Naval Research Advisory Committee Summer Study

Sponsored by: Hon. Sean Stackley, Assistant Secretary of the Navy (Research, Development, and Acquisition)

Navy Budget Activity 4

(BA-4, Advanced Component Development and Prototypes)

October 2011

This report is a product of the Naval Research Advisory Committee (NRAC) Panel on *Budget Activity 4 Account (BA-4, Advanced Component Development and Prototypes).* The opinions, recommendations, and/or conclusions contained in this report are those of the NRAC Panel and do not necessarily represent the official position of the Department of the Navy, or the Department of Defense.

Executive Summary

Following the 2010 Naval Research Advisory Committee (NRAC) study and report on the *Status and Future of the Naval R&D Establishment*, the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RDA) tasked the NRAC to assess the Naval BA-4 account in a manner that focused on its adequacy as a primary transition vehicle for Naval S&T and as the first step in the formal systems acquisition process.

The NRAC 2010 assessment considered the "as is" capability to meet the Department of Navy (DON) technological needs and, in particular, the ability to innovate in areas of anticipated technological need. That study focused primarily on "technology push," i.e., the Science and Technology (S&T) and Budget Activities 1 through 3. Of at least equal (and arguably greater) importance for successful technology transition is the BA-4 (Advanced Component Development and Prototypes) account - the "requirements pull," counterpart of S&T.

The GAO report to Congress (GAO-07-1058 Defense Acquisition, September 2007) and the 2009 Weapons Systems Acquisition Reform Act (WSARA) pointed out the criticality of a robust BA-4 program. The total annual Naval BA 4 funding is on the order of $4B (about twice the size of the entire S&T investment). The non-ACAT portion of BA4, in particular, receives minimal outside assessment or scrutiny.

This report provides an assessment of the Naval BA-4 account process, culture and structure. It focuses on the adequacy of BA-4 as a primary transition vehicle for Naval S&T and as the first step in the formal systems acquisition process.

Specific recommendations address the BA-4 process, culture, and structure:

1. Change the BA-4 *process* to accelerate innovation: Foster early iteration of technology and operational concepts to accelerate the transition process.

2. Change the BA-4 *culture* to improve probability of success: Build teams by embracing industry's best practice of incentivizing movement of key personnel from project idea through prototype /productization.
3. Change the BA-4 *structure* to re-engage the Fleet throughout execution: Increase priority of line officer assignment to billets throughout the Naval material establishment.

The Panel recommends a transformational idea: Create and encourage *entrepreneurial skills* within the Navy which promote a willingness to take risks early in the Research, Development, Test & Evaluation (R&DT&E) process. And, in parallel, create opportunities for cross-organizational, cross-disciplinary team formation including a mechanism to allow for government personnel assignment to entrepreneurial companies for several years.

Finally, the NRAC Panel recommends restoration of the Department's senior line officer (3-star) to provide focus and oversight to the development of warfighter capabilities incorporating technology and innovation.

Table of Contents

Panel Membership

Dr. James Bellingham
Study Panel Chair
Monterey Bay Aquarium Research Institute

RADM Charlie Young, USN (Ret)
Study Panel Co-Chair
Oceaneering International, Inc

VADM Bill Bowes, USN (Ret)
NRAC Vice Chair

Dr. Mark Bregman
Neustar

Dr. Patricia Gruber
ARL Penn State Univ.

Dr. Marv Langston
Independent Consultant

Dr. David Mindell
MIT

Mr. Charlie Nemfakos
RAND

Dr. John Sommerer
NRAC Chair
Johns Hopkins APL

Professor Patrick H. Winston
MIT

Executive Secretary

Mr. Bob Smith
ONR

The NRAC Panel was composed of individuals with wide-ranging knowledge and experience in the military, government, industry, and academic domains.

Panel biographies are in Appendix A.

Study Terms of Reference (TOR)

- **Objective:**

  The NRAC shall assess the Naval BA-4 account in a manner that focuses on its adequacy as a primary transition vehicle for Naval S&T and as the first step in the formal systems acquisition process.

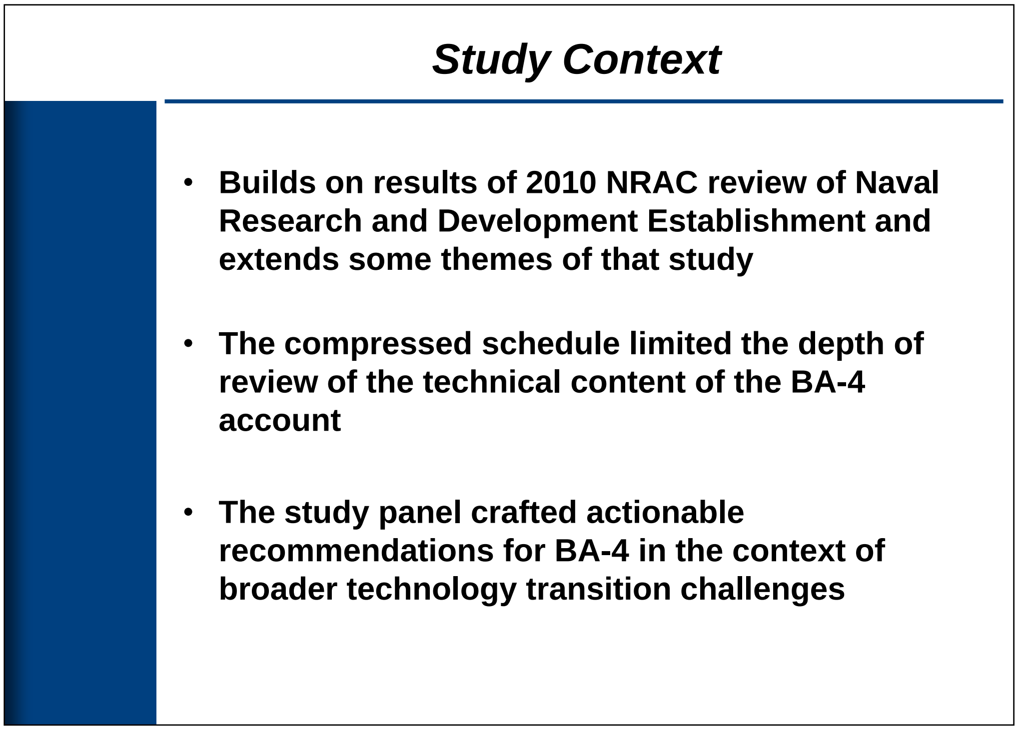
- **Specific Taskings:**

  The NRAC shall assess the Naval BA-4 investment, examining issues such as governance, strategic planning and oversight, technical quality and effectiveness as a transition vehicle for Naval S&T investment .

  – **The study shall address:**
    - **Leverage of the BA-4 account to enhance the CNO's "Speed to Fleet" initiative.**
    - **Governance and investment strategy of the Naval BA-4 account. The investment balance decision process; how to ensure the best technical solutions are pursued.**
    - **Technical content of the BA-4 account, especially non-ACAT BA-4. Is it appropriate for the funding category, and does it represent an appropriate technical cross-section for transition of Naval S&T into systems acquisition?**
    - **Coupling of BA-4 to Naval S&T. The ability of the current BA-4 investment to transition Naval S&T efforts; establishment of funded transition plans from S&T.**
    - **Transition of BA-4 programs to systems acquisition. Potential applicability of private sector technology transition processes for transition from BA-4 to BA-5 programs.**

The terms of reference (TOR) for this study were developed as a logical follow-on to the 2010 NRAC study *Status and Future of the Naval R&D Establishment*. The 2010 study focused primarily on S&T and the Budget Activities 1through 3. This study looks at Budget Activity 4, the Advanced Component Development and Prototypes Account, and the movement of technology from technology readiness level (TRL) 5 across to TRL 7. This transition is often called the "valley of death."

The Navy's BA-4 funding has been approximately $4 billion annually – twice the size of the S&T (i.e., BA-1 through BA-3) accounts. The specific tasking of this study addresses technology transition funding and how to improve its utilization. The full TOR is in Appendix B.



As previously mentioned, this study builds on the results of the 2010 NRAC study – extending some themes of that study. Unlike previous studies, this had a very compressed schedule which limited the conduct of an in-depth review of the technical content of the BA-4 account. However, the Panel aggressively reached out to all available sources to obtain relevant information on this topic. They reviewed previous studies and met with some of their authors; they took briefings from OPNAV resource sponsors, the Deputy Assistant Secretary of the Navy for Budget (FMB), Systems Command and Warfare Enterprise Chief Technology Officers, selected Program Executive Officers, current and former Chiefs of Naval Research, high-tech company leaders and academia. With this fact-finding approach, the NRAC study panel was able to craft actionable recommendations for improving the technology transition challenges facing the Navy and Marine Corps.

Speed To Fleet

> **"The rapid pace of technological change in today's world outpaces how we currently deliver capabilities; we must realize that our current processes won't serve us well going forward, particularly the excessive, inefficient developmental and operational test regimes to which we subject ourselves. We must rethink how we get 'speed to Fleet.'"**
>
> Admiral Roughead, Jan. 2011

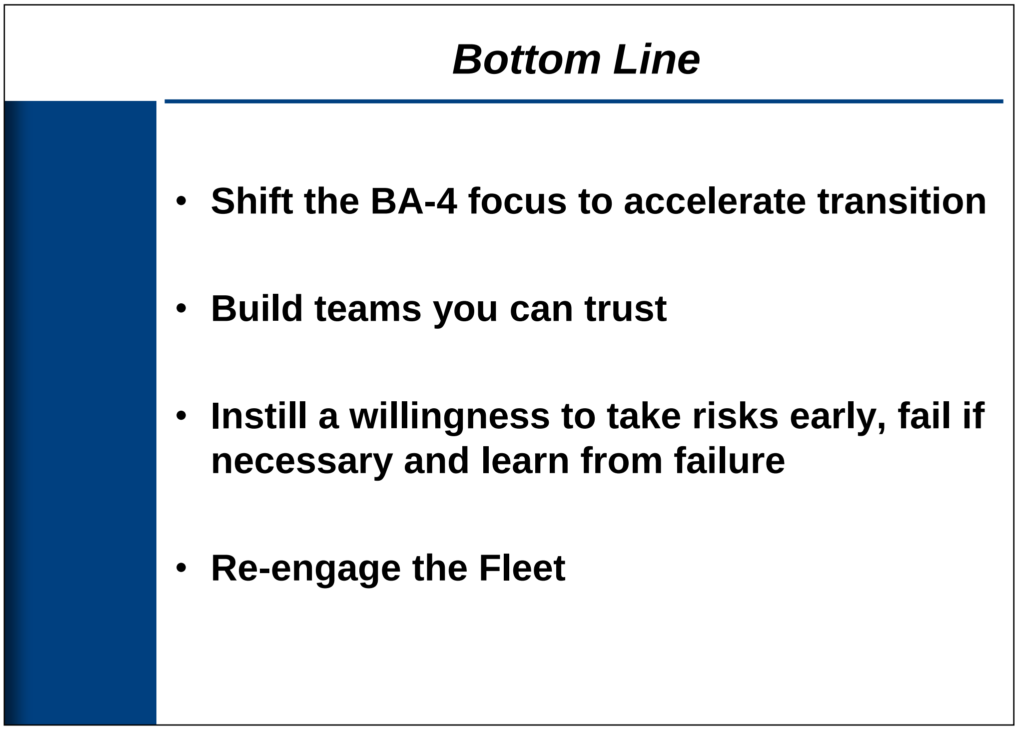
CNO Roughhead's "Speed to Fleet" initiative seeks to accelerate insertion of maturing technologies into the Fleet/Force to address critical Naval needs, providing initial advanced capability to the warfighter while allowing the acquisition process to address doctrine, organization, training, material, leadership and education, personnel and facilities (DOTMLPF) issues. This non-traditional approach accelerates transition of prototype Technology Readiness Level (TRL) 6 S&T products from Advanced Technology Development (Budget Activity 6.3) to Research and Development (R&D) Advanced Component Development and Prototypes (Budget Activity 6.4) and enables extended user experiments in a relevant operational environment.

Military end-user evaluations provide valuable lessons and direct feedback to the S&T and acquisition communities. Additionally, this process will enable the Fleet/Force to develop, test and refine Concept of Operations (CONOPS) and evaluate integration with existing warfighting capabilities. Successful demonstrations will build Fleet/Force support for the technology, identify lifecycle implications across the DOTMLPF spectrum and provide risk mitigation for acquisition. These technologies can either be complete systems or components. Limited quantities may be retained by the Fleet/Force to provide interim capability until the formal acquisition process procures the system/components and provides the required lifecycle sustainment.

In 2009, to enable faster transition of technology, Congress provided the Navy the ability to add BA 6.4 funding as an option on an S&T contract to facilitate the transition from S&T to R&D (Section 819 of the National Defense Authorization Act for Fiscal Year 2010). This can significantly shorten the current contracting process as well as support the goal of rapid transition of technologies.

Examples of Speed to Fleet projects that provide initial capabilities to the Fleet/Force:

- MK 18 MOD 1 SWORDFISH is a small (two-person portable), low-cost UUV, for U.S. Navy Explosive Ordinance Disposal Forces;
- Compact Rapid Attack Weapon (CRAW) is a lightweight anti-submarine torpedo designed to be deployed from the Fire Scout Unmanned Aerial Vehicle;
- Transportable Electronic Warfare Module (TEWM) installed on USS Sampson during RIMPAC 2010 provides surface ships a layer of protection from kinetic and non-kinetic attack;
- U.S. Marine Corps Mobile Modular Command & Control Vehicle (M2C2) provides command and control elements with efficient, broadband connectivity for voice and data communications.



The fundamental need underlying this study is to improve the process of transforming research and development activities into systems and methods that materially improve Fleet capabilities. We identified four thrusts that will contribute to a more effective BA-4 process. Those are:

- Ensure BA-4 resources are being used for transition activities. Our findings generally agree with other studies (see Appendix E) that found that some BA-4 funds are not being used for transition activities due to lack of overall oversight of the BA-4 account.
- Build integrated teams of experts for development activities, and keep them together through the transition process. While the skills involved with technology maturation and productization change as the process evolves, continuity of key talent is critical for success.
- Predicting success of individual projects is impossible, and sometimes high-impact activities look particularly risky in their early stages. Consequently, risk

taking should be encouraged. However, risk taking should occur in a tiered process that weeds out failures early.

