Status and Future of the Naval R&D Establishment

NRAC Summer Study

Sponsored by

Hon. Sean Stackley

Assistant Secretary of the Navy

(Research, Development, and Acquisition)

September 2010

NRAC

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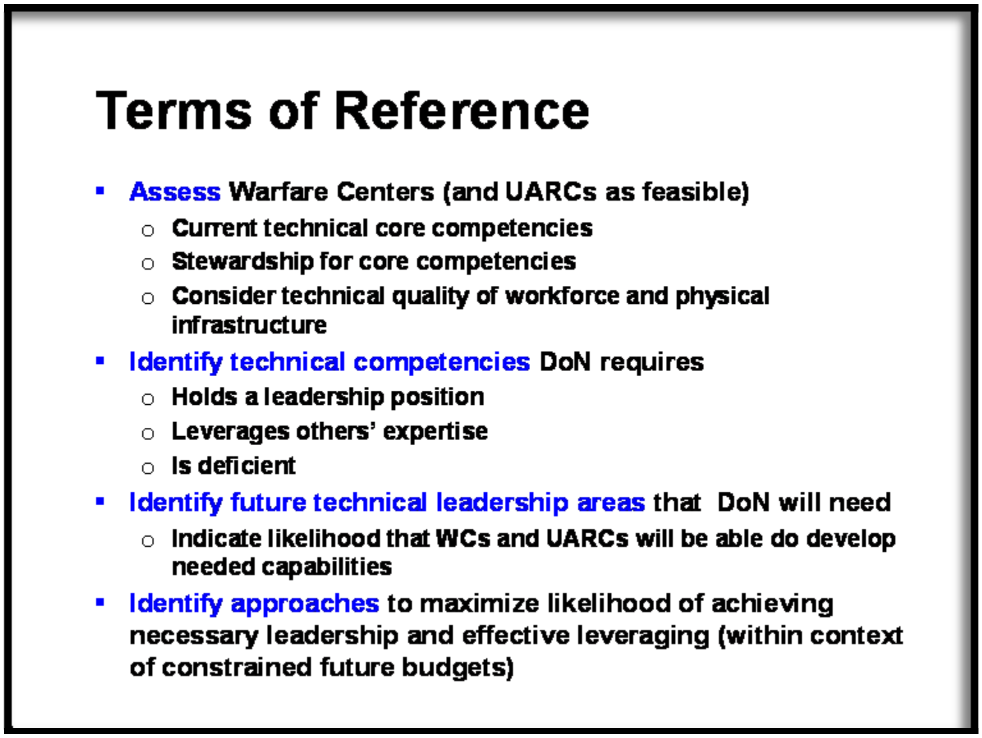
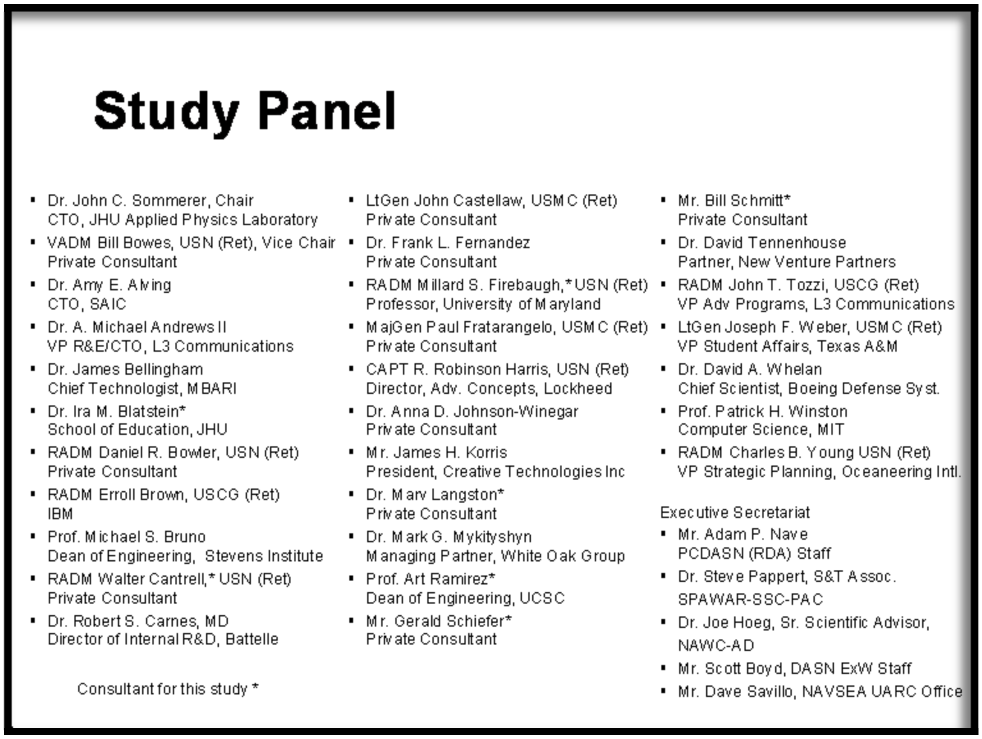


The original TOR called out the Marine Corps Warfighting Laboratory (MCWL) and the Marine Corps Systems Command (MARCORSYSCOM) as analogous to Naval Warfare Centers and Navy SYSCOMs, however, MCWL is not a Lab and MARCORSYSCOM has no Warfare Centers – but uses those of the Navy. The complete Study Terms of Reference (TOR) document is in Appendix A.

This is an unusual NRAC study in several respects: larger than usual scope; and, more policy and organizational content than usual for a *research* advisory committee study. The NRAC panel felt it would be failing in its responsibilities if it did not engage those important issues, particularly in view of the tasking in the fourth element of the Terms of Reference.

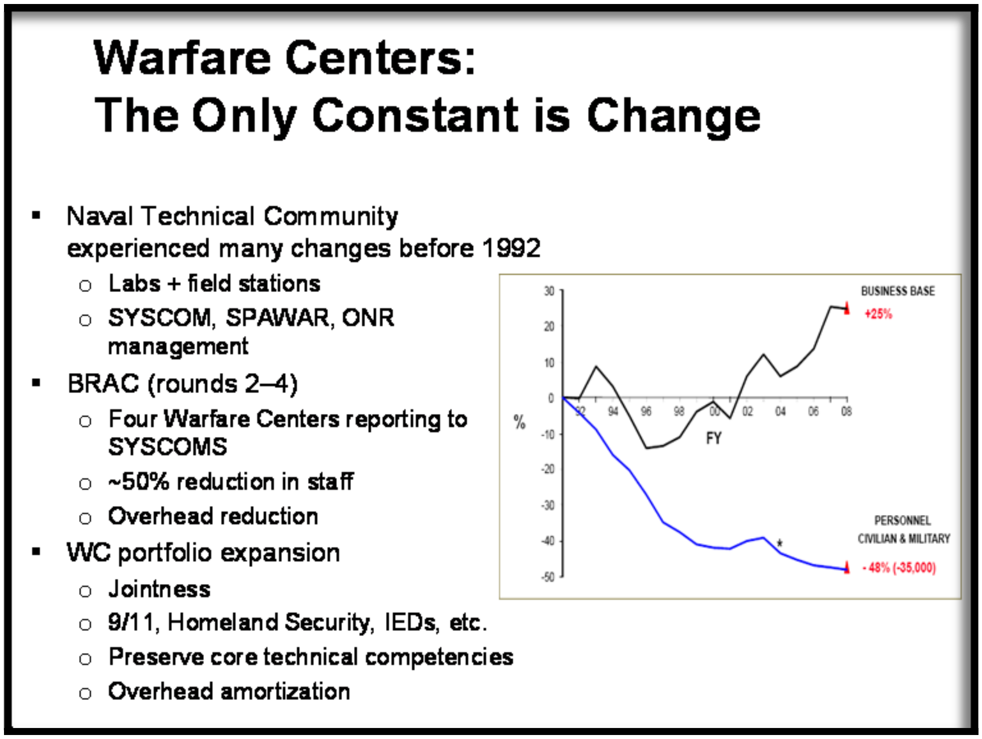


Given the scope of the Study, the NRAC membership was augmented with a number of consultants. This Panel represented deep expertise and diverse achievements.

The Panel had:

- Former operators who, in uniform, depended on the technology base of the Department,
- Experienced and successful acquisition executives,
- Former senior leadership of the Navy's technical community, both military and civilian,
- Technical experts in a variety of fields,
- Entrepreneurs who have successfully bridged the technological "valley of death",
- Executives who have deep experience in technology investment in government, private industry, and the nonprofit sector.

Also, invaluable assistance was provided by the executive secretaries assigned to the study. These individuals – each with germane expertise – greatly facilitated the Panel's engagement with the DON technical community, and provided significant information that informed the findings and recommendations.



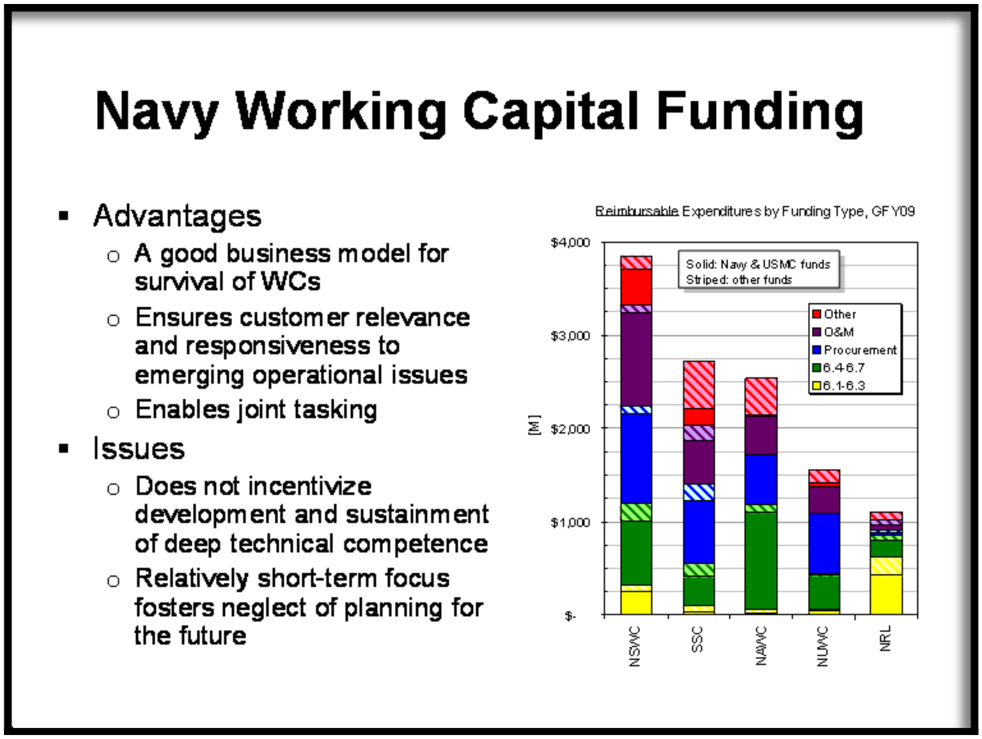
The Naval technical community has always been in a state of flux. Concern about the technical community's missions, functions, and roles has driven much of the change. In the 60s, 70s and 80s, there were a number of laboratories (e.g., Dahlgren, China Lake) under the Director of Navy Laboratories (DNL). The DNL reported at various times to the Chief of Naval Materiel (NAVMAT), Chief of Naval Research (CNR) and Space and Naval Warfare Systems Commander (SPAWAR). There were field stations like NOS Louisville and NAVSSES Philadelphia that reported to the Systems Commands (SYSCOMs). During all this time, the Naval Research Laboratory (NRL) reported to CNR.

In the 1990s, rounds two through four of the Base Realignment and Closure (BRAC) process established a new structure to manage the government portion of the Naval R&D Establishment (NRDE). Although BRAC did not directly affect the UARCs, they underwent significant oversight changes during this time period.

All Naval laboratories and field stations were consolidated into four Warfare Centers (WCs) reporting to the SYSCOMs. NRL continued to report to the CNR. A governance body, Navy Laboratory and Center Coordinating Committee (NLCCG) was set up to manage the government portion of the NRDE and to ensure that BRAC actions were executed. An oversight body, the Navy Laboratory/Center Oversight Council (NLCOC) was chartered to resolve issues across the NRDE and the SYSCOMs. The NLCOC was chaired by the ASN (RD&A).

Under BRAC, a number of sites were closed. Over the next decade, the NRDE *reduced its government workforce by approximately 50%*. Budget pressures during this time, also resulted in significant overhead reductions at government sites. Reduction in overhead funding limited the ability to refresh the technical community, its equipment, and facilities.

During the current decade, the WCs expanded their technical portfolios in reaction to several stimuli. First, the emphasis on joint service collaboration or "jointness" required the Navy to work more closely with the other Services. WCs began working for other Services in order to integrate Naval systems into a joint environment. Second, new national security challenges arose after 9/11, including homeland security requirements, countering IEDs overseas, etc. Third, preservation of core Naval technical competencies that may not be adequately supported – required seeking other funding sources. This additional work allowed the R&D establishment to amortize overhead costs over a larger number of direct work years, and reduce the cost of work to Navy customers.

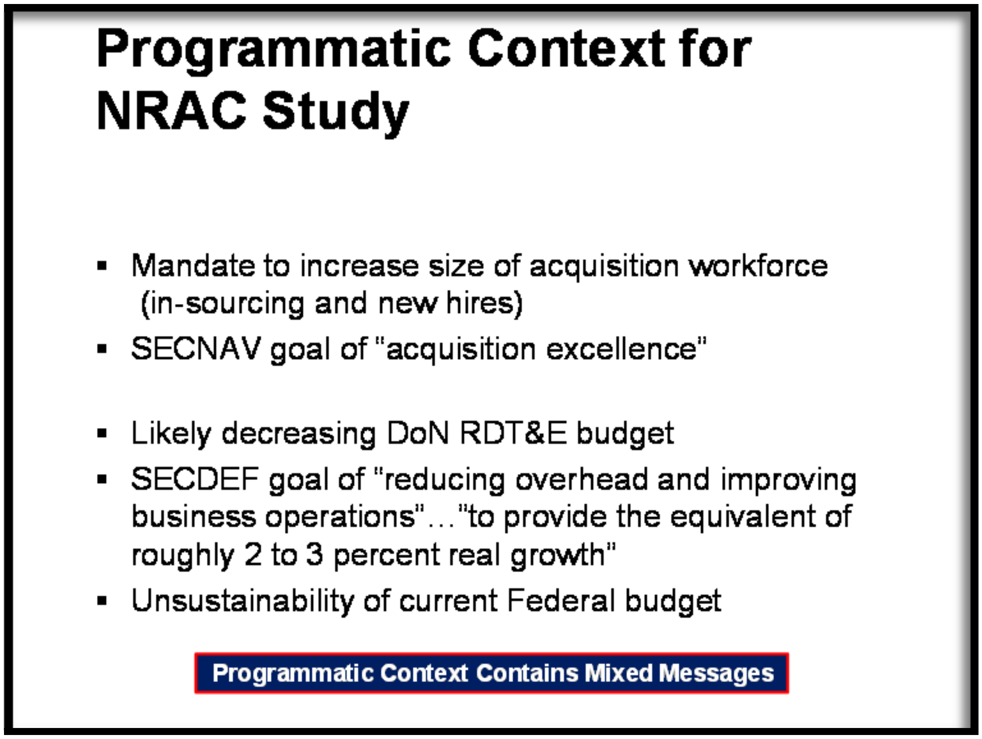


The Navy has used the Working Capital Fund (WCF) model for over forty years. Operating under this business model, the Warfare Centers have (almost) no mission funding and instead are funded only by other organizations, which are charged for carrying out specific tasks. This model has several advantages. It incentivizes the WCs to be relevant and responsive to the needs of their primary customers, the SYSCOMs and PEOs, and this keeps their focus on Navy customer needs. It also allows the Navy to be responsive to joint needs because the WCF provides a mechanism for WCs to expand their business base across other customers. This broader business base has the added benefit of reducing overhead rates to all customers. The WCs have been very successful at developing business under the WCF model from both Navy/USMC funds and non-Navy customers.

However, the Panel found two areas where the WCF does not incentivize important functions. First, S&T work is not a priority of the WC customers, and as a result, S&T funding at the WCs has fallen to very low proportions, threatening their ability to develop and sustain deep technical expertise, especially in emerging areas of future importance. Today total S&T funding is less than 1% of the total “reimbursable” expenditures of the WCs; and only NRL and NSWC – specifically, Dahlgren and Carderock – receive significant Navy S&T funds. The WCs are not broadly incentivized to develop and sustain deep technical competence.

Second, the near-term focus of the WC customers does not incentivize planning for the longer-term future. The customer work necessarily is focused on “Today’s Navy” or the “Next Navy” – not on the long-term future. Because WCs have little discretionary funding, their workforce cannot focus on the longest-term challenges or participate in a meaningful way in technology development, integration or experimentation that will provide the basis for future capabilities.

This represents a serious risk, when the Department's organic scientists and engineers cannot focus on the longest-term challenges or get involved in helping develop, integrate or experiment with technologies that will provide the basis for future capabilities. It's a particular risk in a world where both technology and operations are evolving rapidly.



In response to President Obama's March 2009 memo on "Government Contracting," Secretary of Defense Gates announced his intent and recommendations to change the Department's strategic direction and reform the DOD acquisition process. These actions will increase the Defense Acquisition Workforce from 127,000 to 147,000 by 2015. It will return the workforce above its 1998 level of 146,000. About half, or 10,000 of the planned growth will result from in-sourcing selected acquisition support services and performing these services with government employees. The Navy will add 6,922 personnel to its Acquisition Work Force by 2015, to include 3,505 acquisition in-sourcing hires.

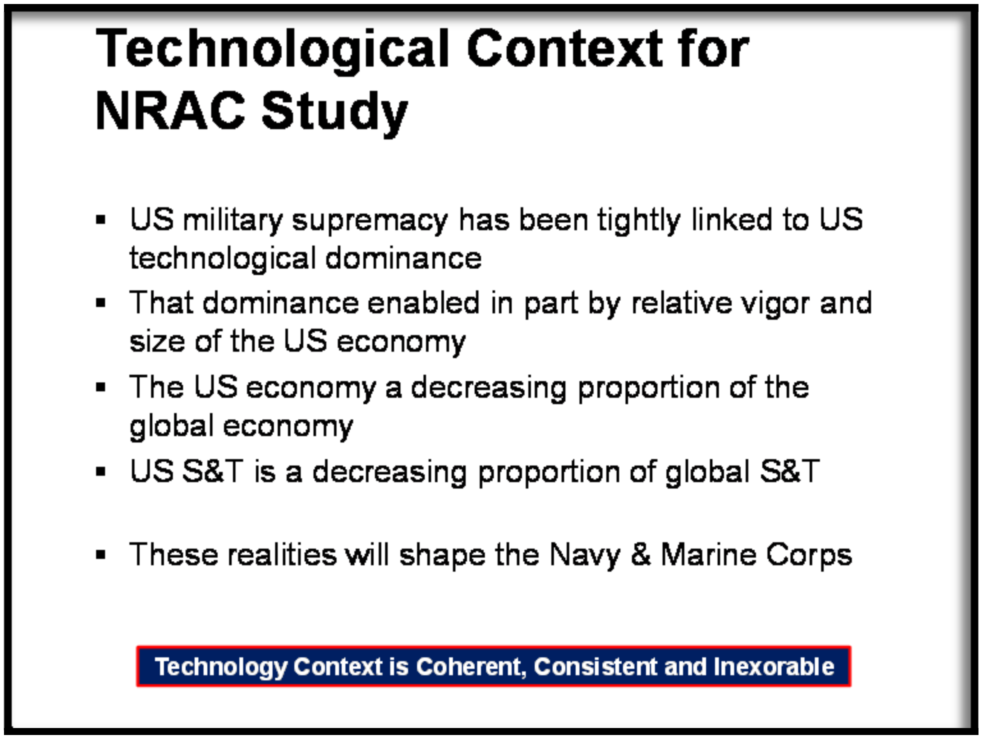
In May 2010, SECNAV announced his Acquisition Excellence principles:

- Clearly identify the requirements,
- Raise the bar on performance,
- Rebuild the acquisition workforce,
- Support the industrial base,
- "Make every dollar count."

Two of the principles "Raising the Bar on Performance" and "Rebuild the Workforce", were assessed in the course of this study. The Secretary of Defense has recently set a goal to find more than $100 billion in overhead savings over the five fiscal years starting in FY 2012. With this, he is hoping to provide the equivalent of roughly 2-3% real growth for the Department's budget.

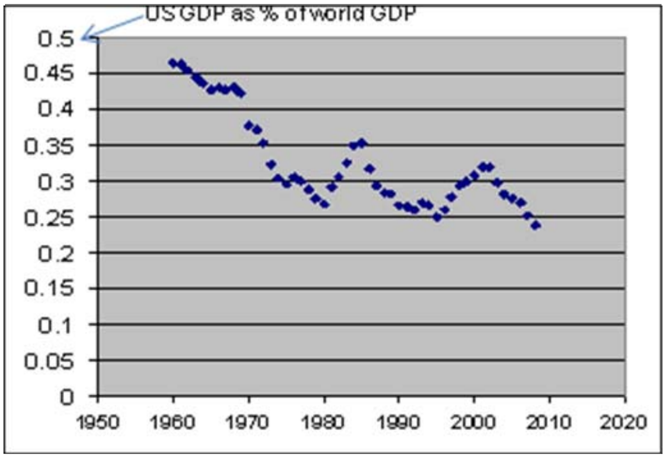
The programmatic context of this study was conducted in an environment of "mixed messages:"

- Grow the workforce,
- Cut $100 billion in DoD overhead by 2016,
- Wean the services from Overseas Contingency Operations funding,
- Reset the force, following the return of forces from Iraq and Afghanistan,
- USMC estimate to "reset" its force: $13.5B,
- USMC cutting its S&T investments level to 3%.

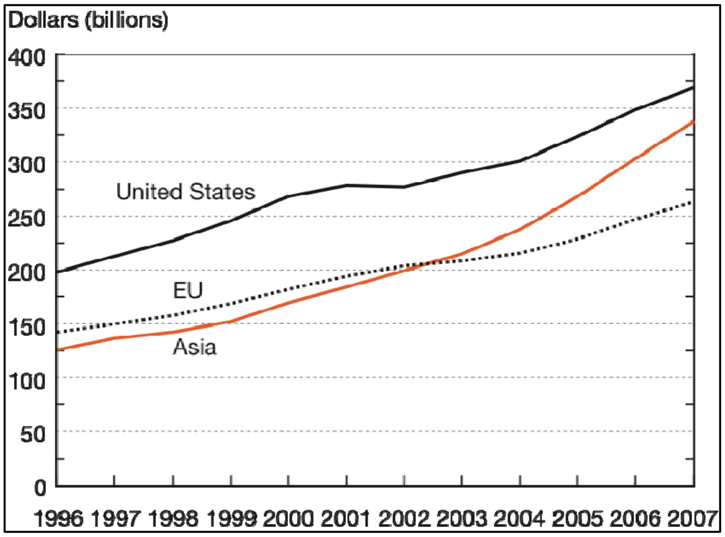


The military dominance of the United States and U.S. Naval Forces in particular, is closely coupled to technical superiority of our military equipment and systems. This superiority is evident in such diverse areas as nuclear weapons and naval nuclear propulsion, radar, electronic warfare, and missile systems. The technical superiority has enabled the military to counter threats even operating at a numerical disadvantage.

The technical superiority of U.S. military equipment and systems is in turn tightly coupled to the size and vigor of the U.S. economy, which provides the tax base enabling the military to pay the premium necessary to obtain the best equipment. The dominance and competitive vigor of the U.S. economy has in turn fostered both technical capabilities and business practices which the U.S. military has leveraged to enable and maintain technical superiority.



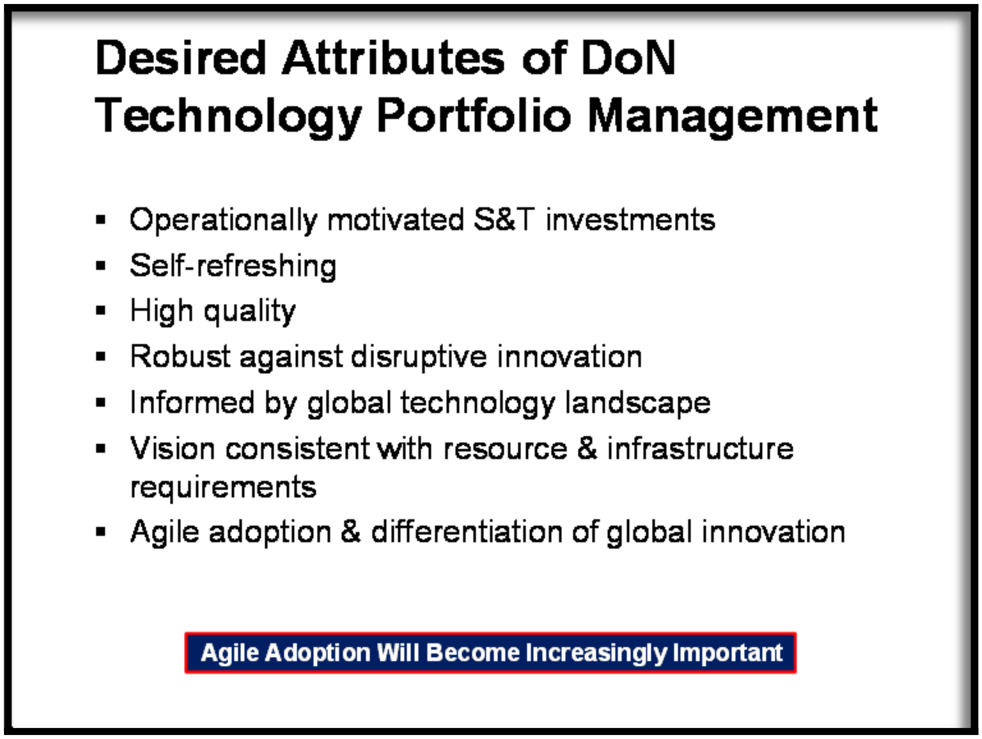
While the U.S. population is less than 5% of the world population, the U.S. Gross Domestic Product (GDP) comprises 25% of the cumulative world GDP. As emerging markets in the developing world grow, the U.S. economy is a smaller and smaller faction of the world economy



(graph to right: U.S. GPD as compared to world GDP from World Bank data).

Although the U.S. government and U.S. companies continue to invest in R&D, the increasing economic strength of developing countries and their R&D investments means that R&D is increasingly a global enterprise. (graph at left: taken from National Science Board, Science and Engineering Indicators 2010).

While the U.S. economy will remain the 'big dog" for the foreseeable future, the changing global landscape means that the U.S. Navy can no longer assume that U.S. companies will be technically superior to their foreign competitors. Where this is unacceptable, it will be incumbent on the NRDE to anticipate unfavorable shifts in technology dominance and act to preserve its best interests. Where shifts are less threatening, the global marketplace will become a resource in the form of ideas, equipment, and systems. Dealing effectively with these changing realities will determine the effectiveness of NRDE and will shape the future Navy and Marine Corps.

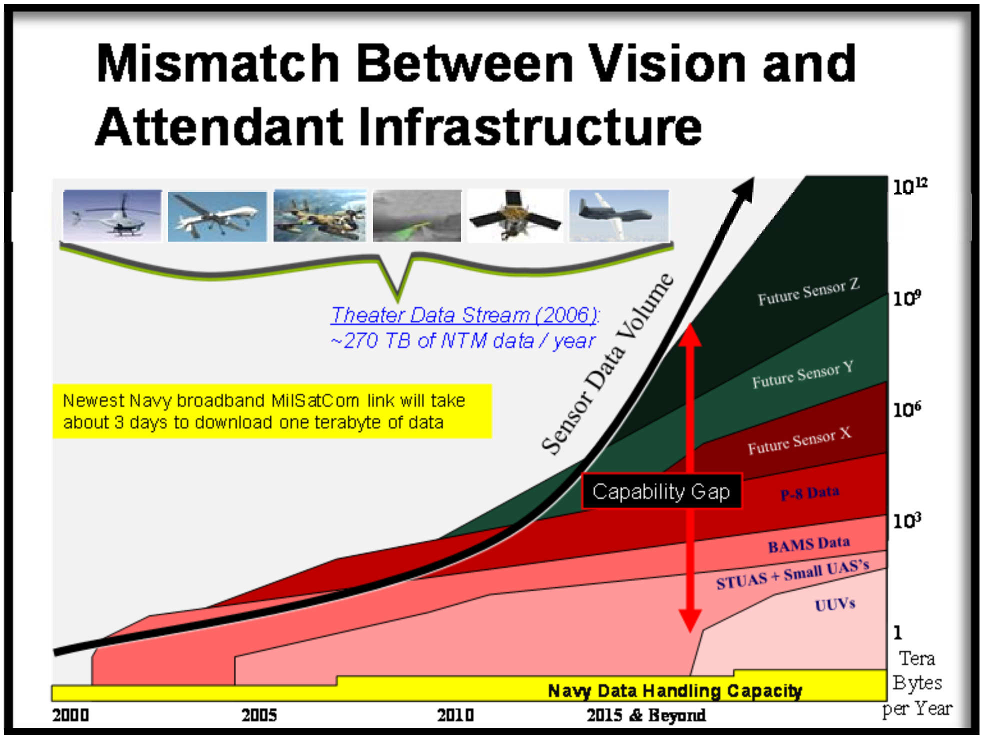


As previously stated, the DON technology position will be shaped by the increasingly global nature of S&T. Even if Navy/Marine Corps R&D budgets were to remain a constant fraction of U.S. GDP, they would be a declining fraction of global S&T investment. Therefore, those R&D investments must achieve a greater effectiveness per dollar to maintain U.S. Naval technological superiority. Important attributes include:

- Operationally motivated S&T investments: S&T investments should be connected to some vision of how they will positively impact Naval capabilities. Indeed, a core competency of the NRDE must be maintaining a clear understanding of how new or emerging technical impacts might impact Naval capabilities. This should not rule out exploratory S&T that might enable revolutionary new capabilities. Rather for this portion of the portfolio, the goal should be to ensure technical innovation is coupled to equally innovative concept development.
- Self-refreshing: The scientific and technical workforce is the engine that drives the NRDE, yet is highly perishable in nature. Technical capabilities once lost, may take a decade to re-establish. At the same time, the dynamic nature of science and technology means that the NRDE must be in a constant state of re-invention.
- High quality: The difference between the best and the average technical individuals can result in productivity differences of orders of magnitude – writing software for example – a factor of 10 is well documented. At higher

levels, the leadership of a few individuals can make the difference between success and failure of entire industries – Steve Jobs at Apple for example. Consequently it makes sense, from both a cost and technical productivity perspective, to recruit the highest quality scientific and technical talent while maintaining a culture of technical excellence.

- Robust against disruptive innovation: The extremely dynamic nature of the global technology landscape – new markets can emerge and flourish in mere years – means that the NRDE must have sufficient understanding of technology changes to protect the value of major acquisition programs.
- Informed by global technology landscape: The globalization of R&D means that NRDE must engage beyond the borders of the United States. By maintaining a clearer understanding of how technical capabilities might impact (and possibly revolutionize) operational capabilities, the U.S. NRDE should be positioned to identify DON-relevant innovations earlier than potential competitors.
- Agile adoption and differentiation of global innovation: When promising innovations in the global market are identified, the task of the NRDE is to influence the external community development directions to satisfy Naval needs, and perhaps – with NRDE funding – to develop key elements that ensure an advantage to Naval capabilities.
- Vision consistent with resource & infrastructure requirements: The increasing cost of technology and limitations of the Federal budget suggest that the NRDE must focus on developing affordable capabilities. Further, the interplay of conceptual systems with existing systems and infrastructure must be a factor in the decision process. An example is shown in a subsequent chart that depicts the mismatch of demand for bandwidth and available bandwidth in future Naval combat systems.

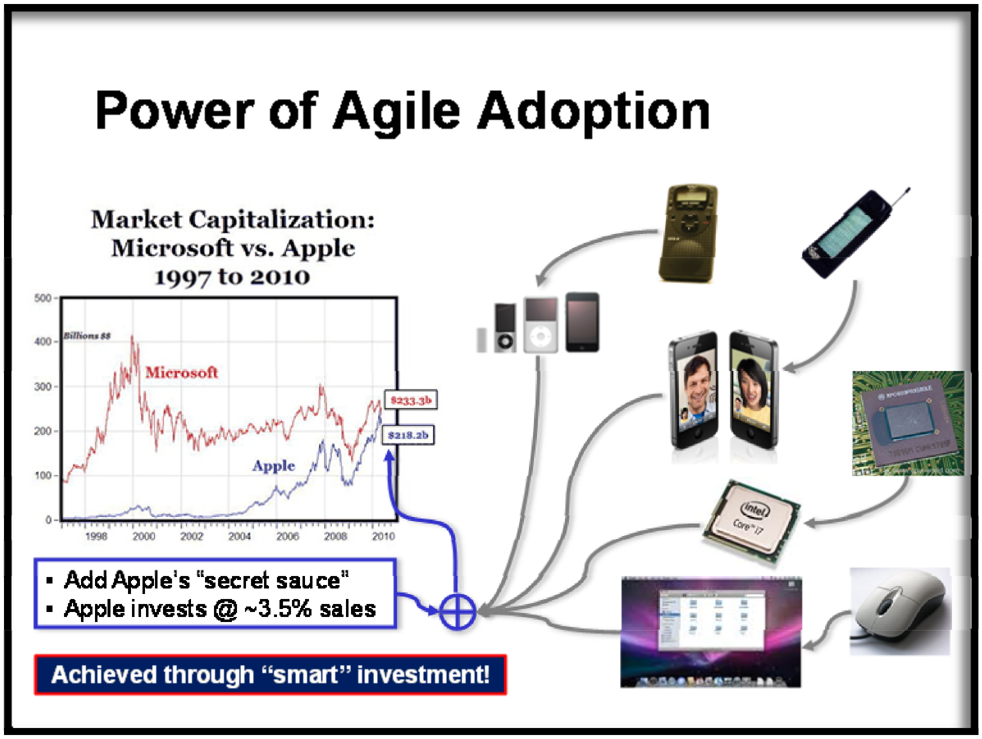


Professor Emeritus, Albert Bartlett, University of Colorado, has spent the past decade focused upon the issue of exponential growth, despite his background as a nuclear physicist. His famous quote, "The greatest shortcoming of the human race is our inability to understand the exponential function" is useful to consider as one compares the existing and planned sensor data production compared to the DON investment in infrastructure currently planned and funded. The modern state of information technologies has reversed the situation that the DON struggled with four decades ago when computer processing and storage capability cost millions of dollars in equipment and supporting data facilities just to have the equivalent of today's desktop computer capability. At the same time, because the amount of data that is created in modern imaging and video sensors is so large, moving this data has become the new long-pole-in-the-tent. Although the DON can process, store and transport hundreds of megabytes of data per second today, it is small in comparison to the large amount of data that soon will be generated by existing and emerging sensors on manned and unmanned platforms.

The issue is not that this new data cannot be effectively processed and used, but rather that very few people are thinking about the need to process, store, and transport these larger amounts of data. The current division of labor within the SYSCOMs tends to obscure who is working on the entire wide area network. And, it is not surprising that the platform and sensor engineers assume that the larger Naval wide area network will be able to support these emerging network requirements. Unfortunately, it is easier to understand and rationalize the warfare capability provided by the sensors and platforms than it is to understand the need for infrastructure to be put in place to support these new capabilities.

As shown in this chart, the National sensor systems produced as much as 270 terabytes of data in 2006 and this data production continues to grow each year. As the newest sensor platforms such as P-8 and BAMS are deployed, the Navy will be generating petabytes (1 petabyte = 10^{15} bytes or 1000 terabytes) of data each year, independent of the petabytes of data that will be produced by the other Services, and National systems. Even with the best local data processing, parsing, and analysis, information contained within the remaining sensor data will require some portion of it to be moved into facilities that can further fuse and analyze it to provide additional critical information. In a world of petabytes, it will remain important to transport a small percentage of that data. If local processing can reduce the amount of data that must be moved to fusion centers, it remains likely that terabytes of data will need to be moved among data and operational centers. Using today's ashore and afloat infrastructure, it would require two days to move just one terabyte of data – if the full infrastructure were dedicated to the task. Should we then desire to move that much data to or from the largest Navy ships, 15 days would be required. Even with current future planning, an aircraft carrier will not be able to move a terabyte of data in less than 3 days of dedicated satellite communications resources.

This information infrastructure challenge is just but one example of the challenges facing the technical workforce within the NRDE.



Earlier this year (26 May 2010), a crossover event took place in the stock market that provides an important lesson in achieving technological dominance: the market capitalization of Apple surpassed that of Microsoft. Apple has often been viewed as fundamentally a boutique company, one strong in design concepts but limited in potential market share because of its emphasis on user experience over the business establishment's practical focus on cost reduction. The market-cap crossover secures Apple's position as both a technology innovator and a leading business force.

Apple's success is due, in part, to its agile adoption of synergistic technologies invented in other places, and often in much earlier times. Examples of non-Apple inventions that have been developed into iconic Apple products include: the desktop architecture (originally conceived by Alan Kay at the Xerox Palo Alto Research Center) and the mouse (Douglas Engelbart at Stanford Research Institute – later SRI) enabling Apple's introduction of the graphical user interface in its first Macintosh computers; commercial digital audio player (Audio Highway) leading to Apple's iPod product line; and the first smart phone ("Simon", by IBM) eventually leading to Apple's iPhone series.

But Apple's success requires more than simply appropriating inventions from the global market place. Apple has also added its own "secret sauce" to make its products stand out from the crowd, whether in hardware such as the examples above or by innovating in business models to create new markets (e.g., iTunes, iPhone App Store). The secret sauce allows Apple to differentiate its products from the commodity technology components it adopts from the outside world. Apple's recipe for success includes vision, world-class design, strict interoperability, the purposeful development of a network of partners, suppliers and "complementors" – and significant funding in areas of strategic focus.

Apple has maintained – and even slightly increased – its relative investment level as sales have skyrocketed, from 3.3% of sales in its FY07 to 3.6% in FY09; during that two-year window sales increased by over 50%. Apple's rationale is provided in its SEC filings (10-K, FY 2009):

> "The Company continues to believe that focused investments in R&D are critical to its future growth and competitive position in the marketplace and are directly related to timely development of new and enhanced products that are central to the Company's core business strategy. As such, the Company expects to make further investments in R&D to remain competitive."

Apple's model can provide useful guidance to the desired Navy approach to S&T investment: vision, strategy, aggressive adoption of technology from the global market place coupled with strong differentiation to provide discriminating advantage, and sustained funding.

Study Approach

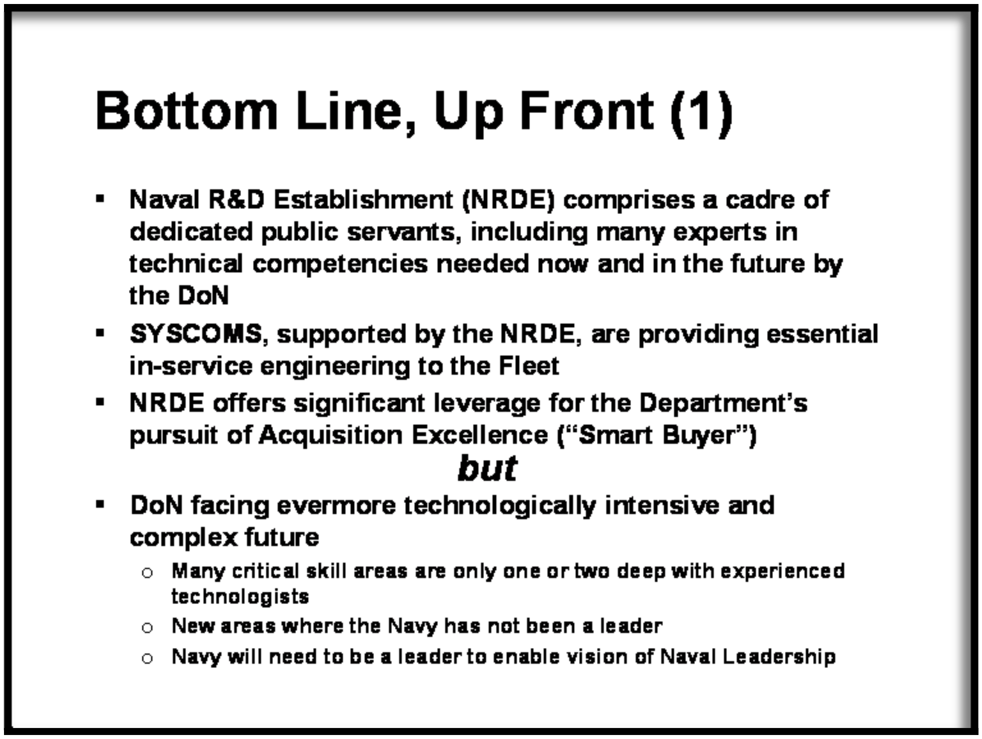
	NAVSEA	NAVAIR	SPAWAR	MARCORSYSCOM	NRL	UARCs	Integration
Panel Chair	Young	Bowes	Fernandez	Fratarangelo	Bellingham	Harris	Sommerer
Vice Chair	Blatstein	Schiefer	Cantrell	Johnson-Winegar	Ramirez	Tozzi	Bowler
Panel	Brown	Castellaw	Langston	Andrews	Andrews	Firebaugh	Alving
Members	Firebaugh	Mykityshyn	Tozzi	Weber	Bowler	Schiefer	Subpanel Chairs
	Harris	Schmitt			Bruno		Selected Panelists
	Schiefer	Whelan			Carnes		
	Schmitt	Winston			Korris		
	Tozzi				Tennenhouse		

>600 Staff-days fact-finding
>60 Site visits to:
- *SYSCOMs & Warfare Centers*
- *NRL*
- *UARCs*
- *PEOs & PMs*
- *Industry*
- *Naval Leadership*

Given the study's large breadth and scope, the 29 member Panel was divided into sub-panels as shown. Next, there was an intensive six month period of fact-finding and interviews, based on a common framework developed by the whole panel – with a number of members assigned to several panels to spot common issues across the NRDE.

At the various SYSCOMs, Warfare Centers, and UARCs, the sub-panels had interaction with a wide range of staff from new hires to Warfare Center leadership and the Commanders of each Systems Command. Generally, the institutions were cooperative and extremely candid in sharing information with the sub-panels. To provide "cross bearings" on the information gained during this process, WC and UARC customers – including Industry technology peers – were interviewed. Finally, several Panel members met with senior Naval leadership to gain context and background on today's R&D issues.

The appendices E-J contain SYSCOM-specific mini-reports prepared by their respective sub-panels.

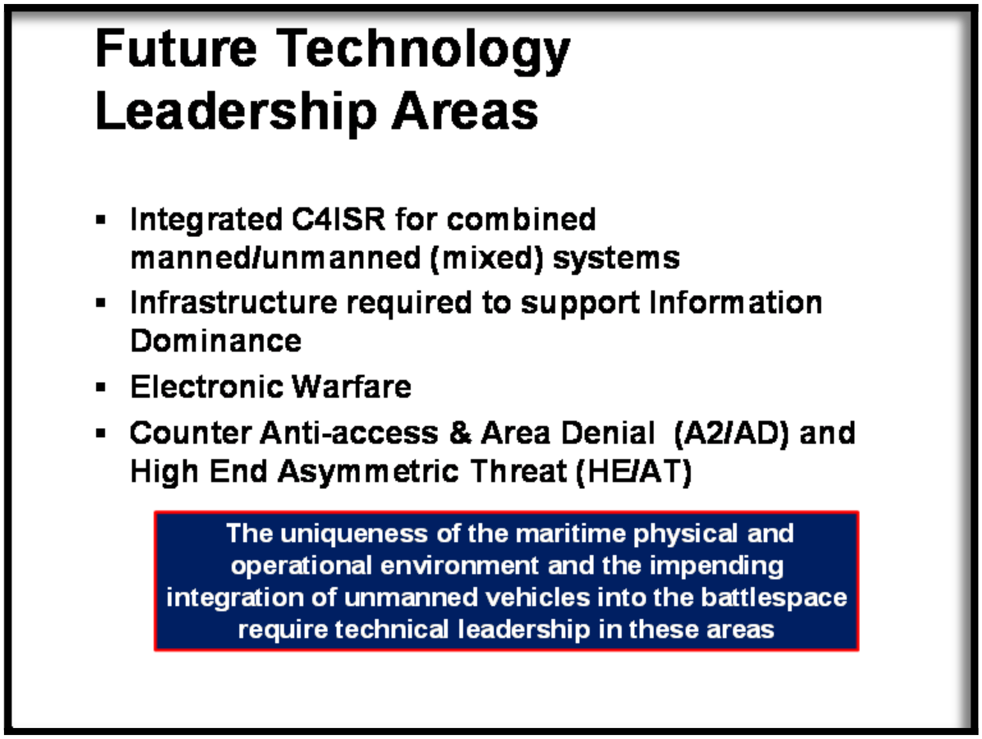


The NRAC Panel visited all of the principal NRDE venues including the various Warfare Centers, ONR, NRL, SYSCOMs and UARCs. (Appendix B has the complete list of site visits). Discussions were held with all levels of the professional technical workforce. The individuals with whom the sub-panels interacted are dedicated to public service and proud of their support to the operating forces. Many are acknowledged experts and leaders in their fields, but in many technical competencies the DON has only one or two experienced technologists.

The SYSCOM headquarters technical staffs and the Warfare Center staffs have a major in-service engineering role in support of naval operating forces. For example, Warfare Centers must maintain and operate replicas of the various configurations of fleet combat systems in order to troubleshoot problems and test upgrades. Without these systems, fleet combat systems would soon become ineffective.

Additionally, the NRDE provides support for the acquisition process – such as assuming the role of Technical Development Agent and System Engineering Agent – as well as operating test and evaluation facilities and ranges that are deemed national assets and conducting essential developmental testing.

But, as the technologically challenging and complex future unfolds, the NRDE is on the verge of and falling behind in many areas. Given that the globalization of technology is a given, and therefore *globalization of military technology must also be a given* – now is the time to ensure that adequate NRDE resources are brought to bear. Efforts such as ONR Global are but a small step in the right direction of efforts needed to aggressively exploit, extract, differentiate, and deploy emerging technologies before our enemies can.



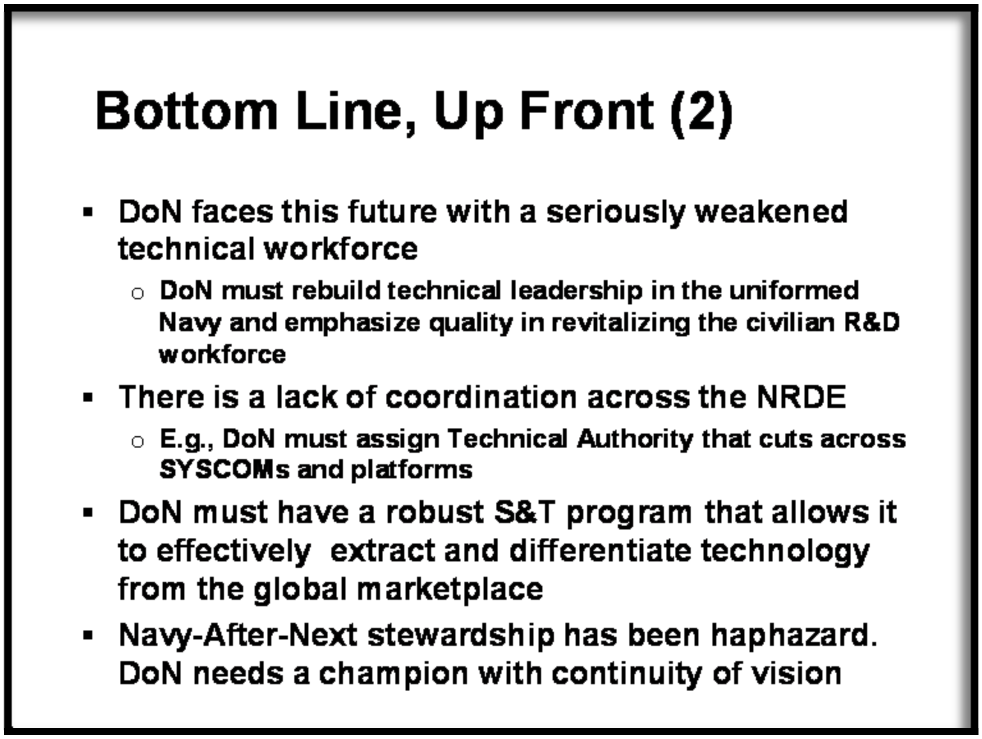
This chart enumerates the four areas that the NRAC panel believes the DON must develop the technical competencies for leadership in the future. (Appendix C provides additional information). The Panel chose to emphasize areas where the Naval Service must address issues that are unique to the maritime environment – both physical and operational.

