New Paradigms in Naval Science and Technology

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Introduction

Through the years the Department of Defense (DoD) has been able to provide its forces with superior warfare capabilities with their innovative use of human resources. These significant advances in warfare capability were brought about in large part by successful transformations introduced through the enterprise of science and technology (S&T). Today, DoD must continue to adapt to the current pace of technological change, rapidly integrate new and breakthrough technologies into its operational systems, and sustain a research and development environment that fosters innovation in order to preserve our significant lead in military capability.[1-9] To do this, DoD must continue to attract and retain the very best scientists and engineers in its workforce.[2] This is especially true for those scientists and engineers working at the forefront of emerging S&T, who need a unique set of technical skills in order to transition S&T to the fleet.

There are many that truly believe the DoD of the future should simply turn all S&T matters over to academia and private industry for solutions through the new acquisition reform process. However, as numerous studies have pointed out time and again over the last thirty years, the DoD can never fully out-source its S&T agenda through contract reform. Without its own internal personnel having competency in new and emerging S&T arenas, the DoD would find itself short on technical understanding, becoming simply an administrative interface useful only for dealing with the outside world as a purchasing agency. It would be unable to identify its own needs to 1) define military problems in technical terms, 2) know how to identify those who can potentially solve those problems, and 3) be technically capable of verifying a correct solution when it is presented. Clearly, DoD with its complex technical infrastructure requires the internal ability to work along with academia and industry to provide and sustain critical S&T capabilities.[3]

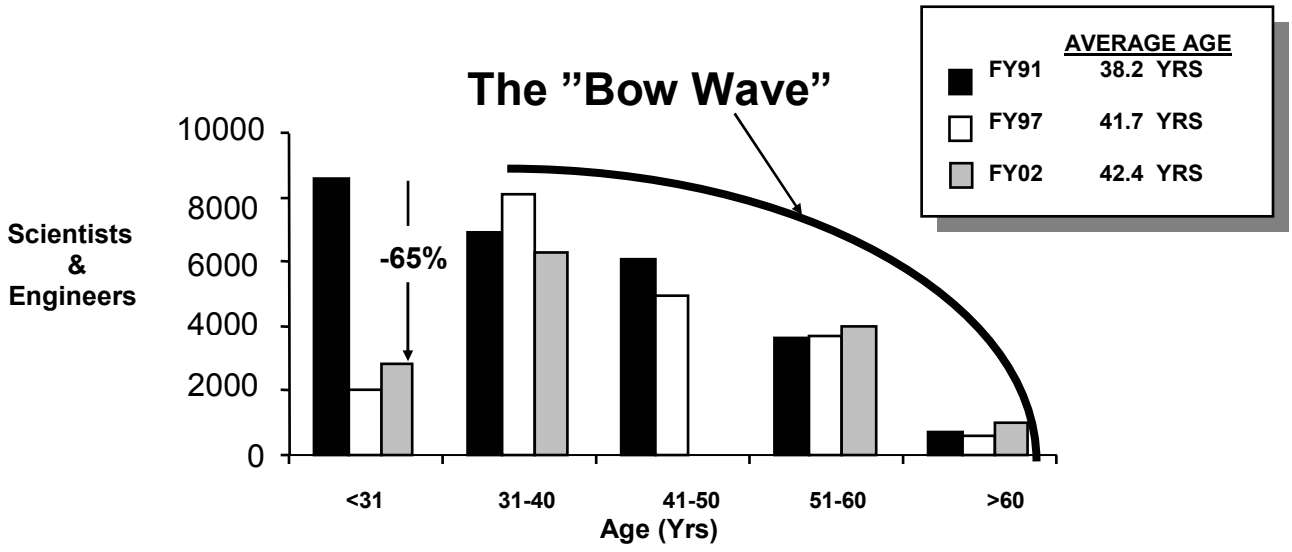
However, despite all this concern, the system is in serious disrepair. Colvard[4] maintains "the Navy has lowered its level of intellectual involvement in research and development and weakened its entire infrastructure, which at the end of WWII was the strongest in the world. For a service that sleeps on its weapons, this weakened institutional position in the world of science and engineering is dangerous." The government defense laboratories continue to lose bright engineers and scientists to industry thereby making it extremely difficult to carry out research in areas of importance to national defense. This is particularly true when you consider that industry is not capable or interested in research areas which have small markets. "Specialized defense technologies often have little or no applicability to commercial products. Unlike the situation

during World War II, or even the Vietnam era, the DoD market is now often too small to justify a significant investment of scarce capital. For instance, Intel stopped making customized chips for the military because it was expensive and the volumes were too small."[5] Clearly it is imperative that the Defense Laboratories need to continue to conduct significant and innovative in-house research. Otherwise this "undermines the ability of government to respond effectively to the needs and aspirations of the American people, and ultimately damages the democratic process itself."