- The Fleet needs to engage early in the process, participating in identifying and championing innovative opportunities.

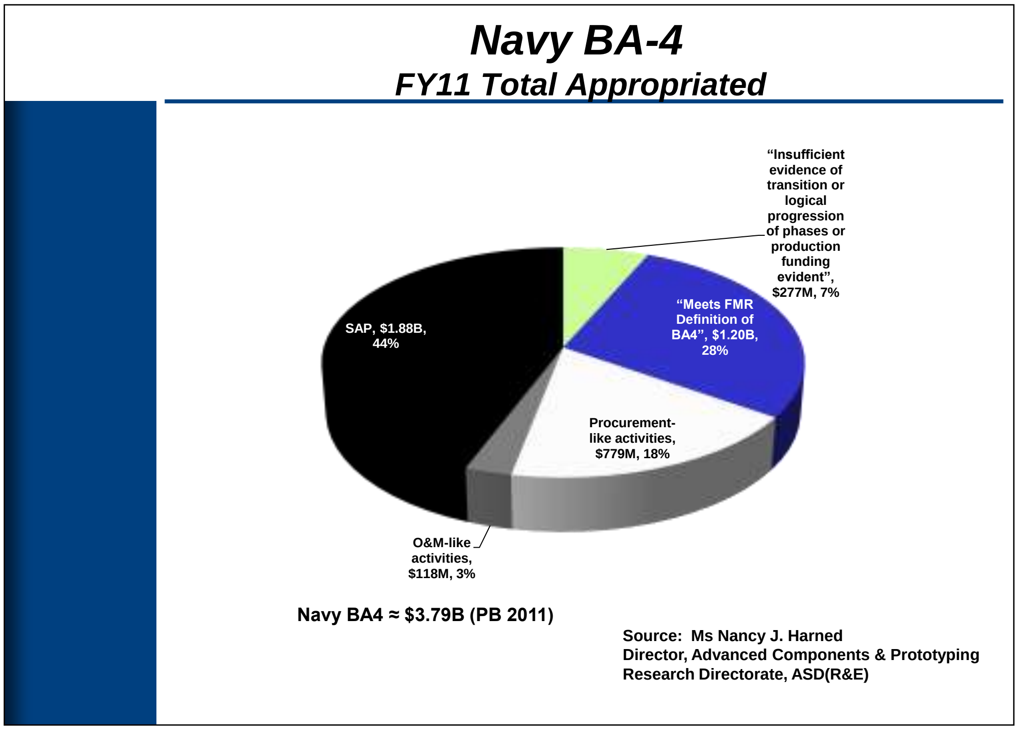
Cumulatively, these changes cut across the structure, process, and culture of transition activity in the DON.

The Panel heard from many of the players that spend or control Department BA-4 funding (including the Navy Audit Service). Also, they interfaced with Silicon Valley and Boston-area entrepreneurs and a venture capitalist to better understand the bridging of the technology-to-implementation gap. Finally, they visited the Massachusetts Institute of Technology to investigate an extremely effective process for enabling “entrepreneurship”. The complete listing of the fact-finding contributors is in Appendix C.

What is BA-4 ?

- **Efforts prior to Milestone B including technology demonstrations**
- **Advanced Component Development and Prototypes**
- **Proving component and subsystem maturity**
- **Completion of TRL 6 and 7 should be achieved for major programs**

The Budget Activity 4 (BA-4), previously titled 6.3B, is the R&D budget activity that includes all efforts necessary to evaluate integrated technologies in a near-realistic operating environment to assess the performance or cost reduction potential of advanced technologies. As defined by DOD financial management regulations and the NAVCOMPT manual, BA-4 funding is for efforts prior to Milestone B which include: Technology demonstrations, advanced component development and prototypes to prove component and subsystem maturity. BA-4 funding takes technology from TRL 4 or 5 to TRL 6 or 7 in an effort to cross the technology "valley of death."



The Department of the Navy (DON) BA-4 budget essentially funds three distinct categories of expenditures: Special Access Programs (SAP), Major Defense Acquisition Programs (MDAP), and non-MDAP programs. On average, each category accounts for approximately one-third of the total BA-4 funding. The pie chart above shows a categorization of BA-4 appropriated funds for FY 2011. The NRAC panel had no insight into the BA-4 expenditures for the SAP programs, but was assured by the Navy's FMB that these programs are effectively managed – with direct oversight from the CNO and Marine Commandant. The BA-4 funds for MDAP programs are being used to fix identified system problems and to add needed program capabilities. The remaining BA-4 funds, which in FY11 represented 28% of the total BA-4 appropriation, is the funding category that is the focus of this study. A listing of Navy BA-4 Program Elements is in Appendix D.

Relevant Significant Findings from Past Reports on BA-4

- **Chasm exists between S&T (TRL 5) and acquisition (TRL 7)**
- **No overall Naval leadership or responsibility in developing investment strategy for BA-4**
- **Freezing requirements too early causes mismatch between technology enabled capabilities and requirement expectations**
- **Ability to specify, develop, test and insert new technologies into programs has atrophied**

Numerous studies and reports have been written on the use of R&D funds by DOD, and in particular, the Department of the Navy. A listing of these, with particular relevance to the NRAC study, is in Appendix E.

Significant findings from these reports include:

- A chasm exists between S&T (TRL 5) and acquisition (TRL 7). Reference: *Report to the Congress on Technology Transition*, July 2007.
- No overall Navy leadership or responsibility exists for developing the investment strategy for the BA-4 budget account. Reference: Naval Sea Systems Command, Dr. James Meng, *Search of Navy Budget Activity 4 Metrics for Effective Technology Transition*, August 2011.
- Freezing requirements too early causes a mismatch between technology-enabled capabilities and requirement expectations. Reference: Air Force Studies Board of

the National Research Council of the National Academies report *Evaluation of U.S. Air Force Preacquisition Technology Development*, 2011.

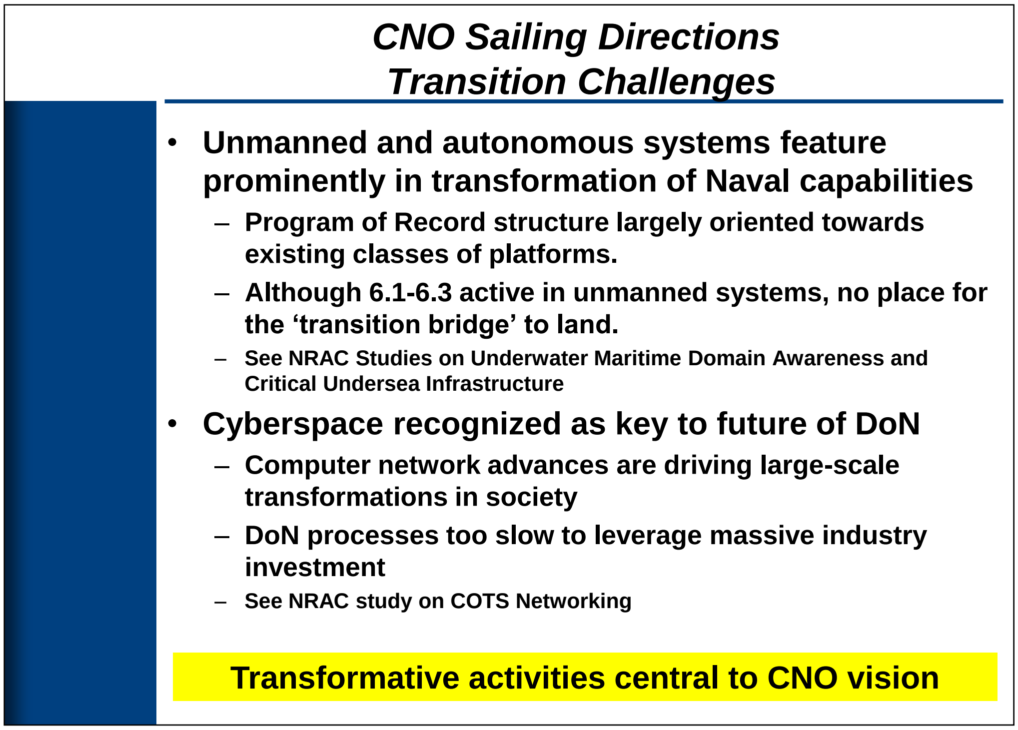
Ability to specify, develop, test and insert new technologies into programs has atrophied.

***CNO Sailing Directions** (excerpts)*

Over the next 10 to 15 years, the Navy will evolve and remain the preeminent maritime force.

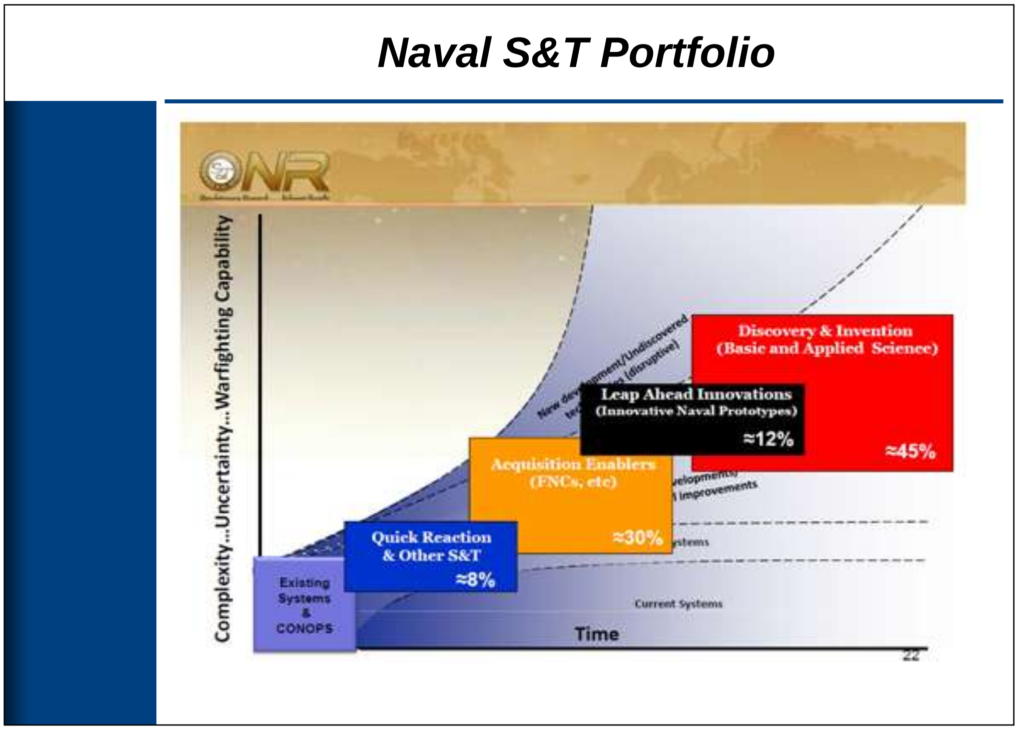
- **The reach and effectiveness of ships and aircraft will be greatly expanded through new and updated weapons, unmanned systems, sensors, and increased power.**
- **The Air-Sea Battle concept will be implemented to sustain U.S. freedom of action and Joint Assured Access.**
- **Unmanned systems in the air and water will employ greater autonomy and be fully integrated with their manned counterparts.**
- **The Navy will continue to dominate the undersea domain using a network of sensors and platforms - with expanded reach and persistence from unmanned autonomous systems.**
- **Cyberspace will be operationalized with capabilities that span the electromagnetic spectrum – providing superior awareness and control when and where we need it.**

The DON faces great challenges in the coming years with a high likelihood that potential adversaries will grow more capable even as DON resources shrink. The ability to keep sea lanes open for commerce, and to ensure the territorial integrity of allies is challenged by growing anti-access, area denial capabilities around the world. Consequently, incremental improvements of existing systems will be insufficient. Transformational capabilities are required, and feature prominently in the plans of the CNO.



Transformation is critical to the CNO’s vision for the future Navy – but, unfortunately, true transformation is poorly supported by the Navy’s existing process, culture, and structure.

Most current programs of record are platform centric and are not structured to support the effective transition of emergent capabilities – especially those capabilities supported by autonomy and cyber systems and networks. The painfully slow pace of government acquisition of new technologies means that other more agile (and faster) entities have the potential of beating us with our own technology.



This figure shows how ONR allocates and manages the Naval S&T portfolio. The bulk of S&T funds, termed *Discovery and Invention*, are long-term technology investments that act as a hedge against uncertainties in future threats and opportunities. *Discovery and Invention* builds S&T capacity that helps address current problems, reduces risk, and provides technology options for future capabilities. *Leap Ahead Innovations* are high-risk technology investments that are potentially disruptive in nature. These are technologies for which there is not currently a defined requirement but which could, if realized, be game changers for the warfighter. *Quick Reaction* and *Existing Systems* & *CONOPS* are projects that are responsive to immediate needs or compelling innovation identified by the Fleet/Forces or Naval leadership. *Acquisition Enablers* encompass the Future Naval Capabilities (FNC) program. ONR implemented the FNC program in order to facilitate the transition of S&T and ensure alignment with requirements, Acquisition and Fleet needs. The NRAC panel focused on this portion of the Naval S&T portfolio because it is the predominant pathway for transition to BA-4 and Acquisition.

