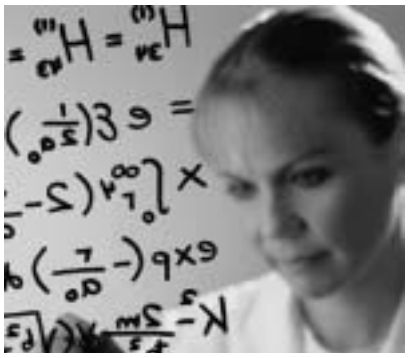

Ensuring Excellence

Action Steps to Increase Return on Investment from ONR and NRE Education Programs

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A Report to the Office of Naval Research

Presented by

BEST
Building Engineering & Science Talent

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Building Engineering and Science Talent (BEST) is a public-private partnership dedicated to increasing the participation of under-represented groups in the science, engineering and technology professions.

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EXECUTIVE SUMMARY

The Office of Naval Research (ONR) asked Building Engineering and Science Talent (BEST) to undertake a four-month effort to assess how ONR can best impact Naval Research Enterprise's (NRE) ability to attract and retain qualified candidates into NRE's science, technology, engineering and mathematics career pipeline. ONR asked BEST to determine which ONR education programs funded or managed by Code 363 demonstrate the greatest return on investment, and to suggest changes to that might provide NRE with the greatest impact on its short and long-term workforce needs.

Return on investment is defined in this study as "the success of a program in attracting high-quality science and technology talent into the NRE or its university and corporate partners." By design, this definition does not encompass ONR's stake in funding cutting edge research. The findings and recommendations below are based on:

- More than 70 interviews with managers and customers of education programs at ONR, NRL, and a representative group of warfare centers;
- Analysis of available data on program execution and impact; and
- Benchmarking NRE education programs against design principles of best practice BEST identified in a two-year Congressionally mandated study.

Context

The NRE consists of several distinct and dispersed organizations that share some common needs but have distinctive missions, interests and operating practices. Some of BEST's key observations regarding the enterprise-wide context into which Code 363 and other education programs fit include:

- Current and Future Skills Needs: The technical workforce of the NRE consists of approximately 4,000 scientists and engineers who work at least half time on research-related tasks. About 1,800 hold Ph.D.s, including about 880 in the Warfare Centers, 820 at NRL and 100 at ONR. NRL requires both entry-level and experienced scientists and engineers, with a significant concentration of Ph.D.s. ONR requires primarily mid-career scientists and engineers, mostly Ph.D.s, while the workforce at the Warfare Centers consists primarily of engineers, most of which hold bachelors or masters degrees.

- Education and Pipeline Programs: BEST learned about dozens of small, medium and large pipeline programs developed by NRL, individual Warfare Centers, and some ONR Program Offices to serve their own formal and informal recruitment needs. These programs, funded through a variety of sources, and the ONR Code 363 programs often have similar purposes and elements. This proliferation creates complexity and duplication for technical program managers who try to use the programs.

- Recruitment and Hiring Practices: Organizations within the NRE use a wide variety of recruiting and hiring practices to meet their needs, ranging from reliance on peer referral for experienced scientists and engineers within ONR and NRL to very aggressive programs of advertising, attendance at technical conferences and job fairs. In recent years, some of the Warfare Center divisions have developed centralized recruiting systems, such as the "One NavAir" system for its 8 locations.

- Role of Technical Managers and Human Resources: ONR, NRL and each of the Warfare Centers has its own human resources organization, yet most of these organizations vest primary responsibility for recruitment and hiring in individual technical managers. Given the time and energy required to use the many and complex tools and processes available for aggressive recruiting, many managers may rely on only one or two programs.

Key Findings

Investments in the Education Pipeline

- NRE has a rich variety of recruitment and education pipeline programs that, if used strategically, could position NRE as an "employer of choice," and increase NRE's ability to compete for high quality science and engineering talent.

- NRE education programs are currently managed in isolation without connection to a human capital needs assessment or strategy.

- ONR Code 363 programs are few in number and minimally funded, and several are not fully controlled by ONR. Therefore, as currently structured, they have a minimal impact on NRE recruitment.

- There is a knowledge gap at the corporate level regarding return on investment of education pipeline programs because their outcomes are not typically measured.

- The lack of knowledge about these programs across the NRE and at the corporate level contributes to unnecessary duplication, missed synergies, complexity for applicants, and failure to disseminate "lessons learned."

Recruitment and Retention Practices and Incentives

- Despite the barrier to competitive hiring posed by the length of the government hiring process, NRE is relatively well positioned to capitalize on its pipeline programs because of the significant recruitment and retention incentives at its disposal.

- Recruitment efforts are uneven across the NRE, and dependent on the leadership of individual program managers and selecting officials.

Principal Recommendation

Develop and implement a human capital strategy for the NRE addressing pipeline, recruitment, retention and workforce development issues.

NRE should develop a comprehensive, integrated human capital strategy that clearly defines NRE's current and future workforce needs, and outlines a strategic approach to meeting those needs. The N-STAR Strategic Plan has offered a blueprint for creating many of the components of a human capital strategy. NRE should make it a priority to bring together elements such as workforce data analysis, recruiting, student identification and development, and workforce retention and development, and weave them into an integrated, coordinated strategy.

A human capital strategy would place NRE's recruitment, retention and workforce development goals on an equal footing with other mission areas, and lay the groundwork for greater management attention to recruitment and workforce development goals. Strong leadership will be needed to manage the transition to a world-class recruitment and workforce building system, elevate the importance of these activities within NRE, articulate the importance of the strategy throughout NRE and to Naval leadership, acquire needed resources, and nurture the strategy over time.

Recommended Action Steps

1. Complete a comprehensive workforce needs assessment for the NRE

2. Create an integrated portfolio of education programs that address NRE's strategy

    - Establish educational investment criteria that are aligned with "best-in-class" design principles
    - Re-direct Code 363 Pre-K-12 funding to programs more closely aligned with NRE's needs and interests
    - Concentrate resources on internship programs (SEAP, SEAP/CQL, NREIP), that engage promising students and researchers at all levels directly in the work of the NRE; consolidate and re-structure the internship programs according to "best in class" design principles
    - Create an educational pathway into the NRE by adding components into current and future programs that reinforce a connection to NRE and measure ROI
    - Re-direct funding for faculty research programs toward programs more closely aligned with recruitment objectives

3. Develop an NRE-wide approach to expand the demographic pool from which NRE draws

- Review current use of mandated 5% funds for HBCU/MIs, and align future spending with the human capital strategy
- Expand relationships with women and minority-serving institutions and organizations throughout the NRE programs
- Consider NRE career potential of other non-traditional groups

4. Develop and expand NRE-wide tools and resources to support the human capital strategy

- Create a data base to expand NRE access to qualified candidates
- Create a one-stop web portal for job announcements and candidate recruitment
- Develop and implement relevant training for incumbent staff
- Develop and implement an NRE-wide mentoring program addressing the needs of entry-level and mid-level employees
- Embrace diversity by including support mechanisms in everything NRE does (performance measures, affinity groups, newsletter, mentoring, etc.).
- Add performance measures for workforce development to all manager jobs, and hold managers accountable for results
- Create an Executive Development Program to groom senior managers for SES

5. Establish an NRE-wide capability to support recruitment and hiring

- Establish a support function that provides timely information to technical program managers and builds an enterprise-wide data base on needs and outcomes

6. Market NRE as a “great place to work”

- Create a positive and compelling NRE brand
- Craft targeted external campaigns to attract key S&T customers and engage students at all levels with age-appropriate, relevant communication
- Market ONR and NRE programs within the Navy

7. Make a sustained commitment to change

- Engage top leadership
- Empower workforce excellence “champions”
- Provide adequate funding and resources
- Hold managers accountable

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STATEMENT OF WORK

The organizations that make up the Naval Research Enterprise are at the heart of an innovation process whose productivity will determine future U.S. Naval capabilities. A defining feature of the enterprise is interdependence. The capital resources and management skills supplied at the headquarters level by ONR are indispensable drivers of innovation. However, they will not suffice unless the pool of scientific and engineering talent across the entire enterprise is world class.

While the NRE today is a premier R&D entity, the factors that may jeopardize it's capacity to innovate are widely recognized. They include declining R&D budgets, personnel down-sizing, pending retirements, intensified competition from other organizations for world-class technical talent, a changing labor market, and a changing education and training pipeline for scientists, engineers, and technology workers.

As part of the Navy's response to these challenges, the Office of Naval Research (ONR) asked Building Engineering and Science Talent (BEST) to undertake a four-month effort to assess how ONR can best impact NRE's ability to attract and retain qualified candidates into NRE's total science, technology, engineering and mathematics (STEM) career pipeline. ONR asked BEST to include an assessment of the diversity of that pipeline, suggestions for extending the outreach where or when advisable to K-12 students, and a determination of which ONR education programs funded or managed by Code 363 demonstrate the greatest current or potential return on investment. In addition, ONR asked BEST to suggest what changes to ONR's/NRE's current investments and practices might provide NRE with the greatest return in short- and long-term recruiting needs.

The BEST team engaged in three types of activities to accomplish this effort: 1) interviews with ONR leadership, current and former managers of ONR's Code 363 education programs and "customers" of these programs within ONR, the Naval Research Laboratory (NRL) and key Warfare Centers1; 2) research of publicly available information on ONR/NRE programs; and 3) benchmarking ONR/NRE programs against best-in-class design principles emerging from BEST's Congressionally mandated study of program effectiveness.

More than seventy people were interviewed from late May through late August 2004. Some interviews were conducted privately with key individuals; others were conducted with small "focus groups" of knowledgeable employees. During many of these visits, BEST collected data and information on each operating unit's workforce needs, as well as recruitment and retention initiatives. BEST used a standard interview template designed to solicit interviewees' impressions and opinions regarding:

- The current and future workforce needs of the operating unit and the NRE

1 BEST conducted site visits at the Naval Research Lab (NRL), NAWC at Patuxent River and China Lake; NSWC at Indian Head; NUWC in Rhode Island; and SPAWAR in San Diego. We visited at least one of each type of Warfare Center, focusing on principal S&T sites.

- Whether and how their operating unit has done human capital planning
- Recruiting and hiring practices used by each operating unit and the NRE
- How their operating unit and the NRE address issues of diversity
- The workplace culture and environment within their operating unit and the NRE
- Whether each operating unit was aware, and took advantage of, the ONR programs
- Their perceptions of the value of ONR programs in their operating unit's and the NRE's current and future workforce needs.

The bottom line consideration BEST sought to address in this inquiry was ONR's return on investment (ROI). The operating definition of ROI that we used to measure the value of individual programs and broader initiatives was "the success of a program in attracting high-quality science and technology talent into the NRE or its university and corporate partners." This is a focused definition of return, encompassing both people and intellectual capital.2

Context

The NRE consists of several distinct and dispersed organizations: ONR, the Naval Research Lab (NRL) and the Warfare Centers. While these organizations have some common needs and interests, each entity also has specific needs, interests and operating practices. In addition, there can be significant differences in activities among individual locations within Warfare Center divisions, driven by geography and mission orientation. As a result, throughout the NRE, there are many and varied perspectives on, and methods for addressing, issues relating to recruitment, retention and workforce development.

To set the context for BEST's findings and recommendations, following is a brief overview of our observations about the various NRE organizations' skills needs, recruitment and hiring practices, and their use of recruitment, retention and pipeline programs.

NRE's Current and Future Skills Needs

The NRE's science and engineering workforce consists of approximately 20,000 employees. About 4,000 of these (the "S&T workforce") spend at least half of their time on science and engineering research funded by the 6.1, 6.2 and 6.3 accounts. ONR's priority interest is in the recruitment, retention and workforce development issues relating to this subset of 4,000 S&T employees. However, the BEST team found that the labs (NRL and the Warfare Centers) are equally concerned with recruitment and hiring challenges and strategies for the full range of scientists and engineers required to fulfill their missions.

