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ACQUISITION RESEARCH PROGRAM
CASE STUDY

A Case Study of Managing Information Technology Through Design

30 May 2013

Maj Michael A. Gavin, USMC

Thesis Advisors: Frank Barrett, Associate Professor, John Dillard, Senior Lecturer, and Glenn Cook, Senior Lecturer

Graduate School of Business and Public Policy

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ABSTRACT

In the 1990s, degradation of the United States' submarine acoustic superiority led to what has been termed "The Acoustic Dilemma." The loss of the Cold War competitive forcing function saw the submarine force transition its approach to sonar system development. This transition encountered resistance from the embedded establishment and imposed several managerial challenges. The model that emerged was the Acoustic Rapid Commercial-Off-The-Shelf [COTS] Insertion (ARCI) program. ARCI is a business and technical strategy that capitalizes on the rapid improvements available through commercial technology and enables the submarine Navy to effectively pace the ever-evolving threat. ARCI enabled technology updates at an unprecedented rate. These rapid updates dramatically improved system capabilities, but the constant refresh of technology soon outpaced the operational and support structures' abilities to manage the rapid rate of change. In order to address these challenges, one of the nation's leading not-for-profit centers for sonar systems engineering, research and development coordinated with a design consultancy firm to create the Tactical Advancements for the Next Generation forum. This forum used the principles of design thinking to create a collaborative endeavor that exploited the tacit knowledge of junior sailors in the design of sonar system technology.

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Thank you Janine, Brigid, Mathilda, Oliver, and Elsa for sacrificing your time and allowing me to commit to this research and writing. I love you all.

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ABOUT THE AUTHOR

Major Michael Gavin is a Marine KC-130 pilot. He completed undergraduate studies at the University of Pittsburgh earning a BA in anthropology. He was commissioned through the OCC program. Following graduation from the Naval Postgraduate School, he will report to the Marine Corps Training and Education Command's College of Distance Education and Training in Quantico, VA.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACINT	Acoustic Intelligence Specialist
ACR	Armored Cavalry Regiment
ADM	Admiral
AFTAS	Automatic Fleet Towed Array Sensor
APB	Advanced Processing Build
APL	Applied Physics Lab
ARCI	Acoustic Rapid COTS Insertion
ASD(NII)	Assistant Secretary of Defense for Networks & Information Integration
ASTO	Advanced Systems Technology Office
ASW	Anti-Submarine Warfare
BAA	Broad Area Announcements
CCA	Clinger–Cohen Act
CEO	Chief Executive Officer
COMSUBDEVRON	Commander, Submarine Development Squadron
COMSUBFOR	Commander, Naval Submarine Forces
COMSUBLANT	Commander Submarine Force, U.S. Atlantic Fleet
COMSUBPAC	Commander Submarine Force, U.S. Pacific Fleet
CONOPS	Concept of Operations
COSG	Concept of Operations and Operator–-Machine Interface Support Group
COTS	Commercial-Off-The-Shelf
CNO	Chief of Naval Operations
CO	Commanding Officer
CSDS-12	Commodore, Submarine Development Squadron 12
DAMS	Defense Acquisition Management System
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University

DEC	Digital Equipment Corporation
DEVRON-12	Submarine Development Group-Twelve
DFAS	Defense Finance and Accounting Service
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoN	Department of the Navy
d.school	The Hasso Plattner Institute of Design at Stanford
DSR	Digital Systems Resources
EMSP	Enhanced Militarized Signal Processors
Ens	Ensign
FASA	Federal Acquisition Streamlining Act
FAR	Federal Acquisition Regulation
FY	Fiscal Year
GAO	Government Accountability Office
HCD	Human Centered Design
HMW	How Might We
HSI	Human Systems Integration
I-BAL	Interactive Battle-Space Awareness Layer
IBM	Industrial Business Machines
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
IDEFO	Integrated Definition for Function Modeling
IETM	Interactive Electronic Technical Manual
INCOSE	International Council on Systems Engineering
IPT	Integrated Product Team
ISR	Intelligence, Surveillance, and Reconnaissance
IUSS	Integrated Undersea Surveillance Systems
JCIDS	Joint Capabilities Integration and Development System