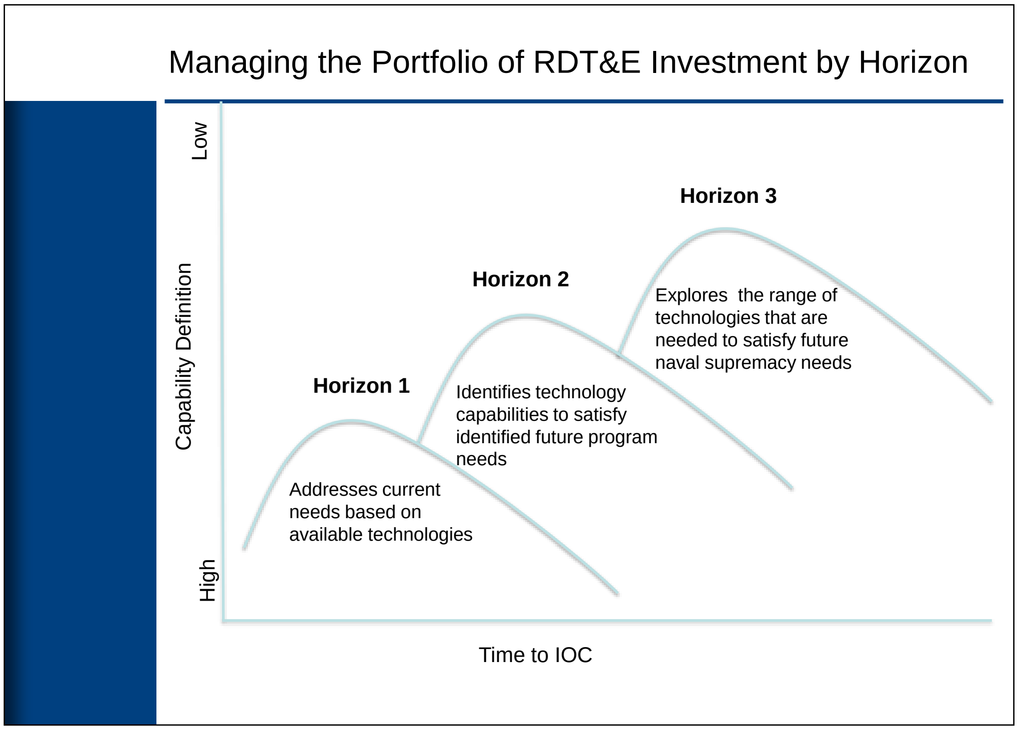
The FNC program is composed of Enabling Capabilities that develop and deliver quantifiable products for insertion into acquisition programs of record (POR) within five years.

Enabling Capabilities are proposed in response to validated requirements. They are reviewed and ranked by a Technical Oversight Group consisting of selected OPNAV Codes (N8, N091, N2/N6), Marine Corps Combat Development Command, ASN RDA, and U.S. Fleet Forces Command representatives with inputs from Pillar integrated product teams. An Enabling Capability must have a Technology Transition Agreement (TTA) that represents a commitment for insertion of the technology into a POR, provided it meets specified exit criteria. The agreement includes a description of the product, level of technical risk, final TRL, transition year and exit criteria. FNCs are reviewed annually and products are tracked. Of the 160 products funded from FY06-FY10, 86% transitioned to Acquisition. Of those products transitioned, 35% failed to deploy to the Fleet/Forces. Analyses by an independent Transition Review Board showed the following reasons for failure to deploy:

- Technology did not meet TTA requirements (27%)
- Technology lost in Acquisition competition (23%)
- Acquisition strategy significantly modified (21%)
- Requirements changed or not adequately specified (17%)
- Acquisition Program Office lost interest (i.e., no transition path or sponsor) (12%)

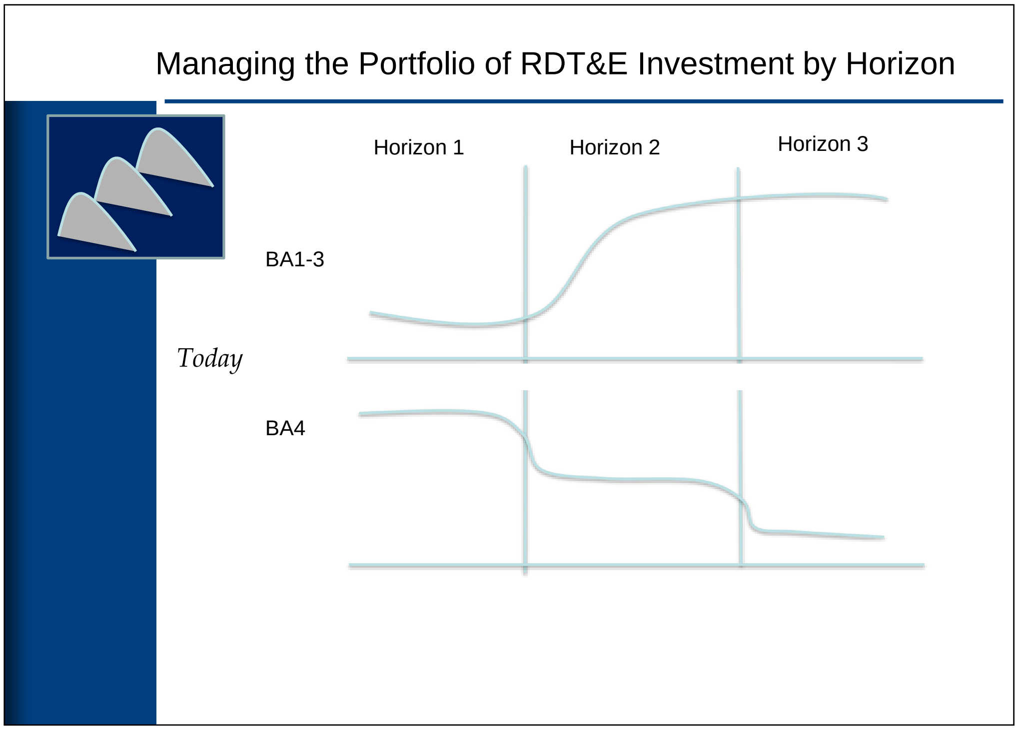
It is expected that not every technology will prove to be successful. Many of these factors, however, highlight the challenges associated with sustaining advocacy and resources for technology insertion across various communities through lengthy R&D programs. There are some examples of FNC products that were partially transitioned or picked up by another sponsor or application, but for the most part, the result was technology being left on the floor of "Death Valley".

FNCs have been shown to be an effective method to transition S&T however, they are very constrained. The FNC program facilitates "requirements pull" but, it doesn't easily permit "technology push" of riskier, but possibly more promising technologies. Furthermore, linking the fate of a technology application to a specific POR eliminates the pathway for innovation in budget environments where acquisition programs are going to be cancelled. In the following charts, we address how BA-4 may be used to improve the likelihood of technology deployment.



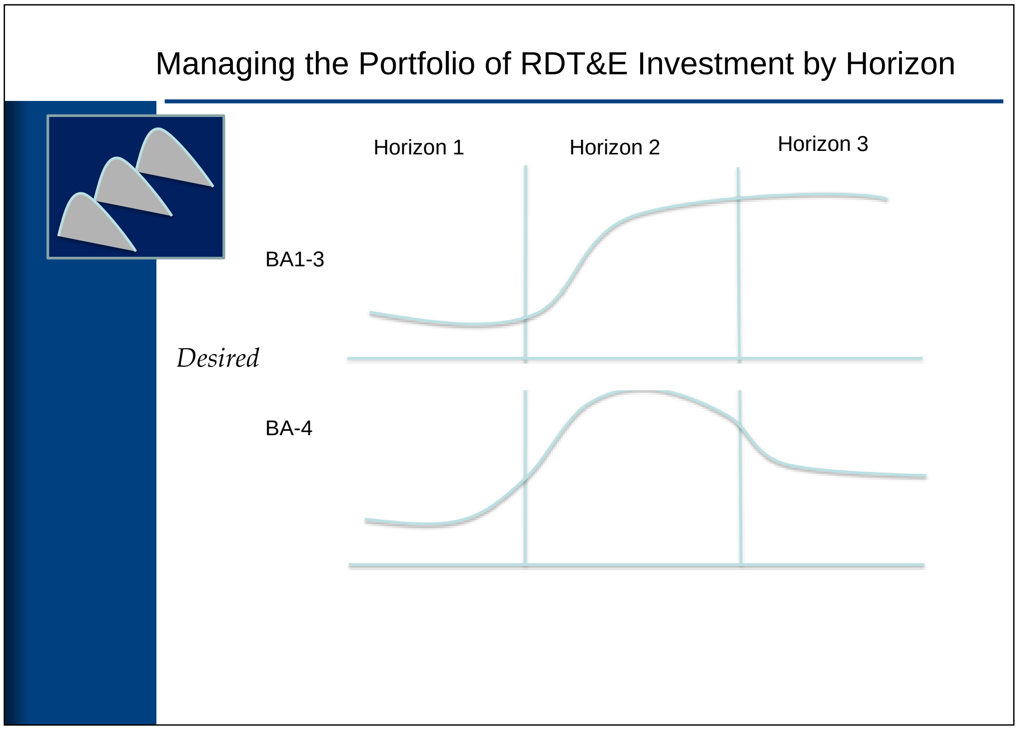
It is useful to divide the R&D portfolio into three separate horizons as described by Mehrdad Baghai, Steve Coley, and David White in their book *The Alchemy of Growth*. Horizon 1 describes the bread and butter of the business; Horizon 2 describes fast-developing emerging ventures; and Horizon 3 describes ideas that will germinate into tomorrow's profits. Applying the same concept to the RDT&E investment portfolio, this chart uses Horizon 1 to denote that efforts which primarily address current needs based on available technologies (e.g., Acoustic Rapid COTS Insertion (*ARCI*) Advanced Processor Build); Horizon 2 denotes technology capabilities that will satisfy already identified future needs (e.g., DDG 51 next flight, Next Generation Enterprise Network); and Horizon 3 represents the exploration of technologies that may fulfill future naval supremacy needs (e.g., autonomy, directed energy, hypersonic applications).

In order to minimize the loss of technologies to the "valley of death" and at the same time avoid so-called "science projects" that may never meet a need in the field, it is important to manage the relative investments in these three horizons.



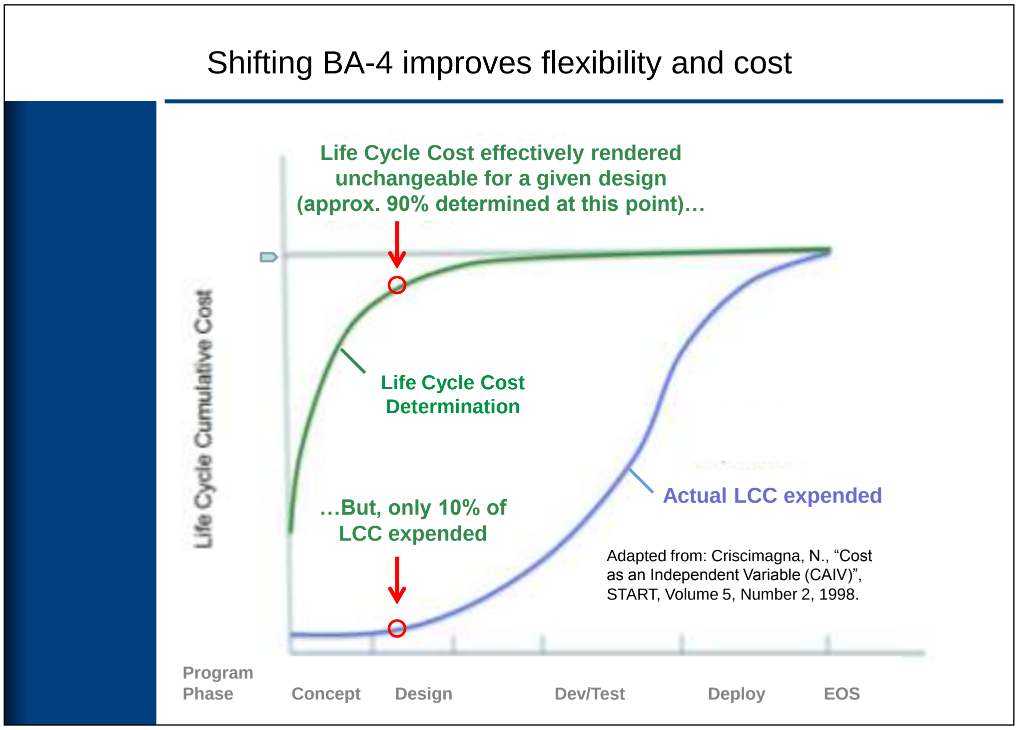
This chart shows the relative distribution of BA-1 through 3 and BA-4 investment among the horizons defined in the prior chart. The majority of the BA-1 through 3 investment occurs in Horizon 3 projects which explore technologies that may be critical to future naval supremacy. There are relatively large BA-1 through 3 investments applied to Horizon 2 that aim to develop technology capabilities in support of identified future program needs. Finally, a small amount of BA-1 through 3 funding is applied to addressing current needs.

In contrast, the majority of BA-4 investment is being applied to solving problems with current programs in Horizon 1. This "starves" investment in prototyping for Horizon 2 and 3 technologies, which leads to their being less mature – with higher risk – when it is time for a program manager to make a decision on adoption of this particular technology.

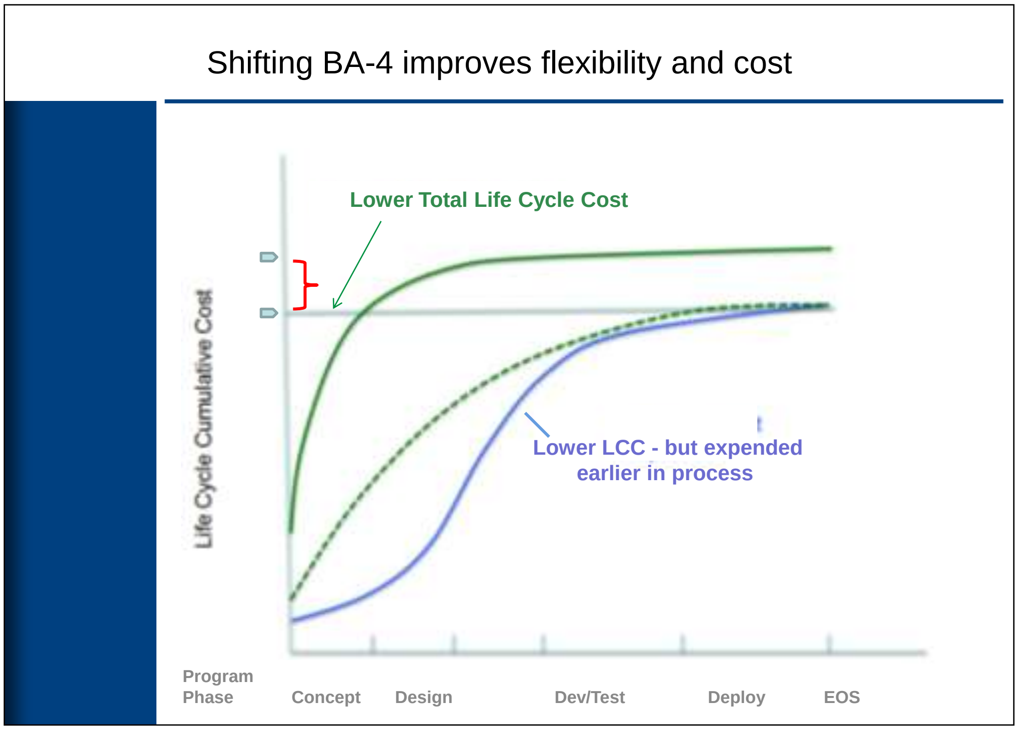


This chart illustrates the desired distribution of BA-4 investment among the three Horizons. The bulk of BA-4 investment should be spent on transitioning technologies that correspond to Horizon 2. This will help to avoid the "valley of death" and ensure that technologies that serve identified needs are introduced to the fleet in a timely manner with less risk.