The first involves the development and operation of integrated C4ISR for networks of combined manned and unmanned systems (i.e., mixed, collaborative systems). It is clear that, whether systems are airborne, on the ocean surface, undersea or in expeditionary air/ground operations – the use of wireless mobile networks consisting of manned and unmanned platforms – offers significant operational advantages in surveillance, targeting and engagement. Further, the combination of this capability with timely intelligence can assist the operational commanders in achieving "Information Dominance". A major technical challenge exits for these heterogeneous systems in maritime command and control in that communications connectivity cannot be guaranteed and as a result, unmanned nodes must be able to "fight through" intermittent connectivity. OPNAV, the Warfare Centers, the UARCS and NRL must all participate in defining the classes of technical issues that must be addressed and in developing the necessary capabilities needed to solve the problems, build the systems and maintain them into the future.

The second is the development of large-scale information transport and management capabilities needed to support "Information Dominance" As earlier noted, the emergent sensor systems that will enable this dominance will be producing data rates that will well exceed new MILSATCOM throughput capabilities. Although free-space lasers may significantly ameliorate this deficiency, the maritime environment can often degrade the available bandwidth for communications. A major role for R&D will be to scout commercial infrastructure techniques for solutions to these kinds of problems. Also, smart networks – where data can be moved, stored, parsed, and accessed as required by individual users – should be examined. This is a transformational area where the Navy must provide the infrastructure needed to achieve its goal. The NRDE must develop the technical competency to support this transformation using both commercial and Navy-specific technologies.

Third, the Navy has been assigned the lead in the DoD for Electronic Warfare (EW). As such, the Navy will need to assure the interoperability of legacy and new systems across multiple platforms, integrating new capability into planned C4ISR systems on different platforms. This will require new technical competencies and experimental infrastructure.

Finally, the countering of red force anti-access and area-denial strategies is a DoD-wide thrust. But, the Navy must assume leadership for the *Naval-unique* aspects of this – such as ASW, for which only the Naval Service has cognizance.



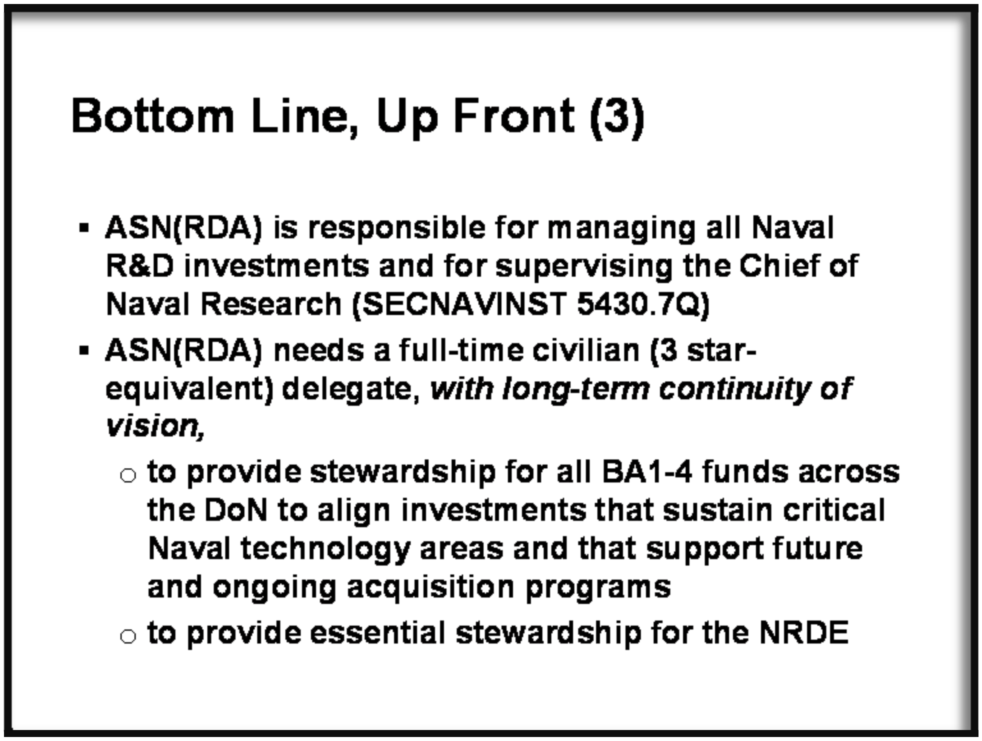
Despite many dedicated public servants working hard to keep up, the DON faces its future with a weakened technical workforce. In critical areas there are too few practitioners to cover the current needs or train successors. Progress in important emerging areas of technology such as networking and exploiting the global marketplace is too slow. There is a loss of quality across many technical areas. Too few technically qualified leaders are being developed in the uniformed military.

We advise that the DON rebuild technical leadership in the uniformed Navy and that in the process of re-invigorating the civilian technical workforce, quality should be the primary consideration.

Extracting and differentiating technology from the global marketplace is important now and will be of surpassing importance in the future. We are not as engaged as we need to be and are not tackling tough issues in facilitating the kinds of interactions that are necessary to succeed in this high leverage activity. The short version of this story is that too many of our technical people don't get out much. They don't get out enough to benchmark, observe, learn, extract, differentiate to our specific needs, and deploy technologies from the global marketplace.

The SYSCOMs, in accordance with the applicable SECNAVINST, have addressed technical authority within their areas of cognizance with mixed results. The NRAC has misgivings with some particulars of implementation of technical authority – but the more important concern is the absence of, or confusion and conflict in designation of lead technical authority in the rapidly developing information warfare and networking fields. Also, clear delineation of technical authority in cross-SYSCOM domains is not being constructively addressed.

Very importantly, the stewardship of the Navy-After-Next has been haphazard. The Panel tried hard to identify specific processes or specific individuals that claimed real ownership for developing the ideas for future operational concepts and supporting technological implementation. We concluded that a champion with continuity of vision, experience, broad and deep technical knowledge and authority is needed to properly deploy the Navy's technical workforce and assets in the service of the Navy-After-Next.



SECNAVINST 5430.7Q assigns the ASN (RD&A) the responsibility to manage all Naval R&D investments and to supervise the Chief of Naval Research. The ASN needs help to carry out all of his important functions. The Panel concluded that the ASN (RD&A) needs a full time senior civilian operating at the three-star level with long-term continuity of vision to provide stewardship for the Navy-After-Next. This new position, Director of Naval Research & Development Establishment (DNRDE), would be responsible for aligning and providing oversight to BA 1-4 (at least) investment across the DON, supervising the CNR, prioritizing issues in conjunction with the CNO, CMC, and CNR and coordinating with OPNAV in ensuring the relevance of the investments to the Navy-After-Next.

The DNRDE would also have the responsibility to transition technologies that address emerging operational requirements as elements of the Navy-After-Next. In the transition aspect of the job, the Director would work closely with CNO-N00X to invest in the appropriate technologies for the Navy-After-Next.

This new position should have the authority to strongly contribute to and enable the future technology direction and development of the NRDE.

Assessment of NRDE Technical Capabilities

- **NRAC WC Sub-panels have received technical capability self assessments from the Warfare Centers and informal feedback from a number of Navy SYSCOMs/PEOs/PMs and Defense Industry Representatives**
- **NRAC did not have the time nor the resources to do an independent, in-depth, comprehensive assessment of the Naval R&D Establishment**
  - **A true assessment of the quality of the technical capabilities in the Naval R&D Establishment would require an extensive internal and external evaluation of each technical capability (e.g. there are >133 TCs just in NAVSEA Warfare Centers)**
  - **NRAC did not assess technical capabilities residing within the SYSCOMs' headquarters program offices and PEOs**
- **Periodic assessment is nevertheless critical to understanding, building, and improving the Department's technical capabilities**

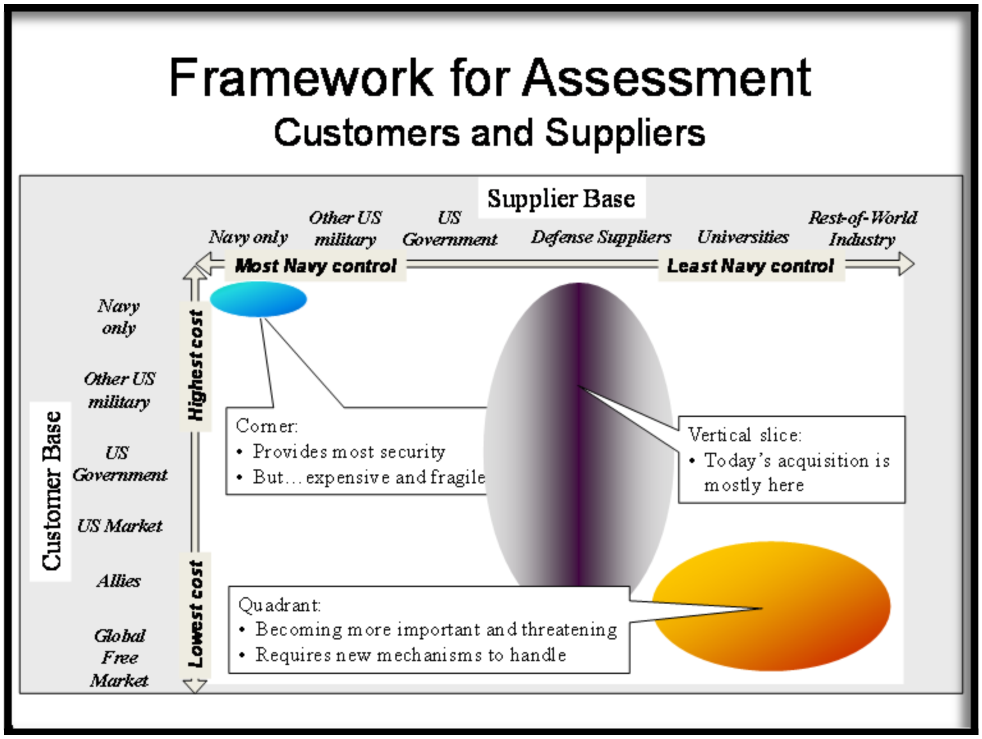
The TOR required the NRAC to assess the components of the NRDE in a number of different dimensions. The Panel intensively engaged the various organizations for approximately six months – with all of the information provided by the NRDE, the ASN staff, and the cross bearings obtained through customer and industry peer interviews – this Panel is confident in its findings at the granularity at which they are presented.

However an in depth, comprehensive assessment of all of the technical competencies represented is simply not practical within the availability of the membership. For example NAVSEA alone accounts for *over 100* identified technical capabilities.

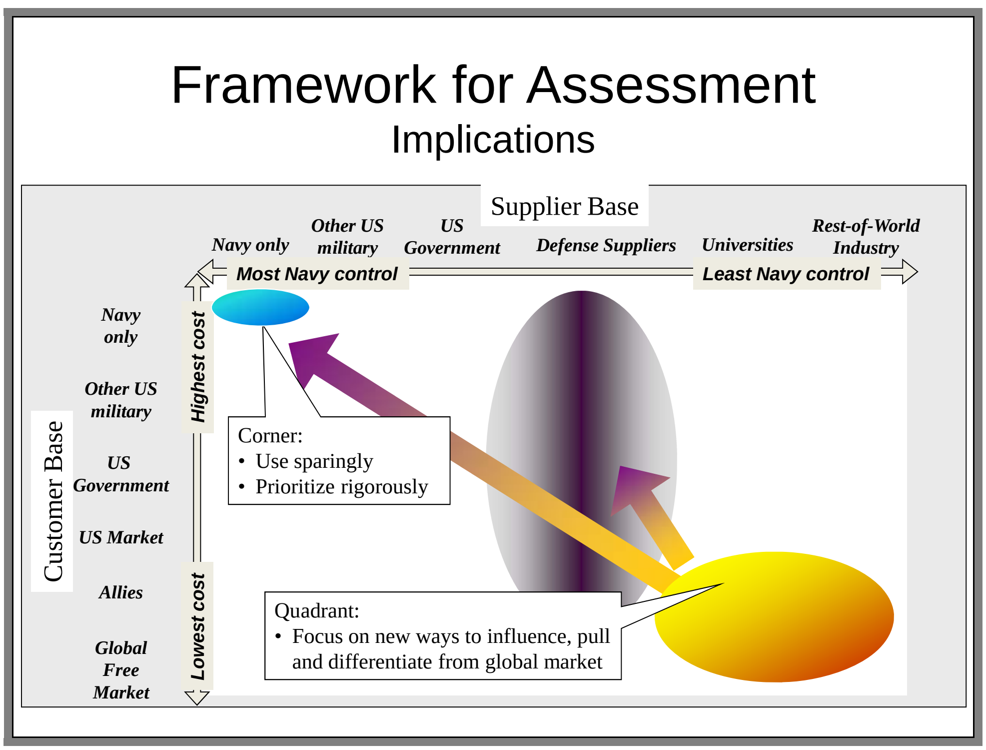
In addition, NRAC did not assess technical competencies residing within the SYSCOM headquarters, the PEOs and Program offices, or other Fleet support establishments. But, the Panel believes that periodic, in-depth, independent assessments are critical to understanding the status and evolution of technical competencies on which the Naval Service is dependent. Such assessments are generally the hallmark of technically excellent institutions that seek to preserve and enhance their technical quality and technical integrity as core values.

Fundamentally, it is the responsibility of the DON to conduct such assessments, and to make them meaningful – to be willing to make significant changes when shortfalls are identified, and to reinforce and enhance existing approaches when success is confirmed in an auditable way.

It is important to note, however, that assessment approaches will vary depending on circumstances – assessment of a leadership capability is different from assessment of a capability designed to leverage developments by industry or other defense agencies.



Framework for Assessment
Customers and Suppliers
Supplier Base
Navy only
Other US military
US Government
Defense Suppliers
Universities
Rest-of-World Industry
Most Navy control
Least Navy control
Customer Base
Navy only
Other US military
US Government
US Market
Allies
Global Free Market
Highest cost
Lowest cost
Corner:
• Provides most security
• But… expensive and fragile
Vertical slice:
• Today's acquisition is mostly here
Quadrant:
• Becoming more important and threatening
• Requires new mechanisms to handle



Framework for Assessment
Implications
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Navy only
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US Government
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Universities
Rest-of-World Industry
Most Navy control
Least Navy control
Customer Base
Navy only
Other US military
US Government
US Market
Allies
Global Free Market
Highest cost
Lowest cost
Corner:
• Use sparingly
• Prioritize rigorously
Quadrant:
• Focus on new ways to influence, pull and differentiate from global market

Across the Naval R&D Establishment, two independent factors are important: the source of technology solutions ("supplier base") and the span of consumers of any solution ("customer base"). The degree of control decreases as the supplier base moves from government sources (left-hand side) to industry and academia within the US, its allies or "rest of world" (right-hand side). The cost of solutions decreases as the customer base increases, with the most expensive solutions being highly specialized, Navy-only solutions that do not have other markets (top of chart) and the least expensive being those with robust and competitive commercial markets (bottom of chart). The Navy does – and should – operate in all portions of this landscape; but its behavior should be different in the various quadrants.

Upper Half: Military/Government-Specific Solutions

The upper left quadrant provides the government with the most security, as is necessary for its most sensitive solutions. Here the government owns the solution birth-to-death, from bench scientists through production, Operations and Maintenance (O&M), to end-of-life. This corner is both the most expensive and the most fragile, because it doesn't benefit from competition in either the market or sourcing.

During the Cold War, the upper left quadrant played a larger role than it does today. Over time, US industry has become an increasingly important provider of solutions to US military needs, and today the bulk of military-specific solutions are provided by US industry. Increasingly, however, suppliers from allied nations are also becoming important. Today even "rest-of-world" industrial suppliers (on the right-hand edge) are important providers, especially for component technologies.

Lower Half: Commercial Markets

The lower half allows for the most cost-effective solutions, enabling the government to leverage market forces that drive quality, robustness, competition, and low price. Over time, some US government-driven technologies have become widely adopted and have created new markets which, in turn, have made new capabilities and solutions available to the government at relatively low cost. Examples of such migration include GPS, satellite and fiber communications, and the internet.

Increasingly, new technologies are being developed outside of the US (lower right quadrant). In a "flat" world, such technologies are often readily available to all, allies and enemies alike, and this means that innovative uses of new technologies are also being developed globally. This phenomenon represents both a threat and an opportunity. The threat is that our foes have demonstrated great agility in applying globally-available technologies in new and deadly ways. The opportunity is for the US to harness these same technologies by adding differentiation that provides discriminating advantage to US forces.

As noted, the upper left corner is the most expensive and fragile place to operate. Therefore, the Navy should use it as sparingly as possible, based on a rigorous prioritization of those technologies and solutions that most require strong control by the Navy. Operating within this corner requires world-class technologists with sufficient critical mass to drive innovation, and funding to sustain their work. It also requires strong workforce management to attract talent in a competitive market and to refresh the expertise in the fast-changing world of technology.

Exploitation of the lower right quadrant requires new mechanisms outside of the NRDE's standard approach. The global market is not driven by the traditional "requirements" process, so the Navy must develop other, indirect means of influence – engaging as early as possible to help shape the direction of technology development. For example, the Navy should participate vigorously in helping set international standards in areas relevant to future Naval capabilities.

In addition, a specialized set of skills are required to effectively harvest these globally developed technologies on behalf of the Navy. These include technology "scouts", who can recognize and pull new technologies that might address unmet operational needs; and hands-on technologists with an "agile adopter" mindset, who can add differentiated capabilities to commonly available technologies. Such practices are outside of the standard, requirements-driven processes appropriate to the upper half of the slide. Therefore the Navy should develop an in-house cadre of experts with these skills who can assist in the transition of technologies from the lower right quadrant, whether the transition takes place via industry (most common) or directly via Navy personnel (specialized cases).

The management of a technology strategy across this domain requires strong leadership, starting with a clear, all-encompassing vision of how the Navy can best exploit the various quadrants of this framework. Currently, the Navy lacks a single focal point to provide such leadership and vision.

Emerging Agile Adoption Areas

- <u>Mixed decision making systems (manned and agent-based)</u>. NRDE must acquire the technical competency to shape, adopt, and adapt this capability for the Naval applications
- <u>Commercially-available Enterprise Information Systems</u>. NRDE must develop technical capability to participate in standards and tools development, especially for Naval unique needs
- <u>Managing software development</u>. NRDE must develop and implement a comprehensive strategy for revitalizing in-house software engineering competency
- <u>Power generation and energy storage</u>. NRDE must be aware of global advances in power generation/control as well as energy efficiency so they can be adapted for Naval-unique uses
- <u>Biology-based innovation</u>. NRDE needs sufficient expertise to monitor and exploit new and emerging areas of technology that are based on biological systems

In addition to but no less important than the future technical leadership areas summarized in the previous charts, the Panel identified five areas where the Navy must learn to be an agile adopter of the investments by other parts of the U.S. government and the commercial sector. (Appendix D has additional information).

In the first two areas, the Navy needs to carefully scout, shape and leverage ongoing commercial investments. They are the area of mixed decision-making systems that combine manned and software agent capabilities to allow for classification, parsing and fusing of heterogeneous data and Enterprise Information Systems for non-combat activities such as logistics, personnel, next generation internet. Both receive significant commercial investment – so NRDE must develop the technical competency to be fully engaged with the community to identify Navy unique needs – to ensure that they are not in conflict with the commercial developments.

The third area, software development, is one where the Navy has allowed a previous capability to degrade and where a comprehensive strategy for revitalizing software competency using modern tools must receive priority.

Globally, large investments in new means of power generation and energy storage are being made. The new capabilities could seriously impact the Navy-After-Next, both with enhanced performance and increased vulnerability. So, it is incumbent on the NRDE to make a serious effort to stay abreast of these developments.

Finally, there is significant investment in biology-based systems for robotics, sensing, and informatics that is very uncertain, sometimes unregulated, highly university-centered and venture capital-driven with very uncertain trajectories. The NRDE must develop sufficient expertise to monitor and exploit this innovation in order to avoid technological surprise.

The remaining report will follow the outline as shown above. As with the study briefing, recommendations will be followed by the pertinent findings in the five areas.

In order to rebuild the weakened technical workforce, we have grouped our recommendations under the overarching need for the DON to "sustain and enhance the current

NRDE technical competencies to support operational and acquisition needs." This can be accomplished by taking aggressive steps to increase the amount of meaningful "hands-on" work that is performed by the Warfare Centers. The technical workforce cannot become expert without doing actual work. Merely overseeing industry will not maintain a technically competent workforce.

NDAA Section 219 should be funded to the limit authorized by the law (i.e. three percent of all available funds) in order to provide the needed education, training and mentoring of the technical workforce. And, incentives must be created to encourage civilian and military personnel to achieve technical (STEM) expertise, and not just to receive graduate education.

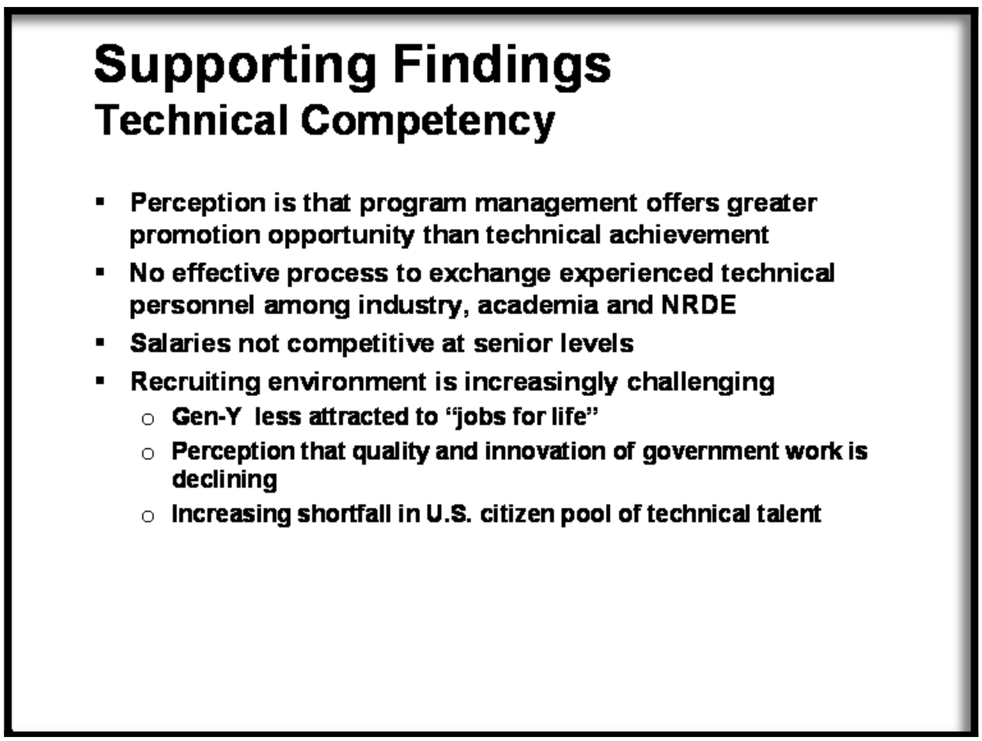
A greater number of technical SES and ST billets should be created at the Warfare Centers to provide improved career growth opportunities in technical competencies and demonstrate the value placed on technical excellence. The number of military billets in the NRDE should be increased in order to provide the NRDE civilian workforce with essential understanding of operational needs by working side-by-side with experienced military personnel.

To accurately assess the technical capabilities of the NRDE and to monitor progress in building the technical leadership to meet future needs, a comprehensive, independent assessment – but not using SYSCOM or ONR personnel – should be conducted biennially on the entire NRDE.

NRL has basic scientists who have some contact, through literature and publishing, with global S&T. To leverage that foothold and their "base program" funding, the Panel recommends that NRL be tasked to develop and experiment with methods to address the "right lower quadrant" in the chart previously discussed (i.e., global technology marketplace). ONR Global, and their foreign-based science officers, provide outstanding value. But it's not enough – Globalization is a contact sport. The NRDE will not be effective unless more is done to access the global span of S&T.

With the rate of growth of technology, and especially outside of DOD and the USA, the NRDE must increase the aperture of the technical community. It must be recognized that the model of recent graduates entering public service and remaining for an entire career is probably not consistent with Gen-Y behavior. The NRDE needs to embrace the increasing trend in workforce mobility as an actual means of achieving technology refresh. During recent NRAC interaction with the UK Ministry of Defence, the members noted that the MOD sponsors the exchange of technologists – even between defense contractors and government acquisition offices within the MOD. Their program has been quite successful and the panel recommends the creation of a pilot program to exchange technical personnel among industry, academia, and the NRDE. This will not only benefit the Navy, but also industry and academia, in bringing to all a broader understanding of technologies and Naval requirements and acquisition processes.

Within the NRDE, emphasis should be placed on workforce mobility to increase technology awareness and to encourage the adoption of new technology concepts and applications.



The Panel found that many critical technical competencies and capabilities across each of the Warfare Centers have been seriously weakened, and in many areas knowledgeable and experienced personnel are only one or two deep. Add to this, the shortage of discretionary overhead funding which supports workforce development and innovation. A weakened technical workforce results in a missing linchpin for enabling the creation of new warfighting capabilities and the development and sustainment of technical leadership in the NRDE.

After years of aggressive "outsourcing" of technical work, the amount of meaningful "hands-on" work performed in the Warfare Centers has declined significantly. Accordingly, the Warfare Centers' role has shifted to almost exclusively that of overseer (hands-off) and away from doing "hands-on" work. This type of work is pre-requisite to building and maintaining a technical workforce to which technical authority responsibilities can be assigned. Additionally, the shortage of experienced personnel in many technical competencies and capabilities has diminished the effectiveness of "smart programmatic decision-making" in PEOs and undermined the effectiveness of technical authority across the SYSCOMs.

In addition, the Panel saw little evidence of the Warfare Centers prioritizing their technical competency requirements that should be provided by their own in-house technical staff.

Fewer active duty military personnel are now assigned to technical billets within the NRDE, and the civilian workforce is provided less at-sea exposure. This would tend to imply that the R&D workforce is slowly losing its first-order understanding of the operational environment in which developing systems will be employed. Additionally, expanding the knowledge and understanding of NRDE capabilities by a larger number of active duty military would enhance their decision-making abilities when they assume key leadership roles in the SYSCOMs or in Pentagon assignments later in their careers.

The Panel saw limited evidence of the Warfare Centers improving their global technology awareness. This need for awareness extends across DOD, as well as academia and industry worldwide. A positive example was noted, however, at the NAWC Aircraft Division, Patuxent River, MD, with the recent creation of a dedicated Technology Awareness Team.

Another disturbing trend noted in Panel conversations with some members of the technical workforce is their perception that greater promotion opportunities can be found in the program manager career track rather that the technical track. This *does not* contribute to the rebuilding of the technical workforce.

There are still significant challenges to hiring and retaining competent technical staff at the WCs despite the current higher-than-normal national unemployment. There is downward trend in the pool of U.S. citizens with technical graduate education. "Gen-Y" graduates are less attracted by the "jobs for life" career choice that has been the model within the NRDE. Added to this is the perception that quality and innovation of government work is declining – that it is more "watching others" – than "hands-on". The perceived conflict-of-interest concerns and lower salaries tend to inhibit experienced personnel in industry and academia from moving to government technical positions – and back again.

These findings tend to indicate that the Warfare Centers are in a slow "death spiral" of diminishing technical competence.

Recommendations
Stewardship

- Strengthen ASN (RDA) stewardship of the NRDE
  - ASN(RDA) designate a ***Director of Naval Research and Development Establishment (DNRDE)*** responsible for aligning investments across the DON, under the direction of the ASN(RDA):
    - Represent the ASN (RDA) in supervising CNR investments of BA1–3 across Navy & Marine Corps
    - Support the ASN(RDA) in prioritization issues across BA1–4 investments among CNO, CMC, & CNR
    - Coordinate with OPNAV to ensure relevance of ONR investment to Navy-After-Next needs
    - Provide continuity in stewardship of NRDE
- Establish a Science Advisor to the CNO
  - Also serve as liaison to ASN (RDA)

Recommendations (2)
Stewardship

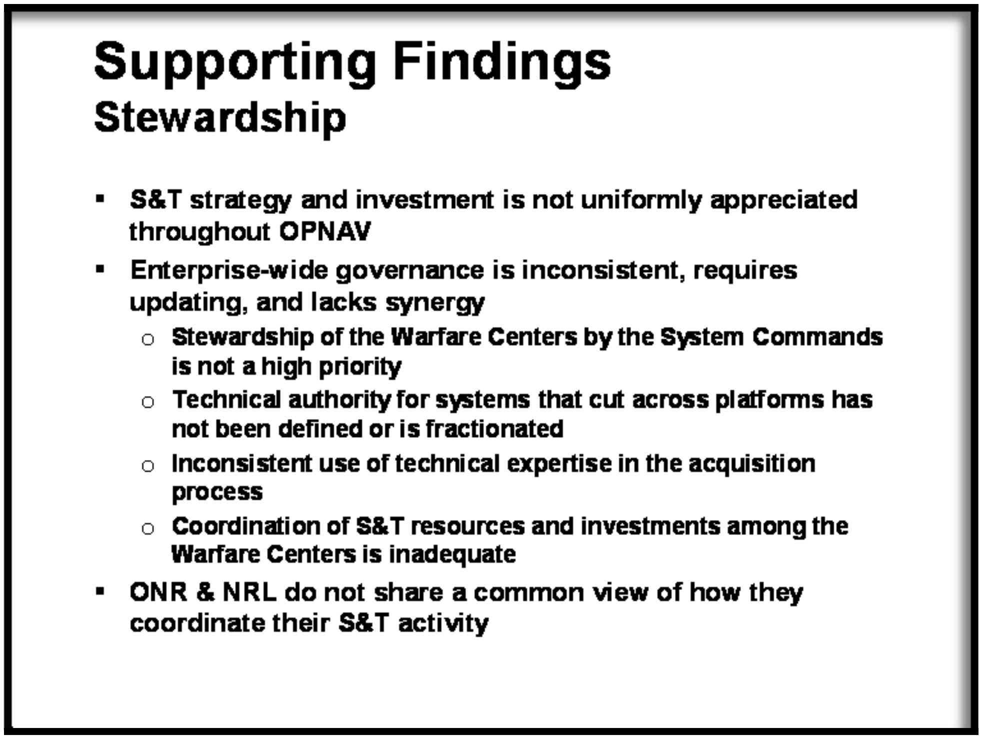
- Strengthen ASN (RDA) stewardship of the NRDE (2)
  - Update/reinstate SECNAV Instructions for governance of NRDE (including NLCCG) and Technical Authority
  - Assign technical authority for systems that cut across SYSCOMs & platforms
  - Increase coordination of the R&D activities that support the Navy-After-Next
  - Establish a process to implement and integrate S&T strategy across the NRDE & SYSCOMs
  - Create a plan to increase the transition of NRL technology and capability into the Warfare Centers and industry

For the purposes of this study, the term “stewardship” refers to the policies and procedures related to the leadership and active management of the workforce, infrastructure, and facilities within the NRDE.

The Panel fully understands that those at the highest level of the NRDE have been impeded by the “tyranny of the in-box” concerning today’s issues – at the expense of their focused attention on “tomorrow’s” issues. This is understandable in the current two-war climate.

But, as the climate begins to shift (given the pressure to revitalize the R&D workforce), the Panel recommends that:

- A Science Advisor should be added to the CNO senior staff, at the SES level (with PhD) who possesses a broad technical background – especially in C4ISR and unmanned vehicles. Currently, the CNO has a senior State Department official assigned to his personal staff to advise him on matters of diplomacy and international relations. Of no less significance, he should receive advice, routinely and directly, on technology matters affecting the 21st century Navy.
- A senior position (3-star equivalent) should be created under the ASN RD&A to husband the R&D segment of the ASN’s wide-ranging responsibilities – which are now dominated by acquisition issues. Among other duties, this new official would take responsibility for the assignment of technical authority for systems which cut across platforms; ensuring comprehensive coordination and alignment across Warfare Centers; working with OPNAV, CNR, NRL, and the SYSCOMs to create processes to implement and integrate an S&T vision across the DON and across BAs 1-4 (at least) to ensure adequate support for the Navy-After-Next; and working to ensure effective stewardship of the entire NRDE.

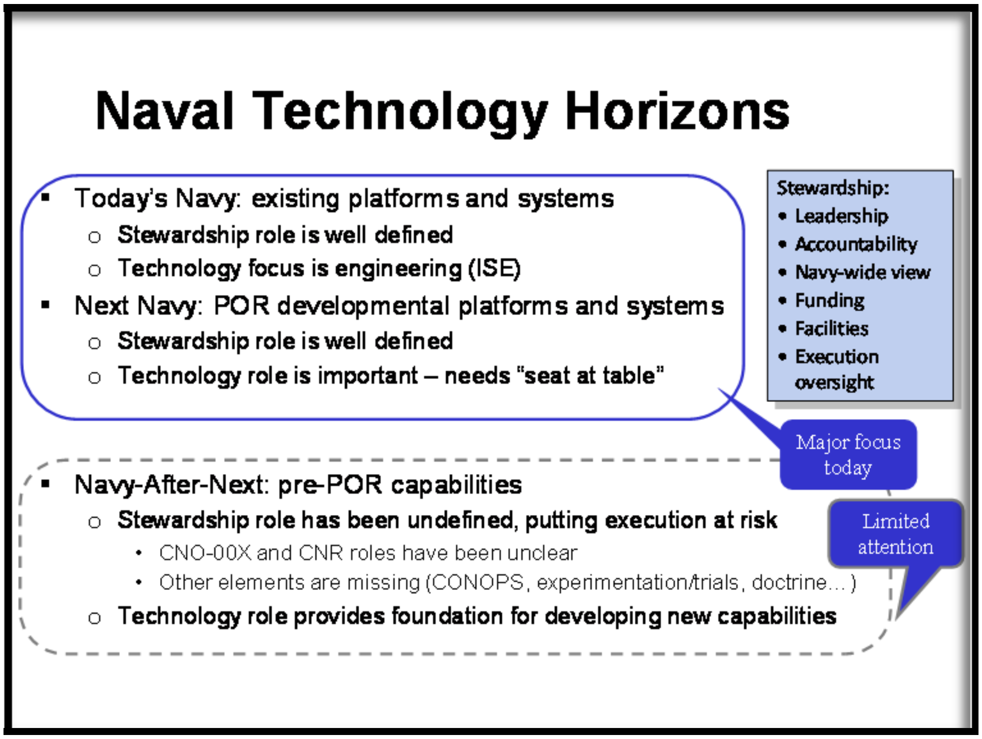


The Panel found that:

- Senior OPNAV staff is focused on defining requirements, building the POM, and responding to tasking from OSD and the "Hill" – with little time to focus on concerns beyond today. OPNAV generally believes that sizeable efficiencies can be achieved within the S&T portfolio – but cuts in this area are often not underpinned by a requisite understanding of the technology and the trade-offs.

- NAVSEA and the other SYSCOMs are focused on responding to "urgent" tasking from Fleet Commanders to resolve their readiness and maintenance issues. This allows little time to focus on the stewardship and future technical health of the Warfare Centers. There is limited attention given to coordination of resources and investments or technical authority to cross-cutting systems/platforms among the SYSCOMs and Warfare Centers. Also, technical experts are rarely invited to participate at the key decision points in the acquisition process.

- S&T coordination between ONR and NRL was deemed weak.



As the NRAC considered the context for the technical capability needs of the Navy, the Panel thought it would be useful to discuss their characteristics and ownership in terms of the time horizon for the Navy. At any given point in time, the NRDE is making contributions across three different time horizons: Today's Navy; the Next Navy and the Navy-After-Next.

- **Today's Navy** is the Navy that is currently operational, i.e. existing platforms and systems,
- The **Next Navy** is being produced by Programs of Record, i.e., platforms and systems that are in development,
- The **Navy-After-Next** is represented by the concepts, platforms, systems, etc., that have yet to be conceived and/or defined and for which there is no Program of Record.

The major focus now is on Today's Navy and the Next Navy, which is appropriate, given that these represent our near-term Naval capabilities and are the major consumers of resources. The Navy-After-Next is less well-defined and less resource-intensive than its nearer-term analogues. On the other hand, it is arguably more important given the global economic and technology context: the Navy-After-Next represents the time horizon at which the Navy's dominance may be seriously challenged.

As the Panel considered the stewardship role for each of these navies, the responsibility for stewardship was indicated by what organization has the leadership and accountability to deliver the Navy-wide technical capabilities, ensuring the funding requirements are properly prioritized, making the necessary facilities available, and taking responsibility for execution oversight of the technical capabilities to achieve the desired requirements.

The stewardship of Today's Navy is well defined. It resides with the Fleet Commanders and is well supported by the SYSCOMs and their Warfare Centers through in-service engineering (ISE).

Stewardship of the Next Navy is also well defined and resides with ASN RD&A through the PEO/PM structure. Technology plays an important role in this developmental Navy: individual PEOs often draw on the expertise of the NRDE directly and there are also mechanisms, such as the Future Naval Capabilities (FNC) process, to couple enabling technologies to the programs of record.

The panel found the stewardship role for the Navy-After-Next was vague at best – with no specific organizational assignment. As a result, execution is sporadic and not coordinated across the technical community. This is a direct result of the lack of leadership and oversight, which is particularly disconcerting given its high-degree of technology reliance – and the risk of technology surprise.

Although both CNO-N00X and CNR currently acknowledge some responsibilities related to the Navy-After-Next, their roles are unclear, and the Panel found no clearly delineated organizational element responsible for the required elements such as future CONOPS and doctrine.

The Navy-After-Next will be defined by the concepts and technical capabilities that are generated, incubated and successfully applied in the future. Clarity of stewardship responsibility is needed to bring the vast array of emerging technologies to bear in a coordinated, cost-effective manner.

Recommendations
Navy-After-Next

- Establish an office of primary responsibility for the management of the necessary competition of ideas attendant to the confluence of concepts with S&T for the Navy-After-Next
  - Empower that office to create and implement a process that incubates and assesses promising concepts across DoN. (Further refine the implementation of OPNAVINST 5401.9)
    - Assign to CNO-N00X
  - Ensure NRDE active participation in concept generation and Concept Development Teams
  - Identify and, where appropriate, champion concepts from other agencies (e.g. DARPA)

Supporting Findings
Navy-After-Next

Stewardship of Navy-After-Next has been haphazard, especially with respect to the engagement of the S&T community

- OPNAVINST 5401.9 is a good starting point for concept development, but does not fully address S&T engagement needs of Navy-After-Next
- Effective stewardship is essential, given global technology context <u>and</u> that Navy-After-Next is point at which U.S. Naval dominance may be challenged
- Current FNC process severely curtails BA 6.3 spending on Navy-After-Next concepts for which there is no Program of Record
- Deep NRDE engagement in both concept generation and in concept development for Navy-After-Next is lacking
- There is no organized process to provide a "landing zone" for innovative S&T-based concepts pioneered by DARPA and/or other agencies
- Long-term guidance on future technical leadership and competency areas is not being provided to the Warfare Centers

As previously discussed, the NRAC found the stewardship of the Navy-After-Next to be poorly defined, with little evidence of the engagement of the S&T community at-large. Full S&T

engagement is especially important given the rise of the expected global technology impact during the time horizon when U.S. Naval superiority will be challenged. The Panel also found there are a number of structural barriers to the full engagement of the NRDE in Navy-After-Next activities. For example:

- The Working Capital Fund approach severely limits the degree to which the WCs can engage in the development of concepts for which there is no acquisition program – and thus no source of program funding.
- Similarly, the FNC process, which ensures appropriate focus on the Next Navy, severely curtails spending on Navy-After-Next concepts for which there is no program, thus precluding advanced research and demonstration of NRL-developed technologies.
- There is no ability to create “landing zones” for new concepts and capabilities developed by other agencies, such as DARPA. Thus, even when alternative sources of 6.3 funding are leveraged, their results cannot be harvested in a timely manner.

The NRAC recommends that the Navy-After-Next (NAN) be established as an ongoing activity with an office of primary responsibility whose ultimate goal is to turn selected new ideas for both concepts and capabilities into new Programs of Record. This office must manage the necessary “competition of ideas” attendant to the confluence of emerging concepts with S&T. It must also be empowered to provide the sustained leadership, management and resources to guide selected projects from the concept generation phase to being acquisition-ready, i.e., suitable for program selection by a future CNO:

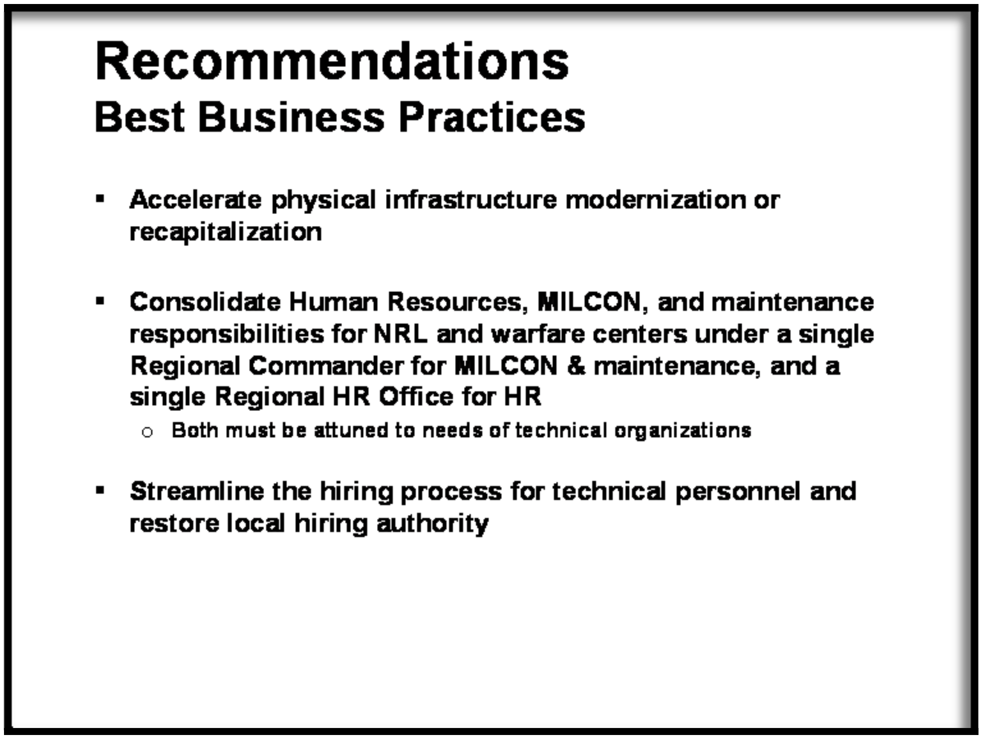
- Within the DON, there should be a consistent flow of new ideas and concepts, sourced from both the operational and NRDE communities – and from interaction between the two.
- There should be a vigorous “competition of ideas” amongst proposals with a spiral selection process that involves cycles of competition and hybridization.
- There should be resources and mechanisms for the exploration and maturation of selected capabilities and concepts (“Concepts-of-Record”) including, where appropriate, applied research, advanced development, analysis, experimentation and assessment.
- There should be a clear process through which mature capabilities and concepts “graduate” into acquisition programs.

Concept generation and S&T should be highly coupled activities, and the NRDE should be an integral part of the process, playing at least three roles in shaping emerging capabilities for the Navy-After-Next:

- Generation: results from basic research can sometimes lead to concepts that would not even be imagined were it not for awareness of the "new Science" enabling them.
- Selection: new concepts, independent of their source, should be filtered early and often based on, among other things, their technical feasibility.
- Enabling: new concepts can be accelerated and/or enabled by bringing the expertise of the NRDE to bear on specific technical challenges.

An important advantage of the above heightened degree of NRDE engagement in these activities is that it would create greater awareness of the Navy's long-term needs within the NRDE, allowing NRL and the WCs to accurately identify future technical leadership and competency areas and shape their workforces accordingly.

OPNAVINST 5401.9 and the role it outlines for CNO-N00X is of significant relevance to the Navy-After-Next activities described above. This instruction provides a good starting point for the establishment of a process for concept generation. The process should be adapted and extended to suit the needs of the Navy-After-Next and to ensure greater engagement of the NRDE with CNO-N00X and other stakeholders – ASN (RDA) and the CNR.



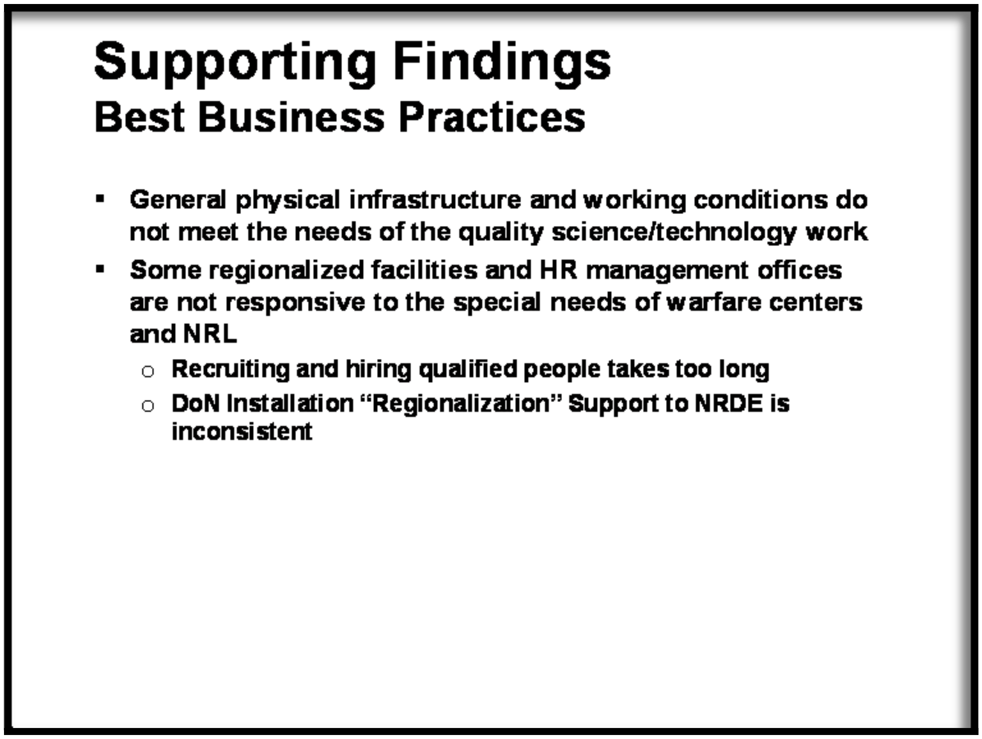
Most of the WCs and NRL were established prior or during World War II. Many of the original buildings and facilities are still being used. Obviously, modernization or replacement of these facilities has not kept pace with needs. BRAC was instituted to close sites, amalgamate facilities, and eliminate infrastructure from the modernization requirement. This helped, but there are still many buildings that need modernization or replacement.

