps management informed.
- The Assessment Function focuses on developing an objective sense of the progress being made toward the technical goals and the conformance to schedule and budget as well as judging the potential impact of results achieved.



S&T MANAGEMENT REALIGNMENT

S&T
STRATEGY



The schematic above depicts an S&T structure that is oriented by specific program interests rather than by the category of appropriated funds. The planning and programming function is conducted by a Planning and Analysis Group that supports the CNR and a set of Program Directors. This group conducts analyses of options and constructs draft policy guidance and resource allocations for the CNR to issue to the Program Directors. Program Directors perform the program direction function. They are organized along specific program lines and distribute funds of all three types to the performers.

The Performers, consisting of in-house laboratory, university, industry, etc., are people responsible for program execution. The assessment function is conducted by the P&A group and the Program Directors. Both are concerned with the progress being made for the investment to date and with the potential impact of the results achieved. The P&A group maintains a corporate perspective that makes assessments across customer lines, while the Program Directors assess within their area of focus.

The ONR approach to program direction for 6.1, which has served the DoN very well, provides a model for Program Directors in the realigned S&T organization. That is, a respected, technically competent expert that exercises personal judgment

in selecting performers, assessing the quality of the effort, and developing candidates for increased or decreased investment, and who acts as the CNR's responsible agent in an area of S&T investment. The shading in each of the boxes under a single Program Director qualitatively indicates the amount of funding of each category for which they act as the CNR's responsible agent. We recognize that the pervasive nature of basic research may argue for the retention of one or more program directors whose portfolio of activities is oriented to executing research and technology programs that impact a broad set of the other Program Director's customers.

The two most important features of this structure, in terms of a departure from current modes of operation, are: (1) a single, integrated Planning and Analysis function and (2) the Program Directors responsible for all S&T work in their specific area's three types of S&T funds.



- **DoN S&T Authority**
 - **Resources**
 - **Programs**
- **Responsible for S&T Planning, Analysis, Program Strategies, Execution, and Assessment**
- **Provides Guidance and Funding to Program Directors**
- **Principal DoN Interface with all DoD and Other S&T Organizations**
- **Responsible for Fostering and Maintaining S&T Customer Feed-back and Feed-forward**

We endorse the basic functions of the CNR given in SECNAVINST 5430.20 D. As manager of naval basic research (6.1), exploratory development (6.2), and advanced technology development (6.3A), CNR provides S&T planning, analysis, program strategies, execution management, and assessment.

CNR is the authority for S&T resources and programs and in this capacity, provides funding and direction to program directors. Policy direction and S&T oversight are also provided to Navy Corporate Laboratories and R&D Centers.

The CNR is charged with exploiting S&T results for developmental, tactical, and policy implications for the Navy and Marine Corps. This tasking necessitates fostering and maintaining S&T customer feed-forward and feed-back links and S&T interfaces across DoD, other government agencies, domestic industry, and foreign S&T activities as well.



- **Understand Customer Needs**
- **Evaluate Conceptual Approaches, Designs, and Trade-offs**
- **Analyze Program and Operational Utility**
- **Evaluate Affordability Estimates**
- **Develop Integrated S&T Priorities, Milestones, and Resource Allocations**

The CNR needs an integrated S&T planning and analysis activity to ensure that: customer needs are fully understood; options are formulated and fully considered; and program direction is developed and transmitted based on a clear understanding of needs and options.

Planning and analysis personnel should communicate informally across the DoN to obtain the perspective of weapon system operators, logistics organizations, and developers. They can complement the program directors in gleaning insights and, by virtue of the breadth of their interactions, identify synergisms or duplications which might otherwise go unnoticed.

The development of conceptual approaches, designs, and trade-offs are fundamental P&A functions. The potential gain associated with technical innovation and bold approaches (both operational and technical) should be fully explored by the P&A staff, as well as application of foreign and commercial products, processes, and technology.