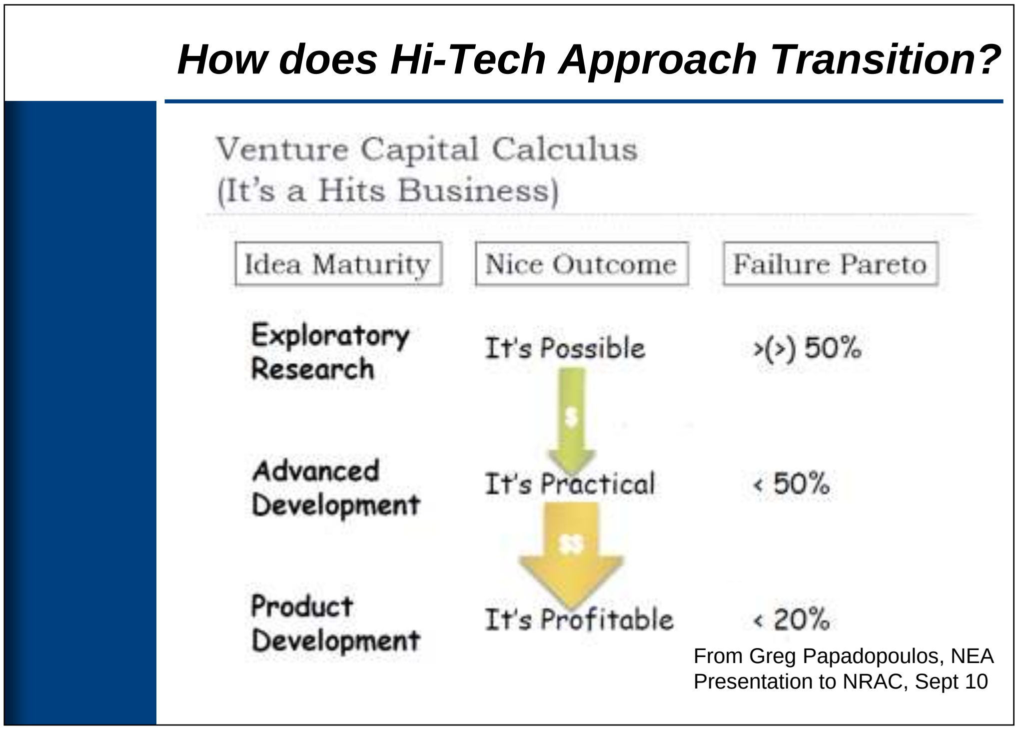
Also, significant BA-4 investment should be directed toward prototyping of Horizon 3 technologies in order to accelerate learning and ensure earlier decisions on the viability of emerging technologies. Those technologies that fail in transition can be abandoned while the maturation of those that pass this phase can be accelerated.



Several studies have documented that only about 10% of the Life Cycle Cost (LCC) of an acquisition system is expended prior to Milestone B, as shown by the blue line in this figure. Conversely, nearly 90% of the LCC is determined prior to Milestone B or during the early stages of R&D as shown by the green line. This leads to a well-known systems engineering principle that the cost of design changes escalate rapidly in later stages of the system lifecycle. The best opportunity to influence the LCC and therefore, the most effective point at which to invest BA-4, is in the front end of the acquisition process.



The Panel recommends shifting the focus of BA-4 earlier in the system lifecycle (i.e., Horizon 2, as discussed previously). This changes the slope of the LCC cost curve (dotted green line) – and it significantly reduces the total cost over the system's life. The use of BA-4 for early prototyping, with Fleet involvement, can benefit acquisition systems by increasing the maturity of the technology, permitting the investigation of technology options and obtaining user feedback. These benefits will reduce the risk in Acquisition, mitigating the need to spend BA-4 to fix problems in programs. More importantly, this could result in lower overall LCC by introducing cost reduction concepts early and reducing design changes in later stages of R&D.



What lessons can be learned from other approaches to bringing technology to the practical application? Silicon Valley high tech Venture Capitalists (VCs) face many of the same challenges, which include: identifying technology ripe for transition, finding embodiments of the technology that will succeed in a competitive market place, and implementing the resulting solutions in a rapid and efficient manner. Since venture capitalists function in a highly competitive domain, the strategies of successful venture capitalists should contain useful lessons.

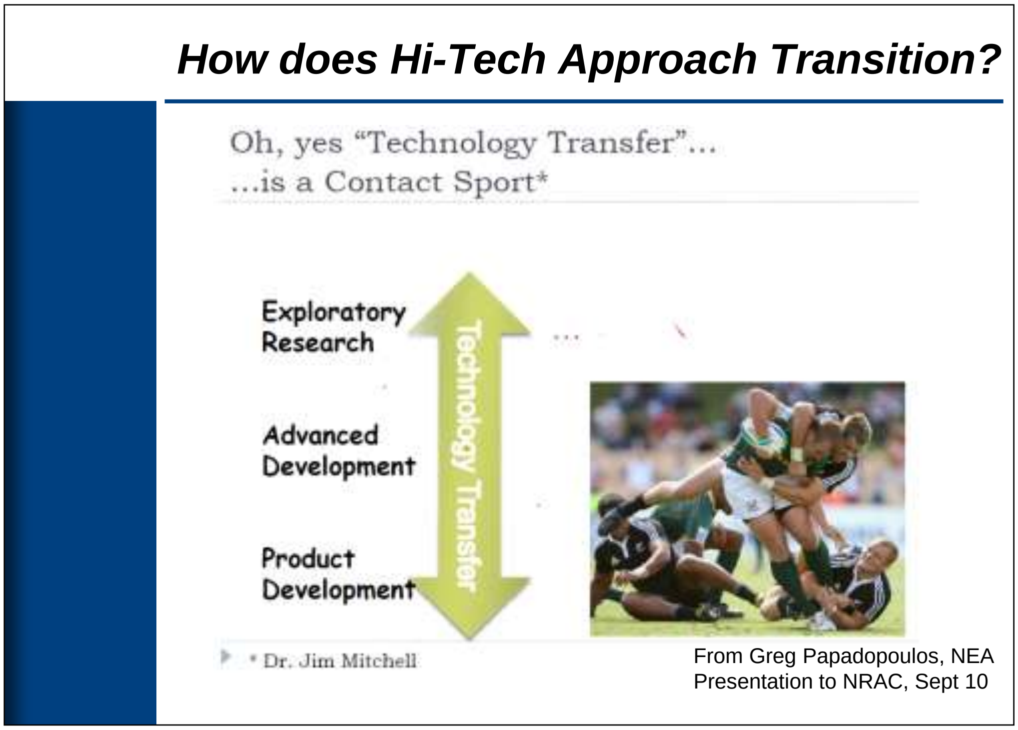
An important lesson from the venture capital community is that a small fraction of the ventures funded will account for the majority of the return. This pattern will be discussed again, and is summarized here as "it's a hits business". The challenge is that it has proven impossible to identify which early-stage ventures will be the big hits. In part this is simply due to the uncertainly associated with early stage technology, but it also stems from other factors not under the control of the venture capitalist such as the development of other competitive approaches, and trends in the market as a whole. To deal with this uncertainty, they take a tiered investment approach, initiating a large number of activities, but then weeding out unsuccessful ventures rapidly.

The goals for a particular venture become progressively more practical as it progresses through the stages of venture capital funding. In the first round, the goal may be a simple as determining the feasibility of the technology at the core of the idea. For example, a company developing a new solar power technology might demonstrate that an innovative fabrication technology can be accomplished in this early stage. If the company is not successful, then the VCs will be ruthless in terminating the activity – the goal is to concentrate resources on the "big hits". Consequently, more than half of the early stage projects are likely to proceed to the second round.

If the basic feasibility is demonstrated, the next stage of funding will address more practical aspects associated with the venture. For example, with the notional solar power company, can its fabrication technology be scaled up to large volume production at a competitive cost? Again, the failure rate of projects will be high, probably near 50%.

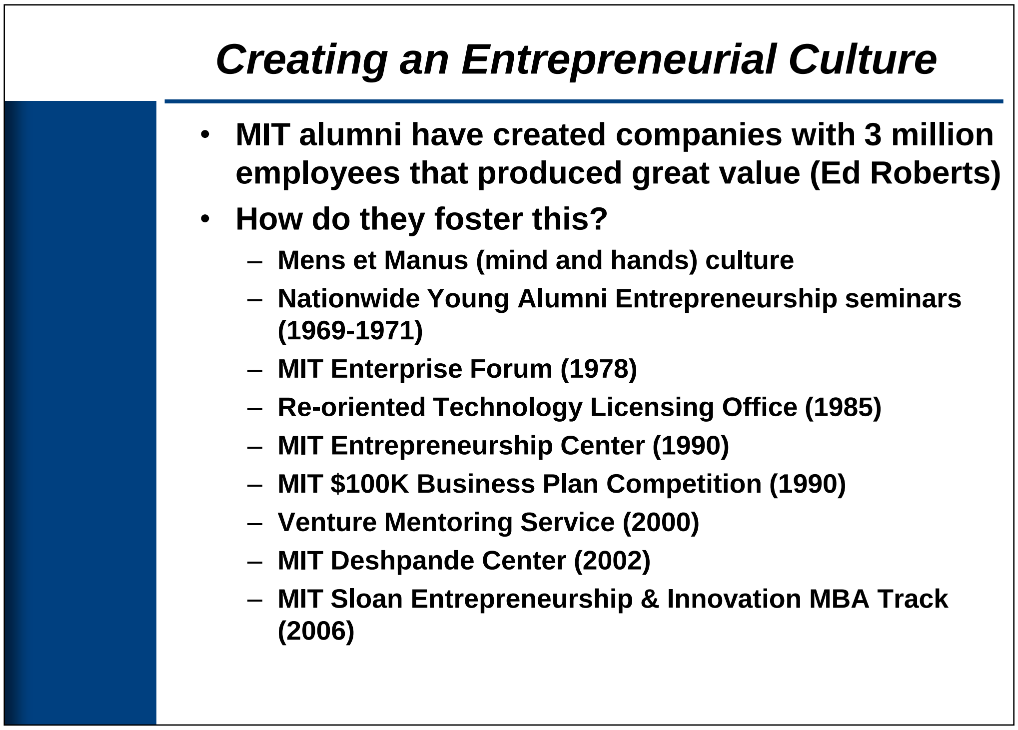
The final round of funding is particular costly, as this is the phase in which the project will be brought to the market and the venture becomes a real business. Our notional solar power company will require funding for manufacturing facilities. It will also have to develop relationships with suppliers, develop a distribution apparatus, and train personnel for almost every stage of the enterprise. At this stage of the venture, expectations for success are high, with fewer than 20% of such ventures expected to fail.

The differences between traditional DON processes and those for venture capital investment largely revolve around failure rates and attitudes towards failure. VCs start many ventures, but then kill projects early and frequently. In contrast, once an activity begins the transition process within the DoD, the expectation is that the project will succeed. (In fact, military careers are greatly enhanced from successful transitions.) In the VC world, failures are valued for the lessons they provide: the individuals involved with one failed venture may be recruited for a new venture. In the DON, involvement with a failed venture can end an otherwise promising career. The VC process treats projects as disposable until they are proven, but places a high value on individuals, the DON process does the opposite, valuing projects highly but treating individuals as disposable.



A key lesson from the venture capital process is the importance of keeping teams together. In the early stages of a high technology startup, the identity and commitment of the key players are critical because the technology and market are often ill defined. Investors are investing in the people as much as the idea, because the numerous setbacks and lessons will refine and in some cases redefine fundamental assumptions as the enterprise progresses. The people are the one constant through the venture. In later stages, the value of individuals will be so great that subsequent rounds of funding will typically be contingent on the participation of the core team. There will be new talent and some turn-over, as the challenges will evolve as the enterprise matures. *But maintaining continuity of key individuals is a central concern of venture capitalists managing emerging technology.*

The comparison between VC and DON processes clearly shows opportunities for improving transition within the DON. In the VC world, the innovation and the organization (i.e., the new company) are the same, so keeping teams together is largely a function of keeping staff employed by the company. In the current DON, transitions involve moving activities between different organizations. For example, an ONR-University S&T collaboration may lead to formation of a small startup company (if the technology demonstrates its promise), and then one of the top tier system integrators buys the startup, completing the technology transition. The potential for continuity certainly exists on the academic and industry side, but government employees will be engaged only for portions of the process.