A thorough analysis of the recruitment challenges facing NRE for this S&T workforce would require detailed, comprehensive and uniform data on this cohort that was not available.3 We therefore used the best available

2 Because most education programs in NRE do not define or track outcomes, measuring ROI in a traditional sense is not possible. Accordingly, BEST's definition of ROI focuses only on the success of a program in attracting talent, rather than how cost-effectively it does so.

3 A detailed description of the data sources used by BEST, analysis, and methodology may be found in Appendix A.

data to assess what the NRE's S&T recruiting and retention needs will be. Of the 4,000 total, approximately 2,200 work in the Warfare Centers, about 1,600 in the NRL, and about 200 at ONR headquarters. Of this 4,000, about 1,800 (45 percent) hold Ph.D.s: about 880 in the Warfare Centers, 820 at NRL and 100 at ONR.

S&T employment in NRL was highly concentrated in a handful of occupations: the top two —physicists and electronics engineers—account for just over half of all NRL scientists and engineers. The next five largest occupations—computer scientists, chemists, oceanographers, mechanical engineers, and aerospace engineers—account for another 25 percent of NRL scientists and engineers. In total, the top ten S&E occupations account for 5 in 6 jobs at NRL. The vast majority of NRL physicists, chemists, oceanographers, and meteorologists hold Ph.D.s; in contrast, most electronic engineers and computer scientists hold lower degrees.

Similarly in the Warfare Centers, employment is highly concentrated in a few occupations, though much more heavily weighted toward engineering than NRL's S&T workforce. In total, the top ten S&E occupations in the warfare centers account for 9 of 10 jobs at the Warfare Centers. These numbers loom larger when we note that the NRE requirement to hire from the pool of U.S. citizens who have earned S&E degrees creates another challenge: at the doctoral level, more than half the Ph.D.s granted in engineering, computer science, mathematics, and physics are earned by foreign students.

Top Science and Engineering Occupations Within ONR, NRL and Warfare Centers (Entire population—from DDR&E data):

Rank	Series	Series Description	Current Workforce	Series	Series Description	Navy Hiring Projections
1	855	Electronics Engineering	7,072	855	Electronics Engineering	1,784
2	830	Mechanical Engineering	3,361	830	Mechanical Engineering	609
3	1550	Computer Science	1,793	1310	Physics	342
4	861	Aerospace Engineering	1,503	1550	Computer Science	340
5	1310	Physics	1,084	801	General Engineering	328
6	801	General Engineering	884	861	Aerospace Engineering	230
7	854	Computer Engineering	854	1520	Mathematics	199
8	1520	Mathematics	583	854	Computer Engineering	165
9	850	Electrical Engineering	480	1320	Chemistry	131
10	1515	Operations Research	453	1515	Operations Research	121
11	1320	Chemistry	373	899	Engr & Arch Stud Trainee	110
12	871	Naval Architecture	272	871	Naval Architecture	106
13	806	Materials Engineering	265	850	Electrical Engineering	73
14	893	Chemical Engineering	237	806	Materials Engineering	65
15	896	Industrial Engineering	196	1360	Oceanography	48
		Share of Total			Share of Total	
		Top 5 Occupations	73.3%		Top 5 Occupations	68.5%
		Top 10 Occupations	89.4%		Top 10 Occupations	85.6%
		Top 15 Occupations	96.0%		Top 15 Occupations	93.7%

Hiring projections mirror the composition of the current NRE science and engineering workforce, similarly concentrated in a handful of occupations: electrical engineering, mechanical engineering, physics, computer science, and general engineering. These top five account for more than 68 percent of projected hires; the top ten occupations, 86 percent; and the top fifteen occupations, nearly 94 percent. Seventy-two percent of hires are projected to be in engineering occupations. The similarity in percentages may reflect the reluctance of NRE organizations to make hiring projections that go beyond replacing existing S&T employees; a reluctance that results both from years of down-sizing and budget cutting, and also from Navy guidance that the NRE's S&T workforce will not grow in the next few years.

In addition to these broader occupational fields, the Navy requires several highly specialized science and engineering occupations within its designated National Naval Responsibility areas: ocean acoustics, undersea weapons, and Naval engineering. Several hundred of these personnel work directly for the Navy and a few of its contractors at any given time. and according to a report by the National Research Council, several hundred of these individuals are in the science and engineering education pipeline at any given time. Two of the

Warfare Centers BEST visited—China Lake and Indianhead—face significant upcoming retirements in their technician workforce.

Education Pipeline Programs

During visits to various NRE organizations, the BEST team learned about dozens of small, medium and large programs devoted to recruitment and the education pipeline. The NRL, the individual Warfare Centers, and some of the ONR Program Offices have or are developing their own formal and informal recruitment and pipeline programs funded through a variety of sources, including their own budgets. Many of these programs have similar purposes and elements. Most NRE entities take advantage of some of the applicable ONR Code 363 programs, although the level of awareness and use varies considerably. Almost everyone interviewed said they found value in the programs that they use.

Recruitment, Hiring and Retention Practices

Organizations within the NRE use a variety of recruiting and hiring practices to meet their needs. For example:

- ONR primarily recruits experienced scientists and engineers, and relies almost exclusively on peer referral and technical conference participation for recruitment. ONR does not currently appear to experience significant difficulty in recruiting the talent it requires, but there is very little turnover at this level to propel hiring. Most managers interviewed believe the hiring process takes too long, and would like more help in identifying and marketing to a more diverse set of prospective candidates.

- NRL uses a wide range of recruitment methods, including peer referral, technical conference participation, job fairs, and advertisements. Among these, NRL considers peer referral to be its most successful recruiting strategy. NRL appears to hire a number of candidates from NRE's postdoctoral and student employment programs.

- The Warfare Centers use a variety of strategies to identify and recruit employees, including participation in job fairs, advertising, and building relationships with communities and universities (primarily regionally), as well as with universities with programs in Naval-specialty skills. In recent years, some of the Warfare Center Divisions have developed centralized recruiting systems, such as the "One NavAir" system for its 8 locations. The system is funded by a combination of a "tax" on the centers and a recruiting budget that pays for marketing, job fairs and giveaways. This centralization allows NavAir to recruit aggressively in many geographic regions, offers prospective employees a single face and image of NavAir, and provides a one-stop recruitment web site. NavAir maintained a data base of 14,000 resumes in 2004.

In general, the Warfare Centers are very engaged in their local communities. Many have long-standing relationships with universities specializing in Navy-relevant research. However, the geographic locations of some of the centers are generally homogeneous in their racial and cultural makeup, which creates a challenge in attracting and retaining a diverse work force in these communities.

In some parts of the NRE—and in particular ONR— there is a general, traditional assumption that the S&T workforce will remain in place because they "love the work". There is awareness across all organizations within NRE that younger employees are more likely to leave in the face of the small number of opportunities for promotion, a result of the relatively small number of positions (and therefore openings) at the most senior levels. Warfare Centers in more remote locations are concerned about attrition among young scientists and engineers, who often are interested in proximity to urban areas. Nevertheless, there are few retention programs or practices designed to address these issues, currently or for the future.

Role of Technical Managers and Human Resources in Hiring

ONR, NRL and each of the Warfare Centers has its own human resources organization, yet most of these organizations vest primary responsibility for recruitment and hiring in individual technical managers. Given the time and energy required to use the many and complex tools and processes available for aggressive recruiting, many managers rely on only one or two programs which they have had time to learn about.

Some technical managers responsible for Ph.D. hiring expressed a concern that the often passive nature of the recruiting process (relying on candidates to find and apply to posted vacancies) may result in less qualified candidates since NRE competes for the best and brightest candidates against private organizations with more aggressive recruiting strategies.

A number of those we interviewed expressed a desire for additional support from the human resources function, both in identifying potential candidates and marketing jobs, and in using the tools and programs available. In some parts of the NRE, and in ONR in particular, the human resources organization focuses primarily on the mechanics of the hiring process, such as developing position descriptions and advertising positions.

Many technical managers we met believe that the actual hiring process takes too long, and that candidates are often lost due to delays in processing. However, some organizations, such as NRL, have dramatically streamlined their processes.

Investments in the Education Pipeline

NRE has a rich variety of recruitment and education pipeline programs that, if used strategically, could position NRE as an "employer of choice," and increase NRE's ability to compete for high quality science and engineering talent.

These programs include ONR Code 363 programs and many more developed and/or used by ONR program offices, NRL and the Warfare Centers. They operate at all points along the education pipeline, with the potential to attract promising candidates from early education through undergraduate and graduate school, post-doctoral experiences and on to eventual employment within an NRE organization.

NRE education programs are currently managed in isolation, without connection to a human capital needs assessment or strategy.

Most of the Code 363 education programs, as well as others throughout the NRE, were not established for the purpose of recruiting talent into the NRE. Rather, they were created to strengthen public relations, or in response to a Congressional mandate or interest. With a few recent exceptions, none of the programs within the NRE define goals or outcomes, assess student or lab experience, or measure success in achieving results. The lack of connection to an overall strategy contributes to a lack of strong support for successful programs across the NRE.

ONR Code 363 programs are few in number and minimally funded, and several are not fully controlled by ONR. Therefore, as currently structured, they have a minimal impact on NRE recruitment.

ONR's "portfolio" of investments in education is quite small, funded at approximately $14 million in FY 2004. In addition, about half of the funds are invested in faculty programs—the Young Investigator Program and the Summer Faculty Research and Faculty Sabbatical programs—which support academic research partnerships, not recruitment and retention. In addition, a few of the well-known and widely-used programs are controlled outside of ONR, such as DOD's National Defense Science and Engineering Apprenticeship, or funded outside of Code 363, such as the NREIP. By themselves, ONR's education programs represent only a limited response to NRE's overall recruiting needs.

There is a knowledge gap at the corporate level about the extent and return on investment in recruitment and the education pipeline across the NRE.

Outside of the Code 363 programs, there is no NRE-wide accounting for the multitude of programs designed to seed the STEM pipeline or to support recruitment and retention. This has resulted in gaps in corporate knowledge of the overall investment and its return.

The lack of knowledge about these programs across NRE and at the corporate level, contributes to unnecessary duplication, complexity for applicants, missed opportunities, failure to disseminate "lessons learned," and inefficient use of resources.

There is duplication and lack of connection among the many education and recruitment programs of the ONR Codes, NRL and the Warfare Centers. Some programs are available to all NRE organizations, while others are available only to a limited subset. Program elements and requirements may be similar, overlapping or exclusive, creating an unnecessary level of complexity that makes it difficult for program managers–and students–to use the programs effectively and increase ROI.

Recruitment and Retention Practices and Incentives

Despite the barrier to competitive hiring posed by the length of the government hiring process, NRE has a relatively generous set of recruitment and retention incentives at its disposal.

Although NRE organizations (including NRL and many of the Warfare Centers) may not be able to match private sector salaries, many with approved personnel demonstration projects have greater flexibility to offer salaries that are more competitive with the private sector, both for entry-level employees and high performers. However, all parts of the enterprise have authority to offer repayment for student loans, recruitment and retention bonuses, and authority to fund employees' continuing education. There is a great deal of uncertainty regarding what policies will be adopted in the new National Security Personnel System, and some risk that NRE could lose flexibility in the new system.

Recruitment efforts are uneven across the NRE and dependent on the leadership of individual program managers and selecting officials.

NRE vests primary responsibility for hiring and recruitment in busy technical managers, and offers varying levels of support to these managers. Given the complex nature of ONR's education programs and recruitment incentives, NRE managers who do not have employee recruitment and development as their principal occupation may be unable to take the time—or have the patience—to become familiar enough with programs to use them effectively. Accordingly, awareness and use of Code 363 programs varies considerably among NRE organizations, and among technical managers within each organization.

