

## **AC 2009-2390: MAINTAINING THE SCIENCE AND ENGINEERING PIPELINE**

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## **Maintaining the Scientist and Engineering Pipeline**

### **Abstract:**

Technology is advancing at an ever increasingly rapid pace. This is particularly true in the Department of Defense (DoD). Test and Measurement Systems (TAMS) require a continued influx of scientists and engineers properly trained to advance the TAMS support structures for new and advanced technology applications while maintaining existing support structures for current equipment. The demand for engineers and scientists continues to rise faster than the supply. The US is simply not producing the numbers of engineers and scientists needed. Couple this with the fact that there is a huge wave of baby boomers reaching retirement age that currently provide a great amount of scientific and engineering services. We all are facing a substantial problem. This problem is magnified for DoD which requires that its workforce be US citizens capable of obtaining the appropriate level of security clearances. The need for US citizens working in Science and Engineering (S&E) will continue to be in demand as technology continues to advance exponentially and the need for S&E in our nations defense continues. This paper explores a comprehensive and proactive approach that is currently being practiced and developed by a Navy engineering activity working in the S&E fields to help ensure that the pipeline of US citizens in science and engineering is supported at every step along the way. The approach presented is applicable beyond DoD and applies to any organization that relies on hiring technical employees raised through the US educational system. Through a number of community outreach activities, interventions at the grade school level through High School provide ample opportunity to strengthen the S&E pipeline at these early stages. Active participation with Universities through board participation, partnerships, internships, and career fair participation provide the critical link between the qualified entry level workforce and the needed defense sector jobs. Once the scientist or engineer makes the transition from student to defense sector employee, their continued development, advancement, rewards, and ultimate retention needs to be attended to in a systematic way. Stemming the brain drain from the wave of baby boomer retirements can be brought about by providing contract work as a transition from full time work to full time retirement.

### **Background:**

This background is included to provide the context of how and why NSWC Corona Division and its Navy Metrology Engineering Center needed a whole system approach to obtaining, developing and training its technical and leadership workforce. Included are reasons that caused the organization to chose to participate in continuing outreach activities at the elementary, middle, high school and college levels as an important part of its overall human capital strategy. The remainder of the paper will focus on the Employee Pipeline.

A consequence of the end to the cold war was that the Department of Defense (DoD) found itself with an excess amount of infrastructure that was no longer required. The excess infrastructure included personnel no longer needed to support our post cold war efforts. This lead to congress authorizing a number of Base Realignment and Closure (BRAC) rounds to be conducted into the mid-1990's that were intended to right size DoD both in physical plant infrastructure as well as in personnel resources. BRAC rounds were conducted every odd numbered year culminating in

the last, and most extensive, round occurring in 1995. This periodic BRAC process did reduce the size of DoD. However, several collateral consequences occurred to various sectors of the DoD workforce as a result of the periodic BRAC rounds; one being that DoD scientists and engineers who had been traditionally secure in a safe, stable employment environment were now included in the down sizing actions of BRAC. Some activities experienced large losses of personnel when bases were closed and functions relocated. Some engineers would voluntarily leave to find employment at other non-DoD government agencies to reconnect with a stable, predictable work environment. Others simply left for jobs in industry. Each DoD activity had its own BRAC experience.

The Navy Metrology Engineering Center and Gage and Standards Laboratory (now consolidated into the Measurement Science and Technology Laboratory) are located at the Naval Surface Warfare Center, Corona, CA (NSWC Corona Division). This Metrology Engineering Center and associated Laboratory provide for all of the Navy and Marine Corps Test and Measurement Systems (TAMS) research, development and engineering support. The engineering capabilities required to be sustained in order to perform this important function span a multitude of disciplines from electronic/electrical (both high and low power), mechanical, microwave, chemical, pressure, temperature, and physical/dimensional to name a few. Further, engineering expertise must be maintained to handle emerging technologies as well as those that were fielded 40 years ago, but remain in the military. In essence, the engineering talent must be maintained across both the time domain as well as the technical discipline domain in order to adequately execute the mission of providing full life cycle support for all Navy and Marine Corps TAMS.

In 1990, there were 1,200 employees at NSWC Corona Division of which about 425 employees worked in the Metrology Engineering Center and associated Laboratory and functions. About 80% were scientists and engineers. Many had 5 to 15 years or more experience. As NSWC Corona Division proceeded through the various BRAC rounds, the work and employee base continued to erode. Less and less technical support was required for the shrinking DoD structure as bases were closed and ships and aircraft were retired and excessed.

By the last BRAC round in 1995, NSWC Corona Division had shrunk to about 670 people and the Metrology Engineering Center was down to 170 (40% of its former total just 5 years earlier). Many of the “survivors” were senior employees with 20 or more years experience with many nearing retirement age. During BRAC 1995, NSWC Corona Division was specifically addressed as a base that was performing important technical functions, but was deemed too small to stand alone. It was identified as an activity that should be closed with its needed functions and personnel to be relocated to other DoD activities. The Metrology Engineering Center functions and associated personnel were proposed to be relocated to a Navy activity in Indiana. This, of course, caused the highly experienced and technical workforce to begin to plan for a potential uprooting of homes and families and relocation to Indiana should the proposal be accepted by the BRAC Commission who had the final say. While the case was argued and reviewed, many employees found other jobs in Southern California. Others awaited an outcome. A generous severance package would be available for those who chose to await the final outcome and then be involuntarily separated rather than relocate. One can clearly imagine the multitude of negative effects on the metrology engineering workforce during this time period.

The 1995 BRAC Commission, in its televised proceedings, spared NSWC Corona Division and the Metrology Engineering Center from closure and relocation. The base survived, but the technical workforce had severely suffered. The Center was heavily populated with very experienced individuals, but there existed “gaps” where very marketable engineers had left for a stable life. Little progress had been made to recover the numbers of engineers needed to provide the increasing technical support required of a now downsized Navy that was starting to refresh technology and systems. The difficulty that NSWC Corona Division was experiencing was heightened by the fact that DoD requires that its employees be United States citizens capable of obtaining proper security clearances. The southern California university and college system had insufficient numbers of engineers with US citizenship available to meet the high demand by both industry and government. NSWC Corona Division’s increasing demand for engineers willing to work at government wages could not be met without continuing to augment hiring through other avenues. With the high cost of living in Southern California, finding engineers elsewhere to relocate and remain was not proving effective.