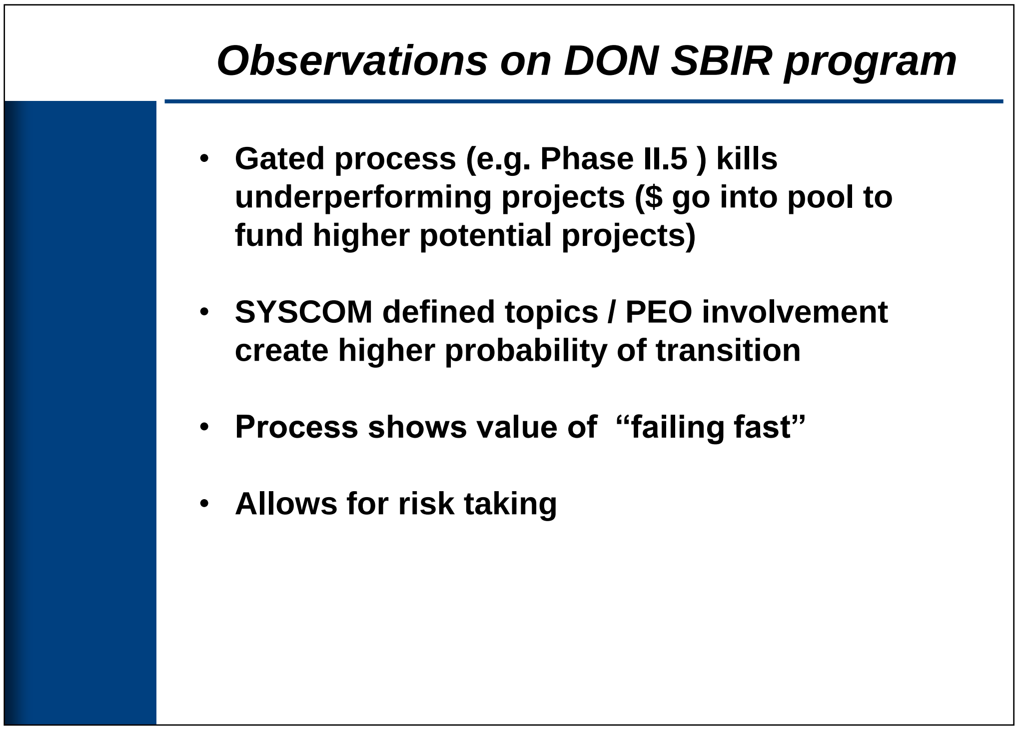
Ed Roberts, senior MIT Professor of Management, has focused on entrepreneurship throughout his career. In his view, scientists and engineers want to change the world, they often start companies as a means toward that end, and those companies do, in fact, change the world. Over the years, entrepreneurial graduates of MIT have created companies with more than three million employees and $2 trillion/year in sales. If these companies were a country, they would be roughly equivalent to the tenth largest economy in the world.

An easy conclusion is that “driven” entrepreneurs – determined to prove an idea right – constitute a highly effective technology transfer mechanism. Sending the innovators along with the innovation ensures passion and determination to see an idea through, which rarely characterizes licensing arrangements. Over the years, MIT has established mechanisms that encourage entrepreneurial thinking in faculty, staff, students, and alumni. For example in 1985, the MIT Technology Licensing Office shifted its mission toward marketing, de-emphasizing patenting. Revenue sharing was revised such that inventors, their laboratory, and MIT would share equally in proceeds after expenses.

Nevertheless, innovators often choose not just to hand over their ideas to the Technology Licensing Office, but rather to take a leave of absence to start a company that licenses the innovators' intellectual property back to them. Sometimes these innovators return (e.g., the web company Akemai); sometimes they do not (e.g., Heartland Robotics). MIT benefits either way: if the innovators return, they return with a profoundly improved understanding of the world outside academia; if they do not, they contribute to renewal.

To encourage students to become entrepreneurs, MIT created the “50k”, now “100k” competition. Participants form teams that create and pitch business plans, with the $100,000 prize providing seed capital to start the business described in the winners' plan. The annual buzz around the contest boosts entrepreneurial awareness and encourages enrollment in MIT's dozens of classroom subjects that focus or touch on entrepreneurialism. The creation of the Venture Mentoring Service was another major step forward. Volunteers with entrepreneurial experience are paired with students and young alumni with ideas, helping those students and young alumni to turn their ideas into successful companies.

All these initiatives – seminars, licensing policy change, competitions, centers, mentoring mechanisms, subjects, and curricular tracks – increase the campus prestige of those with innovative ideas, lower barriers to making things happen, and lead to high-impact results.

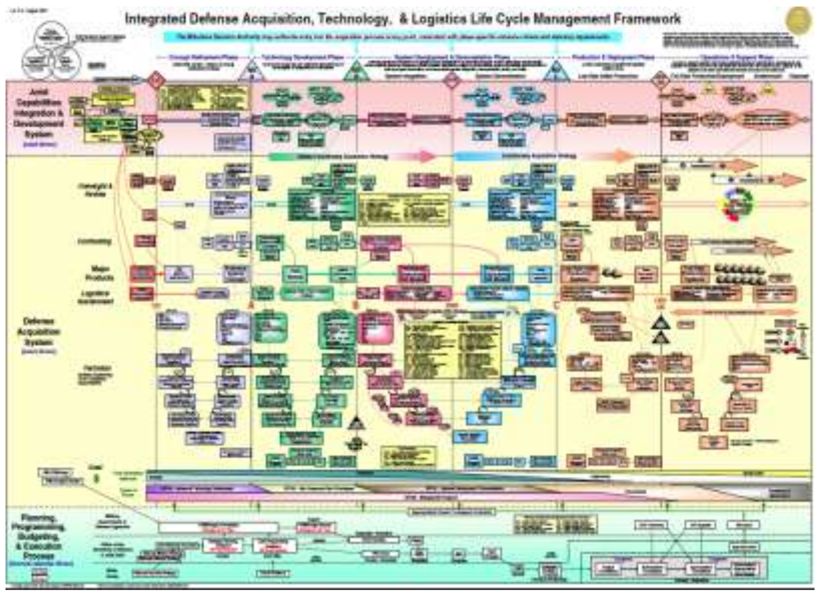


Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are funded by a tax (2.5% for SBIRs, 0.03% for STTRs) on 6.1 through 6.7 funding. These funds, $390 Million in FY11, are held in a System Development and Demonstration (i.e., 6.5 funding) account but can be used for any RDT&E type. The Navy SBIR program is widely recognized among government agencies as having achieved significant success in the insertion of SBIR-funded technologies into the acquisition process. Some key features of Navy SBIR are worth noting as models for technology transition.

The SBIR Phase II.5 process was introduced in FY07 as part of an accelerated transition initiative. In the past, Phase II awards were fixed at $750,000 for an 18 to 24 month development timeframe. A Phase II.5 is based on a gated process that partially funds Phase II projects for less than $250,000 over approximately nine months. At that point, there is a go/no go decision. This allows underperforming projects to be terminated and promising projects to be funded up to $1.5 Million and/or receive matching PEO funds. This process is consistent with the "fail fast" approach of high tech industry and fosters a willingness to take risk.

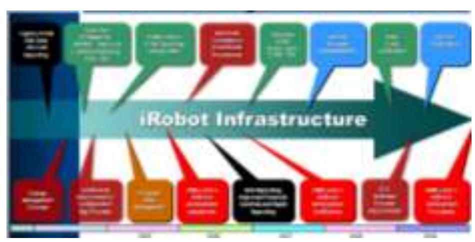
SBIR funds are given back to PEOs minus Navy SBIR administrative funds. The SBIR topics and awards are selected by PEOs and aligned with acquisition offices. The administrative structure of SBIR includes SYSCOM Program Managers, PEO Technical Liaisons and SBIR Field Offices at the Warfare Centers. This engages the PEOs in the technology development and ensures that the SBIR projects are addressing acquisition needs. Also, the Navy SBIR process makes a Transition Assistance Program available to all Phase II companies to accelerate transition. This program includes market research, Phase III strategy development and Prime Contractor partnering opportunities. As noted by Charles Wessner, representing the National Research Council in his February 2011 Senate testimony, "Teaming among the SBIR program managers, agency procurement managers, the SBIR awardees, and, increasingly, the prime contractors is important in the transition of technologies from projects to products to integration in systems." This Panel strongly recommends an extension of this SBIR philosophy to the administration of BA-4. And further, it encourages engagement – not just with the PEOs – but with the Fleet early in the R&D process.

Burden of the DoD Acquisition Process



Process Burden on a Typical Company

- **Regulatory demands on industry are very high**



iRobot
Bedford, MA

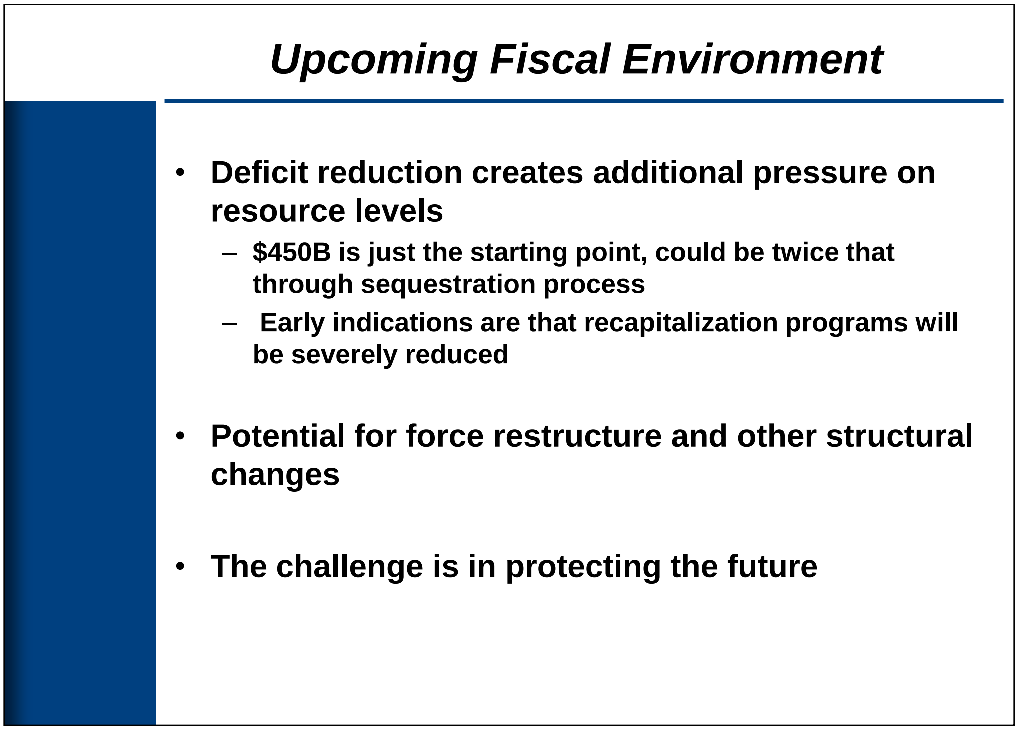
- **Statutory and regulatory underpinnings of these burdens will not easily change**
- **We need to look to BA-4 improvements to enable our ability to protect the future of naval supremacy with reduced resources**

In 2006, the Government Accountability Office completed a report: *Defense Acquisitions: Major Weapon Systems Continue to Experience Cost and Schedule Problems* *under DOD's Revised Policy*. In this report, GAO states that: "Changes made in DOD's acquisition policy over the past 5 years have not eliminated cost and schedule problems for major weapons development programs." Today's acquisition process is primarily driven by the Goldwater-Nichols DOD Reorganization Act of 1986, and the Clinger-Cohen Information Technology Management Reform Act of 1996. The legislation contained within these two Acts has driven the buildup of the current large and bureaucratic acquisition processes used to acquire all Defense systems, including all of the Naval platforms, weapon systems, and related support systems used by the Navy and Marine Corps. The first chart (from the Defense Acquisition University (DAU) web-site), and the second chart above are a testament to process run amok and the implied burdens imposed both on those working in the processes and those that have to respond to them. Substituting process for trust carries a very heavy cost burden that is borne by both industry and the tax-payer.

While this study does not attempt to unravel today's complex Naval acquisition processes, it does focus on the burden to innovation that results when this lack of trust, and unwillingness to accept risk, leads to an out-of-control mega-process. These individual processes have been put in place over time in an attempt to eliminate all acquisition risk by preventing the recurrence of every problem that has ever occurred. Through Congressional direction and SECDEF policies, increased oversight in requirements, acquisition, and budgeting has created the resulting incredible complexity depicted in the "spaghetti" chart, shown on a previous page. This overall process is the convergence of interdependent requirements, acquisition, and budget processes all operating within their own semi-independent activities. Unfortunately, the resulting cost to the Navy and DOD is additional manpower, in an environment when there is pressure to reduce billets; increased acquisition timelines, in an environment where fielded capability is critical; and loss of innovation opportunities, in an environment where technical capability is often the discriminator between winning and losing.

It is an example of process trumping culture and structure. It results in the unintended consequence of driving away innovative entrepreneurs and creating a culture of risk avoidance at all cost. U.S. technological leadership was not achieved by a fear of failure. But in today's DOD process-driven environment, technical entrepreneurs are being driven away – or who DOD can no longer attract – thus potentially jeopardizing our success in future warfare.

In addition to creating burdens, there is another penalty to be paid. It is the creation of an environment so hostile for entrepreneurs that it can create significant disincentives for those very companies whose innovative thinking we seek to engage. Because many of these process burdens are not sensitive to company size or contractual engagement, companies must be fully responsive to all of the DOD regulatory requirements. The fear is that many companies will elect to avoid the entire DOD sector, particularly those with an already rich commercial market. Because the dynamic changes in technology application make those commercial sector capabilities essentially required for DOD, methods to engage these companies must be found. The obvious solution – disable the needless regulations – is not easily arrived at.



As a nation we serially struggle with the need to rebalance priorities and redirect resources away from defense expenditures. President Eisenhower made strategic choices based on resource considerations, and at least five times in the intervening years we have had to deal with the "defense burden" issue. Over the last fifty years, the U.S. government has taken unusual steps to improve the balance of spending priorities about every ten years or so. Each time has been a different challenge and each time represented a differing defense structure and appropriation account reality. We have seen the Vietnam-era large force and industrial base evolve into the "end of the Cold War" changes in threat/force/modernization efficiency. This has morphed into today's smaller force structure and compressed industrial base. The reality has been that each time required the defense establishment to make do with fewer resources. Some have calculated, for example, that military build-downs have historically taken a 30% reduction from the defense top-line over a ten-year period of time. Because of the changes over time to the defense establishment, even the potential 10% reduction currently being aired leads to significant structural difficulties.

Foreseeing pressures to reduce the defense top-line and wanting to forestall large reductions that would stress the force and unhinge modernization plans, Secretary of Defense Gates initiated an effort to identify efficiencies with the hope that displaying good stewardship would deflect reductions and allow some flexibility in paying modernization bills. The deficit crisis over the 2011 summer disrupted that approach to rebalancing priorities and the resulting Budget Control Act of 2011 would result in $450 Billion in reductions, with the potential for over twice that amount being reduced in a worst-case scenario.

While many voices have expressed dismay, including the political and uniformed leadership of the Department of Defense and the Defense industry, the reality is that one way or another, large reductions will occur to defense spending levels, even if Congressional leaders manage to make substantive changes to the Act. In prepared comments by the Chairman of the House Armed Services Committee, reductions of $ 90-105 Billion per year would result without action to change the law. The President has signaled his unwillingness to back any changes to it. Clearly, there will be opportunities to deflect "heavy damage", but in even the most benign situation large reductions will be sustained. The Military Departments have already signaled plans to cut end-strength, to reduce employment and to restructure modernization plans. While there have been signals that these actions would further derail economic recovery from the "Great Recession", there does not appear to be a political will to take the steps necessary to protect the future. After the Great Depression, such steps were taken with the resulting benefit to the industrial base, to the lab structure, experimentation and a well-oriented technical workforce.

