AC 2008-1420: NAVAL RESEARCH, MENTORING AND EDUCATION -- FACULTY RESEARCH AND INTERN PROGRAMS AT THE NAVAL SURFACE WARFARE CENTER, CARDEROCK DIVISION

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Naval Research, Mentoring and Education -- Faculty Research and Intern Programs at the Naval Surface Warfare Center, Carderock Division

Introduction

The Carderock Division of the Naval Surface Warfare Center (NSWC), headquartered in West Bethesda, Maryland, exists as the navy's full-spectrum laboratory for surface and undersea vehicle hull, mechanical, and electrical (HM&E) systems propulsors and logistics under the Naval Sea Surface Command (NAVSEA). The term full-spectrum means performing long-term basic and applied research, development through test and evaluation, fleet support, and in-service engineering. NSWC Carderock also has the unique mission within the Warfare Centers of supporting the Maritime Administration and maritime industry as some of our capabilities in HM&E systems has commonality with commercial marine systems. To fulfill our mission of technology stewardship and enabling the smooth incorporation of the appropriate scientific and technical innovations to the fleet, we need to continuously renew our scientific and engineering expertise and reach out to emerging knowledge in academia and industry. In today's climate of strong competition for resources and shifting priorities, predicting areas to hire and emphasize is a tricky business. A dynamic intern program is a great aid to these goals.

The Carderock Division strategically uses the visiting faculty and intern program sponsored by the Office of Naval Research to achieve these goals. Furthermore, our approach is to involve the interns in ongoing projects supported by the Office of Naval Research (ONR) or other Navy Sponsors for research, acquisition or fleet support (generally this means NAVSEA and the Program Executive Offices) that explicitly includes mentoring of the student interns by scientists and engineers from within the Division.

The Office of Naval Research started the Naval Research Enterprise Intern Program in the summer of 2002. The programmatic details can be found at the website of the American Society for Engineering Education (http://www.asee.org/). The rationale for the program was two-fold: to encourage and stimulate the brightest scientific and engineering students in the nation to pursue careers in areas that could benefit the military and specifically the Navy and invigorate research at the Naval Warfare Centers and Laboratories. At the time, management at both ONR and the laboratories were grappling with both problems and the NREIP program was conceived by then Chief of Naval Research RADM Jay Cohen as part of the plan to address both issues. Although from the laboratory point of view, hiring of young professionals into Navy labs was part of the strategy; this is not explicitly a goal of the program. Some effort is made to point out to the students that R&D of value to the Nation and the Navy is performed in many arenas such as academia, small and large companies, and in government-owned laboratories. Wherever the students go in their careers, the intern experience should seed and nurture the capabilities needed for defense research. The program is open to both undergraduates (with sophomore status or higher) and graduate students.

In 2007, 1594 students applied to the program nationally with internship offers being made and accepted for 194 positions (a 12% acceptance rate). Since the program's inception in 2002, the Carderock Division has hosted a total of 272 interns for the 10-week summer internships. We have record of 26 being hired into positions within the US Navy. (The majority of hires work

in our Carderock Division but some are at Naval Shipyards and other labs). Table 1 shows the statistics of the total number of interns who applied to the program nationally, those graduate and undergraduate applicants who chose the Carderock Division as their first choice, the number of undergraduates who chose Carderock as their first choice, and the final number of interns who actually performed their internship at Carderock.

The Carderock Division's major areas of work center on the mission of Hull, Mechanical and Electrical systems, which translates to all Ship's Systems excluding weapon systems. The Technical Departments at Carderock are aligned to the NAVSEA commands that bear the responsibility of acquisition and stewardship of these systems.[1] In order to better integrate and define our work within the Warfare Center system, we have organized the technical areas into 7 Core Equities. These are:

- Ship Integration & Design - *Naval Architecture, systems engineering and analysis*
- Hull Forms & Propulsors – *Hydrodynamics and Hydromechanics,*
- Machinery Systems & Components – *All shipboard electrical and mechanical systems*
- Structures & Materials – *Structural Analysis, metallic and non-metallic materials, smart materials*
- Environmental Quality Systems – *wastewater systems, shipboard solid waste systems*
- Vulnerability & Survivability Systems – *ship vulnerability assessments, shock*
- Signature & Silencing Systems – *acoustics, electromagnetic and magnetic signatures*