After many years of using traditional hiring strategies in attempts to replace and renew the engineering workforce impacted by BRAC and its aftermath, the current NSWC Corona Division demographic distribution by age and tenure is displayed in Figure 1. Note the large number of young, inexperienced workers as well as the large number of older, experienced workers with a large trough in the middle. This illustrates the clear need for a broad based systematic approach that nourishes the “Front End” of the engineering pipeline to encourage the availability of future quality engineering students ready for hire and also addresses the urgent need to effectively train and advance hired employees to replace an increasingly aging and retiring workforce.

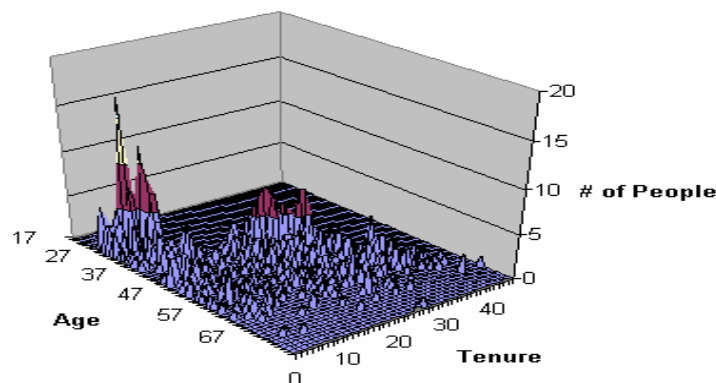


Figure 1. Age vs. Tenure Demographic

As a result of the experiences over these many years with obtaining and developing employees coupled with the present day facts indicating an aging workforce and diminishing supply of engineering graduates; NSWC, Corona Division embarked on developing a whole systems approach to achieving our human capital strategy. This NSWC, Corona Division strategy includes two major objectives: (1) influence the “Front End” of the Engineering Pipeline to increase the availability of local engineers and scientists to pursue as new employees and (2) develop a whole system approach to employee development and training (including both technical and leadership). Part 1 of this paper will discuss NSWC, Corona’s involvement in the STEP Program as the dominate effort to influence the “Front End” of the Engineering Pipeline.

Part 2 will address the creation of the Employee Development Program as the systematic approach to long term employee development.

## Part 1: Developing the “Front End” of the Engineering Pipeline through the Science and Technology Education Partnership (STEP) Program

Because of the emphasis on hiring to address the engineer shortage discussed above and the resultant awareness of the critical shortage of qualified engineers generally, NSWC Corona Division decided that it would be of long term strategic importance to engage in outreach activities beyond basic recruiting activities with universities and colleges. Until 2000, NSWC Corona Division had simply participated in standard nationwide recruiting activities at various colleges and universities. No routine formal outreach regarding the attempt to inspire young students to seek an education in engineering and science had been part of the overall human capital strategy. This all changed as a result of NSWC Corona’s introduction to the STEP Program.

NSWC, Corona Division and its Metrology Engineering Center became one of the first partners to become involved with the STEP Program. The STEP Program represented an excellent opportunity to focus multiple outreach efforts through a single organization. The combined common interests of all the STEP partners towards the common goal of increasing the number of local students qualified and interested in pursuing degrees in science, engineering and mathematics allowed leveraging of resources across the partnership to achieve impacts that no single partner could afford or achieve individually. NSWC, Corona Division utilizes the STEP Program as it’s dominate outreach activity regarding the 3<sup>rd</sup> to 12<sup>th</sup> grade focused development of the earliest stages of the engineering pipeline. With this in mind, a discussion of the formation, development and activities of STEP will be addressed in a general sense with the understanding that NSWC, Corona Division remains an instrumental, active partner in these STEP activities.

The Science and Technology Education Partnership (STEP) Program:

### The Beginning:

The beginning of STEP involves California Congressman Ken Calvert who represents the 44<sup>th</sup> District that includes a large portion of the Inland Empire region of Southern California (Riverside, CA). Congressman Calvert had committee assignments on the Science Committee and recently on Appropriations. He belongs to numerous House caucuses including the House Science, Technology, Engineering, and Mathematics Education Caucus.

In November 1999, Congressman Calvert received the “California Report on the Environment for Science and Technology” (the CREST Report) produced by the California Council on Science and Technology<sup>1</sup>. The report indicated that 9.3% of all jobs in California were in high tech industries which was well above the national average of 5.6% at the time. About 20% of the nations R&D was being performed in California at the time of the report. This R&D helped to sustain and advance California’s high tech industrial base. Simply put, California was the nations leading science and technology state. Science and technology was the underpinning of

California's leadership in agriculture, aerospace, defense, electronics, computers, software, movie production, multimedia entertainment, biotechnology, medical devices, environmental technologies, and telecommunications. This leadership position provided jobs, sustained a high standard of living, and offered numerous other benefits to California residents. The report further provided a wake-up call by announcing that California was at risk of losing the lead it once enjoyed. Several factors were cited as contributing with the highlight being the inability of the state's educational system to produce a technologically skilled workforce in sufficient numbers and capable of sustaining the R&D activity. Findings included that a significant number of Californians did not have the education needed to benefit from job opportunities created in the high tech sector and that Californians graduating from the K-12 educational system and community college system were simply not adequately prepared to enter the high tech arena. Several recommendations were advanced to address the findings.

More recent studies continue to illuminate California's problem. In 2004, California ranked 48<sup>th</sup> in the nation for high school students going on to college. Statewide, 47 percent of high school graduates in 2006 enrolled in a state public university. For the Inland Empire region which is comprised of Riverside and San Bernardino Counties (an area east of Los Angeles and about the size of the state of New Jersey), the numbers were even lower at 38 percent. Only about 26 percent of Inland Empire high school students met the admission requirements for the University of California and California State University systems<sup>2</sup>.

The Inland Empire region had mostly missed out on the high tech prosperity enjoyed by its neighbors in San Diego, Orange County and Los Angeles. There was a keen interest in building a high tech sector in the region. The Inland Empire region is as populous as San Diego; however, it lags far behind in high technology employment. The challenge to build a high technology presence in the region, especially in the face of the CREST Report and other findings was the start of the activity that lead to the formation of STEP.

In January 2000, Congressman Calvert received a report from the Hispanic Outreach Task Force he had assembled to study ways to improve science and mathematics skills among K-12 students, particularly among the region's Hispanic population. This report provided a similar call to action for the need to address the education of our youth. Not only are minorities in need of assistance in math and science, but females also. A very recent article by Dr. Pamela S. Clute, professor of mathematics and education at the University of California, Riverside, again highlights this long known fact. She states that: "While it is true that women [now] represent 57 percent of the nation's college population, less than one-third major in science, technology, engineering, or mathematics. Research shows they [females] have the ability, but lack the interest."<sup>3</sup>.