Implications for R&D Investment

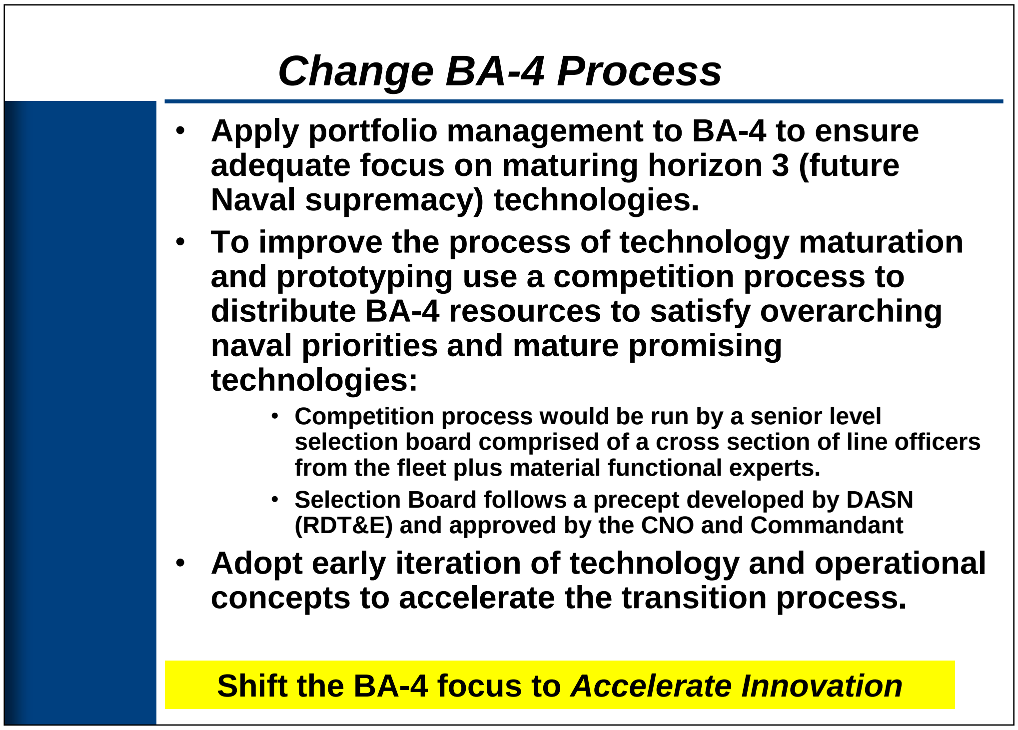
- **Need to place a higher premium on technology readiness for the future to prevent atrophy of technical capability in the Naval Establishment**
- **Need alternative path for transition when FNC transition funding is lost**
- **Need to be more focused on our objectives for technology investment**
- **Need to be more focused on the allocation of resources in BA-4 to better prepare for future capability readiness**

As the Department adjusts to a sharply reduced top-line, many of the leaders in the Department are addressing the implications of the reductions and how they would go about conducting business in the future. A broad range of areas of adjustment has been identified, but, almost universally, reductions in numbers and quantities in investment programs and reductions in people have been at the top of the lists. Without attempting argument if those approaches are the most suitable ones, it is clear that at least those two mechanisms for addressing top-line reductions hold significant implications for R&D investment. And, although defense procurement and R&D expenditures may be cut in the future, global technology development will continue. *Our adversaries will have the same access to new technology as we have*. Therefore, the Naval Enterprise must maintain enough focus on the nature and amount of R&D activity to ensure that our technology infrastructure, both facilities and people, does not atrophy as we move toward an uncertain national security future.

Interestingly, there is a compounding problem given the ONR FNC process. For each defined FNC capability transition, there is a firm requirement that it be tightly tied to a specific acquisition program of record. In the past, technology transition agreements (TTAs) have ensured a tight coupling of operational needs with technologies for transition. In an era of declining budgets leading to a reduction of funded programs of record, the previously established process (i.e., required TTAs) will not produce the requisite momentum. It is imperative to look for other paths for emergent technology transition. During a period when acquisition programs of record are truncated, reduced, or completely eliminated by budget necessity, BA-4 becomes important for more than just addressing program gaps in various dimensions. It also must shoulder the burden of maintaining focus on prototyping and risk-reduction of nascent technologies even without defined acquisition targets as expressed in programs of record. In that context, BA-4 investments also help to identify and sustain critical human capital needs so as to protect future development understanding and capabilities.

Achieving these objectives in a constrained resource environment requires focus, discipline and a process that enables the essential elements of a forward-looking research and development program. Only senior Naval leadership effectively engaged in the resource allocation processes for BA-4 can deliver the clear objectives of the Naval Enterprise: providing the precepts and culture to foster an entrepreneurial and innovative – risk taking – technology construct to protect the future of the Enterprise and the ability to anticipate the Nation’s national security needs.

Recommendations and Actions



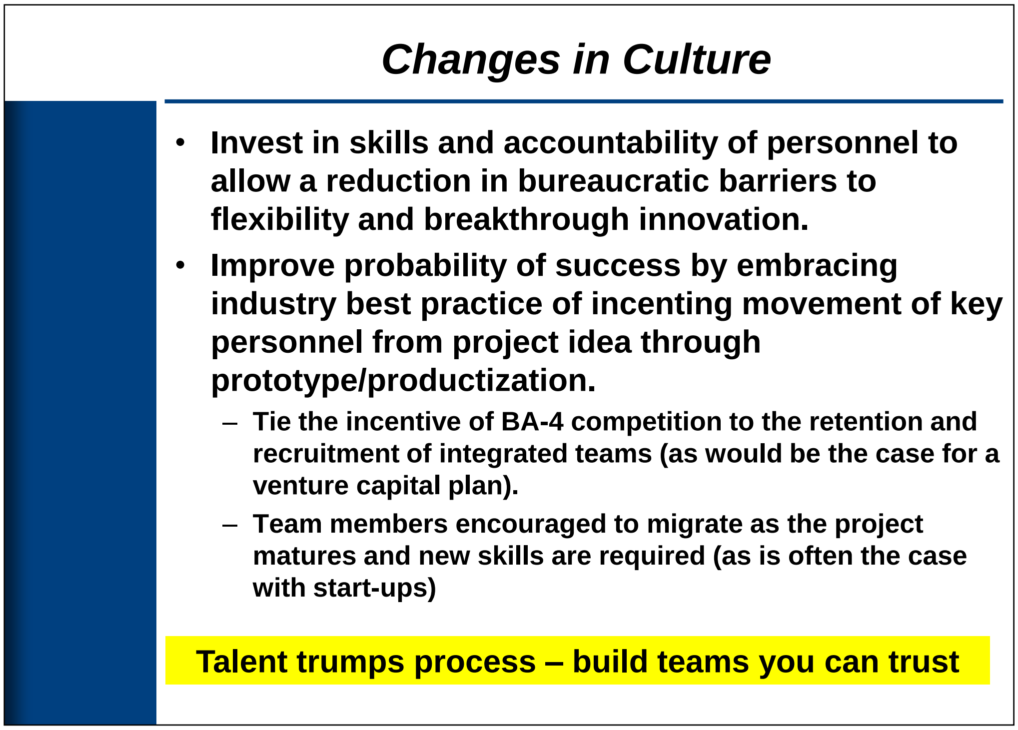
This chart describes some recommended changes to the current management of BA-4 funding:

- First, the previously discussed Horizon portfolio perspective should be applied to the BA-4 investment process to ensure that there is linkage between BA-1 through 3 and BA-4 investments. This is especially important for Horizon 3 projects.
- Second, a competition process should be introduced, managed by a senior-level selection board using specific precepts developed by DASN (RDT&E) and approved by the CNO and Commandant. This competition would allocate BA-4 resources among projects to meet the needs of naval priorities and help mature promising technologies. There would be clear winners and losers based on each program's alignment with the defined precepts.
- Third, early iteration of technology and operational concepts should be fostered to accelerate the transition process.

Actions 1-3

- **ASN RDA define and monitor BA-4 portfolio balance among horizons 1-2-3 to ensure adequate focus on maturing horizon 3 (future Naval supremacy) technologies.**
- **ASN RDA establish a competition process to distribute BA-4 resources to satisfy overarching naval priorities and mature promising technologies:**
  - **Competition process would be run by a senior level selection board comprised of a cross section of line officers from the fleet plus material functional experts.**
  - **Selection Board follows a precept developed by DASN (RDT&E) consistent with the BA-4 portfolio balance and approved by the CNO and Commandant.**
- **ASN RDA establish a process for early iteration of technology and operational concepts to accelerate the transition process.**

This chart summarizes the actions recommended to the ASN RDA to fulfill the recommendations of the prior chart on BA-4 process changes.



Over time, and in response to visible failures of one type or another, the Department of Defense has evolved a culture which is unwilling to accept failure – or even to run the risk of failure. Some credit for this culture must be attributed to outside "shaping" from the various DOD-related Congressional committees. After Vietnam, during the apogee of finger-pointing, a different dialogue emerged that had the bureaucracy more sensitive to being blamed for "wrong-doing". The Iranian hostage rescue failure in 1980, the Beirut bombing of the Marine barracks and the United States-led invasion of Grenada in1983, inflation and deficit reduction impacts on defense programs and other events all contributed to an atmosphere by the late 80s that reflected a "prime imperative" to avoid risk and possible failure at any cost. After the Packard Commission report in 1985 – and the resulting statutory interventions by the Congress – focus has been on process (i.e., the check-list approach to avoiding problems) rather than on innovation. Those structural changes tended to diminish real innovative approaches – where some risk of potential failure existed. Accordingly, the Department's decision-making and acquisition processes tend to be risk-averse. The NRAC observed many processes developed to minimize risk during the fact-finding phase of this study.

The imminent and significant reduction of resources available to the Department put a premium on employing practices that provide the most “bang for the buck”. Part of the approach must be to reduce the bureaucratic barriers that impede personal and institutional innovation.

Because the knowledge of how to do this is largely a “lost art”, the best way to kick-start the process is to look at the current state-of-the-art in the entrepreneurial private sector. These entities are known for encouraging risk-taking and innovation in ways that can be adopted by the Department. Their approach is based on the ability to attract and aggregate key talent into teams that can “move” technology from a preliminary idea to eventual product delivery. Accordingly, the competition process for BA-4 resources – mentioned previously – would have to consider the nature of the assembled team as well as the technology application. Another idea would be to create incentive structures to encourage team members to migrate with and grow their skill sets as the project matured. The bottom line should be a focus on quality people as opposed to quality process.

Actions 4-5

- **ASN RDA identify the resources and processes necessary to support the investment in skills and human capital development so as to:**
  - **enhance technical expertise**
  - **improve flexibility**
  - **encourage early risk taking**
  - **reward entrepreneurial behaviors**
- **ASN RDA establish a program that will encourage the retention and recruitment of integrated teams and encourage team members to move with their project as it progresses through the transition process.**

This chart summarizes the actions recommended to the ASN RDA to fulfill the recommendations of the prior chart on culture changes. Historically, when recommendations for institutional change have relied on good will to be executed, even when there is common agreement on the merit of the recommendations, not much has happened. In the case of these recommendations, there are specific steps that will require the application of senior executive attention and the provision of resources to be effectively executed. Improving the expertise, flexibility, risk acceptance and reward mechanisms to fundamentally change our talent pool will require the application of resources to both attract and further develop human capital, both uniformed and civilian. Because human capital development is usually one of the first things eliminated in rebalancing resource priorities, the ASN RDA will have to create a centrally managed resource line in R&D and then devote the necessary high-level attention to ensure that the resources allocated are producing the desired results.

Similarly, the movement of personnel to support Departmental strategic goals cannot be allowed to occur in an unstructured environment. Given the nature of civilian personnel assignment practices in the General Schedule, achieving the goal of teams moving with product development through its various stages will require central attention and direction. It may well be that legislative enablement will be required, if the available "demonstration" rules do not provide sufficient coverage.

Changes in Structure

Recommendation

- **Enhance SYSCOM commanders ability to mature promising technologies and deliver innovative capabilities to the fleet including the use of additional line officers assigned to the materiel establishment.**

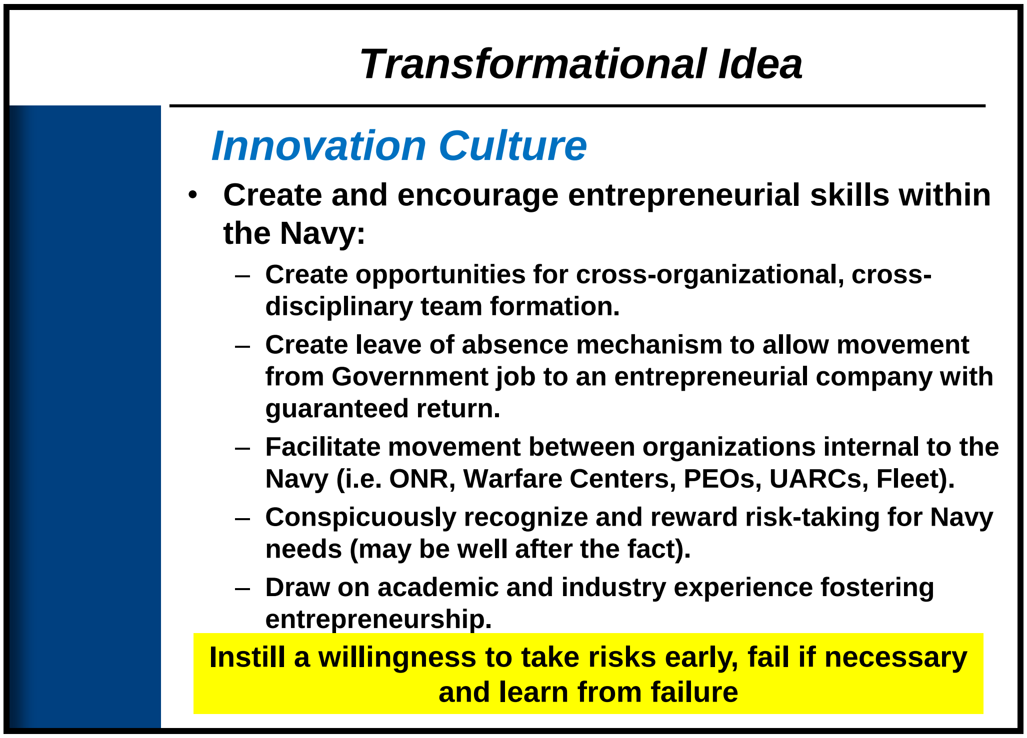
Action 6

- **RDA coordinate with the CNO to assign additional line officers to the materiel establishment to be "technology scouts".**

Re-engage the Fleet

To deliver effective warfighting capabilities to the fleet in an effective and efficient manner requires early and frequent engagement by fleet operators. This is much more than just defining the top level requirements. Scientists and developers must understand the context, environment, operational and strategic conditions under which the systems/subsystems will be employed.