In some cases the recapitalization of buildings (e.g., at NRL in D.C.) is calculated to be is on a 700-year schedule. Most sites are well over a one hundred year schedule. Only BRAC "receiver" sites or Congressionally-targeted facilities have updated or new facilities.

The lack of modern facilities impedes attracting world-class scientists and engineers and can impede the quality of work performed by the current technical workforce. The modernization of these facilities must be reprioritized and accelerated.

In a previous "cost cutting" effort, the public works and human resources functions were transferred to regional offices. Over the years these offices have became divorced from the mission of the Warfare Centers and have been detrimentally unresponsive to their needs. This has delayed much needed facility modernization and the hiring of new employees. It has also caused the establishment of a parallel set of offices in each center in an attempt to mitigate the problem. The savings intended by regionalization are probably non-existent.

Accordingly, the Panel recommends that a single regional commander be designated with specific responsibility to the Warfare Centers – particularly in terms of the hiring of scientists and engineers and technical facility support issues.



At most sites, the regionalization of the Public Works and Human Resources offices was mentioned as causing significant problems for the individual Warfare Centers. Examples given: major or critical projects were delayed because of the unresponsiveness of the regional Public Works office; college graduates with technical degrees accepting jobs in the private sector because of the three month hiring delay caused by the slow approval process at the offsite HR office. The direct tangible result is inefficiency within the NRDE.

Example SYSCOM-Specific Findings

NAVSEA WCs	• WC indirect funds viewed as bill payer, resulting in reduced investment in WC advanced technical equipment and innovation • Capability, competency and skills in offensive mine warfare and energetics are decaying due to lack of sustaining developing work
NAVAIR WCs	• All warfare center personnel are organizationally integrated into the systems command • High turnover of technical personnel assigned to programs
SPAWAR WCs	• Although SPAWAR has specific TA responsibilities, Navy-wide C4ISR TA is not well-defined, disciplined or consistently practiced • Customer opinions regarding warfare center technical competencies highly variable
NRL	• Base funding is primary investment in Naval in-house fundamental research and is critical to sustaining technical competency • Base funding is not fully coordinated with ONR's external research investments
UARCs	• Ingrained culture of independence. Ability to hire technical staff at commercially competitive salaries and benefits ensures quality technical workforce. Ability to capitalize (and amortize) at own discretion results in adequate facilities • Navy funding declining as a percentage of total UARC funding

Technical Support & Overlap in the NRDE

- Issue of "overlap" is exaggerated
- Evaluation of technical support requires in- depth understanding
- Real risk: critical technical capabilities lacking stewardship could be lost

This chart shows example findings that were specific to SYSCOM warfare centers, NRL, and the UARCs. Each organization has an appendix with more complete information (see Appendices E through J). The subject of "technical support and overlap within the NRDE" was brought to the Panel's attention at several sites and is discussed in the following paragraphs. (Additional discussion is in Appendix K.)

As beauty is in the eye of the beholder, the selection of technical support of Navy program offices may be based on: technical capabilities and defined roles and responsibilities, necessary or unnecessary competition, overlap/redundancy, or entrepreneurialism run wild. But the judgment of the nature of the technical support – and the need for it – depends on a detailed knowledge of that technical support several layers down into the program details. Often opinions are formed as to the "goodness/necessity" of the specific technical support in a vacuum, relatively speaking, and based on superficial information.

An exemplar of a highly disciplined program where various Warfare Center sites and UARCs all play carefully defined roles (very significant private industry support is not addressed here) is the Strategic Systems Program Office (SSPO). At the "strategic systems" level or even the "missile" level there appears to be redundancy. But as one delves into the specific technical capabilities that are being utilized, a different picture emerges. SSPO is a well informed customer who goes to the best place for its specific needs and ensures discipline in the system, while ensuring all the players work together as a team. And, these sites represent the Navy's corporate knowledge about the details of these critical Navy systems. This is a very good example of technical collaboration and the utilization of appropriate capabilities wherever they reside. Other examples can be found where sites are maintaining duplicate capabilities for good and sufficient reasons (e.g., explosives buildings that can disappear spontaneously). Also, there is a need to foster real competition for risk mitigation.

Over the last two decades under BRAC, resources were expended to eliminate many of the egregious examples of overlap by purifying technical capabilities, collocating major technical capabilities at specific sites, building new facilities, and either moving people or hiring new people. Numerous sites have been closed and the total WC workforce has been reduced by approximately one-half.

The Warfare Centers and SYSCOMs have processes in place to maintain discipline in order to prevent too many redundancies from re-appearing. In some cases, consolidation is under way, but often this is accomplished in a staged manner to ensure the preservation of critical technical capabilities as corporate knowledge is transferred from one site to another. In other cases, multiple sites within the Warfare Centers and UARCs (JHU-APL, in particular) are cooperating to ensure support of critical programs that require capabilities resident at multiple organizations.

NRAC visits to program offices and field sites have demonstrated that well informed, disciplined program managers can obtain work from the WC system very effectively, while avoiding the creation of unnecessary system redundancies. There will always be a constructive tension between a program manager's desire to have freedom in choosing where to obtain technical support and the larger Navy desire to centralize the decision process for the sake of anticipated (or perceived) efficiencies. As long as the customer has the ability to go wherever he wants to get the best technical support, there will be the risk of redundancy. But if the system centralizes the buying decisions too much, the Navy will pay a steep price in reduced responsiveness and agility.

Summary of Actions

CNO
- Establish a process to coordinate concepts and technology for Navy-After-Next

- Establish a Science Advisor to the CNO

ASN (MRA)
- Consolidate HR responsibilities

ASN (IE)
- Consolidate MILCON and maintenance responsibilities

Summary of Actions

ASN (RDA)
- Designate *Director of Naval Research & Development Establishment*
- Ensure SYSCOMs are investing in Navy technology leadership areas
- Ensure future needs are reflected in BA1-BA4 investments
- Commit to maximum NDAA 2009 Section 219 funding
- Update/reinstate SECNAV Instructions
- Conduct biennial assessment of the NRDE technical capabilities
- Allocate a greater number of technical SES and ST billets to WCs
- Accelerate physical infrastructure modernization or recapitalization

CNR
- Enhance tools and techniques to expand global technology awareness

Based on their findings and recommendations, the NRAC panel recommends that the following actions be taken to rebuild and modernize the Naval R&D Establishment:

For the Chief of Naval Operations

- Work with the stakeholders to develop a process to nurture the concepts and technologies for the Navy-After-Next,
- Establish and fill the position of Science Advisor to the CNO,
- Support the consolidation of management for Warfare Center-focused Human Resources, Military Construction, and facility maintenance offices.

<u>For the ASN (Manpower and Reserve Affairs)</u>

- Implement the consolidation of management for Warfare Center-focused NRDE Human Resources.

<u>For the ASN (Installations and Environment)</u>

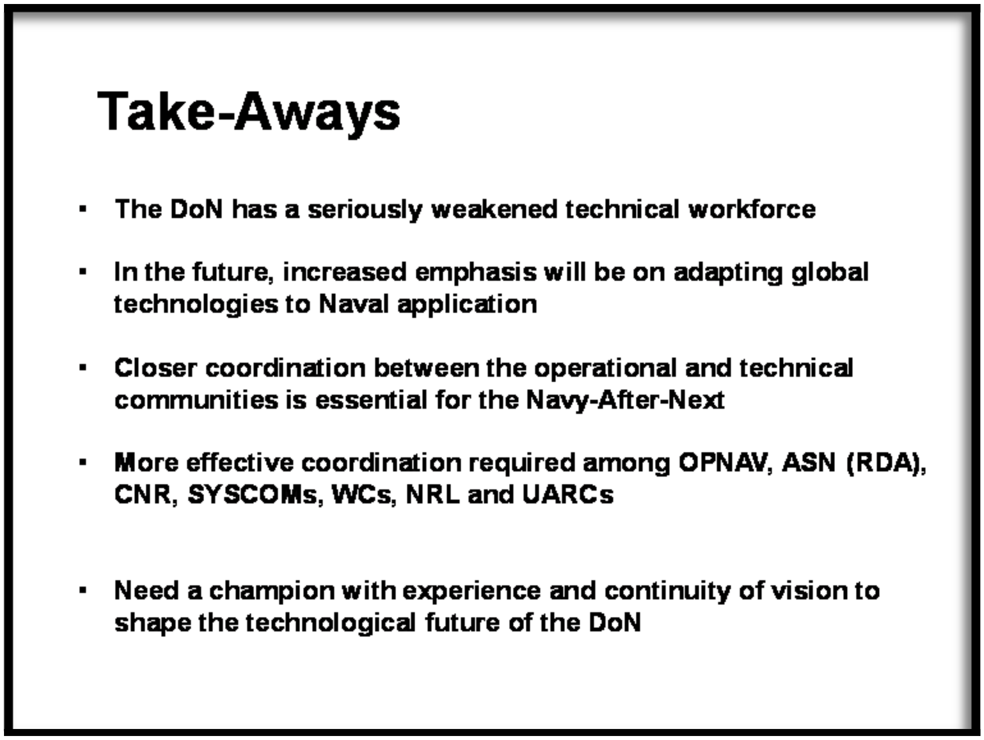
- Consolidate NRDE MILCON and facility maintenance responsibilities.

<u>For the ASN (Research, Development and Acquisition)</u>

- Establish a new position of Director of Naval Research & Development Establishment within the ASN staff,
- Ensure the NRDE is properly investing in the requisite Naval technology areas that will ensure enduring leadership,
- Ensure that Section 219 funding is utilized to the limit of 3%,
- Review, then modify or update SECNAV instructions that pertain to the NRDE,
- Conduct biennial assessments of NRDE technical capabilities; add to the number of SES and ST billets at the Warfare Centers,
- Coordinate with ASN (I&E) to accelerate physical infrastructure modernization or recapitalization.

<u>For the Chief of Naval Research</u>

- Enhance the tools and processes needed to exploit global technology for the NRDE.



The DON has a weakened technical workforce with only one or two experienced and fully qualified technical experts in many technical competencies. This problem will only get worse unless actions are taken to rebuild the technical workforce, both military and civilian personnel.

The Naval Research & Development Establishment is the gateway between current and emerging technologies and future Naval warfare capability. While this has always been true, the complexity of modern information-dominated warfare is far greater than the days of WW II battleships and low-bandwidth radio systems. Since the end of WW II, the U.S. has enjoyed a global leadership role – in economic power and technology development/exploitation. These conditions are now changing as other countries emerge onto the world stage. For example, China – once an inward looking agrarian country – now dominates global telecommunications in fiber-optic and fourth generation wireless equipment sales. Further, a telecommunication workforce of 45,000 engineers has positioned China as a global leader of telecommunications invention and implementation.

Without strong NRDE leadership in technology transformation for the DON, future forces may not enjoy maritime dominance in all warfare areas. Twenty years of reorganization, moves and downsizing have weakened the NRDE. The result is that the Warfare Centers today provide effective support for current in-service-engineering, only adequate support to platform/ system acquisition, and are not focused on the Navy-After-Next.

The NRAC panel feels strongly that the NRDE is not adequately valued for the important resource that it is, nor is it being effectively led from the top. Just as the global stage is changing, the source of future Naval technology is changing. While Naval technologies were largely generated from within the NRDE in the past, much of the global, emergent technology and applications must be now be adopted and adapted from “open-source” technologies – also available to potential adversaries. Leadership must play a critical role in enabling the NRDE to become “agile adopters” to preclude a loss of capability vis-à-vis adversary navies. Leadership must also recognize the need to better coordinate the efforts of the NRDE stakeholders.

To fully address these challenges the ASN (RDA) will need a dedicated NRDE leader and champion to address the challenges with long-term vision and continuity to ensure the Navy-After-Next will meet the challenge.

APPENDICES

A. Terms of Reference

B. Site/Organization Visits by the Sub-Panels

C. Future Technology Leadership Areas

D. Emerging Agile Adopter Areas

E. NAVSEA Warfare Centers

F. NAVAIR Warfare Centers

G. SPAWAR Warfare Centers

H. Marine Corps Marine Corps Systems Command

I. NRL

J. UARCs

K. Technical Support and Overlap within the NRDE

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APPENDIX A

Terms of Reference

NRAC Study
Status and Future of Naval R&D Enterprise

Objective

In the context of the Maritime Strategy, the NRAC shall study the Navy's technical competencies which reside primarily in the Naval Warfare Centers to develop an assessment of their "as is" capability to meet the technological needs of the Navy and in particular their ability to innovate in areas of anticipated Department of Navy technical need. This assessment should include consideration of the current technical workforce, physical infrastructure, and technical planning, as well as the strategic planning for future development and investment. Further, the NRAC should recommend what future technical core competencies will be required, and identify both "white space" in the current Warfare Center/ laboratory structure, as well as redundancies.

Background

Since the formation of the Naval Warfare Centers, there have been significant pressures on their ability to sustain and develop the technical underpinnings that the Department of the Navy will need in the future. The elimination of "mission funding" in favor of the Navy Working Capital Fund, several rounds of Base Realignment and Closure, cost-cutting and headcount reduction, combined with emphasis on acquisition support as well as near-term support for current military operations may have taken a toll on laboratory personnel, physical infrastructure, and perhaps most importantly, the flexibility to effectively innovate for the future.

Because of the unique nature of their military customers, Naval Warfare Centers often support long-term research in which industry will not invest, because of probably low returns. Importantly, Warfare Centers must address the full spectrum of technologies (currently) required by DON, including those that cannot be addressed by academia (or industry). In an era of technology globalization, there is significant risk that Naval forces could lose their technological edge against future adversaries if the Department does not maintain a robust, productive, and cutting-edge laboratory system that is capable of addressing not only technology needs "just in time," but also "just in case."

Specific Tasking

- Assess the current technical core competencies of the Warfare Centers employed by the SYSCOMs and PEOs, as well as the stewardship provided for those competencies. Also assess the technical core competencies that are provided by the Navy UARCs. Consider technical quality of the workforce and physical infrastructure. Specifically, the scope of the study should include:

  - Warfare Centers and NRL in support of SYSCOMs, PEOs, and ONR
  - MCWL in support of MARCORSYSCOM
  - To the extent practical, Navy UARCs in support of SYSCOMs, PEOs and ONR

- Identify areas where the Department of the Navy holds a leadership role in science & technology, areas where it leverages other technologies in the US Government, the US commercial sector and throughout the world, and areas where it is deficient relative to the state-of-the-art.
- Identify areas where the Department of the Navy will be required to provide technical leadership and competency in the future, within the context of the Maritime Strategy and assess the likelihood that the Warfare Centers will be able to develop these competencies under the current structure.
- Recommend approaches (within the context of constrained future budgets) to maximize the likelihood of achieving the required technical leadership and of leveraging global science and technologies.

APPENDIX B

Site/Organization Visits by the Sub-Panels

Site, Organization or Individual	Sub-Panel
Applied Physics Laboratory-University of Washington	UARC
Applied Research Laboratories-University of Texas (Navy)	UARC
Applied Research Laboratory-Penn State	UARC
Applied Research Laboratories-University of Texas (Army)	UARC
Assistant Commandant	Integration
Boeing	NAVAIR
Chief of Naval Research	NAVSEA, NRL
Chief of Naval Operations-N00X	NAVSEA
Commander, Naval Air Warfare Systems Command	NAVAIR
Commander, Naval Sea Systems Command	NAVSEA
Defense Advanced Research Products Agency	SPAWAR
Director, Strategic Submarine Programs	NAVSEA
Fleet and Forces Science Advisors	Integration
General Dynamics HQ	SPAWAR
General Dynamics-Bath Iron Works	NAVSEA
General Dynamics-NASCO	NAVSEA
Johns Hopkins University Applied Physics Laboratory	UARC
Lockheed Martin	NAVAIR
Marine Corps Combat Development Command	Marine Corps
Marine Corps Systems Command	Marine Corps, SPAWAR
Marine Corps Warfighting Lab	Marine Corps
Naval Air Warfare Center/Aircraft Division (Lakehurst)	NAVAIR
Naval Air Warfare Center/Aircraft Division (Orlando)	NAVAIR
Naval Air Warfare Center/Aircraft Division (Pax River)	NAVAIR
Naval Air Warfare Center/Weapons Division (China Lake)	NAVAIR
Naval Air Warfare Center/Weapons Division (Pt Mugu)	NAVAIR
Naval Research Laboratory-DC	NRL
Naval Research Laboratory-Monterey	NRL
Naval Research Laboratory-Stennis	NRL
Naval Surface Warfare Center (Crane)	NAVSEA
Naval Surface Warfare Center (Dahlgren)	NAVSEA
Naval Surface Warfare Center (Indian Head)	NAVSEA
Naval Surface Warfare Center (Panama City)	NAVSEA
Naval Surface Warfare Center Headquarters	NAVSEA

Site, Organization or Individual	Sub-Panel
Naval Surface Warfare Center (Carderock, West Bethesda)	NAVSEA
Naval Undersea Warfare Center (Newport)	NAVSEA
Naval Undersea Warfare Center Headquarters	NAVSEA
NAVSEA 00B	NAVSEA
NAVSEA 05	NAVSEA
NAVSEA 05B	NAVSEA
OPNAV 00X	Integration
OPNAV N2/N6	SPAWAR
PEO Air ASW, Assault and Special Mission Programs	NAVAIR
PEO Aircraft Carriers	NAVSEA
PEO Command, Control, Communications, Computers and Intelligence	SPAWAR
PEO Enterprise Information Systems	SPAWAR
PEO Integrated Warfare Systems	NAVSEA
PEO Littoral and Mine Warfare	NAVSEA
PEO Ships	NAVSEA
PEO Space Systems	SPAWAR
PEO Submarines	NAVSEA
PEO Tactical Air Programs	NAVAIR
PEO Unmanned Aviation and Strike Weapons	NAVAIR
Raytheon	NAVSEA/NAVAIR
Selected ONR Directors/Department Heads	NRL, NAVSEA, NAVAIR, SPAWAR, Integration
Sikorsky	NAVAIR
SPAWAR Space Field Activity	SPAWAR
SPAWAR Systems Center Atlantic	SPAWAR
SPAWAR Systems Center Pacific	SPAWAR
SPAWARSYSCOM HQ	SPAWAR
United Kingdom MOD and Selected Vendors	NRAC Members
Vice Chief of Naval Operations	Integration

APPENDIX C

Future Technology Leadership Areas

The following are four examples of Naval capability areas that the Panel believes that the NRDE must gain and maintain technology leadership for the foreseeable future.

Integrated C4ISR for Mixed Systems Leadership

- *Integrated C4ISR for combined manned/unmanned (mixed) systems*
- To include: conceptual design, development, testing, fielding and maintaining maritime and expeditionary C4ISR networks consisting of a combination of mixed manned/unmanned systems. This is true in general, but especially for
  - Mixed Undersea Operations
  - Mixed MAGTF Operations
  - Mixed Carrier Air Operations
  - Mixed Surface Operations
- Because maritime operations cannot guarantee communication continuity, unmanned nodes must have capability to “fight through” intermittent connectivity

Given the current trend toward military operations using mixed *Manned/Unmanned Systems* , the Warfare Centers must acquire the technical competency to support the required C4ISR capability for these maritime/expeditionary systems

In the future, U.S. Naval forces will operate in rapidly changing, data rich environments in which timely decision-making will be dependent on the effective combination of human cognition and automation. Furthermore, the data sources, computation capabilities and human expertise will be globally distributed. A Navy-unique aspect of this requirement is that the maritime communication environment is characterized by links that are lower bandwidth and sometimes unreliable, relative to the connectivity available in most terrestrial environments.

The gap between the availability of data and maritime communication capacity is becoming so large that it must be addressed on multiple fronts:

- Efforts to improve the capacity of the maritime communication infrastructure must be accelerated.

- Data management technologies, such as replication, data de-duplication, data warehouses / data-marts, data ageing, column and stream-oriented databases, etc., should be studied and, where appropriate leveraged, to identify ways to reduce the load and real-time dependence on communication links.
- Agent-based and machine learning technologies that facilitate search, classification and mixed (man + machine) decision-making should be adapted to the maritime communication environment.
- Technologies should be adapted and/or developed to facilitate the automated fusion of results from a multiplicity of independently operating data sources and decision-making systems into a common operating picture (COP).

The global IT industry has made significant advances in the development and deployment of mixed decision-making systems, i.e., those in which significant parts of the decision-making process have been automated. Many of these systems are based on the use of software agents in which programs are empowered to act on behalf of the user/operator, i.e., have the ability to analyze data and the authority to determine which actions are appropriate and when. Typically, these agents are tasked in advance and activate themselves in response to some external stimulus. In more sophisticated systems, large groups of agents – which may be distributed – communicate and work together to achieve an objective.

Google Alerts are an example of such a system that allows millions of users to task agents to search the Internet on their behalf on an ongoing basis and alert them when data satisfying their search criteria is added to the World Wide Web. More sophisticated and computationally-intensive examples of mixed decision-making, such as automated trading systems, combine agents with sophisticated machine learning capabilities and/or data warehousing.

There are a very large number of ways in which these technologies can be applied to Naval decision-making. Furthermore, given the rapid pace at which universities and private industry are driving progress in these areas, mixed decision-making represents an excellent agile adoption opportunity. Capitalizing on that opportunity will require “hands-on” awareness and shaping of these emerging technologies and addressing the challenges associated with their specific application to maritime communication environments.

Infrastructure for Information Dominance Leadership

- Support Infrastructure to enable "Information Dominance" Future Navy.
  - All previous naval transformations have required investment in support infrastructure (e.g. nuclear propulsion, aviation, strategic systems)
  - Information Dominance will require data movement, storage, access and parsing, fusion to support warfare time lines…radical infrastructure improvements

NRDE must develop the technical competency to enable and support this transformation which will use both commercial and Navy-specific technologies

As the Department of Navy moves into the era of information dominance, it must be capable of leveraging National and Joint Service information, combined with organic Naval force information, in order to dominate theater operations. To remain capable during communications disruptions, damage to afloat forces or supporting ashore infrastructure, Naval forces must have the capability to operate autonomously from the shore infrastructure when disruptions occur.

As the Naval Service was transformed from sail to steam propulsion to nuclear propulsion, from battleship to carrier aviation warfare, new supporting infrastructure was required to make each of these transformations capable and successful. Although not as obvious, the same situation applies to the transformation to information dominance. In the past, it was much more expensive to store and process data than to move the relatively small amount of processed information. Today, information technology advances have made it possible to store and processes massive amounts of information relatively inexpensively. The new challenge is the movement of huge data streams across RF (radio frequency) systems (e.g., SATCOM, shore-based wide area networks).

The data movement challenge is a result of new sensor and platform technologies that make it possible to generate orders of magnitude more data today than was the case just a few years ago. With the advent of small, inexpensive synthetic aperture radar, acoustic, electro-optical and infrared imaging sensors, coupled with small full-motion video cameras that are easily placed on all sensor packages, it is not uncommon to create far more sensing data than can be transmitted to a control station. For example, the newest Maritime Patrol aircraft (P-8) will be capable of generating terabytes of information each day. A terabyte is one million megabytes – the equivalent of about one million photos from a handheld digital camera. Because modern processing and storage equipment is so capable, it is actually easier to process and store terabytes of information in a space equivalent to a small office refrigerator. What is more difficult is digitally transporting this much data. For example, it would require about 39 hours of dedicated bandwidth to move a terabyte of information using the current fleet support wide-area network. Similarly, using today's dedicated aircraft carrier satellite communications capability would require 15 days to move this much information. Even employing DOD's future Wideband Global Satellite system, it would still require three days to move this much data off an operating carrier.

A data strategy and the resulting afloat/ashore infrastructure must be created to allow Naval Forces to maintain information dominance.

Electronic Warfare Leadership

- Navy has the lead role in the Department of Defense for Electronic Warfare (EW)

Warfare Centers must have the technical competency to maintain DoD legacy systems and support the design, development and integration of new systems to anticipate and meet evolving threats. These must also be integrated with current and planned C4ISR systems

In the late 1990’s, the U.S. Air Force decommissioned its EF-111 fleet – effectively ceding the lead role for the Electronic Warfare mission area to the U.S. Navy. Each service, however, must meet its unique Electronic Warfare mission area needs. Additionally, the CNO has increased the Navy’s emphasis on the “left end of the kill chain” (or “soft kill”). This is the domain of Electronic Warfare.

There are three types of EW systems:

- Electronic Support (ESM); related to SIGINT, COMINT, ELINT,
- Electronic Attack (ECM); offense; a form of joint fires; jamming, expendable decoys, counter radio-controlled improvised explosive devices,
- Electronic Protection (EP), also called Electronic Counter-Countermeasures (ECCM); defense; protects people, facilities, capabilities, and equipment; flares, Emissions Control (EMCOM), stealth, spectrum hopping.

The Navy is the DOD leader in EW because it is the dominant player in Electronic Warfare, particularly offensive EW and AEW (operating the EA-6B Prowler and the EF/A-18G Growler); joint force commanders will not conduct offensive operations against high-end threats without employing airborne EW platforms; EA-6B and EF/A-18G aircraft are essential to achieve success in an Anti-Access and Area Denial environment, and are key assets in the Air-Sea Battle Concept. For both legacy and new systems, in-service engineering agents within the

Warfare Centers must ensure that EW systems are fully integrated with Navy and joint C4ISR systems. It is imperative that the Navy's EW research community pursue a technology leadership role.

Counter Anti-Access and Area Denial and High-end Asymmetric Threat Leadership

- Counter Anti-Access and Area-Denial (A2/AD) and High-end Asymmetric Threat (HE/AT) technology areas to include air, surface, subsurface, expeditionary and cyber domains
  - DoN A2/AD and HE/AT technology programs must be integrated and coordinated with Air Force and Army research organizations

Given the global proliferation of Anti-Access and Area Denial systems and capabilities and growing High-end Asymmetric Threats (HE/AT) which pressure the ability of U.S. maritime forces to operate freely, the Warfare Centers must have the technical competencies to support the technology responses to these systems.

Full access to the world's sea lanes is critical to the Navy's Cooperative *Strategy for 21st Century Seapower* and to our national security. There is nothing more fundamental to the Navy than being able to "go anywhere at any time." There are growing competitors who seek to limit the United States access (e.g., selected littorals, Arctic) through pronouncements, threats, or actions.

Examples of the capabilities and technologies included in Anti-Access and Area Denial (A2/AD), and High-End Asymmetric Threats (HE/AT) are:

- Ballistic Missiles,
- Anti-Satellite Weapons,
- Anti-Air Weapons,
- Anti-Surface Systems,
- Anti-Submarine Systems,
- Cyber Attacks,
- Terrorism,
- Long range reconnaissance and tracking (e.g., satellites, signal exploitation, unmanned systems)

The Naval Research & Development Establishment (NRDE) must develop and manage the significant number of technology portfolios needed to combat these A2/AD and HE/AT systems, capabilities, and technologies. Because of the breadth and depth of the problem and its impact on the joint force, it must be closely coordinated with the Office of the Secretary of Defense, the other Services and their research agencies, as well as other defense agencies.

To adequately address the technologies, systems, and capabilities necessary to counter A2/AD and HE/AT, the following areas must be viewed as requiring technology leadership within the NRDE:

- Cyber warfare,
- Air- and surface-launched weapons vs. next generation ships and aircraft,
- Sea-based unmanned vehicles with munitions and ISR sensors,
- Concealment and Deception,
- Electronic Warfare,
- Ballistic Missile Defense,
- Communications in non-satellite environment,
- Anti-Submarine Warfare,
- Sea Base systems and technologies,
- Indications & Warning,
- Precision Targeting,
- Mine warfare and mine countermeasures.

The Under Secretary of Defense for Policy has noted that the battle for access may prove not only to be the most important – but also the most difficult. The scale of the threat posed, given the proliferation of advanced high-end systems, and the real potential for non-state actors to employ such technology is real and noteworthy. It requires a comprehensive, well-led, and well-managed response from the NRDE.

APPENDIX D

Emerging Agile Adopter Areas

The Panel recommends that the following five "agile adoption" areas be vigorously pursued by the NRDE.

Commercial Information Technology Agile Adoption

- **Commercial Information Technology Adoption** to include: Understanding all commercial IT, associated standards and implementation best practices, and investigating best ways to augment the areas of technical leadership with commercial technologies (e.g. enterprise architectures, cloud computing)

Navy has committed to use of commercially available IT in all of their Enterprise Information Systems. Warfare Centers must develop technical capability to be active participants in standards and tools development, especially with regard to Navy unique needs

The DON, as with commercial business, is beginning to buy and deliver capability from the third era of information technology (i.e., computing, storage, and networks). Unlike the first and part of the second IT eras, the Navy will have made little contribution to how this latest technology delivers capability – other than as a consumer and builder of applications that utilize this new technology. With the mainframe-based computer systems of the first IT era, the Navy was a primary inventor and builder of the solid-state computer, the associated components, and communications data links. The client-server/networking, or second IT era, began with the Navy initially designed and building military computers. But during the middle of this era, at the recommendation of the NRAC and others, it eased the requirement to purchase militarized computers in favor of adopting and adapting commercial computers and networks into mission critical systems. This second IT era initiated the Internet and featured global technology development and manufacturing as the dominant form of IT advancement.

The third IT era has been underway for a decade and is just now gaining a strong foothold within the DON. This is the era of cloud, or virtualized computing, ubiquitous broadband networking, and serviced-based applications. This era has enabled the relocation of computer infrastructure from individual businesses in favor of buying off-site computing services including data storage, networking, and applications – much like we buy electricity. When the DON adopts commercial technology, it must be adapted to accommodate the shipboard challenges of shock, vibration, and disconnected/constrained communication links. Cloud computing and service-based architectures have much to offer the DON in terms of rapid capability and low-cost, agile change that will create orders of magnitude improvement over today's information and knowledge capability.

Because IT is so critical to the current Naval warfare areas, they are all at various states of risk from potential adversaries who may employ information warfare (IW) techniques. IW – unlike all other warfare domain areas – can remain largely disconnected from the constraints of physical location and distance. Because bits and bytes are relatively inexpensive, and networks are now global, our adversaries can be almost anyone, anywhere.

It is obvious that the NRDE technical workforce must remain at the forefront of understanding IT evolution and capabilities, but, must also be capable of rapidly adopting new technology to support future capabilities.

Mixed Decision Making Systems Agile Adoption

- Decision making in an data rich, low bandwidth, unreliable communication environment
  - Communication infrastructure
  - Data management strategy
  - Agent based search and classification of data from disparate sources
  - Time critical automated heterogeneous data fusion in a COP

Given the current trend in the IT industry toward mixed decision making systems (manned and agent based), the Warfare Centers must acquire the technical competency to shape, adopt and adapt this capability for the Navy

In the future, U.S. Naval forces will operate in rapidly changing, data rich environments in which timely decision-making will be dependent on the effective combination of human cognition and automation. Furthermore, the data sources, computation capabilities and human expertise will be globally distributed. A Navy-unique aspect of this requirement is that the maritime communication environment is characterized by links that are lower bandwidth and sometimes unreliable, relative to the connectivity available in most terrestrial environments.

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Software Development
Agile Adoption

- Software dominates control of all of our systems.
  - Warfare Centers must develop and maintain technical competence to manage risk, cost, reliability in large software development projects
  - Warfare Centers must also provide backup when OEM support is no longer available
  - Warfare Centers must have the technical competence to provide the Naval Establishment with the ability to leverage emerging trends such as cloud computing, open source, where applicable.

The Navy needs to develop and implement a comprehensive strategy for managing software development into the future to include revitalizing in-house software engineering competency.

The warfighting capabilities of Naval systems are increasingly dominated and defined by their imbedded complex computer-based software programs. Warfighting superiority is frequently defined and delivered by the quality of the software.

Out-sourcing has shifted government software engineering resources away from the active role of prime developer and systems integrator (i.e., hands-on) to a passive role of certifier and overseer (i.e., hands-off). Consequently, this critical skill and the associated abilities to apply domain expertise and life cycle support are fast eroding. This compromises independent government capability to understand “what’s under the hood”, understand risk, offer “smart buyer” recommendations to the acquisition community and provide in-service engineering support to the Fleet. This is an insidious erosion of an essential capability that is happening at an accelerating rate.

We must sustain and revitalize the expertise residing within the NRDE in order to shepherd software-based technologies and competencies for the future. A comprehensive strategy should be pursued.

Power & Energy
Agile Adoption

- Power and Energy
  - US and Global investment in new power supply, energy storage systems very large
- Results could strongly influence Navy-After-Next concepts

The Naval R&D Establishment should become aware of what is going on in the large investments in the US and Globally in power generation and energy storage, and look to see where this work can be shaped and, eventually, leveraged for Naval unique uses.

The outside world is making large investments in new means of power generation and energy storage. Because the Navy of the future will rely heavily on unmanned system capability that require better sources of power, the NRDE must position itself to comprehensively understand this technology thrust. It must have a respected cadre of scientists and engineers who have extensive knowledge of "global' progress in this area – and also knowledge of Navy-unique constraints. Ultimately, the goal is to influence commercial standards to make it easier to adapt innovations to Naval systems.

This is a very good example of a potential "global technology leverage" opportunity and should be considered as one of the test cases for ONR/NRL to enable NRDE awareness of this transformational area.

Biology-based Technologies
Agile Adoption

Biology-based technologies

- Technical breakthroughs which will enable applications in materials science, robotics, sensors, informatics are globally driven
  - Bio-inspired design, Bio-defense, Bio-based sensors, Bioinformatics.
- Volatile, university-centered, venture-driven, uncertain trajectories

Naval R&D Establishment needs sufficient expertise to monitor and exploit biology-based innovation, in order avoid technical surprise.

Many new and emerging areas of technology are based on biological systems in order to exploit and leverage those inherently complex interactions. In fact, the most complex hierarchy organized chemical structures can be found in nature. Since the early days of materials research, progress in materials science and engineering has strongly benefited from achieving better insight into complex biological systems.

In the area of material science, progress is being made. The coupling of biological inspiration with nanoscale design, “bio-nanotechnology”, leads to enhanced performance and materials properties for demanding aerospace applications. Work in the topics of self-assembly, self-repair and self-healing, increased sensitivity and response in sensors and actuators, and advanced composites represent new approaches to the needs of the next generation of space vehicles and astronauts – with spin-off benefits to ceramics, polymers, composites, and adhesives technologies.

Another example where biological systems are being exploited is bio-based sensors. Specifically, various kinds of living cells can be used to detect chemical agents, or other toxic materials. These cell-based systems are chosen based upon receptor sites which are specific for the compound to be detected. For example, there are prototype systems available that use tissue-culture grown neurons that are exquisitely sensitive to a limited array of classical nerve agents or other neuro-toxic compounds.

Bioinformatics (defined as the application of statistics and computer science to the field of molecular biology) now entails the creation and advancement of databases, algorithms, computational and statistical techniques and theory to solve formal and practical problems arising from the management and analysis of biological data. Over the past few decades, rapid developments in genomic and other molecular research technologies and developments in information technologies have combined to produce a tremendous amount of information related to molecular biology. Common activities in bioinformatics include mapping and analyzing DNA and protein sequences, aligning different DNA and protein sequences to compare them and creating and viewing 3-D models of protein structures.

These new areas are frequently funded by venture capital and the research is often conducted in universities or small businesses. While the payoff for those technologies that prove out is very high, the risk inherent with these technologies is equally high – making this area of technology extremely volatile and uncertain. Currently, the DON is not staffed nor funded to participate to a large extent in these areas; however, the NRDE should maintain sufficient expertise to monitor these areas in order to exploit new technologies and adapt to specific Naval needs as required.

APPENDIX E

NAVSEA Warfare Centers

NAVSEA Summary

- NAVSEA WC's have identified and assessed their technical capabilities to steward "today's Navy" and current programs. (Process identifies near term WC technical capability gaps).
- WC TDs are functioning more as Business Managers than Technical Directors.
- Inconsistent utilization of the engineering technical capabilities inherent in NAVSEA WCs' in the Navy acquisition process impedes integration of "Smart" with "Buyer".
- A key element in several highly successful acquisition programs is early-in-program specific tasking of the WC in roles such as Systems Integrator, Technical Design Agent , In-Service Engineering Agent , etc.
- Introduction of the technical authority construct throughout NAVSEA is a positive step. Implementation requires significant refinement/development and adaptation to acquisition.
- WC investment funds (overhead) are viewed as a bill payer, which results in reduced discretionary investment in WC advanced technical equipment and innovative research.
- Capability, competency and skills in offensive Mine Warfare and Energetics are decaying due to lack of sustaining development work.

A. Introduction

In addressing the Terms of Reference for the 2010 NRAC Study, the NRAC panel participants were assigned to sub-panels, each addressing a different major organizational segment of the technical workforce. The Naval Sea Systems Command addressed the technical workforce in the Naval Surface Warfare Center, the Naval Undersea Warfare Center and the headquarters technical staff reporting to SEA 05. It should be noted that within the total technical workforce associated with NAVSEA the engineering staffs of the naval shipyards, the supervisors of shipbuilding, Naval Reactors and the small technical staffs working directly in the offices of the PEO's and PM's were not included in our study. Our study was focused primarily on the technical workforce executing RDT&E, N in the NAVSEA Warfare Centers.

The NRAC NAVSEASYSCOM sub-panel was chaired by RADM Charles B. Young, USN (ret). THE Vice-chairman was Dr. Ira Blatstein. Members were RADM Erroll Brown, USCG (ret), RADM Millard S. Firebaugh, USN (ret), CAPT Ronald Harris, USN (ret), Mr. Gerald Schiefer, Mr. William Schmitt, and RADM John Tozzi, USCG (ret).

Members of the sub-panel visited all of the NSWC and NUWC Divisions with the exception of Port Hueneme, Keyport, Corona and EOD Technical Division. Our work spanned the period from Jan –July 2010. The Division TD's were forwarded a set of questions as reported in Section 2 of this appendix. The questions were forwarded in advance of the visit. During the Division visits the questions were answered and discussed. Typically the visits to the Warfare Center Divisions included a tour of the facility as well as presentations describing the personnel, management, and technical resources of the division. We also visited the Warfare Center Commanders and TD's for a top level view of their concerns with respect to their work-force. We visited all of the NAVSEA associated PEO's and the Director of the Strategic Systems Project, again with an agenda centered on a set of questions that focused on their appreciation of the technical workforce from the point of view of customers for tasks performed in the Warfare Centers. We visited Commander Naval Sea Systems Command, the NAVSEA Executive Director and SEA 05 who directs the NAVSEA HQ technical staff. All of these interactions benefited from a high degree of cooperation, candor and professionalism on the part of all of the individuals with whom the panel members interacted.

B. Background

The work of the Naval Sea Systems Command and its associated organizations is intensively technical. The ships, equipment, weapons and electronic systems that are the products of NAVSEA and its affiliated organizations are among the most complex technical systems ever developed.

The NAVSEA organization and the context within which it operates relates to the complexity of the technical work involved. Major influences include the following:

- The NAVSEA organization includes the Naval Reactors organization of the Director of Naval Nuclear Propulsion responsible for the nuclear power plants of the Navy's aircraft carriers and submarines. Because these ships are sites for nuclear power plants there is an intimate relationship between the design, engineering, construction, operation and maintenance of these ships and the technology of the power plants. This technology must operate at a very high level of technical precision and integrity because the impact of error could have disastrous and lasting consequences for the US Navy and national security.
- The modern NAVSEA is an institution assembled from prior, more individually specialized, entities each of which had a well developed culture before being conjoined in NAVSEA. For example, ship technology, often referred to as Hull, Mechanical and Electrical (HM&E) evolved from a rich history in the Bureau of Ships into the modern NAVSEA. HM&E technology traditionally relied on a strong headquarters technical staff. Weapon technology evolved differently in the Bureau of Naval Weapons with more of the supervisory technical expertise

developed in field activities. Combat systems electronic technology which has a more recent, mainly post -WW II history, evolved differently from both ships and weapons. Combat system electronics evolved with field activity technical expertise and expertise arising mainly in industry managed through a more programmatic technical staff in headquarters. These differing histories are still in evidence in the current NAVSEA organization and show up as different technical approaches to developing and delivering technical systems to the Navy.

- NAVSEA is the headquarters for the operation of the four Naval Shipyards that are government owned and operated industrial facilities responsible for most of the depot maintenance of the nuclear ships as well as a good deal of the maintenance of the other ships of the Navy.
- NAVSEA brings together both submarine technology and surface ship technology. These two basic types of ships share many common technologies but also have very distinctive differences. These ship types are paralleled by two Warfare Centers, The Naval Surface Warfare Center (NSWC) and the Naval Undersea Warfare Center (NUWC). But, of course, surface ships in the Navy have a role in undersea warfare so some surface ship technologies are under the technical cognizance of NUWC and some of the HM&E technologies that undergird the submarine program were specialized over the hundred ten year history of submarines from their origins in surface ship technology. The modern NSWC and NUWC have intertwined responsibilities for ship, weapon and combat systems electronic technology for both submarines and surface ships.
- Ships and submarines are a central concept for the US Navy. Ships bring together the HM&E, the weapons of naval warfare, combat system electronic systems and naval telecommunications and networking. The Navy's shipbuilders in private industry have an important technical role in developing the detail designs of the Navy's ships and submarines and in integrating all of the equipment systems and providing for the stowage of weapons and the installation of weapon launchers. This complex work is conducted with a degree of technical oversight by the Navy. Specialized contract administration organizations with technical staffs, the Supervisors of Shipbuilding provide day-to-day on site administration of shipbuilding contracts. They are another technical element in NAVSEA.
- NAVSEA administers the contracts between the US Navy and the University Affiliated Research Centers (UARCs) providing another rich and somewhat independent source of specialized technical capability.
- NAVSEA HQ is located in Washington DC. The NAVSEA related programs have historically been of intense interest to the Congress, because of high visibility in the form of jobs spread about the nation as well as the pride that many feel in husbanding a great Navy.

These and other factors provide a background for understanding the current capabilities of the NAVSEA technical workforce in the two NAVSEA Warfare Centers and the headquarters technical staff.

The NRAC NAVSEA sub-panel notes that the range and depth of the NAVSEA technical workforce in most areas of its responsibilities is capable and effective but there are deficiencies that need to be addressed.

As will be discussed later in this appendix there are certain areas in which the technical capability is deficient.

C. Findings (Common across NAVSEA Warfare Center Divisions):

1. Technical authority, technical leadership, experience and judgment.

During the NRAC NAVSEA Sub-panel NAVSEA HQ and NAVSEA Warfare Center visits and discussions with various leaders, and subsequently in deliberations among the sub-panel members, several findings merged into a recommendation that concerns technical authority, technical leadership, experience and judgment.

A key responsibility of NAVSEA is the technical authority for the technologies for which it is the cognizant Navy entity. The NRAC NAVSEA sub-panel has concerns that the NAVSEA implementation of technical authority places a great deal of responsibility on relatively lower level engineers in the organization. This implementation may be placing an undue burden for personal accountability at a level too junior to bear that burden wisely. The sub-panel found instances in which individuals exercising technical authority did not have the experience to understand how to make the required determinations and act effectively. Additionally the NRAC panel overall noted that technical authority in important areas that bridge across SYSCOM has not yet come into focus. More detailed comments follow.

a. Technical Authority

The Naval Sea Systems command has developed a very detailed implementation of **technical authority.** The implementation to date involves the identification of some 220 areas of technical cognizance assigned to technical warrant-holders. Most of the warrant holders are in NAVSEA HQ. Some are in Warfare Centers. New warrant-holders are still being identified as experience dictates and as new areas of technical activity that are important to the acquisition support and in-service engineering missions of NAVSEA emerge. In the implementation:

- The technical areas are very specific and detailed.
- The responsibilities of the warrant-holders are well defined.

Where the expertise appropriate to the responsibilities of a warrant-holder is found in a Warfare Center vice in NAVSEA HQ the technical warrants are assigned to a Warfare Center individual. Policy is evolving as to the relationship of the Warfare Centers Commanders to the NAVSEA Chief Engineer who has the over-all delegated responsibility for technical authority in the NAVSEA cognizance technical areas.

Policy as to funding for the activities of the technical warrant-holders in the Warfare Centers appears at this writing to still be evolving. Apparently some of the Warfare Center technical warrant-holder work is being absorbed in Warfare Center overhead, some of the Warrant Holder time is funded by direct work paid by Warfare Center customers, and some (~1/4) is being funded directly from NAVSEA HQ. Possibly at issue is the matter of the technical independence of the Warfare Center warrant-holder whose part-time technical authority work may involve controversial decisions in the very areas in which he has been funded by a Program Manager through the Navy Working Capital Fund (NWCF).

Because technical authority has been sub-divided to a very fine level of detail many of the warrant-holders are rather junior in terms of grade-level and experience. **These warrant-holders may indeed be well educated in their technical field but inexperienced in the application of their knowledge to complex business, programmatic and interlinked technical matters.**

The NRAC NAVSEA Sub-panel came across two very specific instances in which lack of experience led the warrant-holder into difficulty. One involved the ASDS Lithium-ion battery and the other a technically minor but very costly decision made in the case of a ship structural detail. What is concerning about these two situations is that the **experience of more senior engineers with broader experience did not come into play** at least in part because the warrant-holder has the warrant and the latitude to make the decisions.

The issue is that somehow the warrant-holder seems to be accountable but the chain of command that is informed by the experience and judgment of senior engineers did not necessarily come into play in making decisions and creating consequences.

b. Technical Leadership

During the visits and discussions at Warfare Center Divisions the NRAC NAVSEA Sub-panel came away with the distinct impression that the Technical Directors and their immediate subordinates spent most of their time on various aspects of running the Warfare Center, as a business, dealing with resources, community relations, personnel, facilities, workload forecasting, administrative efficiency and the like. But, the execution of the technical program, including the quality of the technical work performed, was mainly a matter between a principal investigator or equivalent and an Assistant Program Manager in a Program Office. The Sub-panel noted that, in general, the Technical Directors did not seem to be very much involved in the execution of the technical work. The Sub-panel noted that the technical advice of the senior technical staff at the Warfare Centers was not solicited in the Program Decision process. This was a matter of some expressed frustration by the TD of NUWC and the TD of NUWC, Division Newport. This created a concern on the part of the very experienced individuals on the NRAC NAVSEA Sub-panel that in the much bandied phrase justifying a role for the Navy's in-house technical staff, "smart buyer," there was "smart" and there was "buyer" but in important ways the two are not connected.

c. Experience and Judgment

In the complex engineering that underlies the ships, weapons and systems that NAVSEA supports, **experience counts for a lot**. The technology of the ships, weapons and systems is always in a business and operational context that is also complex. It behooves NAVSEA to organize and manage in ways the bring not only acute technical engineering knowledge at a very detailed level to the many technical decisions that must be made but to apply that knowledge with a broad understanding of the context in which the consequences of its decisions will play out.

2. Overhead funds

Warfare Center indirect funds are viewed as a bill payer, resulting in reduced investment in Warfare Center advanced technical equipment and innovation.

3. Navy-After-Next

The NRAC NAVSEA sub-panel found that the Warfare Centers and UARCs are not sufficiently involved in the planning for the Navy-After-Next (NAN). This is unfortunate because absent a close working relationship between those who are most knowledgeable about emerging science and technology capabilities (i.e., Warfare Centers and UARCs) and those with current operational experience (i.e., OPNAV and Fleet Commands) the NAN is likely to be sub-optimized. Stated more starkly, the NRAC NAVSEA sub-panel believes that important opportunities are being missed that could lead to a more effective and efficient process for connecting the NAN to emerging science and technology. In explaining this finding, first we will define our terms, and then we will explain the situation we found.