Staff research further produced more alarming facts: California ranked last among 40 states according to the results of the 2000 National Assessment of Educational Progress (NAEP)<sup>4</sup> tests, U.S. students in the final year of secondary school scored well below the international average in math and science according to the Third International Math and Science Study (TIMSS), the US ranked 18<sup>th</sup> among 21 industrialized nations also per TIMSS, surpassing only Lithuania, Cyprus and South Africa<sup>5</sup>. New information from the Organization for Economic Cooperation and Development which consists of 30 member countries shows that American 15 year olds have

actually lost ground in math and science compared to other member countries. In the organizations latest studies, the highest achieving U.S. students were either at or below its average across member nations. Almost 25 percent of U.S. students demonstrated very low proficiency in science and 28 percent scored below the minimum level in mathematics. In math, Finland, Korea, and China were top performers with Finland taking top ranking in the science assessment<sup>6</sup>. The evidence of a need for a proactive program to improve science and technology education was overwhelming if the Inland Empire was indeed committed to advancing in the high tech sector.

William D. Green, CEO of a global management consulting and technology services company and vice-chairman of the Business Roundtable Education & the Workforce Task Force, has stated: “In every business, high performance begins and ends with education. In particular, we must re-double our investments in math and science education. We need people with skills in critical thinking, analytic reasoning, and problem solving. We need to be able to speak, to write, and to communicate. We need to enhance the richness and diversity of the American workforce, and we need it to be more confident. The Business Roundtable Education & the Workforce Task Force believes the United States must take the steps to begin to close America’s growing talent gap, and they [the steps] all focus on improving education. First, we need to benchmark U.S. performance against the best in the world and learn from these best practices to strengthen math and science education programs in kindergarten through 12<sup>th</sup> grade. We must also recruit and retain outstanding math and science teachers.”<sup>7</sup>. William D. Green continues on to discuss the need to actively address the problem. However, the call for a program like STEP along with nationwide efforts has continually been at the forefront of the need to halt the erosion of America’s scientific base. The earlier studies drove the eventual formation of the STEP Program. The continuing evidence of the need to close our growing talent gap keeps STEP focused and active.

#### The Formation of STEP:

In June 2000, Community, Education, Business and Technology Industry Leaders began organizing to form the non-profit, 501C(3) STEP Corporation funded privately by partner companies investing in the education of local children to attempt to raise the numbers of high technology educated workers in the community. STEP’s Board of Directors is comprised of industry (such as AT&T, Boeing, Southern California Edison, Computer Science Corporation, and others), university/colleges (such as University of California, Riverside and California Baptist College and others), the local educational institutions (Riverside County Office of Education), and local high tech government agencies such as the Navy Metrology Engineering Center. The Inland Empire is fortunate to have a number of innovative academic, government and business institutions involved in STEP to encourage students, especially those from underrepresented groups who do not have a family tradition of attending college. STEP believes that it is critically important to reach out not only to teachers (who can identify and nurture promising students) and to the students themselves, but also to families to create an environment conducive to success.

#### STEP’s Mission and Purpose:

STEP's primary mission is to "Inspire students to pursue careers in math, science, engineering and technology" through an innovative, proactive approach that engages students, teachers, and the local K-12 educational system with high technology companies, universities/colleges, high tech government agencies and all of their collective resources to achieve its purpose of increasing and sustaining the high technology job sector in the Inland Empire. Through the formation of new educational partnerships between businesses, academia, and government entities within the community, STEP seeks to pave the way to achieve a prosperous future for all Inland Empire citizens based on the sustainable growth of a high technology industry. Specifically, STEP seeks to: Raise parental, industry, and community awareness of the skills gap between K-12 students and the labor needs of the high tech sector, Stimulate and inspire children's interests in pursuing math, science, engineering and technology educations, Motivate parents, teachers, the K-12 educational system, and business leaders to create a set of plans to address the educational situation to help achieve success, and Stimulate the Inland Empire into becoming a high technology leader.

#### How STEP Works:

STEP is all about forming mutually beneficial partnerships with an eye towards the long term collective success and growth of the region. STEP is a people-centered, community building program aiming to strengthen the quantity and quality of our technologically skilled workforce. STEP causes the educational system at all levels to interact with high tech industry, business and government for the benefit of students, families and teachers. STEP's purpose is not to reinvent the many resources available in the community, but rather to connect them together to help make them more effective. STEP serves as a repository of information and a catalyst for action.

STEP's role is to make teachers, students and families aware of the educational resources available to help them succeed in math and science, and to foster awareness of the programs that can help students prepare for and succeed in college. STEP helps them to connect to the services available. STEP works with businesses and the community to identify employment trends and other technological infrastructure needs and works to help assure that the Inland Empire region has the resources it needs for success. To deliver these services, STEP sponsors an annual student and teacher conference, has educational outreach programs, provides seed money to pursue relevant recommendations to further its purpose, collaborates with business development organizations and individual businesses, and operates a website with information for all our conferences, partnering opportunities, and outreach activities.

#### STEP Operations:

STEP operates through annual Student and Teacher Conferences and various other mission related outreach activities in addition to the STEP Board's partnering activities. The STEP Student Conferences began in 2000 and have been conducted annually for the past 9 years. The student conference provides a free science show conducted by General Atomics engineers under an outreach grant. Also, about 30 companies set up booths and displays to provide a "hands on" exhibition for students to meet engineers and scientists from various technical fields. The science show lasts an hour and the exhibition lasts an hour. There are four science shows/exhibition periods per day over a two day period. About 3,500 students from local 3<sup>rd</sup>



through 12<sup>th</sup> grades attend the two day conference each year. In addition, a Teacher Conference is provided separately from the Student Conference to engage teachers in activities to help them develop their skills in teaching math and science. Lesson plans and example activities are provided. About 125 teachers attend each year's conference provided free of charge by the STEP Program. A STEP Community Leadership Luncheon is included during the conference week to renew commitment to STEP activities, review progress and obtain new and continuing support for the privately funded program. A keynote speaker is the center piece of the luncheon where speakers such as Arnold Schwarzenegger (current California governor), Dr Sally Ride (former astronaut), and others have highlighted the need to inspire children to pursue educations and careers in mathematics, science and engineering.