JHU/APL	Johns Hopkins University Applied Physics Lab
LAMBDA	Large Aperture Marine Basic Data Array
LCDR	Lieutenant Commander
LT	Lieutenant
LTj	Lieutenant, Junior Grade
MIL-SPEC	Military Specification
MIL-STD	Military Standard
MNS	Mission Needs Statement
MOSA	Modular Open Systems Architecture
MPP	Multi-Purpose Processor
MTM	Multi-Purpose Transportable Middleware
MTT	Modernization Training Team
NATO	North Atlantic Treaty Organization
NAVSEA	Naval Sea Systems Command
NDI	Non-Developmental Item
NUWC	Naval Undersea Warfare Center
OMI	Operator–Machine Interface
OMIWG	Operator–Machine Interface Working Group
ONI	Office of Naval Intelligence
ONR	Office of Naval Research
OPNAV	Office of the Chief of Naval Operations
OPNAV N87	Office of the Chief of Naval Operations, Director, Submarine Warfare
PEO	Program Executive Office
PEO IWS	Program Executive Office, Integrated Warfare Systems
PEO IWS5A	Program Executive Office, Integrated Warfare Systems, Advanced Development
PEO, SUB	Program Executive Office, Submarines
PM	Program Management
PMS 425	Submarine Combat System Program Office

PO1	First Class Petty Officer
PO2	Second Class Petty Officer
PO3	Third Class Petty Officer
PPBE	Planning, Programming, Budgeting, and Execution
RADM	Rear Admiral
R&D	Research and Development
ROI	Return On Investment
SBIR	Small Business Innovation Research
SDWG	Sonar Development Working Group
SEI	Software Engineering Institute
SEM	System Employment Manual
SES	Senior Executive Service
SLBM	Submarine-Launched Ballistic Missiles
SLC	Submarine Learning Center
SME	Subject-Matter Expert
SMMTT	Submarine Multi-Mission Team Trainer
SOF	Special Operations Forces
SOSUS	Sound Surveillance System
SSBN	Ship Submersible Ballistic Nuclear Powered
SSGN	Ship Submersible Guided Missile Nuclear Powered
SSTP	Submarine Superiority Technical Panel
SSN	Ship Submersible Nuclear Powered
STRG	Submarine Tactical Requirements Group
SUBLANT	Submarine Force, U.S. Atlantic Fleet
SUBPAC	Submarine Force, U.S. Pacific Fleet
SURTASS	Surveillance Towed Array Sensor System
TANG	Tactical Advancements for the Next Generation
TEASG	Test, Evaluation, Analysis Support Group
TI	Technical Insertion
TM	Technical Memorandum

TRE	Tactical Readiness Evaluation
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USMC	United States Marine Corps
USN	United States Navy
USO	Uniformed Service Organization
VADM	Vice Admiral
WSTA	Watch Section Task Analysis

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I. INTRODUCTION

A. FRAMING THE PROBLEM

In 2010 at a conference in North Carolina, Joint Forces Commander General James N. Mattis, USMC, made the stark comment that “PowerPoint makes us stupid” (Bumiller, 2010). During that same conference, Brigadier General H. R. McMaster, USA, who had banned PowerPoint presentations when he commanded the 3rd Army Cavalry Regiment (ACR) in Tal Afar, Iraq, characterized PowerPoint as an internal threat. McMaster said, “It’s dangerous because it can create the illusion of understanding and the illusion of control. ... Some problems in the world are not bullet-izable” (O’Neil, 2010). These statements, while generally recognized by military members to be true, have done very little to stem the tide of agonizing PowerPoint briefs as the standard method of information transfer.