The NAN is the Navy that will follow "Today's Fleet In-Being" and the "Next Navy" which is the Program of Record (POR) Navy that is currently under acquisition by the Program Executive Officers (PEOs) and Program Managers. The steward of the technology of today's Navy is the CNO acting with the Fleet Commanders and, for purposes of maintaining the technology, the SYSCOMs and their associated Warfare Centers. The stewards of the technology of the Next Navy are the PEO's and Program Managers supported by the SYSCOMs and their associated Warfare Centers. But, stewardship of the technological capability that will define the NAN is not clear. The CNO has a clear role in determining future roles and missions of the Navy. Those roles and missions will be supported and possibly even defined by the technologies that are chosen and developed. The Warfare Centers and UARCs should be heavily involved in identifying the enabling technologies for the NAN---unfortunately that is not what we found.

The NRAC NAVSEA sub-panel found was that the Warfare Centers and UARCs do indeed have important roles in supporting today's Navy and the Next Navy. The Warfare Centers and UARCs collectively are a cadre of scientists and engineers with supporting technicians, craftsmen, and administrative staff that constitute the Navy's in-house resource of technical knowledge[1]. They conduct a variety of technical activities on a task basis. Many of these activities are grouped under the headings of "Agents." For example, in support of today's Navy, a Warfare Center Division may be designated as an "In-service Engineering Agent (ISEA)." This designation recognizes the role of the technical staff at the Warfare Center providing continued engineering support for the complex technologies that the Navy employs. In support of an acquisition program creating the Next Navy, a Warfare Center Division may act as a "Technical Development Agent (TDA)" or as a "Systems Integration Agent (SIA)." These "agent" roles bring in-house in-depth technical experience and judgment unaffected by commercial interests to the complexities of developing technology and engineering systems that is part of the on-going or contemplated activity of acquiring the Next Navy. Similar designations for fleet support and acquisition support are used in tasking UARCs.

The relationships between the Warfare Centers and UARCs to the Science and Technology budgets and, more importantly, the connection between the experienced technical staffs of the Warfare Centers and the process of focusing emerging science and technology on future naval applications appears to be much more *ad hoc* than those relating to in-service engineering, technical development, and systems engineering. Of course, there are many well-motivated, thoughtful individuals involved in these matters, so there are numerous cases in which, despite an *ad hoc* process, good work is being done by an ONR PM working with a Warfare Center or UARC scientist or engineer. Yet, the relationship between the Warfare Centers and UARCs and CNR/ONR appears to the NRAC NAVSEA sub panel to be excessively dependent on working level relationships operating without a clear over-arching plan or concept of operations. Through the allocation of 6.1 and 6.2 funds ONR has a pivotal role in connecting evolving global science and technology to the specific needs of the NAN. Based on a number of observations made by Warfare Center staff to the NRAC NAVSEA sub-panel there seems to be no operative policy that specifically directs ONR PM's to interact vigorously with the Warfare Center Division TD's and the UARC Directors in determining what ought to be connected and how. That said, the ONR-administered Future Naval Capability (FNC) program apparently does

[1] For present purposes the UARCs are regarded as an in-house resource as opposed to a resource acquired through a commercial contract with industry.

stimulate some dialog and connectivity between the development agent and the eventual introduction of the technology into the Navy.

Lastly, the NRAC NAVSEA sub-panel received an appeal by the Technical Director (TD) at each of the Warfare Center divisions for an allocation of 6.1/6.2 funding to be spent in projects determined by the TD (subject to a review at the level of the Warfare Center TD). The so-called 219 funding is eagerly awaited as fitting this notion of discretionary funds available for a division TD to spend in fulfilling the vision of the division to foster robust connection between emerging science and technology and the NAN.

D. Recommendations (Across NAVSEA Warfare Center Divisions):

1. Technical authority, technical leadership, experience and judgment.

a. The NRAC NAVSEA Sub-panel recommends that the very detailed **technical warrant-holder process** by which NAVSEA exercises its necessary technical authority for the benefit of the Navy **be re-thought** with the objective of being sure that the warrant-holders understand that they are in a matrix of experience and that the **experienced senior staff are specifically involved and accountable for quality of the decisions made in their organizational element of NAVSEA.** The Sub-panel believes that attention to this matter both for warrant-holders in the HQ staff and in the field will improve the quality of the technical work being performed and the accountability. This is particularly important in dealing with the potential conflicts that could arise in a situation in which a warrant-holder must make a technical call with short-term adverse programmatic consequences involving the work for which he is funded at a Warfare Center under the NWCF. Senior people generally have had the experience of making tough calls and dealing with the pushback and frustration that sometimes accompanies such situations. Senior people may also have a broader, more comprehensive insight into both the strengths and weaknesses of a particular specification and they ought to have developed the confidence to take a fresh look. Additionally, **individuals higher in the organizational structure whose experience and expertise covers broad technical domains are often better equipped to see the important gaps and overlaps in technical areas under consideration than their more specialized subordinates.**

b. With respect to the activities of the Warfare Center and Warfare Center Division Technical Directors, the NRAC NAVSEA Sub-panel recommends that measures be taken to **put the TDs squarely into the matters of execution of the technical work** in their Centers. And we recommend that the highly developed process of the PEO, NAVSEA HQ and Secretariat level Program Reviews require a place at the table for the Center TDs. They are our most experienced technical people and they ought to be placed in a position in which they stand accountable for the technical work of their institution and in which their technical experience and judgment is explicitly available to the leaders making critical program decisions. **"Smart" and "Buyer" need to be conjoined.**

c. Increase the number of NAIP (NAVSEA Acquisition Intern Program) billets allocated to the Warfare Centers. This is based on the success of the program, a high retention rate and a high rate of demonstrated accomplishment in R&D directly applicable to the future needs of the Navy. Allocate Naval Acquisition Associates Program (NAAP) billets to the Warfare Centers. The ability to provide training for mid-career scientists and engineers joining the government with industry experience would accelerate strengthening the NSWCCD core technical workforce.

2. Overhead funds

The NAVSEA Sub-panel advocates for the retention of Warfare Center overhead at the site where it is generated. The intent would be to judiciously use these funds for Technical Stewardship initiatives. While the Congressionally mandated Section 219 funding greatly assists in workforce development, there are associated facilities and capabilities that need to be improved, reconstituted, or established to permit the innovative research called for in the "Naval Innovative Science and Engineering Program Policy" (DON, ASN RDA, 30SEP09). These facilities or capabilities are neither appropriate for MINCON nor MILCON, will not traditionally be considered for funding by program sponsors, but are critical to the recruitment, retention, and effective use of Navy R&D personnel.

3. Navy-After-Next

The NAVSEA Sub-panel recommends that an overarching concept of operations (CONOPS) be developed by the ASN (RDA) linking the Warfare Centers and UARCs with ONR for the stewardship of the Navy-After-Next. The CONOPS would include mechanisms to elevate the S &T dialog so that Warfare Center division TDs, Warfare Center Commanders and TD's, UARC Directors, the CNR and ONR leadership and the SYSCOM Commanders develop a mutual appreciation of how the technology of the Navy-After-Next will be provided for and what will not be provided for and how that technology will support evolving Navy roles and missions. Recommended Case Studies:

a. Chemical Energetics vis-a-vis Electric Weapons: This study would address priorities within ONR and the Warfare Centers and it should address the Navy role and responsibly for energetics S&T, as well as, the apparent duplication of facilities for Electric Weapons between NSWC Dahlgren, ARL UT, and NRL.
b. Offensive Mining: This study would deal with the extent to which the lack of support for any program related to future offensive mining capability was reached by consensus among Navy leadership rather than through inattention.

E. Technical Capabilities

1. Approach and Stewardship of Technical Capabilities/Competencies (what is being done to improve the workforce technical competence)

The NAVSEA Warfare Centers use multiple internal and external processes and drivers to steward their technical capabilities. The internal processes include:

a. Internal processes/drivers:
   i. Technical Capability Health Assessment.
      The NAVSEA Warfare Centers have 133 separate Technical Capabilities (TC) that are mapped within the 10 Divisions. Each TC has a specific descriptor of its technical and operational scope. Each TC is broken down further into sub-elements called Knowledge Areas (KAs); there are almost 1,600 KAs. TC's represents the blending of intellectual and physical assets provided by a cadre of technical people with knowledge, skill, experience and requisite facilities and equipment that yield the ability to deliver technical products. The work in a TC is core when the function enables the accomplishment of a WFC Division's key mission element and/or is inherently governmental, particularly in the case of value judgments affecting technological superiority; i.e., the quality and effectiveness of weapons, combat systems, and ship systems.

      The Warfare Centers have developed a robust Technical Capability Health Assessment that analyzes and assesses the over 'health' of the TC based on workload, workforce variables over the FYDP. This assessment considers whether there is sufficient workload to match the available resources; if there is an overcapacity/under capacity of workload for available resources. It has been used over the last several years for budgeting and workforce planning by senior leadership.

ii. Work Assignment and Approval Process (WAAP).
This is a web-based process that ensures Divisions accept and execute work that is appropriate for their mission. This is a comprehensive and process that defines and allocated every task given to a Division.

iii. Warfare Center Investment Board.
This is an independent board that reviews and prioritizes overhead investments to develop a corporate perspective to address those areas of greatest need.

They include:

- workforce development/technical development (includes Section 219 funding),
- infrastructure (Capital Purchase Program and MILCON).

b. External drivers:

i. Budget guidance: these include the targets directed by FMB annually for Net Operating Result (NOR) and End-strength. These impact overhead investments and hiring authorities for the Divisions. These constraints limit and constrain a Divisions ability to meet stewardship/ technical capability needs.

ii. Technical Authority. This is the principal tool used by NAVSEA and its Warfare Centers to address those areas deemed to be critical technology areas. NAVSEA currently has 220 Technical Warrants with 22 of them vacant. Warrants essentially break down into two categories: Platforms (HM&E) and Combat Systems. Typically, HM&E warrants are held by Engineers within NAVSEA headquarters and Combat systems are distributed into the Divisions.

2. Sub-panel consolidated grouping of NAVSEA Technical Capabilities.

The NAVSEA Sub-panel reviewed the Technical Capabilities assigned to NAVSEA Warfare Centers and established a rolled up list that are grouped as follows: Navy Leadership (Majority of RDT&E done in house); Navy Ownership (Navy sets requirements & funds R&D), and Navy should be an agile adaptor (R&D conducted outside):

a. Navy Leadership required:

i. Submarine and Surface Combatant Ship Design

a. Vulnerability and Survivability

b. Active and Passive Signature Management (Acoustic, Optical, Electromagnetic)
c. Submarine Propulsors
d. Naval Nuclear Propulsion

ii. Strategic Systems
  a. Strategic Systems Integration

iii. Submarine and Surface Combatant Weapons System
  a. Energetics, including Insensitive munitions
  b. Underwater Warheads (including fuzing)

iv. Undersea Warfare Systems
  a. Mines, Mine Countermeasure and Clearance Systems

v. Explosive Ordnance
  a. Disposal
  b. Countermeasures

b. Navy Ownership (set requirements & fund) required:

i. Submarine and Surface Combatant Combat Systems
  a. Electronic Warfare
  b. Electromagnetic and Electro-optic Reconnaissance Search and Track
  c. Weapons Control Systems
  d. Countermeasures

ii. Submarine and Surface Combatant Ship Design
  a. Platform Systems Integration
  b. Expeditionary Warfare Systems
  c. Hull, Machinery, Machinery Control, Propellers

iii. Strategic Systems
  a. Strategic Targeting
  b. Strategic Reentry Systems
  c. Submarine Launched Ballistic Missiles
  d. Nuclear Weapons Security and Safety

iv. Submarine and Surface Combatant Weapons System
  a. Torpedoes and Countermeasures
  b. Missiles
  c. Electric Weapons

v. Special Warfare Systems
  a. Mobility

vi. Undersea Warfare Systems
  a. Submarine and Surface Combatant Sonar Systems

b. Undersea Surveillance Systems

vii. Unmanned Surface and Undersea Systems

a. Platforms and Platform Signatures

b. Navigation

viii. Chemical, Biological, Radiological Warfare

ix. Diving and Salvage

c. Navy as an Agile Adaptor:

i. Materials for Maritime Environments

ii. Special Warfare Systems

iii. Weapons and Sensors

iv. Unmanned Surface and Undersea Systems

a. Autonomy

b. Power Sources

Below is a listing of the more detailed NAVSEA Warfare Center Technical Capabilities with the latest self assessment of the health of these Technical Capabilities and the Knowledge Areas that support the Technical Capabilities.

133 WFC Technical Capabilities

Carderock
CD01 Ship & Submarine Design & Integration
CD02 Ship & Submarine Acquisition Engineering
CD03 Ship & Submarine Sys Concepts, Techs & Processes
CD04 Surf & Undersea Vehicle Machinery Sys Integration (Phil)
CD05 Combatant Craft & Marine Corps Vehicles
CD06 Unmanned Vehicles Naval Architecture & Marine Engineering
CD07 Hull Forms & Fluid Dynamics
CD08 Propulsors
CD09 Surf & Undersea Vehicle Mechanical Power & Propulsion Sys (Phil)
CD10 Surf & Undersea Vehicle Electrical Power & Propulsion Sys (Phil)
CD11 Surf & Undersea Vehicle Auxiliary Machinery Sys (Phil)
CD12 Surf & Undersea Vehicle Hull, Deck, & Habitability Machinery Sys (Phil)
CD13 Surf & Undersea Vehicle Mach Auto, Controls, Sensors & Network Sys (Phil)
CD14 Surf, Undersea, & Weapon Vehicle Materials
CD15 Surf & Undersea Vehicle Structures
CD16 Alternative Energy & Power Sources R&D
CD17 Liquid Waste Management, Science & Sys
CD18 Solid Waste, Hazardous Material, & Radiation Tech Mgt, Science & Sys
CD19 Advanced Logistics Concepts & HM&E Life Cycle Logistics Support
CD20 Surf, Undersea & USMC Vehicle Vulnerability Reduction & Protection
CD21 Ship Recoverability & Damage Control
CD22 Surf & Undersea Vehicle Underwater Signatures, Silencing Sys & Suscept
CD23 Surf & Undersea Veh Non-Acous Topside Signas, Silencing Sys & Suscept
CD24 HM&E for Undersea Vehicle Sail Sys & Deployed Sys

NAVSEA Warfare Centers
10 Divisions
12 Sites
133 Technical Capabilities

Dam Neck
DD27 Tactical Common Data Comms Sys Integr'n & I/O
DD35 Integrated Surf Combat Control Sys Support
DD36 Integrated Training Sys
DD37 Radar Distribution Sys
DD38 Joint C&C Sys Integr'n & Arch Dev

Corona
AC01 Warfare Sys Performance & Readiness Assess
AC02 Quality & Mission Assurance Assessment
AC03 Metrology, Test, & Monitoring Sys Assessment
AC04 Force Training Assessment
AC05 Weapons Sys Interface Assess

Dahlgren
DD01 Force & Surf Platform Level Warfare Sys Analysis & Modeling
DD02 Weapon Sys Analysis, Effects, & Effectiveness
DD03 Radar & Electro-Optic Sys RDT&E
DD04 Surf Warfare Sys Engineering & Integration RDT&E
DD05 Surf Combat Sys Engineering & Integration RDT&E
DD06 Surf Combat Control Sys S&T, RDT&E
DD07 Surf Conventional Weapon Control Sys RDT&E
DD08 Surf Warfare System & Force Level Certification/IV&V
DD09 Human Sys Integration Science & Engineering
DD10 Missile Sys Integration
DD11 Surf Conventional & Electromagnetic Gun Sys RDT&E
DD12 Directed Energy Sys RDT&E
DD13 Weaponization of Surf & Air Unmanned Sys
DD14 Marine Corps & Other Weaponry Sys RDT&E
DD15 Strategic Mission Planning, Targeting, & Fire Control Sys
DD16 Re-Entry Sys
DD17 Surf Electronic Warfare Sys Architecture & CS Integration RDT&E
DD18 Surf Warfare Sys Safety
DD19 Surf Warfare Electromagnetic Environmental Effects
DD20 Chemical, Biological, & Radiological Warfare Defense Sys RDT&E
DD21 National Response Missions Incl Homeland Security & Defense
DD22 Physical & Non-Physical Vulnerability Analysis
DD23 Force Level Warfare Sys Eng & Integration
DD24 Force Level Warfare Sys I/O Engineering

Newport
NP01 Submarine Exterior Communication Systems
NP02 USW Communication Antenna Systems
NP03 USW Combat Systems
NP04 USW Trainer Systems
NP05 USW Sensor & Sonar Systems
NP06 Submarine Periscopes & USW Imaging Systems
NP07 USW EW, SIGINT, IO Sensors & Sys Integration
NP08 Undersea Surveillance Sys
NP09 USW Launcher Sys & Payload Integration
NP10 Submarine Tactical Missile Integration
NP11 USW Autonomous Vehicles
NP12 Torpedo & Sonar Defensive & CM Systems
NP13 Torpedo Sys
NP14 Undersea Warfare (USW) Analysis
NP15 USW Env Assessment Effects Analysis
NP16 Undersea Range Technology & Application
NP17 Atlantic Range Management
NP18 USW Test & Training Operations
NP19 USW Sys Test & Evaluation
NP20 USW Distributed Netted Sys

Keyport
KP01 Pacific USW T&E Range & Test Facility Operations
KP02 Independent USW Sys T&E & Experimentation
KP03 USW Weapons & Vehicles Range & Env Test Sys
KP04 Torpedo & UUV Maintenance & Repair
KP05 Obsolescence Manage for Undersea Warfare Sys
KP06 Undersea Warfare Sys Material Depot
KP07 Torpedo & Unmanned Undersea Vehicles ISE & ILS
KP08 Submarine USW Sys ISE & ILS
KP09 Carrier USW Sys
KP10 Fleet Training & Training Mgt Sys

Panama City
PC20 Chemical & Biological Warfare Individual Protection System
PC21 Expeditionary Coastal & Maritime Security System Engineering & Integration
PC25 Air Cushion Vehicle Sys
PC26 Expeditionary Maneuver Warfare Sys Eng & Integration
PC27 Special Warfare Maritime Mobility Mission Sys & Mission Support Equipment
PC28 MCM Detect & Engage Sys, Modular Mission Packaging & Platform Integration & Handle
PC29 Littoral Mission Sys Integration & Modular Mission Packages Certification
PC30 Unmanned System Eng & Int'n, Autonomous Operations, Joint I/O & Common Control
PC31 Mine Sensor & Target Detection Tech, Mine Delivery Platform Integrate & Minefield Arch
PC33 Diving & Diving Support Sys
PC34 Surface Life Support Sys for Extreme Environments

Port Hueneme
PH01 Strike Force Interop & Theater Warfare Systems ISE, T&E, & ILS
PH02 Surface Combat Systems ISE, T&E, & ILS
PH03 Surface Weapon Systems ISE, T&E, & ILS
PH04 Underway Replenishment Systems ISE, RDT&E, & ILS
PH05 Surface Gun Systems ISE, T&E, & ILS
PH06 Surface Missile Systems ISE, T&E, & ILS
PH07 Surface Missile Launcher Systems ISE, T&E, & ILS
PH08 Radar Systems ISE, T&E, & ILS
PH09 Directed Energy Systems ISE, T&E, & ILS

Crane
CR01 Strategic Systems Hardware Engineering, AE, & Sustainment
CR02 Conventional Ammunition Engineering & Sustainment
CR03 SPECOPs Hardware ISE, Procurement & Sustainment
CR04 EW Sys RDT&E/Acquisition/Sustainment
CR05 Radar Component Sustainment
CR06 Energy & Power Source AE, ISE, T&E & Sustainment
CR07 Acoustic Sensors AE, ISE & Sustainment
CR08 Microwave Technologies RDT&E, AE & Sustainment
CR09 Microelectronic Technology RDT&E, AE, & Sustainment
CR10 Infrared CMs & Pyrotechnic RDT&E & Sustainment
CR11 Defense Security Sys AE, ISE & Sustainment
CR12 Navy Electronics Depot
CR13 Electro-Optic, AE, ISE & Sustainment
CR14 Obsolescence Management

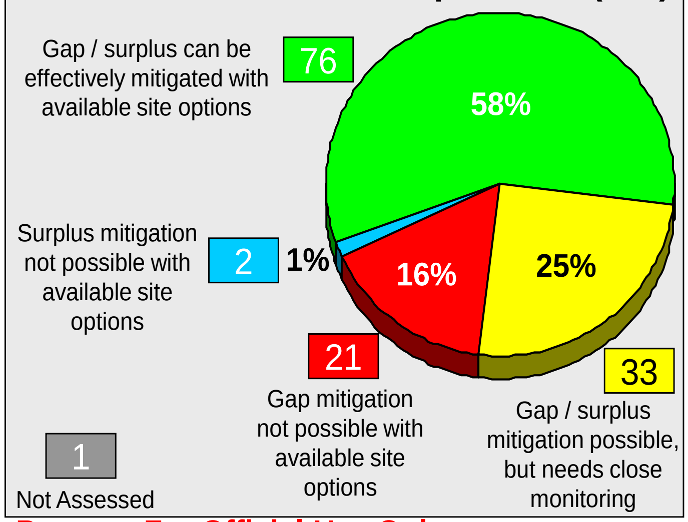
Indian Head
IH01 Energetic Sys RDT&E, AE, ISE & Sustainance
IH02 Energetic Sys & Material Scale-up, Manufacture & Manufacturing Tech
IH03 CADs, Cutters, Sounding & Specialty Devices RDT&E, AE, ISE, Sustainance, & Mfg
IH04 Weapon Simulators, Trainers, Training, Test & Diagnostic Equipment RDT&E, AE, ISE, & Sustain
IH05 Energetic Safety, Environmental Technology, Logistics, & PHST RDT&E, AE, ISE & Sustain

EOD
ED01 C-IED Technology
ED02 C-IED Information
ED03 EOD Technology
ED04 EOD Information
ED05 Crew Tech
ED06 Crew Info

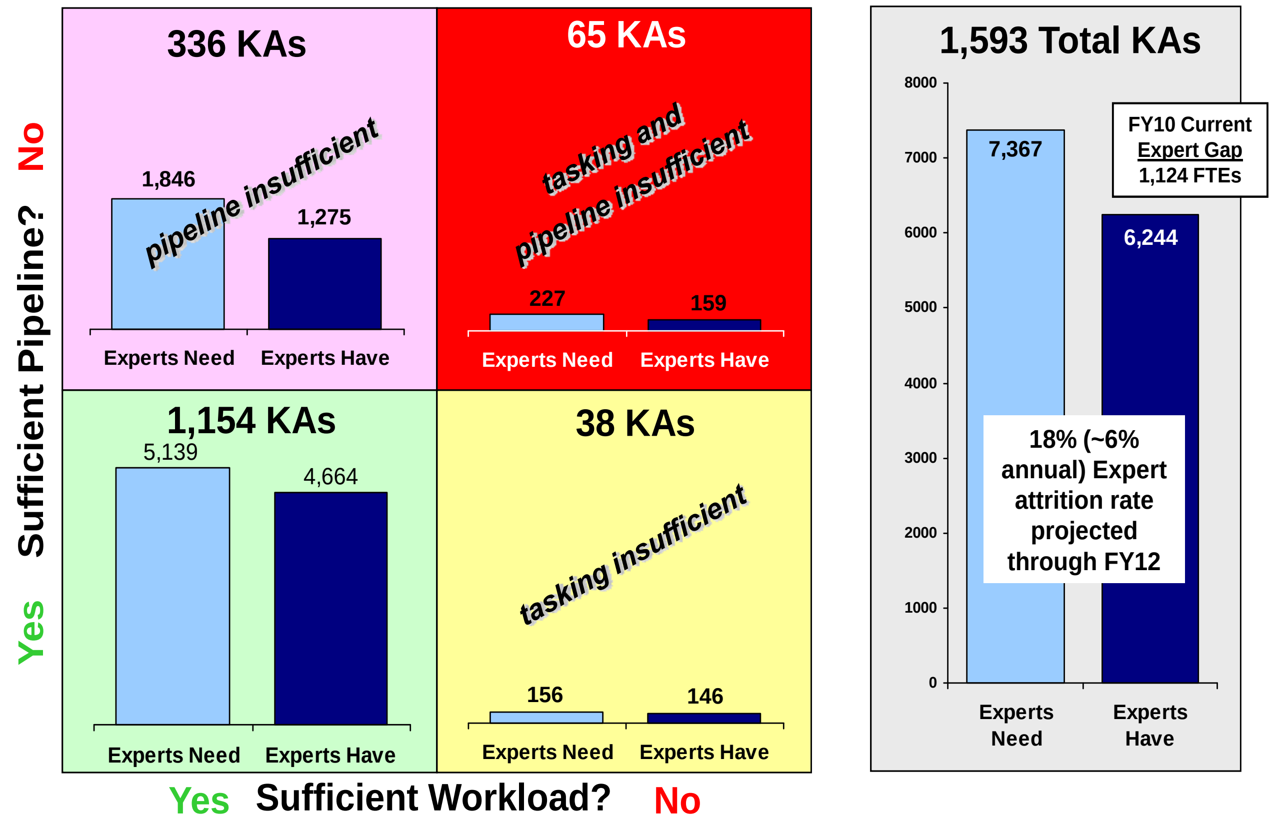
Sites Technical Capabilities

DD	DD 01	DD 02	DD 03	DD 04	DD 05	DD 06	DD 07	DD 08	DD 09	DD 10	DD 11	DD 12	DD 13	DD 14	DD 15	DD 16	DD 17	DD 18	DD 19	DD 20	DD 21	DD 22	DD 23	DD 24
CD	CD 01	CD 02	CD 03	CD 04	CD 05	CD 06	CD 07	CD 08	CD 09	CD 10	CD 11	CD 12	CD 13	CD 14	CD 15	CD 16	CD 17	CD 18	CD 19	CD 20	CD 21	CD 22	CD 23	CD 24
NPT	NP 01	NP 02	NP 03	NP 04	NP 05	NP 06	NP 07	NP 08	NP 09	NP 10	NP 11	NP 12	NP 13	NP 14	NP 15	NP 16	NP 17	NP 18	NP 19	NP 20				
CR	CR 01	CR 02	CR 03	CR 04	CR 05	CR 06	CR 07	CR 08	CR 09	CR 10	CR 11	CR 12	CR 13	CR 14										
PC	PC 20	PC 21	PC 25	PC 26	PC 27	PC 28	PC 29	PC 30	PC 31	PC 33	PC 34													
KPT	KP 01	KP 02	KP 03	KP 04	KP 05	KP 06	KP 07	KP 08	KP 09	KP 10														
PH	PH 01	PH 02	PH 03	PH 04	PH 05	PH 06	PH 07	PH 08	PH 09															
EOD	ED 01	ED 02	ED 03	ED 04	ED 05	ED 06																		
DN	DD 27	DD 35	DD 36	DD 37	DD 38																			
AC	AC 01	AC 02	AC 03	AC 04	AC 05																			
IH	IH 01	IH 02	IH 03	IH 04	IH 05																			

WFCs Total Technical Capabilities (133)



Knowledge Stewardship - All Divisions



KS Evaluation – Looking Forward to Ensure Technical Health

NAVSEA Warfare Center Personnel demographics (as of 4/20/2010):

FY10	Total	S&E	Techs	Other	PHDs	Masters	SES	ST	SL	SSTM	On site Ktrs*	Fleet	SYSCOM	OPNAV
NSWC HQ	16	6	0	10	0	5								
CARDEROCK	3,372	2,209	437	726	158	626	1	6	0	1	767	0	16	0
CORONA	993	710	88	195	5	151	1	0	0	0	310	0	0	0
CRANE	2,764	1,137	667	960	40	332	1	0	0	0	1452	0	1	2
DAHLGREN	3,436	2,469	252	715	105	674	1	3	1*	2	963	0	1	3
EOD STUMP NECK	322	87	15	220	4	31	0	0	0	0	131	0	0	0
INDIAN HEAD	1,333	641	179	513	52	159	1	2	0	1*	103	0	0	0
PANAMA CITY	1,228	853	87	288	52	244	1	1	0	1	322	1	8	1
PORT HUENEME	1,941	973	347	621	6	198	1	0	0	0	415	0	0	0
NUWC HQ	25	17	0	8	2	11	2	0	1	0				
KEYPORT	1,538	498	302	738	7	212	1	0	0	0	582	15	16	2
NEWPORT	2,719	2,025	182	512	127	657	2	5*	0	3	1036	18	46	27
Total	19,671	11,619	2,556	5,496	558	3,295	12	12	1	8	6081	34	88	35

F. NAVSEA Warfare Center Division Summaries

NSWC Carderock Division

NSWC Carderock Division has its headquarters in West Bethesda, MD but also has a large presence in Philadelphia at the Ships Systems Engineering Station. Approximately 3347 people are engaged at Carderock Division’s 9 sites conducting full-spectrum research and development, test and evaluation, engineering, and Fleet support for the Navy's ships, submarine, military watercraft, and unmanned vehicles. Carderock Division core competencies include: Ship Design & Integration; Environmental Quality Systems; Hull Forms & Propulsors; Structures and Materials; Signatures, Silencing Systems, and Susceptibility; Machinery Systems; and Vulnerability and Survivability Systems. The Division's expertise spans more than 40 disciplines, from electrical and mechanical engineering to computer engineering and physics.

The mission and workload of the Carderock Division requires extensive facilities. Work is performed across the life cycle of naval vehicles and includes the full breadth of technologies associated with surface ships; submarines; boats and craft; unmanned vehicles, ranging from small models in laboratories to large models; and operational ships in the ocean environment.

Many of the facilities needed to support the Division's mission are unique in the Navy, in the nation or in the world. Since workload is variable for individual facilities from year-to-year and because many of the facilities have little or no commercial application, there is little economic incentive for industry to develop or maintain similar capabilities.

Although analytical models and analysis techniques have been developed and are being continually refined, facilities are still needed to validate the models/techniques and to ensure that new ships meet performance specifications on delivery and operational units continue to perform as designed before going in harm's way. Consequently, the Carderock Division is one of the Navy's most facility-intensive research and engineering activities.

NSWC Carderock Division West Bethesda Technical Capabilities Health Summary:

- Demand Increases in following Programs results in Supply shortfall across multiple TCs (Carderock TCs are Technology based, not Program based)
  - Ohio Replacement Program
  - VIRGINIA Block’s III and IV
  - Joint Multi Mission Submersible
  - In-service OPALTS/TEMPALTS
  - Moored Training Ship, Conversion
  - Marine Corps Support
  - Special Operations Support
  - DDG-1000
- Demand Fluctuations: funded work is not always available to maintain expertise in all knowledge areas
- Continuing to perform overtime at a higher rate than desired (TC average of 9%, max of 16%)
- Personnel related comments:
  - Aging Workforce: Expertise is concentrated in those approaching or beyond retirement eligibility. Age Demographics of concern.
  - Hiring Authority not always directly tied to need
  - Increasing End Strength by 138 (61 from in-sourcing) in FY10
  - Current Expert Gap concentrated in areas of Information Technology and Financial
  - A portion of the end strength increase we received in FY09/FY10 is being used to address Business Capability Knowledge Areas
  - Overhead funding cost cap constrains ability to refresh workforce

NSWC Carderock Division West Bethesda Technical Capabilities Health Summary:

- Projects are not direct Fleet Support and stack up poorly when aggregated at Navy level

- Time from development of requirement to funding is typically greater than 5 years.
- Requirements often change by the time a project is funded.
- MILCON Program itself is underfunded.
- Current thresholds restrict flexibility
- Most Significant West Bethesda facility issues:
    - Bayview Pier
    - Structural Damage to 125

NSWC Carderock Division Philadelphia:

- Particular disciplines, functions or technical areas that NAVSSES feels they are recognized, or should be recognized, internationally among the "best" for R&D are as follows:
    - Submarine Life Support
    - Naval Applications of Superconductivity
    - Turbomachinery (fans)
    - Submarine Machinery Silencing
    - Shipboard Electrical Distribution Systems
    - Full Scale, Full Power Machinery Systems Testing
    - Particular disciplines, functions or technical areas that NAVSSES feels they are recognized nationally among the "best" for R&D are:
    - Electromechanical Modeling and Simulation
    - Submarine Electric Actuation
    - Marine Engineering Systems Integration and Modeling and Simulation

- The following gaps exist in facilities and personnel:

    - Turbomachinery (fans) - NSWCCD capability is based on a single world-class expert. No sponsor support or advocacy from 1995-2008 to reconstitute facilities and design tools. Current research opportunities only support limited growth.
    - Solid State Power Electronics - NSWCCD capability is based limited world class and national level expertise. Technical expertise since 1995 has been tasked in a program management or technical advisory role with no hands-on S&T/R&D funding to grow the next generation of in-house expertise.
    - Shafting and bearings - There has been virtually no research funding

or sponsorship interest in these areas since 1999. Virtually all of the NSWCCD technical R&D expertise has retired or transitioned to other areas. No maintenance of facilities or design tools has taken place since 1999. Recent technical issues show that this is an area that still requires Navy expertise.

- Mission shortcoming for shipboard machinery systems:

  Many problems on ships today are attributable to the lack of proper training of ships force. While NSWC Carderock Division Philadelphia often provides training as part of their In-service responsibilities while visiting a ship, it's not part of the Warfare Center's mission, and therefore has very limited funding support. It is recommended that machinery system maintenance & operation training be made a specific mission of NSWC Carderock Division Philadelphia.

NSWC Carderock Division Warrant Holders:

- Systems Engineering – Technical Authority (SETA) funding approach for reimbursable Warrants and warranted engineering services has been reduced for several years (2 years ago reimbursable warrants moved to Overhead
- 66 Warrants Supported by NSWC Carderock
- 6 Warrant Holders at NSWC Carderock
  - Surface Ship Arrangements
  - Ship Design Manager Egyptian FMC
  - Product Data Integration Exchange
  - Ship Design Manager Boats & Craft
  - Fasteners
  - Submarine HM&E Sail Systems
- 131 Engineering Managers from Carderock
- 667 Lead Engineers from Carderock

NSWC Crane Division

NSWC Crane is located on approximately 64,000 areas in Southwest Indiana. Approximately 2765 people are engaged at this site in acquisition engineering, in-service engineering and technical support for sensors, electronics, electronic warfare and special warfare weapons. They apply component and system level product and industrial engineering to surface sensors, strategic systems, special warfare devices and electronic warfare/information operations systems, and execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

The technical capabilities supporting NSWC Crane focus areas are:

- Strategic Systems Hardware
- Special Operations Hardware
- Electronic Warfare Systems
- Radar Components
- Energy & Power Sources
- Microwave Technologies
- Microelectronic Technologies
- Infrared Countermeasures & Pyrotechnics
- Defense Security Systems
- Electro-Optic Systems
- Obsolescence Management
- Conventional Ammunition
- Acoustic Sensors
- Navy Electronics Depot

Assigned NAVSEA Technical Warrants

- Electro-Optics (EO) & Infrared (IR) Sensing Systems (except submarines)
- Anti-Tamper Implementation
- Electronic Warfare and SIGNIT Programs (including Ground EW and Intelligence Collection Equipment)
- Small Arms and Weapons
- Shipboard Anti-Terrorism and Force Protection

DOD Executive Agent

- Microwave Power Tube Industry
- Printed Circuit Board Technology

Multiservice, Joint, and National Work

- 65.5% Navy
- 11.5% Marine Corps
- 8.0% Air Force
- 7.1% Army

- 6.4% DOD
- 1.2% OGA
- 0.2% Private Party

Crane has a very extensive and mature planning framework. Their input includes Quad charts and business data that feed the Crane Business Model (based on the GE/McKinsey Matrix**).** Results of the Crane Business Model permit ranking of projects by Market Attractiveness and Business Unit Strength. They have a planning cycle that details the strategic planning, business planning and resource planning activities that must be completed on a specific timeline. The outputs of these activities are reviewed quarterly to ensure the process is adhered to. Most notably, there are metrics embedded and monitored in each of the activities.

Business Health Projection (areas requiring attention based on trends beyond FY12)

- Missile Defense Agency SSBN(x)
- SOF & USMC End Strengths
- Anti-Access Denial
- Maritime Domain Awareness
- Rotary Wing/Unmanned Vehicle Sensors

Crane has a very comprehensive, mature and well documented TC Health Assessment process. Underpinning the TC HA is their very detailed knowledge stewardship assessment. They have used this to effectively predict and implement mitigating strategies to ensure that manager consistently perform an analysis of their respective knowledge areas. Of the 164 knowledge areas, they identified 56 knowledge gaps.

Facility Footprint (by age)

- 60+ years old   171 buildings
- 41-60 years old 16 buildings
- 21-40 years old 34 buildings
- 20 years & less   57 buildings

Major Facilities

- Special Missions Weapons Center
- Joint Electro-Optics Center
- Special Missions Center
- Electronic Warfare Center
- Strategic Radar & Sensor Complex

- Strategic Missions Center

Areas exclusively engaged in by Crane

- Infrared Countermeasures Research and Development
- Anti-Tamper Technical Assessments
- Radiation Hardening of Electronics
- Special Forces Weapons and Munitions Development
- Special Forces Electro-optics sensor integration and development
- Microwave Tube Testing
- Microwave Tube Acquisition

Probably the biggest take-away from the Crane visit was the evidence of the impact of the engagement of the Technical Warrant Holders. Below are examples of when TWHs were engaged early in the process and examples of when they were not.

Early involvement:

Early in the DDG 1000 program, the Navy Technical Team and NAVSEA TWH for Electro-Optic and Infrared (EO/IR) Sensing Systems (except submarines) recognized an issue with the lack of available EO/IR window material for the Component Electro-Optic Laser Rangefinder System (CELS). Due to demanding DDG 1000 requirements for imaging performance, low radar cross-section, and other stringent environmental specifications, the window material needed to be multi-spectral in optical transmission, conformal to the deckhouse structure, large in size, and very hard in fracture toughness, etc. No EO/IR window material was (or is to this day) production ready to meet these requirements. Through early engagement, the EO/IR TWH was able to help raise the visibility of the issue and initiate identification of ONR Manufacturing Technology (ManTech) R&D funding to address the problem (i.e., risk reduction). A ManTech project is currently underway to build the prototype window using advanced materials and production processes.

Late involvement:

Small Arms ISEA was notified that Ships were replacing standard Navy mounts with non standard mounts and non-approved ballistic shields. Both the Small Arms and the AT/FP TWH's raised the issue to the SEA 00 level which worked with Fleet Forces to have the non-standard mounts and shields removed and replaced with approved mounts and shields. The TWH's worked to have existing degraded shields tested and determine that some ships were incorrectly installing the shields resulting in the shield not offering proper protection and actually becoming a hazard. The AT/FP TWH worked with SURFOR to generate a message informing the ships on how to determine the proper installation of the shields and aided in formation of a SURFOR ballistic shield requirement. The AT/FP TWH worked with USFF to document Fleet requirements for Ballistic Shields that were adopted and approved by OPNAV N8. AT/FP is currently being funded by SEA05C to develop two ballistic shield Mil STDs to assist Program Office in Ballistic Shield acquisition.

Of particular note, Crane has implemented a Naval EW Technology Integration Center (NEWTIC) and a Critical Technology Innovation Center (CTIC). These are based on a Science and Technology team who actively employ a threat based capability pull, engage a larger, “outside the gate” EW community of interest. Additionally, on a parallel activity there is a critical technologies community of interest. Both of these initiatives were developed at Crane.

Additionally, Crane has implemented an extensive and broadly recognized Electro-Optic (EO) Technology Roadmap that incorporates an extensively broad national and international technical community (industry, military, academic). They have created an active collaboration community and employs scanning tools and techniques to ensure there is a comprehensive awareness of the state of the technology environment.

NSWC DAHLGREN

NSWC Dahlgren is located on roughly 4000 acres near Fredericksburg, Va. There are approximately 3000 employees on the base, which is home to a number of additional Commands. NSWC, Dahlgren’s mission is to perform research, development, test and evaluation, analysis, systems engineering, integration and certification of complex naval warfare systems related to surface warfare, strategic systems, and combat and weapons systems associated with surface warfare.

The NAVSEA Sub-panel visit to Dahlgren demonstrated that they are using their available innovation funds to explore several areas that will likely be important to the Navy in the future. They have significant exploratory efforts in rail guns and laser weapons. In both cases Dahlgren is supplying limited internal funds for infrastructure, and leveraging limited Navy program funds with other external funding to develop a capability in these advanced areas. Dahlgren did express concern at the limited amount of discretionary funds that they had available to pursue these and other innovation areas. Currently most NSWC Dahlgren S&T funding is customer-directed. The ability to establish a mix of directed and internal discretionary funding would be more appropriate. Such a mix would allow the lab to be more responsive to fleet needs, encourage innovation, and increase the rate of technology transition to the fleet. And section 219 funds had still not arrived, nor did they expect these 219 funds to be substantial when they arrived.

Dahlgren was asked to identify technical capabilities that it is expected to have in the future, but is currently (or projected in the next 5 years) to have a gap (people or facilities). It identified the following areas where gaps exist or may appear:

- Mission analysis, cost analysis, operations engineering
- Combat system engineering
- Command and control system engineering
- Test and evaluation
- Combat system certification
- Surface Radars. The NSWCDD engineering team has historically represented a critical piece of Naval radar systems. However, the majority of current tasking has migrated to top-level systems engineering, requirements analysis, and acquisition. Additional infrastructure will be required for prototyping and testing.
- Software engineering. Acquisition strategies for software-intensive systems have reduced the workload and the ability to maintain critical workforce skills in being the "smart government buyer" of software.
- Safety, Legal and Operational Issues for Future Weapon Systems (Directed Energy Weapons and Autonomous Systems)

NSWC INDIAN HEAD

NSWC Indian Head occupies 3500 acres on a peninsula in Indian Head Md. Approximately 1500 people are engaged at this site in research, development; scale up, test and evaluation and in-service support of energetics and energetic materials for warheads, propulsion systems, ordnance and pyrotechnic devices and fusing for Navy, Joint Forces, and the Nation. NSWC IH is heavily facilitized with all of the buildings, machines, and equipment to mix, scale up and test all types of explosives as well as produce a number of warheads. Additional NSWC IH sites on the East Coast provide additional energetics and energetic packaging expertise.

NSWC IH staff represents the Navy's corporate knowledge in underwater explosives and u/w warheads. NSWC IH is responsible for producing all of the cartridge actuated devices (CADs) and propellant actuated devices (PADs) that propel the escape systems in many military planes. NSWC IH produces and tests a wide variety of explosives, devices, and warheads.

Because Indian Head is heavily facilitized, it must continually invest significant funds in maintaining and upgrading its facilities. And it must charge all of its customers to recover these funds. With a limited set of customers with critical needs, Indian Head must avoid a downward spiral, whereby its high rates drive customers away, resulting in even higher rates for those remaining customers. This issue has been partially addressed by additional Congressional funds for facilities that help modernize Indian Head's capabilities. But the regional approach for maintenance and repair does not recognize or respond to Indian Heads significant and highly technical maintenance requirements.

In addition, Indian Head requires specialized hiring for their explosives production and test facilities, including technicians. The regional HR system now in place handles these requests as routine requests, not recognizing or understanding the special skills these people must have in this dangerous, complex environment. Indian Head therefore has significant difficulty getting the HR system to efficiently and effectively identify and hire the right people to meet their needs. Finally while the Director has substantial technical experience and expertise in combat systems, he has limited expertise in energetics. Thus it is difficult for him to evaluate and shape the technical efforts of his employees.

NSWC Panama City

NSWC Panama City is a Navy laboratory with roughly 2000 people located on the western coast of Florida. Its mission primarily centers around conducting RDT&E in mine warfare systems, mines, naval special warfare systems, diving and life support systems, amphibious/expeditionary maneuver warfare systems, other missions that occur primarily in coastal (littoral) regions.

NSWC PC is a vibrant laboratory with significant hands on work in most of its primary mission areas. One noticeable exception is mines, where the lack of any mine development program makes the preservation of the Navy's corporate knowledge in mine development a difficult prospect. Senior laboratory management is attempting to preserve that knowledge by having these people work in related areas, such as UUVs. But that strategy can only work for so long. This could eventually hamper their ability to contribute in the anti-mine warfare.

At NSWC PC relatively unique work on diving and life support systems is conducted. They have also made significant contributions to beefing up ground vehicles that move ahead of convoys in IRAQ, Afghanistan, etc to protect the convoys from IEDs. Much of the RDT& E on LCACs is conducted there. Panama City is relatively tightly focused on its mission areas.

NSWC PC is heavily involved in the development of mission packages that are integrated into unmanned systems, particularly for littoral warfare mission areas.

The CO at Panama City is an ED who is very conversant with the ongoing technical work and is clearly providing added value to the laboratory, both in oversight of the technical programs and managing the site. The CO and Director both expressed concern about the limited amount of funding available for innovation at Panama City. Pressures on overhead had reduced the funds available from that source. At the same time 219 funding had not come in and was not expected at the maximum possible amount if and when it came in. So they felt very constrained in their ability to fund their staff to explore innovative ideas and create a more innovative environment going forward.

Panama City management also described how severe pressure on overhead had required them to evaluate how the time that supervisory personnel spent was allocated between direct and overhead accounts. The end result was higher charges to direct programs and a savings in overhead that may be more apparent than real.

Panama City is very concerned about obtaining access to National LambdaRail, an ultra high-band performance network/test bed for advanced research at over 280 universities and private and U.S. government laboratories and advanced programs across the country. Navy security issues may be an obstacle that prevents NSWC PC and other Navy laboratories from obtaining access to this resource and benefiting from the research of others on this network.

NUWC Newport Division

Naval Undersea Warfare Center is a Navy activity located in Newport RI, with roughly 2700 personnel, 78% of whom are engineers and scientists. Its mission centers around research, development, test and evaluation, engineering, analysis and assessment, and fleet support capabilities for submarines, autonomous underwater systems, and offensive and defensive undersea weapon systems, and stewardship of existing and emerging technologies in support of undersea warfare.

Observation: Newport has 31 active duty military personnel assigned. There are five SES positions associated with NUWC: one at NUWC HQ, two Division Technical Directors (Newport and Keyport Divisions). There are also two NUWC" surrogate" NAVSEA billets - employees who travel back and forth from NAVSEA. The number of SES billets at NUWC has declined from 12 to 3. NUWC has 3 SSTMs.

Finding: The systemic reduction in senior level positions over time has caused detrimental effects:

- Career ladder upward mobility incentives are constrained by the few senior billets (steep pyramid)
- Insufficient senior representation constrains the effectiveness of NUWC representation within high level "circle" in DON (access).

Observation: NUWC's acquisition role for highly complex computer software-based systems has shifted from prime developer and integrator having ultimate insight into the how the system works, to monitor and certifier where the job is much more directed at oversight. More and more, Warfare Centers have seen their tasking in software development/software engineering moved to industry.

Finding: The replenishment and recapitalization of their talent pool in this competency is fast eroding along with ability to apply domain expertise to critically important software-based technology in both acquisition support (smart buyer) and life cycle support of legacy systems.

Observation: A highly successful acquisition was achieved by NUWC for the submarine common radio room. PEO Submarine asked NUWC as a Technical Design Agent (TDA), and In-Service Engineering Agent (ISEA) with specific responsibilities for:

- RDTE
- Engineering Model development
- Specification development
- Facilities and Systems Integration
- Test and certification (including land-based equipment test facilities)
- Installation management
- In-service support

NUWC also noted that a companion benefit of such “up front” tasking was a return on investment to NUWC technical capabilities by:

- Directly providing the "hands-on" work essential to developing and sustaining TDA/ISEA competency for the life cycle of the system
- Maintaining a core competency in Government in key technical areas
- Facilitating the role of “smart buyer” and “honest broker”.

Recent PEO tasking of NUWC for support of the submarine Photonics Mast program did not include the above “early involvement” attributes and is consequently a troubled program.

Finding: The key elements of the approach successfully demonstrated by NUWC for the submarine radio room acquisition should be considered for adoption as a model acquisition process.

Observation: NUWC has used an Innovation Cell methodology to successfully identify technologies and capabilities that provide a rapid advance in capability into the fleet.

Finding: This technique is increasingly stifled because such activity is funded from overhead which is diminishing available.