The various STEP outreach programs have been bounded by financial considerations. The Annual STEP Awards for the Inland Science and Engineering Fair division winners (STEP provides awards in each of the three divisions: Elementary-\$200 savings bond, Junior-\$500 savings bond, and Senior-\$1,000 savings bond) has been a positive incentive for students. They are the largest monetary awards given at the regional Science Fair. STEP volunteers help to serve as science fair judges at local competitions throughout the region. The Science Olympiad assistance keeps the Inland Empire active in this national competition and helps the volunteer teachers improve their skills through the three stipends offered annually. The annual STEP Conference poster and essay contests allow classrooms to engage before the conference with an opportunity to win a monetary award for placing in the three different divisions. It also allows those students who lean more towards English, literature, or the arts to engage their minds on science and technology. STEP publishes a periodic newsletter called "In STEP" for teachers, administrators, sponsors, and community leaders to provide information on upcoming events, profile regional technology companies, and promote teaming and partnering activities. The In STEP Newsletter is the periodic update on conference and outreach activities and resources available in the area. Finally, STEP provided \$6,900 seed money to Future Scientists and Engineers of America (FSEA) to jump start after-school Science Clubs at several local middle schools.

#### STEP Conference and Outreach Summary:

The STEP Student Conferences have exposed some 23,000 students and 1,100 of their teachers to science, technology and engineering through the science shows and high tech expo held annually for the past 8 years. The STEP Student Conference format has stabilized and continued to serve about 4,000 3<sup>rd</sup> to 8<sup>th</sup> grade students and their teachers annually. The feedback forms we obtain from attendees indicate continued high marks. Our data indicates that we get only about a 10% repeat population in our attempts to provide the experience to those who haven't yet had the opportunity to participate. The STEP community leadership and partner luncheon provides an annual opportunity to renew and expand the partnership, make new connections, obtain continued and additional support and sponsor funds, and outline past, present and future STEP plans. The STEP Teacher Conference has settled into an evening format hosted by the local university. It is focused predominately on mathematics and teacher activities to improve their skills. The STEP Teacher Conference also gives STEP an opportunity to thank the teaching community for their dedication to serving our children.

In addition, the various STEP outreach activities have served countless other students. By helping current science fair activities achieve their goals, STEP helps to serve its own mission. Likewise, efforts to help organized efforts such as Science Olympiad and FSEA continue to help inspire students to careers in engineering.

#### Further NSWC Corona Outreach:

The active participation in the STEP Program has resulted in strengthening NSWC Corona Division's partnerships with the local universities and colleges who also are STEP partners. NSWC Corona has pursued formal relationships with STEP partner universities and colleges and developed formal Memorandum of Understandings (MOU's) where specific mutually beneficial activities are agreed to such as engaging in formal internships, hiring fair and engineering partner activities. NSWC Corona Division has signed MOU's with the University of California, Riverside and California State Polytechnic College, Pomona. A formal relationship with the newly established engineering school at California Baptist College in Riverside, California is currently in the works. These formal agreements provide important linkages into the activities of each learning institution. Example successes include our invites to recruit and speak at engineering societies on campus such as the Society of Women Engineers (SWE) and other engineering societies of ethnic representations and engineering disciplines of interest. Additionally, NSWC has held its own on-base career fairs attended by interested local students by advertising through the local university and college partners. NSWC Corona Division has experienced a marked improvement in successfully hiring many more quality engineering students since developing these formal relationships and outreach programs. In addition, the attrition rate has dropped significantly as NSWC Corona has discovered that hiring locally produces more long term career employees as compared to the previous nationwide practice of hiring engineers who had high attrition rates in the first 3 to 5 years of employment.

#### Part 2: Nurturing the employee pipeline

This part 2 is specific to NSWC Corona Division and its work to craft and Employee Development Program to meet its specific needs. The processes and products however could be potentially useful to other organizations with the proper application and the inclusion of site specific information.

#### The Necessity for a Systematic Process of Employee Development

Once the scientist or engineer makes the transition from student to defense sector employee, their continued development, advancement, rewards, and ultimate retention needs to be attended to in a systematic manner. The urgency of this need has never been greater. Because of the events discussed in part 1 above, the NSWC Corona Division demographic distribution of age and tenure are shown again in figure 2 for reader convenience. Notice how there is a large number of young and inexperienced workers as well as a large number of older experienced workers with a large trough in the middle. As time passes, the older experienced workers will be leaving as the exodus of baby boomers continues and, unless mid career people are hired, many of the replacements will need to come from the younger less experienced employees. These workers are largely from Generation Y where they have a high expectation that they will be able to move

up and around<sup>8</sup>. Organizations in this situation will need to facilitate that movement and advancement through development and opportunities.

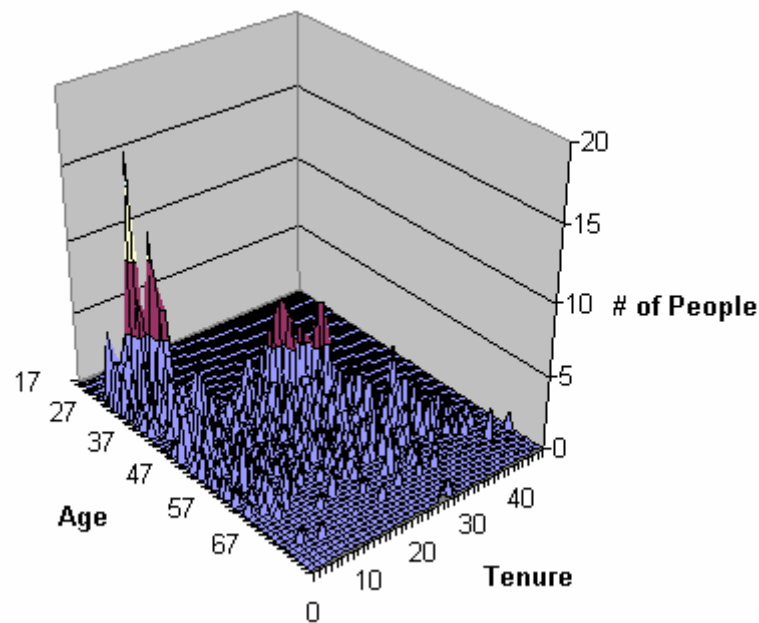


Figure 2. Age vs. Tenure Demographic

Technical organizations that offer a great deal of diversity in the kinds of work performed have both opportunities as well as challenges. The opportunity to move around and try different jobs without the employee ever leaving the organization is a plus. In many cases this diverse set of experiences is exactly what the organization is looking for in its top leaders. The challenge however lies in the diverse areas often being highly technical and specialized. Therefore, we need a systematic approach to career development and ultimately succession planning that is unique to the diverse needs of the organization.