Systems performance analyses are used to determine the effectiveness of various approaches. Operational utility analyses are performed to determine the practicality of use, including training, maintenance, and logistical considerations.

Affordability estimates are required, and risk should be assessed in terms of performance, cost, and schedule. The results of these investigations provide program directors and the CNR a clearer understanding of the pros and cons associated with the various approaches for meeting customer needs and guiding resource allocations.

Under direction of the CNR and in coordination with the program directors, the P&A staff conducts program analysis and develops S&T priorities, milestones, and resource allocations. The P&A staff assists the CNR in coordinating the resulting program direction and in issuing and conveying the end product.



- **Interfaces With Customers**
- **Maintains Recognized Technical Expertise in Assigned Program Area**
- **Serves as CNR's S&T Spokesman and Sponsor in Assigned Area**
- **Initiates all S&T Procurements in Assigned Area**
- **Acts as Source Selection Authority**
- **Monitors and Assesses Program Performance and Progress**

Establishing program director functional responsibilities is pivotal for achieving improvements of:

- 6.1 to 6.2 cooperation;
- elimination of 6.2 to 6.3A barriers;
- concentrated attention on linkages with customers;
- strengthened coupling and interaction with customers.

The program director is the single authority, responsible and accountable for the management and execution of projects and programs assigned to his or her specific area. Based on the guidance, direction, and funding provided by CNR and as assisted and supported by CNR's planning and analysis capabilities, the program director:

- directs the performers in the execution of approved projects and programs;
- allocates the funds provided by CNR to projects and programs;

- provides technical oversight and direction, as required;
- Interfaces with combat systems operators, supporting forces, systems developers and performers, as required;
- serves as a facilitator for feed-forward and feed-back;
- serves as a spokesperson and represents CNR and DoN S&T interests in interactions (normally technical) with external authority (e.g. DoN, DoD, Joint Chiefs of Staff (JCS), other Departments and Services, foreign, etc.), as required;
- fosters cross-communication, and technical exchange and support between S&T program directors in specific areas.

Clearly, the intent of this realignment is to improve S&T productivity and effectiveness. The tendency to grow larger must be resisted vigorously. To that end, the program director is given considerable flexibility in the delegation of his responsibilities. Functions (all or in part) that could be passed to the performers include:

- S&T procurements in the program director's specific area;
- source selection authority (while retaining final approval);
- detailed monitoring and assessment of project and program performance and progress.

The keys to program director success are:

- not micromanaging the performers in the execution of project or program plans;
- keeping track of projects or programs;
- staying in contact with the customer;
- operating within established policy and direction;
- remaining bold and innovative;
- remembering that the DoN consists of two services.



- **Realign OCNR into a Single, Nearly Seamless, Integrated DoN S&T Organization**
- **Within OCNR, Establish a Single, Integrated Planning and Analysis Staff**
- **Within OCNR, Establish Program Directors Each With Responsibility For All S&T Work in a Specific Area**

X. SUMMARY

- **Maintain Present Core of DoN-Critical Research Areas**
- **Pursue Seven Key Technologies Which Support the "Cheney Paradigm" and Require an Integrated Approach to S&T for Execution**
- **Enhance Warfare Center/NRL Role in S&T**
- **Realign OCNR to Improve S&T Planning and Management**

The core areas of research that have been identified and pursued for long term DoN needs are also appropriately formulated within the changing threat and competitive budgetary environment. Ocean sciences, advanced materials, and information sciences all contain basic research opportunities that underpin the key technologies of interest to DoN.

The "new" or "Cheney paradigm" will be supported by several key technologies which we recommend as S&T priorities for new or additional focus. These key technologies address needs for improved affordability, casualty reduction, and continued combat systems superiority. These key technologies require an integrated approach for program execution across research, exploratory technology, and advanced technology demonstrations. They also identify two specific emerging technologies that appear ready for DoN S&T exploitation.

The DoN Laboratory and Center realignments provide for Warfare Centers and a NRL that can get the job done in a changing development and acquisition environment. The Panel recommendations support and refine the intent of the recent lab realignment and Center establishment.

