Review of the Naval Sea Systems Command (NAVSEA) Draft Memorandum: NAVSEA's 21st Century Engagement, Education, and Technology Initiative

DETAILS

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Committee to Review the Naval Sea Systems Command (NAVSEA) Draft Memorandum, "NAVSEA's 21st Century Engagement, Education, and Technology Initiative"

Board on Higher Education and Workforce

Policy and Global Affairs

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

May 30, 2008

Mr. John H. James, Jr.
Naval Sea Systems Command
1333 Isaac Hull Ave., SE
Washington Navy Yard, DC 20376-1080

Dear Mr. James:

In 2007, an ad hoc committee of the National Academies released a report entitled, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* That report concluded that "the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength."[1] The report identified a series of challenges to competitiveness and four areas of recommendations for the nation to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st Century.

The Naval Sea Systems Command (NAVSEA), the largest of the Navy's five systems commands, "maintains the current Navy, acquires the next Navy and designs the Navy after next. Accounting for nearly one-fifth of the Navy's budget, NAVSEA manages more than 150 acquisition programs and has 33 activities in 16 states. With a force of 53,000 civilian, military and contract support personnel, NAVSEA engineers, builds, buys and maintains the Navy's ships and submarines and their combat systems."[2] NAVSEA employs scientists and engineers in a variety of fields: electrical engineering, mechanical engineering, engineering technology, nuclear engineering, general engineering, electronic engineering, and computer science. These professions account for 35 percent of NAVSEA's workforce.

In 2007, NAVSEA asked the National Academies to review the draft memorandum, "NAVSEA's 21st Century Engagement, Education, and Technology Initiative", which responds to the call to action set forth in the *Gathering Storm* report. The memorandum outlines NAVSEA's proposed contributions to this national effort.[3] Discussions between NAVSEA and the National Academies led to the creation of an ad hoc committee[4] tasked with commenting on the memorandum.[5] Observations and recommendations are based in large part on committee expertise and opinions, drawing on information provided by NAVSEA personnel. This report, which was reviewed according to National Academies' policies,[6] fulfills that charge.

[1] NAS/NAE/IOM. 2007. Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Washington, DC: National Academies Press, p. 3.
[2] http://www.navsea.navy.mil/
[3] A copy of the draft memorandum presented to the committee is in Appendix V.

[4] A list of committee members is presented in Appendix I.
[5] The committee's charge is detailed in Appendix II.
[6] The committee would like to thank the reviewers, who are listed in Appendix III.

SUMMARY

First, it is heartening and reassuring that NAVSEA recognizes the critical challenge of maintaining an adequate number of skilled Science, Technology, Engineering and Mathematics (STEM) professionals. NAVSEA correctly reasons that this challenge has implications for its own workforce development, and its commitment to address this challenge as it relates to its own mission is commendable.

The committee recognizes that the program outlined in the draft memorandum is an early attempt to lay out a comprehensive solution for NAVSEA in the context of existing efforts there and in the Navy more broadly. The focus of the proposed activities should be on fulfilling NAVSEA's needs, drawing on its unique resources. Our review is offered in the spirit of strengthening and enhancing NAVSEA's potential contributions. The committee's review is summarized in the following four points:

- The committee was unclear in reviewing the memorandum as to what problem NAVSEA was trying to address. The committee assumed that the issue revolved around maintaining a highly qualified and diverse workforce. NAVSEA should clearly lay out its objectives for the proposed program. This would both enable a better understanding of the program and serve as a basis for establishing metrics by which achievement of program objectives can be measured.

- The concept of a long-term program with three ongoing phases (plant, nurture, and produce) demonstrates NAVSEA's understanding that this type of initiative requires both a long-term perspective to achieve sustaining results and a focus on engaging students at different age groups. There is the implication, however, that these phases are distinct and that we must wait until 2015-2018 to produce the desired results. The Committee urges a more dynamic and iterative relationship between the three phases proposed. Further the committee recommends that NAVSEA carefully consider how wide a scope it can adequately address, given the available resources and the amount that would be needed to target different age groups.

- The draft memorandum contains a wide range of initiatives, and probably too many to be effectively managed to the desired results. Several initiatives (e.g., NAVLAB) are not described in sufficient detail to evaluate them effectively or their potential for successful implementation. In other instances (e.g., basic research), it is not clear that NAVSEA is best positioned to oversee the effort.

- The committee believes that NAVSEA should concentrate its efforts where it can best leverage its existing resources and its broad geographic presence. To this end, NAVSEA would be well served to make a robust competitive scholarship program and an intern and summer work initiative the centerpieces of its program. NAVSEA should focus on programs where it has unique value added. It should not "reinvent the wheel," but rather do what it does best to meet its needs and consider partnering with other branches, services, federal agencies, or professional societies to enhance currently beneficial programs.

- The committee agrees with NAVSEA's view that a diverse workforce is important to its future and commends the efforts that it has taken thus far to engage the minority community. With that in mind, the report has a very strong emphasis on the role of Historically Black Colleges and Universities (HBCUs) and has only fleeting reference to the potential of women and Hispanics and other people of color to its future workforce. While the draft memorandum lays out a very broad program, the execution plan it describes is narrowly focused on HBCUs. While this is a good start, NAVSEA should decide where it wants to take this program and what resources it will need to make it sustainable.

- In the K-12 area, the committee recommends that NAVSEA undertake further research on how to engage effectively in this important but very broad arena. There are a number of existing successful programs in the Department of Defense (DOD) and in the private sector that should be examined.

PRIMARY RECOMMENDATIONS

1. NAVSEA should more clearly identify the problems that these initiatives were designed to address, with particular emphasis on using this information to measure the success of the activities.

Specifying the problems would both enable a better understanding of the programs and serve as a basis for establishing metrics by which achievement of program objectives can be measured. This is the most important, first step in refining the memorandum.

NAVSEA's S&E personnel needs relate to a variety of factors, including existing vacancies, future retirements, efforts to increase the diversity of personnel, increasing skills needs, need for security-cleared workers, downsizing, hiring authorizations, and competition from the private sector (including the issue of competitive salaries).[7] Without more information on which of these areas constitute NAVSEA's primary concerns, the committee could not determine with any specificity what actions might be the most effective. This is an important issue not directly addressed in the memorandum. NAVSEA should clarify the nature of its demand for S&E personnel (e.g., its personnel and skills needs) in relation to the supply of S&E personnel (e.g., number of degrees awarded and availability of individuals with appropriate skills).

Appendix IV provides some data which may be useful to NAVSEA in exploring these issues: the number of S&E personnel and new hires in Navy laboratories (Figures IV.1 and IV.2), the number of graduate students in science and in engineering (Figure IV.3), the number of graduate

[7] One area where NAVSEA may face a substantively different challenge than for the United States at large is in the need for personnel who are U.S. citizens. Richard Freeman writes: "U.S. agencies that hire citizen S&E talent only will have increasing difficulty maintaining top-flight workforces. With a smaller U.S. share in the global supply of science and engineering talent, any policy that restricts agencies involved in R&D and national security issues to U.S. citizens risks lowering the productivity of those agencies relative to what it would be if, like the major multinationals, they globally searched for the best candidates for jobs." Richard Freeman, Globalization of the Scientific/Engineering Workforce and National Security, pp. 81-89, in Titus Galuma and James Hosek, Perspectives on U.S. Competitiveness in Science and Technology, Santa Monica, CA: RAND Corp., 2007, CF-325-OSD.

students by individual engineering field (Table IV.1), and the number of all S&E graduate students who are U.S. citizens (Figure IV.4). Figures IV.5 and IV.6 describe the employment sector of S&E degree holders in general and of doctoral degree recipients specifically. While these data provide interesting background, more information is needed to identify where there are particular imbalances between supply and demand for NAVSEA S&E personnel.

2. NAVSEA should attempt the three phases (plant, nurture, and produce) of its program simultaneously.

Initially, there was some confusion as to whether the draft memorandum described the evolution of the proposed NAVSEA activity (e.g., "plant" would refer to the early years of the activity) or whether it referred to three phases of activity related to the ages (or the stages of development) of the individuals to be targeted. In conversations with NAVSEA personnel it became clear that it is the latter. In the memorandum, it would help to directly state that NAVSEA will initiate activities at each of the three phases (levels) in year one. The initiative may be described as an "incremental effort," but it has activities that can result in NAVSEA hires in the near term (e.g. graduate fellowships) and not just ten years out. Navy leadership will be more interested in this approach because it is known to want results in the near term and will look for progress each year in order to sustain the needed funding. In addition, NAVSEA should consider enunciating how resources will be divided among these three phases and how this, in turn, will influence the scope of the activities to be undertaken during each phase.

3. NAVSEA should work more with other Navy programs and other services to identify lessons learned in order to improve the chances that its activities will be successful and will not needlessly duplicate other efforts.

NAVSEA already has some programs in place, as noted in the draft memorandum. Additionally, it participates in programs with other parts of the Navy. Examples include the joint NAVSEA/ONR National Naval Responsibility for Naval Engineering (NNRNE) program[8] and the SeaPerch program[9], the latter of which provides hands-on underwater robotics experiences for K-12 students and has been largely supported by NAVSEA and ONR.[10] Similarly, the Human Powered Submarine (HPS) races for high school and college students, held every other year at the NSWC-Carderock, already involve close Navy interaction.

There are also existing programs in the other services (e.g., in the Army lab community), in other federal agencies and departments, and in the private sector that could be mined for lessons learned. It may be possible to link to some of these programs as well. The committee had some concern that NAVSEA work to build efficiencies across the DOD. Of course, it, may implement an idea done elsewhere, if its target population is not being reached. NAVSEA might want to begin to think now about how its programs, if proven successful, might be scaled up, as well as how they might articulate with similar efforts. For instance, it might very well be that the plant and nurture phases can be articulated with other efforts and pathways so that participants could be channeled into multiple pathways.

[8] http://www.nnrne.com/Main_History.htm
[9] http://web.mit.edu/seagrant/edu/seaperch/
[10] http://www.coe.drexel.edu/seaperch/overview/index.php

4. NAVSEA should focus on a few initiatives.

Several of the activities sound like very interesting and good ideas. For example, the Carrier, Ship and Sub Camps are excellent ideas, and we encourage moving forward soon in defining how they would operate, where they would be located, how they would be funded, etc. The camps have the potential to both impart STEM skill experience and facilitate student interaction directly with NAVSEA personnel. NAVSEA might draw lessons from the National Aeronautics and Space Administration's (NASA) Space Camps as one successful model.

Some of the activities need further development. In particular, the NAVLAB is an area where further details would be essential to understand the potential for NAVSEA to engage in this type of enterprise. Based on the information presented in the memorandum the committee questions the viability of a NAVSEA-managed laboratory at an educational institution.[11] There are numerous regulatory and conflict issues which need to be addressed before this concept should be considered.

Several criteria can aid NAVSEA in considering how to select from among the menu of activities outlined in the draft memorandum. First, as noted in Recommendation 1, clearly specifying the problem will facilitate a prioritization of activities. An additional step is to conduct a cost/benefit analysis on each activity. For example, in the proposal to "Expand the NAVSEA potential to fund R&D at Advancing Minority Interest in Engineering (AMIE) institutions to $500M over the next 10 years," the objective should be rephrased to emphasize what is to be gained by such an investment. Evidence that AMIE institutions have the capacity to absorb that level of funding in an effective way or develop and put forth alternatives should also be included. A third step in prioritizing these initiatives is to ask whether similar programs already exist and whether it would be preferable to devote more resources to them or expand them. Finally, NAVSEA should elaborate on its unique value added in conducting the activities. Concerning the discussion of basic research, for example, it is not immediately clear that NAVSEA is best equipped to execute this program; it might be better served by leveraging the Navy's existing programs through the ONR.