### Laying the Foundation

With the demographic situation discussed above, the need to develop leadership capability across the entire organization becomes apparent. The next generation of leaders are likely to be much younger than their predecessors were when they first assumed similar positions of responsibility. Fortunately, part of the NSWC Corona organization's culture includes the principle that leadership is everybody's responsibility and that it is essential to High Performance. This made the notion of training a newly hired engineer in leadership fundamentals more natural.

To begin the journey toward crafting the systematic development process, we began by surveying the top business schools across the country. With our needs clearly in mind and a budget estimate in hand, we ended up selecting the University of Texas at Austin (UTA) to provide our basic management training and the University of Notre Dame (ND) to provide the leadership training and to facilitate the internal development of the program. The UTA offerings were audited by senior managers locally at UTA and those that met the needs of the organization were brought on site to Corona. The courses were off the shelf for the most part but did afford

some degree of tailoring. The ND courses were also off the shelf but afforded a much greater degree of tailoring. Executive Education at the Mendoza College of Business provided the consultation and set the organization on a journey into a Whole-system Executive Leadership Development (WELD) program.

### The Process

The ND consultants realized early on that a successful program of executive development needed to come at least partially from within the organization. It was further realized that the top of the organization had the responsibility to support and champion the effort. A leadership academy was created using a combination of conventional leadership development in a tightly defined program with a 360 degree assessment, coaching, and an on-line component. The academy was tiered across the entire organization with higher layers of the organization being exposed to greater depth and breadth of learning. This set the stage for the WELD activities that followed<sup>9</sup>.

The WELD approach consisted of multiple groups engaged in action learning activities which were guided by Organizational Development (OD) theories. The prominent theory pioneered by Ken Wilber was Integral<sup>10, 11, 12</sup>. The process also included a considerable emphasis on action learning where by the actual work performed in the creation of the WELD products was itself a leadership development activity. The process consisted of using a maximum mix, or max-mix teams of people from across the organization. This approach assures that the teams working on the issues are demographically representative of the larger organization. The groups would work on their respective pieces of the Whole-system and then convene at a Large Scale Event (LSE). The process was repeated across phases and graphically looks something like figure 3. In Phase III the scope of the program was expanded to include all of the technical competencies at the organization in addition to leadership, supervision and management and the program was renamed the Employee Development Program (EDP).

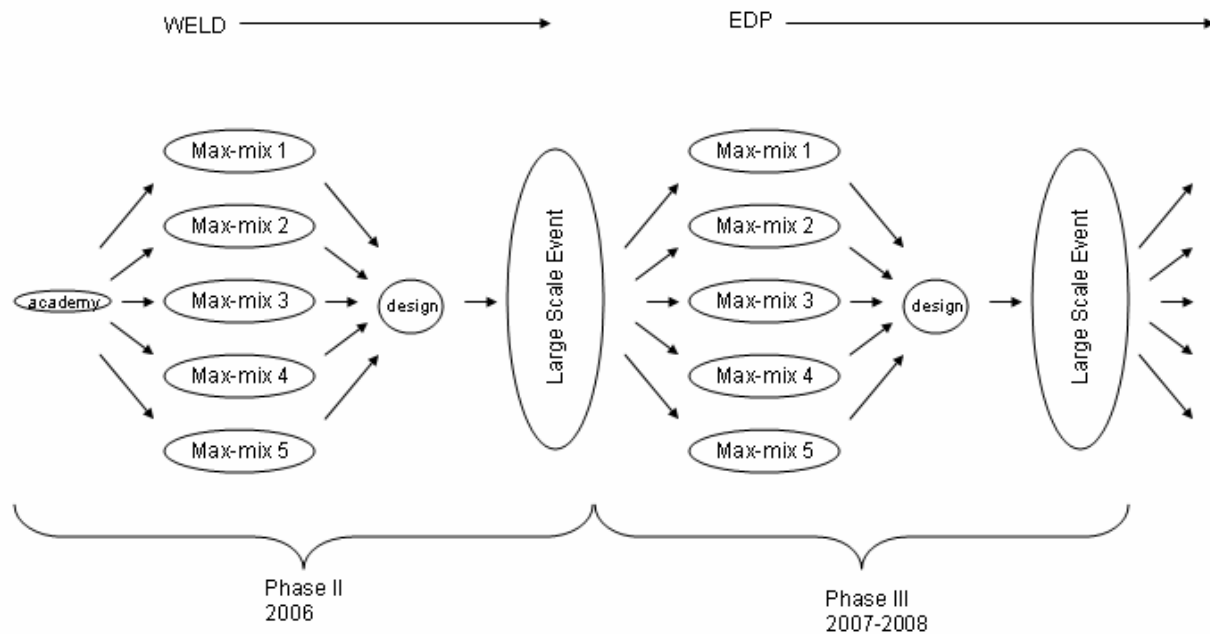


Figure 3. Action Learning WELD and EDP Process

## The WELD Products

### Competencies

The WELD approach started out with an emphasis on leadership competencies. It was realized from the beginning that regardless of what the competency model looked like when it was completed, it needed to have been created from within the organization to be accurate and relevant. To import and use “generic” competencies would be a set up for future failure when they didn’t fit correctly. To make that happen, we used a series of 360 degree focus group interviews of employees at all levels of the organization. The interviews asked what people at their level in the organization thought was required to be successful at their own and other levels in the organization. What resulted was a rich first draft of competencies, knowledge, skills, abilities, and traits to be successful at each of the levels of project leader, line manager, middle manager, and executive manager positions.

### Career Planning

It was also realized early on in the WELD phase that the employees needed some career planning guidelines. Draft supervisor and employee guides were developed that outlined the responsibilities of both employee and the organization in career planning. It is the employee’s responsibility to take control of their own career and to be proactive in their development, mobility, and advancement. At the same time the organization has the responsibility to provide guidance, resources, and opportunities for employees to develop themselves and move into positions of added or different areas of responsibility. This max-mix team also created the notion that the positions at the organization need to be mapped to career paths. These paths show the logical progression from entry level to senior employee in each of the respective

technical areas. They also show areas where it is easy to move from one position to another horizontally because the positions share many of the same competencies.