Workforce Skills Needs

It is unclear, and a matter of some disagreement among those interviewed, whether or not NRE faces potential shortages in any key occupation.

Individual S&T managers have encountered problems recruiting for certain positions from time to time, and many said that they wished they had a larger pool of candidates from which to select. Understandably, this problem occurred more frequently in connection with Ph.D. hires. Some managers told us that they frequently

had only one candidate for any open Ph.D.-level position. In the current budget-cutting environment, the prevailing mindset is to hire only due to attrition, which complicates any analysis of future needs and the picture regarding potential shortages.

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NRE should develop a comprehensive, integrated human capital strategy that clearly defines NRE's current and future workforce needs, and outlines a strategic approach to meeting those needs. The N-STAR Strategic Plan has offered a blueprint for creating many of the components of a human capital strategy. NRE should make it a priority to bring together elements such as workforce data analysis, recruiting, student identification and development, and workforce retention and development, and weave them into an integrated, coordinated strategy.

A human capital strategy would place NRE's recruitment, retention and workforce development goals on an equal footing with other mission areas, and lay the groundwork for greater management attention to recruitment and workforce development. Strong leadership will be needed to manage the transition to a world-class recruitment and workforce building system, elevate the importance of these activities within NRE, articulate the importance of the strategy throughout NRE and to Naval leadership, acquire needed resources, and nurture the strategy over time.

Key steps in developing and implementing the strategy should include:

A. Complete a Comprehensive Workforce Needs Assessment for the NRE

Some very good work has been done in connection with N-STAR to create an understanding of he current and projected skills needs for the NRE's S&T workforce. It is very important that this work be completed so that NRE has the tools needed to match NRE's demand with the supply side education programs.

Creating a data set that allows a review of the occupational composition of NRE's S&T workforce, as well as the degree composition of each occupational group, is essential to determining NRE's true skills needs, and to developing a meaningful human capital strategy4. Having such data is critical to a comprehensive understanding of the challenges facing the NRE in meeting its workforce requirements and the effectiveness of the programs designed to help address these challenges. For example, many of the steps required to hire a Ph.D. physicist are different than those required to hire a bachelor's level mechanical engineer, and different programmatic responses are appropriate for each. In addition, it is important to understand issues such as workforce diversity and retirement eligibility by discipline (and by degree level within that discipline) in order to identify potential problem areas (such as looming high retirements in a Ph.D. specialty area).

For each occupational category within NRE, the data set should include: a breakdown of degrees among bachelors, masters and Ph.D.s, gender and ethnicity information, age and retirement eligibility, and distribution across each NRE organization.

4 A detailed description of the data sources used by BEST, analysis, and methodology may be found in Appendix A.

Once created, this data set will be an invaluable tool to help NRE track changes in its workforce from year to year, identify important trends, and address potential shortages and problems.

B. Create an Integrated Portfolio of Education Programs that Addresses NRE's Strategy

1. Establish educational investment criteria to align ONR/NRE investments in education programs with "best in class" design principles

a. Inventory existing programs across NRE; set priorities according to NRE's priority needs

The inventory's purpose would be to provide information about what initiatives and activities are in place, what is their purpose and what ONR, NRL or Warfare Center needs are being met, numbers of NRE staff and external participants engaged, cost and funding sources.

Once the inventory is complete and assessed within the context of Federal budget constraints, research and application demands, and expected increase in NRE recruitment and direct hires, NRE's strategy and portfolio of programs should focus on three priorities:

- Direct recruiting of candidates into the NRE
- Building skills for future NRE recruitment, and to support NRE's academic partners and private sector contractor base
- Filling the science and engineering workforce pipeline generally, focusing on early identification and development of young candidates to pull them into the NRE pipeline

In setting priorities, NRE should pay particular attention to ensuring that it has programs in place to attract Ph.D. candidates to the NRE. Although no areas of "shortage" have yet been identified, many managers complained that they typically have a small pool of applicants from which to choose. This could indicate that NRE is not attracting the best candidates, and could be an early indicator of a more serious problem. Given the continuing decline in U.S. citizens pursuing Ph.D.s, the situation is likely to worsen within the next few years. Within NRE's Ph.D. occupations, particular care should be given to recruitment of physicists, given the large number of Ph.D. physicists currently employed by NRE, and the serious decline in the number of physics degrees awarded to Americans.

Other occupations on which NRE is heavily dependent—at all levels—include electrical and electronics engineering, mechanical engineering, and computer science. As NRE sets priorities, it should also give special attention to ensuring it is attracting individuals in these disciplines. (For a full discussion of these issues, see Appendix A).

b. Apply Fundamental BEST Design Principles

All education programs included within the new portfolio should include BEST principles for effective intervention in the science and engineering pipeline:

Defined Goals and Outcomes: Most of NRE's current programs were not designed with recruitment and retention goals in mind. The starting point for creation of a new portfolio of NRE-wide recruitment programs is applying a consistent set of goals that contribute specifically to recruitment objectives, combined with outcome measures that are appropriate in the new context.

Challenging Content: Program content is a key determinant of whether students who participate in NRE-sponsored fellowships, internships, and other work and learning experiences will be attracted to NRE employment. Content should go beyond minimum competencies, should be consistent with local and national standards appropriate to the student's education level, and should relate to real-world, Navy-specific applications.

Personalization: A key goal of the programs should be development of students as individuals. Mentoring and peer interaction should be integral parts of NRE programs, and individual differences, uniqueness and diversity should be recognized and welcomed. Attention should be given to selecting mentors who interact with NRE program participants, and ensuring that participants have positive experiences.

Engagement: The full support and engagement of technical professionals—both within NRE and within participating universities and private sector partners—is a key determinant of a successful program. Scientists and engineers who serve as teachers, mentors and coaches for participating students and fellows provide needed support, set expectations, and stimulate interest among the participants.

c. Bring the pipeline programs to bear at key intervention points in the student education pipeline

To maximize the value of NRE's pipeline programs for meeting NRE's recruitment goals, mechanisms should be developed to: engage students at key decision points in the education pipeline; track their progress through NRE programs; connect them with follow-on program opportunities; and continuously market NRE experiences and opportunities to them.

d. Use outcome-based metrics to measure program effectiveness, including tracking program participants

Most of the key ONR programs are administered through contract with outside organizations. ONR/NRE should immediately begin to require these performing organizations to track participants in

the programs, and to the extent possible, to produce tracking information for previous program participants.

This tracking information should include whether each student continues to participate in the next level of NRE-sponsored programs; whether each student completes an undergraduate degree; whether the student continues graduate studies and earns a Ph.D.; and ultimately, how many of these students become NRE employees, or employees of NRE's academic or private sector contractors. There are a few programs, such as Code 333's University/Laboratory Initiative that have begun to do this. All programs should measure, at a minimum, the number of student participants who entered the NRE as employees (by discipline and level), and should include student GPAs, as a basic indicator of quality.

d. Make existing pipeline programs simpler, more flexible and easier to access and use

NRE has excellent basic legal authorities, programs and tools with which to develop a world-class portfolio of incentives to attract promising candidates into the NRE pipeline at an early stage, and to pull them through undergraduate, graduate and possibly post-doctoral experiences, and to eventual employment with an NRE organization.

In addition to linking NRE's existing programs to its strategy, ONR/NRE should take steps to simplify and streamline existing programs, and reduce the complexities currently faced by NRE managers as they seek to recruit prospective employees, and as potential candidates seek support for their education, or internship and career opportunities. Recommendations 2-4 below contain several suggestions for accomplishing this goal.

2. Re-direct Code 363 Pre-K-12 funding to programs more closely connected to NRE needs and interests

There are hundreds of government, corporate, and community programs nationwide offering pre-college students exposure and encouragement to pursue science, engineering, and technology careers. ONR should consider, given its priorities, what the organization can do in this space that makes a difference, first for its extended enterprise, and secondly for the country at large. ONR is currently investing about $1.5 million in pre-K-12 programs, all in national programs which ONR does not control, and which are not currently connected to ONR/NRE's recruitment goals. Where NRE does make a difference in this area is at the individual laboratories and Warfare Centers, where many NRE employees are actively engaged in their local communities. We believe ONR has two options:

a. Eliminate ONR sponsorships for the current collection of science fairs, awards programs and the Jason Project, and re-direct those funds to programs directed toward undergraduate and/or graduate students, OR

b. Re-direct these funds to NRL and the Warfare Centers, according to an NRE-wide strategy (to be developed by ONR, NRL and the Warfare Centers) for more effective use of funds for local/regional partnerships among the laboratories and schools, and early identification of candidates for NRE attention

3. Concentrate ONR's Limited Resources on Internship Programs; Consolidate and Re-Structure Internship Programs at all levels (SEAP, SEAP/CQL, NREIP), according to "best in class" design principles

a. Consolidate ONR Code 363 funding, ILIR and lab funds for NREIP, etc.

There are currently at least seven programs within the NRE offering internships or other kinds of summer work experiences to students of all levels. NRE should focus on consolidating these disparate funding streams, and creating a new program that combines the best features of the others. For example, SEAP is limited by failure to pay housing and transportation costs. NREIP is limited by its focus solely on NROTC universities, and by the uncertainty of continued program funding. Neither of these programs allows non-competitive hiring of interns, as does the Federal government-wide Student Career Intern Program. Incentives for professors also should be added to these programs to encourage professors to send NRE their best students. Several of the newer internship programs within the other ONR codes have adopted this approach, and it has proved successful.

ONR/NRE should consolidate and re-structure these programs to create, to the greatest extent possible under governing authorities, a single simple internship program, which can be customized for the needs of each hiring manager and student, according to a menu of options. NRE should convene a design group (including, for example, current/former interns, mentors from participating labs and schools) to develop a program template for this new initiative.

b. Strengthen mentoring components of Internship programs, and develop NRE-wide guidelines and practices regarding mentoring of student interns

Mentoring is an extremely important component providing value to an internship experience for the student, and determining whether the student will remain interested in the field of study and/or the NRE over time. If NRE wishes to increase the number of interns who eventually become NRE employees, it needs to give significant attention to ensuring that NRE interns have positive experiences. Setting guidelines for mentor selection, defining mentor qualifications and responsibilities, offering training and mentor support, and collecting data on this aspect of the programs is important.

4. Add program components into existing and future NRE education programs that reinforce the connection to the Navy and measure program ROI

a. Track, evaluate and model new programs that exemplify this approach, specifically the University/Lab Initiative (Code 33) and the N-STAR/NSF partnership program.

b. Add Navy-related research interests and service commitment to criteria for selecting Navy fellows for the DOD National Defense Science & Engineering Graduate Fellowship (NDSEG)

c. Add an NRE service component to HBCU/MI Future Engineering Faculty Fellowship

d. Create pathways between programs to keep students connected to the NRE

Well-designed programs should identify students as early as possible in their education, pull them into NRE-sponsored programs, and create a pathway for them to continue in their studies, while building a relationship with NRE. For example, undergraduates who participate in summer internship programs could become N-STAR fellows or pulled into other programs for graduate study.

e. Hold annual conference to showcase participants and research from these programs, in order to strengthen awareness and connections among NRE employees and students.

5. Re-direct funding for faculty programs toward programs more closely aligned with recruitment objectives; fund university R&D partnerships through R&D—not education—budgets

While ONR's Coded 363 faculty programs are worthy endeavors for strengthening science, engineering, and technology faculty at U.S. universities, and ensuring that research desired by NRE is performed, their linkages to NRE/ONR recruitment needs are much weaker than the programs directed toward students. These programs should be funded from R&D accounts, rather than from accounts set-aside for recruitment and the education pipeline.

C. Develop an NRE-wide Approach to Expand the Demographic Pool from which NRE Draws

1. Review current use across NRE of mandated 5% funds for HBCU/MIs

There appears to be considerable flexibility in ONR's ability to set priorities within the HBCU/MI funding parameters, and therefore, an opportunity to re-direct some of this investment toward more aggressive outreach to the minority student community. Using some HBCU/MI funds to support the participation of minority students in NRE's internship and fellowship programs would be extremely valuable.