5. NAVSEA should concentrate its efforts where it can best leverage its existing resources and its broad geographic presence.

Working with the local communities where NAVSEA has a large presence has more promise for two main reasons: 1) it would contribute to the community in which the current workforce lives, e.g. through summer work programs and the proposed camps at NAVSEA activities, and 2) the current NAVSEA workforce can volunteer (or be paid for) their time to work on the programs, e.g. the camps and K-12 outreach visits. Where NAVSEA has large installations there are employees with STEM careers (and others) who can talk to and mentor students from nearby schools. NAVSEA personnel can make visits and act as role models, thus encouraging students not just to gain STEM skills but to consider working for NAVSEA in the future. Also, programs like the Carrier, Ship and Sub Camps, that bring students to NAVSEA facilities once a month, will be better attended and vastly less expensive if the students involved live in the local area. There is a strong trend today for corporations to take on more community responsibility.

[11] An alternative model would be to actively recruit educational institutions willing to send their high school or undergraduate students to conduct experiments at the Navy laboratories.

Communities view large organizations such as NAVSEA like corporations, and if. NAVSEA's activities have a substantial local involvement, they can be "sold" as asserting strong community responsibility. Current NAVSEA employees will also find it rewarding to see their community benefit from such programs. Overall, NAVSEA has a wonderful opportunity to connect to and contribute to local communities through some of its initiatives.

6. NAVSEA should expand the scholarship component.

The committee thought very highly of the scholarship component of the initiatives. NAVSEA should consider sponsoring more than 80 undergraduate and graduate scholarships over 10 years. The awards should be competitive. At least some fellowships and scholarships should be targeted towards women and underrepresented minorities; all should be targeted to U.S. citizens. Finally, fellowships and scholarships should include an internship at a NAVSEA facility,[12] which can be an additional way to connect to the local community. Internships need to be carefully managed. Interns need to be given challenging assignments consistent with their level of education, lest they lose interest.

The memorandum mentions a number of existing exchange and intern programs, including the Undergraduate Training Assistance Program (UTAP), the Naval Research Enterprise Intern Program (NREIP), and the Undersea Research Scholar Program. Additional programs are the National Defense Science and Engineering Graduate (NDSEG) Fellowships program, which gave over 60 ONR sponsored awards in 2007[13], the Science and Engineering Apprentice Program (SEAP) funding eight-week internships for high school students at a handful of DOD laboratories (including six Naval Surface or Undersea Warfare Centers)[14], SMART fellowships[15], the ONR Summer Faculty Leave/Sabbatical Leave program[16], and the HBCU Future Engineering Faculty Fellowship Program,[17] and the Krell fellowships at the Department of Energy (DOE), which require internship work at a DOE laboratory and include annual conferences for awardees.[18] In addition, the Navy itself has several internship/fellowship programs targeting minorities, high school, college, and graduate students, and faculty.

NAVSEA should carefully consider whether to create new internship programs rather than expand existing ones. In either case, it can draw lessons from existing programs in the Navy as well as other external programs.

7. NAVSEA should broaden its diversity focus to include women and Hispanics.

The committee is in agreement with NAVSEA's view that a diverse workforce is important to its future, and that it should focus its efforts where it has the best chance of finding its future workforce. NAVSEA's current work with HBCUs is to be complemented; these programs seem to be quite effective. At the same time, it is very good to build upon organizations and programs that have a proven track record, and NAVSEA could and should go further. While the report makes a

[12] Given the high cost of education, paid internships are preferred.
[13] https://www.asee.org/ndseg/2007awardees.cfm
[14] http://www.asee.org/seap/index.cfm
[15] http://www.asee.org/fellowships/smart/Navy-Labs.cfm
[16] http://www.asee.org/summer/
[17] http://www.onr.navy.mil/sci_tech/3t/corporate/hbec.asp
[18] http://www2.krellinst.org/csgf/index.shtml

reference to the potential of women and Hispanics for its future workforce, there is an opportunity for NAVSEA to directly address this very important segment. Both of these populations represent a huge potential pool for the STEM workforce. While the memorandum discusses a very broad program, the plan of execution seems very narrowly focused on a small part of the potential pool with its emphasis on the role of HBCUs.

Diversity is an important goal for the U. S. Navy.[19] The challenge facing the Navy is that the demographics of the student population and the future naval workforce are changing. On the one hand, the proportion of underrepresented minorities and women in the population is growing, as are their numbers in higher education. A second challenge facing the Navy is the rise in the number of foreign students seeking education in science and engineering and a reduction in the number of U.S. students in some fields in higher education. The Navy needs people who can gain security clearances—usually U.S. citizens. Underutilized sources of U.S. citizens are women (half or more of the population) and minorities, including Hispanics (fast becoming a dominant segment of the population), all of whom have low representation in STEM careers. Successfully reaching out to all these potential workers will require including, but going beyond, the HBCUs.

There are 104 HBCU institutions in the U.S. with 11 (soon to be 13) that have ABET[20] accredited engineering programs and are therefore eligible for membership in the Advancing Minorities Interest in Engineering (AMIE) program. The 11 AMIE schools, representing about three percent of all engineering schools in the country, enroll and graduate between 25 percent and 30 percent of all African Americans who receive baccalaureate degrees in engineering each year, and have begun to award a growing number of the graduate degrees awarded annually to this population. NAVSEA has appropriately elected to pilot its program where there is a critical mass of both students and programs.

By the same token, there are minority students at other institutions that NAVSEA could also target. NAVSEA could also encourage university-affiliated research centers (UARCs) to do more partnering with minority serving institutions and work with professional societies that focus on women (e.g., Society for Women in Engineering) or minorities (e.g., the National Action Council for Minorities in Engineering) to disseminate information about NAVSEA opportunities and programs.

8. In the K-12 area, NAVSEA should do further research on how to engage effectively in this important but very broad arena.

The NAVSEA authors are clearly and correctly concerned about middle and high school connections. Generating interest in STEM in K-12 education is important for the nation. The memorandum focuses on breadth, mentioning many good ideas. NAVSEA should first and foremost assess the return on investment from focusing resources on K-12 education. Many current middle or high school students will not end up working at NAVSEA. Second, should NAVSEA wish to pursue activities in this realm, it is encouraged to design one or perhaps two, focused, targeted initiatives aimed at middle and high schools, that include a component to conduct research on their effectiveness.

[19] "CNO: Diversity a Leadership Issue." Meridian, Fall/Winter 2005, p. 3.
[20] Formally known as the Accreditation Board for Engineering and Technology.

In so doing, it will be important to have a clear understanding of the context of K-12 schools and professional development. There are many ways to influence curriculum development and reform, but they require a long-term investment in collaborative efforts between scientists, mathematicians, curriculum developers, learning theorists, and teachers. Such development requires pilot and field testing of new curricula, and substantial revision of curricula based on feedback.

Concerning teacher development, there are a wide range of professional development opportunities offered for teachers. Teachers tend to select opportunities in their particular area of interest. If NAVSEA wants to reach large numbers of teachers, then a strategy that works through a state or school district is more likely to succeed. High quality professional development includes multiple components: long-term opportunities to experiment with ideas in classrooms and reflect on those experiences; materials that are aligned with standards and assessments; early and steady "buy in" by teachers; materials focused on student learning of specific content; grounding in research and clinical knowledge of teaching and learning; facilitated collaboration among teachers both within and across schools; use of existing teacher expertise to plan activities and cultivate leaders: and mechanisms for garnering support from principals. Such programs focus on good practices and provide teachers with active learning opportunities, to build teachers' content knowledge and pedagogical skills. Finally, they are intensive, sustained over time to allow for integration of new knowledge into practice, and include follow-up support.[21] Recognizing this complexity, NAVSEA should work with organizations that are knowledgeable about designing effective professional development programs so that its efforts to encourage teachers to incorporate principles, examples, etc. of interest to NAVSEA are most effective.

Any work at the K-12 level requires considerable knowledge of the current policy environment. NAVSEA might consider establishing one or two partnerships with school districts to build collaborative curriculum and professional development projects using NAVSEA expertise and infrastructure, and NAVSEA should encourage its employees to work with those young people (leave time given). FIRST is an example of a program that might be a helpful model,[22] along with examples in the DOD and private sector programs such as Project Lead the Way.[23]

[21] I.R. Weiss, & Pasley, J. D. (2006). Scaling up instructional improvement through teacher professional development: Insights from the local systemic change initiative. Research report of the Consortium for Policy Research in Education (R8-44). Philadelphia: CPRE.
[22] For a description of the FIRST program, see: http://www.usfirst.org/who/default.aspx?id=34.
[23] http://www.pltw.org/index.cfm

OTHER RECOMMENDATIONS

9. NAVSEA should explain how it plans to procure funds for its ten-year plan, given that the current anticipated funding cycle is for a period of six years.

Another issue that NAVSEA faces is that of the Program Objective Memorandum (POM) cycle and federal budgeting. In the civilian sector the first step in the funding of a new initiative is "seed money." These monies can come from several sources: discretionary in-house dollars, planning grants, or philanthropy. Government funding is far less permissive of incremental funding. It is essentially an all-or-nothing approach with no real guarantee of downstream funding. The content of the draft memorandum would be fine for a planning grant. For long-term funding, it is short on detail, leaving many unanswered questions as to the specific steps and timeframes that will be required. NAVSEA personnel have suggested that a $20M/year budget is anticipated for a six-year period. If so, the proposed ten year plan needs to match the anticipated funding profile.

10. NAVSEA should begin thinking now about defining metrics of success and measuring impact.

NAVSEA should decide early on about how it will assess whether its activities are having their desired effect. This should include defining metrics of success as well as plans to collect data and carry out a program evaluation or research throughout the projects. Such research ought to be designed to allow for continuous improvement of each stage and to generate important information for other efforts/stages. Many federal agencies and other groups conduct program evaluations and there is a wide body of literature on this topic.

11. NAVSEA should elaborate on its efforts to attract and retain qualified STEM applicants to its workforce.

The draft memorandum contains little discussion on efforts to recruit or retain NAVSEA personnel. Certainly, the two are interrelated. NAVSEA may find it easier to develop and retain a workforce that is already attracted to it. At the same time, its ability to attract S&E personnel depends in part on what it does to develop and support those employees once they are hired. Achieving the goal of being one of the top ten places to work is a formidable undertaking that cannot be accomplished through modest modifications to the work environment. NAVSEA should think carefully about what initiatives like educational opportunities for personnel.[24] That will result in an engaged workforce that is capable of the innovations needed to fulfill the NAVSEA's mission.

[24] This participation can be mutually beneficial: as noted in the memorandum, NAVSEA employees can gain valuable educational experience by connecting with universities. As a direct result of NNRNE funding, Virginia Tech (VT) transitioned their distance learning MS degree program to an entirely online delivery format (see http://www.nnrne.com). Many of VT's online students are U.S. Navy civilian employees. Under NAVSEA support, the University of Michigan created a "Summer Naval Surface Ship Design Program," targeting subjects of direct interest to civilians working with the surface fleet (see http://www.umich.edu/~snssdp/).

12. Finally, NAVSEA should note in the draft memorandum that the *Gathering Storm* report was authored by the National Academies (NA), and not the National Academy of Sciences (NAS).