The Naval Warfare Centers

The Navy has tremendous intellectual capital in its S&T workforce, a large portion of which is resident in the Warfare Centers (WCs). Currently there are 2200 scientists and engineers (S&Es), include 850 PhDs, who work predominately on S&T. These S&Es are unique and valuable catalysts for innovation. They must have the skills and resources to achieve the required major advances in naval warfighting effectiveness. WC research is tightly linked to warfighting capabilities and provides a critical bridge from S&T to the Fleet. Naval innovation has consistently resulted in products that significantly improve overall warfighting capability.

Despite a well documented track record in both performance and transitioning S&T products into the fleet, the WCs find themselves in a perilous state. Perhaps most troubling is the demographic structure of this community. Figure 1 shows that the largest losses, during the 1990s downsizing, occurred mainly in the under-30 population. When this is combined with the aging of the current population of S&Es at these centers, the "bow wave" effect is created, whereby there are simply not enough S&Es coming through the pipeline to replace the generation who can retire in the next ten years.



SOURCE: DTIC/DMDC (DEFENSE CIVILIAN PERSONNEL DATA SYSTEM, APR 03

Figure 1. Naval RDT&E Centers

Further exacerbating the situation is the fact that the workforce focused on applied research (funding code 6.2) projects decreased twice as fast as the funding level in that category of

research during the last decade, as shown in Figure 2. In addition, intensified recruiting from industry and the reduced number of US citizens acquiring advanced science and engineering degrees is resulting in a competition for technical talent unsurpassed in recent times.

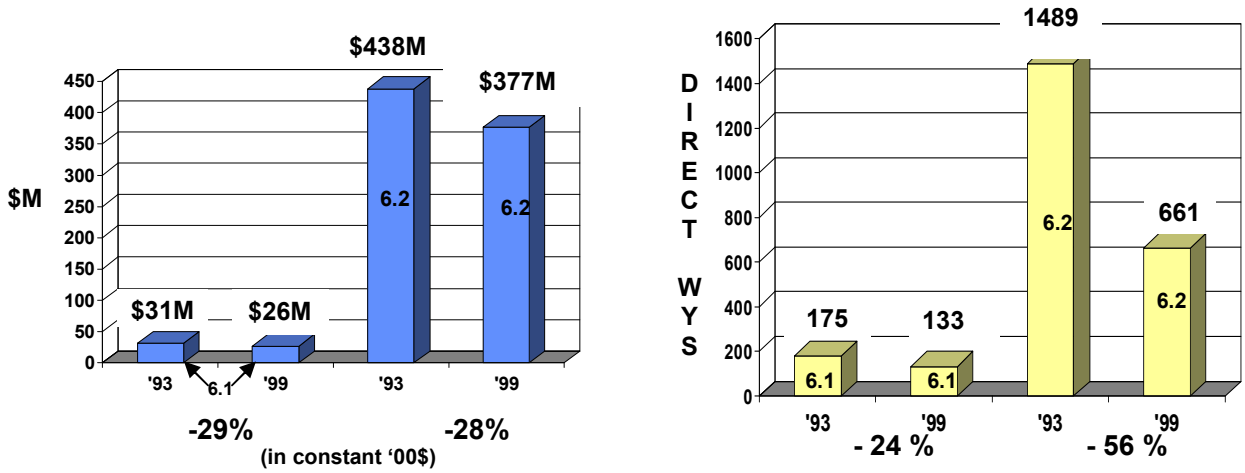


Figure 2. Funding and Personnel Trends at Warfare

There is other disturbing evidence of decline in the Navy's S&T workforce. For example, the in-house S&T workforce in some areas is perceived as less capable than their academic peers. In many areas here is a diminished focus on "doing research" and a greater inclination to outsource research. Finally, despite recent initiatives to modernize the DoD personnel system to make it more flexible, many of the changes proposed will not impact in the main the ability to recruit and retain preeminent research talent. Taking all these issues into consideration it becomes apparent that the need to act is urgent. The decline of this crucial portion of the Warfare Center population from the personnel pipeline threatens future generations of warfighting systems.