Just as importantly, fleet operators must understand the limits and opportunities for technology to deliver capability to the Sailor and the Marine. This requires in-depth understanding of both the state of art and state of practice in the development and employment of available technologies. Today, there are few billets that are routinely filled by active duty line officers during their shore tours. The Naval Warfare Centers, in particular, would benefit from embedded ship, aircraft and submarine-qualified operators with recent fleet experience. Conversely, the line officers professional development would be greatly enhanced with exposure to the Naval material establishment.

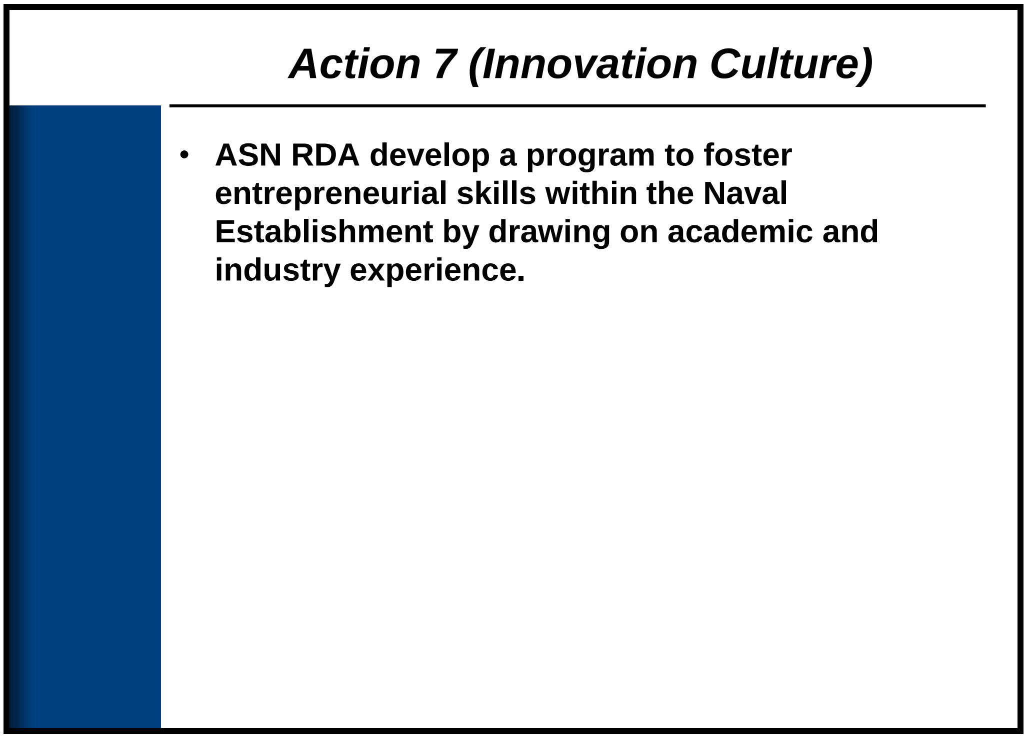


There is ample evidence that an innovator’s desire to see an idea through to successful deployment is the primary motivation for individuals to start companies, rather than to get rich. Passionate people work much harder to prove an idea right if it is their idea. This experience suggests the Navy would benefit from a culture that enables individuals to move with their ideas along the research and development chain. This can be accomplished via personnel policies to enable researchers to follow an idea from their own laboratory all the way to the fleet. Another approach would be to implement analogs to university mechanisms (e.g., MIT) that promote entrepreneurial idea transfer. Small changes in personnel practices that de-stigmatize early failure and unleash innovation could have significantly more impact than mandates aimed at ensuring adherence to policy intent. For example, building on university experience with the benefits of fostering entrepreneurship, the DON could create a leave-of-absence mechanism for laboratory researchers desiring to take an idea from concept to product, thereby eliminating the risk associated with leaving a DON laboratory altogether.

In some cases, leave will turn into departure. This can be a multiple success for the laboratory: first, the laboratory-born idea gets to the fleet. Second, the laboratory-born company becomes a success story that can be used in subsequent recruiting. In other cases, leave will turn into return, with a wiser, real-world-hardened laboratory employee, ready to leave an idea behind and ready to move on to another, better idea. Such an evolution should be seen not as failure, but as a proxy for the fail-fast idea that entrepreneurs today see as the right way: give an idea a chance, and move on if it does not catch on.

Either way, the laboratory/warfare center is the winner.

Of course, management will worry about the loss of head count, loss of their best people, and so on, and those concerns must be addressed. Given a convinced, enthusiastic laboratory/warfare center director and the personnel policies to match, the organization could actively promote entrepreneurial leaves of absence for the technical workforce.



This chart summarizes the action recommended to the ASN RDA to fulfill the recommendation of the prior slide on “innovation culture”.

Transformational Idea

Senior Line Officer

Recommendation

Restore the assignment of a senior line officer to direct the focus of BA-4 and oversee the development of capabilities incorporating technology and innovation for delivery to the fleet.

Action 8

CNO: Reestablish a 3 Star position with responsibilities similar to Director of Research and Development Requirements, Test and Evaluation OP-098.

This position would be the OPNAV counterpart to DASN RDT&E.

Re-engage the Fleet

The BA-4 account is a diverse funding account which crosses all Naval warfighting materiel and capabilities. Budgeting and execution of BA-4 also crosses organizational lines that can lead to inefficiencies and lost opportunities to leverage technology synergies. System Commanders have insight in their particular areas of responsibility but there seem to be many gaps in BA-4 accounts that should receive additional oversight.

Accordingly, the NRAC recommends the CNO re-establish a senior Line Office (3-star) position with responsibilities similar to the previous Director of Research and Development Requirements, Test and Evaluation, OP-098. This official would provide oversight to the important BA-4 account that is equivalent to the DASN RDT&E's oversight of the BA-1 – BA-3 accounts.

Appendix A: Panel Biographies

Chair - 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.

Vice-Chair Rear Admiral Charles Young, U. S. Navy (Retired) is Vice President for Strategic Business Planning, Oceaneering Advanced Technologies. . 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. Additionally, he served as Director, Resources and Evaluation on the staff of the Assistant Secretary of the Navy for Research, Development and Acquisition; Program Manager for the Navy's Unmanned Undersea Vehicles Program Office; Deputy Commander, Naval Sea Systems Command for Undersea Technology; Commander, Naval Undersea Warfare Center; Vice Commander, Naval Sea Systems Command; and Program Executive Officer for Undersea Warfare, Rear Admiral Young was the 11th Director of Strategic Systems Programs 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. 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.

<u>Vice Admiral William Bowes,</u> 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.

<u>Dr. Mark Bregman</u> is Senior Vice President and Chief Technology Officer of Neustar. He is responsible for Neustar's product technology strategy and product development efforts. Prior to joining Neustar, Dr. Bregman was Executive Vice President and Chief Technology Officer of Symantec Corporation. Dr. Bregman's portfolio while CTO of Symantec included developing the company's technology strategy and overseeing its investments in advanced research and development, security and technology services. Prior to Symantec, Dr. Bregman served as Executive Vice President, Product Operations at Veritas Corporation, which merged with Symantec in 2005. Prior to Veritas, he was CEO of AirMedia, an early mobile content marketplace, and spent 16 years in a variety of roles at IBM. Dr. Bregman serves on the board of ShoreTel (SHOR), a VoIP Unified Communications company, chairman of the board of the Bay Area Science & Innovation Consortium and the Anita Borg Institute, which focuses on increasing the impact of women on all aspects of technology. He holds a bachelor's degree in physics from Harvard College and a master's degree and doctorate in physics from Columbia University.

<u>Dr. Patricia L. Gruber</u> is the Deputy Director of the Applied Research Lab (ARL) at the Pennsylvania State University with responsibility for strategic planning, overall direction of laboratory and accountability for 1,200 faculty, staff and students (2009 – present). Dr. Gruber served as the Director of Research at the Office of Naval Research where she was responsible for Naval S&T strategic planning and for the overall integration of the Discovery and Invention portfolio (6.1 and early 6.2) in support of naval mission areas (2006-2008). Prior to her ONR assignment, she served as a Senior Research Associate, at ARL Penn State, focused on opportunities to expand ARL research funding base and build core capabilities in defense technologies (2003-2005). Dr. Gruber has held a number of technical management and business development positions at Lucent Technologies Bell Laboratories and Marconi Communications focused on successful delivery of telecommunications networks (1996-2002). At AT&T Solutions, she was a solution architect responsible for development and implementation of complex IT outsourcing contracts. As a Distinguished Member of Technical Staff at AT&T Bell Laboratories, she was a program manager for Navy undersea surveillance programs. She began her career as a Research Physicist in the Acoustics Division at the Naval Research Laboratory. Dr. Gruber is a recipient of the Superior Public Service Award. She is a consultant to the Army Science Board and is a member of the Acoustical Society of America. Dr. Gruber received a BS in Meteorology from Penn State and a MS and PhD in Marine Physics from the University of Miami.

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.

Dr. David Mindell is a Dibner Professor of the History of Engineering and Manufacturing, and Professor of Aeronautics and Astronautics at MIT. He is also director of MIT's Program on Science, Technology, and Society (STS), and interdisciplinary department. He is an expert on human/machine relationships in broad technical, social, and historical context. For the past fifteen years, Mindell has been combining engineering and historical research into the evolution humans' relationships to machines. His most recent book, Digital Apollo: Human and Machine in Spaceflight (MIT Press, 2008) examined the computers, automation, and software in the Apollo moon landings their effects on human performance. Mindell's previous book, Between Human and Machine: Feedback, Control, and Computing before Cybernetics (Johns Hopkins, 2002) rewrote the history of computing through the lens of human/machine interaction. His first book, War, Technology, and Experience aboard the USS Monitor (Johns Hopkins, 2000) explored personal and professional dimensions of mechanization in the U.S. Civil War and was awarded the Sally Hacker Prize by the Society for the History of Technology. Mindell's current research involves the new Laboratory for Automation, Robotics, and Society, an interdisciplinary group that examines human/machine relationships in extreme environments, including human spaceflight, military robotics, undersea exploration, aviation, and surgery, with a goal toward developing general models. He is founder and director of MIT's "DeepArch" research group in technology, archaeology, and the deep sea. He has degrees in Literature and in Electrical Engineering from Yale University, and a doctorate in the history of technology from MIT.

Mr. Charles Nemfakos is a Senior Fellow at RAND after leading Nemfakos Partners LLC in supporting public and private sector clients, here and abroad, in dealing with the demands of the emerging defense/security realities and the pressures of the global marketplace. Previously, Mr. Nemfakos was an executive with Lockheed Martin Corporation, directing efforts to rationalize product lines, providing program focus to enhance competitive strategies, seeking new directions and opportunities for growth among the various Corporation companies by anticipating demands of transformational processes. Mr. Nemfakos served in assignments as a budget analyst and as a planner in the Office of the Secretary of Defense and the Department of the Navy. He served in a variety of financial positions, as Deputy Assistant Secretary for Installations and Logistics, as Deputy Under Secretary, and as Comptroller. He was responsible for formulation, presentation, and execution of the Department's budget, directing the base closure process, providing executive-level continuity in institutional management and strategic planning, and supporting privatization initiatives, incentive structures, and right-sizing efforts. Mr. Nemfakos was the Department's Chief Financial Officer. He played a central role in the transformation of the Department after the Cold War. Mr. Nemfakos has lectured extensively on public policy in resource allocation, on national security issues, on public administration policy and on public/private entity relationships. He has served on Boards of Directors and/or Advisors of companies and non-profit, educational entities, as a Senior Fellow at the Center for Naval Analyses and an Adjunct at the National Defense University. Mr. Nemfakos has been recognized by three U. S. Presidents with four Presidential Rank Awards, by the Secretary of Defense as one of nine Career Civilian Exemplars by American University with the Roger W. Jones Award for Executive Leadership, and by National Academy of Public Administration as an elected Fellow.

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.

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.

Appendix B: Terms of Reference

Background

In 2010, the NRAC conducted an assessment of the Naval Laboratory System with respect to the Department of Navy's "as is" capability to meet the DON technological needs and, in particular, the ability to innovate in areas of anticipated technological need. That study proved to be very valuable, and led to the creation of the DASN (RDT&E) position to ensure appropriated stewardship of and facilitate technology transition within the Naval RDT&E Establishment. The study, as would be expected, focused primarily on "technology push," i.e. the Science and Technology (S&T, Budget Activities 1-3) side of the equation. Of at least equal (and arguably greater) importance for successful technology transition is the BA-4 Advanced Component Development and Prototypes account - the "requirements pull," counterpart of S&T. The GAO report to Congress (GAO-07-1058 Defense Acquisition, September 2007) and the Weapons Systems Acquisition Reform Act (WSARA) of 2009 pointed out the criticality of a robust BA-4 program. The annual Naval BA 4 funding total is on the order of $4B annually (about twice the size of the S&T investment). The non-ACAT portion of BA-4 in particular receives minimal outside assessment or scrutiny. The NRAC shall assess the Naval BA-4 account in a manner that focuses on its adequacy as a primary transition vehicle for Naval S&T and as the first step in the formal systems acquisition process.