Overall the committee is supportive of the general thrust of the NAVSEA initiative. We believe that the overall budget and program will be more defensible if it is more carefully focused and there is a well laid out plan to track results back to clear objectives.

Sincerely,

Marc Pelaez, Chair
Rear Admiral, U.S. Navy (Retired)

Committee to Review the Naval Sea Systems Command (NAVSEA) Draft Memorandum, "NAVSEA's 21st Century Engagement, Education, and Technology Initiative"

Appendix I

Committee to Review the Naval Sea Systems Command (NAVSEA) Draft Memorandum, "NAVSEA's 21st Century Engagement, Education, and Technology Initiative"

RADM Marc Pelaez, (USN, ret.) (Chair)

VADM William C. Bowes, (USN, ret.)

CAPT Albert Curry, (USN, ret.), United States Coast Guard

Dr. Eugene DeLoatch, Dean of the School of Engineering, Morgan State University

Dr. Anita Jones, Lawrence R. Quarles Professor of Engineering and Applied Science in the School of Engineering and Applied Science, at the University of Virginia

Dr. John Moxley III, Senior Consultant, Korn/Ferry International

Dr. Suzanne Wilson, Director, Center for the Scholarship of Teaching in the Department of Teacher Education, at Michigan State University

Study Staff

Peter Henderson, Director, Board on Higher Education and Workforce
John Sislin, Study Director
Rae Allen, Administrative Assistant
Jim McKinney, Financial Associate

Appendix II

Committee Charge

An ad hoc committee will review the draft Department of Navy memorandum, "21st Century Engagement, Education, and Technology Initiative" in light of the recent National Academies report, "Rising Above the Gathering Storm." This publicly available memorandum articulates a plan for NAVSEA to address the shortage in the Science, Technology, Engineering, and Mathematics (STEM) professional workforce that is vital to its mission success. The committee will advise on the viability and implementation of the activities proposed in the memorandum: activities to generate interest and capability in STEM in K-12 and higher education; engaging academia and industry; and efforts to improve recruiting and retention of STEM workers within NAVSEA and the Navy. The committee will prepare a brief report detailing its advice and recommendations.

Appendix III

Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

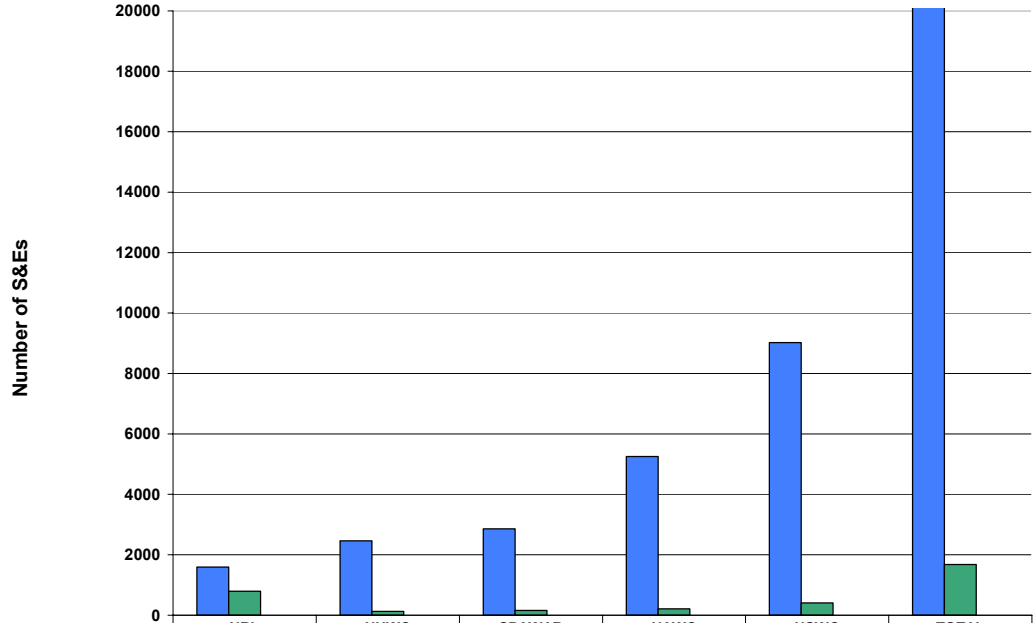
We wish to thank the following individuals for their review of this report: Beth Asch, The RAND Corporation; Charles Brown, University of Michigan; Walt Cantrell, U.S. Navy (Retired); Paul Gaffney, Monmouth College; James Johnson, Howard University; Leigh McCue, Virginia Tech; Phillip Sakimoto, University of Notre Dame; and Nancy Tippins, Valtera Corporation.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

In addition, the committee would like to thank everyone at NAVSEA who provided information to assist the committee's deliberation.

Appendix IV

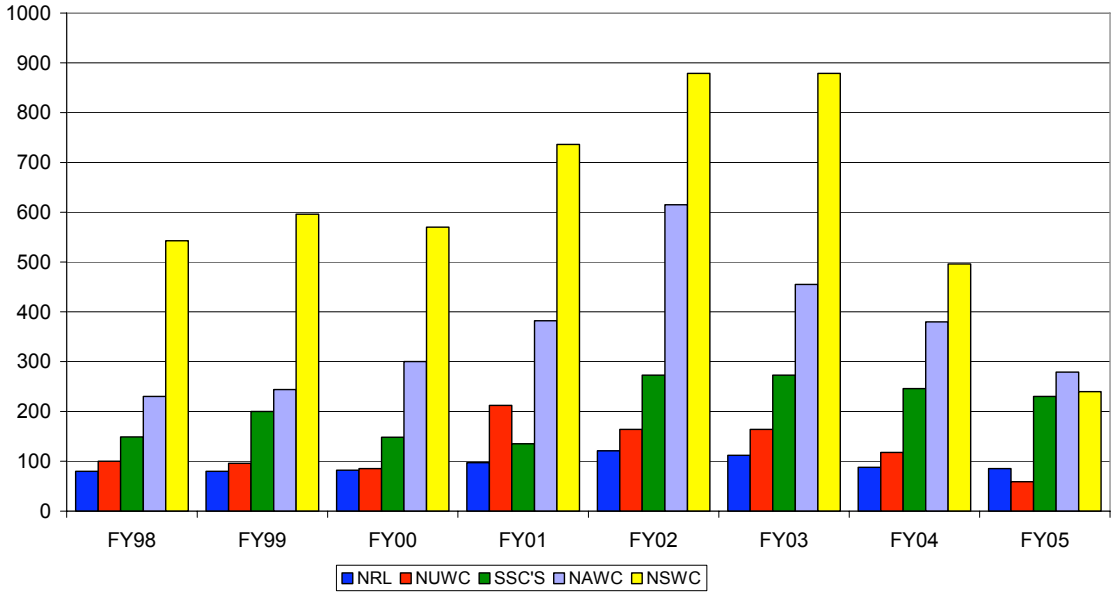
Figure IV.1 Number of Scientists and Engineers in Navy Laboratories



	NRL	NUWC	SPAWAR	NAWC	NSWC	TOTAL
Scientists/Engineers	1593	2459	2859	5252	9022	21185
PHD's	791	120	152	206	404	1673
%PhDs	50%	5%	5%	4%	4%	8%

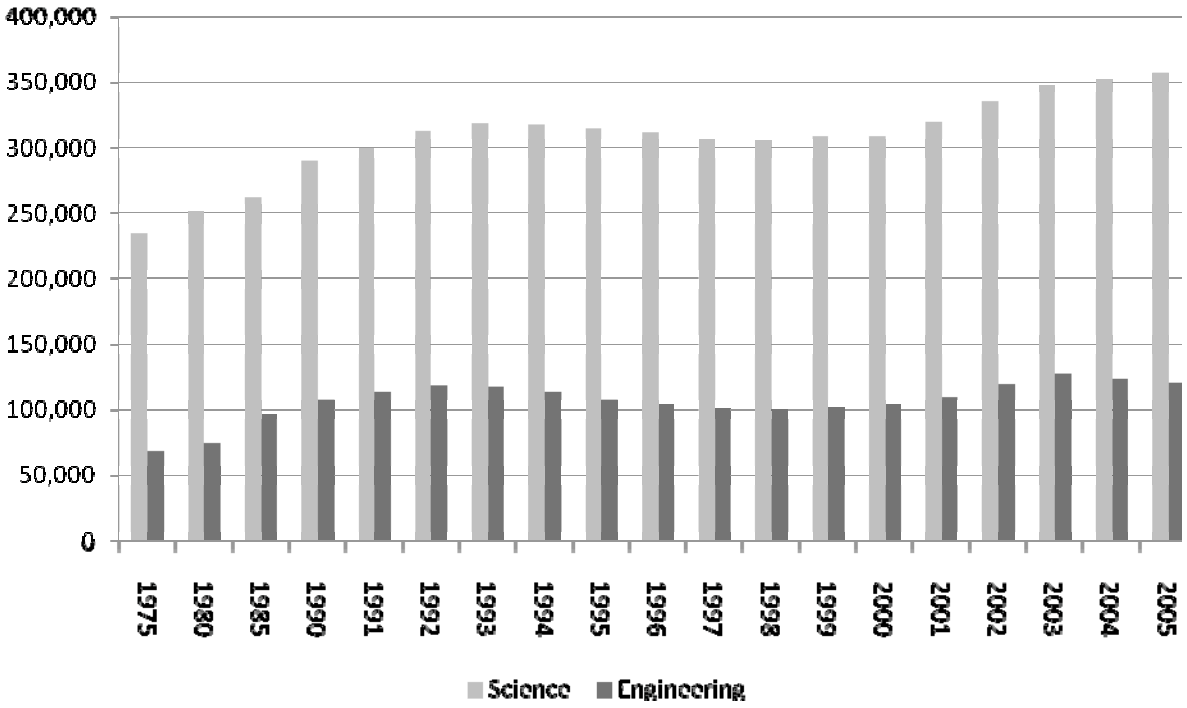
SOURCE: NSCCG 2005

Figure IV.2 New Hires of Scientists and Engineers in Navy Laboratories



SOURCE: NSCCG 2005

Figure IV.3 Number of Graduate Students in Science and Engineering in all Institutions, by Field: 1975-2005



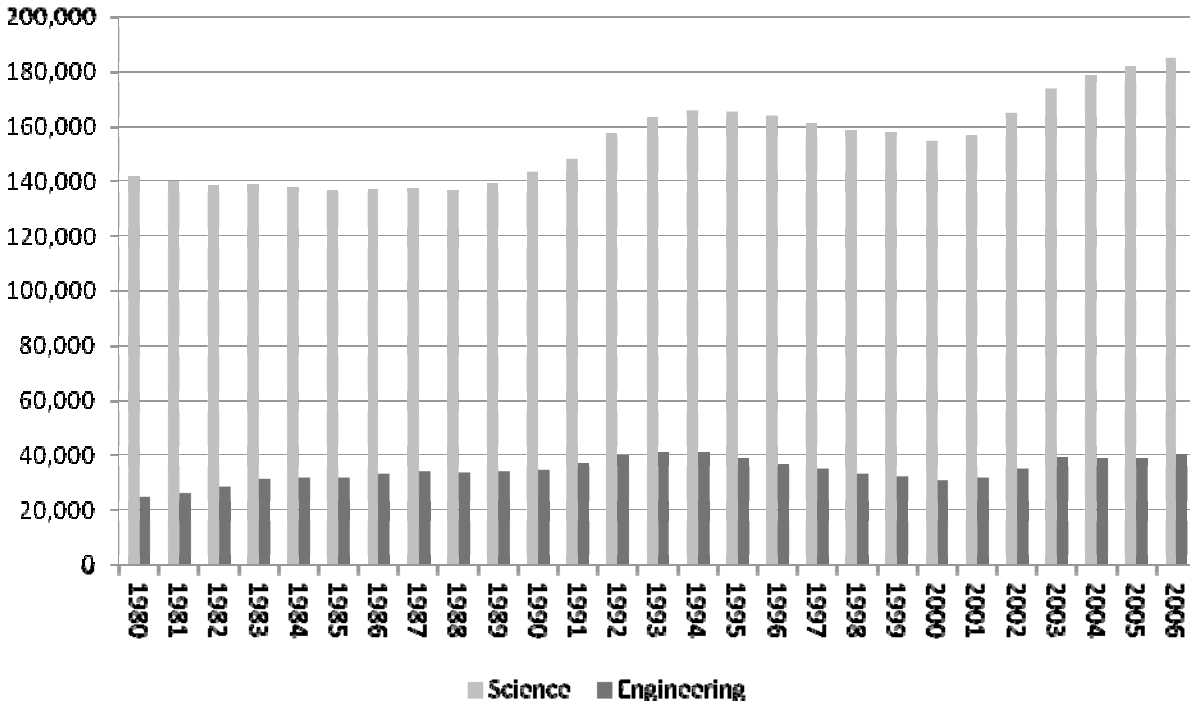
SOURCE: National Science Foundation, Division of Science Resources Statistics. 2008. Graduate Students and Postdoctorates in Science and Engineering: Fall 2006. NSF 08-306. Arlington, VA. Adapted from Table 1.