PowerPoint is deeply embedded into the military culture and has been elevated from the status of useful tool to the de facto required method of imparting information. This accepted method is due less to the efficacy of PowerPoint than to the fact that PowerPoint has been the industry standard since the early 1990s. PowerPoint’s obsession with hierarchical distinctions is a format easily accepted by a traditional military audience. Organizational acceptance of “death by PowerPoint” as a necessary evil raises serious concerns about how this practice stifles discussion, suppresses critical thinking, and eliminates thoughtful decision-making.

The commanding general of the Marine Corps Recruiting Command, Brigadier General Joseph L. Osterman, said, “Our survival, status and reputation as an elite force are dependent on our connection with the American people, and specifically with today’s youth—the millennial generation” (Flynn, 2012b).

The USMC’s current recruiting campaign, “Towards the Sounds of Chaos,” was designed around strategic research conducted among recruit prospects and their influencers to determine their perceptions of military service (Flynn, 2012a). This research determined that today’s millennial generation is more politically, culturally, and socially diverse than previous generations and that it is technologically savvy, comfortable, and capable.

The traits that the military is recruiting are the very traits that the current standard of training, education, and operations are failing to leverage. Organizational reluctance to change outdated modalities, like the overreliance on PowerPoint, represents a significant capability gap. The requirement to attract the best and the brightest of American youth is stymied by the inability of the current system to accommodate and exploit the skills and abilities of those millennial-generation youths who commit to military service.

This thesis research concerns a recent effort of the United States Navy's submarine community to exploit its millennial-generation assets by leveraging the innate technological abilities of millennial-generation submariners. A former junior officer submariner arranged a meeting between current junior officers and young submariners with a consultation team from IDEO, a world-leading firm in design and innovation. The group's initial purpose was to use the technological acumen of the millennial-generation submariners to make submarine combat systems more intuitive.. This group conducted the first Tactical Advancements for the Next Generation (TANG) Forum. This research investigates the historical events that led to the initial TANG Forum in order to explore the applicability of the effort to support effective program management and requirements engineering in the Department of Defense (DoD).

B. BACKGROUND

As acquisition programs' resources become scarce, competition for those resources will increase. It is imperative, therefore, that government acquisition programs deliver the product that they are designed to produce. This is a necessity to ensure that the program brings value to the end users and because every dollar spent on one program means one less available dollar to fund other efforts (Government Accountability Office [GAO], 2009). To ensure acceptable results, federal acquisition programs must make use of every available advantage. Those advantages include exploiting all available human capital to ensure quality service to the warfighter and to curtail the legacy of recurring program management problems.

In 1995, senior defense and international affairs advisor to the U.S. Comptroller General, Frank C. Conahan, testified before the U.S. House of Representatives Committee on the Budget:

> Over the years, we have reported on the persistent problems that have plagued weapons acquisition. Many new weapons cost more, are less capable than anticipated, and experience schedule delays. These problems are typical of DoD's history of inadequate requirements determinations for weapon systems; projecting unrealistic cost, schedule, and performance estimates; developing and producing weapons concurrently; and committing weapon systems to production before adequate testing has been completed. (Conahan, 1995, pp. 2–4)

The DoD has had a distressing history of procuring elaborate, high-tech, software-intensive systems that do not work, and cannot be relied upon, maintained, or modified (Department of the Air Force, Software Technology Support Center, 2000, p. 1-1). The Defense Acquisition University (DAU) hosts a semi-annual program manager (PM) forum. During each forum, over 20 major DoD PMs identify and rank their major concerns. Since 2007, each forum has listed some form of the term "requirement" in the top seven issues that PMs battle. In 2010 and 2011, the out-briefings listed "requirements and testing" as their number one issue (Mohney, 2011). Unstable requirements lead the list of recurring problems and have been identified as the major cause of program failure. Requirements errors are the most common errors in the acquisition process and are by far the most expensive to fix. Statistically, requirements errors consume 25–40% of the total project budget (Gallagher, Elm, & Mishler, 2005).