2. Expand relationships with women and minority-serving institutions and organizations

a. Potential minority science and engineering institutions:
One key to expanding NRE access to minority students is forging partnerships at the national level with organizations that have in-depth knowledge of minority-serving and majority institutions that are leading producers of minority talent. NRE will want to focus on top producers of minority technical talent in key disciplines of importance to NRE, such as electrical and mechanical engineering, physics and computer science.

At the undergraduate level, one potential partner is the National Action Council for Minorities in Engineering, the largest private source of scholarships for African American, American Indian and Latino men and women in engineering. NACME, whose president is a member of BEST's National Leadership Council, has provided more than $100 million in undergraduate scholarships over the past 25 years. It has institutional partnerships with 22 colleges and universities in about a dozen states, including HBCUs and top technical schools such as Georgia Tech and RPI. NACME appears to be a natural partner for NRE in identifying promising candidates for NRE pipeline programs and their support mechanisms, for cooperation in HBCU capacity building, as well as for recruiting newly training engineers for employment in NRE.

At the graduate level, the Alfred P. Sloan Foundation has been nationally recognized for its success in supporting successful African American, Hispanic, and Native American Ph.D. candidates in science and engineering. The Foundation has created a rich network of committed faculty members across the country who have agreed to supervise doctoral candidates in disciplines that are of core interest to ONR. A partnership with the Foundation has the potential to give the NRE a competitive edge by leveraging its resources through a proven feeder system.

Other potential partner organizations include: American Indian Science and Engineering Society, National Consortium for Graduate Degrees for Minorities in Engineering and Science, National Society of Black Engineers, Society for the Advancement of Chicano and Native American Scientists, Society of Hispanic Professional Engineers, and Society of Mexican American Engineers and Scientists. These groups have formed a coalition—a potential intermediary organization with substantial reach into the minority community—the National Coalition of Under-represented Racial and Ethnic Advocacy Groups in Engineering and Science.

b. Potential women's science and engineering organizations:

Comparable resources can be accessed to expand relationships with institutions that are national leaders in producing undergraduate and graduate women in technical fields. In the engineering arena,

the Society of Women Engineers (SWE) and the Women's Engineering Professional Network (WEPAN) maintain active data bases and strong ties to engineering schools nationwide. The Henry Luce Foundation also supports a program exclusively dedicated to women in engineering which could provide a valuable resource. Similarly, the American Chemical Society, American Physical Society, and Association of Women in Science (AWIS) could help NRE target a core group of leading institutions. Since women earned 57% of baccalaureate degrees awarded last year, the NRE has a compelling interest in cultivating this source of technical talent.

As with under-represented groups, it also will be important for NRE to partner with individual universities that excel in producing technical talent in NRE's top disciplinary areas, and a track record of graduating women. For example, the computer science program at Carnegie Mellon has a reputation for technical excellence, as well as for graduating larger numbers of women.

4. Consider NRE career potential of other non-traditional groups

There are other groups of potential candidates—both for direct hire and for NRE's pipeline—that are underserved by NRE's portfolio. These include: military personnel who are leaving active duty service, science and engineering personnel who have been laid off by private employers (such as the numerous IT workers who lost their jobs during the dot.com boom and as a result of off shoring), and career changers.

Furthermore, there are students—especially students of lesser financial means— who begin their college education in the community college setting. Some U.S. community colleges have programs that begin to prepare students for technical careers or prepare them to move to four-year universities to pursue technical degrees there. In addition, students increasingly participate in other non-traditional forms of post-secondary technical education, including on-line learning and at private, for-private learning institutions. It is unclear whether NRE currently considers such students of interest, or attempts to identify candidates following increasingly popular non-traditional education paths.

D. Develop and Expand NRE-wide Tools and Resources to Support Recruitment, Recruitment, Retention and Workforce Development

1. Recruitment

a. Create a data base to expand NRE access to qualified candidates

Although NRE organizations often cannot hire new employees in anticipation of needs, it can address this challenge by creating a shared data base of qualified candidates, that can be searched when a job opening occurs, and so that candidates who are not a good fit for one organization's needs can be introduced to other NRE organizations. Each NRE organization could serve as an "intake" valve for an overall system in which NRE organizations would share information about needs, job candidates, and NRE employees who are interested in new opportunities within the NRE system.

NAVAIR has developed such an initiative, and NUWC in Newport has a similar system, operated by Rhode Island University.

b. Create a one-stop web portal for job announcements, pipeline programs and candidate recruitment

NRE should consider emulating the "one-stop shop" recruitment website of many high-tech companies, that provides information and direction to all prospects with an interest in NRE—from recent college graduates and experienced technical workers seeking employment with NRE, to current employees seeking to access NRE's academic support programs, to high school students seeking academic or career guidance, to undergraduates seeking scholarships, internships or summer employment.

2. Retention

a. Develop and implement an NRE-wide mentoring program geared to the needs of entry-level and mid-level employees

b. Embrace diversity by including support mechanisms in everything NRE does (affinity groups, performance measures, newsletter, mentoring, etc.). NRE should replicate existing programs from within NRE, such as those in Indian Head, that help under-represented groups make the adjustment within the lab and the community.

3. Workforce Development

a. Benchmark, and hold information sessions for managers, on workforce development practices in other organizations, including: Federal agencies and business

b. Add performance measures for workforce development to all manager jobs and hold managers accountable for results

c. Create an Executive Development Program to groom senior managers for SES

d. Expand programs like ESDP or NPP NRE-wide to provide work orientation and business training skills to technical workers

e. Survey Program Officer interests in research and derive program to respond to that, building on or eliminating ROPO.

4. Establish an NRE-wide Capability to Support Recruitment and Hiring

NRE should consider creating a modestly sized dedicated capability to assist technical managers in implementing NRE's human capital strategy. NRE organizations vary considerably in the level of support they offer individual program managers and selecting officials involved in recruiting. Because managers and supervisors have other responsibilities, it places an undue burden on them to become experts on the mechanics of the pipeline programs in order to meet their own recruiting needs.

These experts would also be responsible for monitoring developments in the labor market for scientists, engineers, and technical personnel to identify opportunities (such as layoffs in an industry known for having personnel desirable to NRE organizations), and to spot potential trouble (such as rising salaries, tightening labor markets, or declining enrollments in key technical fields). These experts would operate like corporate headhunters and benchmark their operations against those headhunting operations in other technical worker – intensive "employers of choice."

The NAVAIR National Recruiting Program has many elements of a strategic and integrated approach that could be incorporated into NRE component organizations' efforts, for example, command-wide alignment and efficiency, and a "One NavAir" image with prospective employees. NSWC also has a specialized unit focused on hiring scientists and engineers, and will have some "lessons learned" to apply to developing these capabilities NRE-wide.

5. Market NRE as a "Great Place to Work"

The need for improved marketing of ONR's pipeline programs—both internally and externally—was a strong theme throughout the interviews. In addition, better marketing of job opportunities within NRE, as well as the positive attributes of the communities in which NRE facilities reside, appears needed.

a. Create a positive and compelling NRE brand

Recruiting and advertising are inexorably linked. NRE must sell itself as an "employer of choice" to potential recruits by creating a positive and compelling identity for NRE. NRE has much to attract scientists and engineers: exciting research, opportunities for travel, an ability to "make a difference" in the nation's security. NRE should define its key recruitment messages and develop a robust, high-impact marketing campaign that includes attractive, informative and engaging print materials and a one-stop website that leaves recruits thinking, "NRE is the place for me."

b. Craft targeted campaigns to attract key audiences (gender, ethnicity, disability, tech area, veterans), and engage students at all levels with ongoing, age- appropriate, relevant communication. This should include featuring specific benefits that would appeal to different groups, for example, flexible work hours for working parents

c. Market ONR and other NRE programs within the Navy

1. Provide funds for promotional materials/give always
2. Consider internal communications programs in other organizations
3. Promote information exchange among ONR, Warfare Centers and NR, and distribute news regarding recruitment initiatives and program success

e. Make a sustained commitment to change

NRE—and ONR in particular—has given significant attention to the challenge of ensuring that NRE can attract, recruit and retain the science and engineering talent it needs to remain a premier R&D organization. There have been four studies since 1997 on ways NRE (or ONR) can improve its workforce development, diversity and pipeline programs, and incremental improvements in these programs and practices have been made. However, it appears that workforce development has not been fully embraced as a priority at all levels and parts of the NRE. For example, our interviews throughout the NRE revealed that employees are not uniformly encouraged or rewarded for recruitment efforts, nor penalized for lack of them.

BEST believes that in order to increase the NRE's capacity to gain access to and attract high-quality technical talent, NRE needs to undertake a major effort to drive systemic change, conducted at the enterprise level (rather than led by one of NRE's operating units). NRE needs to formally adopt as a priority "mission" the goal of ensuring it can attract, retain and develop a science, engineering workforce necessary to support Naval science and technology. This mission should be backed up with a set of principles and guidelines providing broad, high-level direction to NRE managers and supervisors.

The process of developing and implementing a human capital strategy to address NRE's needs certainly will be a significant undertaking; yet the BEST organization has studied many organizations now considered to be leaders in science and engineering workforce development, that have previously faced and overcome the challenges now faced by NRE.

Like other change efforts, developing and implementing the management, financial, programmatic and cultural changes necessary to recruit and retain a world-class workforce is a formidable challenge, particularly in the S&E workplace. The traditional S&E organizational culture is hierarchical, patriarchal, and closed. Making real change requires institutional commitment with leadership from the top, backed by meaningful action, closely linking S&E recruitment and retention goals to organizational strategy, holding management accountable for meeting recruitment and retention goals, and a commitment to continuous improvement.

There is no "one size fits all" approach, and like other organizations, NRE will need to develop its own unique strategy and portfolio of tools and incentives to meet its needs. However, through our prior research, BEST has identified four fundamental principles that characterize successful science and engineering workforce recruitment and retention programs. Successful sponsors:

- Build their programs on a solid business case that communicates why the workforce development program is good for all individuals and the organization at large, and fully integrates recruitment and retention goals into their business strategy.

- Make a long-term, sustained commitment at every level of the organization, to create systemic change within their organization. This particularly requires strong, involved, and continuous leadership from the top of the organization. Frequently, this means the ongoing personal involvement of the chief executive, and/or identifying and empowering "champions" for change, who are responsible for carrying out the plan, and engaging the support of others. This also requires devoting the time and financial resources necessary to implement the program.

- Put systems in place to measure the effectiveness of their efforts, and hold managers at all levels accountable for results. This means creating rewards and incentives for progress toward workforce development goals, as well as penalties for erecting barriers to change.

- Regularly evaluate and adjust their programs to make them more effective.

These features create the conditions that will make implementing best practices possible in any organization. None of these "principles of excellence" works in isolation. Organizations that have succeeded in increasing S&E diversity developed and implemented a comprehensive, holistic strategy, on which programs and initiatives were built to permanently change their organizational culture.

To apply these principles, the NRE will first need to make a visible and sustained commitment to change, including the following key elements:

1. Engage Top Leadership. The Admiral and key technical leadership within ONR, NRL and the Warfare Centers will need to make developing and implementing a human capital strategy a top priority, and communicate that message frequently to all audiences from top to bottom of the NRE. Top leadership will need to "walk the talk," both communicating the importance of these issues in a variety of ways, and also to put systems in place that make it more likely that change will occur.

2. Empower Workforce Excellence "Champions." Successful efforts can only be conducted at the corporate/enterprise level, not within a single operating unit. Because of the dispersed nature of NRE operations, top NRE leadership must empower an individual or a team to lead the effort for the entire enterprise and provide the support necessary to develop and implement a human capital strategy for NRE.