Table IV.1 Graduate Students in Engineering Fields in all Institutions by Detailed Field: 1999-2006

Field	1999	2000	2001	2002	2003	2004	2005	2006
Engineering	101,691	104,112	109,493	119,668	127,377	123,566	120,565	123,041
Aerospace engineering	3,349	3,407	3,451	3,685	4,048	4,089	4,170	4,482
Agricultural engineering	986	943	947	952	1,058	1,041	1,059	1,073
Biomedical engineering	3,069	3,197	3,599	4,338	5,301	5,807	6,067	6,482
Chemical engineering	6,883	7,056	6,913	7,414	7,516	7,452	7,173	7,261
Civil engineering	16,226	16,451	16,665	17,713	18,890	18,561	18,114	17,802
Electrical engineering	31,822	33,611	36,100	39,948	41,763	38,995	37,450	38,265
Engineering science	1,627	1,632	1,798	2,121	2,240	2,198	1,951	2,046
Industrial engineering	11,803	12,119	12,940	14,033	14,313	13,852	13,650	13,829
Mechanical engineering	14,956	15,235	15,852	17,139	18,393	17,852	17,373	17,919
Metallurgical/materials engineering	4,481	4,377	4,721	4,992	5,131	5,059	5,160	5,268
Mining engineering	328	287	240	267	278	308	279	244
Nuclear engineering	830	792	801	795	885	971	1,013	1,099
Petroleum engineering	642	627	656	766	849	845	808	813
Engineering, other	4,689	4,378	4,810	5,505	6,712	6,536	6,298	6,458

SOURCE: National Science Foundation, Division of Science Resources Statistics. 2008. Graduate Students and Postdoctorates in Science and Engineering: Fall 2006. NSF 08-306. Arlington, VA. Adapted from Table 10.

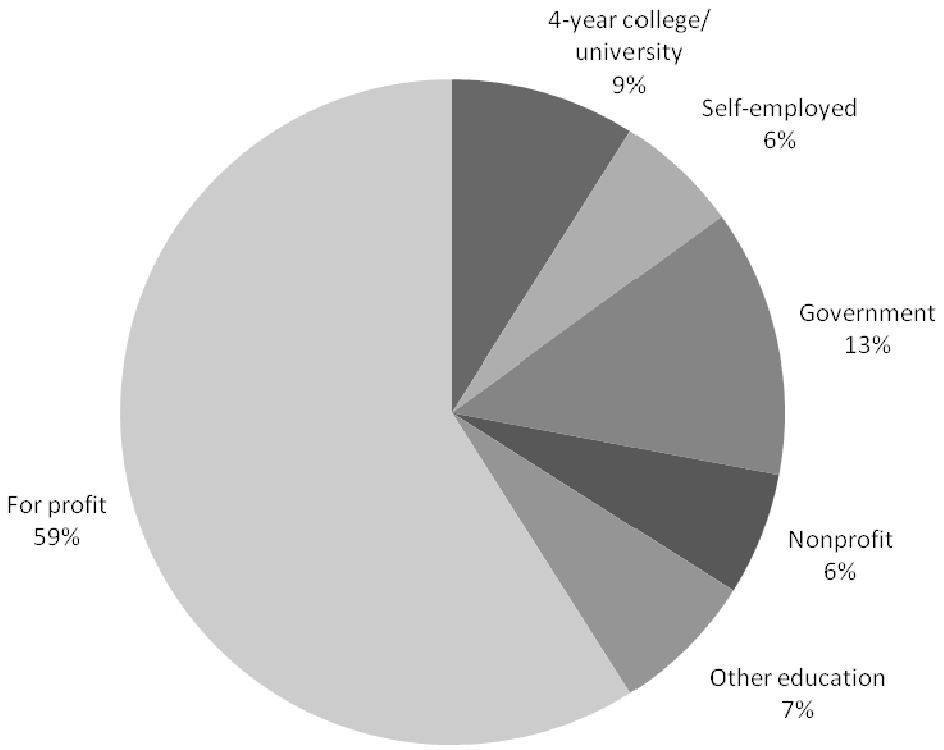
Figure IV.4 Number of S&E Graduates Who Are U.S. Citizens or Permanent Residents: 1980-2006



NOTES: Distribution by citizenship status was not requested before 1980. Figures for 1991 and earlier years do not include permanent residents.

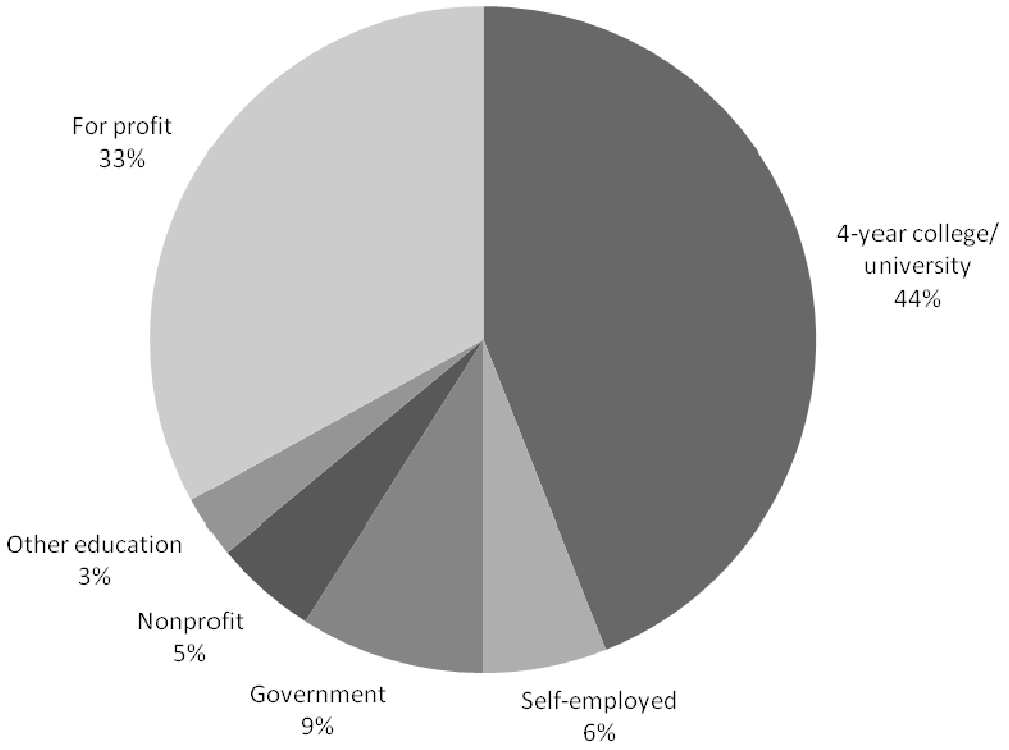
SOURCE: National Science Foundation, Division of Science Resources Statistics. 2008. Graduate Students and Postdoctorates in Science and Engineering: Fall 2006. NSF 08-306. Arlington, VA. Adapted from Table 8.

Figure IV.5 Employment Sector for All S&E Degree Holders: 2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2003, http://sestat.nsf.gov. In National Science Board. 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A), Figure 3-16.

Figure IV.6 Employment Sector for S&E Doctoral Degree Holders: 2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2003, http://sestat.nsf.gov. In National Science Board. 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A), Figure 3-16.

Appendix V

NAVSEA's 21st Century Engagement, Education, and Technology Initiative

A Response to the

National Academy of Sciences

Study Report

"Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future"

17 May 2007

NAVSEA
NAVAL SEA SYSTEMS COMMAND

DRAFT Memorandum

Table of Contents

I. Preface

This paper provides a proposed course of action to respond to the increasing shortage of Science, Technology, Engineering, and Mathematics (STEM) professionals that are necessary to ensure the national and economic security of the United States. It specifically responds to the recommendations and proposed actions developed in the National Academy of Sciences (NAS) report entitled "*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.*" (NAS Storm Report)

This paper consists of an Executive Summary, a Purpose statement, the Context, a View of the Problem, a description of NAVSEA's 21st Century Engagement, Education, and Technology Initiative, and an Implementation Plan. Additionally, Appendix A provides linkages between the NAS Recommendations/Actions and the proposed activities discussed in this paper. Appendix B provides a model for engagement with academic institutions.

II. Executive Summary

The Naval Sea Systems Command (NAVSEA) is the largest of the U.S. Navy's systems commands and accounts for approximately one-fifth of the Navy's annual budget. It employs almost 50,000 people in 310 primarily STEM-oriented occupations engaged in cutting edge technology development and implementation—from Research and Development (R&D) to real time engineering. NAVSEA's responsibilities span the systems engineering life cycle of aircraft carriers, ships, submarines, and their components. This ranges from acquisition through support to the Navy Program Executive Officers (PEOs), to in-service engineering, maintenance, and retirement. NAVSEA team members serve the Navy with four supervisors at four major shipbuilding locations across the United States, through the undersea and surface warfare centers, and at the headquarters, currently located at the Washington Navy Yard, in Washington DC. NAVSEA comprises 33 major installations in 16 different states with large population centers.

One of the great challenges confronting NAVSEA leaders and the nation, as noted in the recent NAS *Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology study*, is to provide this full spectrum of services in the twenty-first century in an environment of continual downsizing, declining Research, Development, Test, and Evaluation (RDT&E) resources, and increasing competition from the private sector for STEM human resources. Moreover,

NAVSEA recognizes that this challenge actually exists at three distinct levels: the national, the Naval Enterprise, and the NAVSEA organizational.

The national level challenge is well addressed in the NAS report entitled "*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,*" (NAS Storm Report) which offers four specific solutions based on application of resources at the national level to provide:

- Improved education in science and engineering,
- Incentives for basic research,
- Improved conditions for the conduct of research activities, and
- Improved processes for intellectual property management and protection.