Observation: With the regionalization of facilities maintenance and construction under CNIC, NUWC has experienced difficulty in obtaining maintenance services contracted by the region and MILCON funding for RDT&E facilities improvements and new construction. The CNIC "brokering" process that prioritizes allocation of limited MILCON funding, inherently favors fleet "Quality of Life" and operational support projects over RDT&E projects within the region.

Finding: This is appears to be an unintended consequence of the DON regionalization that deserves redress to arrest the death spiral of sacrificing RDT&E facilities needs for the Navy of the future.

Observation: NUWC presented the NUWC-specific results of the NAVSEA Warfare Center common methodology for assessing the health of assigned technical competencies. The methodology assesses both competency and required manpower skills for assigned technical competencies. The methodology results of these periodic assessments are being used by each WF Center to build detailed hiring plans and to shape training plans to adapt workforce knowledge areas and skills to meet projected workload. The NUWC-specific assessment shows numerous competencies and skills areas where current workforce is fragile, lacking adequate depth in both capacity and competency/skill. Numerous factors, such as continual downsizing (through imposed manpower ceiling constraints not tied to working capital fund flexibilities) and outsourcing of acquisition support technical capabilities away from Warfare Centers to industry and private contractors, have conspired to create this death spiral situation over the last 15 years.

Finding: There are numerous factors which confound to impede Warfare Center ability to manage workforce skills and competencies so as to achieve and sustain requisite state of the art knowledge and skills in their respective assigned Technical Capabilities. Examples include:

- Diminished 6.1 and 6.2 funding and elimination of discretionary R&D funding (cessation of "Block Funding")
- Complex hiring authority policies. elimination of local hiring authority and unresponsive HR support (HR regionalization)
- imposed manpower ceiling constraints not tied to working capital flexibilities
- Diminished and noncompetitive pay incentives for career progression
- Constrained R&D facilities modernization and dilapidated working conditions
- Diminished awareness of WF Center capabilities and contribution potential due in part to diminution of SES billets and to inexperience of uniformed Navy leadership with WF Centers.
- Numerous, uncoordinated and conflicting policy guidance from multiple competing higher level authorities (DDR&E, PDASN,NAVSEA, ASNRD&A)
- WF Center management overload with numerous nonaligned Corporate Initiatives (e.g. Diversity, Lean, TOC)

Note: The NAVSEA Sub-panel did not visit or assess the following NAVSEA Warfare Center Divisions (time & resource constrained). For completeness, a short summary of their technical capabilities is provided below:

NSWC Corona Division: Joint Warfare Assessment Laboratory and Center, Measurement and Science Technology Laboratory, Navy Gauge and Standards Laboratory.

NSWC Explosive Ordnance Disposal Tech Division: Foreign Ordnance Electronics Exploitation Laboratory, Magnetic Signature Test Facility, Ordnance Disassembly Complex, Radiography and Photography Laboratories, Chemical Laboratory (Explosives), Explosive Test Ranges, Hypervelocity Test Facility, Oxygen Cleaning Laboratory, Model Shop, EOD Diver Complex

NSWC Port Hueneme Division: Engineering Development Lab, Littoral Combat Ship Mission Package Support Facility, Surface Warfare Engineering Facility, Test Ship, Underway Replenishment Test Site, VLS Launcher Lab, Desert Ship (White Sands), Mk 45 Magazine (Louisville), Radar Lab (Virginia Beach)

NUWC Keyport Division: Pacific Northwest Undersea Range Complex, San Clemente Island Underwater Range (SCIUR), Hawaiian Island Underwater Range (HIUR), Shipboard Electronic Systems Evaluation Facilities, Magnetic Silencing Facilities, Fleet Operational Readiness Accuracy Check Sites, Collaborative Test & Evaluation Capability Center, Torpedo & UUV Maintenance Depot/Intermediate Maintenance Activity (IMA), Undersea Warfare Mines Depot, Rapid Prototyping & Repair Technology Development Facilities, Customer Engineered Solutions/Obsolescence Resolution Facilities, Integrated Warfare Systems Lab & Integration Facility, Strike System Hardware Support Facility, Submarine Countermeasures Lab, Fleet Training & Interactive Media Development Lab, Aviation Maintenance Training Continuum System Software Module (ASM) Lab, FMS Weapons Training Facility (Bangor).

APPENDIX F

NAVAIR Warfare Centers

NAVAIR Summary

- NAVAIR and the NAWC are seamless
  - All warfare center personnel are organizationally integrated into the systems command
  - PMA technical staffing demand is met by the competencies that span across all NAWC sites
- Naval Aviation Enterprise is an effective cross-functional framework
  - CNAF, DCMCAir, N-88, NAVAIR work together to achieve cost wise readiness, establish future requirements, and develop Naval Aviation S&T objectives
- Today's technical workforce is threatened by:
  - Too few experienced technical experts across multiple competencies
  - High turn over of technical personnel assigned to programs
    - F/A-18 has had 100% turnover of personnel in the past three years
  - Insufficient discretionary funding for education, training and mentoring new hires
  - Insufficient hands-on work to build experience and maintain essential Navy technical competence

BACKGROUND

The Naval Air Systems Command (NAVAIR), working with its warfare centers, has the management authority and accountability for assigned naval aviation programs with the exception of that authority and responsibility specifically assigned to a PEO or DRPM. This includes designing, developing, procuring, and supporting naval aviation systems used by the Navy and Marine Corps. Support to the PEOs is provided by NAVAIR and the Naval Air Warfare Center in accordance with an operating agreement that is approved by the ASN (RDA). NAVAIR and the PEOs provide acquisition and life cycle support for:

- Aircraft,
- Aeronautical weapons and IT systems,
- Associated subsystems to include life support, propulsion and power, armament/ordnance, avionics, mission support, and aviation support equipment and

related systems and equipment including training, photographic and reconnaissance, airborne mine countermeasures, aircraft launching and recovery and target systems

NAVAIR, PEOs (A, T, U&W) and AIR 1.0 work as an integrated entity in support of the Naval Aviation Enterprise (NAE). The NAE is a transparent, collaborative and cross-functional framework that was created and put processes in place that optimized functions fundamental to Naval Aviation readiness. The NAE behavioral model has clarified accountability for and works to achieve Navy and Marine Corps-wide efficient use of resources, and promotes enhanced coordination and collaboration to achieve mission effectiveness, and streamlines decision-making.

NAVAIR is a "competency-aligned organization" with 12 functional competencies that provide resources (people, processes, leadership, and tools) to integrated product teams (IPTs), which support the platforms and services provided by NAVAIR and the aviation PEO's. The competencies encompass NAVAIR headquarters, all divisions (NAWCAD & NAWCWD), In Service Support Centers, and Fleet Readiness Centers. All NAWC personnel are organizationally integrated into the systems command, enabling a seamless NAVAIR/NAWC organization. With the exception of contracts, legal and program office management positions, all NAVAIR and PEO program offices obtain their technical and logistic support from the respective NAVAIR engineering, T&E, and logistics competencies. If the NAVAIR competency is not able to provide the required technical or logistics support they, working with the program office, will obtain the needed support from either a UARC, FFRDC or support contractor. This construct both balances program competency demand with the supply of qualified personnel and ensures NAVAIR technical competency leadership has the responsibility for the technical expertise provided to every program.

Major/ Unique Technical Facilities

Patuxent River: 10 Hangars, 5 Runways, 780 Restricted Sq. Miles of Airspace, 5000 controlled surface to 85,000 feet, Offshore Atlantic Ranges 30,000 square miles Surface to unlimited altitude. Facilities include but not limited to, Air Combat Environment Test and Evaluation Facility (ACETEF), Atlantic Test Range, Shielded Hangar, Large and medium a/c size anechoic chambers with full electronic stimulation and simulation and reconfigurable manned flight simulator, aircraft prototype facility w/ capabilities for SAR/SAP, Propulsion Systems Evaluation Facility, horizontal accelerator, windblast facilities, ejection tower, Advanced Maritime Technology Center for adaptation of aviation systems to the maritime environment, Aircrew Survival System labs, Crew Station Technology Lab, Rotorcraft Flying test bed Platforms, Open Range Dynamic Radar Cross Section Measurement, Test Squadrons(VX-23 Strike, VX-20 Force, HX-21 Rotary Wing), US Naval Test Pilot School, Maritime Targets and Marine Operations Support, Extensive Materials Labs and Facilities, Surface/Aviation

Interoperability Lab, Ship/Shore Based Electronic Systems, Air Traffic Control and Landing Systems, Shipboard Radio Communication Systems, Fixed and Mobile Communication systems, Electromagnetic Environmental Effects Testing, Electromagnetic Pulse Facility, Facilities for Antennas and RCS Measurements, Rain Erosion Measurement Lab, Advanced Sensor System Integration Labs, Bio Fuel Testing capability, Environmental Altitude Chambers, Aircraft Test and Evaluation Facility, Steam Catapult for Evaluating Landing Gear

China Lake: Land range 1,777 sq mi; airspace 20,000 sq mi; Open-air Radar Cross Section Range; Supersonic Naval Ordnance Research Track; Joint Counter IED Test and Techniques Development Range / Facility; Land-Vehicle RF Signature Characterization Facility, Electronic Combat Ranges; Missile Engagement Arena; High Performance Computing Center; National Parachute Test Range; Integrated Battlespace Arena and Precision Engagement Center, Chemical Propulsion Laboratories, Energetics Pilot Plant, Live Fire Solid Rocket (tactical and strategic) Test Structures, Hypersonic Air-breathing Rocket Test Facilities, Warhead & Explosive Test and Evaluation Sites, Aircraft & Weapons Survivability Lab, EO/IR/RF Missile Hardware in the Loop Facilities, Airfield, Unmanned Systems operating sites, Laser / Optics Development and Evaluation Laboratory, Conventional and Diamond Turned Optics Fabrication Laboratories, Advanced Weapons Laboratories, Aircraft Weapon Systems / Mission Systems Integration Laboratories, Weapons Environmental Test Facilities, Chemical Synthesis / Analysis Laboratories, Thin-film and Coatings Laboratories, and Advanced Scanning Electronic Microscopy Facilities.

Pt Mugu: Sea range 36,000 sq mi- expandable to 125,000 sq mi; Electronic Warfare Integration and Test Laboratories; Threat / Target Systems Laboratory; Radar Reflectivity Laboratory; Aircraft Weapon Systems / Mission Systems Integration Laboratories; San Nicholas Island airfield and test site;

Lakehurst: Facilities include but not limited to prototyping and manufacturing facility- sole manufacturer of cross deck pendants and purchase cables, ALRE test and development facilities (steam and EMALS catapults), Elevated fixed platform for RAST helicopter recovery system, advanced arresting gear test sites, jet car tracks, shipboard water-cooled jet blast deflector, runway arrested landing site), support equipment and ALRE design analysis laboratory.

Orlando: Physically located in the nation's premier center for simulation and training, immediately adjacent to the campus of University of Central Florida. TSD occupies space in two UCF buildings, Partnership I and II, the USMC Program Manager Training Systems is located in Partnership II, and one of TSD's buildings is shared with the Army PEO STRI. Orlando is also home for National Center for Simulation.

INTRODUCTION:

A. Introduction

In addressing the Terms of Reference for the 2010 NRAC Study, the NRAC panel participants were assigned to sub-panels, each addressing a different major organizational segment of the technical workforce across each of the Navy's systems commands' warfare centers. The Naval Air Systems Command sub-panel addressed the technical workforce in the Naval Air Warfare Center at both Aircraft Division and Weapons Division. It should be noted that within the total technical workforce associated with NAVAIR the engineering staffs of the warfare centers (NAWC AD and NAWC WD), the eight Fleet Readiness Centers (Whidbey Island, WA; Lemoore, CA; North Island, CA; Jacksonville, FL; Cherry Point, NC; Oceana, VA; Atsugi, Japan; Solomons Island, MD), and all of the aviation PEO and NAVAIR program offices as well as the engineers assigned to NAVAIR headquarters are all integral parts of the NAVAIR competency aligned organization.

The NRAC NAVAIRSYSCOM sub-panel was chaired by VADM Bill Bowes, USN(Ret), vice chairman Mr. Gerald Schiefer, and the following sub-panel members: LGEN John Castellaw, USMC (Ret), Dr Mark Mykityshyn, Dr. David Whelan, Dr Patrick Winston and Mr. Bill Schmitt from the NAVSEA sub-panel.

The NAVAIR sub-panel visited the following NAVAIR and NAWC locations: Patuxent River, Md.; Lakehurst, NJ; Orlando, Fl; China Lake, Ca; and Pt Mugu, Ca.

FINDINGS:

SUMMARY

The technical workforce across NAVAIR and the two NAWCs has excellent capabilities, but numerous competencies have gaps with only a few experts, such as flutter, IO, anti-tamper, autonomous systems, etc. All of the reported competencies that are lacking or threatened in depth or breadth are listed below. One manifestation of many competencies having a shortage of experienced personnel is a high turnover of personnel in program offices in order to satisfy the many competing needs for similar experienced competency personnel. For example, the F/A-18 program office (PMA-265) experienced 100% turnover of personnel during the past three years, and the average turnover of personnel in all of PEO(T)'s programs was 80% during the past three years.

A significant amount of training and education of the technical workforce is ongoing across the two NAWC's. However, because of a shortage of discretionary funding, primarily as a result of the constraints placed on overhead expenses by NAVCOMPT, the needed amount of education, training and mentoring required for the many new hires cannot be provided. Added to this is a lack of meaningful "hands-on" work that is essential to building and maintaining technical competence. One must "do" to become an expert, and one cannot become experienced in a technical competency merely by overseeing work. The net result is literally a death spiral of technical competencies as more and more experienced personnel retire or leave the technical competencies to pursue program management job openings while the education, training, mentoring, and “hands-on” work needed to grow experienced replacements or to keep abreast technology growth are not available.

At NAWCWD China Lake a small program was established using overhead funds to develop a small, UAV sized, short range missile. This entire program, called Spike, from initial design to flight demonstration was conducted by new hires and less experienced personnel in order to provide “hands-on” experience in every phase of missile design, development, fabrication, assembly, and test. This innovative training effort shows the seriousness of the lack of funded “hands-on” work being sent to the NAWC. Another positive finding in meaningful “hands-on” work is the aircraft prototype work being performed at NAWCAD Pax River. The recently opened Aircraft Prototype Facility designed to enable highly classified aircraft modification work is expected to bring additional “hands-on” work. The NRAC was told that NAWCAD had a waiting list of engineers seeking assignment to this area.

Very little focus is being placed on the Navy after Next technologies because funding is not provided for this work, and the warfare centers are working capital funded. However, NAWCAD has created a Strategic Awareness Team, headed by an SES, to maintain cognizance of all of the forces and technologies that can have an impact on the future needs for NAWCAD support. In addition the NAE published the Naval Aviation Enterprise S&T Objectives document which identifies the Navy and Marine Corps Aviation needs, with near, mid and far term metrics identified. Needed research areas within core capabilities are prioritized, and required infrastructure and personnel have been defined for the recommended science and technology investments to address the capability requirements of Naval Aviation.

The amount of S&T funding to the NAVAIR has greatly diminished over the last fifteen years. In 1985 S&T funding was 3% of the command’s TOA, and today S&T funding is only 1% of the command’s TOA. However, significant research is still being done, but not at a level that provides workforce “refreshment. The NAVAIR CTO has done an excellent job in providing oversight over all S&T work being performed within NAVAIR and the two NAWC’s and providing an increased focus for S&T across NAVAIR. However, the lack of opportunity for “bench scientists” causes critical scientists and engineers to look for other avenues of advancement.

An example of how little funded S&T work exists at NAWC sites is that only one man year of BA-1 and one man year of BA-2 was funded at Lakehurst in 2009. EMALS was started ten years ago at Lakehurst from an innovative S&T project that was conceived of and totally run by Lakehurst, and an electromagnetic catapult is now a reality, enabling the removal of steam from the next generation aircraft carriers. Section 219 of the FY2009 National Defense Authorization Act (NDAA) will provide much needed relief for the shortage of discretionary funding to both fund needed education and training and also to fund meaningful “hands-on” S&T

work at the NAWC's. Despite this initial increase, availability of discretionary funding to address priority research areas remains an issue.

The NAVAIR CTO worked closely with the NAE in writing the Naval Aviation Enterprise Science & Technology Objectives document. In this document, capability gaps have been identified and objectives developed which capture Navy and Marine Corps aviation needs, with near, mid and far term metrics identified. Competency core capabilities have been identified and defined. Needed research areas within core capabilities are prioritized, and required infrastructure and personnel have been defined.

The number of military personnel assigned to the warfare centers and especially those assigned to work side-by-side with the technical workforce has decreased significantly from the past. As a result, technologists and program offices often do not have the operational experience that would help them execute their work and better understand the environment in which the systems they are working on will operate. Test pilots are now all assigned to test squadrons, and no longer work side-by-side with the scientists and engineers at NAWCWD as was the case in the past.

At every NAWC site that was visited the issue of the adverse impacts that the Navy's regionalization of human resources and public works was raised. Examples were given where both college graduates, and in particular experienced engineers and scientists, accepted jobs elsewhere because they would not wait for the three months it took to get approval to hire them. During a series of successive snow storms at Pax River, snow removal efforts were criticized simply because a follow-on storm was forecast in the next couple of days. Delaying snow clearing would have resulted in delayed flight tests adding schedule delays and cost increases to programs.

Essential Technical Capabilities/Competencies

- Aircraft structural design for catapult launch, arrested landings and other shipboard loads
- Aircraft carrier catapults and arresting gear
- Materials and design practice for highly demanding environments (corrosion, electromagnetic)
- Shipboard aviation capability design and certifications
- Automatic Carrier Landing Systems including Sea-based precision GPS systems
- Marine Corps expeditionary field equipment for aviation and airborne weapons
- Energetics, including insensitive munitions
- Warhead and rocket motor design, development and testing
- Fusing components and devices
- Shipboard visual landing aids compensated for ship pitch, roll and heave
- Testing of air and sea weapons systems

- Aviation personal protective equipment for maritime environments including underwater ejection capability, underwater seat pan oxygen breathing equipment, exposure suits, sea water activated releases, etc.
- Aircraft/ship platform interoperability
- Flight Test Engineering
- Lift, thrust and flying qualities for safe launch and recovery
- Full spectrum airborne weapons systems engineering
- Fundamental and applied research in:
  - Chemical sciences (e.g., domes, taggents, meta-materials, coatings, organic energetics, specialty polymers, nano-materials, insensitive munitions, green fuels)
  - Physical sciences (e.g., physics, optics, lasers, directed energy)
  - Computational sciences (e.g., mathematics, signal processing, image processing, automatic target recognition)
- Weapons related technology development, weapons and weapons components design and development, modeling & simulation, test & evaluation, in-service engineering
- Directed energy
- Electro-Optical, Infrared and Radio Frequency cross-section measurements, characteristics and modeling
- Threat analysis and exploitation
- Targets and Threat Systems
- Miniature munitions
- High speed propulsion
- Electronic Warfare
- Systems of Systems requirements analysis, systems development and T&E
- Air Platform and Weapons Integration
- Signal Processing and Decision Aides
- Visual engineering and simulation
- Weapons system and software integration
- Advanced weapons and guided missiles components and systems
- Interoperability of warfare systems
- Undersea operations training systems.
- Ship handling training systems.
- Shipboard aviation operations training systems.
- Expeditionary operations training systems.
- Command and Control training systems
- Fleet Synthetic Training.
- Naval Special Warfare training systems.
- Facilities to support the initiative(s) to replace fossil fuels.
- Human Performance Modeling and Assessment.

- Human, Social, Cultural, Behavioral Modeling.
- Interactive Experimentation (Distributed Live, Constructive Simulation/Training).
- Virtual Environments and Simulation.
- EMI, EMP, etc.

Technical Capabilities that are Lacking, or Threatened in Depth / Breadth

- Radar System Engineering
- EO/IR Engineering
- RF engineering
- Defensive Electronic Warfare Techniques
- Closed-loop threat simulation
- Mission Systems Software Development
- Net-centric operations
- Information/Operations (I/O)
    - Information Assurance
    - Information warfare
- Future Computer Science Technology
    - Automation of Target Acquisition Functions
    - Vehicle Autonomy
    - Artificial Intelligence
    - Computer Network Operations
- Unmanned Training Solutions.
    - Undersea unmanned vehicle/craft training systems
    - Surface unmanned vehicle/craft training systems
    - Shipboard Aviation unmanned training systems
- Live and Virtual Entities in distributed events
- Experimental Psychology
    - Cognitive
    - Human Factors
    - I/O
    - Neuroscience
- Live, Virtual, and Constructive Simulation
- Navy Continuous Training Environment (NCTE) Operations and Sustainment.
- Distributed Training Events.
- Irregular Warfare and Rapid Warfighter Response integrated training
- Advanced Avionics with integrated embedded training modes and capabilities
- Enhanced Decision Making displays and training and support tools.
- Net-Centric Interoperability in Joint/Coalition Environment

- Autonomous systems and robotics including all aspects of Unmanned Aerial Systems
- Lead Systems Integration (LSI) Engineering
- Interoperability Engineering
- Anti-tamper Engineering
- Structural engineering, especially flutter
- Nano-Technologies and Meta-Materials
- Signature characterization, analysis, shaping and measurement
- High speed aerodynamics
- 3G/4G technology with embedded intelligence security
- Photonics and photonics computing
- Digital signal processing
- Sensor data / image fusion
- Traditional weapons engineering competencies including
    - Guidance, control systems and Navigation
    - Rockets, ramjets and propellants
    - Aero, structures, thermal, environmental, electro-magnetic
    - Plume signature, combustion stability, thermal batteries
    - RF engineering including antennas
    - Telemetry
    - Environmental engineering
    - System Architecture
    - Swarm tactics - collaborative
    - Electronic Safe and Arm systems
    - Weapons Fusing
    - Weapons Seeker Systems
    - Weapons Target Sensing / Trigger Devices
    - Organic energetics
    - Production engineering
    - Reliability, safety, quality engineering
    - Warheads,
    - Missile Propulsors
- Power systems (thermal batteries, high capacity capacitors)
- High speed weapons propulsion (ramjets, scramjets, air-breathing rockets)
- Industrial and manufacturing engineering
- Airborne (Tactical) Directed Energy Weapons
- Signal Processing and Decision Aides
- Skilled Artisans and Technicians on test ranges
- Visual Engineering and Simulation

Areas Where NAVAIR Holds a Leadership Role in S&T:

- Warheads and explosives
- Fusing
- Energetic materials
- Directed energy
- Aircraft catapult/arresting gear design
- Shipboard visual landing aides for all aircraft types
- Electromagnetics focused on EMALS and AAG
- Dynamic Signature Measurement
- Aircraft crew systems
- Materials for highly corrosive environments
- Combustion Sciences
- Advanced Missile Domes
- Miniature Weapons / Components
- Weapons Guidance, Control and Navigation
- Aided target recognition

Areas Where Other Technologies in Government, Commercial Sector or Throughout the World are Leveraged

- High power electronics
- Energy storage devices
- Aircraft structural design
- GPS applications
- Aircraft and weapon signature reduction
- Hypersonic systems and components
- Simulation
- Visualization
- Solid State Electronics
- Information Technology
- Communication

APPENDIX G

SPAWAR Warfare Centers

SPAWAR Summary

- Large variability in customer opinion of SPAWAR technical competency…sometimes very different than SPAWAR self assessments.
- N2/N6, SPAWAR resource sponsor, is making significant changes in needed technical capabilities… ~35% of Navy Procurement Authority in FY12.
  - In many cases, technical capability needs to cut across system commands and platform sponsors.
- Although SPAWAR has specific TA responsibilities, Navy wide C4ISR TA is not well defined, disciplined or practiced

Warfare Center Technical Competencies

As was stated in the main part of the study, it has not been possible for the NRAC, in general, or the NRAC SPAWAR sub-panel, in particular, to perform a detailed assessment of the competencies of the Warfare Centers. Nevertheless, in order to try to independently assess the current status of Warfare Center technical capabilities and the future needed technical capabilities of the SPAWAR Warfare Centers, the NRAC SPAWAR sub-panel visited the SPAWAR Warfare Centers, SPAWAR Headquarters, the SPAWAR PEOs (C4ISR, EIS, Space, JTRS), DASN C3I, ONR, DARPA, and also talked with various industry representatives that work for and with the Centers. In addition, N2/N6, the OPNAV SPAWAR resource sponsor was interviewed to get their assessment of current and future technical capability needs.

In these visits, the sub-panel asked for opinions on current Warfare Center technical competencies, on deficiencies, on needs for the future and on suggestions for increasing the likelihood of meeting these needs.

There are three major results from these fact-finding activities. First, there is large variability in customer opinion of SPAWAR Warfare Center current technical competency. In addition, sometimes the customer assessments are quite different from SPAWAR self-assessments. In particular, PEO C4I, JPEO JTRS felt that SSC PAC/LANT represent solid resources for engineering talent and services. Likewise, MARCORSYSCOM started that they rely heavily on SSC LANT. However, DASN C3I gave them a mixed report card as did ONR and DARPA who stated that they use selected individuals or small groups at the Centers but not for leading edge S&T technology development. PEO Space and PEO EIS told the panel that they do not rely on SPAWAR Centers to support them to any significant degree because they felt that there were other more competent places for them to go for support. Second, the SPAWAR resource sponsor N2/N6 represents a major change in OPNAV organization, emphasizing a focus on Information Dominance and a move to invest more heavily on the left-hand side of the kill chain. This change results in the fact that many needed technical competencies, such as networking and EW will need to cut across SYSCOMS. N2/N6 felt that the technical competency/capability of the Centers required the exercise of “Technical Authority” (TA) by the SYSCOMs and that this authority was not assigned in many areas and was not being exercised in many of the areas in which it was assigned.

The N2/N6 representatives felt that SPAWAR was strong in C2, networks, data fusion, decision systems but weak in autonomous systems and cyber warfare. They felt that NRL was a key player in Cyber Defense, EW, data fusion, and decision systems, although very understaffed. Their opinion was that the “go to” place for unmanned/manned system C2 was NAVOCEANO.

Finally, they stated, emphatically, that although SPAWAR has specific TA responsibilities, Navy wide C4ISR TA is not well defined, disciplined or practiced. As stated at the beginning of this appendix, SPAWAR has nine clearly defined, though limited TAs.

In the material the sub-panel received, the closest acknowledgement of these nine SECNAV-assigned responsibilities is in the SPAWAR brochure entitled “Decision Superiority through Information Dominance” (page 3 listing of SPAWAR areas of expertise). Likewise, the exercise of technical authority by SPAWAR was only alluded to in one of the briefs by the SPAWAR Chief Engineer. A more expansive listing was in the SPAWAR engineering capabilities viewgraph which included C4ISR integration, sensor systems, mobile C4I systems, networks and communications, command center services, cyberspace and cyber warfare, anti-terrorism/force protection, intelligence/surveillance/reconnaissance, air traffic control, metrology and navigation systems and technical services, plus a list of eight lesser capabilities.

The Colvard 2006 study titled *Navy Warfare Center Study: A Look at the Navy's Technical Infrastructure* that was briefed to NRAC as background information for this Study included some observations which should cause us to not be surprised by what we are finding. The statement "we still have just in-time capability, but we lack just in-case capacity" was deemed apt then and it appears to be so now. The statement in the fourth paragraph on page 1 of that report addressed the lack of leadership and technical oversight of the warfare centers at higher levels and the absence of planning for the warfare centers' future. It appears to still be relevant. The limitation on investment in people and equipment imposed by Working Capital Fund (WCF) as an impediment to developing and maintaining technical competency in the workforce appears to remain today notwithstanding recent initiatives. In short, it appears that nothing has changed since the 2006 study except possibly the sanctioning of a bit more work in the centers from sources outside the Navy.

The SPAWAR Study Sub-panel could not see clear evidence of the exercise or stewardship of technical authority by SPAWAR. Absent clear plans to sustain currently known technical leadership/authority areas and absent clear identification of future essential technical areas, shortfalls will exist in needed technical competencies. The sub-panel could not say that either SPAWAR or the Centers could articulate the mandatory future needs in their areas of responsibility. It appears the Centers have the "just in time" capability, but are not prepared for the "just in case" capability. The Centers claim leadership in a wide array of areas, several of which are unique to the Navy/Marine Corps, but many are nice to have (and bring in WCF), but are not essential to the Navy.

Core technical competencies must reflect the maritime physical and operational environment. The uniqueness of the maritime domain and the impending integration of unmanned vehicles into the battlespace require that the Warfare Centers focus on the unique technical aspects of this paradigm shift.

<u>NRAC Sub-panel recommended leadership and agile adopter areas</u>

Integrated C4ISR is being pursued across the DOD and, to a lesser extent, in other operational areas of both federal and state governments. In addition, the Naval establishment is actively pursuing the modernization of and transition from legacy business management, personnel and logistics systems to integrated enterprise level systems. PEOs, DRPMs and SPAWAR are responsible for acquiring these capabilities for the Navy and Marine Corps. SPAWAR is the technical authority for these capabilities. To fulfill this function, SPAWAR and its Systems Centers, in support of the PEOs and DRPMs, must be able to both leverage applicable external technologies and to lead the Nation and the world in the areas which are unique to naval integrated C4ISR.

The Maritime Domain imposes some Naval unique environmental and operational factors into this challenge. The Naval unique effects of the maritime physical environment have been recognized for a long time as an area where the Navy must take the technical lead. These include navigation and precision timing in a GPS-denied area and reliable communications above, on and below water's surface and the adjacent land. When Naval forces are in port they are very similar to commercial sea going and land enterprises and they can and should exploit commercial technologies. However, when they deploy, they encounter very different conditions. Current Naval operations are moving away from large, self-contained strike groups to more distributed aggregations of diverse assets, including coalition units. This has precipitated a fundamental adjustment to existing operational concepts with the ever-expanding use of ad hoc, flexible, networks of traditional and non-traditional manned and unmanned platforms. However, many Naval technologies, especially those which required significant investment for development and support infrastructure, will remain in the inventory for a long time to come.

Finally, as the Department of Navy moves into the era of Information Dominance it must be capable of leveraging National and Joint information, combined with organic Naval force information, in order to dominate theater operations. In order to remain capable in the face of communications disruptions, damage to afloat forces, or damage to supporting ashore infrastructure, Naval forces must also maintain the capability of operating autonomously from the shore infrastructure when disruptions occur.

As DON transformed from sail to steam propulsion, from steam to nuclear propulsion, and battleship to carrier aviation warfare, new supporting infrastructure was required to make each of these transformations successful. The same situation applies to the transformation into information dominance. Unlike previous information technology eras where it was more expensive to store and process data than to move the relatively small amount of information being processed, technology advances have reversed this situation. Today's information technology advances have made it possible to store and process massive amounts of information relatively inexpensively. The new challenge has become the movement of data across radio frequency systems to include satellite communications, and even across shore based wide area networks.

The data movement challenge is a result of new sensor and platform technologies that make it possible to generate orders of magnitude more data today than was the case in earlier Naval eras. With the advent of small, inexpensive synthetic aperture radar and acoustic sensors, electro-optical and infrared imaging sensors, coupled with small full-motion video cameras that are easily placed on all sensor packages, it is not uncommon to create far more data than can be transmitted from the sensors to surface control or receiving stations during the period of sensor platform operations. As an example, the Navy's newest ASW aircraft will be capable of generating terabytes of information each day. A terabyte, while easy to say, is actually a million megabytes, or the equivalent of a million pictures from a modern digital consumer camera each day. Because processing and storage equipment have grown so fast, it is actually easy to process and store terabytes of information in spaces equivalent to a small office refrigerator. What is more difficult is moving this much data. For example, it would require 39 hours or almost two days of dedicated bandwidth, to move a terabyte of information using the Navy's current fleet support wide area network. Similarly, using current dedicated aircraft carrier satellite communications capability would require 15 days to move this much information. Even using DOD's future Wideband Global Satellite system, which improves the aircraft carrier capability by five orders of magnitude, it would still require three days to move this much data.

Clearly these challenges require that DON create alternative architectures to become an information dominant Naval force. In short, a data strategy and the resulting ashore and tactical afloat infrastructure will need to be created to be information dominant as new sensors and sensor platforms are deployed. In order to design, develop, and deploy this new infrastructure, the DON will need to rely on the capability of its technical workforce to support the programs that will put this capability into the service of today and tomorrow's Naval forces.

Given this background, the recommended list of areas where SPAWAR and its Systems Centers must be technical leaders now and into the future is as follows:

- ***Legacy Naval IT and Maritime C4ISR System Support*** including providing the Navy and Marine Corps with technical support for legacy communication and personnel support, logistics systems and for modernization of these.
- ***Maritime communications*** to include: VLF, LF, HF, VHF, UHF, SATCOM, undersea, and shipboard interior and exterior, electromagnetic interference, and all associated spectrum understanding, implementation and research. All of these communication mediums have unique maritime properties and are critical to all naval operations.
- ***Maritime Networking*** to include: all technologies that augment communications and point-to-point interfaces above, on and below the water's surface in order to connect through wired and RF networks supporting shipboard and support shore functions in the most effective, adaptive, and survivable manner. This includes especially architectures and concepts of operations that support effective networking at the tactical edge, which even under benign conditions is characterized by limited bandwidth and intermittent connectivity.
- ***Precision navigation & timing*** to include: inertial, celestial, GPS, and all things related to evolution of materials and technologies that can improve all areas of navigation and timing including countering countermeasures.
- ***Environmental Modeling & Sensing*** of surface and sub-surface global maritime environment including the computational processing and fusion of METOC and near real-time Navy sensor data.
- ***Marine Mammals*** to include: research, training, maintenance, and operational support.

These C4ISR and EIS technology areas have been identified taking into account the unique maritime physical & operational environment that is unique to the Navy.

In addition, the SPAWAR Systems Centers must be agile adopters in the following technology areas:

- ***Information Security & Information Operations*** to include: maritime encryption, network operations, communications spoofing, signal intelligence, electronic warfare, all related technologies and technical interface with other DOD and other government activities.
- ***Commercial Information Technology Adoption*** to include: understanding all commercial IT, associated standards and implementation best practices, and investigating best ways to augment the areas of technical leadership with commercial technologies (e.g. enterprise architectures, cloud computing).
- ***System integration*** to include: Shore-based emulation of afloat fleet C4ISR capability, integration of command and control functions with intelligence, surveillance and reconnaissance using communications, interfaces, software integration and networking technologies.

Again, the unique maritime physical & operational environments have led to these needed core competencies.

Finally, the NRAC SPAWAR sub-panel decided that the Systems Centers need to acquire the technical capabilities to make the Navy a leader in the development and operation of integrated C4ISR for systems consisting of networks of combined manned and unmanned nodes (mixed systems). It is clear to the NRAC that, in the air, on the ocean surface, under the water and in expeditionary air/ground operations, the use of wireless mobile networks consisting of manned and unmanned platforms offers significant operational advantages in surveillance, targeting and engagement. Further, the combination of this capability with timely intelligence can help provide the DON with the ability to achieve its goal of "Information Dominance". A major technical challenge exits in the area of command and control for these very heterogeneous systems in a maritime environment that cannot guarantee communication continuity and where, as a result, unmanned nodes must have the capability to "fight thru" intermittent connectivity. OPNAV, the Warfare Centers, the UARCS and NRL must all participate in defining the classes of technical issues that must be addressed and in developing the necessary capabilities needed to solve the problems, build the systems and maintain them into the future. Therefore, a future core competency includes:

Integrated C4ISR for combined manned/unmanned (mixed) systems to include: designing, developing, testing, fielding and maintaining maritime and expeditionary C4ISR networks consisting of a combination of hybrid manned/unmanned systems. This is true in general, but especially for:

- Mixed Undersea Operations
- Mixed MAGTAF Operations
- Mixed Carrier Air Operations
- Mixed Surface Operations

Because maritime operations cannot guarantee communication continuity, unmanned nodes must have capability to “fight thru” intermittent connectivity. This future needed Naval C4ISR capability has been identified taking into account the trend toward military operations using mixed *Manned/Unmanned Systems*, as was reinforced with discussions with OPNAV (N2/N6).

In the opinion of the SPAWAR sub-panel, these areas represent the minimum list of competencies needed to provide the Navy and Marine Corps with integrated C4ISR and business related IT capability, now and into the future.

Background

SECNAVINST 5400.15C defines Technical Authority as “the authority, responsibility, and accountability to establish, monitor and approve technical standards, tools, and processes in conformance with applicable Department of Defense (DOD) and DON policy, requirements, architectures, and standards."

SECNAVINST 5400.15C also states that SPAWAR is responsible for exercising technical authority and certification authority for:

1. Command and Control Systems
2. Communications Systems
3. Intelligence Systems
4. Undersea Surveillance Systems
5. Space Systems
6. Enterprise Information Systems
7. Development of force level warfare systems architecture and conduct of force level space and electronic warfare system engineering
8. Force Warfare System Engineering Board Coordination among the SYSCOMs
9. Additional duty assignments as the FORCEnet/C4ISR Chief Engineer.

In response to SECNAVINST 5400.15C, SPAWAR is the Navy's acquisition command and technical authority for C4ISR and the IT systems used for personnel management and logistics. The SPAWAR enterprise consists of the Echelon II System Command

(SPAWARSYSCOM) located in San Diego, and direct reporting Echelon III organizations including two Naval Warfare Centers or System Centers (SSCs) headquartered in San Diego (SSC Pacific) and Charleston (SSC Atlantic), as well as the SPAWAR Space Field Activity (SSFA) located in Chantilly. There are three associated Navy Program Executive Offices (PEOs): C4I (San Diego), Space Systems (Chantilly), and EIS (Crystal City) that have a direct reporting line to ASN (RDA), and a JPEO JTRS (San Diego) with an Army reporting chain. These PEOs have a dotted line reporting responsibility to SPAWARSYSCOM. These four PEOs are considered part of Team SPAWAR and the organizational structure is shown in Figure 1.

Team SPAWAR had an FY09 Total Obligation Authority (TOA) of $9.86B and is responsible for development, acquisition and support of Naval Enterprise Information Systems, C4ISR, Networks, and Space Systems in the interest of national defense. In these areas, Team SPAWAR provides:

- FUTURE CAPABILITIES (TECHNOLOGY & SYSTEMS ACQUISITION)
- CURRENT READINESS (SUSTAINMENT)
- DECISION SUPPORT

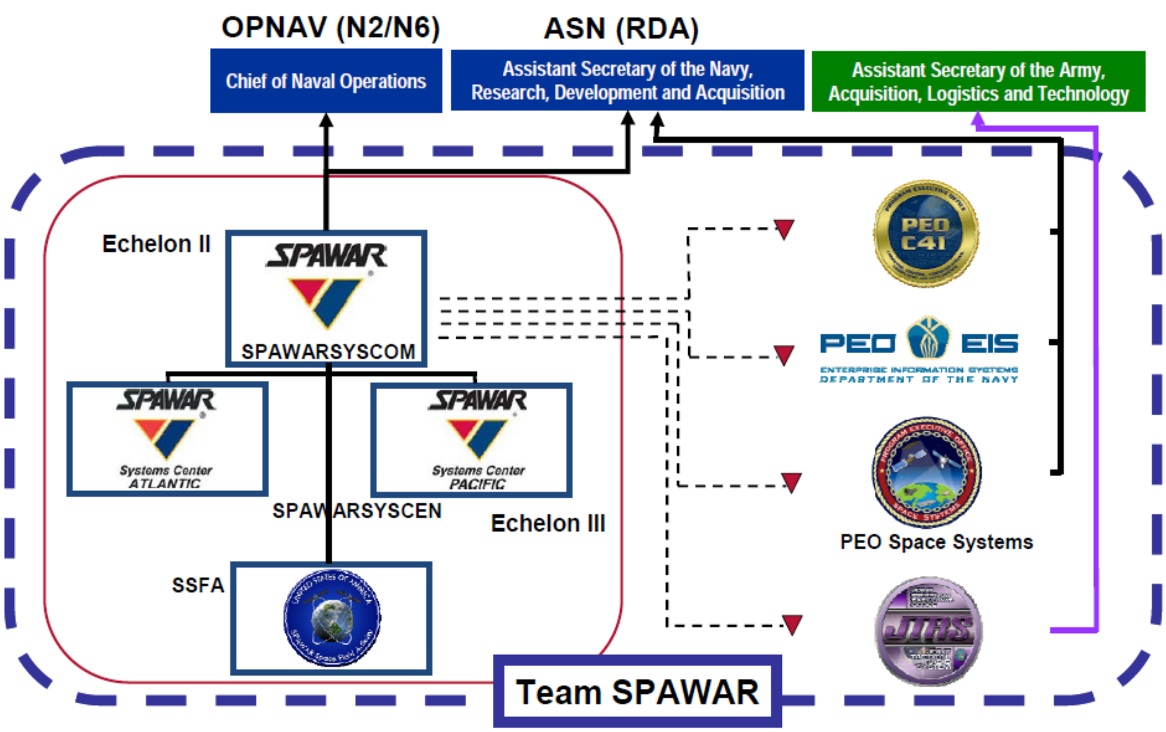


Figure 1. Team SPAWAR construct

The in-house technical competency and future readiness infrastructure (S&T activities/enterprise) for Team SPAWAR largely resides in the Echelon III activities at the two Warfare Centers, SSC Pacific (SSC PAC) and SSC Atlantic (SSC LANT), and as such have been the principal focus of this NRAC sub-panel investigation. This report reflects this emphasis and is heavily focused on SSC LANT/PAC information and assessments, and to a lesser extent the SSCs interaction with headquarters (SPAWARSYSCOM), Naval and DOD customers, and industry partners/competitors.

Top Level Description of Organizations (SPAWARSYSCOM, SSCs and SSFA)

SPAWARSYSCOM is the Navy's Command, Control, Communications, and Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) command for acquisition and life-cycle management of communications and Naval warfare systems. SPAWARSYSCOM is mission funded with an FY09 appropriated budget of $308M. It has an on-site government workforce of 462 (371 civilian; 91 military) employees and draws heavily from the SSCs (~$70M sent to SSCs in FY09) to fully execute its engineering and technical authority functions in support of OPNAV and the PEOs. SPAWARSYSCOM currently has 316 on-site contractors to assist in executing its mission. Approximately $200M total budget was contracted out in FY09. The SPAWARSYSCOM total funding distribution for FY09 between top level functions is shown in Table 1. The SPAWARSYSCOM funding distribution by function sent to the SSCs in FY09 is shown in Table 2 which represents <25% of its total budget.

SPAWAR HQ FY09$ BY FUNCTION (GWBS)			
Systems Engineering	$	66,543,872	21.6%
Prime Mission Product Development	$	65,980,993	21.4%
Program Management	$	61,594,169	20.0%
Command/PEO Management and Administration	$	58,976,624	19.1%
Initial Spares	$	17,357,516	5.6%
FSETs	$	15,055,227	4.9%
Prime Mission Product Production	$	6,367,419	2.1%
Other < 2% Each	$	16,187,180	5.3%
Total	**$**	**308,063,000**	

Table 1. SPAWARSYSCOM FY09 total funding distribution by function.

SPAWAR HQ FY09$ BY FUNCTION (GWBS) SENT TO SSCs			
Program Management	$	16,543,688	23.5%
Command/PEO Management and Administration	$	13,183,619	18.7%
Initial Spares	$	11,262,941	16.0%
Systems Engineering	$	10,219,225	14.5%
Prime Mission Product Development	$	7,926,748	11.3%
Prime Mission Product Production	$	3,807,789	5.4%
Platform / Site Activation / Installation	$	2,130,000	3.0%
In Service Engineering Activity (ISEA)	$	1,797,560	2.6%
Other < 2% Each	$	3,529,457	5.0%
Total	**$**	**70,401,027**	

Table 2. SPAWARSYSCOM FY09 funding distribution by function sent to SSCs.

SSC PAC is a Working Capital Funded (WCF) Naval Warfare Center that has 4264 employees (4033 civilian; 231 military) and an FY09 TOA of $2.6B ($2.1 New Orders in FY09). Its workforce includes 140 PhDs, 848 Masters, and 1924 Bachelors level government employees with 2050 Scientists & Engineers (S&Es). It has major laboratory facilities located in San Diego and Hawaii. SSC PAC provides Naval, Joint and National knowledge superiority through research, development, acquisition, test and evaluation (RDAT&E) and full life cycle support of effective C4ISR, IO, EIS and Space capabilities. As a measure of its technical productivity, SSC PAC published 196 peer-reviewed journal articles, 205 conference presentations, filed 47 patent applications, and was issued 31 patents in FY08 (last full year data available).

SSC LANT is a Working Capital Funded (WCF) Naval Warfare Center that has 3424 employees (3310 civilian; 114 military) and an FY09 TOA of $5.0B ($3.9B New Orders in FY09). Its workforce includes 21 PhDs, 506 Masters, and 1471 Bachelors level government employees with 1247 Scientists & Engineers. It has major laboratory facilities located in Charleston, New Orleans, and Norfolk. SSC LANT provides full-service systems engineering and acquisition to rapidly deploy capabilities to the Naval, Joint and National Warfighters through the development, test, evaluation, production and fielding of sustainable, survivable, and interoperable C4ISR, IO, EIS, and Space capabilities that enable knowledge superiority. As a measure of its In-Service Engineering and rapid fielding production capability, SSC LANT to date has provided final C4I integration and delivered over 16,000 Mine Resistant Ambush Protected (MRAP) vehicles to our Warfighters.

SSFA is a mission funded organization that supports PEO Space Systems and the NRO in maintaining a strong Naval presence in space. It has 244 employees (62 civilian; 182 military) and its mission is to provide Naval space and warfare expertise to develop space systems in support of all National, Joint, combined, and Naval missions and operation. Its activities include support of the current UFO satellite constellation and its replacement MUOS.

Due to the nature of the SSFA business, its organizational composition, and its business model, it is not considered a major focus of this NRAC study and will not be considered further in this report.

<u>Major/Unique Technical Facilities (SSCs)</u>

SSC PAC physical facilities include:

- 217 buildings totaling 3.0M sq ft
- 1.8M sq ft of lab space
- 211,000 sq ft of SCI facilities
- 4 piers
- 100 sq-miles of test range on San Clemente Island
- 14 buildings in Hawaii, Japan and Guam

Unique laboratory/center/range facilities at **SSC PAC** include:

- Navy marine mammal training and research facility
- One-of-a-kind model range for testing ship antenna design and signal characteristics
- World-class Cyber Operations Lab
- End-to-End Test and Certification Lab (E2C)
- C4ISR training ranges for unmanned vehicle
- Shore based emulators of fleet afloat C4ISR capability
- Transducer Evaluation Center (TRANSDEC) replicating open ocean environments
- One of only 21 High Performance Computing Centers (HPCC) in the nation
- C4ISR depot and crypto repair facility and calibration lab
- C4ISR robotics lab for design, testing and repair of robotic and autonomous systems
- San Clemente Island – fleet operating range

SSC LANT physical facilities include:

- 125 buildings totaling 2.5M sq ft located in Charleston, Norfolk and New Orleans
- Current MILCON ($20M) in Little Creek, Norfolk and Charleston

Unique laboratory/center/range facilities accessible to **SSC LANT** include:

- End-to-End Test and Certification Lab (E2C)
- Charleston Data Center Lab (thru BRAC)
- C4I integration facility
- Radio frequency test facility
- Environmental test facility (TEMPEST, Navigation)
- Common submarine radio room
- Mobile systems integration environment
- Air Traffic Control facility
- Co-located with Charleston Air Force Base
- Co-located with Military SDDC (841st Transportation Battalion)

Financial Overview (SSCs)

SSC PAC FY09 Funding: $2.6B TOA ($2.1B FY09 New Orders)

Figure 2 shows the FY09 SSC PAC funding distribution by sponsor. Figure 3 shows the FY09 SSC PAC funding distribution by type. Figure 4 shows the TOA over a ten year time span. Figure 5 shows the New Orders over time broken out by total, in-house, and S&T in-house.