3. Provide Adequate Funding and Resources. If recruitment, retention and workforce development are to be top priority missions of NRE, then NRE leadership must find financial resources adequate to support strategy development and program implementation.

4. Hold Managers Accountable. Exemplary organizations recognize that systems of accountability for workforce excellence are necessary to achieve results. These organizations put systems in place to hold managers at all levels personally accountable for meeting diversity objectives, and to pressure all operating units of the organization to perform. NRE also should create a set of meaningful incentives to reward employees who excel in meeting recruitment, retention and workforce development goals.

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ANALYSIS OF ONR AND NRE EDUCATION PROGRAMS

ONR asked for BEST's assessment of "what's working" among the education programs funded and/or managed by Code 363, in terms of the return-on-investment for short and long-term recruitment of NRE's science, engineering and technology workforce. However, there are no real answers to these questions, for the following reasons:

- Most of the Code 363 programs were not established for the purpose of recruiting individuals into the NRE; rather, most were created to strengthen public relations or in response to a Congressional mandate or interest.
- The programs do not have defined outcomes specific to the Navy, nor outcome-based measures, systems or practices to collect such data.
- Several programs, and almost half of the funds, support temporary research opportunities for university faculty in ONR, the NRL and the Warfare Centers. While these programs have obvious benefits for the NRE, they have little relevance for S&T pipeline development.
- Awareness and use of these programs is inconsistent across the NRE, for reasons that have little to do with potential program value. In addition, there are varying and incorrect assumptions within ONR and other NRE organizations about program purpose, use and funding that lead to confusion about what these programs are expected to accomplish.
- Finally, it is difficult to analyze a set of programs in isolation, when the environment in which they operate is filled with similar, competing initiatives. Individual ONR codes, the NRL, and the Warfare Centers each have developed or participate in education programs that are specific to their mission, their geographic location, funding opportunities, or special directives. The extent and cost of these programs is unknown, and this information is necessary in order to determine the ROI of the Code 363 programs.

Given these circumstances, reviewing the Code 363 programs for purposes and characteristics (such as impact on recruitment) that have not formed part of their establishment or management is not possible or useful. What can be useful is to examine the role they have played, whether they have been used (and why or why not), and whether they are considered to be of value for the short and long-term interests of the NRE. We also note suggestions for changes to the programs that may help serve to transform them into producing a clear return on investment.

Taken together as a unified portfolio, the Code 363 and other NRE education programs constitute a wide variety of responses to the challenges of the so-called "STEM pipeline." If used strategically, this portfolio of NRE-wide programs has the potential to attract promising candidates to the NRE pipeline in early education, to keep them "connected" to the Navy through undergraduate and graduate education and post doctoral

experiences, and to attract them to eventual employment within the NRE or in an NRE-related university or contractor.

On the other hand, both the Code 363 portfolio and the other programs lack an overall strategy, driven by the NRE's needs and supported by an integrated operation. Some programs are available to all NRE organizations, others are not. Some are well known by all entities within NRE, others are not. A number of Navy lab personnel noted that the "rules of engagement" differ for each so it can be hard to integrate and co-ordinate them for an individual site. Much work is needed to take the basic legal authorities and program structures and create a new portfolio of flexible, streamlined and easy-to-use programs to recruit, retain and develop NRE's S&T workforce.

Outreach to Increase Diversity

Diversity is a concern to all entities across the NRE, both in terms of the demographic make-up of the future workforce and the value of a diverse workforce in general. Many of the labs and the ONR program offices have initiatives in place focused on recruiting a diverse workforce. With regard to the Code 363 programs in particular, however, none of these was established with goals or measures to drive participation by under-represented groups (some do state that women and minorities are "encouraged" to apply). In cases in which program data is available for particular labs, the representation tends to reflect the make-up of the S&E student population in general. As a result, BEST has not singled out this component in the following program analysis.

Conclusion

One of the more striking aspects of these programs is that each has been initiated, structured, managed, and funded in isolation, and in the absence of an overarching human capital strategy. It is therefore not surprising that the programs are supported by different constituencies for different purposes, and that there is significant overlap and duplication in the total NRE program portfolio.

In general, programs were established with no defined outcomes or expectations, other than that they provide scholarship funds, stipends and/or internship opportunities to individuals who compete for these on merit. From this "outreach" perspective, the programs have been successful. The challenge to transforming them into programs that respond to new interests and needs - defining outcomes and measures, revising requirements, adding systems for collecting data, and possibly altering management and funding – lies in the multiple authorities, funding sources, and cultures that oversee and benefit from these programs.

To maximize value and return on investment from these programs, they must be closely linked to NRE's needs and to an enterprise-wide strategy for meeting those needs. Rather than continuing to manage the current set of programs—both within Code 363 and other parts of the NRE—in isolation, NRE should consolidate and re-structure programs that are similar and overlapping. In addition, NRE should simplify the portfolio, and make programs simpler, more flexible and easier to use.

The discussion that follows provides suggestions for improving some of the individual programs, but more importantly, for taking the steps necessary to use the existing programs, tools and legal authorities as building blocks from which to create a new and stronger program portfolio that is tightly linked to meeting NRE's needs.

We begin with the programs – and budgets – of the Code 363 portfolio. After a brief description and comments about each of these, we describe programs from other organizations within NRE focused on the same target population.

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Code 363 Corporate Programs

Pre-College Science Fairs and Awards Programs

- Naval High School Science Awards Program (NSAP)

Internships

High School and Undergraduate

- Science and Engineering Apprentice Program (SEAP and SEAP/CQL)

Undergraduate and Graduate

- National Defense Science and Engineering Graduate Fellowship (NDSEG)
- Naval Research Enterprise Intern Program (NREIP)

Graduate and Post-Doctoral Fellowships

- National Defense Science & Engineering Graduate Fellowship Program – NDSEG
- HBCU/MI Future Engineering Faculty Program

Other HBCU/MI Programs

- HBCU/MI Education Programs

Faculty Programs

- Faculty Summer/Sabbatical Leave Research Programs
- Young Investigator Program (YIP)

Employee Development

- Research Opportunities Program Officers (ROPO)

Code 363 Education Programs ONR Code 363 Funds Other funds *(data from Code 363; ASN RDA S&T Review)*	**FY03**	**FY04**
NSAP: Naval High School Science Awards Program *(Includes JSHS, ISEF, science fairs; NOSI; NOPP)*	$1,042,000	$938,000
JASON Project *(Curriculum/program to interest pre-college students in science, math and technology)*		$570,000
Science and Engineering Apprentice Program (SEAP/SEAP-CQL) *High School and Undergraduate Interns*	$500,000	$450,000
Naval Research Enterprise Interns (NREIP) *Undergrad & Grad Interns* FY04 additional interns funded by NRL & WCs	$1,500,000	$828,000 ILIR funds
DOD National Defense Science & Eng. Graduate Fellowship (NDSEG)	ONR URI Funds	AF URI Funds
HBCU/MI Graduate Future Engineering Faculty Fellowship	$500,000	$1,350,000
Faculty Summer/Sabbatical Leave Research Program (Navy funding; ONR budget funds HBCU/MI participants)		$1,000,000 *for HBCU/MI participants*
Young Investigators Program (YIP)		$7,500,000
Research Opportunities for Program Officers (ROPO)		$600,000

CODE 363 - NSAP: Naval High School Science Awards Program
Budget [inclusive]: FY04 $938,000; FY03 $1,042,000

Regional, District and State Science and Engineering Fairs
International Science and Engineering Fair (ISEF)
National Ocean Sciences Bowl – ONR is a funder.
The National Oceanographic Partnership Program (NOPP) – no 363 funding
Junior Science and Humanities Symposia – JSHS [Army, Navy, Air Force]

The services take turn sponsoring this program; ONR is the sponsor in spring 2005. More than 10,000 students participate in the 48 Regional Symposia held on university campuses across the country and in DOD schools in Europe and the Pacific.

In addition to the science fairs and awards programs funded by ONR Code 363, there are a wide variety of diverse tools and programs across the NRE focused on pre-college students. These programs tend to be driven by the local interests and needs of the particular lab or Warfare Centers and include: work experiences, seminars and symposia, education and promotional material, tuition and scholarship funds, tutoring, mentoring, lab tours, equipment donation, release time for NRE personnel to teach in high school or work with high school students and their teachers, and more.

While many of these and other activities are worthy, politically and publicly popular, and often focused on the national imperative of building the science and engineering pipeline in general, the national level science fairs and awards funded, in part by ONR, have only tenuous links to the Navy. Further, because ONR is a sponsor or, at most, a periodic "host" organization, it does not and cannot exercise control over the parameters of these programs. For instance, ONR cannot influence whether or not these programs aggressively seek out participants from economically disadvantaged schools.

As one staff member commented, ONR is "small potatoes" in the big world of pre-college science and engineering initiatives, lacking the resources to compete with the private sector or Federal agencies like the NSF. It is on the local level, where personal relationships and local access are possible, that participation in this type of program can have the greatest return.

Given the likelihood that such activity will continue, there is value in developing a data base of what programs are in use, with what funding, partners, measures, or other systems that have the potential to lead to reduced cost and or improved outcomes. Measurement and evaluation of these programs should focus on: candidates entering NRE pipeline programs, increases in the awareness students have about NRE, and increased interest in pursuing a science, engineering or technology career within the NRE.

Other Pre-College Programs

- Code 33—Code 33 invests $3.3million per year for naval engineering. Approximately 30% of these funds go directly to education programs, including outreach at all education levels. They focus on 9th graders, and are developing a "Call of the Sea" CD to promote careers in naval engineering. This CD is sent to high school guidance counselors, and then Navy personnel follow up with them.
- Code 34—*Timbuktu Academy at Southern University* connects elementary, high school and college kids to improve science and math skills. It is an award-winning program, but it doesn't provide a connection to Navy.
- NRL—*Partners in Education* is designed to enhance student knowledge in mathematics, science, technology and citizenship. The program involves 10 schools in a formal program, with activities such as tutoring, mentoring, role models, career awareness programs, science fair judging, laboratory tours, and equipment donations. NRL also provides similar support to schools in NRL's region on an informal basis. In FY 2003, NRL devoted 1450 person hours to these activities, down from 2275 hours in FY 2000 and FY 1999.
- Indian Head—*Project "Lead the Way" is a science development and education program focused on middle school; NSF grant to look at tech education development program w/ local school system; Materials World Module program*
- Staff also participate in science fairs, programs with elementary schools, mentoring program that work with students in local high schools. Also plan to bring teachers into base and Warfare Center personnel demonstrate what they do.
- China Lake –*Expanding Your Horizons* is national program for middle school girls interested in S&T; a local chapter was started by their female scientists.
- Federal Government-wide *Student Career Experience Program (SCEP)*—Tuition assistance is available to students, along with travel and transportation expenses. High school and college students are eligible. SCEP students can be hired into NRE positions without competition, which many NRE organizations found advantageous.

CODE 363

Science and Engineering Apprentice Program-CQL (SEAP-CQL) *Initiated by DOD in 1980*
Places high school students with interest and ability in science and mathematics as apprentices in DOD laboratories for 8 weeks during the summer, with stipends of $1400+, working with scientists and engineers who act as mentors. Over 35 Navy and Army laboratories currently participate. In FY03, 217 high school students participated at 15 Navy labs; 32 college students participated. Extending this program into college allows SEAP high school mentors and students the opportunity to continue their association during their college years.

Naval Research Enterprise Intern Program (NREIP)
Designed by ONR with a pilot in 2002, this 10-week intern program is to provide opportunities for undergraduate and graduate students to participate in research, under the guidance of an appropriate research mentor, at a participating Navy laboratory (Participating Labs are in CA. FL, MD, MI, NJ, PA, RI, VA, and Washington DC. Students must be enrolled at university with NROTC programs. All majors relevant to the research interests of the laboratories are eligible. NREIP stipends are $5,500 for undergraduates and $6,500 for graduate students.