However, the challenge grows more acute at the Naval Enterprise level, which comprises the entire Department of the Navy (DoN) including operating forces as well as the engineering and acquisition community. It is further exacerbated at the NAVSEA organizational level, which represents a tight focus on the specific application of STEM capabilities in RDT&E to realize the technical innovation necessary for the Navy to meet national security needs.

This paper offers an approach to implement the NAS report's recommendations—working from the bottom up. First is at the NAVSEA organizational level to iteratively prototype (and then prove) means to attract, develop, and maintain a world class STEM workforce through ongoing engagement with students and educators from middle school through post graduate school. Second is to adapt the approach as it matures in order to meet the needs of the broader Naval Enterprise. The goal here is to define higher level approaches that yield improvements in STEM capabilities development and applications throughout the DoN. Third is to adapt the approach from the Naval Enterprise level to meet the strategic, national needs identified in the NAS report.

To address the NAS recommendations, we articulate a ***"21st Century Engagement, Education, and Technology" Initiative***, which brings together a number of existing initiatives in the widely dispersed NAVSEA organization while developing a rapidly expanding infrastructure to attract short, mid-, and long-term entrants into the STEM workforce. It further engages partners with proven performance in the development of STEM capabilities in academic environments. The initiative also links the NAS recommendations with implementation of the Navy's Diversity Strategy, which will ensure the diverse world class workforce that is necessary to the design, development, and delivery of cutting edge systems for our national security.

We define developmental efforts to foster excitement and interest in STEM occupations among students, faculty, and researchers from high school through post graduate school. Specific elements of the approach include:

- Outreach by NAVSEA leadership and employees to community, university, education, and other organizations to build awareness of NAVSEA opportunities and gain insights into challenges facing the STEM community;
- Engagement with key partners in academia and industry to plant the seeds upon which success will depend;
- A Carrier, Ship, and Submarine Camp (CSSC);
- A NAVLAB to develop research facilities and support basic and applied research activities in NAVSEA and other (e.g., industry, academic, not for profit, other government agency) environments; and
- Improved facilities, opportunities for self-directed research and internal information exchange via collaborative environments.

As depicted in Figure 1, the NAVSEA's initiative comprises three stages:

- Plant,
- Nurture, and
- Produce.

Plant is the initial phase where current, independent NAVSEA activities are collated to provide a synergistic and coherent foundation upon which to build. Here, activities in NAVSEA command elements that engage with local community educational and other resources are used to define objectives and leveraging opportunities that benefit both the local community and NAVSEA. Nurture is the phase in which activity sets and infrastructure are further developed to sustain the relationships with potential candidates and academic organizations and other stakeholders who develop the STEM workforce. Produce is the phase in which STEM professionals are attracted to NAVSEA's workforce. This will result from phased implementation over the ten year spectrum in which trust and strong relationships are built.

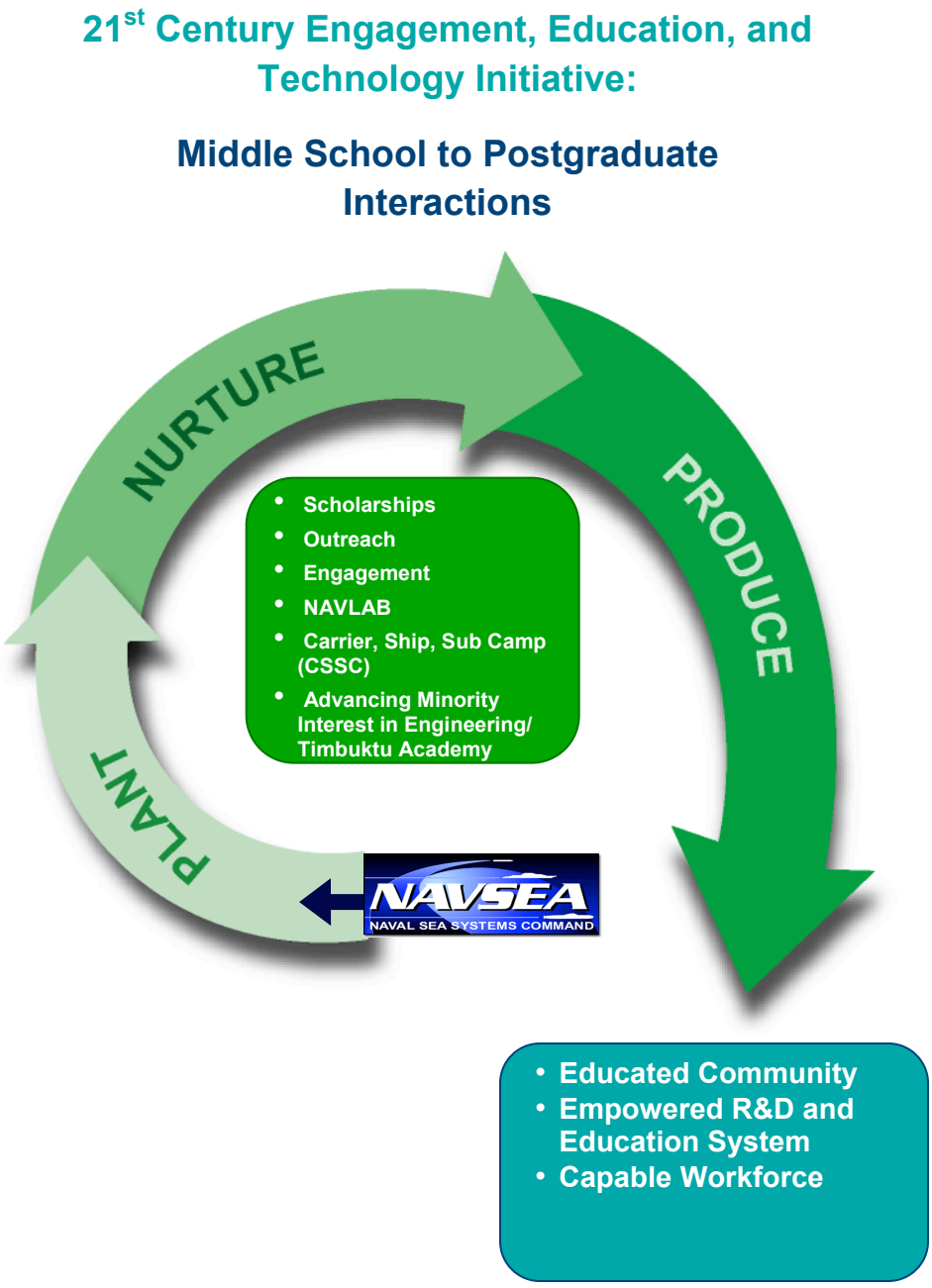


Figure 1. NAVSEA's 21st Century Engagement, Education, and Technology Initiative

NAVSEA is superbly positioned to define, refine, and adapt processes to implement the NAS report recommendations through it's:

- Geographical dispersion,
- Focus on application of STEM capabilities in RDT&E acquisition efforts,
- Size of technical staff, and
- Ability to function as an incubator and prototype for development of a diverse workforce.

These processes will be built upward throughout the Naval Enterprise, and ultimately applied at the national level.

"Science and technology have never been more essential to the defense of the nation and the health of our economy."

– President George Bush as stated in NAS Storm Report[25]

Although the US economy is doing well today, current trends … indicate that the United States may not fare as well in the future without government intervention. This nation must prepare with great urgency to preserve its strategic and economic security. Because other nations have, and probably will continue to have, the competitive advantage of a low wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring.[26]

III. Purpose

This paper describes Naval Sea Systems Command's (NAVSEA's) **"21st Century Engagement, Education, and Technology" Initiative.** It is NAVSEA's response to the recommendations and actions resulting from the recent National Academy of Sciences (NAS) *Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology study*. That study calls for a comprehensive national effort to develop the requisite Science, Technology, Engineering, and Mathematics (STEM) workforce capability to ensure U.S. strategic and economic security in a globalizing world. Specific needs identified by the study that this initiative addresses are:

- Improved education in science and engineering,

[25] NAS Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology Committee on Science, Engineering, and Public Policy, "*Rising Above The Gathering Storm Energizing and Employing America for a Brighter Economic Future*", The National Academy Of Sciences, The National Academy Of Engineering, and The Institute Of Medicine of The National Academies, 2005, ES-12

[26] Ibid., ES-2

- Incentives for basic research,
- Improved conditions for the conduct of research activities, and
- Improved processes for intellectual property management and protection.

The 21st Century Engagement, Education, and Technology Initiative links the need for STEM workforce improvement with the Navy's existing Diversity Strategy[27] at the NAVSEA organizational and Naval Enterprise levels. It also maps specific NAVSEA implementation concepts to the study recommendations and actions. Finally, NAVSEA's initiative comprises several complementary activities that provide for:

- Outreach and information exchange with the STEM educational and research communities with focus on education and teacher development,
- Targeted engagement with military and education partners to leverage existing programs and develop them,
- Leverage of basic research and technology development activities at NAVSEA facilities, and
- Improvements in quality of work life to make NAVSEA the preeminent place to conduct interesting and important work.

These activities articulate the means by which NAVSEA and the broader Naval Enterprise will achieve specific goals and objectives over a ten year time frame using an incremental development approach: "plant" (2007-2010), "nurture" (2011-2014), and "produce" (2015-2018).

IV. Context

In 2005, Congress challenged the National Academies to answer the following questions,

> "What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the

[27] The Navy Diversity Policy and Strategy is maintained on the Diversity Directorate's web site; http://www.npc.navy.mil/CommandSupport/Diversity/

> global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of those actions?"[28]

In the resulting NAS report entitled "*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*," the authors call for comprehensive and immediate action to address an increasing economic and national security threat to the United States: **the impaired ability to grow and compete in a globalizing world for the scarce STEM professionals needed to ensure the capability for technological innovation**.

Appendix A provides a clear mapping of NAVSEA's intended actions to provide solutions to the NAS authors' four recommendations with twenty supporting actions to implement them. NAVSEA embraces the comprehensive approach described in these actions. NAVSEA also recognizes that meeting the challenge actually has three human capital dimensions that must be integrated:

- The sustainment and development of a STEM professional workforce;
- Ensuring a diverse workforce that mines the best from many perspectives; and
- Quantifying and measuring performance in achieving a diverse STEM workforce.

V. The Problem – Balancing Perspectives

The problem can be viewed from three interrelated perspectives: strategic (national level), operational (Naval Enterprise level), and tactical (NAVSEA organizational).

At the strategic national level, the nation is faced with fierce competition for scarce STEM resources in a globalizing environment where the US is *decreasingly* competitive as the preeminent location to develop professionally. In fact, only 1 of 16 sets of

[28] NAS report; Charge to the Committee by Senator Lamar Alexander and Senator Jeff Bingaman.

respondents in the NAS study indicated the US as the primary place for STEM development.[29]

At the Naval Enterprise level, comprising the entire DoN community, the Navy and Marine Corps must attract, develop, retain, and motivate these professionals to ensure our national security through technological innovation.

At the NAVSEA organizational level, our work environment must provide the incentives, equal opportunity, and quality of life that mine diverse viewpoints and capabilities to provide the best possible capabilities to support our national security.

NAVSEA further recognizes a multitude of stakeholders at each of these levels—each with sometimes complementary, but often differing priorities. While all view the problem through their unique lens, success will require the ability to communicate across and balance these perspectives.