The realignment of the OCNR into a single, integrated DoN organization is the linchpin for supporting the "Cheney paradigm" and successfully establishing the technology bridge into the 21st century.

XI. APPENDIX A - GLOSSARY

ASN	Assistant Secretary of the Navy
ASW	Anti-Submarine Warfare
ATD	Advanced Technology Demonstration
CNA	Center for Naval Analyses
CNR	The Chief of Naval Research
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
DoN	Department of Navy
DRPM	Direct Reporting Program Managers
EATD	Enhanced Advanced Technology Demonstration
EO	Electro-Optic
HQ	Headquarters
IR	Infrared
JCS	Joint Chiefs of Staff
MILSPEC	Military Specification
NRAC	Naval Research Advisory Committee
NRL	Naval Research Laboratory
OAT	Office of Advanced Technology
OCNR	Office of the Chief of Naval Research
OPNAV	Staff of the Chief of Naval Operations
ONR	Office of Naval Research
ONT	Office of Naval Technology
OSD	Office of the Secretary of Defense
P&A	Planning and Analysis
PEO	Program Executive Officer

R&D	Research and Development
S&T	Science and Technology
SIMNET	Simulation Networking
SYSCOM	Systems Command
USMC	United States Marine Corps
UUV	Unmanned Underwater Vehicle

APPENDIX B - FORMAL PRESENTATIONS TO THE NRAC PANEL ON SCIENCE AND TECHNOLOGY

RADM W. Miller, USN
Chief of Naval Research
Overriding Investment Strategy Considerations

Dr. F. Saalfeld
Office of Naval Research
ONR Investment Strategy and 6.1 Reliance

Dr. P. Selwyn
Office of Naval Technology
ONT Investment Strategy and Tri-Service Reliance

Mr. G. Spalding
Office of Naval Technology
ONT Investment Strategy and Tri-Service Reliance

Dr. J. DeCorpo
Office of Advanced Technology
OAT Investment Strategy and Reliance

Dr. A. Milton
Office of the Assistant Secretary of the Army (RD&A)
Army S&T Strategies

MGEN Robert Rankine, USAF
Air Force Systems Command
Air Force S&T Strategies

Dr. R. Vaughn
Office of the Chief of Naval Operations (OP-091)
OPNAV Perspective — S&T Guidance

Mr. I. Blickstein
Office of the Chief of Naval Operations (OP-80)
OPNAV Perspective — Program Planning

Mr. C. Childers
U.S. Marine Corps Systems Command
USMC Perspective — S&T Guidance

Mr. L. Lundberg
Naval Air Systems Command
S&T Strategy and Laboratory Consolidation

Dr. F. Ventriglio
Naval Sea Systems Command
S&T Strategy and Laboratory Consolidation

Mr. G. Miller
Program Executive Officer for Cruise Missiles and UAV's
PEO Perspectives

Dr. T. Coffey
Naval Research Laboratory
The Corporate Laboratory/Laboratory Consolidation

Mr. E. Messere
Naval Undersea Warfare Center
Laboratory Consolidation and S&T Perspectives

Mr. P. Wessel
Naval Command, Control, and Ocean Surveillance Center
Laboratory Consolidation and S&T Perspectives

Mr. G. Catrobone, Mr. E. Liska, Dr. J. Montgomery
Navy 6.2 Program Block Managers
Block Manager Panel

LT J. Cottle, USN
Defense Intelligence Agency
OSD Threat Analysis for the Future

CDR R. Hubbard, USN
Office of Naval Intelligence
Navy Threat Analysis for the Future

Mr. C. Meyers, Jr.
Private Consultant/Center for Naval Analyses
Littoral Warfare Paradigm Shift

Dr. D. Zeltzer
Massachusetts Institute of Technology
Virtual Environments and Simulation

Dr. S. Zornetzer
Office of Naval Research
Virtual Environments and Simulation