FY03 – 1,825 applicants; 203 undergrads/51 grad students participated

FY04 - 223 in labs now; 30 have been extended for some weeks, 7-8 have been offered jobs. Funding for this year (FY04) came from ILIR budget line item and only paid for 134 interns; labs funded the others.

Internship programs from all sources – ONR's SEAP and NREIP, Federal agency-wide programs such as SCEP (Student Career Employment Program), and others–are widely used and valued across all organizations within the NRE. These programs share characteristics that serve the interests of both students and NRE organizations, providing financial support and engaging work experiences for the students and an opportunity to showcase Navy research and benefit from youthful perspectives for the NRE. Further, most of these internships cut across multiple stages of the education pipeline – an important characteristic because it offers the opportunity for a student to move through multiple education levels while participating in the same program.

Staff in a number of the labs argued that intern programs on the college level are very important in recruiting, because they promote name recognition for the lab – a key factor in attracting graduates. A number of lab/university partnerships are motivated by this issue, such as the NUWC (Newport) collaboration with the University of Texas (Austin) in nanotech. One of the program associates at ONR expressed the view that the

loss of the undergraduate and graduate-level intern programs would lead to a loss of their "mentor pipeline", with its benefit of cross-pollination among Navy, academia and industry.

Mentoring is an especially significant component in the value of an intern experience for the student and in whether the student will remain interested in the field and/or sponsoring organization over the long term. The mentoring process in the NRE is not defined or practiced uniformly; although many of the labs have both formal and informal mentoring programs for new employees (as NavAir does), as well as for interns or fellows on a summer assignment. In many of these instances, the lab coordinators and scientists decide jointly on who will act as mentor, but it is not clear whether the person selected always is well-suited to this role. Acting as a mentor is viewed by many as diverting lab time away from more senior researchers and, at the Warfare Centers and NRL, from efforts to acquire research funds.

Both the SEAP and NREIP programs have large numbers of student participants, but the incentives they offer for both students and labs are weaker than other programs: for example, they do not offer tuition assistance or non-competitive conversion to Federal employment upon graduation, such as the Student Career Experience Program, the Defense Career Intern Program, or the forthcoming ONR/NSF Partnership program developed under N-STAR.

Because SEAP does not offer transportation or housing assistance, it is effectively restricted to students who live near participating labs. Several staff in ONR and the labs commented on the importance of adding these incentives, in order to increase the NRE's competitive position. NREIP has been in wide use since its inception as a pilot in 2002, although its unstable funding is a drawback. Several NRE staff also advocated eliminating the NROTC requirement for university eligibility.

Despite their appeal, both SEAP and NREIP warrant review on several counts:

- Adding incentives for professors: A number of NRE staff with whom we spoke commented on a barrier to attracting interns: university professors already involved with NRE research. Although in theory, such a professor would be logical contributor of students to internships at Navy labs, many of these professors prefer to keep students working for them. If internships are to continue to be a successful strategy for engaging students, they need to build in an incentive for the professor. Such incentives have been incorporated in both the Code 333 University/Laboratory Initiative and in the N-STAR pilot.

- Developing and applying standards for the mentoring process: Such a process would include defining qualifications and responsibilities for mentors, offering training or mentor support, mutual mentor/student assessments, and data on this aspect of the programs.

- Merging SEAP and NREIP: SEAP, although funded by ONR Code 363, was authorized by DOD and it is not clear whether or not it can be changed. If so, merging SEAP and NREIP would simplify management of the two, and provide an opportunity to revise components, including financial incentives and the mentoring process.

Other Undergraduate Programs In NRL, WCs, ONR Codes

Undergraduate programs are critical to building the NRE pipeline for several reasons:

- They build the foundation of knowledge and theory used in research and learning in advanced science and engineering education.
- NRE and its contractor base employ large numbers of engineers and computer professionals, occupations in which the bachelor's degree is often the working-level degree.
- Naval transformation will require excellence in technology development, IT development, technology insertion, and testing; engineering and IT skills are among the most important in these technical efforts.
- Data analysis shows that increasing the numbers of under-represented minorities in the science, engineering, and technology education pipeline requires getting higher numbers of these individuals into undergraduate programs. (In many technical fields, once minorities are in college they choose to pursue science, engineering, and technical degrees at rates roughly equal to or greater than white students.)

At this level, NRE needs to focus on building the cadre of employees who will carry out its research and engineering, and gain the experience that will propel them into leadership positions later in their careers.

The N-STAR/NSF Fellowship, although still in pilot phase, is structured with key elements that promise success both in seeding the "pipeline" and in providing an opportunity to attach the student to Naval research. The N-STAR Fellowship offers support during the last two years of undergraduate study for a BS in mathematics, engineering and physical sciences, with follow-on support for Ph.D. work. To strengthen work readiness and connection with the NRE, N-Star requires its scholars and encourages its fellows to spend some time in an internship or performing research in a Naval R&D center. Further binding the candidate to NRE are service agreements and, in a strong incentive for retention, those who complete their Ph.D.s in the fellows program are able to fulfill their service agreement at the Naval R&D center of their choice, and receive two years of research funding.

Another recent example, the University/Laboratory Initiative, was developed to respond to concerns about the workforce pipeline in undersea weaponry. U/LI provides funding to each of the three "partners" in a chosen project: the Navy mentor (in labs that do research on "undersea weapons"), the academic advisor (in universities in geographical proximity to labs), and the student in an MS or Ph.D. program. Students must provide a "letter of intent" that they are "open" to working in Navy labs once they finish their degrees.

- Federal Government wide: *Student Career Employment Program (SCEP)*

Tuition assistance is available to the students, along with travel and transportation expenses. High school and college students are eligible.

- Code 33—*Special program with Penn State ARC* (summer 2003): Undergraduates act as "assistants" to PIs, receiving paid housing and transportation for 10 weeks.

- Indian Head–*Partnership with College of Southern MD.* Many other local initiatives also address the looming problem of the aging technician workforce.

- Newport—*University of Rhode Island Student Services Contract program*: Any US undergraduate can post a resume to the URI site; NUWC staff pick those they want to work with up to 1000 hours per year (mostly during summer). Students are eligible for hiring every year while they remain undergraduates, and their pay grade rises as they move up. This program also gives students an opportunity to see what it's like working in a Navy lab. Funding comes from project budgets. About 30-50 are hired each summer, and some become permanent employees.

- SPAWAR—*SW Community College Project*

CODE 363

NDSEG: National Defense Science and Engineering Graduate Fellowship ONR Budget: AF URI funds.
Joint program of Army, Navy and Air Force within the URI. DoD awards approximately 100-170 three-year graduate fellowships (tuition, fees, stipends) each year to individuals for study and research leading to doctoral degrees in, or closely related to, the disciplines of interest to DOD. To increase number of U.S. citizens trained in disciplines of science and engineering important to defense goals. Applications encouraged from women, minorities and persons with disabilities. ONR selects its awardees: in FY04: 53; FY03: 39; FY02: 116.

HBCU Future Engineering Faculty Fellowship Program
Two to three recipients each year (formerly there were as many as nine), who have agreed to join the engineering faculty of an HBCU after receiving their degrees are competitively selected for study and research support leading to doctoral degrees in engineering. The tenure of a Fellowship is generally 36 months. Program pays tuition and fees, plus stipend.

Fellows are eligible to participate in research at Navy laboratories during the summer.

Designed to develop and attract qualified engineering faculty to HBCUs with engineering programs. Fellows tracked as of 2004: 26 alumni – 14 on HBCU faculty; six in industry.

At the graduate and postdoctoral levels, NRE's goals for its programs involve building deep scientific and technical expertise in its critical skill areas for service in the research arena (such as 6.1 and 6.2, for its academic research partners, and contractors), along traditional lines. Individuals at this level must be trained to not only lead the NRE's research endeavors, but to also push the science and technology to new frontiers.

Programs aimed at graduate and post-doctoral candidates typically offer one or more of three types of incentives: financial assistance (tuition and stipends), work experiences (typically paid), and opportunities to pursue research. The financial demands of pursuing advanced education in a technical field can constitute the greatest barrier to achieving a technical degree. This challenge can be especially difficult to overcome for lower income minority candidates, or adults who have family responsibilities. For minority students, who are often disproportionately operating at the edge of financial viability, an economic setback can mean a student must withdraw from the education pipeline. Therefore, these financial incentives can play a decisive role in attracting and keeping some candidates in the advanced education pipeline.

The NDSEG Fellowship takes a "no-strings attached" approach to fellows: there is no NRE-related internship or work experience, nor does the Navy track student progress or maintain contact with them. Because the program is authorized and funded at the DOD-level, making changes requires agreement of the other services. However, this program has very flexible authorities, and few requirements, so change is possible.

In an effort to revise the program to include at least some closer connection to the Navy, ONR will be able to specify in the FY05 announcement that selection will depend on service relevance as well as academic excellence. ONR also would like to engage its researchers more closely in the process of reviewing candidates, both to provide closer research links and also to serve as future "hosts" for engaging the students.

Despite the option for fellows to participate in research at Navy labs, the purpose of the *Future Engineering Faculty Fellowship* program is to develop faculty for HBCUs. In an effort to develop a potential connection to the NRE, for cases in which there are no available jobs in HBCUs or a former fellow chooses to leave a faculty position, there is some interest in revising the program to add a summer internship at a Navy lab at some point in the 3-year fellowship, and/or to offer the option of a post-doc, possibly in conjunction with NRL. In the latter case, there is some concern that a summer requirement makes this post doc less competitive against NSF post-docs.

The Navy Post-Doctoral Program, although not a part of Code 363's portfolio, is worth singling out both because it is highly visible and valued, and because it includes elements that respond to the research and job interests of post-doctoral participants and the recruitment and research needs of the labs. Most of the Warfare Centers as well as NRL take advantage of the program, which is funded by the Navy and managed by NRL. The only criticism of the program appears to be that despite the open competition for post-doctoral awards, a lab may not hire the participant into a permanent position without an open competition job posting.

Other Graduate and Post-Doc Programs

- Newport: *NUWC long term education program for Ph.D. degrees* has been in place for over 35 years, with an annual budget of $0.5M; the program provides funds for 1 year but participants can apply for 2nd. Full tuition and ½ day pay for completion of degree at any university. Target is the individual who has taken courses part-time for some years and could finish with a year of fulltime coursework

- Indian Head – *CECD Energetics Enterprise: C*ollaboration with other NSWC locations to trade research dollars for employee schooling at the University of Maryland's Center for Energetics Concept Development

- *Acquisition Intern Program* (GS 7-12)—Asst Secretary's program; work several years then get schooling assistance. They get 6-8 engineers from this program each year.

- SPAWAR - *UCSD Partnership:* joined Corporate Affiliates Program which has provided a greater link to university departments and to CA IT2; the program has resulted in 3X increase in hires in a 1 year period. Have student information days and sponsor 10 week student projects; they can funnel them into NREIP, etc. Require industry participation—Year One: discretionary funding; Yr. 2 : industry matching funds; Yr. 3: sponsor pays all

- China Lake: *Fellowship Program:* trying to build this back up as has been reduced over time; advanced training with obligation to stay to repay; budget from center overhead; usually 2-4 per year; Chico, Northridge,etc.

- NRL: *Edison Memorial Fund:* supports graduate studies within the geographical commuting area; has a solid track record, with 41 participants in the last six years; 61 percent of them have earned degrees and 92 percent remain at NRL.

- NRL: *Select Graduate Research Program and participation at the Naval Postgraduate School*—have few participants, 5 between them in 6 years.

Presidential Executive Orders and DOD Directives mandate that at least 5% of DOD funds for higher education be provided to HBCU/MIs. Over the past decade, ONR has fulfilled this obligation in various ways. Some of these efforts have focused on building capacity that would allow HBCUs and minority serving institutions to move into the main funding pool.