Stakeholders at the strategic level include the American public, students at all levels, industry, federal government agencies, and foreign nations. At the Naval Enterprise and NAVSEA organizational levels, the stakeholders include the Department of Defense (DOD), the DoN, NAVSEA, educational institutions, the engineering and scientific workforce, employers, educators, local and state governments, professional societies, labor unions, and others with a record of success in training, retraining and rewarding capable people.[30]

The initiative addresses:

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[29] NAS Storm Report, p. ES-9

[30] Bryan, L.A. "*Trying Times For U.S. Engineers*", A Statement on behalf of The Institute of Electrical and Electronics Engineers – United States of America at the Pan Organizational Summit on the U.S. Science and Engineering Workforce, November 12, 2002 IEEE, p. 3

1) The need for development of a NAVSEA/DOD oriented cadre of scientists and engineers through early and ongoing engagement in the educational process.

2) Establishing a clear link between the work force development and the Navy Diversity initiatives.

3) Pilot efforts with historically black colleges and universities (HBCUs)/minority institutions (MIs), to leverage *existing and proven* programs that bring previously untapped candidates into the STEM workforce.

4) Developing an implementation framework with incremental, but comprehensive budgets to move forward over a 10 year time frame to:

- Concentrate upon a broad educational continuum;
- Attend to DoN needs, but in an expandable DOD (ultimately interagency) construct;
- Develop options to expose and expand interest in STEM through activities from summer camps to fellowships; and
- Define possible foundations for cultural learning across organizations, teams, and individuals residing in diverse structures in the Navy and the broader community (e.g., interagency, industry, academia).

Considerations

Specifically, NAVSEA and similar organizations require a workforce that is at the vanguard of technological development and that draws upon the diversity that the changing American population and global community offer. As noted in the NAS Storm Report as well as in an additional NAS report referencing National Science Foundation study findings:

> "The demographics of the United States are changing. Women and minorities together make up 60 percent of the total workforce,[14] but they are dramatically underrepresented in S&E. Women comprise 46 percent of the total labor force, but only 23 percent of the S&E labor force.[15] African Americans and ethnic minorities constitute 24 percent of the total population but only 7 percent of the S&E labor force.[16] This means the majority of Americans is [untapped] in S&E." [31]

From a broader community perspective, industry articulates a "formidable, five-part challenge:

- How to assign responsibility for and share the cost of lifelong learning that will enhance the viability of engineering careers with continuous focus on performance, productivity and employability;
- How to make professional careers in engineering more attractive to U.S. citizens and legal permanent residents at a time when more and more employers view engineering services as commodities to be purchased at the lowest possible cost, here or overseas;
- How to address U.S. corporate needs for maintaining a positive worldwide competitive position while also maintaining a viable technical workforce for the security and economic vitality of the U.S.;
- How to reconcile fundamental economic laws of supply and demand … ; and

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[31] Jackson, S.J., National Science Foundation, "*Envisioning A 21st Century Science and Engineering Workforce for the United States: Tasks for University, Industry, and Government,"* National Academies Press, 2003. Internal citations from:

> 15-National Science Foundation. *Science and Engineering Indicators 2002* [p. 3-12]. Arlington, VA: NSF, 2002. Available online: http://www.nsf.gov/sbe/srs/seind02/start.htm
>
> 16-National Science Foundation. *Science and Engineering Indicators 2002* [p. 3-13]. Arlington, VA: NSF, 2002. Available online: http://www.nsf.gov/sbe/srs/seind02/start.htm

- How to minimize the unintended consequences of targeted government interventions."[32]

NAVSEA also recognizes that acquiring its STEM workforce differs from the broader STEM community in two respects. First is NAVSEA's need for security cleared personnel—a decreasing pool as more STEM professionals are drawn from other nations.

Second, while many federal employees stay long past retirement eligibility, the simultaneous loss of large numbers would certainly impact NAVSEA's capability to deliver world class products. For example, based on internal research, 60% of NAVSEA's workforce could retire simultaneously.[33] In fact, a rapid retirement of a large percentage of the workforce would exacerbate the national security challenge because training new accessions does not make up for lost experience.

The latter challenge raises two issues: actual vulnerability and perceptions of vulnerability. For example, NAVSEA's current vulnerability to large scale retirement results from previous cycles of concern—today's retirees represent a "professional boom" resulting from the Sputnik launch fears of inadequate STEM resources in the late 1950s that generated many government programs providing access to US universities and resources. In addition to these two challenges, NAVSEA's situation is also impacted by limited hiring over the last 15 year period.

Today, again, there is wide ranging concern across many communities that the need is real, immediate, and must be comprehensively addressed. *NAVSEA shares this concern.*

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[32]Bryan, L.A. "*Trying Times For U.S. Engineers*", A Statement on behalf of The Institute of Electrical and Electronics Engineers – United States of America at the Pan Organizational Summit on the U.S. Science and Engineering Workforce, November 12, 2002 IEEE p. 6

[33] Findings from Program Executive Office Submarine (PEO SUB) research, 2006.

Therefore, NAVSEA's initiative focuses on a ten year window to establish a comprehensive program of engagement, outreach, and resource development starting at "the roots": the educational community from middle school to high school to undergraduate to graduate to the doctoral level. This approach would help implement many of the NAS Storm Report actions and results from recognition that:

- 8th Graders today will become the future Navy Sailors who will join the Navy after high school graduation in 2012.
- 8th Graders in FY07 (2006-2007) will be graduating college in 2016 and taking jobs in STEM fields.
- 8th Graders today will become the future math and science teachers in 2016 at the elementary, middle school, and high school level.
- 8th Graders today will become the future Naval Officers receiving commissions after graduation in 2016.
- 8th Graders today will become the future college professors training future leaders in the STEM fields in 2020.

Leveraging Points

NAVSEA recognizes that there are many (individual) initiatives *already underway* throughout the Navy, the academic community, and industry, which can contribute to NAVSEA's expansion of the NAS approach. With better coordination and resources, NAVSEA initiatives could be expanded to other agencies and institutionalized by Congress in pending House and Senate National Defense Education Acts.

Examples of initiatives at NAVSEA are:

- A collaborative interaction with HBCUs to initiate a workforce development effort emphasizing job articulation (Dimension), quality of life to retain the workforce (Retention), and a career development pathway (Ascension).
- Engagement with MIs including groups oriented towards women and Hispanics.
- Small business interactions to leverage federal government funding initiatives including Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs.
- Warfare centers and field command programs such as the Naval Underwater Center's (NUWC's) Upward Bound Program with Rhode Island College, Naval

Surface Warfare Center's (NSWC's) Star Program, and NUWC's Mathematics and Science Educational Outreach Plan.

- Engagement with industry, not for profit organizations, and other agencies both in and out of DOD.

VI. NAVSEA's 21st Century Engagement, Education and Technology Initiative

Overview - A Phased Approach

NAVSEA's initiative will develop three phases: "plant," "nurture", and "produce" as depicted in Figure 1. The first will "plant" the seeds for success by early engagement with tomorrow's potential STEM professionals through better coordination of existing initiatives. It will focus on establishing a physical and virtual NAVSEA environment that brings together students, educators, NAVSEA professionals, university and school laboratories, as well as NAVSEA infrastructure in a combination of processes and activities to foster interest in the Navy and NAVSEA related work.

Second is to "nurture" the seed by developing activities to sustain the relationships with potential candidates and academic organizations and other stakeholders who develop the STEM workforce. This will be done using an iterative process that is fueled by outreach and engagement activities, research initiatives, and incentive programs such as science fair participation and scholarships. These activities will build up relationships with educators and increase motivation as future STEM professionals see the value and reward that NAVSEA and the Naval Enterprise offer.

Third is to "produce" the STEM professionals and attract them to NAVSEA's workforce. This will result from the phased activities over the 10 year spectrum in which trust and strong relationships are built.

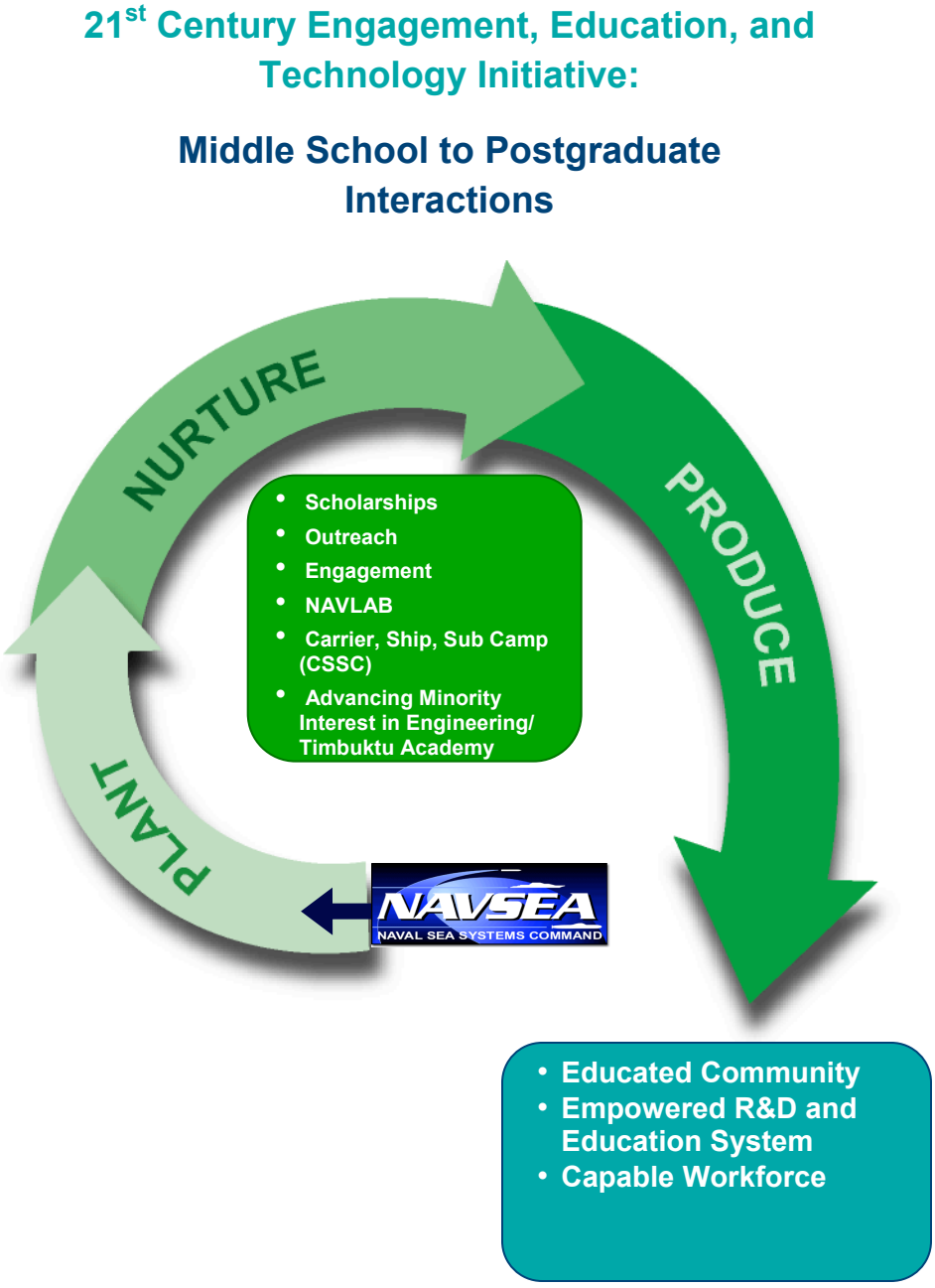

Figure 1. NAVSEA's 21st Century Engagement, Education, and Technology Initiative

Linking these activities to the recommendations provided in the NAS Storm Report offers an excellent opportunity to realize an economy of scale, cost, and value in

developing a diverse STEM workforce, using NAVSEA as a prototype that the Naval Enterprise can adapt and implement as it matures.