We place interns in projects involving all the Core Equities, but certainly placement into the Core Equities is not uniform. Two factors that effect the placement of interns into the Core equities is the amount of Basic and Applied Research performed in the area and the training level needed for the individual projects in a particular area. A larger cross section of the academic science, technology, engineering, and mathematics (STEM) fields are represented among the applicants. Certainly the hard sciences are mostly where we recruit for our laboratory. The most represented fields are mechanical and aerospace engineering. These disciplines can be found in every Department and technical area. For example, the Hydromechanics Department is the main user of Aerospace Engineering students as those skills translate easily to the needs of that Department's work. The most diverse Core Equity is Structures and Materials that uses materials science, chemical engineering, physics and chemistry, math. Two areas of note are the Environmental Quality systems which, together with some of the related materials area, have been successful in bringing in biology students. The other is our Machinery Department, which is located in Philadelphia on the site of the former Navy Yard. They are a strong source of projects for electrical engineering students due to the strong push in the Navy for all-electric ship propulsion and auxiliary systems. In Philadelphia, some interns get the distinct experience of working on engineering problems that are of direct impact to the fleet today which is very rewarding to see the work have immediate application.

The Carderock Division is headquartered in West Bethesda, Maryland but has detachments and facilities across the country. The Naval Ship Systems Engineering Station in Philadelphia is the largest detachment and is approximately equal in size to the West Bethesda headquarters. Interns can work in any of the detachments and we have had interns as far away as our

acoustics signatures site in Bayview in the panhandle of Idaho. We have had interns who spend most of their time in the field.

The Center for Innovation and Ship Design

The Center for Innovation in Ship Design (CISD) is a chartered organization located at the West Bethesda site of the Naval Surface Warfare Center, Carderock Division. The charter was signed in 2002 by the heads of the Office of Naval Research, the Naval Sea Systems Command's Ship Design, Integration and Engineering Directorate (SEA05), and the Naval Surface Warfare Center establishing the CISD as part of the ONR's National Naval Responsibility for Naval Engineering (NNR-NE) initiative. Its mission is defined to "ensure the future capability (people, tools and knowledge) of the nation to develop innovative ship designs to effectively meet defense needs". This is broken out into several elements including:

- Revitalize and sustain Naval Engineering education in the US by supporting ONR's implementation of the National Naval Responsibility for Naval Engineering.
- Develop ship designers that create innovative designs to affordably meet national defense capabilities. This implies both developing the naval designer community and also ensuring that sufficient numbers of the community are inspired to pursue a career within the Department of the Navy.
- Revitalize and sustain the technology base to support naval engineering education and innovative ship, surface/sub-surface unmanned vehicle and submarine design.

The CISD activities in support of these tasks are focused on the concept of the Innovation Cell. An Innovation Cell team is typically comprised of 2-4 multidisciplinary undergraduate and/or graduate student interns focused on exploring innovative ship designs and techniques. Generally, teams are tasked with developing concepts or solutions to real-world current or perceived military requirements for which there is no suitable current or planned solution and for which the act of design or research will provide a unique educational opportunity for innovative design. The instruction for the students is that their task is to develop a concept, provide a design, or perform analyses that will show sufficient promise for the US Navy to develop further.

While the CISD accepts candidates studying a variety of engineering and scientific disciplines, interns assigned to CISD innovation cell teams are generally 50% to 75% through an undergraduate degree in a mechanical, aerospace, or naval engineering-based curriculum. They have usually undertaken a general engineering design course and the foundation classes in their main engineering discipline. Most students do not have specific military or naval content to their degree and about 50% have been exposed to some marine, offshore or naval architecture courses. For most students the innovation cell is their first independent design experience.