## **Training System**

Another area that needed attention to facilitate the use of the career paths and competencies was a comprehensive training system. Initial work indicated that although training happens at the organization, the existing process represents only parts of a system and was largely ad hoc. As a logical starting point, the organization's leadership decided to mandate the use of Individual Development Plans (IDP) for all employees. An electronic form and data base was created and training on how to use the IDP was developed and delivered to the entire workforce. A command level achievement award was offered if the organization could achieve 90% of all employees with an IDP on file. Within months of setting the goal, 98% of the organization's employees had an IDP on file.

## **Succession Planning**

As a final piece of the Whole-system approach, a max-mix team was formed to look at succession planning. Following the premise set forth in the HBR article *A Players or A Positions*<sup>13</sup>, a set of criteria were developed to assess the criticality of various positions at the organization. Criteria were developed around the areas of strategic value, scope of authority, customer relations, advocacy, and influence over business practices. Each area has a narrative describing both average and above average criterion from which to assess the position against. The team also developed a basic weighting and scoring method.

## **Refining the WELD Products: The Employee Development Program**

The WELD products were unveiled to the organization's management and other senior technical leaders at the first Large Scale Event. As a result of the LSE and the learning from the WELD phase it was decided that in order for the program to continue to evolve and develop, a dedicated Program Manager (PM) needed to be selected. Once that position was filled, the PM quickly learned all of the aspects of the WELD efforts and set the stage for the EDP Phase which included the expanded scope. To reinvigorate the workforce, the PM and the Corona Technical Director held all hands meetings with the workforce. The message was to explain why we were doing WELD, what we have done so far, and where we need to go. The meetings were also a call-to-arms to get volunteers to participate in the next phase of development. The call was answered and teams were established around the previous WELD structure. The teams were structured in a max-mix arrangement with some additional employees added to round out the mix.

In this phase, the focus was on having very clear entrance and exit criteria. The entrance criteria were the results from the WELD efforts. The exit criteria were based on where the PM thought the program needed to go. The teams were fully empowered and created their own charters. In some cases the teams deviated from the PM's expectations but in every case the deviations were to exceed the initial exit criteria. The program was well resourced and staffed allowing for the expanded scope.

## **Refined Competency Products**

### **Competencies**

The original draft of the competencies and Knowledge, Skills, and Abilities (KSAs) was refined in a series of workshops. The participants were selected based on their expertise with leadership and management competencies and knowledge of Human Resources. Multiple sources of competency models were reviewed including the Office of Personnel Management (OPM), Defense Acquisition University, and other NAVSEA Warfare Centers. The original draft was refined into a coherent model of competency areas, competencies, and KSAs for both leadership as well as supervision and management. In addition, the workshops produced tasking statements that paralleled the competency and KSA products. These products formed the input for the max-mix team.

The team took the competency model a step further and worked to map the existing training being offered at the organization to the competencies and KSAs. People who had taken the courses were asked to select which competencies and KSAs were covered in the courses. The data was aggregated and revealed several courses that were high leverage in providing numerous competencies and KSAs. This analysis influenced which courses were subsequently offered at the organization.

The team also developed a set of guidelines on how to use the various products. The competencies and KSAs are the primary building blocks that drive development while the tasking statements can be used for job announcements. Both can be tailored for use in behavioral rating scales to aid in succession planning. The training matrix provides a resource for employees to elect to take a particular course in order to obtain a specific competency or KSA and helps in the creation of their IDP.

### **Expanded Career Planning**

The expansion in scope that occurred after the WELD phase requiring the inclusion of the technical competencies and KSAs caused the new max-mix team to pull from some preexisting data. The organization had developed technical skills dictionaries in the recent past so that data was used as a starting point. The team developed a tool to house the new competency model using a basic tree structure. The tool was unveiled at the second Large Scale Event where over 200 employees from across the entire organization were assembled. Their comments revealed that although the structure of the data was usable, the content was incomplete for its intended use. The individual technical Departments had the task of going into their respective parts of the organization and defining what their competency models look like. In parallel, a set of organization wide competencies was developed which rounded out the complete competency model.

To add further clarity to the career paths developed in the WELD phase, an overarching career path model was overlaid on the local path model. Employees could now see their position within a role nested within the local career path structure and aligned with an overarching path

structure. This set the stage for the alignment with higher headquarters work described below.

The tool unveiled at the Large Scale Event evolved to marry up the career path maps with the competency model. In order to effectively build the position's individual competency model, a means for scaling the competencies across the levels within the role was needed. Some departments used general KSAs statements with general labels for the levels while others used separate KSA statements for each level. The intent was to provide enough flexibility so the uniqueness of the Departments could be captured in their own competency model that was ultimately useful to them while at the same time providing enough structure so that employees who look across Departments can make valid career choices. The practicality of these various approaches has yet to be assessed.

### A Refined Training System Model

The Employee Development Program max-mix team that addressed the training system took the learning from the WELD phase and started with a use case analysis to determine the requirements. The team augmented that set of requirements using a LEAN SIPOC approach<sup>14</sup>. This approach segmented the requirements by user type. The team members independently developed what they thought a model of the training system might look like. Several prototypes were proposed and one stood out among the rest. A basic overview of that model is provided in figure 4.