A Change in Culture

The Naval S&T community has undertaken several initiatives to revitalize S&T capabilities with the Warfare Centers. We will highlight three of these initiatives in this paper. These examples are reflective of the changing culture in these centers, where the linkage between the Universities and the Warfare Centers is at the heart of revitalization.

The N-STAR Program

An initiative to strengthen the Naval Warfare S&T community began with the desire expressed by the leadership of the Office of Naval Research (ONR) and the Warfare Centers to strengthen S&T in the WCs. A study team was formed in July 2000 to address the state of S&T work being performed in the WCs (Naval Surface Warfare Center (NSWC), Naval Undersea Warfare Center (NUWC), Naval Air Warfare Center (NAWC), and Space and Naval Warfare Systems Command (SPAWAR)). This led to a series of discussions between the Chief of Naval Research (CNR) and WC leadership on developing a strategy for "S&T Revitalization." CNR provided $5M in FY02, and the WCs contributed similarly to launch an initiative to develop the critical capabilities necessary for the 21st Century. The position of Director, S&T Revitalization was established at ONR to launch this new program. This new initiative is the "Navy-Science and Technology for America's Readiness" (N-STAR) Program.

N-STAR has one simply stated goal, viz. provide a Department of Navy (DON) civilian S&T workforce that enables transition of technology into the Naval forces of today and the future. This goal directly supports the Naval Transformation Roadmap. It will also provide a critical component of the intellectual capability at the WCs today and tomorrow.

The N-STAR Strategic Plan consists of four objectives and supporting strategies and is consistent with the General Accounting Office (GAO) Model of Strategic Human Capital Management. The strategies are to:

- Establish the DON Foundation for S&T Revitalization
- Develop and Define a Robust and Forward-looking Set of S&T Workforce Requirements
- Recruit, develop and Sustain Preeminent S&T Talent
- Convey Program Importance via an Integrated Communications Approach

The plan and these strategies are grounded on GAO's four human capital cornerstones of leadership, strategic human capital planning, acquiring-developing-retaining talent, and results orientated organizational cultures.

The challenge then is to attract and retain the brightest scientists and engineers into the Warfare Centers. One important aspect to achieving this is to create an educational, research and training environment commensurate with the best organizations throughout the country today. Thus, a critical component of N-STAR will be to take advantage of emerging opportunities in the new educational environment unfolding in our leading Universities.

The NNR project

The Naval Studies Board was commissioned by ONR in 1999 to perform an assessment of the ONR program in Undersea Weapons S&T. One of the outcomes of that study was the creation of a focused program in undersea technology. This led to the establishment of ONR's National Naval Responsibility (NNR) Program in undersea weaponry to address S&T topics of unique interest to this community. As part of the NNR in Undersea Weapons a University/Laboratory Initiative (ULI) was established. The objective of this initiative is to develop a consortium that will attract, develop, and retain highly capable individuals in career fields that support science critical to undersea weapons technologies. A secondary objective is to build confidence that within the universities, where the Navy has had historical success in hiring new employees, there are departments with students well suited to pursue research in areas aligned with topics germane to the ONR undersea weapons NNR program.

This consortium will thus provide the technical expertise critical to the health of the Navy's Undersea Weapons (USW) Enterprise (i.e., the ability to conceive and develop undersea weapons). The consortium will include the Naval Undersea Warfare Center, Newport Division (NUWCNPT), the Naval Surface Warfare Center, Indian Head Division (NSWCIHD) and the Applied Research Laboratory at Penn State University (ARLPSU), and universities dedicated to research and education in the disciplines related to the broad field of undersea weapons technology. Depending upon input from the ONR Program Officers other organizations may also be included. Typically, each university will receive support directly from ONR for graduate

students, post-doctoral students and faculty to perform research on topics deemed of national interest in USW by ONR. It is intended that the participating students/faculty will be paired with one of the naval organizations working on problems of interest to ONR and the particular organization. This will assure the educational continuity and sustained research accomplished in universities is supported by the ONR undersea weapons NNR program.