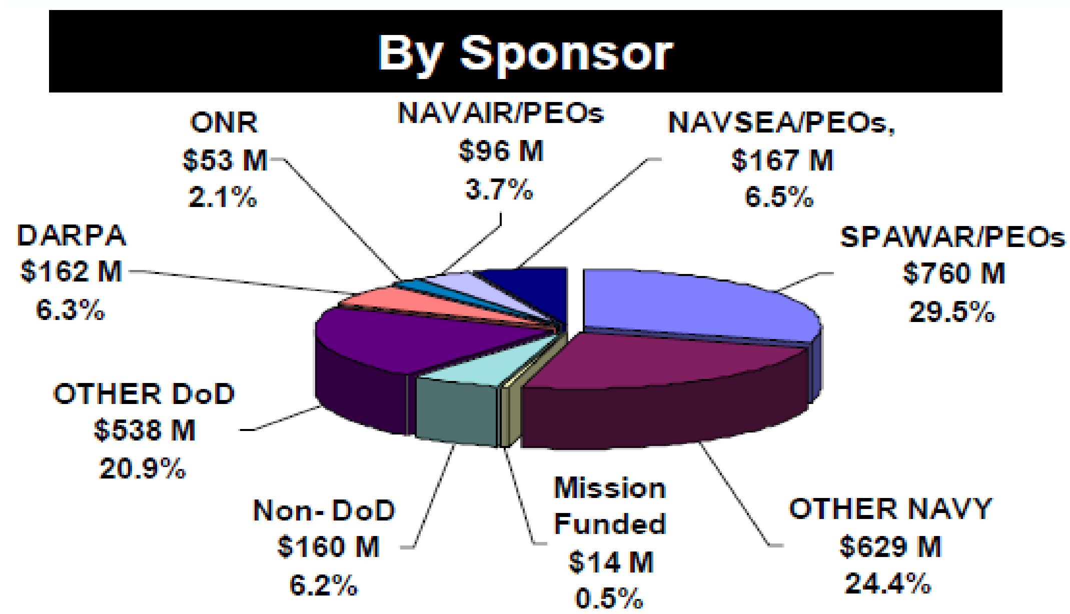


Figure 2. FY09 SSC PAC funding distribution by sponsor

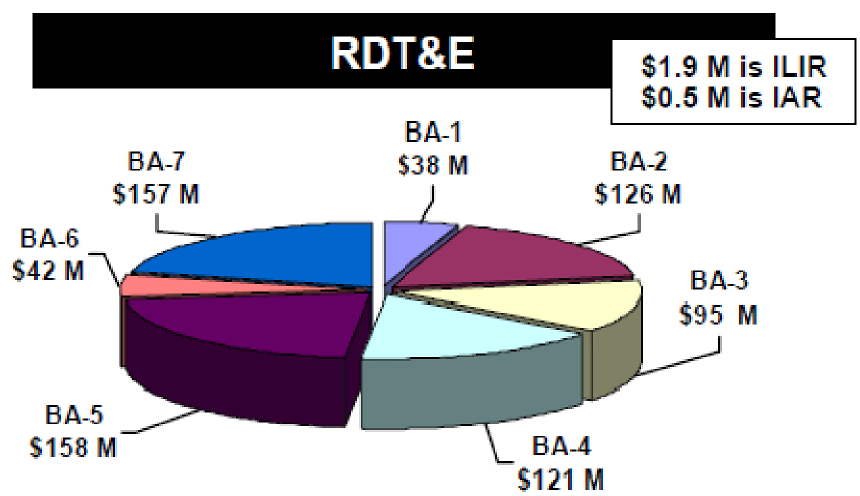


Figure 3. FY09 SSC PAC funding distribution by type.

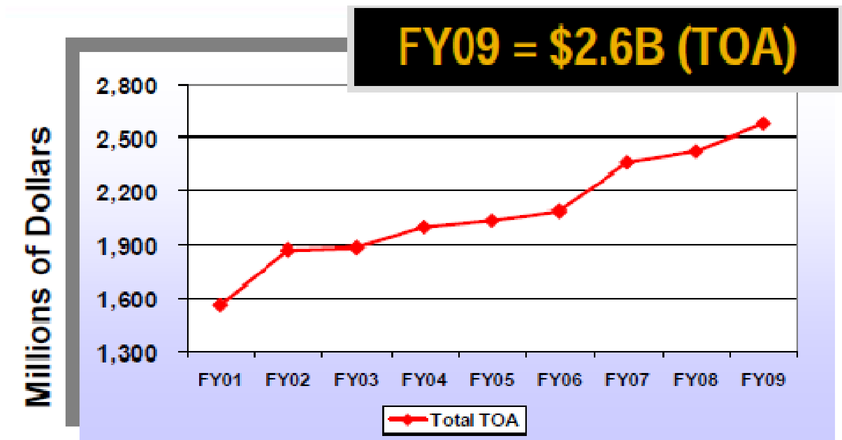


Figure 4. SSC PAC Total Obligation Authority (TOA) growth over time.

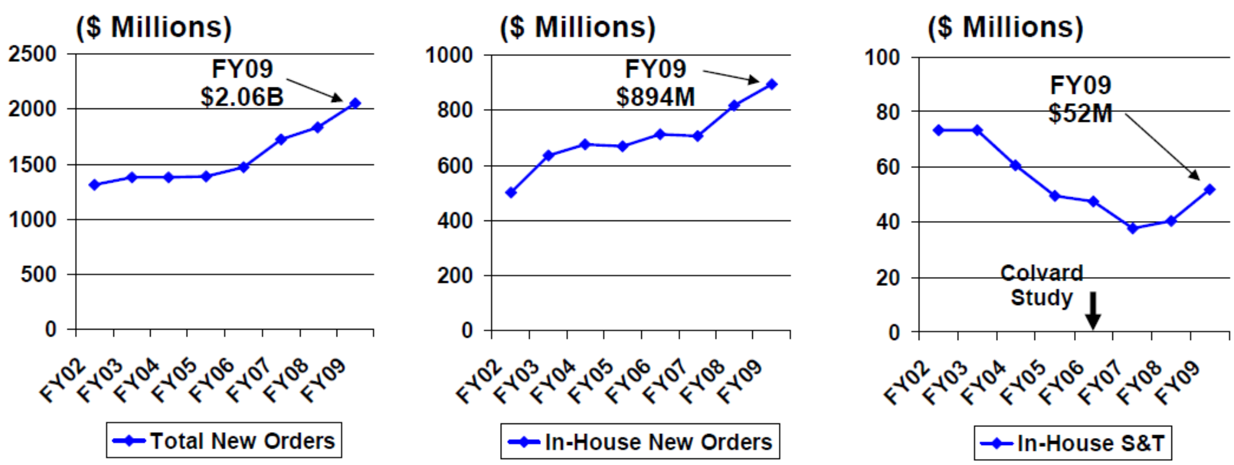


Figure 5. SSC PAC New Orders data versus time (fiscal year) broken out by total, in-house, and in-house S&T.

Some notable facts regarding **SSC PAC** funding (based on FY09 numbers):

- Less than 30% of SSC PAC money is executed in support of SPAWAR/PEOs
- DARPA executes a lot of S&T dollars (>$160M) thru SSC PAC (~$10M in-house)
- Very little mission funding directly appropriated to SSC PAC (0.5% of TOA)
- 28.5% of TOA is RDT&E dollars (38% of SSC PAC WYs (work years) are RDT&E)
- $259M S&T dollars (BA-1, BA-2, BA-3) supporting 220 in-house S&T WYs
- TOA increased over 60% in 8 yrs (RDT&E percentage dropped over this period)

- In-house business grew over 75% in 8 yrs
- In-house S&T down over 8 yr period (25%) but is showing an upward trend since the 2006 Colvard Study.

SSC LANT FY09 Funding: $5.0B TOA ($3.9B New Orders)

Figure 6 shows the FY09 SSC LANT funding distribution by sponsor. Figure 7 shows the FY09 SSC LANT RDT&E funding distribution by type. Figure 8 shows the FY09 SSC LANT RDT&E funding distribution. Figure 9 shows the FY09 SSC LANT S&T funding distribution. Figure 10 shows the New Orders over time broken out by total, in-house, and S&T in-house.

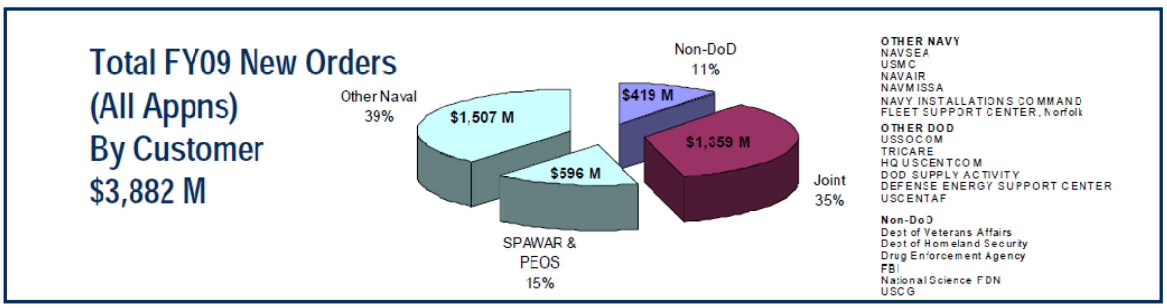


Figure 6. FY09 SSC LANT funding distribution by sponsor.

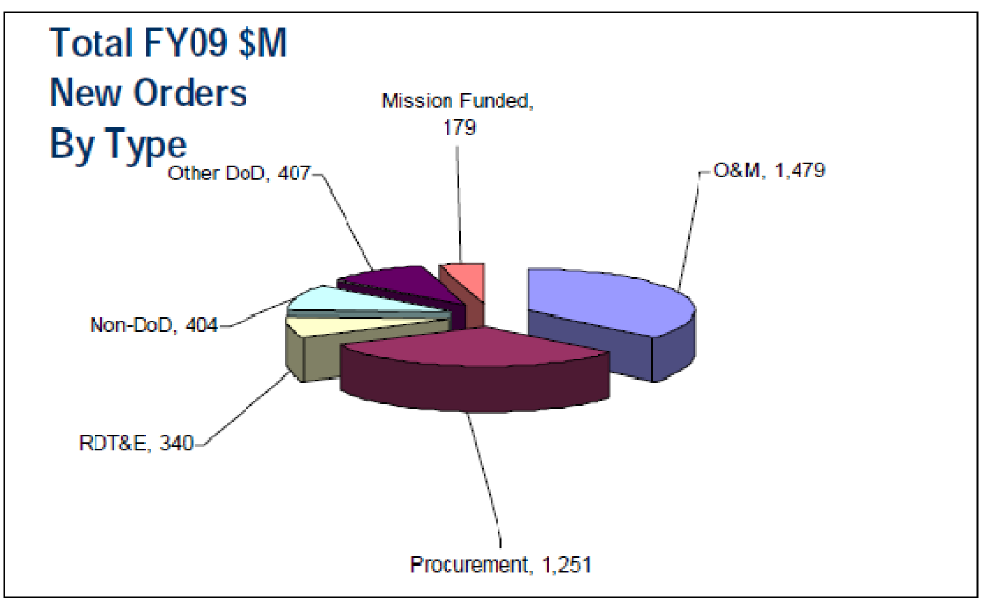


Figure 7. FY09 SSC LANT funding distribution by type.

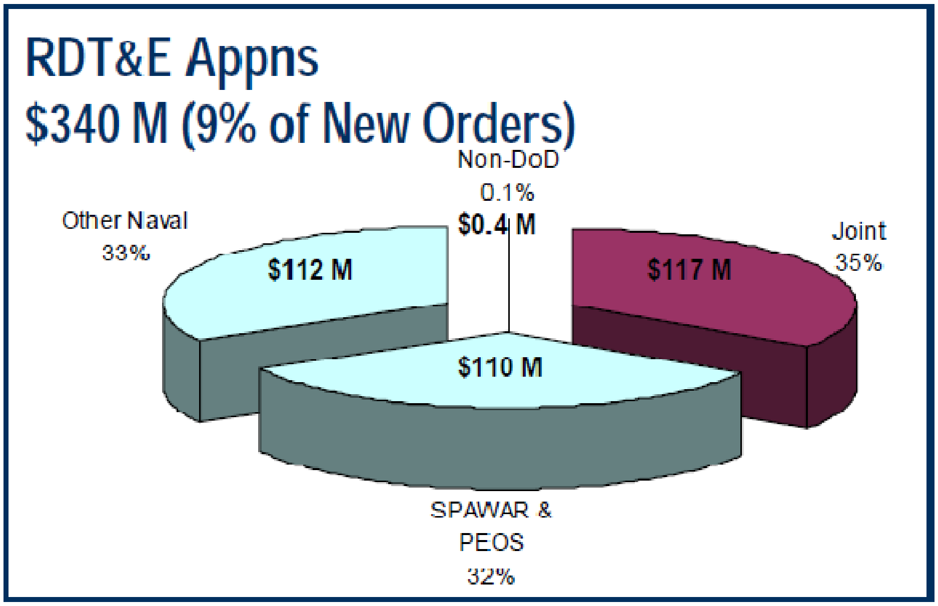


Figure 8. FY09 SSC LANT RDT&E funding distribution.

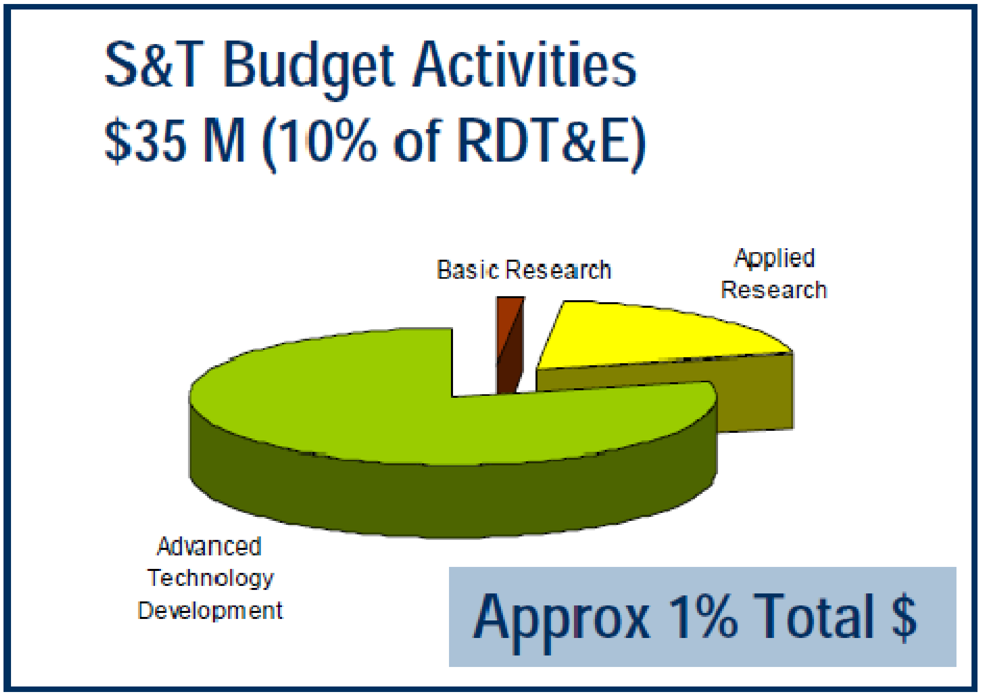


Figure 9. FY09 SSC LANT S&T funding distribution.

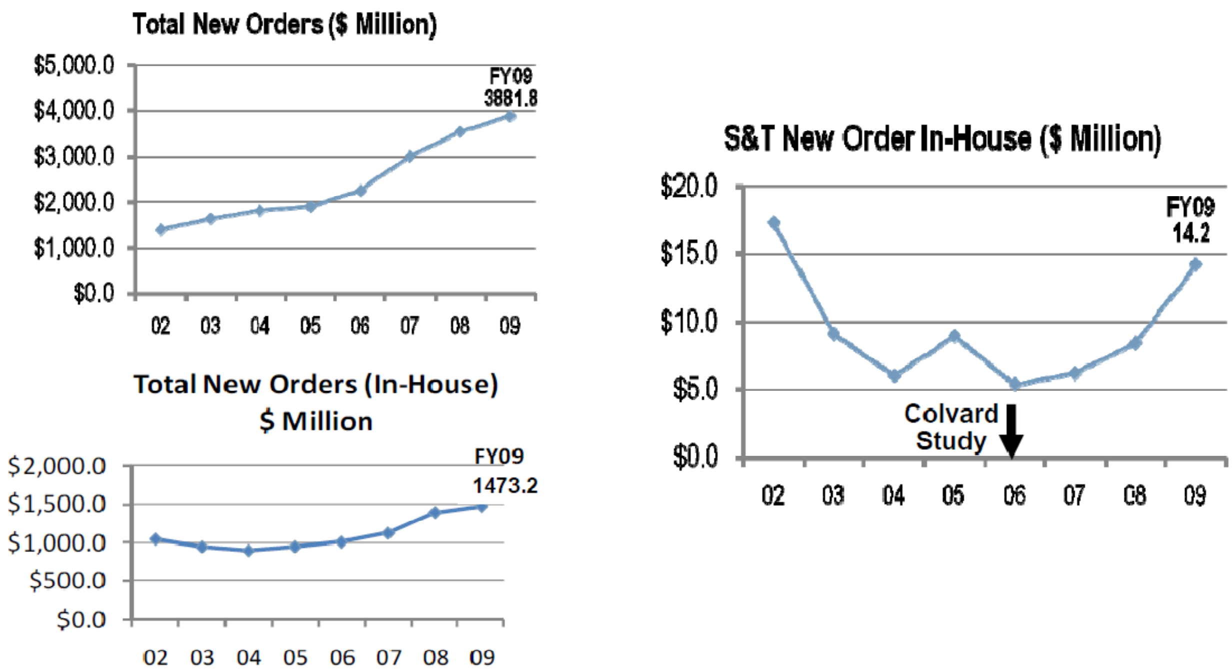


Figure 10. SSC LANT New Orders data versus time (fiscal year) broken out by total, in-house, and in-house S&T.

Some notable facts regarding **SSC LANT** funding (based on FY09 numbers):

- Only 15% of SSC LANT money is executed in support of SPAWAR/PEOs
- 67% of Direct workforce work is Naval
- 9% of TOA is RDT&E dollars
- RDT&E dollars evenly split between SPAWAR/PEOs, other Naval, and Joint
- 69% of RDT&E workforce is Naval
- Total business grew well over 100% in 8 yrs
- In-house business grew over 40% in 8 yrs
- $35M S&T dollars (BA-1 (2%), BA-2 (20%), BA-3 (78%)) (~40% of total in-house)
- In-house S&T down slightly over 8 yr period but is showing an upward trend since the 2006 Colvard Study.

Technical Workforce (SSCs)

SSC PAC: Mil/Civilian workforce of 4,264 people supported by ~1,500 on-site technical and administrative contractor personnel. Workforce includes 140 PhDs, 848 Masters, and 1924 Bachelors level government employees with 2050 Scientists & Engineers (S&Es). Average age of S&E workforce is 44 years. The SSC PAC workforce demographics are summarized in Figure 11.

Inventors, Innovators, Integrators

CIVILIANS	4033
Scientists & Engineers	2050
Technicians	372
Tech Specialists	766
Administrative	543
Clerical	275
Ungraded / Other	19
Scientist/Technologists	2
SES	6
MIL	**231**
Officers	65
Enlisted	231
TOTAL	**4264**

Figure 11. SSC PAC workforce demographics.

SSC LANT: Mil/Civilian workforce of 3,424 people supported by ~3,500 on-site technical and administrative contractor personnel. Workforce includes 21 PhDs, 506 Masters, and 1471 Bachelors level government employees with 1247 S&Es. SSC LANT has a young and vibrant workforce with over 55% having less than 10 years experience. The SSC LANT workforce demographics are summarized in Figure 12.

Inventors, Innovators, Integrators

CIVILIANS	3310
Scientists & Engineers	1247
Technical	1106
Other Tech Specialists	125
Administrative	752
Clerical	25
Ungraded / Other	54
Scientist/Technologists	0
SES	1
MIL	**114**
Officers	22
Enlisted	114
TOTAL	**3424**

Figure 12. SSC LANT workforce demographics.

<u>Capabilities and/or Technical Competencies Where SPAWAR Needs to be Technology Leaders</u>

During the NRAC sub-panel visits to the Warfare Centers, SSC PAC and SSC LANT provided inputs with respect to the technical competencies where they and the Navy need to be technology leaders. Their responses are summarized below.

<u>SSC PAC INPUT (Areas where SSC PAC must lead)</u>

- Networked and disconnected operations
  - Undersea networks
  - Networking to/from the Tactical Edge – Seabed to Space
  - Networked sensors and systems in a Maritime Environment
- C4ISR Resilience
  - Countering vulnerabilities and threats
  - Operate in maritime degraded / disconnected conditions
  - Cyber vulnerabilities
  - International C4ISR Capabilities
- Navy dependency on Over-the-Horizon and Space COMMS
- Marine Mammals
- Navigation
- Ocean surveillance / maritime domain awareness

<u>SSC LANT INPUT *(Areas where SSC LANT must lead)*</u>

- S&T leadership in the following areas:
  - Naval SIGINT – Provide all ground receivers for Navy and USMC systems.
  - Naval Enterprise Services - C2 and Business IT- Provide Naval core services for service oriented architectures (SoA)
  - Naval Platform C4I Integration – SCN, MRAP, etc (Provide C4I integration for all new Navy ships and major mobile systems)
- Major contributors for the Navy and its programs in the following areas:
  - Naval wireless communications
  - Naval networks –routing, control, and monitoring
  - Naval information assurance and information operations.

SPAWARSYSCOM has endorsed these Warfare Center responses and has provided additional input also included below:

SPAWARSYSCOM INPUT (Additional areas where SPAWAR must lead)

- C4ISR Enterprise Systems Requirements Analysis and Assessments
  - Maritime Operations Center (MOC)
- C4ISR Enterprise Systems Architectures and Standards
  - Next Generation Network (NGEN), Consolidated Afloat Networks and Enterprise Services (CANES)
- C4ISR Enterprise Disruptive Technology Evaluation
  - Full Motion video, Internet Protocol version 6 (IPv6)
- C4ISR Lead Systems Integrator
  - NGEN Systems Integration
- Information Dominance Mission Area Chief Engineer
  - Joint Strike fighter (JSF) Information Exchange Requirements
- Information Dominance Technical Authority and Technical Review
  - Navy Enterprise Resource Planning (ERP)
- C4ISR TOC Engineering Estimation
  - Data Center Consolidation
- Prognostics and Remote Monitoring of C4ISR Systems

Capabilities and/or Technical Competencies for Which SPAWAR Must Have State of the Art Knowledge (Agile Adopter)

SSC PAC and SSC LANT provided inputs to the NRAC related to the question of what technical areas they needed to be smart practitioners or agile adopters. Their responses are summarized below.

SSC PAC INPUT *(Areas where SSC PAC must be agile adopters)*

- Agile Software Development
- Development of open, non-proprietary solutions
- Assured information sharing
- Advanced Information Technology (IT)
- C4ISR for Unmanned Autonomous Systems
- Precision Navigation and timing
- Satellite Communications
- Decision Support
- Data Fusion
- Ensuring Interoperability thru effective system engineering, integration, T&E

- Smart buyers
- Technical Oversight of Delivery and integration of new C4I capability into existing and new platforms.

SSC LANT INPUT (Areas where SSC LANT must be agile adopters)

- Naval enterprise architectures, services, and data centers (Cloud computing under disconnected, intermittent or low bandwidth)
- Naval cyber analytics and technology
- Naval cognitive radio and advanced communications (IP over full RF spectrum)
- Naval control for adaptive cooperative systems (UAS planning, support)
- Legacy technologies no longer supported by industry but required by the fleet (VLF, HF, etc)

SPAWARSYSCOM has endorsed these responses and has provided additional input that is included below:

SPAWARSYSCOM INPUT (Additional areas where SPAWAR must be agile adopters)

- Applications and services architectures including widgets, Service Oriented Architecture (SOA), and Cloud Computing
- Wide Area Network (WAN) Technologies and architectures
- Space, terrestrial, and air-borne layer transport
- Local Area Network (LAN) and Desk-top topologies
- Security and Identity Management
- Cyber capability
- Emerging technical capabilities and standards
- Modeling, simulation, and analysis tools for integration and assessment of alternatives
- Approaches for technical reviews
- Test & Evaluation (T&E): Investments in lab infrastructure needed to support transition to SOA

Science and Technology Self-Assessment

SSC PAC and SSC LANT have assessed their current state in S&T. Their inputs are shown below along with SPAWARSYSCOM additional inputs:

SSC PAC INPUT (S&T self-assessment)

- **Leadership Role:**
  - Undersea communications
  - Marine Mammals
  - Signals Intelligence
  - Multi-INT Fusion
  - C4ISR for UVs in Maritime
  - Decision Optimization
  - IPv6 Implementation
  - C4I Topside Design, including low radar cross-section antenna systems
  - Miniaturized sensors (tags/beacons)
  - Non Linear Dynamics including dynamic RF filtering;
  - Cryogenic cooling for RF systems
  - Modeling and simulating RF, optical, acoustic propagation in a maritime environment
  - E2E challenges in Navy C4ISR systems
  - Maritime Experimentation

Areas where SSC PAC holds a leadership role

- **Leveraged**
  - Unmanned Vehicles
  - Intelligent Agents
  - Decision Support
  - Wireless Communications
  - Electronics / IT
  - Information Assurance
  - Open applications
  - Photonics
  - Cloud Computing & Data Centers

Areas where technologies in government, commercial sector or throughout the world are leveraged

- **Deficient**
  - Nanotechnology
  - Quantum Computing
  - Complexity of Massive Networks
  - Dynamic reconfigurable communications networks
  - S&T for CNA/CNE/CND

Areas where SSC PAC is deficient relative to the state of the art

SSC LANT INPUT (S&T self-assessment)

- **Leadership Role:**
  - Communications and Software Radio
  - Land based deployable Air Traffic Control
  - C4ISR Rapid Integration
  - Enterprise Systems and Cloud Computing
  - Service Oriented Architecture
  - Federated Identity
  - Agile Programming
  - Mobile ad-hoc networks

Areas where SSC LANT holds a leadership role

- **Leveraged**
  - Advanced Information Technologies
  - Displays and Visualization
  - Mobile computing protocols

Areas where technologies in government, commercial sector or throughout the world are leveraged

- **Deficient**
  - Quantum Networks and computing
  - Knowledge discovery and exploitation

Areas where SSC LANT is deficient relative to the state of the art

SPAWARSYSCOM INPUT (S&T self-assessment)

- **Leadership Role:**
  - C4ISR Enterprise Systems Requirements Analysis and Assessments
  - C4ISR Enterprise Systems Architectures and Standards
  - C4ISR Enterprise Disruptive Technology Evaluation
  - C4ISR Lead Systems Integrator
  - Information Dominance Mission Area Chief Engineer
  - Information Dominance Technical Authority and Technical Review
  - C4ISR TOC Engineering Estimation
  - Prognostics and Remote Monitoring of C4ISR Systems

Areas where SPAWAR holds a leadership role

- **Leveraged**
  - Applications and services architectures including widgets, Service Oriented Architecture (SOA), and Cloud Computing
  - Wide Area Network (WAN) Technologies and architectures
  - Space, terrestrial, and air-borne layer transport
  - Local Area Network (LAN) and Desk-top topologies
  - Security and Identity Management
  - Cyber capability
  - Emerging technical capabilities and standards
  - Modeling, simulation, and analysis tools for integration and assessment of alternatives
  - Approaches for technical reviews
  - Test & Evaluation (T&E): Investments in lab infrastructure needed to support transition to SOA

Areas where technologies in government, commercial sector or throughout the world are leveraged

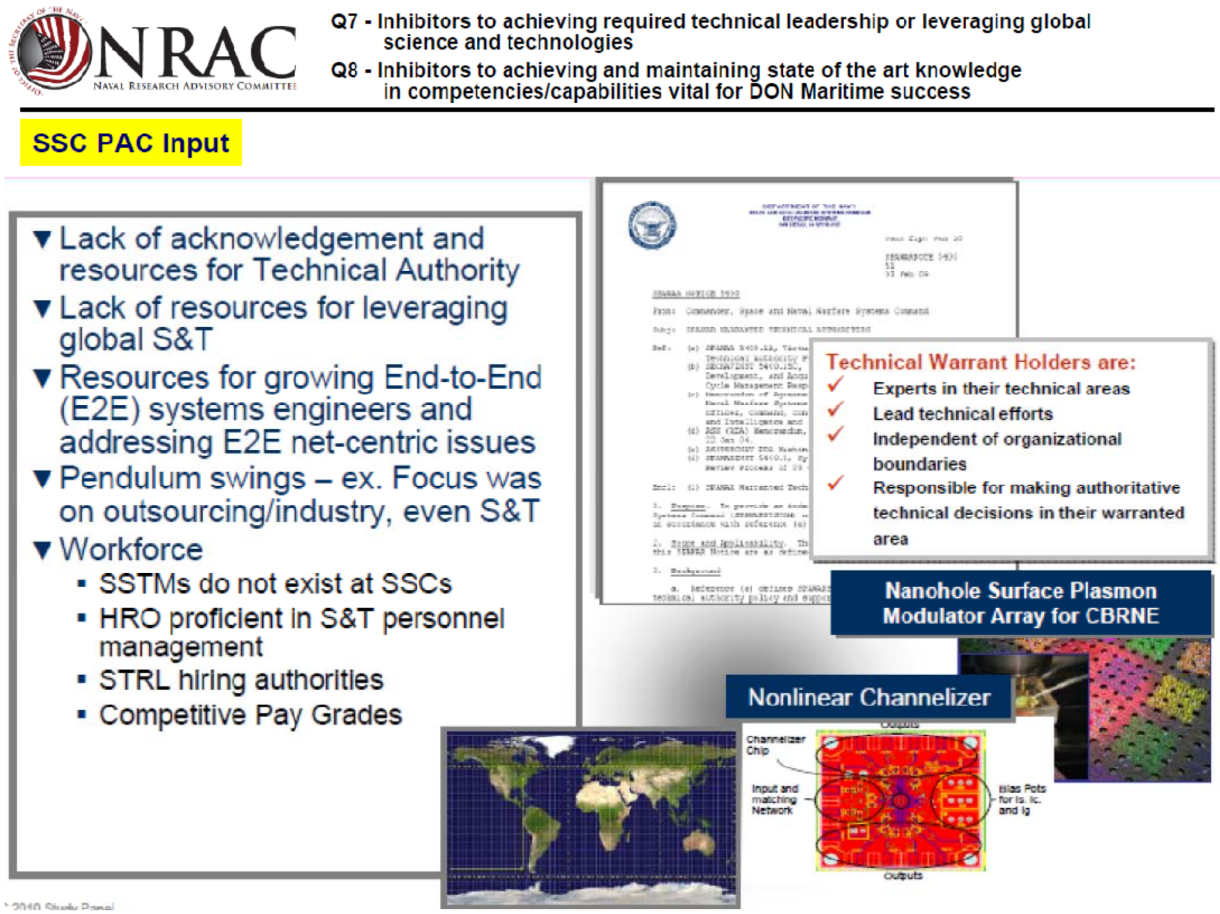
- **Deficient**
  - There are 188 Technical Warrant Holder (TWH) areas (identified by Mission Organization Working Group) and 35 TWH positions have been identified as gaps (identified by the Engineering Governance Board (EGB))

Areas where SPAWAR is deficient relative to the state of the art

Inhibitors to Achieving Required Technical Leadership or Leveraging Global S&T. Inhibitors to Achieving and Maintaining State of the Art Knowledge in Competencies/Capabilities Vital for DON success in future

The SSC PAC and SSC LANT responses relating to these important questions are included below. SPAWARSYSCOM has endorsed these responses and has provided additional input also included below.

SSC PAC INPUT (Inhibitors)



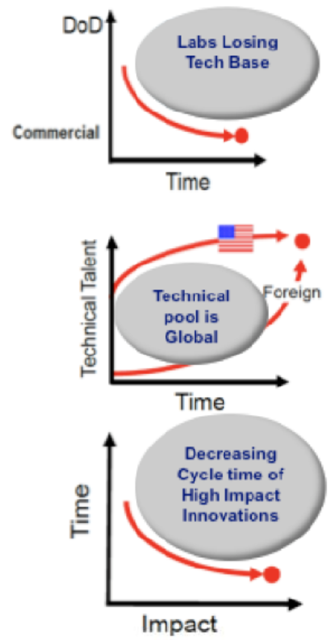
SSC LANT INPUT (Inhibitors)

Q7 - Inhibitors to achieving required technical leadership or leveraging global science and technologies

Q8 - Inhibitors to achieving and maintaining state of the art knowledge in competencies/capabilities vital for DON Maritime success

SSC LANT Input

- Recapturing (a portion) technical leadership
- Developing innovative ways to leverage the massive R&D budgets Industry uses to drive Information Technology for the exclusive benefit of Naval Labs
- To achieve and maintain technical leadership, we need the following:
  - Mechanisms and incentives to recruit, retain, and provide on-off ramps into Naval S&T
  - Effective partnerships with industry and academia
  - Visiting Researcher / Industry Mentor program
  - Developing Rapid Research and Engineering capability
- Lack of Navy-wide work shaping and acceptance process that provides clear swim lanes, reduces overlap, and balances the QDR competitive prototyping and need for clear roles and responsibilities
- Inability to leverage Global S&T due to citizenship requirements and ITAR
- Establish/Reassign (6-30) Mission funded billets to manage the S&T posture and provide technical authority at the warfare centers



SPAWARSYSCOM INPUT *(Inhibitors)*

NRAC
NAVAL RESEARCH ADVISORY COMMITTEE

Q7 - Inhibitors to achieving required technical leadership or leveraging global science and technologies

In addition to SSC inputs, SPAWARSYSCOM adds:

SPAWAR HQ Input

- Lack of resources
  - No funding assigned
  - Insufficient inventory of adequately educated engineers to refresh/sustain the workforce
  - Instability in Science and Technology (S&T) funding, fragmented across multiple resource sponsors lead to lack of short term sponsors for long range research
- Requirements / Expectations for Systems Engineering increasing, but funding from Resource Sponsor declining
  - Trend of funding decrease
- BRAC Risk
  - Lab consolidation could lead to loss of Navy Working Capital Fund (NWCF) model
- Competency Aligned Organization (CAO) has given better visibility into labs
  - Communities of Interest (COIs)
  - Tier II National Competency Leads (NCLs)

NRAC
NAVAL RESEARCH ADVISORY COMMITTEE

Q8 - Inhibitors to achieving and maintaining state of the art knowledge in competencies/capabilities vital for DON Maritime success

In addition to SSC inputs, SPAWARSYSCOM adds:

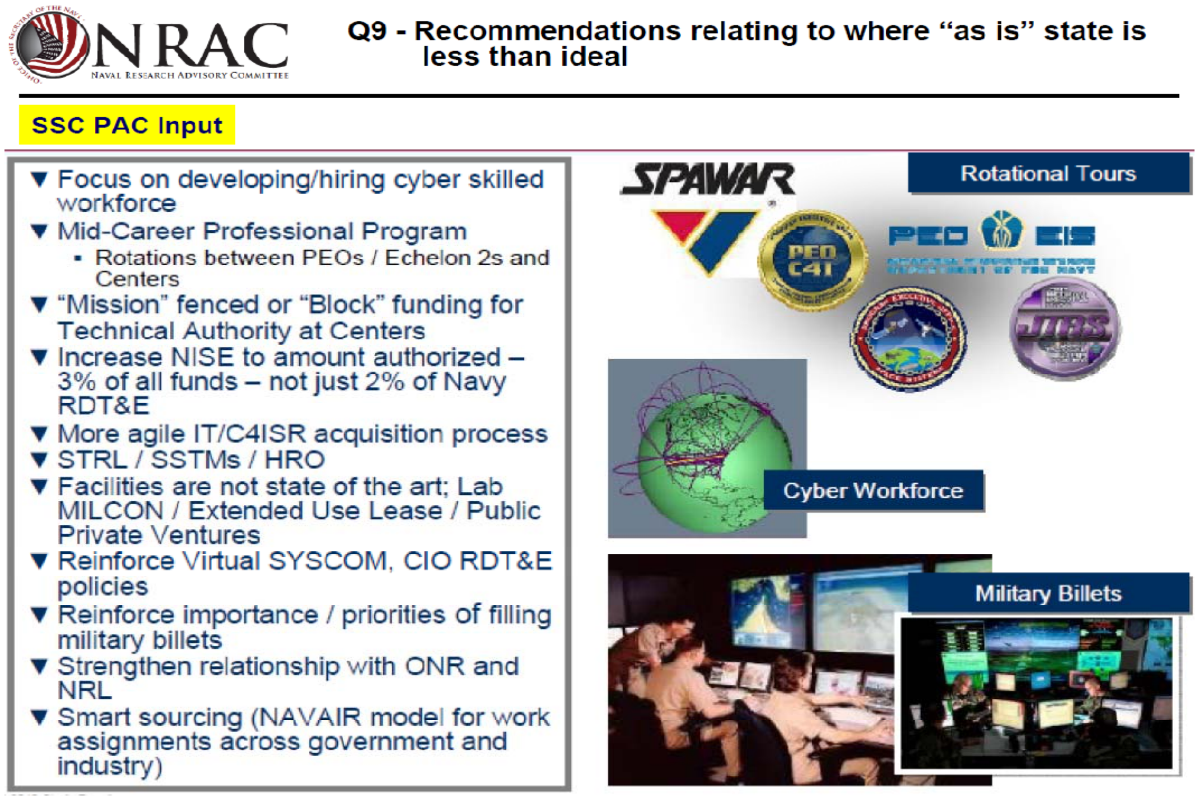
SPAWAR HQ Input

- Lack of continuing training for existing workforce to upgrade knowledge in specific technical areas
- Lack of Concepts of Operations (CONOPS) to guide development of future capabilities
- No equivalent to 219 type funding at Headquarters
- Section 219 of the FY 2009 DoD Authorization Act established a way for defense laboratories to use up to three percent of all funds available to the laboratory to fund:
  - Innovative basic and applied research that is conducted at the laboratory and supports military missions;
  - Development programs that support the transition of technologies developed by the defense laboratory into operational use;
  - Development activities that improve the capacity of the defense laboratory to recruit and retain personnel with needed scientific and engineering expertise; and
  - Revitalization and recapitalization of the laboratories.

Recommendations relating to where "as is" state is less than ideal

The SSC PAC and SSC LANT responses relating to this question are provided below. SPAWARSYSCOM has endorsed these responses and has provided additional input also included below.

SSC PAC INPUT (Recommendations)



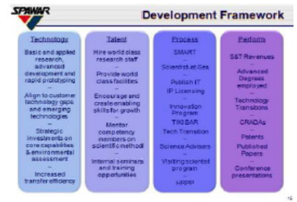
SSC LANT INPUT (Recommendations)

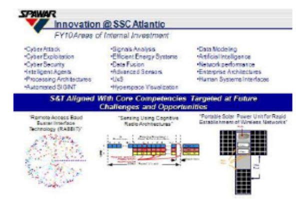
Q9 - Recommendations relating to where "as is" state is less than ideal

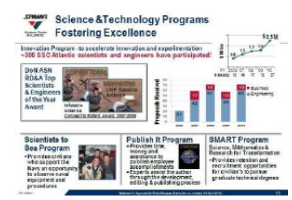
NRAC
Naval Research Advisory Committee

SSC LANT Input

- Develop mechanisms and incentives to recruit, retain, and provide on-off ramps into Naval S&T capability
- Reinforce establishment of effective partnerships with industry and academia
- Funded Visiting Researcher / Industry Mentor program
- Establish Navy-wide work shaping and acceptance process that provides clear swim lanes, and reduces overlap
- Establish/Reassign (6-30) Mission funded billets to develop and manage the S&T technical base and provide technical authority at the warfare centers with warfighting relevance
    - Warfare Centers should have greater influence over SBIR discretionary spending
    - Consider moving Naval S&T contracting to Warfare Centers providing focused interaction between S&T community and warfighter gaps
- Recommend effective Command and PEO research and engineering utilization of SSC Atlantic assigned swim lanes
- SSC Atlantic evolving facilities and infrastructure are inadequate to meet future requirements for cyber, data center, cloud computing, etc. Infrastructure investment is required to develop multipurpose, configurable labs and integration facilities







SPAWARSYSCOM INPUT (Recommendations)

NRAC
NAVAL RESEARCH ADVISORY COMMITTEE

Q9 - Recommendations relating to where "as is" state is less than ideal

In addition to SSC inputs, SPAWARSYSCOM adds:

SPAWAR HQ Input

- Requirements / Expectations for Systems Engineering increasing, but funding from Resource Sponsor declining
- IN 2009, ASN RD&A obtained a plus-up for Systems Engineering, but OPNAV N2N6 decremented the funding by an equivalent amount
- Without current 802/852 funding, would have no flexibility to respond to changing demand signal
- Section 802 - Resource Management Decision (RMD) 802 realigns funds for FY10 through FY14 in-sourcing. The Department of the Navy (DON) portion of this acquisition workforce growth is to in-source approximately 3,500 contractor positions. This effort, in conjunction with Section 852, is to identify proper size and skill mix requirements (based on demand signal analysis) in bringing core technical and business functions back into the organic acquisition workforce.
- Section 852 - Established the Department of Defense Acquisition Workforce Development Fund (DAWDF) to provide funds in addition to other funds available for recruitment, training, and retention to ensure the acquisition workforce has the personnel and skills to perform its mission, provide oversight of contractor performance, and ensure the Department receives the best value for the expenditure of public resources.

NRAC SPAWAR Sub-Panel Assessment, Summary

Warfare Center Technical Competencies

As was stated in the main part of the study, it has not been possible for the NRAC, in general, or the NRAC SPAWAR sub-panel, in particular, to perform a detailed assessment of the competencies of the Warfare Centers. Nevertheless, in order to try to independently assess the current status of Warfare Center technical capabilities and the future needed technical capabilities of the SPAWAR Warfare Centers, the NRAC SPAWAR sub-panel visited the SPAWAR Warfare Centers, SPAWAR Headquarters, the SPAWAR PEOs (C4ISR, EIS, Space, JTRS), DASN C3I, ONR, DARPA, and also talked with various industry representatives that work for and with the Centers. In addition, N2/N6, the OPNAV SPAWAR resource sponsor was interviewed to get their assessment of current and future technical capability needs.

In these visits, the sub-panel asked for opinions on current Warfare Center technical competencies, on deficiencies, on needs for the future and on suggestions for increasing the likelihood of meeting these needs.

There are three major results from these fact-finding activities. First, there is large variability in customer opinion of SPAWAR Warfare Center current technical competency. In addition, sometimes the customer assessments are quite different from SPAWAR self-assessments. In particular, PEO C4I, JPEO JTRS felt that SSC PAC/LANT represent solid resources for engineering talent and services. Likewise, MARCORSYSCOM started that they rely heavily on SSC LANT. However, DASN C3I gave them a mixed report card as did ONR and DARPA who stated that they use selected individuals or small groups at the Centers but not for leading edge S&T technology development. PEO Space and PEO EIS told the panel that they do not rely on SPAWAR Centers to support them to any significant degree because they felt that there were other more competent places for them to go for support. Second, the SPAWAR resource sponsor N2/N6 represents a major change in OPNAV organization, emphasizing a focus on Information Dominance and a move to invest more heavily on the left-hand side of the kill chain. This change results in the fact that many needed technical competencies, such as networking and EW will need to cut across SYSCOMS. N2/N6 felt that the technical competency/capability of the Centers required the exercise of “Technical Authority” (TA) by the SYSCOMs and that this authority was not assigned in many areas and was not being exercised in many of the areas in which it was assigned.

The N2/N6 representatives felt that SPAWAR was strong in C2, networks, data fusion, decision systems but weak in autonomous systems and cyber warfare. They felt that NRL was a key player in Cyber Defense, EW, data fusion, and decision systems, although very understaffed. Their opinion was that the “go to” place for unmanned/manned system C2 was NAVOCEANO.

Finally, they stated, emphatically, that although SPAWAR has specific TA responsibilities, Navy wide C4ISR TA is not well defined, disciplined or practiced. As stated at the beginning of this appendix, SPAWAR has nine clearly defined, though limited TAs.

In the material the sub-panel received, the closest acknowledgement of these nine SECNAV-assigned responsibilities is in the SPAWAR brochure entitled "Decision Superiority through Information Dominance" (page 3 listing of SPAWAR areas of expertise). Likewise, the exercise of technical authority by SPAWAR was only alluded to in one of the briefs by the SPAWAR Chief Engineer. A more expansive listing was in the SPAWAR engineering capabilities viewgraph which included C4ISR integration, sensor systems, mobile C4I systems, networks and communications, command center services, cyberspace and cyber warfare, anti-terrorism/force protection, intelligence/surveillance/reconnaissance, air traffic control, metrology and navigation systems and technical services, plus a list of eight lesser capabilities.

The Colvard 2006 study titled *Navy Warfare Center Study: A Look at the Navy's Technical Infrastructure* that was briefed to NRAC as background information for this Study included some observations which should cause us to not be surprised by what we are finding. The statement "we still have just in-time capability, but we lack just in-case capacity" was deemed apt then and it appears to be so now. The statement in the fourth paragraph on page 1 of that report addressed the lack of leadership and technical oversight of the warfare centers at higher levels and the absence of planning for the warfare centers' future. It appears to still be relevant. The limitation on investment in people and equipment imposed by Working Capital Fund (WCF) as an impediment to developing and maintaining technical competency in the workforce appears to remain today notwithstanding recent initiatives. In short, it appears that nothing has changed since the 2006 study except possibly the sanctioning of a bit more work in the centers from sources outside the Navy.

The SPAWAR Study Sub-panel could not see clear evidence of the exercise or stewardship of technical authority by SPAWAR. Absent clear plans to sustain currently known technical leadership/authority areas and absent clear identification of future essential technical areas, shortfalls will exist in needed technical competencies. The sub-panel could not say that either SPAWAR or the Centers could articulate the mandatory future needs in their areas of responsibility. It appears the Centers have the "just in time" capability, but are not prepared for the "just in case" capability. The Centers claim leadership in a wide array of areas, several of which are unique to the Navy/Marine Corps, but many are nice to have (and bring in WCF), but are not essential to the Navy.

Core technical competencies must reflect the maritime physical and operational environment. The uniqueness of the maritime domain and the impending integration of unmanned vehicles into the battlespace require that the Warfare Centers focus on the unique technical aspects of this paradigm shift.

NRAC Sub-panel recommended leadership and agile adopter areas

Integrated C4ISR is being pursued across the DOD and, to a lesser extent, in other operational areas of both federal and state governments. In addition, the Naval establishment is actively pursuing the modernization of and transition from legacy business management, personnel and logistics systems to integrated enterprise level systems. PEOs, DRPMs and SPAWAR are responsible for acquiring these capabilities for the Navy and Marine Corps. SPAWAR is the technical authority for these capabilities. To fulfill this function, SPAWAR and its Systems Centers, in support of the PEOs and DRPMs, must be able to both leverage applicable external technologies and to lead the Nation and the world in the areas which are unique to naval integrated C4ISR.

The Maritime Domain imposes some Naval unique environmental and operational factors into this challenge. The Naval unique effects of the maritime physical environment have been recognized for a long time as an area where the Navy must take the technical lead. These include navigation and precision timing in a GPS-denied area and reliable communications above, on and below water's surface and the adjacent land. When Naval forces are in port they are very similar to commercial sea going and land enterprises and they can and should exploit commercial technologies. However, when they deploy, they encounter very different conditions. Current Naval operations are moving away from large, self-contained strike groups to more distributed aggregations of diverse assets, including coalition units. This has precipitated a fundamental adjustment to existing operational concepts with the ever-expanding use of ad hoc, flexible, networks of traditional and non-traditional manned and unmanned platforms. However, many Naval technologies, especially those which required significant investment for development and support infrastructure, will remain in the inventory for a long time to come.