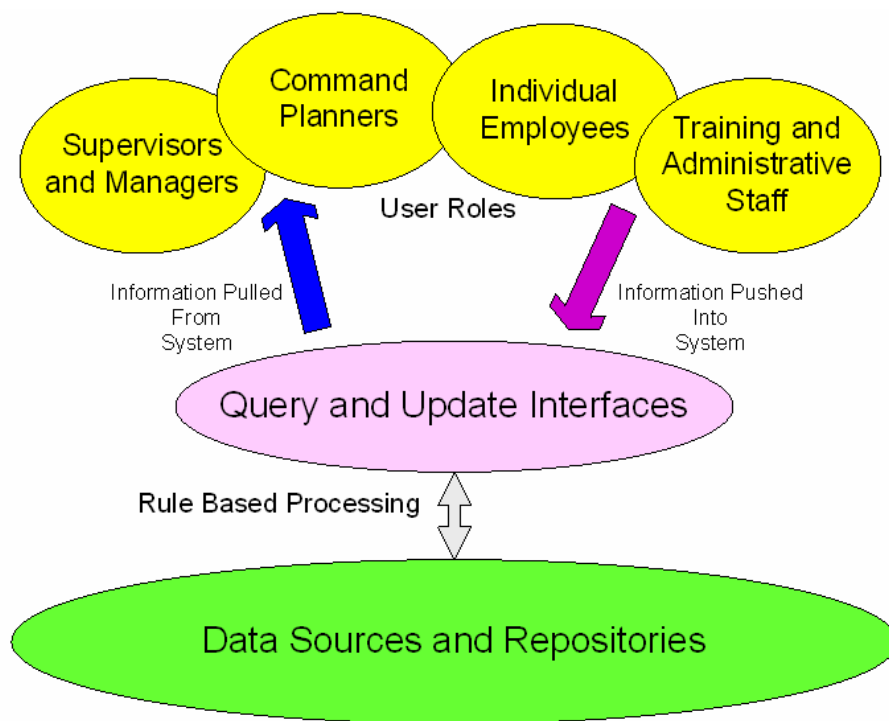


Figure 4. Basic Training System Model

The model met all of the requirements of the general user groups identified by the pulling and pushing of relevant data through an interface into and from data sources and repositories. The model was validated using the original use cases. It was further validated at the second Large



Scale Event where participants were asked to try out their own use cases. The model withstood all of the rigorous testing.

## Succession Planning Process

The team for succession planning took a different approach than the WELD team took in that they wanted to define what the succession planning process actually looks like. They developed the flow diagram in figure 5.

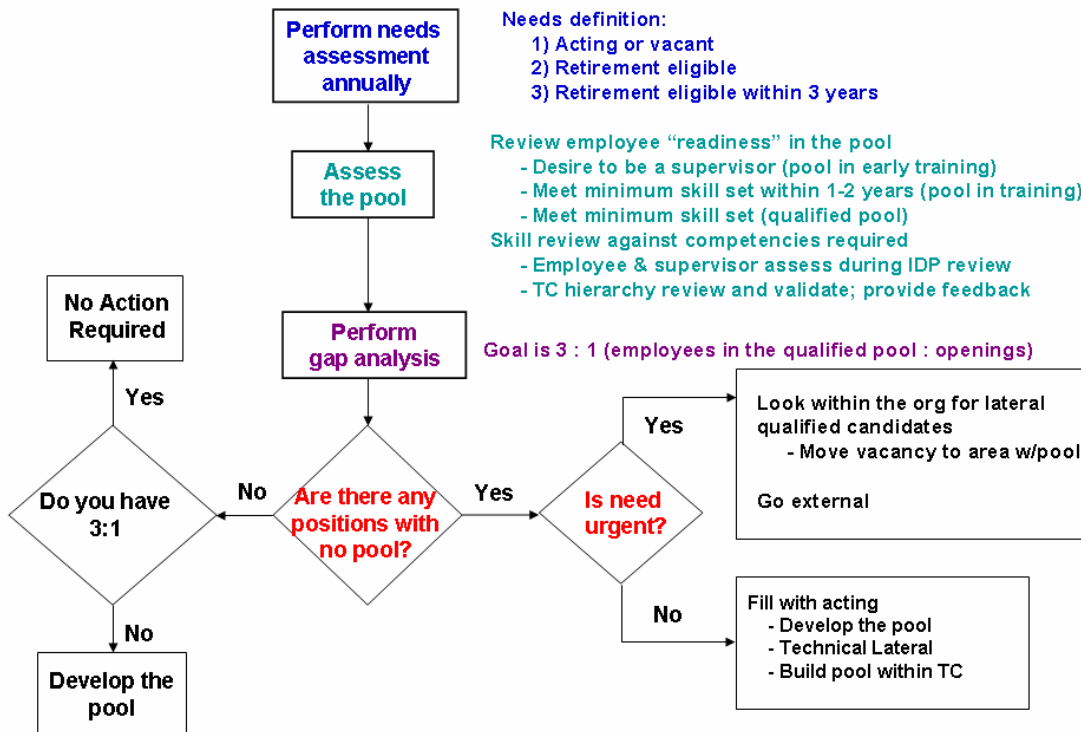


Figure 5. Basic Succession Planning Process

The team decided to use the first line supervisor position at the organization to test the process. Data was pulled on the retirement eligibility of all of the supervisors and a basic vulnerability assessment was performed. In order to assess the pool, the team determined that from the comprehensive list of supervision competencies and KSAs, there is a select subset that forms the critical skills. From that subset, they followed techniques from the training world and developed a behavioral rating scale<sup>15</sup>. The scale takes the critical KSA statements and translates them into task statements and assigns a scale ranging from almost never to almost always. The scale is best used as a 360 degree instrument where raters have had the opportunity to observe the behavior of the person being rated. The creation of the scale can be easily extended to rating instruments based on any well written set of KSA statements. The results of the assessments can be used in the gap analysis required to develop the succession plan.

## External Recognition of the EDP Process

Over the last two years, the approach NSWC Corona has been following to craft a full spectrum Employee Development Program has received multiple recognitions and awards. First, the partnership with the University of Notre Dame was truly a mutually beneficial relationship. The consultants from Executive Education at the Mendoza College of Business worked collaboratively with NSWC Corona to craft a program from within the organization itself. The process drew heavily from organizational development theory and was tailored to meet the unique needs of the Corona culture. NSWC Corona received the Excellence in Executive Education from the University of Notre Dame in 2007 in recognition of this innovative and collaborative work. In 2008, the International University Consortium for Executive Education (UNICON) and the Ashridge Business School co-sponsored a research project to look at the leading edge of business school evolution. The study sought to find the innovations in executive development occurring in business schools worldwide. NSWC Corona was selected as a case study for the research. “This case study describes a leadership and organizational development intervention for a division of the US Navy delivered in partnership with Notre-Dame. It was selected for the innovative use of Integral theory as the overarching framework to inform the methodologies and theories used to effect individual and whole system change. The case study also demonstrates the value of an engaged workforce in embedding change and taking ownership for their future development.”<sup>9</sup>. Later in 2008 the approach was again recognized by the Under Secretary of Defense for Acquisition, Technology & Logistics with a silver level Workforce Development Award. The award lauded not only the whole-systems approach to employee development, but also the many related benefits of recruiting, retention, and leadership development.

These external credits and validations point to the efficacy of the approach.