The HBCU/MI programs managed by Code 363 are in a period of transition. One long-standing program, the Naval Research Education Partnership Program (NREPP) that included partnerships with 22 HBCU/MIs at its height, has been discontinued, and funding ends as of Fiscal Year 06. Comments about this and other programs range from expressions of frustration at the lack of continuity in supporting those that were "working" to the observation that there have been too many programs with uneven quality.

There appears to be considerable flexibility in ONR's ability to set priorities within the HBCU/MI funding parameters, although reportedly, there has been no attempt to develop a systematic process for using these funds across NRE. Certainly there is opportunity here to re-direct some of this investment toward more aggressive outreach to the minority student community. Using some HBCU/MI funds to support the participation of minority students in NRE's internship and fellowship programs also would be valuable.

One good example of this type of approach is the *Summer Undergraduate Research Enhancement Program, established in 1998 by Code 341.* This program was developed jointly with Texas A&M, in partnership with two HBCU/MI universities (Texas A&M International, an HBCU, and St. Mary's University, a private Catholic school with substantial Hispanic student body). Subsequently, Jackson State in Mississippi was added.

Students are chosen by merit for intensive research experience during a summer at Texas A&M. Faculty in the three HBCU/MI schools provide special preparation to students during the year prior to the summer work. During the internship, students are enrolled as fulltime Texas A&M students and also receive a stipend. The program culminates in presentation at a colloquium (jointly with NSF which runs similar program). Students are tracked, particularly from the perspective of reversing the trend among minorities toward graduate work in law or medicine. During the colloquium, ONR has an opportunity to discuss its research and to promote interest among students. The budget for the program is split among all the colleges and ONR Code 3341. To date, there have been approximately 80-90 students, about eighteen a year.

CODE 363

Faculty Summer and Sabbatical Leave Programs – Summer Faculty Research Program
Science and engineering faculty members participate in research at Navy laboratories for 10-week period during the summer. Three levels of appointment: Summer Faculty Fellow, Senior Summer Faculty Fellow, and Distinguished Summer Faculty Fellow. Repeat participants can bring along graduate students. Stipends vary by level of appointment and are set each year. Faculty from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) are especially encouraged to apply.

FY03 – 574 applicants, 93 participants (57 from HBCU/MIs)

Faculty Sabbatical Leave Program
Science and engineering faculty conduct research at Navy laboratories while on sabbatical leave. Participants receive a monthly stipend making up the difference between salary and sabbatical leave pay from their home institution. Appointments are for a minimum of one semester and a maximum of one year. Participants must conduct research on site.

Young Investigator Program (YIP)
Awards of up to $100,000/year for 3 years, with the possibility of additional support for capital equipment or collaborative research with a Navy laboratory, are made, based on research proposals and supporting materials. Special attention will be given to proposals in naval priority research areas. *Purpose:* To attract outstanding new faculty members at institutions of higher education to NRE, to support their research, and to encourage their teaching and research careers. FY04: ~24 new awards; FY03: 26 awards (2/S&T Division)

The Summer Faculty Research Program's publicly stated purpose is to offer college and university faculty members an experience that can benefit them professionally. Participants can establish research relations with R&D personnel in NRE labs, which may result in sponsorship of the participant's research in home institutions. The Navy's goal is that faculty take Navy lab scientific investigation/field back to university, strengthening ties between university and lab; also potentially seeds parallel research at university, which is cost-effective for government.

Perspectives on the value of the Young Investigator Program vary considerably, perhaps because the program consumes a significant portion of the Code 363 budget allocation for education programs, in order to support fellows in relatively few organizations within NRE. Some argue that the research is very valuable, that it would not happen under normal conditions, and that YIP provides NRE access to outstanding talent—of both professors and students—that helps keep NRE at the cutting edge of innovation. Others maintain that the money is simply a "supplement" to activities that would otherwise occur. Still others feel that YIP does not help

to develop new “stars,” (particularly women and minorities), but rather funds those who would succeed anyway.

While all of these faculty programs are worthy endeavors for strengthening science, engineering, and technology faculty at U.S. universities, providing NRE access to talent in academe, and ensuring that research desired by NRE is performed, they lack direct linkages to ONR/NRE recruitment needs.

Employee Development

Standout organizations in the private sector give priority to creating an inclusive work culture that values individual contributions and nurture employee career development, both through educational opportunities, and through mentoring relationships. The principal problem with creating educational opportunities for Navy civilian personnel is that there is no budget for educational and career development experiences (unlike on the military side, where education and training is a priority, and is budgeted). At this time, operating units must find funds for employee development.

CODE 363

Research Opportunities for Program Officers (ROPO)—ONR Only

A Program Officer receives up to $15,000, including travel, for up to 20% of his or her time to pursue a project of interest (research they might do if at university, for example). ROPO provides program officers, whose responsibilities are largely management, with an opportunity to perform hands-on research that enables them to remain connected to their fields of expertise. A Department Head makes a decision on each project, based on relevance to their field, not necessarily to the Navy. The program is evolving and may become much more individually focused.

There is little information or comment on this program, other than the view that “most program officers don’t have enough time to do ROPO”.

- Code 34—*Sabbatical program for program officers*

- ONR—*Executive Leadership Program* for senior level managers to shadow on work assignments in other facilities. Provides a "fantastic broad experience".

- China Lake *Engineering & Scientist Development Program (ESDP)*—GS-5/8 and GS-9/11 Equivalent Positions that do hands-on work on new technologies (defined by Technology Networks; about 20 projects going now). Funded at $1 M by China Lake internal overhead.

- NRL—*Advanced Graduate Research Program* is a generous incentive, allowing employees to participate in research or studies for one year at an appropriate research facility or university in any geographic location, while continuing to maintain their full salary and benefits. This program appears to strongly support retention. Of the 19 employees who participated in the program from FY99-FY04, 16 (or 84 percent) remain NRL employees. This type of program could have similar retention benefits in other parts of the NRE.

- Pax River—*Acquisition Workforce Tuition Assistance—DOD funded*

- NUWC (Newport) *Fellows Program*—Program was to fund 3 categories: Distinguished Fellows (older); Fellows (mid-career) and Post-Doc Fellows, but only have funds for first 2 categories. Funds research for mid-career work.

Financial Incentives for Recruitment and Retention

NRE has a generous set of financial incentives available to attract potential employees and to help retain them once they are on board. Some of these incentives are available NRE-wide, while others are available on a more limited basis. These include:

- Reasonably competitive entry salaries
- Recruitment bonuses
- Relocation bonuses
- Relocation assistance
- Repayment of student loans
- Payment for interview expenses
- Salary flexibilities (pay banding)
- Pay for performance
- Bonus for management/supervisory roles
- Job security
- Transportation subsidies
- Special research opportunities
- Attendance at meetings/conference
- Training linked to official duties
- Paid sick leave for family care
- Part time employment
- Paid vacation leave
- Paid sick leave
- Paid Federal holidays
- Part time employment
- Retirement plan
- Savings plan

- Financial Incentives for Recruitment and Retention
- Health, life, and long-term care insurance
- Generous support for graduate studies
- Support for academic degree training
- Support for attaining credentials
- Unpaid family and medical leave

One area of weakness, in comparison to the private sector, is that there are significant salary disparities at all rungs of the career ladder, except at the entry level. For example, in the past five years, the number one reason for declining a job offer at NRL was inadequate salary. While NRE salaries are often competitive at the entry level, NRE salaries lose competitiveness at higher levels. Nevertheless, NRE does have a number of tools to partially compensate for lower salaries, for example, the use of recruitment and relocation bonuses, which have been used more frequently in the past several years.

NRE organizations (including NRL and China Lake) with approved personnel demonstration projects have more flexibility to offer competitive salaries, due to pay banding, which allows for somewhat higher salaries for some employees (such as high performers and new hires). However, salary is only one of many factors that make a job package competitive. For example, job security is a big issue today for IT professionals, and the Federal government's highly competitive insurance benefits (health, life, and disability), family friendly policies, and flextime/compressed work schedules offer working parents a real benefit. Probing job candidates' needs, and helping them look beyond salary to the complete job package should be a routine part of recruiting for NRE organizations.

A second area of serious weakness is the time required to hire job applicants, which, due to government competitive hiring requirements, inevitably will be longer than private sector employers. Many of the technical managers BEST interviewed stated they have lost attractive candidates because the time to hire was too long. One approach to address this—at least at the entry level—would be to increase use of, and hiring from, internship programs such as SCEP, which allow for non-competitive hiring of participants at the end of their internship.

Diversity

ONR, the NRL and most of the Warfare Centers with which we met are concerned about diversity to some extent, in terms both of retention and recruitment. Many of the labs, as well as ONR, have diversity plans, although these appear to have less influence on actions than do workforce needs and/or leadership mandates. Certain of the Warfare Centers that face substantial loss of workforce capability from retirement and that also are in locations with minimal ethnic diversity, such as Indian Head and China Lake, have put aggressive initiatives in place to address the changing demographic nature of the workforce.

Selected Programs to Encourage Diversity in Recruitment and Retention

Pax River

There is a diversity report for NAVAIR as a whole, and each NavAir location also has its own plan. There is particular concern about replacing the aging workforce, especially Ph.D. level, so diversity is important to them. Pax River has recruitment goals for particular segments of under-represented groups each year. They select schools for recruiting based on their needs, and have made strides for women and Hispanics. In addition to setting formal goals, diversity is embedded throughout other processes, including annual training requirements and an annual diversity luncheon.

Indian Head

Indian Head has a Recruiting Advisory Board that meets monthly. It views diversity as one if its key indicators of the well-being of the lab. Indian Head's senior leadership is very committed to employing a diverse workforce, communicating expectations of a changed workforce profile. Managers are held accountable for meeting diversity goals. The combination of targeted recruitment among under-represented groups and the homogeneous nature of the local community prompted Indian Head to develop a variety of internal and external actions designed to support and integrate various cultures.

Newport

The population in Newport is not particularly diverse, making recruiting for diversity a challenge. Newport addresses this by including diversity goals a part of their overall workforce development plan and they have an active diversity committee that makes sure the issues are addressed. They set diversity hiring goals and try to meet them. Newport developed a New Employee orientation that includes a regular survey of new hires – of all ethnicities; a "new employee" group; website and phone trees to offer support.

The efforts described above, and others throughout NRE, are important steps toward enterprise-wide diversity. NRE should build on these successes, and expand diversity practices enterprise-wide. Having a diversity plan, attending minority professional association conferences, and conducting nationwide recruitment can help attract more candidates from under-represented groups to the NRE. In addition, forming relationships with groups on campus would further extend NRE's reach in this community. To attract more women, partnering with women's organizations and societies (including groups on campus), using the generous incentives in the pipeline programs, and highlighting certain job benefits that may be attractive to women may sway some to choose science and engineering education or to pursue employment in the NRE.

ONR, NRL, and the Warfare Centers have long standing relationships with certain universities, and that is commendable. However, with the small number and highly sought after number of minority candidates in the science and engineering pipeline, relying on only a handful of schools is unlikely to produce higher numbers of minority candidates (due to their modest representation in college generally). While some of this is unavoidable, for example in the highly specialized Naval-related fields, some is simply habit and custom. The NRE could benefit from expanding recruitment beyond currently-favored institutions.

In addition, there are several groups of potential candidates—both for direct hire and entry into NRE's pipeline—that are underserved by NRE's portfolio. These include: military personnel who are leaving active duty service, science and engineering personnel who have been laid off by private employers (such as the numerous IT workers who lost their jobs during the dot.com boom and as a result of off shoring), and career changers. In addition, some students—especially students of lesser financial means, minorities, and also others (for a variety of reasons)—opt for beginning their college education in the community college setting. Some U.S. community colleges have programs that begin to prepare students for technical careers or prepare them to move to four-year universities to pursue technical degrees there. In addition, students increasingly participate in other non-traditional forms of post-secondary technical education, including on-line learning and at private, for-private learning institutions. It is unclear whether NRE considers such students of interest, or attempts to identify candidates following increasingly popular non-traditional education paths.