Goals and Objectives

NAVSEA's goals are straightforward and are supported by specific objectives:

- *Create and sustain initiatives to generate STEM interest and capability in youth and Academic institutions.*
    - Establish "camps" to regularly engage students and educators in NAVSEA areas of interest.
    - Sponsor middle school to college level contests and activities with STEM focus.
    - Expand the NAVSEA potential to fund R&D at Advancing Minority Interest in Engineering (AMIE)[34] institutions to $500M over the next 10 years.[35]
    - NAVSEA co-sponsor or fund 80 undergraduate scholarships over the next 10 years to promising high school students who are encouraged to work in research areas of interest to NAVSEA.
    - NAVSEA co-sponsor or fund 80 graduate fellowships over the next 10 years to promising undergraduate students who are encouraged to work in research areas of interest to NAVSEA.

- *Create partnerships that lead to new academic and industrial development, which will broaden the base for all STEM activity.*
    - Establish NAVSEA research capabilities and facilities on HBCU campuses.
    - Establish partnerships with University Research Facilities for NAVSEA employees to leverage non-DOD sponsored activities using AMIE.
    - Initiate research projects relevant to NAVSEA

[34] All HBCUs in AMIE are schools with accredited Engineering programs

[35]The AMIE coalition is described in Appendix B.

- *Attract and retain the broader more capable STEM workforce within NAVSEA and the Navy.*
    - Utilize NAVSEA existing Warfare Center laboratory structure and sponsor 1 to 2 year visiting professor research/ teaching fellowships at NAVSEA's labs.
    - Leverage university level graduate courses to provide opportunity for NAVSEA employees to study in emerging technical areas to refresh and update their skills.
    - Participate in campus job fairs and science demonstrations to promote the importance and opportunity within the Navy and NAVSEA enterprise.

NAVSEA's Initiative Components

NAVSEA's initiative introduces physical and virtual environments as well as activities and processes as the foundation for success. The initiative is actually a combination of existing, emergent, and new initiatives/activities to bring together students, teachers, researchers, industry, and NAVSEA employees. It establishes processes and linkages that generate opportunities for immersion by students and faculty in NAVSEA Research and Development and applied engineering.

Specifically, components of NAVSEA's initiative will include:

- Outreach by leadership and others to community, university, education, and other organizations to build awareness of NAVSEA opportunities and gain insights into challenges facing the STEM community;
- Engagement with key partners in academia and industry to plant the seeds upon which success will depend;
- A Carrier, Ship, and Submarine Camp (CSSC);
- A NAVLAB to develop research facilities and support basic and applied research activities in NAVSEA and other (e.g., industry, academic, not for profit, other government agency) environments; and
- Improved facilities, opportunities for self-directed research, and internal information exchange via collaborative environments.

Each is described below.

Outreach

Outreach activities will focus on building relationships with communities and civic organizations where NAVSEA facilities are located. The objective is to gain insights and recommendations into how best to communicate STEM as stimulating fields in which students can have fun now and grow into professionally and academically. Opportunities include middle school, high school, and college campus visits by NAVSEA leadership and other employees. Outreach includes information booths and prize sponsorship for achievements in STEM areas.

Additionally, outreach will engage community service groups that sponsor extracurricular, recreational, and after school activities. Other efforts will explore opportunities with professional and industry organizations at conferences and symposia to determine and leverage scholarship and other incentive programs to meet NAVSEA initiative's goals.

While outreach activities will include NAVSEA leadership visits, they will also offer opportunity for interested NAVSEA employees to network and support these non-DOD sponsored programs. Finally, outreach will include developing descriptive materials on the NAVSEA initiative and disseminating them through the activities listed above as well as the media, as feasible.

Engagement

NAVSEA proposes to meet the need for STEM professionals while implementing the NAS Storm Report recommendations and the Navy's Diversity Strategy by leveraging and expanding upon the initiatives undertaken by HBCUs. These initiatives use a partnering approach that provides a model to focus on the development of tomorrow's teachers and researchers as well as today's needed STEM resources.

Two organizations that advocate for HBCUs and increased development of STEM capabilities in the minority community will be partners: the Advancing Minorities Interest in Engineering (AMIE) coalition and The Timbuktu Academy. Both are discussed in Appendix B. Senior NAVSEA leaders and key personnel from partner institutions will attend the annual AMIE annual conference to ensure that meaningful and collaborative relationships grow quickly.

Engagement with middle and high schools will include a number of targeted participative activities. For example, NAVSEA could engage with a Junior Naval Reserve Officer Training Corps (NJROTC) unit to which it provides resources, tours, lectures, and other support to stimulate interest in STEM fields as a career option. Further activities will include "co-op" employment opportunities to develop job skills in STEM related areas for high school students. Additionally, to the extent feasible, engagement will include sponsorship and partnership in Science Fairs with NAVSEA providing judges and prizes.

Further groups to engage with on a regular sponsorship basis include clubs, recreational, and other activities that would provide access to students with potential interest in STEM areas.

Carrier, Ship and Sub Camp (CSSC)

CSSC will consist of NAVSEA sponsored education camps for middle school to college students and faculty where teachers and students are immersed in stimulating, practical application of STEM concepts to develop technology solutions. It will comprise "Carrier Camp," "Ship Camp," and "Sub Camp" to bring students and faculty into NAVSEA activities once a month for information and knowledge exchange, mentoring, and practical activities leveraging the interests of students and faculty to respond to and expand NAVSEA areas of interest. Supported by NAVSEA volunteers as part of "mentoring," CSSC will allow NAVSEA employees to be paid while participating in these activities.

To the extent feasible, CSSC will include specific mapping of the Knowledge, Skills, and Abilities (KSAs) of interest to the Naval Enterprise to school curricula. This

mapping will allow targeted engagement and generate programs of hands on learning based on common KSAs.

CSSC also will include summer events oriented towards products and accomplishments, both by students and faculties. CSSC (possibly sponsored by DOD and other government agencies, industry, and academic institutions) would provide opportunity to tour NAVSEA facilities and other naval environments, e.g., ship tours, aircraft tours, sub tours, gunnery ranges, etc.

Additionally, CSSC will include sponsored seminars and research activities for middle school, high school and college faculty (possibly with accredited adult education a goal). It further will hold interactive events combining students, faculty, NAVSEA and operational community members to address cutting edge technology development challenges.

The CSSC will also include a "Classroom at the Yard" component which will provide opportunities to link school curriculum with focused visits to NAVSEA facilities to see STEM concepts at work. Additionally, CSSC will leverage and expand apprenticeship activities already in place in NAVSEA.

"NAVLAB"

NAVLAB will comprise two types of research facilities as well as a number of basic research initiatives. First is a set of NAVSEA labs on partner campuses. The objective is to embed an actual NAVSEA facility in a university environment to foster collaboration and communication while focusing on NAVSEA needs. NAVSEA will establish a lab that is managed and operated by NAVSEA employees, with a NAVSEA director, where students and faculty will participate in research for real Navy programs. These will include laboratory facilities and linkages to NAVSEA resources.

Second is a university partner operated, NAVSEA sponsored (leveraging NSF, ONR, DARPA, and similar research sponsors) lab that would offer access by NAVSEA to university research and resources. The objective would be to leverage wide ranging

research that is not focused on NAVSEA's specific needs, but may provide a catalyst to technological innovation that is relevant. Emphasis would be on tapping into resources normally unavailable to NAVSEA – uncleared researchers that are increasingly the mainstream of the STEM professional workforce.

NAVLAB also would seek to stimulate interest in teaching through including current teachers in research activities as well as students that may become interested in STEM teaching through work study partnerships with local industry to build interest in science/engineering firms as summer job environments. It will also support faculty exchange programs, cooperative education, intern programs, and guest lecturers to include emphasis on the Undergraduate Training Assistance Program (UTAP), Undersea Research Scholar Program, and Naval Research Enterprise Intern Program (NREIP).

Additionally, basic research activities will be coordinated through NAVLAB to include Small Business Innovative Research (SBIR)/Small Business Technology Transfer (STTR) programs, contract incentives for HBCU participation, leveraging of other partner resources (e.g., contractor resources – labs, simulators, co-ops, mentoring partnerships), scholarships, fellowships/visiting professors, selected equipment and facility access.

Finally, NAVLAB in coordination with the other activities comprising the NAVSEA initiative, will offer incentives including recognition, cash prizes for science fairs, and science and engineering contests such as DARPA's Grand Challenge Race.

Work Environment

Quality of work initiatives will focus on making NAVSEA one of the top 10 places to work. NAVSEA's initiative envisions an approach that introduces physical and virtual environments as well as activities and processes as the foundation for success in attracting, recruiting, and retaining a capable workforce. It establishes processes and linkages that generate opportunities for immersion by employees, students, and faculty in NAVSEA Research and Development and applied engineering.

NAVSEA also recognizes the importance of encouraging innovation and that, "There is no simple formula for innovation. There is, instead, a multi-component 'environment' that collectively encourages, or discourages, innovation."[36] As a result, the NAVSEA initiative is designed to encourage innovation at all levels. Representative opportunities and incentives include:

- Formal independent research funding for R&D Labs ,
- Programs to encourage and support workforce education at all levels,
- Discretionary funding sources available to R&D Lab management to support selected high benefit/pay-off projects, which is intended to stimulate a culture that encourages risk taking,
- Financial and merit reward systems for entrepreneurial patent activity within NAVSEA and the Naval Enterprise,
- Participation in development of US Intellectual Property (IP) protection laws as well as promulgation of up to date information on IP, and,
- Reachback.

On-going data collection through surveys, throughput analysis, resource utilization and other tools will provide a quantitative basis to assess return on investment.

VII. Implementation Plan - First Steps

Pulling together the above described activities to generate a comprehensive and coherent approach will require focus upon the NAS Storm Report recommendations and actions. The NAS Storm report bases its recommendations on four key themes:

[36] W. A. Wulf. Review and renewal of the environment for innovation. Unpublished paper, 2005, as quoted in the NAS Storm Report, p. 8-1.

1. Improve K-12 education in STEM with emphasis on increasing the number and quality of STEM teachers.
2. Emphasize basic research initiatives to include incentives for disruptive innovation and a willingness to accept risk.
3. Ensure that the United States is the preeminent place to study and conduct research.
4. Ensure the United States is the preeminent place to innovate by revamping incentives and streamlining processes to protect intellectual property, e.g., patents.

Many of these recommendations and actions are described from a national, strategic perspective in terms of their implementation. NAVSEA recognizes that the majority of activities that it can undertake to support national goals are limited to the resource base that NAVSEA possesses or can influence at the NAVSEA organizational level. Therefore, short term emphasis will be on implementing the "plant" phase. Three strategic priorities that derive from the recommendations in the NAS report will be the focus of initial activities in the present to 2009 timeframe:

- Engage with middle and high school students and faculty in the communities in which NAVSEA facilities are located.
- Engage with student and faculty in college environments using facilitative partners. See Appendix B for an example with the Timbuktu Academy.
- Establish research incentives to stimulate risk taking and basic research to support technological innovation.