Topics for Innovation Cell projects come from a variety of sources, but they all have a common element: they are real-world US Navy problems that provide unique technical challenges and include multifaceted operational implications. One particular area that has proven to be a fertile ground for developing projects for interns to tackle is the Navy's Seabasing concept of operation. Seabasing is a loosely defined term that refers to a collection

of ships at sea conducting operations that enable forces to operate ashore without a large logistics footprint. Such an operation may require a wide variety of ships to transfer cargo such as pallets, containers, and vehicles to one another under sometimes-severe weather and environmental conditions. Illustrations from example CISD projects are shown in Figure 1.

Seabasing projects are excellent topics for Innovation Cell work because they provide a unique operational construct for design education in which many high priority challenges remain unresolved and innovative solutions can be advanced. Since February 2003, the CISD has been working to identify the challenges of seabasing in many areas to help narrow the focus of this broad subject area. Teams have concentrated on interface issues between a sea base and the supply and delivery vehicles, particularly whole ship concepts, material transfer in high sea states, and ship-to-shore cargo delivery systems.

A successful student project is measured by its innovativeness and acceptance throughout a wide audience. Some projects garner additional ONR funding to pursue further development of the concept. Some projects follow the students back to their academic institutions where they become the topics for senior design projects, while some inspire the student's faculty to initiate grant proposals in key research areas that support the concept. In the past several years, three concepts developed by student interns - the Intermediate Transfer Station (ITS), Deep Water Stable Crane Ship, Sea Base Hub, and the Transformable Craft - have all been selected for further concept development.

Besides participating in innovation cell projects, we also provide other learning experiences for CISD interns to get them better familiar with the various missions of the Navy Warfare Centers. We take all the students for a 2-day "meet the fleet" trip to the Norfolk Navy Base where they can go aboard different class ships, talk to the sailors and officers manning the ships, and witness first-hand life aboard ship. We also take them on a 1-day trip to our SSES Detachment in Philadelphia and a 1-day trip to the Combatant Craft Detachment at Little Creek, VA. To learn more about the various projects and technical research being conducted by Carderock scientists and engineers, weekly brown bag presentations and discussions are also conducted. All these activities, combined with their cell projects, leads to a full spectrum experience for the students.

Since its inception, the CISD has hosted over 150 personnel including 105 undergraduate and graduate student interns, 26 United Kingdom (UK) exchange students, a handful of summer faculty, industry, newly hired employees and personnel from other government agency. Of the student intern alumni, nearly 75% have graduated and gone on to careers in naval engineering within Carderock, other naval organizations, and industries supporting naval ship design.

The CISD will continue to exploit seabasing, as well as other Navy concepts of operations, as an educational tool for developing the next generation of naval engineers. Innovation cells that tackle real-world Navy problems provide excellent challenges for students that allow them freedom to innovate, to increase their design knowledge, and inspire them into a future naval design career.

The Intern Program and the In-House Basic and Applied Research Programs

Approximately one-third of the interns in any given year are working on projects related to the Carderock Division's In-house Laboratory Independent Research (ILIR) and Independent Applied Research (IAR) Programs. These two programs are funded at the Navy labs by the Office of Naval Research for research within the mission area of each laboratory or Center. The ILIR is Basic Research (RDT&E Budget Activity 1) and the IAR is Applied Research (Budget Activity 2) research.[2] These programs are well suited to intern projects as each principal investigator drives the research with a view towards high-quality science and transitioning new technologies and systems into the fleet. Many of the investigators plan intern projects into their research and interns are frequently co-authors of publications and patent disclosures. Almost all of the research projects have significant external collaboration with academia or industry and the academic collaborators area a natural source of potential interns. These internship opportunities span almost all disciplines of fundamental and applied science within our mission area. Table 2 lists some of the areas of intern projects in ILIR and IAR over the 5 years of the program, not including those under the auspices of the Center for Innovation and Ship Design.

We have a small but critical program bringing academic researchers to NSWC Carderock through the Office of Naval Research's Summer Faculty Research Program.[3] Historically, these faculty members number about 10-15 per year with roughly half in our Philadelphia Machinery R&D detachment and half in our West Bethesda headquarters. We do not try to couple the visiting faculty directly with the ONR Intern program, but a number of faculty have brought students to work with them and we have had several hires of former students from relationships established through the visiting faculty program.