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APPENDIX A

A thorough analysis of the recruitment challenges facing NRE for the approximately 4,000 scientists and engineers working in the science and technology arena (those for whom 50 percent or more of their funding comes from 6.1, 6.2 or 6.3 funds) would require detailed, comprehensive and uniform data on this cohort that was not available to BEST.

Specifically, the data required would include a breakout of the 4,000 S&T employees by occupational series; then, for each occupational series, it would provide a breakout by degree level. This data—which would include age, retirement eligibility and other information—could be used to project loss data over the five to ten year period. Finally, this loss data could be combined with information about changing mission requirements, technology priorities, and appropriations to identify the number of new scientists and engineers, by discipline and degree level, that the Navy will need to hire. In addition, it is important to understand issues such as workforce diversity and retirement eligibility by discipline (and by degree level within that discipline) in order to identify potential problem areas (such as looming high retirements in a Ph.D. specialty area).

Since this detailed data is not available, we used the best available data[5] to assess what the NRE's S&T recruiting needs will be.

We know that the NRE S&T workforce numbers approximately 4,000, with the Warfare Centers accounting for approximately 2,200, NRL accounting for about 1,600 and ONR for about 200. Of this 4,000, about 1,800 (45 percent) hold Ph.D.s, with the Warfare Centers accounting for about 880, NRL for about 820 and ONR for about 100. In addition, data provided by ONR, NRL and the Warfare Centers to DDR&E provides an occupational breakout of each organization's entire S&E workforce. We analyzed this full cohort of 20,214 to understand the aggregate demand of the Navy.

Analyzing the NRL data included in the DDR&E data set provides insight into the occupational composition of 40 percent of the NRE S&T cohort, since all NRL scientists and engineers are part of this cohort. We found that NRL S&T employment was highly concentrated in a handful of occupations. The top two occupations—

5 ONR provided BEST with data collected at the request of DDR&E on the entire population of scientists and engineers (approximately 20,000) employed in ONR, NRL and the Warfare Centers. The information provided to DDR&E does an excellent job of defining the key occupations of scientists and engineers working in these organizations. It does not segregate out the approximately 4,000 scientists and engineers working on research-related tasks (6.1, 6.2 and 6.3), nor does it provide any information regarding the breakdown of bachelors, masters and PhDs within each occupation.

An effort is ongoing, in connection with the development of N-STAR, to provide more detailed information solely on the subset of those scientists and engineers working at least half time on research-related tasks. The portion of that data shared with BEST shows the numbers of those approximately 4,000 scientists and engineers with bachelors, masters and PhD degrees, but this data does not link those degrees to their occupations. In addition, NRL and several of the warfare centers keep their own data regarding the composition of their science and engineering workforce, although these data collection efforts have not been coordinated, and do not provide a common set of information across the NRE.

physicists and electronics engineers—account for more than half (50.8 percent) of all NRL scientists and engineers. The next five largest occupations—computer scientists, chemists, oceanographers, mechanical engineers, and aerospace engineers—account for another 25 percent of NRL scientists and engineers. In total, the top ten S&E occupations account for 5 in 6 jobs at NRL.

A separate data source provides information on the degree level of the NRL scientists and engineers. More than half (52.3 percent) of NRL scientists and engineers hold Ph.D.s; those holding master's degrees account for about 21 percent, while bachelor's degree holders account for about 22 percent. Less than 5 percent of NRL scientists and engineers have less than a bachelor's degree.

Nearly half of the NRL Ph.D.s are held by physicists; other occupations with significant numbers of Ph.D.s include chemists, electronics engineers, oceanographers, meteorologists, and computer scientists. The vast majority of NRL physicists, chemists, oceanographers, and meteorologists hold Ph.D.s; in contrast, the vast majority of electronic engineers and computer scientists hold less than a Ph.D..

While not a perfect mirror of the S&T component of the warfare centers, we also examined the DDR&E data for the overall science and engineering workforce at the warfare centers.

Once again, we found employment at the warfare centers to be highly concentrated in a handful of occupations, though much more heavily weighted toward engineering than NRL's S&T workforce. The top two Warfare Center occupations—electronics engineers (36.4 percent) and mechanical engineers (18.0 percent)—account for more than half of the Warfare Centers' scientists and engineers. The next five largest occupations—computer science, aerospace engineering, general engineering, computer engineering and physics—account for another 29.3 percent. In total, the top ten S&E occupations in the Warfare Centers account for 9 of 10 jobs at the Warfare Centers.

Viewed together, the NRL and the Warfare Centers data indicate that NRE should be focused on recruitment in a handful of key academic disciplines: electrical/electronics engineering, mechanical engineering, aeronautical engineering, physics and computer science. Trends in these degree areas may affect the availability of graduates from which NRE will recruit:

Electrical/Electronics Engineering. After a 10-year, 40 percent decline, the number of U.S. bachelor's degrees earned in electrical engineering has risen 13 percent since 1997, to 18,371. The number of master's degrees has remained relatively flat. Since peaking at 753 in 1997, the number of Ph.D.s earned by U.S. citizens has fallen by 44 percent to 423 in 2002.

Mechanical Engineering. Bachelor's degrees in mechanical engineering have experienced a long-term steady decline, dropping by nearly a quarter to 13,160 in 2001. Master's degrees have fallen by a fifth to 3,472 since peaking in 1995. The number of U.S. citizens earning Ph.D.s has dropped by more than a third since peaking in 1997, falling to 286 in 2002.

Physics. Degrees in physics—at all levels—have been in long-term decline. Bachelor's degrees have fallen by 20 percent since 1989. Since 1994, master's degrees have fallen by nearly 30 percent. The number of Ph.D.s earned by U.S. citizens has fallen by a third, from 789 in 1994 to 524 in 2002. Given the large number of Ph.D. physicists employed by NRE and the decline in Ph.D.s awarded to U.S. citizens, NRE should direct care and attention to the pipeline.

Computer Science. Explosive growth in demand in the information technology occupations in the mid-1990s produced a resurgence in the number of computer science degrees awarded. In 1998, the number of bachelor's degrees awarded began to rise, then skyrocketed through 2001 when the number of computer science degrees awarded hit an all-time high of 43,184, a 76 percent jump since 1996. However, the Taulbee Survey conducted by the Computing Research Association indicates that bachelor's enrollments in computer science have fallen for the past three years, taking an especially sharp turn downward in 2003-2004. Falling enrollments will lead to declining computer science degree production in the coming years. The trend is likely a market response to the end of the dot-com boom, and the off-shoring of U.S. IT jobs.

Master's degrees in computer science have also grown rapidly since 1997, rising from 7,510 to 10,833 in 2001, an increase of 56 percent. U.S. citizens earned 51% of these degrees, totaling 5,524.

In contrast to the rapid growth in computer science bachelor's and master's degrees, the number of U.S citizens earning computer science doctorates fell substantially from 1998 to 2001, dropping from 476 to 357, a decline of 25 percent.

The downturn in the information technology labor market could prove to be an asset for the NRE. Today, IT occupational unemployment rates are at historical highs. Many well-educated, highly experienced U.S. citizens who have been released by their former employers seeking lower cost labor abroad are actively seeking employment in this field. The NRE would be an especially attractive employer given its ability to offer stable employment and substantial benefits. NRE should undertake an aggressive campaign to identify and recruit the most talented members of this pool of available labor before market conditions improve and they are reabsorbed by the private sector.

Aeronautical/Astronomical Engineering. Bachelor's degrees in aeronautical/astronomical engineering have been in long-term decline. Since 1988, the number of bachelor's degrees has dropped by half, from 3,092 to 1,498. Master's degrees peaked five years later in 1993 at 1,047, and have since fallen more than 40 percent to 611 in 2001. The number of U.S. citizens earning doctorates in aeronautical/astronomical engineering have fallen substantially since peaking at 166 in 1996, declining by more than half to 81 in 2002.

Of the occupations at the top of NRE's hiring projections, there are fewer degrees earned in aeronautical/ astronomical engineering—at each level—than any other. This means the pool that the NRE will be competing for against the private sector will be very small. Because of these small numbers, a turn-up in private sector

demand could make it difficult for the NRE to meet its hiring requirements. Therefore, the NRE should take care to nurture and secure the aeronautical/astronomical engineers it needs through its pipeline programs.

U.S. Citizens' Share of Science and Engineering Degrees. The fact that NRE must hire from the pool of U.S. citizens who have earned S&E degrees creates another challenge. The challenge is small at the bachelor's level, increases at the master's level, and is quite serious—particularly in some disciplines—at the doctoral level. Foreign students earn less than 10 percent of bachelor's degrees in the physical sciences, engineering, mathematics, and computer science. Foreign students earn a significantly higher share of U.S. master's degrees in science and engineering disciplines than at the bachelor's level. In computer science, U.S. citizens' and permanent resident's share fell sharply from 67 percent in 1992 to 51 percent in 2001, as did their share of engineering degrees, which fell from 67 percent in 1997 to 58 percent in 2001. In mathematics, their share has fallen from 72 percent in 1998 to 63 percent in 2001, while in the physical sciences their share has remained relatively constant.

At the Ph.D. level, the problem is most pronounced. In 2001, U.S. citizens accounted for less than half of all Ph.D.s granted in engineering, computer science, mathematics, and physics. Chemistry is the one field in the NRE's occupational concentration in which U.S. citizens account for a majority (62.2 percent) of the earned doctorates.

Because of the significant reduction in U.S. citizens pursuing doctoral degrees, BEST believes it is particularly important for NRE to define its doctoral hiring needs with specificity. This would include counting all Ph.D. scientists and engineers in the NRE's workforce by occupation, as well as understanding which of those scientists and engineers will be retirement eligible, and projecting needs for Ph.D.'s to meet mission requirements. NRE clearly should use its master's and doctoral programs aggressively to induce students to pursue graduate level work in the areas in which it expects significant hiring.

APPENDIX B

KEY METRICS

Following are examples of metrics frequently used in recruitment and education pipeline programs similar to NRE's programs. NRE may want to consider these as a starting point, but ultimately will need to develop customized metrics appropriate to its new program portfolio and agreed definition of ROI.

High School

Short Term

- Is the program attracting a diverse mix of students (geographic, gender, ethnicity, socio-economic)?
- Do participants in the program continue in the program in subsequent years?
- Do participants move to other NRE-sponsored programs in subsequent years?
- Do participants enroll in S&T degree programs in college?

Longer Term

- Do program participants perform better than general student population on standardized math and science tests?
- Do program participants select S&T degree programs more frequently than general population?

Undergraduate

Short Term

- Is the program attracting a diverse mix of students?
- Do program participants continue in the program in subsequent years?
- Do participants move to other NRE-sponsored programs in subsequent years?
- Do program participants complete degrees in S&T fields?
- Do program participants elect to continue in S&T fields of study?
- Are program participants hired by an NRE organization? By NRE's academic
- partners or contractors?

Longer Term

- Do program participants perform better academically than general student
- population?
- Do participants earn S&T degrees at higher rates than the general S&T student
- population?

Graduate

Short Term

- Is the program attracting a diverse mix of students?
- Do program participants continue in the program in subsequent years?
- Do participants move to other NRE-sponsored programs in subsequent years?
- Do program participants complete masters and/or Ph.D. degrees in S&T fields?
- Do program participants elect to continue in S&T fields of study?
- Are program participants hired by an NRE organization? By NRE's academic partners or contractors?

Longer Term

- Do program participants perform better academically than the general S&T student
- population?
- Do participants earn masters and/or Ph.D. degrees at higher rates than the general
- S&T student population?

Postdoctoral

- Is the program attracting a diverse mix of students?
- Are program participants hired by an NRE organization? By NRE's academic partners or contractors?