Finally, as the Department of Navy moves into the era of Information Dominance it must be capable of leveraging National and Joint information, combined with organic Naval force information, in order to dominate theater operations. In order to remain capable in the face of communications disruptions, damage to afloat forces, or damage to supporting ashore infrastructure, Naval forces must also maintain the capability of operating autonomously from the shore infrastructure when disruptions occur.

As DON transformed from sail to steam propulsion, from steam to nuclear propulsion, and battleship to carrier aviation warfare, new supporting infrastructure was required to make each of these transformations successful. The same situation applies to the transformation into information dominance. Unlike previous information technology eras where it was more expensive to store and process data than to move the relatively small amount of information being processed, technology advances have reversed this situation. Today's information technology advances have made it possible to store and process massive amounts of information relatively inexpensively. The new challenge has become the movement of data across radio frequency systems to include satellite communications, and even across shore based wide area networks.

The data movement challenge is a result of new sensor and platform technologies that make it possible to generate orders of magnitude more data today than was the case in earlier Naval eras. With the advent of small, inexpensive synthetic aperture radar and acoustic sensors, electro-optical and infrared imaging sensors, coupled with small full-motion video cameras that are easily placed on all sensor packages, it is not uncommon to create far more data than can be transmitted from the sensors to surface control or receiving stations during the period of sensor platform operations. As an example, the Navy's newest ASW aircraft will be capable of generating terabytes of information each day. A terabyte, while easy to say, is actually a million megabytes, or the equivalent of a million pictures from a modern digital consumer camera each day. Because processing and storage equipment have grown so fast, it is actually easy to process and store terabytes of information in spaces equivalent to a small office refrigerator. What is more difficult is moving this much data. For example, it would require 39 hours or almost two days of dedicated bandwidth, to move a terabyte of information using the Navy's current fleet support wide area network. Similarly, using current dedicated aircraft carrier satellite communications capability would require 15 days to move this much information. Even using DOD's future Wideband Global Satellite system, which improves the aircraft carrier capability by five orders of magnitude, it would still require three days to move this much data.

Clearly these challenges require that DON create alternative architectures to become an information dominant Naval force. In short, a data strategy and the resulting ashore and tactical afloat infrastructure will need to be created to be information dominant as new sensors and sensor platforms are deployed. In order to design, develop, and deploy this new infrastructure, the DON will need to rely on the capability of its technical workforce to support the programs that will put this capability into the service of today and tomorrow's Naval forces.

APPENDIX H

Marine Corps Systems Command

Marine Corps Summary

- MARCORSYSCOM, PEO Land Systems and MCWL are “customers” of NSWC’s and SSC’s for technical and engineering efforts totaling ~ $450M/FY
- Required NSWC and SSC Competencies
  - Interoperable C2; Radars; Sensors; Infantry Training Systems; MAGTF System Engineering Integration; Counter-IED Systems; Wheeled & Tracked Amphibious Vehicles; Small Arms Weapons; Expeditionary Power; Intel Systems
- Challenge for NSWCs and SSCs
  - Maintaining Marine Air Ground Task Force (MAGTF) Mission Expertise

Marine Corps Systems Command (MARCORSYSCOM) is the Commandant of the Marine Corps’ principal agent for acquisition. Part of that mission includes sustainment of systems and equipment used by the operating forces to accomplish their warfighting mission. The Marine Corps does not own or operate a warfare center, or any laboratory to conduct research and development for current or future systems. Rather, Marines act as a research and development (R&D) “customer” (through MARCORSYSCOM, MCWL, and PEO Land Systems) and rely predominately on Navy warfare centers to provide technical and engineering support efforts.

Excluding funds appropriated for ACAT I & II Programs, e.g., EFV, JLTV and MRAP, the annual Marine Corps R&D “baseline” level of funding is approximately $450 million. The key partners for MARCORSYSCOM are SPAWAR (Atlantic) and NSWC (Crane, Dahlgren, Panama City, and Corona). A list of technical competencies needed to conduct the R&D for Marine Corps needs includes some areas that are also of interest to the Navy (e.g. interoperable C2; radars; sensors, and Intel systems), as well as some areas that are more specific to the Marines (e.g. wheeled and tracked amphibious vehicles; infantry training systems; counter-IED systems; and expeditionary power).

The primary issue for MARCORSYSCOM is to ensure that the Navy SYSCOMS and Warfare Centers maintain the appropriate technical expertise to address and support the Marine Air Ground Task Force (MAGTF) mission.

APPENDIX I

NRL

NRL Summary

- NRL S&T successes materially contribute to Navy capabilities.
  - Navy specific needs – ocean & atmospheric prediction, acoustics
  - Space systems (GPS, satellite)
  - Electronic warfare, cyber-warfare
- NRL has excellent working relationship with some operational elements of the Navy (e.g. FNMOC, NAVO, space).
- NRL research portfolio (base funding) not managed as integral part of larger NavalS&T enterprise, thus not realizing full impact of Navy investments.
- Predominant focus on sustaining and improving existing capabilities, not on envisioning creating the next generation of revolutionary Navy capabilities, despite good 6.1 that could enable these capabilities.
- Transitions from NRL to Warfare Centers are problematic.
- General physical infrastructure and working conditions do not meet the needs of quality science/technology work.

Background

The 20th century witnessed the broad acceptance of science and technology in service to society. Early on, the Navy, along with a handful of industrial labs, pioneered the notion of the organizational laboratory, that is, a group of employees whose full time job was to discover and develop technology for practical use. Founded in 1923 at the urging of Thomas Edison, the Naval Research Laboratory (NRL) was established with the purpose of unleashing newly found physical properties of matter and energy for use in the theatre of war. At its beginning, NRL focused on areas of modern acoustics and radio, but the focus areas were swiftly augmented with the start of World War II to include materials, radar, and ballistics. Along with the growth in research topics, World War II saw a ten-fold increase in the size of NRL, with its employment growing from 400 to 4400 between 1941 and 1945. In 2010, NRL employs 2500 people, has a budget exceeding $1B, and performs R&D in areas defined by its four main directorates: Systems, Materials Science and Component Technology, Ocean and Atmospheric Science and Technology, and the Naval Center for Space Technology. The Naval Research Laboratory has three main sites, at NASA's Stennis Space Center in Mississippi, in Monterey California, and at its headquarters in Washington DC.

The Naval Research Laboratory was envisioned as the Navy's "corporate research laboratory", a term still in use. In 1946, Congress created the Office of Naval Research (ONR), which was the first permanent agency to sponsor scientific research and, indeed, provided the model for the National Science Foundation. From its inception, ONR has provided funding to researchers, mainly at universities, in pursuit of scientific knowledge and technology of interest to the Navy. As expected with university involvement, much of ONR's funding has supported published basic research. This research is "use inspired", via alignment with the DON S&T Strategy and under the direction of ONR program managers. NRL's base funding, which supports fundamental research (BA1 – BA3), is provided by the Chief of Naval Research (CNR) via ONR. Thus, ONR has viewed fundamental research as being performed via two routes: in-house at NRL and outsourced via grants to universities. The original motivation for ONR outsourcing fundamental research rested on a desire to engage a broader research community than could be envisioned at NRL. ONR research projects were guided by Program Managers who were mindful of the Navy relevance of the work, but were also aware of the long-term nature (and risks) of such research. While the NRL research portfolio has traditionally included some basic research (BA1), it has differentiated itself from the ONR-supported externally-performed research enterprise by the fact that much of the NRL work is in the applied research domain (BA2 and BA3). Organizationally, the assurance of the essential synergies and leveraging of these separate activities resides with CNR.

The ONR-NRL research enterprise has served the nation well for decades, producing DON-relevant knowledge and technologies that strengthen and enhance today's Navy and Marine Corps while also pointing the way toward the Navy-after-Next. However, the ways in which new knowledge and technologies are developed and delivered are rapidly changing. Today, the nation's foes have unprecedented access to advanced technology and are learning to use it in novel ways. While the degree to which the U.S. can rely on physical resources to prevail in conflicts is continuously decreasing, history has shown that by nurturing technological centers of great intellectual power, it is possible to continually prevail against unforeseen forces. As the nation's premier research laboratory dedicated to solving DON-relevant problems, The Naval Research Laboratory could and should be one of the nation's great technology assets.

The NRAC review of NRL entailed visits to three of NRL's primary sites, in Washington DC, Stennis, and Monterey. In addition, members of the group met with ONR leadership, as well as past NRL and ONR leadership. Numerous internal documents were obtained, including documentation of NRL's formal internal review processes.

Findings and Recommendations

Finding: NRL's S&T successes materially contribute to Navy capabilities

Throughout the years, researchers at NRL have made key discoveries and developed technologies of great importance for both the Naval enterprise and society. One highlight is the Global Positioning System (GPS), the development of which relied critically on NRL's timation technology that enabled clocks to be used in space by broadcasting accurate time reference signals to ground based receivers. The GPS system has radically altered both warfare conduct as well as civilian navigation. Another notable effort was NRL's work in the crystal structure of large biomolecules via x-ray diffraction. This work has speeded up the development of pharmaceuticals and was honored with the award of 1985 Nobel Prize in Chemistry to NRL researcher Dr. Jerome Karl.

In the areas of ocean and atmosphere prediction, NRL researchers have contributed to our fundamental understanding of physical processes while also developing new models and tools of critical importance to the Navy and Marine Corps. This work dates back to the 1940s, when NRL pioneered the development and deployment of instruments to monitor atmospheric conditions such as temperature and pressure. Basic research continues in areas such as air-sea interaction, coastal ocean dynamics, and computational oceanography have led to the development of advanced numerical atmosphere and ocean forecast systems that can be rapidly implemented at any location in the world. The fact that NRL Monterey is co-located with the Fleet Numerical and Oceanography Center, and NRL Stennis is co-located with the Naval Oceanographic Office and the Naval Meteorology & Oceanography Command, has created a unique grouping of operational oceanographers and ocean/weather forecasters with basic researchers who together produce leading-edge knowledge and technologies that support the DON mission around the world.

NRL's Acoustics Division, located at the DC headquarters, is internationally-known for its basic research programs in ocean acoustics, ocean environmental influences on acoustic propagation, and signal processing, to name a few. This activity dates back to one of the initial areas of research at the time of the founding of NRL, when the Sound Division conducted applied research and development to produce active, echo-ranging sonar systems that dramatically improved the detection of submarines. In addition to BA1 to BA3 research, the Division also conducts DON-critical RDT&E programs in underwater acoustics (active and passive), detection, classification, and tracking of underwater targets, and structural acoustics, among others. These activities provide essential support to the operational Navy.

In space technology, NRL has provided both advances in basic understanding and operational systems that have provided great benefit to the DON and to society as a whole. Perhaps the best known example of this success, alluded to earlier, is the Global Positioning System (GPS), which had its origins in NRL basic research activities initiated in the 1960s. The Naval Center for Space Technology has continued this legacy by conducting basic and applied research in various disciplines related to operating safely, reliably and effectively in space, including, e.g., optics and signal processing. Importantly, these research activities support the Center's systems engineering activities that include the development and acquisition of spacecraft, satellite payloads, ground command and control stations, and mission concept development.

The NRAC sub-panel was only able to sample a small fraction of NRL's systems activities. One of these activities was in the area of electronic warfare (EW), where NRL demonstrated current knowledge expertise, sufficient to address near-term challenges. One area of potential concern is that we were not shown examples of new concepts and/or basic research activities that would form the basis for whole new types of EW systems. Another area of NRL expertise is their work on cyber-security. It is impressive that NRL has been able to recruit and retain a solid team in this space, given the high competition for talent with commercial and defense industry players. The NRL team has a track record of developing and transitioning technologies to the Navy, e.g., to the Navy Cyber Defense Operations Command (via SPAWAR). The Naval Academy's Center for Cyber Security Studies also has an internship program through which midshipmen spend time working with researchers at NRL. Given the high degree of investment by the commercial sector and other defense players in this space, we recommend that NRL develop an aggressive 'agile adoption' plan through which it will identify Navy-unique needs in this space, shape external research, and augment emerging technologies so as to address those needs.

Finding: Weak Linkage of Fundamental Research Activities at NRL and ONR

As was discussed in the background section, the DON performs or supports fundamental (BA1 – BA3) research in a variety of ways. Fundamental research is performed at NRL and also in universities through ONR grants, administered via a competitive process. The fundamental research at NRL is funded in large part by the base budget, and projects are selected via an NRL-internal process. Much of this research, as mentioned above, is conducted with the Navy as the sole customer. However, a good fraction of the research, both at ONR and NRL, is in areas of science that have strong adjacencies to research funded by other agencies such as the NSF and DOE.

It appears that the two main mechanisms for determining DON fundamental research topics – ONR BAAs/Program Manager reviews and NRL internal reviews - are not coordinated at a single point. This coordination is especially important, since a key benefit of NRL's fundamental research activity is its pool of talented researchers who are qualified to have a "seat at the table" with the ONR-supported university researchers and are therefore able to amplify the value of the ONR funding by hybridizing the university results with their own and transferring the combined benefit to the warfighter. We thus recommend that the CNR oversee the coordination of the NRL and ONR research activities with the aim of achieving new synergies. In addition to the synergies of ideas and research results mentioned earlier, additional synergies could be realized via the shared use of specialized facilities (at NRL and at US universities) and via collaboration among NRL and ONR-supported researchers. Coordination at the CNR level would also provide greater insight into the needs of the SYSCOMs and WCs, since every project would benefit from the *combined* communication channels of ONR and NRL. This recommendation would also facilitate NRL's research community becoming better engaged with the external community. The type of coordinated administration envisioned here would not impact the independence of NRL's base funding, nor should it lead to NRL controlling ONR funding. In order for the present recommendations to work, it is essential that the leadership of both ONR and NRL be fully committed to increasing the combined impact of their research enterprises.

Finding: Focus on Incremental Naval Concepts

Based on the presentations made available to the NRAC, the predominant focus of the leadership appears to be on sustaining and improving existing Naval capabilities (e.g., in areas such as space, EW, oceanography, etc.). While the quality of much of this work is to be commended, there does not appear to be an appropriate balance between incremental improvements to existing capabilities and the pioneering of the revolutionary new concepts, systems & technologies that will provide the S&T underpinnings for the Navy-after-Next.

We recommend that NRL leadership actively encourage participation in the "competition of ideas" for the Navy-after-Next. This participation should take place both at the concept generation stage, where NRL researchers should be surfacing newly discovered S&T results and identifying new Naval capabilities that these results can enable; and at the concept development stage, where NRL researchers should be participating in Concept Development Teams (CDT's) and identifying and/or developing S&T knowledge that can enable selected concepts.

Finding: Technology Transfer

Although NRL has programs in place to facilitate technology transfer, there remains room for improvement.

- NRL does especially well in the transfer of technologies in areas where it has a direct relationship with the relevant command and/or PEO.
- NRL has difficulty effecting transfers to the warfare centers, a problem which NRL leadership attributes to the near-term focus of the technical expertise within the WC's.
- The transfer of systems-level results is further hindered by the FNC process which, in effect, limits BA3 funding to programs-of-record, making it difficult for NRL to transition research that can enable whole new systems and/or concepts.
- The transfer of component-level (vs. system-level) results may be especially problematic since the natural targets for these may be non-government entities (industry, UARCs, DoE, etc.) who, in turn, supply systems to the Navy.

We recommend that processes and incentives be developed and implemented to facilitate the exchange of technical personnel among NRL, ONR, the WC's, industry, and academia.

Finding: Physical Infrastructure

Although NRL's DC site has some scientific facilities of significant value, the overall physical infrastructure and working conditions at this site do not meet the needs of quality science/technology work.

While it is impractical to relocate the entire DC site instantaneously, we recommend that NRL develop a long term facility plan under which the current DC location should be gradually phased out. In particular, newly built and/or modernized facilities should be located at NRL's other sites and/or at an alternative location within the DC area. As part of the development of this plan, NRL should consider collocating some of its facilities with other research entities (e.g., universities, etc.).

Finding: Leveraging Non-DON Research Investments

Building on the NRAC's broader findings related to agile adoption, the committee believes that NRL is uniquely positioned to take a leadership role in experimenting with new processes for identifying and adopting externally developed technologies of significance to the DON.

NRL's substantial pool of basic research talent and long attention span uniquely qualifies it to be an outward looking organization that excels at the identification of emerging technologies of significance to the DON – independent of their source. Doing so will require that NRL researchers increase their interaction with university and other external researchers around the globe. It will also require a process and expertise through which a vast array of emerging technologies can be distilled down to a selected set of technologies to be monitored, shaped and (potentially) adopted.

- Once a technology area has been selected for monitoring and shaping, NRL will need to acquire additional strength in that area, by recruiting new talent, including visiting researchers.
- At a further stage of this process, NRL should develop the skills to identify Naval unique needs whose absence might preclude adoption of the technology (e.g., corrosion-resistance) and actively work to shape the agendas of external researchers, research funding agencies and/or standards bodies so that, to the extent possible, those needs are satisfied by the emerging base technology.
- Since not all Naval-unique needs will be satisfied through shaping, NRL researchers should explicitly target any remaining gaps that would preclude

DON's adoption of the technology. They should also target the creation of complementary "superiority technologies" that, when combined with the globally available base technology, will provide superiority over other adopters of the base technology.

- Finally, NRL should work with the WC's and engage the Navy and industry to smooth the adoption of the emerging technology, including its Naval-unique and superiority components.
- Success over the extended life cycle described above will require the sort of attention span and long term commitment to specific areas of technical expertise that NRL has already demonstrated through its basic research activities.

This report identifies a number of "agile adopter" focus areas in which NRL should be developing awareness and actively shaping external research agendas. In particular, the Energy space may be a particularly timely one for process experimentation. Larger investments in power generation and energy storage are being made in the US and globally and NRL could be actively surveying and shaping these external research activities so that they can, eventually, be leveraged for Naval unique uses.

APPENDIX J

UARCs

UARCs

- CONTEXT
  - UARCs represent 7% of overall Naval R&D Establishment (NRDE) Funding
  - There are 5 Navy UARC's, however, JHU-APL fits in a category distinct from the other 4 due to its size, facilities, breadth of focus, level of funding, & proximity to DC.
- UARCs are Distinguished By
  - Programmatic Independence ("speak truth to power") and for especially high quality research and analytic capability, e.g.,
    - JHU-APL ASW Assessment for OPNAV c. 2000
    - DDG-1000/DDG-51 BMD Assessment c. 2010
  - Close relationships with students and faculty of parent universities
    - UARC's serve as an invaluable and unique resource to recruit scientists and technologists into naval service
    - Grad students are "cost effective"
  - Ability to hire and pay top notch scientists and engineers at commercially competitive salaries and benefits
- Other Observations
  - Except for APL/UW, there is little 6.1/ 6.2 work (6.6% overall)
  - UARCs are perceived by some as "poaching" in areas of similar skills with Warfare Centers
  - Navy funding declining as a percentage of total UARC funding. (Less than ½ for JHU and UW; ~65% for PSU and UT; zero for UH

The NRAC UARC sub-panel members were:

- Capt. R. Robinson Harris, USN (Ret.), Chairman
- RADM John Tozzi, USCG (Ret.) Vice Chairman
- RADM Millard Firebaugh, USN (Ret.)
- Mr. Gerald Schiefer (former Director of Navy Laboratories)

The UARC sub-panel visited the following UARCs:

- Johns Hopkins APL,
- Penn State ARL,
- University of Texas ARL (Navy),
- University of Texas ARL (Army),
- University of Washington APL.

Johns Hopkins APL fits in a category distinct from the other 4 due to its size, facilities, breadth of focus, level of funding, and proximity to DC.

- Culture of Independence. Perhaps due to their being geographically located on campus with the parent university (except Johns Hopkins APL) and their not being co-located with naval installations, the UARCs have developed a remarkable sense of analytical and research independence. That is, they have repeatedly demonstrated an ability to conduct objective research and analyses and provide advice and recommendations to naval customers quite independent of the customers' possible programmatic bias. Prime examples include:
    - JHU-APL ASW Assessment for OPNAV c. 2000,
    - DDG-1000/DDG-51 BMD Assessment c. 2010.
- Resources. The "culture of independence" would be meaningless were the resources, personnel and facilities, at the UARCs not of high quality. The NRAC investigation suggests that UARC personnel and facilities resources are indeed of high quality. This results from the fact that the UARCs are able to hire technical staff at commercially competitive salaries and benefits. They are able to attract and retain quality personnel. Moreover, the UARCs are able to capitalize and amortize physical facilities much like those in the commercial sector. As a consequence the UARC facilities are competitive with the best.
- Navy Funding. Navy is no longer the principal (majority) funding source for the UARCs at Johns Hopkins APL, the University of Washington APL, and the University of Hawaii ARL. Navy is responsible for less than less than 2/3 of the funding for the Penn State ARL and University of Texas ARL. It is not clear that this has any negative effect on the type or quality of work that the UARCs perform for the Navy.

The sub-panel visited the following UARCs for information/data collection/laboratory tours:

- Johns Hopkins University, 28-29 January 2010,
- Penn State University, 20-22 January 2010,
- University of Texas, 7-8 April 2010,
- University of Washington, 6 May 2010.

Due to its recent establishment, the sub-panel did not visit the UARC at the University of Hawaii. Prior to each visit the UARCs were requested to address the following points:

- Description of current programs and funding levels,
- Areas of interest or potential interest to USN in which subject UARC is the acknowledged scientific/technical leader,
- Areas of interest or potential interest to USN in which subject UARC is one of the academic leaders with significant scientific/technical knowledge,
- Areas where other technologies in government, commercial sector, or throughout the world are leveraged by subject UARC,
- Inhibitors to achieving and maintaining state of the art knowledge in competencies/capabilities vital for DON success in the context of the Maritime Strategy,
- Any needed technical competencies/capabilities that URAC is missing or threatened,
- Priorities for adding technical capabilities needed today or in future,
- Subject UARC Faculty/Staff highlights,
- Overview of subject UARC laboratories/infrastructure/technical facilities,
- Scientific/technical areas that Navy should be investigating but is not.

Background

The Navy-sponsored UARCs (Penn State, Johns Hopkins, University of Texas, and University of Washington) trace their roots to laboratories that were established during WWII. At that time there was a need to tap into the academic talent pool to develop technologies to support the needs of the military. Indeed, ~140 laboratories were established during the 1930s and 1940s. They made highly successful contributions to the development of technologies such as radar and sonar, among others. At the close of WWII many of the laboratories were closed or transferred to the military as their parent universities chose not to continue with classified research. Many of today's Navy Warfare Centers, e.g., Naval Surface Warfare Center Dahlgren Division, trace their origin accordingly. On the other hand, Johns Hopkins, Penn State, and the University of Texas elected to continue work on national security technology and over the past 60 years these UARCs have made important contributions to national security as will be detailed below.

In addition to their common roots in connection with WWII, the UARCs also share a common interest in underwater acoustics and various submarine and anti-submarine warfare systems and technologies. For example:

- Penn State: Undersea weapons propulsion, large UUVs, propulsor acoustic design, power and energy systems for undersea applications, etc.

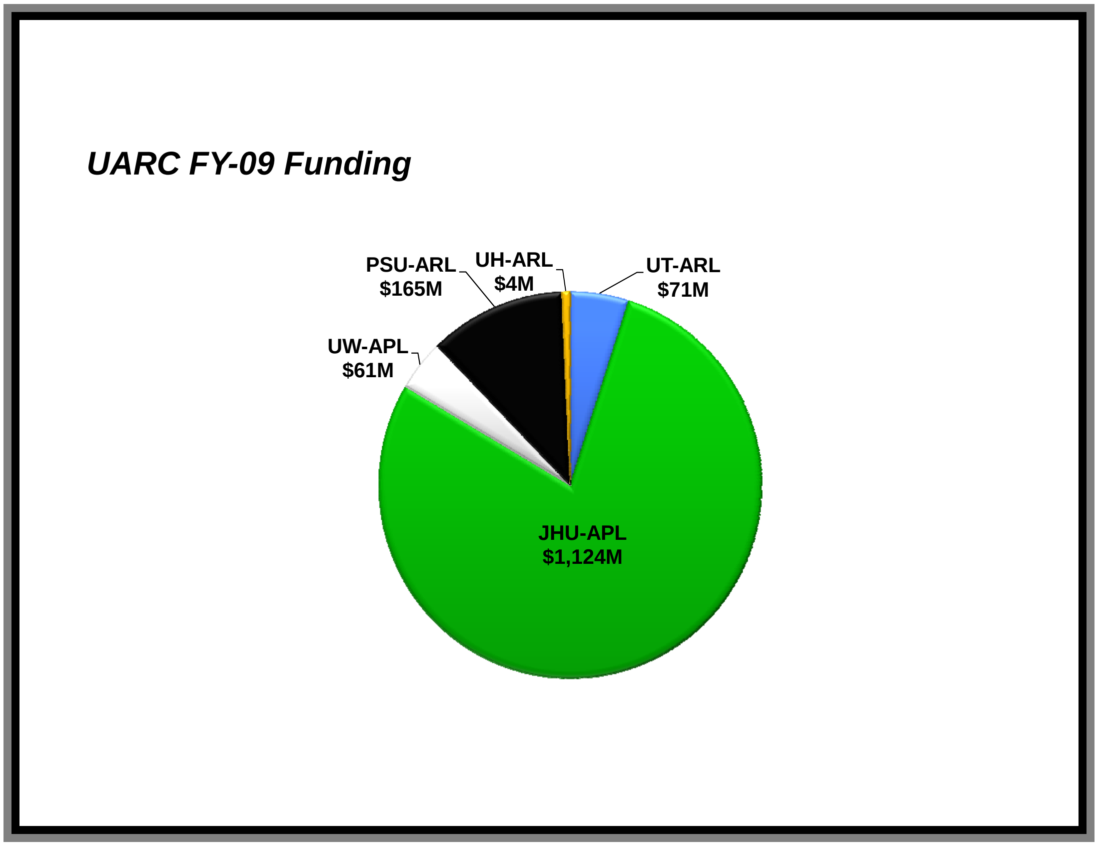
- University of Texas: High frequency sonar for mine hunting, obstacle avoidance, reconnaissance, classification, swimmer detection, precision bathymetry, environmental characterizations, under ice and ocean bottom navigation.
- Johns Hopkins University: Strategic systems test and evaluation, submarine security and survivability.
- University of Washington: Fundamental research to understand the physics of ocean processes and the dynamics of ocean motions and understanding and predicting the performance of Navy sensor, weapons and the systems which operate in the maritime environment.

All of the UARCs have made important contributions in the acoustics/ASW areas. The interest in these areas no doubt began with the emphasis on ASW during WWII and only grew in importance during the Cold War. That said, the UARCs have broadened their interests significantly as will be highlighted below.

Findings

(1) The UARCs represent a small percentage of the overall Naval Research and Development Establishment (NRDE) expenditures: < 10 per cent.

(2) There are five Navy UARC's, but Johns Hopkins APL is distinct from the other four due to its size, facilities, breadth of focus, and level of funding. For example, Johns Hopkins APL funding for FY-09 was ~$1B while funding for the other UARC's was considerably smaller: ARL Penn State, ~$165M; ARL Univ. of Texas, ~$71M; NRL Univ. of Washington, ~$61M; Univ. of Hawaii, ~$4M. (See graphic below).



Regarding the size of Johns Hopkins, its leaders made a business decision to cap its growth in order to avoid the challenges associated with" boom-and-bust" cycles and, consequently, to preserve the quality of its workforce and their work.

(3) Our survey of the UARCs suggests that they are distinguished by:

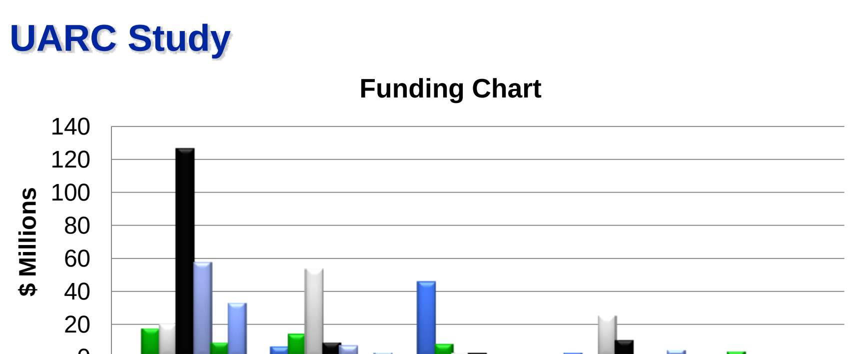
- The ability to hire and pay top notch scientists and engineers at commercially competitive salaries and benefits,
- The ability to focus on sponsors' critical challenges rather than increasing share owner value as does industry,
- The ability to offer Navy program managers access to highly competent technical resources that are relatively free from conflicts of interest,
- A business model that allows responding rapidly with staff and facilities to meet time critical sponsor needs,
- The ability to invest at UARC discretion, as compared to government organizations, in developing capabilities needed for the future via Independent Research & Development and capital investments.

(4) The URACs have a reputation for programmatic independence and for high quality applied research and analytical capability. Examples include:

- OPNAV quandary regarding ASW in the early 2000s. Johns Hopkins APL and the University of Texas ARL were called upon to render independent, objective analyses and recommendations,
- 2009-2010. OPNAV called upon John Hopkins APL to conduct an analysis regarding which platform to use for missile defense (new design start or re-start DDG-51 with modifications.). Personnel from the Naval Warfare Centers were involved in both these studies.

(5) The UARC's have a rich tradition which continues today of a close relationship with the students as well as the faculty of their parent universities. Whereas the Warfare Centers have summer interns from various universities, the UARC's have undergraduate and graduate students in their labs throughout the academic year. Moreover many of these students decide to remain in the government at the UARC's, Warfare Centers, Program Offices, etc. after they graduate. Accordingly, the UARC's provide a valuable and unique resource to recruit scientists and technologists into naval service.

(6) With the exception of the University of Washington APL, the UARCs conduct very little basic research (BA 1/6.1) and the BA 2 has steadily declined. The University of Washington, the exception, focuses primarily on basic oceanographic research. The other UARCs focus primarily on applied research and demonstration funding (BA 3-5). (see graphic below)



Funding Type	JHU-APL	PSU-ARL	UW-APL	UT-ARL	UH-ARL
6.1	0	6.1	45.5	2.3	0
6.2	17.5	14	7.9	1.1	3.5
6.3	20	53.5	2.3	25.1	0
6.4	126.7	9	2.4	10.4	0
6.5	57.5	6.9	0	0.631	0
6.6	9	0.7	0	0	0
6.7	32.7	2.8	0	4.4	0

Assessment

As noted above, the NRAC UARC Sub Panel requested the UARCs to identify those areas in which they are "world class" leaders. Below are the results of the UARCs self-assessment:

ARL Penn State

- Undersea Weapons: Design and Prototyping, Guidance and Control Technology, Sonar Front End / Acoustic Guidance, Underwater Engagement Modeling & Simulation, In-Water Testing,
- Fluids and Structural Acoustics: Acoustic tailoring for marine applications, Propulsor acoustic design, Overset meshing methods, Multiphase flow modeling of supercavitation,
- Power and Energy Systems for Undersea Applications: Heat Exchangers, Compact Condensers, Impulse Turbines, Sterling Engines, Metal Combustion,
- Large Diameter Unmanned Undersea Vehicles: Autonomous Operation, System Design / System Integration, ISR Payloads, At sea demonstration of large UUV systems,
- Materials and Manufacturing: Marine Composites –analysis, design fabrication, test; Advanced Laser Processing Technologies for DOD Applications.

ARL University of Texas

- Characteristics of the medium relative to the ocean acoustic environment and its effects on undersea warfare systems,
- Electromagnetic propagation in atmosphere, troposphere, and ionosphere environments and its effects on electromagnetic information warfare systems,
- High Frequency sonar as applied to war fighting application including mine hunting, obstacle avoidance, reconnaissance, classification, swimmer detection, precision bathymetry, environmental characterizations, under ice and ocean bottom navigation and intelligence collections,
- Acoustic and electromagnetic properties as related to target characteristics, including countermeasures, sensors, and signal processing,
- Signal and information processing and display as applied to acoustic, electromagnetic and electro-optical systems including advanced display/format technology, source and array technology, spatial and temporal processing, and high order spectral methods,
- Navigation and precise location in space, air, water, and on land, including geodetic, acoustic, seismic, and electromagnetic applications,

- Command, control, communications, computers, and intelligence (C4I) as applied to information warfare, modeling and simulation, synthetic forces, C4I Testing, electromagnetic instrumentation and innovation computer hardware and software development,
- Mission related and public service oriented research, technology development, test, evaluation and systems analysis required to provide a quick response to rapidly evolving DOD and other government agency requirements through the application of the above core competencies, along with the complimentary capabilities of the other divisions of the University of Texas.

Johns Hopkins University- APL

- Detection systems information fusion,
- Confidence-based test and evaluation,
- Solar system science and exploration,
- Information assurance.

Also, Johns Hopkins APL assesses itself as a "Fast Follower/Early Adopter" in the following areas:

- Information Systems, Engineering and Networking,
- Cognitive Engineering,
- Sensors and Sensor Systems,
- Maneuvering Body Technology,
- Autonomous Systems,
- Modeling and Simulation,
- RF Technology.

ARL University of Washington

- Ocean Acoustics and Remote Sensing,
- Ocean Physics and Engineering,
- Medical and Industrial Ultrasound,
- Polar Science and Logistics,
- Environmental and Info Systems,
- Electronic and Photonic Systems,
- Experimental Oceanography,
- Acoustic Propagation,
- Underwater Instrumentation and Equipment,
- Marine Corrosion,

- Acoustic and Related Systems,
- Simulation and Signal Processing,
- Mission Related and Public Service Quick Response Research, Development and/or Engineering.

Also, ARL University of Washington assesses itself as having "Parity with the State-of-the-Art" in the following area:

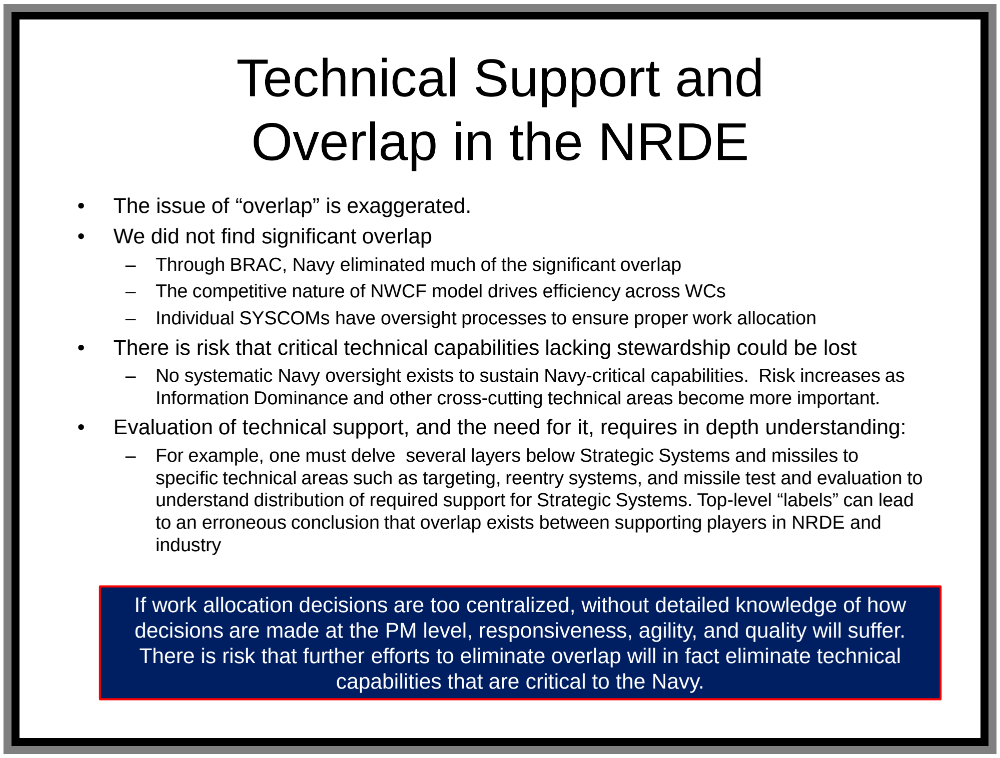
- Wet End engineering of interactive, regional, cabled-to-shore ocean observatory data.

Conclusion

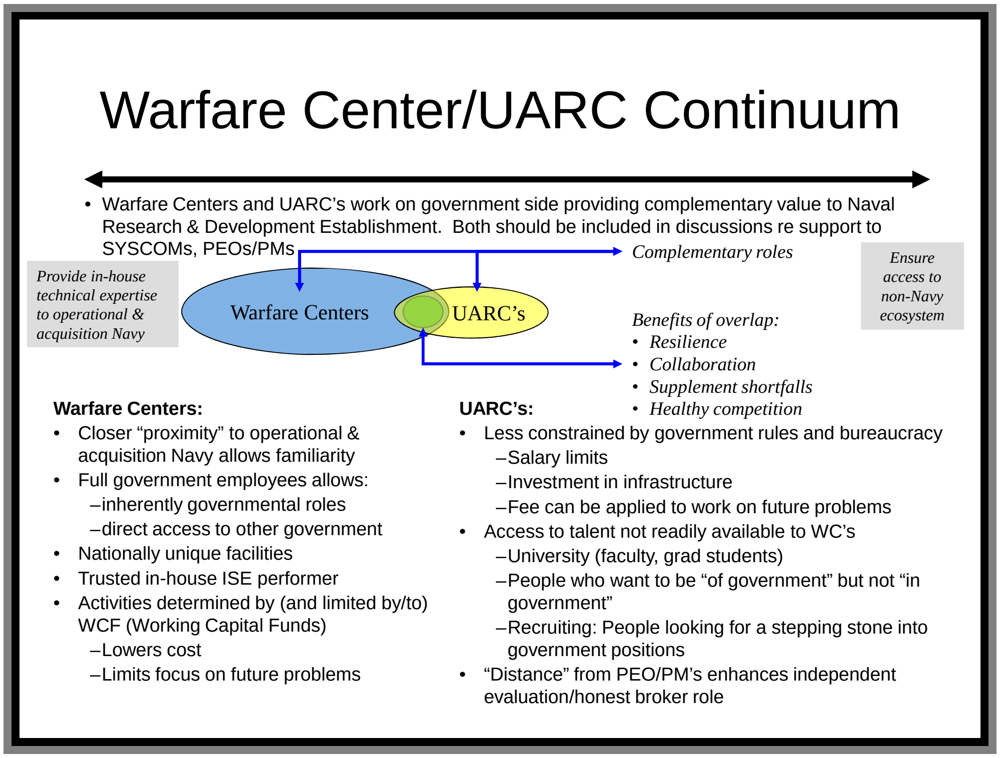
As noted above, the UARCs have gained a reputation for highly independent and objective analysis and research. In the opinion of the NRAC UARC Sub Panel, that characteristic most differentiates the UARCs and renders them of unique importance to the Department of the Navy.

APPENDIX K

Technical Support and Overlap within the NRDE



As beauty is in the eye of the beholder, technical support of program offices in the Navy may be based on technical capabilities and defined roles and responsibilities, necessary or unnecessary competition, overlap/redundancy, or entrepreneurialism run wild. But the judgment of the nature of the technical support, and the need for it, unfortunately depends on a detailed knowledge of that technical support several layers down into the program details. Often opinions are formed as to the "goodness/necessity" of the specific technical support in a vacuum, relatively speaking, and based on superficial information.



The chart above illustrates the complementary "real estate" on which the SYSCOM Warfare Centers and the UARCs operate. Note that there are some technical areas in which both derive customer support.

An exemplar of a highly disciplined program where various Warfare Center (WC) sites and UARCs all play carefully defined roles (very significant private industry support is not addressed here) is the Strategic Systems Program Office (SSPO). Section (1) below describes the roles and responsibilities of the WC and UARC community and the accompanying technical capabilities that these roles are based on. Note that at the "strategic systems" level, or even the "missile" level there appears to be redundancy. But as one delves into the specific technical capabilities that are being utilized, a different picture emerges. SSPO is a well informed customer who goes to the best place for its specific needs and ensures discipline in the system, while ensuring all the players work together as a team. And the people at these sites represent the Navy's corporate knowledge about the details of these critical Navy systems.

Obviously this is a very good example of technical collaboration and the utilization of appropriate capabilities wherever they reside. Other examples can be found where sites are maintaining duplicate capabilities for good and sufficient reasons (explosives buildings that can disappear spontaneously is one good example, Section 2), there is a need for real competition or risk mitigation, or where entrepreneurialism or customer dissatisfaction have led to duplication and redundancy, some of it unnecessary.

Remember that under BRAC, we have spent a lot of time and money over the last two decades eliminating many of the egregious examples of overlap by purifying technical capabilities, collocating major technical capabilities at specific sites, building new facilities, and either moving people or hiring new people. Since 1992, under BRAC, numerous sites have been closed and the total population of the WCs has been reduced by approximately 48% (Figure 1 contains more summary information). And considerable effort has gone into consolidating capabilities at single sites (Section 3).

In addition the Warfare Centers and SYSCOMs have processes in place to maintain discipline in the system and prevent too many of these redundancies from re-appearing. In some cases consolidation is currently under way, but often this is accomplished in a staged manner to ensure the preservation of critical technical capabilities as corporate knowledge is transferred from one site to another (Attachment 4). In other cases, multiple sites within the Warfare Centers and JHUAPL are cooperating to ensure support of critical programs that require capabilities resident at various sites (Section 5).

Our visits to program offices and field sites have demonstrated that well informed, disciplined program managers can obtain work from the WC system very effectively, while avoiding the creation of unnecessary redundancy in the system. There will always be a constructive tension between the program managers' desire to have freedom in choosing where and how they get technical support and the larger Navy's desire to centralize the decision process for the sake of anticipated (or perceived) efficiencies. As long as customers have the capability to go wherever they feel they need to in order to get technical support, there will be the risk of further redundancy. But if the system centralizes the buying decision too far, the Navy will pay a steep price in reduced responsiveness and agility. Only a detailed examination of how this process is done today can lead to informed decisions as to whether to modify it.

Section 1

Naval Surface Warfare Center and Johns Hopkins University Applied Physics Laboratory Technical Capabilities Aligned to Strategic Systems Program Office.

This documents the Naval Surface Warfare Center and JHUAPL Technical Capabilities supporting the Strategic Systems Program Office (SSP). NSWC and JHUAPL relations with SSP span over four decades during which time an experienced workforce has been developed which provides full spectrum support. NSWC Carderock, while not historically a primary NSWC Division supporting SSP, has recently been funded to support the design and development of the Common Missile Compartment for the United Kingdom's Successor Program, the Vanguard Class replacement.

The following NAVSEA Surface Warfare Center Divisions (with associated Technical Capabilities) and JHUAPL provide support to the Strategic Systems Program Office.

NSWC Dahlgren Division:

- SLBM Fire Control Software, development and lifecycle support, SLBM Targeting & Mission Planning Software, SLBM Strategic Targeting System Level Testing, development and support of UK SLBM Fire Control and Targeting Software, design and development for SSGN Attack Weapon Control System, SLBM trajectory modeling, simulation and analysis. Technical Capability - Strategic Mission Planning, Targeting, and Fire Control Systems.
- US/UK Strategic Reentry Systems and technical support, Reentry System analysis, testing and support with emphasis on materials development and aero/thermo analysis, SLBM Extended Navy Test Bed for Reentry Systems, alternate warhead and component and subsystem evaluation. Technical Capability - Re-entry Systems.

NSWC Crane Division:

- Ordnance & Power Systems; D5LE Flight electronics and sensors design and development, radiation sciences, flight sensors and printed circuit board failure and material analysis, qualification testing, lot acceptance testing, D5 and D5LE launcher and missile mechanical support equipment, fire control, launcher and navigation hardware acquisition support, obsolescence management, failure and material analysis and critical parts storage. navigation acoustic sensors - Technical Capability - Strategic Systems Hardware Engineering, AE & Sustainment.
- D5LE Missile and Test Missile Batteries, navigation system batteries – Technical Capability – Energy and Power Source AE, ISE, T&E and Sustainment.

NSWC Corona Division:

- Quality and mission assurance policy, instructions, requirements, and program development guidance, quality and mission assurance assessments of development and production programs, surveillance testing, reliability analysis, data management and SSP Trouble Failure Report. Technical Capability - Metrology, Test, and Monitoring Systems Assessment.
- Metrology and Calibration. Technical Capability - Weapons Systems Interface Assessment.

NSWC Indian Head Division:

- Propellants and Double Base Casting Powder for SLBM launch, manufacture and manufacturing technology, energetics manufacturing technology RDT&E and engineering, energetic chemicals process scale-up and manufacture, pyrotechnics manufacture, DEMIL (Navy's Demilitarization Program) and static firing tests for small ordnance from TRIDENT C4 assets. Chemical and mechanical testing of all C4 booster motors. Igniter Redesign Program for SLBM propellants. Technical Capability - Energetic Materials.

NSWC Carderock Division (Common Missile Compartment):

- Studies to support the development of modern corrosion prevention and control technologies to reduce maintenance. Technical Capability – Surface, Undersea and Weapon Vehicle Materials.
- Development of Pressure Hull Confirmation design and analysis tools and testing of confirmation models and bulkhead design. Technical Capability – Surface and Undersea Vehicle Structures.
- Development of shock requirements. Technical Capability - Surface, Undersea and USMC Vehicle Vulnerability Reduction and Protection.
- Modeling tool development and refinement of models for different ship signature types. Technical Capability – Surface and Undersea Vehicle Underwater Signatures, Silencing Systems and Susceptibility.
- Support to an Analysis of Alternatives Study as directed by ASN RDA. Technology Capabilities.

JHUAPL (Weapon System Independent Evaluator)

- Responsible for understanding the physical and engineering principles underlying the performance of the Navy’s strategic weapon system, and for applying those principles to develop and implement a disciplined testing protocol to evaluate and predict system performance. Requires an expert team of engineers and analysts who have domain knowledge of each of the subsystems of the weapon system, as well as the environment and operational constraints within which the system must function. It also requires establishment of an extensive database of system operational performance from SWS patrol and flight test operations.

Section 2

Energetics Risk Mitigation and Technical Capabilities:

- Indian Head, NSWC and China Lake, NAWC have duplicative facilities to develop explosives, and test and evaluate almost all characteristics of explosives. This is necessary risk mitigation due to the hazardous nature of explosives development, testing, and evaluation in that an explosive accident can destroy an explosives capability or building in an instant. The need for duplicate facilities is driven by the unique nature of Navy explosives in use. Many are insensitive due to shipboard use and therefore unique to the Navy. Underwater explosives are especially formulated for their special underwater applications. As such, the Navy must maintain at all times the corporate knowledge and capabilities to test and troubleshoot Navy explosives and warheads. In addition various WC sites have technical capabilities that are critical in supporting the utilization of explosives and weapons in the Fleet. NSWC Dahlgren maintains a capability for weapon design, Crane for pyrotechnics, and Carderock for shock/survivability testing. NSWC Indian Head's mission is principally energetics and/or energetic systems. It maintains the largest energetics capability, covering S&T through a significant manufacturing capability. NAWC, China Lake, with its large infrastructure and land mass is able to perform live fire testing of ordnance systems that could not be performed elsewhere. Thus all of these sites collaborate in the support of Naval systems in the Fleet.