The University of Maryland at College Park (UMCP) was selected to facilitate the implementation of the ULI for Undersea Weapons and to provide critical assessment and stable stewardship of the program with emphasis on the educational component. UMCP will provide a key role in institutionalizing the proposed activities of undersea weapons NNR program. This approach will empower the ONR program officers to distribute the university portion of the NNR budget consistent with the technical quality of the proposals reviewed. It will also enable NUWCNPT, NSWCIHD, and ARLPSU to anticipate how, where, and when they will begin to be able to apply the results of the university research as they insert their technology into undersea weapons. Finally, it shall develop a pool of technical talent from which NUWCNPT, NSWCIHD, and ARLPSU can recruit the next generation of technical experts in undersea weapons technology. FY02 was the first year for the ULI program, with participants selected from the following Universities: University of Rhode Island, University of Connecticut, Penn State, Princeton, Notre Dame, University of Massachusetts, Carnegie-Mellon, University of Alabama, Prairie View University, Massachusetts Institute of Technology, University of Illinois, Urbana and the Naval Postgraduate School. The specific objective in terms of numbers of PhD-track students is to have 30 in the ULI program each year, so that 10 PhDs are produced per year who will then work in the undersea community.

An important component of this activity is the hosting of annual workshops supporting the ULI, acting as a "clearing house" for ONR in obtaining highly qualified students to participate in the program, and conducting an annual review of work being performed nationally in a specific scientific area relevant to undersea weapons. The annual review will include ONR program officers, university Principle Investigators, graduate students, laboratory researchers and other interested scientists and engineers to review progress and set future agendas for ongoing research. This will give exposure to the graduate students of the broader aspects of their research and an opportunity to network with other young researchers. An added benefit shall be the existence of a forum to entice and eventually hire the students to work in undersea technology. Each workshop shall select a clear theme and at this workshop a committee shall also select the best paper for which a Best Paper Award shall be given.

Over the next 10 years the net result of this initiative will be that 70 PhD-level S&Es will become members of the undersea weapons community.

The Center for Energetic Concepts Development

NSWCIHD has played a critical role in the areas of energetics research and manufacturing for the Navy. Like other WCs it underwent significant reductions in its S&T workforce during the nineties. This resulted in an aging workforce and an inability to engage in certain new R&D opportunities. A concerted effort was undertaken beginning in the late nineties to revitalize the workforce to meet new opportunities and sharpen its capabilities in its core competencies. In fact between June 1999 and June 2001 over 200 new S&Es were brought into Indian Head, a

significant number considering the total population of S&Es is 800. One of the most striking features of this new workforce is the education level of the S&Es. As shown in Figure 3, There has been a dramatic shift towards S&Es with advanced degrees coming into the organization, due in large measure to the increasing complexity and sophistication of the workload at NSWCIHD.