We have instituted a bi-weekly brown-bag lunch colloquium for the interns. Each year we have some of the visiting faculty give a presentation at this forum and we try to balance presentations by external guests and internal researchers to maximize the exposure of the interns to dynamic speakers. Several other social events are planned primarily a picnic for all the interns, visiting faculty, and high-school students who are at our laboratory through the ONR Science and Engineering Apprenticeship Program. A number of other events, such as lunchtime ice cream socials, are put on by the laboratory Employee's Services Association, to which the interns are invited to participate. In 2007, we expanded participation in our picnic to the local Women in Science and Engineering (WISE) chapter which beneficial to the organizations and the interns. Every other year the Carderock Division hosts the International Human-powered Submarine Races at our David Taylor Model Basin at our West Bethesda headquarters.[4] This is a competition; primarily with engineering students from colleges and universities (but with some high-school participation) that is an excellent challenge in Naval Architecture, design, mechanical engineering and even computer data acquisition. We have had interns who participated in this contest as a team member and, at least in once case, went on to become our employee and become a junior investigator in our Independent Applied Research Program.

Conclusions – Issues and Challenges

In the present day environment of constrained resources, the most effective way to grow a vibrant program is to exploit the synergies between diverse areas and people. This integrative approach ("leveraging") is often cited, explicitly or implicitly, purely in terms of finances. ("I don't have enough money to do my program, so I better go out and see where I can find someone to help"). An integrative approach has other values that may not be immediately apparent, but are ultimately of more sustaining value.

Almost any problem of importance on which we work requires pulling together knowledge and people from many diverse backgrounds and experience. This type of collaboration has been recognized to be needed in all areas of science for some time but especially important in R&D for Navy technologies. The hierarchies that we have developed, through human nature and the necessity for specialization, have led to "stovepiping" of work and responsibilities. The challenge is to create an environment that promotes innovation and collaboration while performing our mission to the Navy and the nation. The value of leveraging programs is that it is more inclusive of people and promotes a stimulating environment where contributions can grow out of the collaborations. For example, we have interns, working entirely on fundamental research in materials science, who are exposed to naval engineering disciplines for the first time through the students in the Center for Innovation and Ship Design. Students in the fields of Naval Architecture and marine engineering, microbiology, electrical engineering and physics are not often thrown together in the same environment. Perhaps more importantly, they get to experience the scientists and engineers of our Center working on the same team and for common goals. That experience is what we believe the interns are taking with them back as they move on in their education and careers.

Acknowledgments

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1. More information on the technical capabilities of the Carderock Division of the Naval Surface Warfare Center can be found at: http://www.dt.navy.mil.
2. Definitions of the various RDT&E budget categories and the type of work performed in each can be found at: http://www.js.pentagon.mil/descriptivesum/.
3. Information on the ONR summer faculty program is at: http://www.asee.org/summer/.
4. The website of the International Submarine Race is at: http://www.isrsubrace.org/.

	2002	*2003*	*2004*	*2005*	*2006*	*2007*
Total Applications	--	1,565	1,493	985	1353	1594
NSWCCD First Choice	131	147	195	168	110	189
NSWCCD Undergrad First Choice	73	135	190	156	93	139
NREIP placed at Carderock	26	53	45	46	49	53

Table 1. Statistics of total number of applicants nationwide, those who indicated NSWCCD as a first choice (total number and undergraduate only, and the number that were placed at NSWC Carderock Division.