Section 3

Examples of BRAC Consolidations:

- BRAC Transfer of Surface Warfare Integration Capabilities from Port Hueneme to Dahlgren:

  The 2005 Base Realignment and Closure Commission (BRAC), recommendation #184, realigned the Fleet Combat Training Center, CA (Port Hueneme Detachment, San Diego) by relocating all weapons and armaments weapon system integration research, development, and acquisition, test and evaluation to the Naval Surface Warfare Center Dahlgren, VA. This realignment consolidated surface warfare integration and established a Navy Surface Weapons Systems Integration specialty site at Dahlgren, VA. As part of this action, the project provided for new construction at Dahlgren to consolidate technical research for the purpose of integrating and certifying Non-AEGIS combat systems prior to deployment. The relocation of the Fleet Combat Training Center Port Hueneme

Detachment function now co-locates the AEGIS and Non-AEGIS integration and certification functions at a single site. Every AEGIS and Non-AEGIS (SSDS combat system) proposed for deployment can be replicated on actual host computers and tactical hardware prior to going to sea. By making use of wrap-around simulation environments, NSWCDD can execute engineering and performance tests with accuracy and repeatability. Coupled with the proximity of instrumentation, test tools, and subject matter experts, land-based certification testing for a majority of the US fleet can occur using common processes and procedures. The new Dahlgren facility is rapidly reconfigurable and capable of supporting multiple combat systems concurrently, providing a unique capability to construct and test a land-based battle group comprised of representative ship classes. Large bandwidth fiber connectivity between buildings not only allows interoperability testing within the navy battle group, but provides a conduit to the external environment to test with other Navy and Joint systems, as well.

The longer-term effects of consolidating the Non-AEGIS and AEGIS combat systems under a single management structure is the potential for migration to common components and elements across both large deck platforms (CV/LHD/LHA) and combatants (DDG/CG) in an open architecture. The consolidation of surface navy combat systems integration at a single site puts in place steps to decrease duplication, increase commonality, reduce development and life-cycle costs, and introduce an open architecture whereby new capabilities can be introduced quickly and more affordably across multiple platforms.

- BRAC relocation of the Towed Array Handling Equipment Facility (TAHEF) from Naval Surface Warfare Center (NSWC) Crane to the Naval Undersea Warfare Center (NUWC) Newport:

The1991 BRAC consolidation plan provided approval to transfer OK 276 and OK 542 product lines at the completion of OK 542 production. PMS 435 and NAVSEA approved the transition of the OK 276 and OK 542 and the establishment of an OA-9070 depot in March 1998, . Subsequent to the initial certification efforts the TAHE Facility successfully completed ISO 9000-1994 registration in December of 2001 and the TAHEF continues to maintain its certification to the current ISO standards (ISO 9001:2008).

This realignment consolidated D level operations with all towed array handling equipment technical functions, Design Agent (DA), Technical Design Agent (TDA), In-Service Engineering Agent (ISEA) and Fleet Training into at a single site. As part of this action minor modifications were required to existing facilities at Division Newport, these modifications enabled improved operations and expanded ISEA capabilities, with an overall reduction of facility footprint. Additionally, training was expanded to allow fault isolation and repair of faults by providing students with practical “hands-on” training utilizing a variety of towed system handler units/equipment located at the TAHEF and the Towed Systems Land Based Test Facility (LBTF).

The TAHEF operates similar to a Government Owned Contractor Operated (GOCO) facility with NUWC Newport providing Operations Management and Financial Administration functions and BAE Systems providing the technician labor and operational support functions. Advantages of the TAHEF organizational structure are; Contractor labor pool provides qualified technicians available for workload surge; Flexibility to reassign personnel when workload is fluctuating; Leverages existing NUWC Newport TDA and ISEA engineering expertise to provide best value, lowest cost and most efficient organization for the Navy.

This consolidation of overhaul repair and engineering activities into a single location has led to increased opportunities to closely integrate ISEA and TDA development activities resulting in quicker fielding of engineering design improvements and robust maintenance standards along with expanded training opportunities by allowing Fleet personnel to train on actual equipment. The success of the TAHEF has resulted in an increase in the breadth of its product line to now include the OK-410 surface ship array handling system and submarine Outboard Sensor Assembly (OSA) magnetic and acoustic sensors. The consolidation of towed array handler equipment activities at a single site decreased duplication of engineering staff and facilities, increased commonality, reduced developmental and life-cycle costs, and quickly introduced design improvements that resulted in improved system availability.

Section 4

Consolidation of Surface Electronic Warfare Capabilities within NSWC:

- A principle goal in the 2003 NAVSEA Warfare Center alignment was to eliminate unwarranted duplication and ensure the right work migrated to the right site based on a unique set of site-specific Technical Capabilities (TC’s). An area that received significant attention by the Warfare Center Board of Directors (BOD) was Electronic Warfare (EW). The BOD conducted a thorough review of workload and capabilities across all Divisions in EW and concluded, in consultation with customers, that EW work should be realigned to the following end state:

- Critical mass exists at NSWC Crane through leverage of a variety of EW Programs. Knowledge and skills resident at Crane support the entire life cycle.
- NSWC Crane assumes "Cradle to Grave" responsibility for Surface EW systems and components and is focus for EW systems intellectual capital.
- NSWCDD maintains combat systems integration role for the EW systems and components.

- TC definitions were modified accordingly, and transition plans to realign work in support of relevant programs were developed.

- Since the BOD decision, transition of workload to the final end state has occurred more slowly than originally planned, sustaining a limited amount of duplication between Crane and Dahlgren. Reasons are:

  - Crane is still gaining insights in to the technical complexities of several program support areas
  - Crane continues to develop the requisite knowledge, skills and abilities to fully execute its "Cradle to Grave" responsibility.
  - Until such time as a) and b) are resolved, the Warfare Center will retain critical skills at Dahlgren.

Section 5

Collaboration Across the Technical Community on Navy and Marine Corps Airborne Electronic Warfare (EW):

- A good example of collaboration in support of various Navy and Marine Corps programs is the JATO (JAmming Technique Optimization) Program under PMA-234 and PMA-265. It was begun in 1984 to coordinate testing of new jamming waveforms on the EA-6B ALQ-99 Universal Exciter. It has evolved and grown to coordinate the jamming technique development and testing efforts of NAWC Point Mugu, JHUAPL, Naval Research Lab, NSWC Crane, and others. The JATO Program generates Techniques, Tactics and Procedure (TTPS) recommendations tailored to threat theaters as well as specific missions and threat combinations. It also has grown to support other programs (EA-18G, EP-3, MARCORPSYSCOM) as well as providing guidance on requirements for future EW systems. The JATO process is designed to prioritize program needs, while factoring in urgent real time Fleet requirements. The JATO products range from program acquisition support to operational jammer techniques, tactics, procedures and strategies.

- The high productivity of this effort, which includes real time responsiveness to Fleet tactical needs, is due to the high degree of collaboration between a number of activities who understand their clearly defined roles that draw on their particular capabilities and a program office that enforces disciplined teamwork among the activities. JHUAPL is lead for Communications Electronic Attack (EA), radar and communications, modeling and simulation, and systems engineering. It also provides modeling and analysis on radar/communications threats. NSWC Crane provides depot maintenance support, sustainment engineering, logistics support, and some systems engineering for the next generation system. NAWC, Pt Mugu is lead for Fleet liaison, Radar EA, and Testing and provides extensive product support. NRL provides a communications lab and product support. Various other sites across the country (NAWC, China Lake; NSAWC Fallon, NV; several VXs, etc) are also involved in this highly collaborative effort.

Summary

NLCCG Community change since FY92

Total Workforce	-48% (-35,000)
Business Base*	+25%
Scientists & Engineers / Total Workforce	+16%
Centers' Overhead Cost*	-50%
Centers' Productive Ratio	+20% (to 80%)
Business Base to Contract	+11% (to 77%)
Centers' Average Stabilized Rate*	-$3 / hr
Average S&E Age	+5.6 yrs (to 43.8)

(As of 30 SEPTEMBER 2008) *AFTER INFLATION

APPENDIX L

Acronyms

A2/AD	Counter Anti-access & Area Denial
APL-PSU	Applied Physics Laboratory of Penn State University
ARL-UT	Applied Research Laboratories of the University of Texas
ARL-UW	Applied Research Laboratory of the University of Washington
ASN (IE)	Assistant Secretary of the Navy (Installations and Environment)
ASN (M&RA)	Assistant Secretary of the Navy for Manpower and Reserve Affairs
ASN(RDA)	Assistant Secretary of the Navy for Research, Development and Acquisition
BA	Budget Activity
BAMS	Broad Area Maritime Surveillance
BRAC	Base Realignment and Closure
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
CMC	Commandant of the Marine Corps
CNAF	Commander, Naval Air Forces
CNO	Chief of Naval Operations
CNR	Chief of Naval Research
CONOPS	Concept of Operations
DARPA	Defense Advanced Research Projects Agency
DCMC Air	Deputy Commandant, Aviation
DNL	Director of Navy Laboratories
DNRDE	Director of Naval Research and Development Establishment
DON	Department of the Navy
EW	Electronic Warfare
FNC	Future Naval Capabilities (ONR)
FNMOC	Fleet Numerical Meteorology and Oceanography Center
Gen-Y	Generation "Y" (aka Millennial Generation)
GDP	Gross Domestic Product
HE/AT	High End Asymmetric Threat
HR	Human Resources
IED	Improvised Explosive Device
ISE	In-Service Engineering
JHU-APL	The Johns Hopkins University Applied Physics Laboratory
MAGTF	Marine Air Ground Task Force

MARCORSYSCOM	Marine Corps Systems Command
MCWL	Marine Corps Warfighting Laboratory
MILCON	Military Construction
MILSATCOM	Military Satellite Communications
N2/N6	Directorate of Information Dominance (N2/N6)
NAVAIR	Naval Air Systems Command
NAVO	Naval Oceanographic Office
NAVMAT	Chief of Naval Materiel
NAVSEA	Naval Sea Systems Command
NAVSSES	Naval Ship Systems Engineering Station
NAWC	Naval Air Warfare Center
NDAA 2009	(Rep.) Duncan Hunter National Defense Authorization Act for Fiscal Year 2009
NLCCG	Navy Laboratory/Centers Coordinating Group
NLCOC	Navy Laboratory/Center Oversight Council
NOS	Naval Ordnance Station
NRDE	Naval R&D Establishment
NRL	Naval Research Laboratory
NTM	National Technical Means
NWCF	Navy Working Capital Funds
O&M	Operations and Maintenance
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations
PEO	Program Executive Officer
PM	Program Manager
PMA	Program Manager, Air
POR	Program of Record
RDT&E	Research, Development, Test & Evaluation
S&T	Science and Technology
SECNAV	Secretary of the Navy
SES	Senior Executive Service
SPAWAR	Space and Naval Warfare Systems Command
ST	Scientific or Professional (Civil Service)
STUAS	Small Tactical Unmanned Aircraft System
SYSCOM	Systems Command
TB	Terabyte (1 trillion bytes)
TC	Technical Capability
TD	Technical Director
UARC	University Affiliated Research Center
UAS	Unmanned Aircraft System

APPENDIX M

Panel Member Biographies

NRAC Chair – Dr. John C. Sommerer is the Director of Science & Technology and Chief Technology Officer of the Johns Hopkins University Applied Physics Laboratory (APL), which is the largest of the DOD-affiliated University Research Centers. He manages the Laboratory's research and development program and Science and Technology (S&T) strategy, oversees its Office of Technology Transfer and its support of the educational programs of the University's Whiting School of Engineering, and serves a primary technical liaison with the Academic Divisions of the University. Dr. Sommerer serves on APL's Executive Council, and chairs its Science and Technology Council. He is an adjunct faculty member in several programs of the G.W.C. Whiting School of Engineering at John Hopkins University. Dr. Sommerer also serves on multiple technical advisory bodies for the U.S. Government.

NRAC Vice-Chair – Vice Admiral William Bowes, U. S. Navy (Retired) is currently an aerospace consultant, serves on a number of boards and is vice chairman of the NRAC. He served 33 years in the Navy in numerous operational and acquisition assignments. As a Vice Admiral he served as the Commander of the Naval Air Systems Command, the Principal Deputy Assistant Secretary of the Navy for Research, Development and Acquisition (RDA), and for six months was the Acting ASN(RDA). He is an accomplished test pilot, program manager and PEO. He served as the program manager for the F-14 and Phoenix missile program, the Joint Cruise Missiles Project, which developed and deployed the Tomahawk cruise missile, and was the first director of DOD's Joint Unmanned Aerial Vehicles Project. After retiring from the Navy, Bowes joined Hughes Aircraft as a Senior Vice President and Deputy General Manager of the newly forming Sensors and Communications Sector. After Hughes was acquired by Raytheon, Bowes joined Litton Industries as the Vice President, Corporate Strategic Planning, and subsequently led the creation of the Military Aircraft Electronics Systems business unit after Litton was acquired by Northrop Grumman.

Dr. Amy E. Alving is the Chief Technology Officer at Science Applications International Corporation (SAIC). She leads SAIC's Office of Technology, which is responsible for the creation, communication and implementation of SAIC's technical and scientific vision and strategy. From 2001 to 2005, she served as the Director, Special Projects Office, at the Defense Advanced Research Projects Agency (DARPA), with full responsibility for strategic planning, hiring, operations, finances, security, and program development and execution. During her tenure at DARPA she also initiated and served as Program Manager for two programs that piloted the active-defense approach to protection from chemical and biological weapons. Dr. Alving served as a White House Fellow from 1997 to 1998. Prior to that she was a tenured member of the faculty in the Department of Aerospace Engineering and Mechanics at the University of Minnesota. Dr.

Alving serves on the Board of Directors for Pall Corporation (NYSE:PLL) and in several advisory roles for the US government.

Dr. A. Michael Andrews II is the Vice President for Research & Engineering and Chief Technology Officer of L-3 Communications where he guides the company's long-term R&D initiatives and Chairs the Corporation's Engineering Council. Prior to joining L-3 in June 2003, he served as Deputy Assistant Secretary of Research and Technology/Chief Scientist for the United States Army. Dr. Andrews' was instrumental in the development of the Future Combat Systems and realignment of the Army's S&T towards Future Force capabilities. Prior to coming to the Army in 1997, Dr. Andrews held a variety of leadership positions at Rockwell International. Dr. Andrews has written over 50 technical articles, and has several patents in infrared sensors, materials and signal processors. Dr. Andrews is also a recipient of the Meritorious Civilian Service Award, the Presidential Rank Award, and a Fellow of the Institute of Electrical & Electronics Engineers, University of Illinois Distinguished Alumnus Award, Rockwell's Engineer of the Year Award, the SPIE's Defense & Security 2005 Outstanding Achievement Award and a career profile in the April 2002 *IEEE Spectrum Magazine.*. He is member of the Homeland Security S&T Advisory Committee, a consultant to the Army Science Board and is Co-Chair of the National Academies Committee for Flexible Electronics. He received his B.S. and M.S. in Electrical Engineering from the University of Oklahoma and his Ph.D. in Electrical Engineering from the University of Illinois.

Dr. James Bellingham is Chief Technologist at the Monterey Bay Aquarium Research Institute, and was Director of Engineering from 1999 to 2006. In his time at MBARI he has elevated its Engineering Department to international stature and established it as a center for advanced ocean observing system technology development. Prior to joining MBARI, Dr. Bellingham founded the Autonomous Underwater Vehicle Laboratory at MIT, running it from 1988 to 2000. In 1997, he co-founded Bluefin Robotics Corporation, a leading manufacturer of Autonomous Underwater Vehicles, and served on its board until its purchase in 2005. He serves on a number of advisory boards and councils, including Strategic Advisory Group for Battelle's National Security Division. Today Dr. Bellingham is developing a new generation of ocean observation systems tailored to the needs of global climate and ocean ecosystem studies.

Dr. Ira M. Blatstein (NRAC Consultant) is Assistant Professor in the Division of Public Safety Leadership, School of Education, The Johns Hopkins University. In 1967 Dr. Ira M. Blatstein graduated from Drexel University with a BS in Physics. From 1967 until 1976, Dr. Blatstein performed and led research in underwater explosion effects and explosion acoustics at NSWC, White Oak. Between 1969 and 1974, he earned a M.S. and Ph.D. in physics from Catholic University. In 1976, Dr. Blatstein began his management career as Head, Explosion Effects Branch NSWC White Oak. In 1985, Dr. Blatstein started the first of what became three Senior Executive assignments at NSWC, White Oak and Dahlgren; first as head, Engineering Department, then as Deputy Technical Director, and finally as Head, Research and Technology Department. In 1992, Dr. Blatstein was selected as the first Technical Director of NSWC, the warfare center. In July, 2000 he became Director of Strategic Planning at The Applied Physics Laboratory, Johns Hopkins University. In November, 2009, Dr. Blatstein accepted a position as assistant professor in the Division of Public Safety Leadership, SOE, JHU. Dr. Blatstein has published and given invited papers at technical symposia in the areas of propagation models, underwater explosion effects and ocean basin reverberation. He is the recipient of several awards, including two SES awards, the Presidential Rank Meritorious Award, and the Presidential Rank Distinguished Award.

Rear Admiral Daniel R. Bowler, U. S. Navy (Retired) is the President, The Whitehall Group, LLC, an independent defense consulting company. From 2003-2009, Mr. Bowler was the Vice-President, Navy Systems, Sensors and Advanced Technology Solutions in the Washington Operations office of the Lockheed Martin Corporation. In 2006-2007 he served on the Naval Studies Board assessing Distributed Remote Sensing for Undersea Warfare. In 2008 he was appointed by the Secretary of the Navy to the Naval Research Advisory Committee. Mr. Bowler served in the United States Navy from 1970 to 2003, retiring as a Rear Admiral. He was a Surface Warfare Officer with seven sea tours, including command of USS LEFTWICH (DD 984), USS CHOSIN (CG 65), Cruiser Destroyer Group FIVE and the KITTY HAWK Carrier Battle Group. He participated in combat operations in Vietnam, the Persian Gulf and the Balkans. His shore assignments included Navy training and personnel commands, the Navy staff in the Pentagon, and the Joint Staff. Additionally, he served as the 22nd Commandant of the National War College at Fort McNair in Washington, DC. Mr. Bowler has a Bachelor of Science Degree in Naval Engineering from the U.S. Naval Academy. He was a awarded a Burke Scholarship upon graduation which he used to earn a Master of Arts Degree in International Relations from Georgetown University in 1975. Additionally, he has completed the Massachusetts Institute of Technology's Seminar XXI program in National Security. He has, also, participated in Executive Programs at Harvard University's John F. Kennedy School of Government and has taken executive financial management courses at The Wharton School, University of Pennsylvania.

Rear Admiral Erroll Brown, U.S. Coast Guard (Retired) served over thirty years in the U.S. Coast Guard retiring in 2005. Rear Admiral Brown holds four Masters Degrees; At the University of Michigan he earned a Masters Degree in Naval Architecture and Marine Engineering and a second Masters in Industrial and Operations Engineering. A Masters of Business Administration degree was awarded to Rear Admiral Brown in 1986 from Rensselaer Polytechnic Institute. In 1994, he graduated from the Naval War College with a Masters Degree in National Security and Strategic Studies. RADM Brown completed Harvard's John F. Kennedy School of Governmental Program for Senior Executives in National and International Security. While in the Coast Guard he served in various capacities including Assistant Commandant for Engineering and Logistics, Commander 13th Coast Guard District, Commander Maintenance and Logistics Command Atlantic, Commander Integrated Support Command Portsmouth, Chief Office of Budget, Military Aide to Secretary of Transportation, Executive Officer Coast Guard

Cutter RUSH, Associate Professor of Engineering U.S. Coast Guard Academy, Engineering Officer Coast Guard Cutter JARVIS, Section Chief of the Cutter Boat Design and Construction Branch, Assistant Engineer Officer Coast Guard Icebreaker Burton Island.

Dr. Michael S. Bruno is Dean of the School of Engineering and Science, and Professor of Ocean Engineering at Stevens Institute of Technology, Hoboken, New Jersey. He is also the Director of the Center for Secure and Resilient Maritime Commerce and Coastal Environments (CSR), a Department of Homeland Security National Center of Excellence. His research and teaching interests include ocean observation systems, maritime security, and coastal ocean dynamics. He is the author of more than 100 technical publications in various aspects of the field. Prior to assuming the duties of Dean, Dr. Bruno was the Director of the Center for Maritime Systems and Davidson Laboratory at Stevens from 1989 to 2007. Dr. Bruno is Vice-Chairman of the National Research Council's Marine Board; and serves as the Editor-in-Chief of the Journal of Marine Environmental Engineering; Secretary-General of the Pan American Federation of Coastal and Ocean Engineers; and Visiting Professor at University College, London. A Fulbright Scholar (1996 appointment at the Aristotle University of Thessaloniki, Greece), he served on the Defense Science Board Summer Study on Homeland Security in 2003. Dr. Bruno is a Fellow of the American Society of Civil Engineers. He received the Office of Naval Research Young Investigator Award in 1991, and the Outstanding Service Award from the American Society of Civil Engineers in 1988. Dr. Bruno holds a B.S. degree in Civil Engineering from the New Jersey Institute of Technology, a M.S. degree in Civil Engineering from the University of California at Berkeley, and a PhD degree in Civil and Ocean Engineering from the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution.

Rear Admiral Walter H. Cantrell, U.S. Navy (Retired) graduated from the U. S. Naval Academy and earned an MS degree and a NavEng Professional Degree from the Massachusetts Institute of Technology. He is also a graduate of an advanced program at the Harvard JFK School of Government. His naval career included assignments afloat and ashore; combat and peacetime; and overseas and stateside. He was a designated Engineering Duty Officer for thirty years of his career. He held key research, design, management, safety and leadership responsibilities in nuclear submarine and Trident missile programs. In his final Navy tour he was responsible for development, design, acquisition and deployment of Navy underwater, terrestrial and space communications and other electronics systems. After retirement from the Navy, he was active in developing and applying emerging technologies and new capabilities, including design and construction of a state-of-the-art shipbuilding facility. He supported NASA in numerous capacities culminating in responsibility for the Agency's safe and reliable return-to-flight efforts following the Columbia tragedy. He has served as a consultant in industry and Government, focusing on the effectiveness of processes and procedures to achieve needed technical rigor and safety.

Dr. Robert S. Carnes is the Director of Internal Research and Development for the Battelle Memorial Institute, National Security and Global Business Unit, the world's largest private, nonprofit R&D firm. He manages the Institute’s internal research portfolio across the entire spectrum of research investments that drive defense, commercial, and global business revenues, providing products and services in new materials, electronics, chemical and mechanical engineering, biotechnology, data management, and environmental services. Prior to joining Battelle, he served as CEO of a private consulting business, providing risk management services to government and commercial clients. His other assignments include service as a DARPA Program Manager, and a 32-year career involving Navy Medicine, Naval Aviation, and the United States Marine Corps’ operating forces and supporting establishments. He has served in both academic and managerial assignments, of clinical medicine, where he has served as clinical department chair, and co-director of a major metropolitan trauma center, and tenure-track academic.

Lieutenant General John Castellaw, U.S. Marine Corps (Retired) served in the Marines for 36 years. He held several commands including Marine Medium Helicopter Squadron 264, Marine Aviation Weapons and Tactics Squadron 1, U.S. FORCES EAST TIMOR, and the 2d Marine Aircraft Wing. As a Marine Aviator, he flew more than two dozen different aircraft including the CH-46E SEAKNIGHT, the TAV-8B HARRIER and the MV-22B OSPREY. His last assignments on active duty were in the Pentagon where he oversaw Marine Aviation and the Marine Corps budget creation and execution. In 2008 he retired with the rank of Lieutenant General, returned home to Crockett County and to the family farm. In addition to farming, he serves as a director for the Bank of Crockett and consults for several companies. As a retired general officer, Castellaw maintains a deep interest in National Security issues and is active in veterans’ affairs. He serves on the Department of the Navy’s Naval Research Advisory Committee and participates in national security advocacy groups. As a veteran, he is a member of the Marine Corps League, the Marine Corps Association and serves on the Board of Visitors for the Veteran’s Museum in Halls, Tennessee and the Tennessee State Veterans Homes Board. He is the National Commander of the Marine Corps Aviation Association.

Dr. Fernando Fernandez is currently a private consultant and a Director for various companies. From 2001-2006 Dr. Fernandez was a Distinguished Research Professor in Systems Engineering and Technology Management at Stevens of Technology. In addition, he served as the Chief Technical Advisor to the President for Institute research initiatives, management of intellectual property and commercialization of technology. From 1998-2001, Dr. Fernandez was the Director of the Defense Advanced Research Projects Agency. Under his leadership, DARPA served as the Department of Defense's premier R&D institution, trailblazing paths in biological warfare defense, information security, precision strike and robotics. Before that he started and managed several successful R & D companies specializing in remote detection and identification of hidden objects. In 2001, he was awarded the Distinguished Public Service Award by the Secretary of Defense and an Honorary Doctor of Engineering degree by Stevens Institute of Technology. Dr. Fernandez received his Bachelor of Science in mechanical engineering and Master of Science in applied mechanics from Stevens Institute of Technology in 1960-1961. He received his Ph.D. in aeronautics from the California Institute of Technology in 1969.

RADM Millard S. Firebaugh U. S. Navy (Retired) (NRAC Consultant) is the Minta Martin Professor of Practice, Department of Mechanical Engineering at the University of Maryland. Professor Firebaugh graduated from MIT and became an engineering duty officer in the Navy in 1961. His advanced degrees include an SM in EE, Naval Engineer degree and ScD, all from MIT. His ship design and construction career included the development the SSN 688 Class Vertical Launch system and the development, design and procurement of the SEAWOLF Class nuclear submarines. He became Chief Engineer of the Naval Sea Systems Command, serving until retiring from the Navy as a Rear Admiral in 1995. He was then involved in technical activities in industry including the remediation of nuclear waste, submarine design and engineering as VP, Innovation for General Dynamics, Electric Boat Corporation and power electronics as COO of SatCon Technology Corp. Professor Firebaugh holds the American Society of Naval Engineers Gold Medal and the US Navy Distinguished Service Medal. He is a member of the National Academy of Engineering and was awarded an honorary ScD by the Webb Institute. He edited the second edition of "*Naval Engineering and American Sea Power"*.

Major General Paul Fratarangelo, U.S. Marine Corps (Retired) is President of Contrail Group, Inc., management-consulting company based in Alexandria, Virginia. He served 33 years as a Marine officer to include nine years as a squadron commander for aircraft group, aircraft wing, air base and Joint Task Force. A designated Naval Aviator he has logged over 5900 hours, seen 485 combat missions and 263 carrier landings (primarily in fighter/attack aircraft).

Captain R. Robinson Harris, U. S. Navy (Retired), is Director of Advanced Concepts for Lockheed Martin. In 1998, he retired after 30 years of commissioned service. A Surface Warfare Officer, he served in a number of surface combatants and aircraft carriers. He commanded USS CONOLLY (DD 979) and Destroyer Squadron 32. Captain Harris' shore assignments include: Assistant Professor, Department of Naval Science, University of North Carolina, Chapel Hill; Long Range Planner, Chief of Naval Operations Executive Panel; Executive Assistant to the Assistant to the Chairman, Joint Chiefs of Staff; Director of Programs, SECNAV Office of Legislative Affairs; and, lastly, Executive Director, Chief of Naval Operations Executive Panel. He was a key contributor to the development of the *Maritime Strategy* in the 1980s and *From the Sea* in the 1990s. He coauthored the *Maritime Strategy*. He chairs the Navy Strategy Seminar in DC. Captain Harris holds a bachelor's degree with honors from Pfeiffer University in North Carolina. He holds an MA degree from the University of Georgia, and he earned his PhD Candidacy from the University of North Carolina, Chapel Hill. He is a graduate of the Massachusetts Institute of Technology program for senior executives, SEMINAR 21; and he was a Fellow on the CNO Strategic Studies Group. He continues to serve as an Adviser to the SSG.

Dr. Anna D. Johnson-Winegar is a private consultant for industry, academia, and government clientele. Prior to consulting, Dr. Johnson-Winegar served as the Deputy Assistant to the Secretary of Defense (Chemical and Biological Defense Programs) from 1999 until her retirement in 2003. During which she acted as the single focal-point within the Office of the Secretary of Defense (OSD). Dr. Johnson-Winegar was responsible for oversight, coordination, and integration of the Chemical/Biological (CB) defense, counter proliferation support, chemical demilitarization, and Assembled Chemical Weapons Assessment (ACWA) programs. She was a member of the OSD Steering Committee for CB Defense, where she represented the DOD on multiple interagency and international groups addressing CB issues. As a member of the committee she provided Congressional testimony on numerous occasions.

Mr. James Korris is the President of Creative Technologies, Inc. which focuses on immersive simulation and creative visualization for national defense. CTI is a direct outgrowth of the ground-breaking work of Mr. Korris as Creative Director of USC's Institute for Creative Technologies. Recent CTI efforts include a large-format, mobile simulation project for the US Army's *Future Combat Systems* (FCS) program and content development for the Boeing Company's *Transformational SATCOM.* 2007's *FCS Experiment 1.1 Soldier Exercise* marked CTI's entrance to the realm of large-scale live demonstration. At USC, Mr. Korris led projects including *Full Spectrum Warrior*, the first military application developed for Microsoft's Xbox, along with desktop training simulations *Full Spectrum Command*, and *Full Spectrum Leader*. In 2007, USJFCOM recognized the *Joint Fires and Effects Trainer System*, which James' team developed for the US Army's Fires Center of Excellence at Fort Sill, as the highest-rated Close Air Support simulator in the world. The team also developed Department of Defense 2006 Modeling & Simulation Award-winner *Every Soldier a Sensor Simulation*. Mr. Korris came to USC following work in Hollywood studio production, producing and writing. He began with several creative executive positions at *Universal Television*, moving on to serve as a staff producer for Ron Howard's *Imagine Films*. Recent work includes 2003 American Bar Association Silver Gavel winner *The Killing Yard* for *Paramount/Showtime*. He is a member of the writers' branch of the *Academy of Television Arts and Sciences*, the *Writers Guild of America*, the *Writers Guild of Canada* and the *Society of Motion Picture and Television Engineers*. Mr. Korris earned his undergraduate degree in Economics at Yale University and was awarded an M.B.A. with distinction at the Harvard Business School.

Dr. Mark G. Mykityshyn is a co-founding Partner of The White Oak Group and currently serves as Co-Chairman of the Board of Dataline, Inc. Prior to The White Oak Group, he was a co-founding Partner of Five Paces Ventures, an Atlanta-based venture capital fund, where he led that firm's investment strategy in next-generation network infrastructure software. Prior to Five Paces, he co-founded Backwire, Inc., which was sold to Leap Wireless International (NASDAQ:LWIN). He was a management consultant in the aerospace practice at Booz-Allen & Hamilton where he led and participated in numerous engagements. Dr. Mykityshyn graduated from the U.S. Naval Academy and served as a Marine Corps officer and Naval Aviator. He earned his Doctorate from the Georgia Institute of Technology in systems engineering. He also earned a Masters degree in public administration from Harvard's Kennedy School of government, and the degrees of Engineer of and Master of Science in aeronautical and astronautical engineering from M.I.T. While at M.I.T., he investigated human performance and engineering issues associated with the design and evaluation of advanced avionics and navigation systems. He also worked with NASA on the design, test, and evaluation of the Multifunction Electronic display System (MEDS) that was implemented into the Space Shuttle fleet. Dr. Mykityshyn currently serves as the Chairman of the Board of Visitors of the U.S. Army War College, and is a member of the Naval Research Advisory Committee. He has consulted to the both the Defense Science Board and the Air Force Scientific Advisory Board.

Dr. Marv Langston (NRAC Consultant) has 34 years of public service and six years of private sector service, bringing a broad background to his customers, where he provides consulting services for leadership, enterprise architecture & engineering, project management, and organizational strategy. Following his public service career, Marv served as the COO of a small high-tech start-up, CTO of a large business practice, led large corporation Information Technology transformation, initiated Account Management practices to unify customer trust relationships, and helped rebuild troubled system development programs. In government Marv served as Department of Defense Deputy Chief Information Officer (CIO), where he helped initiate the Global Information Grid, Public Key Infrastructure - Common Access Cards, and led the Defense Department Year 2000 transformation. Prior to that he held positions as Deputy Assistant Secretary of Navy for C4I, Navy's first CIO, and Director of the Defense Advanced Research Projects Agency (DARPA) Information Systems Office. Marv began his Navy career as an enlisted nuclear submarine electronic technician and retired as a Combat Systems Engineering Duty Officer. Before rejoining government he worked at Johns Hopkins University Applied Physics Laboratory supporting U.S. Navy and Missile Defense Agency projects. His education includes: BSEE (Electronic Engineering) Purdue, 1973; MSEE (Electronic Engineering) Naval Post Graduate School, 1978; MPA (Public Administration) University of Southern California (USC), 1993; and DPA (Public Administration) USC, 1994. Government Computer Week magazine honored him with an Executive of the Year award in 1999.

Professor Arthur P. Ramirez (NRAC Consultant) holds a B.S. and Ph.D. degrees in physics from Yale University. He worked at Bell Labs first as a postdoc and eventually as Distinguished Member of Technical Staff, specializing in materials physics. He is credited with the co-discovery of superconductivity in C60 fullerene, and for pioneering the field of frustrated magnetism. He moved to Los Alamos National Laboratory in 2001 where he led the Condensed Matter and Thermal Physics group. In 2003 he returned to Bell Labs, Lucent Technologies as Director of Condensed Matter Physics Research and then in 2005 became director of Device Physics Research. In 2008, he joined LGS, a wholly owned subsidiary of Alcatel-Lucent specializing in telecommunications solutions for the U.S. government. In 2009 he moved to the

University of California Santa Cruz where he is Dean of the Baskin School of Engineering. He has been active in professional societies such as the American Physics Society governance board, the National Academies Solid State Science Committee, and review committees for the National Science Foundation and the Department of Energy.

Mr. Gerald Schiefer (NRAC Consultant) is a retired Naval Senior Executive at the SES 5 level. He retired from Civil Service in August of 1999 after forty-two years of government service. Immediately after retirement he, as a member of Creative Team Concepts LLC, worked as a consultant to the Office of the Secretary of Defense to prepare "lessons learned" from previous BRACs, and to prepare plans and the congressional requests for the next BRAC. He then assisted OSD in the execution of the 2005 Base Closure selection process. This effort terminated at the end of 2006. Mr. Schiefer's area of responsibility was oversight of the Department of Defense Research, Development, and Test & Evaluation facilities. Mr. Schiefer had participated at the Assistant Secretary of Navy / Deputy Chief of Operations level in all other Base Closure Rounds. He previously served as the Director of Naval Laboratories and Deputy Commander of the Space and Warfare Systems Command. There he had responsibility for the Navy's seven Research, Development and Test & Evaluation Centers and nine Engineering Centers. He also had contractual responsibility and oversight of the four navy associated, University Laboratories at the University of Texas, Austin; Penn State, University of Washington and John Hopkins. Mr. Schiefer has been the Technical Director (Head Civilian) at the Naval Weapons Center, China Lake. There he also has previously served as Laboratory Director, head of the Range Directorate, and head of the Electronic Warfare Department. He has been head of the Aircraft Systems Directorate and head of the Weapons Directorate, both of which also included organizations at the navy's Pt. Mugu location. Mr. Schiefer had a tour as Science Advisor to the Commander, Operational Test and Evaluation Force in Norfolk Virginia where he consulted in the evaluation of naval systems before they were certified as "ready for fleet use." In addition, he served on an Army Missile Advisory Board for many years. He was the Technical Program Manager for the High Speed Anti-Radiation Missile, HARM, for which he had oversight of the missile's initial concept proving, design, testing and production planning. He is very familiar with Naval Fleet and Air Force Wild Weasel operations and made five consulting trips to Vietnam on Defense Suppression. The first trip included introducing the SHRIKE Anti-Radiation Missile into combat. He piloted a navy hot air balloon to test improvements to SHRIKE. Mr. Schiefer was awarded the L.T.E. Thompson Award, NWC's highest award for outstanding individual achievement and the Albert Michelson Award for Team & Program Management. He has received the Navy Meritorious Civilian Service award, The Navy Superior Civilian Service Award, and two Navy Distinguished Civilian Service Awards. He is an Honorary Air Force Wild Weasel. He was awarded the Presidential Meritorious Senior Service Rank Award by President Ronald Reagan and the Presidential Distinguished Senior Service Rank Award by President George H.W. Bush.

Mr. William Schmitt (NRAC Consultant) is an independent consultant having retired from the Federal Senior Executive Service (SES-5) with over 32 years experience in the Naval Nuclear Propulsion Program. As a consultant, Mr. Schmitt is currently serving as a consultant to the Naval Research Advisory Committee. Previously he was appointed by the Secretary of the Navy to a panel of six experts charted to examine the Culture of Quality in Navy Shipbuilding and recommend changes in Navy practices to correct recurrent quality problems and unmet performance expectations in delivered naval vessels. In other consulting work, he was selected to provide support to the DOE's Sandia National Laboratories regarding program and project management, independent programmatic assessment and management improvement initiatives. He developed new program and management plans for a corporate-wide initiative to improve product lifecycle management. Mr. Schmitt also consulted for Marinette Marine Corporation on U.S. Navy Littoral Combat Ship lead ship construction program. He advised senior management on corporate response to Navy initiatives for accelerated test program execution and management restructuring for improved test program execution. Mr. Schmitt spent over 20 years as Program Manager for Surface Ship Nuclear Propulsion at (NAVSEA) headquarters in Washington, DC, having reported directly to all five Naval Reactors Program Directors. As the Program Manager for Surface Ship Nuclear Propulsion, Mr. Schmitt reported to and advised Program Directors in all matters involving nuclear propulsion for nine U.S. Navy aircraft carriers and nine cruisers including; Congressional testimony; long range strategic program planning, policy formulation, implementation and enforcement; ship construction, and in-service ship operations management and regulation to ensure safe nuclear propulsion plant operation. He directed the Naval Reactors Headquarters Program for Surface Ships with an annual budget in excess of $300M involving over 5000 personnel at two U.S. DOE prime contractors, two U.S. Navy public shipyards and the largest nuclear-capable private ship builder in the U.S. (Northrop Grumman Newport News). He was responsible for all aspects of oversight of shipbuilder construction of the nuclear reactor plants of five of the U.S. Navy's NIMITZ Class aircraft carriers including construction certification, acceptance testing and delivery acceptance. Mr. Schmitt provided Naval Reactors Program-wide executive program direction and oversight of: long range planning and execution of shipboard reactor refueling; reactor and propulsion plant overhaul, repair, maintenance, and modernization; and post repair testing, including critical reactor plant testing, in nuclear powered aircraft carriers and cruisers. He also provided key leadership in Navy strategy and policy development of new aircraft carrier operational and maintenance plans to respond to the operational demands of the post - 9/11 era and the Global War on Terror. These plans achieved unprecedented increased ship operational availability and nuclear propulsion plant material readiness without sacrificing ship service life, propulsion plant readiness, or safety of nuclear propulsion plant operation.

Dr. David Tennenhouse is a Partner, New Venture Partners. He opened its Silicon Valley office in 2007. He is focused on developing relationships with corporate and government-funded R&D teams. David joined New Venture Partners from Amazon.com, where he had been Vice President of Platform Strategy and CEO of its A9.com subsidiary. Prior to Amazon/A9, David was Vice President and Director of Research at Intel Corporation, where he pioneered an "open collaborative" approach to corporate research. This was, in part, based on his earlier work as DARPA's Chief Scientist and Director of its Information Technology Office. At both DARPA and Intel, David was involved in the strategic planning and execution of programs related to a wide range of technologies, including networking, wireless communications, computer architecture, distributed computing, machine learning, search / data mining, image processing, robotics, MEMs, healthcare, and nano/bio-technology. Dr. Tennenhouse is a Fellow of the IEEE and has held academic appointments at MIT, in the Department of Electrical Engineering and Computer Science and in the Sloan School of Management. He is currently a Trustee of the International Computer Sciences Institute (ICSI) and a member of the Naval Research Advisory Committee. He is also an advisor to Carnegie Mellon University's School of Computer Science and the Mechanical Engineering Department at UC Berkeley. He holds a B.A.Sc. and M.A.Sc. in Electrical Engineering from the University of Toronto and obtained his Ph.D. at the Computer Laboratory of the University of Cambridge.

RADM John T. Tozzi, U.S. Coast Guard (Retired) is Vice President for Advanced Programs L-3 Communication Systems - East. He completed his Coast Guard career in 1999. When he retired, he was Assistant Commandant for Systems, a position he assumed in June 1997 after completing a tour as the Coast Guard's first Chief Information Officer. He is a 1968 graduate of the Coast Guard Academy. His operational assignments included tours in seven high endurance cutters, two of which he commanded. As a flag officer, he commanded Joint Interagency Task Force West, the U.S. Pacific Command's counter-drug joint task force. His postgraduate academic accomplishments include Master's Degrees in Naval Architecture & Marine Engineering and in Mechanical Engineering from the Massachusetts Institute of Technology as well as a Ph.D. (Fluid Mechanics) from the Catholic University of America. Upon his retirement from active service, he took a position as Vice President for Information, Intelligence, and Advanced Technology with BMT Syntek Technologies, Inc., of Arlington, VA, and is currently with L-3 Communications. He is a past member of the Permanent Panel of Associates of the Naval Research Advisory Committee, a member of the Executive Committee of the Surface Navy Association, a National Vice President and National Director of the Navy League of the United States, and a past member of the Board of Directors of the Navy Mutual Aid Association. He received the Superior Public Service Award from the Secretary of the Navy in 2006 and a Distinguished Public Service Award from the Commandant of the Coast Guard in 2007. He and his wife, Mary, reside in Vienna, Virginia. Their son, Gregory, is a 1998 graduate of the Coast Guard Academy, currently serving with the rank of Lieutenant Commander.

Lieutenant General Joseph F. Weber, U.S. Marine Corps (Retired) is Vice President for Student Affairs at Texas A&M University. He was born in Weimar, Texas in 1950 and is a 1972 graduate of Texas A&M University. Immediately upon graduation, he began his 36 years of service to the nation as a commissioned officer in the United States Marine Corps. Over the course of an extensive military career, the General served in assignments throughout the United States and overseas, commanding at all levels and serving in a wide variety of senior staff positions. His primary duties focused on the training, education and readiness of thousands of service members and civilians as well as the responsibility for their health, welfare and overall quality of life, and that of their family members. He has broad experience working with the interagency as well as a multitude of foreign military and diplomatic representatives and agencies world-wide. A strong desire to continue to serve, coupled with the satisfaction gained over a long career of addressing the needs and aspirations of young, dedicated men and women would eventually steer this Marine back to Texas A&M University in August 2008 to serve as Vice President for Student Affairs. The General earned a masters degree from the Lyndon B. Johnson School of Public Affairs at the University of Texas at Austin. He completed a tour on the staff of the United States Naval Academy where he taught leadership and speech, administered and supervised midshipman performance and conduct programs, and served as the Officer Representative to the U.S. Naval Academy football team. Prior to returning to A&M, Lieutenant General Weber's final active duty Marine Corps assignment was as Commander, Marine Forces Command, Commanding General Fleet Marine Forces Atlantic, Commanding General Marine Bases Atlantic where he was responsible for 74,000 personnel with an annual budget of $80 million and holdings and assets totaling $33 billion.

Dr. David A. Whelan is the Boeing Integrated Defense Systems Chief Scientist and Vice President-Deputy General Manager for IDS Advanced Systems, with responsibility to create and explore new technology and business growth vectors for the Boeing Company. Before joining Boeing, Dr. Whelan served as Director of the Tactical Technology Office of the Defense Advanced Research Projects Agency (DARPA). While at DARPA, he created many legacy joint programs with the Air Force, Navy and the Army, most notably, the Discoverer II Space Radar Program. He is currently a member of the National Academy of Engineering, the Air Force Scientific Advisory Board and the Naval Studies Board of the national Research Council. Dr. Whelan was honored for his government service and received Secretary of Defense Medal for Outstanding Civil Service in 2001 and the Secretary of Defense Medal for Outstanding Public Service in 1998. He earned his Ph.D. in physics from UCLA and has numerous publications on electromagnetic radiation, laser plasma phenomena and Defense systems.

Professor Patrick H. Winston is the Ford Professor of Artificial Intelligence and Computer Science at the Massachusetts Institute of Technology (MIT). He is presently a member of the MIT Faculty Policy Committee, which makes recommendations to MIT's President and Provost on all key policy issues. Dr. Winston is involved in the study of how vision, language, and motor faculties account for intelligence. He also works on applications of Artificial Intelligence that are enabled by learning, precedent-based reasoning, and common-sense problem solving. Dr. Winston's publications include textbooks on Artificial Intelligence and several programming languages. He edited a collection of papers about Artificial Intelligence applications, and several MIT research papers. Dr. Winston is Chairman and co-founder of Ascent Technology, Inc., a company that produces sophisticated scheduling, resource allocation, and schedule recovery applications, enabled by Artificial Intelligence technology that is in use throughout the world in major airports and DOD. He is working on a major new research and educational effort, the Human Intelligence Enterprise, which will bring together and focus research from several fields, including computer science, systems neuroscience, cognitive science, and linguistics. Dr. Winston served previous terms on NRAC from 1985 to 1990 and from 1994 to 2000.

Rear Admiral Charles B. Young, U. S. Navy (Retired) is Vice President for Strategic Business Planning, Oceaneering Advanced Technologies. A native of South Carolina, Rear Admiral Young graduated from the U.S. Naval Academy in June 1970 with a BS (Mechanical Engineering) degree. After receiving a Master of Science in Civil Engineering (Ocean Engineering) at the University of Delaware in May 1971, he completed the Navy's nuclear power training program. Admiral Young served on the *USS ULYSSES S. GRANT* (SSBN 631B); *USS PLUNGER* (SSN 595); *USS SAND LANCE* (SSN 660); USS *SAN JUAN* (SSN 751) and *USS HOLLAND* (AS 32). Shore duty assignments included instructor duty at Nuclear Power School, Bainbridge, Maryland; Squadron Material Officer on the staff of Commander Submarine Squadron Sixteen in Kings Bay, Ga.; Director of Tactical Training at the Navy Fleet Ballistic Missile Submarine Training Center in Charleston, S.C.; Deputy Commander for Readiness and Training for Submarine Squadron TWO and Undersea Warfare Assistant Office Director for Advanced Submarine Technology in the Defense Advanced Research Projects Agency. Returning to Washington, DC in August 1994, Admiral Young assumed duties as Director, Resources and Evaluation on the staff of the Assistant Secretary of the Navy for Research, Development and Acquisition. He was the Program Manager for the Navy's Unmanned Undersea Vehicles Program Office from June 1995 to October 1997. From October 1997 to July 2001 he served as Deputy Commander, Naval Sea Systems Command, Undersea Technology. Rear Admiral Young was the Commander, Naval Undersea Warfare Center from October 1998 to July 2001. He served additional duty as the Vice Commander, Naval Sea Systems Command from August 1999 to January 2000 and was the Program Executive Officer for Undersea Warfare from February to April 2000. Admiral Young is a graduate of both the Program Management Course and the Executive Program Management Course at the Defense Systems Management College. He served as Vice Commander, Naval Sea Systems Command from April 2001 to July 2002. Rear Admiral Young became the 11th Director of Strategic Systems Programs in July 2002 where he was responsible for all aspects of the research, development, production, logistics, storage, repair, and operational support of the Navy's Fleet Ballistic Missile Weapon Systems, which include the TRIDENT I and II missiles and their associated shipboard subsystems. He was also the U.S. Project Officer responsible for managing U.S. Government support of the British POLARIS/TRIDENT Force. Since retirement from the Navy, Admiral Young has served on several panels and boards. These include: Submarine Superiority Technical Advisory Group (SSTAG), Defense Science Board Task Force on the National Security Industrial Base for the 21st Century; Navy Research and Advisory Committee (NRAC); advisor to the Threat Reduction Advisory Committee (TRAC) Nuclear Deterrent Transformation (NDT)

Panel; Board of Advisors for Florida Atlantic University's Institute for Ocean and Systems Engineering; Board Advisors for Johns Hopkins University Applied Physics Laboratory' Global Engagement Department; Board of Advisors for the Navy Submarine League; Board of Advisors for the NDIA Undersea Warfare Division; Board of Directors for the United Services Benefits Association; and Board of Advisors for the Advanced Technology Institute in Charleston, SC.