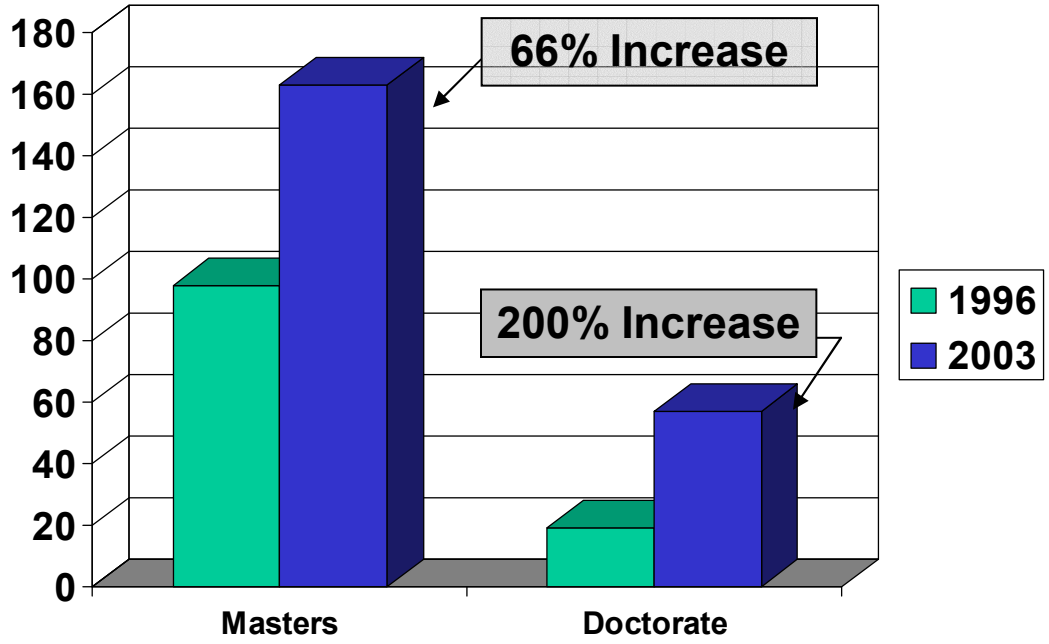


Figure 3. Naval Surface Warfare Center Indian Head, (Degree Trends)

Historically there had been much successful collaboration between Indian Head researchers (many of whom came to Indian Head from NSWC at White Oak) and the faculty at the UMCP. For example, the Zerilli-Armstrong constitutive material models used in many structural analysis codes today were the result of this collaboration. In order to revitalize this partnership in a more formal and long-term sense, a cooperative agreement was inked between NSWCIHD and UMCP in 1998. This arrangement led to the establishment of the Center for Energetic Concepts Development (CECD) with support from the University, the State and NSWCIHD. The Center is concerned with conducting research in areas of mutual interest and central to the mission of Indian Head, establishing a graduate program in energetics, developing an exchange program of S&Es, and supporting IH in a variety of smaller projects. (The web site for the CECD is: www.cecd.umd.edu).

To date over $7M in collaborative projects have been funded in the following research areas: combustion, thermally graded materials, MEMS, harbor safety, knowledge base systems for design, twin screw mixing, analysis and design in virtual environments and applying lean manufacturing principles. Additionally, two of the faculty in Mechanical Engineering has received the highly prestigious Young Investigator Program awards (YIPs) from ONR working in thermally graded materials and combustion.

The graduate program at the University of Maryland was initially designed to be a special program in energetics. A unique element of the cooperative agreement was the offering of free graduate classes to IH personnel. To date almost 100 Indian Head employees have taken roughly 160 graduate courses at College Park. Although these courses are all at College Park campus, they will within the year be offered as a specialized distance learning program designed for the IH workforce. This will happen as a part of a larger effort to offer a more varied graduate program which will include distance learning, courses on campus and some specialized courses at IH. Two full time students have been supported by IH to pursue doctoral degrees in MEMS and twin screw mixing, with one having just received his PhD under the CECD.

Research and graduate education is central to the mission of the partnership. It is envisaged that this relationship will eventually result in the establishment of a technology center for the development of energetics products in virtual environments. Currently a major shortcoming in the incorporation of new energetic materials into systems have been the time it takes to move ideas from research into the fleet being of the order of 20 to 30 years. This "cycle time" is out of sync with system development timelines which are typically 7-10 years. This center will use virtual environments to reduce the "time to market" for energetic systems by prototyping and iterating in virtual space. But perhaps the most important result of establishing CECD and achieving this mission will be a sense of revitalization and excitement in the technical workforce at NSWCIHD.

Conclusions

The three examples highlighted in this paper demonstrate that we have the national infrastructure in place to ensure our Navy's Warfare Center S&T workforce is up to the challenges of tomorrow. During the next ten years, a new generation of scientists and engineers must be employed by DoN to work together with the next generation of Naval Officers facing responsibilities within a changing S&T environment in this nation. This new generation of S&T experts will be empowered to address complex high technology and human interaction issues using new design approaches with the aid of advanced computing environments, virtual presence, and computational intelligence as well as knowledge-based engineering.[15]

The new breed of future S&Es will be networked to one another through the building blocks of virtual consortiums. They will quickly respond to challenges through virtual networks of laboratory and modeling teams with the new tools of the web. They will be educated and continually retrained through resources made available through the virtual e-classroom.[10-15] This revitalized S&T workforce will be absolutely essential to meeting the future challenges and retaining our preeminence. But we must start today.

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