• Shipboard Power Systems	**• Machinery Information & Control Systems**
• Logistics for HM&E Systems	**• Fire Protection**
• Advanced Batteries & Power Sources	**• Coatings & Corrosion**
• Ship Structures & Survivability	**• Propulsors and Propulsion**
• Shipboard Environmental Quality	**• Gas Turbines**
• Magnetostrictive Materials/ Smart Materials	**• Modeling & Simulation**
• Ship Signatures	**• Polymers and Coatings**
• Computational Fluid Dynamics	**• Ceramic Materials**
• Resistance & Powering	**• Unmanned Vehicles**
• Maneuvering & Control, Seakeeping	**• Metals, welding**
• Composites	

Table 2. A sample of intern research topic areas not including those in the Center for Innovation and Ship Design

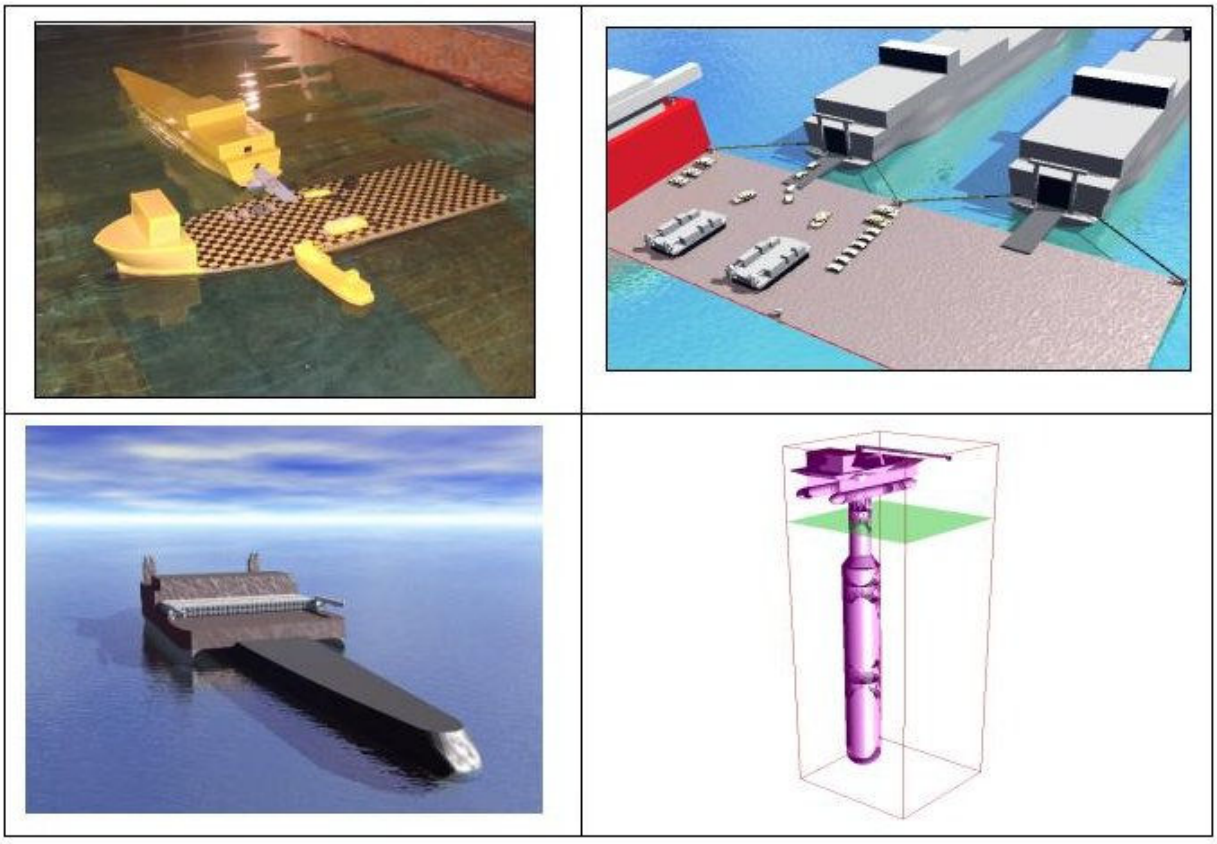

Figure 1. Examples of 4 projects from the Center for Innovation and Ship Design. Clockwise from the upper left they are: (1) Intermediate Transfer Station (ITS) testing in Carderock's 140' Basin, (2) Sea Base ships conducting stern off-load onto Intermediate Transfer Station (ITS) Concept, (3) Deep Water Stable Crane (DWSC) Concept using spar technology, (4) Sea Base to Treeline Connector Concept.