### **EDP Phase III and Beyond**

#### **Process changes**

In phase III of the EDP development, the process shifted toward being less participative and more directive. The goal was to maintain the best of the participative approach while simultaneously getting the best from a directive approach<sup>16</sup>. Activity is also shifting away from being centralized across the command to being decentralized. The individual Departments are pilot testing the products and systems to map the competencies and KSAs to positions in the career paths and to use the built out positions to drive position descriptions, individual training plans, and ultimately succession planning. In addition, the organization released its latest version of a strategic plan. The plan contained a specific strategy to develop and maintain an Employee Development Program. The plan also had goals and strategies relating to new work and strengthening the alignment of the work with DoD and Headquarters. These complimentary goals and strategies have resulted in synergistic efforts between the EDP development and deployment and the other strategic goal team’s tactics and embeds the EDP into the overall strategic planning process.

#### **Integration of the Systems**

An integration team was established midway through the second phase of the EDP and continued

into the third phase. Their primary job was to define the architecture for the EDP. To facilitate that effort, the DoD Architecture Framework was studied and adapted<sup>17</sup>. The framework was a perfect model to manage the complexity of the design and deployment of a system of related systems. The document will guide subsequent development and will assist in the creation of maintenance activities necessary to sustain the program.

The development of the systems has always kept a keen eye on higher Headquarters (HQ) requirements. NSWC Corona Division's parent organization, the Naval Sea Systems Command (NAVSEA), has developed materials to facilitate a Competency Aligned Organization<sup>18</sup>. This structure provides the national level context for the local EDP to reside. The overarching career path is the bridge between the two levels. Also, the strategic planning work on alignment developed the relationship between the mission, the technical warrants, the Technical Competencies (TC), and the competencies. Alignment of these components resulted in the graphic representation in figure 6.

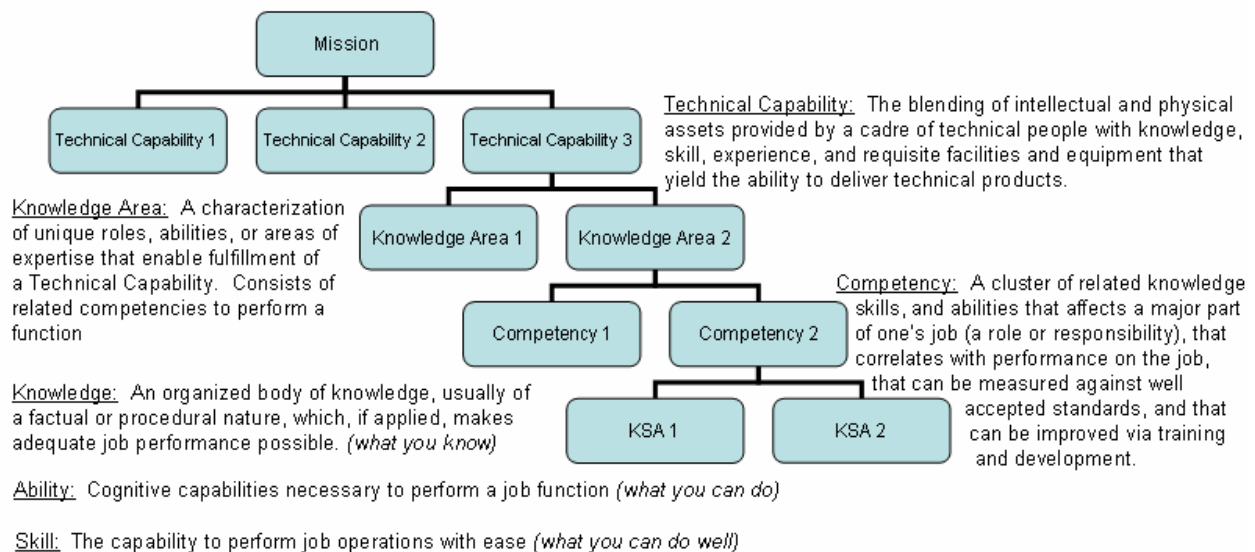


Figure 6. Mission, TC, Knowledge Area, Competency, KSA relationship

Technical capabilities are warranted and unique to the individual Warfare Center Divisions. Knowledge areas were created so that under the CAO construct, the parent organization, NAVSEA, could manage the health of the organization nationally while still allowing the individual Divisions to manage locally. The competencies and KSAs, drawn directly from the literature on organizational Training<sup>15</sup>, next nicely underneath the Knowledge areas. This nesting provides guidance to employees on how to develop themselves so that they can support the health of the organization by maintaining the capacity to deliver technical products.

### The Full Benefit

As the system is deployed and matured, employees will become more comfortable with the idea of their jobs as consisting of competencies and KSAs. Although designed primarily for employee development, the need to do succession planning based on those same competencies is

emergent and becoming more urgent every day as evidenced by the demographics presented at the beginning of this section. In order to effectively create a succession plan, the employees need to be assessed against the competencies and KSAs required of the positions. This assessment not only facilitates individual development, but also organizational development as it generates the information needed for the creation of succession pools. Care needs to be taken to not inflate assessments used for developmental purposes as is often the case when assessments are performed for administrative purposes<sup>19</sup>.

The full functionality of a Career Planning tool will give the eager to move Generation Y employees the ability to see up and across the organization from the perspective of career ladders, competencies and KSAs, and training and development. This capability will facilitate the systematic development and career progression that we will desperately need as the experienced Baby Boomers continue to retire in record numbers over the coming decade. We will be able to systematically plan for their succession by knowing what competencies and KSAs are at risk as the wave of retirements rolls out. In the long run, more employees will grow throughout their careers with a greater breadth of knowledge facilitated by the visibility into the different technical areas offered by the organization. In cases where employees wish to ease themselves into retirement, we can prolong the utilization of their skills by bringing them back as contract employees after they retire from full time federal service.

## **Summary**

NSWC Corona Division's whole system approach to the engineering pipeline continues as a work in progress. Portions of the strategy are in effect and producing valuable results while other portions remain under development. The end state is envisioned as an increasing local pool of engineering students who already have an awareness and positive views of NSWC Corona Division and the Metrology Engineering Center. Many of the incoming engineering students hired will come from the expanding internship programs that are creating NSWC Corona knowledgeable and pre-trained applicants for full engineering positions. Once hired, the Employee Development Program will supply continued developmental training and opportunities to fill the continuing drain of expertise that leaves due to retirement. The whole system approach will allow all to see the end-to-end system and choose their own path. The organization will ultimately benefit with sufficient numbers of well trained engineers to continue to grow and renew itself long term.

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