Additionally, as part of its diversity initiative and quality of life activities, NAVSEA will strive continuously to make working at NAVSEA something STEM professionals will look forward to. Command climate will communicate openness to new ideas, flexibility in approaches to research, and respect for diverse opinions.

Appendix A provides the recommendations and actions from the NAS Storm report and includes a mapping of relevant NAVSEA Implementation Concepts for specific activities and initiatives. The general approach is described below based on the elements of the initiative identified earlier: Outreach, Engagement, Research Facilities, and Work Environment.

Outreach

1. Continue current HBCU efforts:
    a. STTR outreach.
    b. Contract incentives to large and small business partners as a command approach based on existing processes within TEAMSUB.
    c. Grow partnerships between Academia and product line executives.
    d. Program Manager (PM) rotation through campuses for various research and instructional opportunities with local schools to influence curriculum with Navy flavor and examples.
    e. Increase NAVSEA visibility on the HBCU campuses.
    f. Identifying and leveraging current NAVSEA and HBCU activities and resources to support these actions .

2. Introduce HBCU capabilities command wide
    a. Meet with AMIE and Timbuktu Academy to define stakeholder agendas, partner options, resources required.
    b. Attend AMIE annual meetings.

3. Assess and match the HBCUs and NAVSEA Program Executive Offices (PEO) capabilities through AMIE.

Engagement

4. Create the initiative's CSSC Camp pulling together field activity programs under one command initiative similar to the space camp concept. This also includes a focus on NJROTC programs.
5. Engage with local schools and collaborate with academia (middle schools, high schools, and colleges) to influence middle and high school curriculum to include activities, concepts, and problems relevant to NAVSEA requirements
6. Engage with area civic groups and seek recommendations for scholarship recipients.
    a. Provide tutorials, participate in clubs and afterschool programs as mentoring opportunities, host math and science fair, etc.

Research Facilities/NAVLAB

7. Establish on campus presence.
    a. Sponsor lab facilities.
    b. Leadership visits.
8. Leverage Navy research investment in the academic community.
    a. Link to University Affiliated Research Centers (UARCs) as partnership opportunity with HBCUs.
9. Create long-term research partnerships for all contract efforts (small and major).

Quality of Work Environment

10. Develop a recruiting strategy that addresses current and future workforce requirements for scientists and engineers.

NAVSEA also recognizes that many organizations have been engaged in various aspects of improving the sustainment and development of a STEM professional workforce. A pervasive effort throughout all of the initiatives will be to collect, define, develop, and communicate best practices that have been learned and are learned as the initiative matures. These best practices will provide the foundation to develop a proposal for Naval Enterprise adoption of the NAVSEA prototype.

Appendix A

NAS Recommendations and Supporting Actions mapped to NAVSEA Implementation Concept

Recommendation A: *Increase America's talent pool by vastly improving K–12 science and mathematics education.*	
Supporting Action	**NAVSEA Implementation Concept**
Action A-1: Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds.	• Through AMIE and Timbuktu Academy, develop relationships to bring potential teachers into the NAVSEA environment to stimulate interest in application of STEM to real world problems. • NAVSEA funding augmented to allow for co-sponsorship of scholarships
Action A-2: Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and in Advanced Placement (AP) and International Baccalaureate (IB) training programs.	• NAVSEA sponsor summer institutes, "Carrier", "Ship", and "Sub" camps (CSSC) where teachers and students are immersed in stimulating, practical application of STEM concepts to develop technology solutions. • Provide opportunities for teachers to experience cutting edge tools, modeling and simulation, and tour training and laboratory resources. • Host conferences and seminars based on NAVSEA program activities and needs.
Action A-3: Enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science,	• NAVSEA personnel participate in community based mentoring of students to allow individual relationships to build and develop interest in students to address issues and capabilities of interest to NAVSEA. • Science Fair sponsorship with NAVSEA employees acting as judges.

engineering, or mathematics by increasing the number of students who pass AP and IB science and mathematics courses.	• Focus on Middle School Students
Recommendation B: *Sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.*	
Action B-1: Increase the federal investment in long-term basic research by 10% each year over the next 7 years through reallocation of existing funds or, if necessary, through the investment of new funds	• NAVSEA provide contracting incentives requiring a minimum of three percent HBCU/MI participation for all major acquisition contracts. • Continue the focus on STTR/SBIR with ONR and teaming with small businesses/academic institutions. • Support establishing research laboratories on HBCU campuses.
Action B-2: Provide new research grants of $500,000 each annually, payable over 5 years, to 200 of the nation's most outstanding *early-career* researchers.	• Provide access to NAVSEA research and development facilities as "in kind" contributions to augment scholarships. • Support establishing research laboratories on HBCU campuses.
Action B-3: Institute a National Coordination Office for Advanced Research Instrumentation and Facilities to manage a fund of $500 million in	• Establish a competition for basic research in areas of interest to NAVSEA similar to the DARPA Grand Challenge. • Establish and expand upon the Center for Undersea Technology Research (CUTR) concept developed by NUWCDIVNPT

incremental funds per year over the next 5 years—through reallocation of existing funds or, if necessary, through the investment of new funds—to ensure that universities and government laboratories create and maintain the facilities, instrumentation, and equipment needed for leading-edge scientific discovery and technological development. Universities and national laboratories would compete annually for these funds.	
Action B-4: Allocate at least 8% of the budgets of federal research agencies to discretionary funding that would be managed by technical program managers in the agencies and be focused on catalyzing high-risk, high-payoff research of the type that often suffers in today's increasingly risk-averse environment.	• Establish a competition for basic research in areas of interest to NAVSEA similar to the DARPA Grand Challenge.
Action B-5: Create in the Department of Energy an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research	• Support and engage with the agency to leverage resources and resulting technologies and concepts

Projects Agency-Energy (ARPA-E).	
Action B-6: Institute a Presidential Innovation Award to stimulate scientific and engineering advances in the national interest.	• Leverage and co-sponsor activities.
Recommendation C: *Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists and engineers from within the United States and throughout the world.*	
Action C-1: Increase the number and proportion of US citizens who earn bachelor's degree in the physical sciences, the life sciences, engineering, and mathematics by providing 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions.	• Support implementation and sponsoring of scholarships through agencies such as NAS and NSF to provide scholarships at all levels. • NAVSEA offer in kind access to apprenticeships and research resources.
Action C-2: Increase the number of US citizens pursuing graduate study in "areas of national need" by funding 5,000 new graduate fellowships each year.	• Co-Sponsor scholarships • NAVSEA expand on NAVSEA Intern Program and high school apprentice program with access to research resources.

Action C-3: Provide a federal tax credit to encourage employers to make continuing education available (either internally or though colleges and universities) to practicing scientists and engineers.	NOT APPLICABLE TO NAVSEA DIRECTLY.
Action C-4: Continue to improve visa processing for international students and scholars to provide less complex procedures and continue to make improvements on such issues as visa categories and duration, travel for scientific meetings, the technology alert list, reciprocity agreements, and changes in status.	NOT APPLICABLE TO NAVSEA DIRECTLY.
Action C-5: Provide a 1-year automatic visa extension to international students who receive doctorates or the equivalent in science, technology, engineering, mathematics, or other fields of national need at qualified US institutions to remain in the United States to seek employment. If these students are offered jobs by US-based employers and pass a security screening test, they should be provided	NOT APPLICABLE TO NAVSEA DIRECTLY.

automatic work permits and expedited residence status. If students are unable to obtain employment within 1 year, their visas would expire.	
Action C-6: Institute a new skills-based, preferential immigration option.	NOT APPLICABLE TO NAVSEA DIRECTLY.
Action C-7: Reform the current system of "deemed exports".	NOT APPLICABLE TO NAVSEA DIRECTLY.
Recommendation D: *Ensure that the United States is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs based on innovation by such actions as modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.*	
Action D-1: Enhance intellectual-property protection for the 21st-century global economy to ensure that systems for protecting patents and other forms of intellectual property underlie the emerging knowledge economy but allow research to enhance innovation.	• No direct influence • Can offer better access to SBIRs/STTRs
Action D-2: Enact a stronger research and development tax credit to encourage	NOT APPLICABLE TO NAVSEA DIRECTLY.

private investment in innovation.	
Action D-3: Provide tax incentives for US-based innovation.	NOT APPLICABLE TO NAVSEA DIRECTLY.
Action D-4: Ensure ubiquitous broadband Internet access.	• Provide funding for target student populations to gain internet access on a need basis linked to science fair prizes and other innovation oriented programs.

Appendix B

Model for Partnership with HBCU

As noted above, three spirals will be the focus of the NAVSEA initiative over a ten year time frame: "Plant" (2007-2009), "Nurture" (2010-2013), "Produce" (2014-2017). These will evolve as momentum is gained through the initiatives and activity sets described in the paper. Essential to laying the foundation for success will be to coordinate current and evolving initiatives throughout the NAVSEA organization and build links to broader, related Naval Enterprise activities. Additionally, the outreach and engagement activities described above will provide the core set of activities in the short term to leverage existing resources until additional resources can be programmed. To begin the process, NAVSEA will develop its partnerships with AMIE and the Timbuktu Academy to leverage existing and proven process models as noted below.

Engagement Plan with Academia

AMIE is a coalition of industry, government agencies and the Accreditation Board for Engineering and Technology (ABET)-accredited HBCUs Schools of Engineering. It seeks to forge corporate/academic alliances that serve to promote and support quality engineering programs. AMIE's vision is to be "the premier organization that develops industry, government and university partnerships to achieve diversity in the engineering workforce." AMIE develops partnership through a process that includes:

- Identifying HBCUs that best match partnering requirements based on vision, goals, and expectations.
- Identifying and making initial contact to provide a foundation for a strong working relationship.
- Assisting in the writing of a "Memorandum of Understanding" to formalize the partnership and provide a written action plan and mutual expectations.
- Providing follow-up assistance as needed.
- Sharing "Best Practices" with members.

The Timbuktu Academy resides at Southern University, Baton Rouge. It is funded by the Department of the Navy, Office of Naval Research (ONR) and was established in 1990 to mentor undergraduate physics majors. Pursuant to funding by ONR, in 1993, the Academy moved from a demonstration stage to one of national-model status; included pre-college programs; and recruited majors in other fields, with emphasis on engineering and chemistry in addition to physics. They apply the developmental process as a scientific process in itself and use specific measures including journal publications to validate its efficacy and utility.

Specific objectives of The Timbuktu Academy that may be expanded upon by this NAVSEA initiative include:

- Produce 50 well-trained Bachelor degree holders in Engineering, Physics, Chemistry (EPC), and other sciences and to guide these graduates to the successful pursuit of advanced degrees (i.e., Ph.D.);
- Produce and disseminate new knowledge in science, mathematics, engineering and in education/mentoring;
- Render professional services to the educational, private, and other communities through publications, presentations, and consulting.

To date, the Timbuktu Academy has supported over 147 students to complete undergraduate studies with over 92 going on complete graduate degrees. Additionally, over 1675 pre-college students have completed The Timbuktu Academy's summer enrichment programs.

Other areas that The Timbuktu Academy offers as linkages to NAVSEA's initiative includes a framework that provides:

- Systemic Mentoring Activities
- Communication Skills Enhancement
- Financial support
- Conduct Of Specific Research Projects
- Scientific Advisement
- Tutoring
- Generic Research, Literature Searches
- Enhancement Of Computer/Tech. Skills

- Guidance To Graduate School
- Monitoring
- Immersion In A Professional Culture

Additional advocates for HBCUs/MIs and development of a diverse STEM workforce have been identified and are looked at as prospective additional partners.