Specific Tasking

The NRAC shall assess the Naval BA-4 investment, examining issues such as governance, strategic planning and oversight, technical quality and effectiveness as a transition vehicle for Naval S&T investment. Specifically, the study shall address:

- Leverage of the BA-4 account to enhance the CNO's "Speed to Fleet" initiative.
- Governance and investment strategy of the Naval BA-4 account. The investment balance decision process; how to ensure the best technical solutions are pursued.
- Technical content of the BA-4 account, especially non-ACAT BA-4. Is it appropriate for the funding category, and does it represent an appropriate technical cross-section for transition of Naval S&T into systems acquisition?
- Coupling of BA-4 to Naval S&T. The ability of the current BA-4 investment to transition Naval S&T efforts; establishment of funded transition plans from S&T.
- Transition of BA-4 programs to systems acquisition. Potential applicability of private sector technology transition processes for transition from BA-4 to BA-5 programs.

Appendix C: Fact-Finding Contributors

Contributor	Organization
Ms. Mary Lacey	Deputy Assistant Secretary of the Navy – Research, Development, Testing & Evaluation
Dr. James Sheehy	Chief Technology Officer, Naval Aviation Enterprise
Dr. Jim Meng	Naval Sea Systems Command, Special Projects
Ms. Nancy Harned	Director, Advanced Components & Prototyping, Research Directorate, Office of the Secretary of Defense
CAPT Mark Howell	Office of the Chief of Naval Operations, Warfare Integration Division (N8F)
RADM Nevin Carr	Chief of Naval Research
Mr. Richard Rumpf	Rumpf Associates International
Dr. Regan Campbell	Deputy Chief Technology Officer, Undersea Enterprise
Mr. Larry McWilliams	Naval Audit Service
Mr. Steve Smolinski	Office of Naval Research (FNC Management Office)
Dr. Peter Craig	Office of Naval Research, C4ISR Department (FNC Transition Case Studies)
COL Sam Kirby, USMC	Office of Naval Research, Expeditionary Maneuver Warfare and Combating Terrorism Department (Transition Case Study)
Mr. Hugh Montgomery	Special Assistant to the Principal Civilian, ASN RDA
Mr. Doug Marker	Technical Director, Program Executive Office, Integrated Warfare Systems
Dr. Mike McGrath	Vice President, Systems and Operations Analysis, ANSER
RADM James Shannon	Chief Technology Officer, Surface Warfare Enterprise

CDR Joe Santos and Dr. GP Sandhoo	Office of the Chief of Naval Operations, Naval Warfare Assessment (N00X)
Dr. Greg Popadopoulos	New Enterprise Associates, Inc. (Venture Capitalist)
Dr. Reg Kelly	California Institute for Quantitative Biosciences
Dr. John Hanke	Google – Mobile Incubator (a founder and former CEO of Keyhole)
Dr. Bill Vass	President & CEO of Liquid Robotics (former CEO of Sun Microsystems Federal)
Dr. Ken Washington	Vice President and Chief Privacy Leader, Lockheed Martin Space Systems Company
Dr. Edward Roberts	David Sarnoff Professor of Management of Technology, MIT Sloan School of Management
Mr. David Kelly	CEO, Bluefin Robotics
Mr. Jack Turner	Associate Director, MIT Technology Licensing Office
Dr. David Mindell	NRAC Panel Consultant, MIT Professor
VADM Joe Dyer (USN-ret)	Chief Operating Officer, iRobot
Mr. John Williams	Director, Department of the Navy, Small Business Innovation Research Program
Ms. Kathy Harger	Independent Consultant
VADM Bill Landay	Director Defense Security Cooperation Agency (Former CNR, PEO LMW, and PEO Ships)
RDML(Sel) David Johnson	Program Executive Officer, Subs
RDML David Lewis	Program Executive Officer, Ships

Appendix D: Program Elements

Navy BA-4 Program Elements

PE	Program Element Title	FY 2009	FY 2010 (Base & OCO)	FY 2011 Total Request	FY 2011 Appropriated	FY 2012 Total Request
	Aviation					
0603207N	Aviation Survivability	15,373	29,575	9,480	9,480	10,893
0603216N	Aircraft Systems		0	0	0	10,497
0603237N	Joint Precision Approach and Landing Systems	74,060	143,546	159,151	159,151	121,455
0603251N	Tactical Air Directional Infrared Countermeasures (TADIRCM)	42,832	49,067	51,693	51,693	64,107
0603254N	ASE Self-Protection Optimization		4,000	0	0	711
		116,892	***226,188***	***220,324***	***220,324***	***207,663***
	C4ISR					
0603382N	Deployable Joint Command and Control	6,876	8,644	4,275	4,275	3,702
0603502N	Tactical Airborne Reconnaissance	5,743	9,605	6,452	6,452	5,978
0603506N	Combat System Integration	62,472	20,822	24,344	34,344	34,157
0603512N	Single Integrated Air Picture (SIAP) System Engineer (SE)	40,587	46,087	0	0	0
0603513N	Space and Electronic Warfare (SEW) Architecture/Engineering Support	46,251	38,711	34,793	34,793	33,621
0603525N	Electronic Warfare Development - MIP	0	0	663	663	625
		161,929	***123,869***		***80,527***	***78,083***
	Marine Corps					
0603527N	Marine Corps Assault Vehicles	256042	302,099	242,765	222,765	12,000
0603536N	Marine Corps Ground Combat/Support System	57718	72,411	40,505	28,505	79,858
0603542N	Nonlethal Weapons	50424	50,945	43,272	43,272	40,992
		364184	***425,455***	***326,542***	***294,542***	***132,850***

PE	Program Element Title	FY 2009	FY 2010 (Base & OCO)	FY 2011 Total Request	FY 2011 Appropriated	FY 2012 Total Request
	Other					
0603553N	Conventional Munitions	6368	4,087	5,388	5,388	4,753
0603561N	Joint Service Explosive Ordnance Development	111,850	20,253	26,873	26,873	35,154
0603562N	Cooperative Engagement	43424	58,278	52,282	52,282	54,783
0603563N	Ocean Engineering Technology Development	9,492	16,652	13,560	13,560	9,996
0603564N	Environmental Protection	20557	20,707	20,207	20,207	21,714
0603570N	Navy Energy Program	10,271	18,643	30,403	30,403	70,538
0603573N	Facilities Improvement	18,034	9,715	3,746	3,746	3,754
0603576N	Navy Logistic Productivity	18,514	13,400	4,139	4,139	4,137
0603581N	NATO Research and Development	10,767	9,804	9,196	9,196	9,140
0603582N	Counterdrug RDT&E Projects	62439	14,522	0	0	0
0603609N	Joint Counter Radio Controlled IED Electronic Warfare (JCREW)	0	63,485	56,542	50,242	62,044
0603611M	Precision Strike Weapons Development Program	0	39,478	25,121	25,121	22,665
		311,716	***289,024***	***247,457***	***241,157***	***298,678***
	SAP					
0603635M	PILOT FISH	84119	85,100	81,784	81,784	96,012
0603654N	RETRACT LARCH	91183	121,715	142,858	142,858	73,421
0603658N	RETRACT JUNIPER	155636	112,864	134,497	134,497	130,267
0603713N	CHALK EAGLE	236510	392,224	447,804	447,804	584,159
0603721N	CHALK CORAL	105673	71,855	71,920	71,920	79,415
0603724N	RETRACT MAPLE	142877	213,100	219,463	219,463	276,383
0603725N	LINK PLUMERIA	69044	62,009	58,030	58,030	52,721
0603734N	RETRACT ELM	136991	148,795	183,187	183,187	160,964
0603739N	LINK EVERGREEN	21895	84,160	41,433	41,433	144,985
0603746N	Special Processes	59413	82,987	36,457	36,457	43,704
		1,103,341	***1,374,809***	***1,417,433***	***1,417,433***	***1,642,031***

PE	Program Element Title	FY 2009	FY 2010 (Base & OCO)	FY 2011 Total Request	FY 2011 Appropriated	FY 2012 Total Request
	Ships					
0603748N	Advanced Combat Systems Technology	12,071	3,605	1,658	1,658	1,418
0603751N	Surface Ship Torpedo Defense	48,215	57,922	57,796	50,796	118,764
0603755N	Carrier Systems Development	178095	171,441	93,830	91,830	54,072
0603764N	Shipboard System Component Development	35,748	32,008	51	51	0
0603787N	Radiological Control	1,069	1,325	1,358	1,358	1,338
0603790N	Ship Concept Advanced Design	36,240	23,166	17,883	17,883	14,308
0603795N	Ship Preliminary Design & Feasibility Studies	22884	30,928	1,796	1,796	22,213
0603851M	Advanced Surface Machinery Systems	3192	17,319	5,459	5,459	18,249
0603860N	Littoral Combat Ship (LCS)	372,036	421,994	226,288	189,588	286,784
0603879N	Ship Self Defense	9784	6,644	4,385	4,385	0
0603889N	Land Attack Technology	15,966	9,733	905	905	421
0603925N	Directed Energy and Electric Weapon Systems	4,548	18,989	0	8,000	0
		739,848	***795,074***	***411,409***	***373,709***	***517,567***
	Subs/USW/ASW					
0604272N	Air/Ocean Tactical Applications	65,532	112,516	123,331	118,331	94,972
0604279N	ASW Systems Development	38,370	25,144	8,249	8,249	7,915
0604653N	Surface and Shallow Water Mine Countermeasures	94,393	93,750	81,347	79,247	142,657
0604659N	Surface ASW	47,506	21,420	21,673	21,673	29,797
0604707N	Advanced Submarine System Development	153,783	523,132	608,566	559,266	856,326
0303354N	Submarine Tactical Warfare Systems	13,749	10,869	5,590	5,590	9,253
0303562N	Advanced Nuclear Power Systems	157,839	258,803	366,509	366,509	463,683
0304270N	ASW Systems Development - MIP	0	0	2,161	2,161	1,078
0408042N	Submarine Tactical Warfare Systems - MIP	0	0	4,253	4,253	0
		571,172	***1,045,634***	***1,221,679***	***1,165,279***	***1,605,681***

Appendix E: Relevant Reports Addressing BA-4

- Department of Defense “Report to the Congress on Technology Transition”, August 2007
- GAO Report to the Congress “Defense Acquisitions, DOD’s Research and Development Requests to the Congress”, September 2007
- Air Force Studies Board of the National Research Council “Evaluation of USAF Pre- Acquisition Technology Development”, 2011
- “Naval Audit Service Report on BA-4”, 2011
- Panel (chaired by Dr. James Meng) report “In Search of Navy Budget Activity 4 (BA-4) Metrics for Effective Technology Transition”, August 2011

Appendix F: Listing of Findings

- BA-4 exists in three categories: SAP, MDAP, and non MDAP categories – each managed in a different manner.
- BA-4 is used to fix problems and to mature technologies, but there is little evidence that it is being used to avoid problems in future acquisition programs.
- Unlike BA-1 through 3, which is managed by the CNR with the interests of the entire Navy to consider, BA-4 has no equivalent manager with equivalent scope and horizon.
- There is no corporate BA-4 governance process and consequently uniform management practices are lacking.
- As a result of the lack of the BA-4 governance structure, this account provides great flexibility for program execution while at the same time lacks the focus necessary to transition science and technology activity.
- The Urgent Operational Needs Statement (UONS) process has become a work-around to the normal acquisition process.
- There is dissatisfaction among the warfighters with the pace of innovation.
- The warfighter is not part of the early exploration of technology solutions.
- The cadre of uniformed Navy who intimately understand technology development is dwindling.
- The technology development process has been defined to defend and control budgets not to nurture and mature technologies. The end result is cumbersome and lengthy R&D cycles and an unwillingness to adopt new technologies.
- Because budgets are distributed to manage program gaps, the remaining funds in BA-3 and BA-4 to address long-range future technology superiority are limited.
- There is no evidence of iterating new technologies and concepts to allow the Fleet, NRDE, and the resource sponsors to converge on disruptive capabilities.
- There is no upside for new technology insertion into a program in acquisition but significant downside for failing to deliver on time and on budget.

- Communications between the operators and the NRDE is too rigid and structured, slowing processes down.

- The Navy resource & acquisition programs are driven from a platform view and innovation outside that framework is not supported.

- Lack of continuity of personnel leads to a reduced sense of ownership, reduced accountability for outcome and diminished technical savvy (judgment) in program management.

- There appears to be no incentive to take risk: failure can be career limiting rather than viewed as an opportunity for learning.

Bullets below appear to be recommendations NOT findings:

- Effectively using BA-4 for prototyping allows early operator feedback on solutions and can result in a lower overall lifecycle cost.

- In a reduced budget environment, the linkage of RDT&E to ongoing acquisitions may choke transition and further drive resource sponsors to use RDT&E to fix current problems.

Appendix G: Acronyms

ACAT	Acquisition Category
ARCI APB	Acoustic Rapid COTS Insertion Advanced Processor Build
ASN RDA	Assistant Secretary of the Navy for Research, Development and Acquisition
ASD (R&E)	Assistant Secretary of Defense for Research and Engineering
BA-4	Advanced Component Development and Prototypes
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
CNO	Chief of Naval Operations
CNR	Chief of Naval Research
CONOPS	Concept of Operations
DARPA	Defense Advanced Research Projects Agency
DON	Department of the Navy
EOS	End-of-Support
EW	Electronic Warfare
FMB	Financial Management Budget (Office)
FNC	Future Naval Capabilities (ONR)
GAO	Government Accountability Office
HR	Human Resources
IED	Improvised Explosive Device
IOC	Initial Operating Capability
ISE	In-Service Engineering
JCIDS	Joint Capabilities Integration and Development System
LCC	Life Cycle Cost
MDAP	Major Defense Acquisition Program
MILCON	Military Construction
NAVAIR	Naval Air Systems Command
NAVCOMPT	Navy Comptroller
NAVSEA	Naval Sea Systems Command
NRAC	Naval Research Advisory Committee
NGEN	Next Generation Enterprise Network
NRDE	Naval R&D Establishment
NRL	Naval Research Laboratory
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations

OSD	Office of the Secretary of Defense
PB	Presidential Budget (or PresBud)
PEO	Program Executive Officer
PM	Program Manager
POR	Program of Record
RDT&E	Research, Development, Test & Evaluation
SAP	Special Access Program
SBIR/STTR	Small Business Innovation Research Program/Small Business Technology Transfer
S&T	Science and Technology
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SYSCOM	Systems Command
TOR	Terms of Reference
TRL	Technology Readiness Level
TTA	Technology Transition Agreement
UARC	University Affiliated Research Center
UAS	Unmanned Aircraft Systems
VC	Venture Capitalist