The *Defense Acquisition Guidebook* (Defense Acquisition University, [DAU], 2011a), the International Council on Systems Engineering (INCOSE), the Software Engineering Institute (SEI), and any number of other government and not-for-profit agencies offer guidelines on how to successfully generate requirements. These guidelines strive to take highly abstract concepts and develop them into a script of explicit requirements. This specification documentation is intended to be void of any vague language and have little potential for misinterpretation. As the history of recurring requirements problems demonstrates, if there is a way to mistranslate a specification or misunderstand a requirement, then some decision-maker involved in the program will find it.

The evolution of the TANG Forum utilized a unique method to bring together end users, tactical requirements planners, senior leadership, academia, and government contractors to create a collaborative environment, which served to create context for requirements generation and, perhaps serendipitously, to create a shared mental model for all those involved.

This thesis research investigated the TANG Forum's design-based methodology to exploit the submarine community's millennial-generation assets by leveraging the innate abilities of millennial-generation submariners. Throughout the effort, from design to implementation, there was a mix of proponents and resistors that served to present most of the classic change management issues, such as an internal champion, selectivity of the personnel invited to the design exercise, experimentation and prototyping, active and passive resistance, and the co-opting of the effort when it appeared to be headed for success.

This research was conducted in conjunction with separate supporting research conducted by LCDR Thomas Hall (2012), United States Navy (USN). Hall's research investigated the barriers to adopting change in the submarine scenario, the methods utilized by the internal champion of the case, the relationships between the disparate participating groups, the current perceptions of the innovation effort, and the utility of this type of change and innovation within the submarine community.

Both Hall's research and this research address the lack of recorded DoD technology and change implementation events. The unavailability of DoD-specific historical case studies available to educators and students in DoD institutions has imposed significant limitations. The aim of these mutually supporting research efforts was to develop comprehensive case studies of the TANG Forum scenario in order to correct this lack of case study material.

The focus of effort for this research began as an investigation of how a design-based methodology was used to leverage the skills and abilities of millennial-generation Service members and how this unique collaborative effort can be used to support effective program management in the DoD. The researcher investigated the virtue of the design-based methodology used by the TANG Forum through the lens of requirements elicitation. A reproducible framework that can generate innovative ideas and then develop those ideas into unambiguous and actionable requirements would be a significant force multiplier for the DoD's acquisition efforts.

Although this research began as an examination of the TANG Forum's suitability to serve as such a framework, the research necessarily evolved to include an examination of the submarine community's transition to open systems architecture, its implementation of commercial off-the-shelf (COTS) technology, and the management challenges of keeping pace with the rapid insertion of those COTS technologies. The scope of the investigation was broadened to develop a case study that could provide contextual background for the events that spurred the TANG Forum and outlined the submarine community's patently unique infrastructure that provided the performance engine to transform TANG's creative ideas into an innovative reality. The design-based methodology provides the DoD with an elegant process to generate and capture innovative ideas, but the capability to rapidly instantiate those ideas is the requisite and symbiotic partner that completes the innovation puzzle.

The value of conducting this research resides in capturing how this innovation profile applies to the larger military community and demonstrating the feasibility of design-thinking methodologies to actively exploit millennial-generation assets in order to foster innovation and enhance warfighting capabilities.

C. PROBLEM STATEMENT

The DoD has recognized a need to leverage the innate skills and abilities of its human resources. By virtue of their advanced technology skill sets, the millennial-generation members of the Armed Services represent a significant and untapped force multiplier. This group's pervasive technological knowledge, savvy, and comfort level represents an unexploited opportunity for the DoD.

D. PURPOSE STATEMENT

The purpose of this thesis research was to investigate the submarine community's recent efforts to exploit the technological acumen of its millennial-generation assets. The researcher investigated the events surrounding the TANG Forum. This research provides readers with a militarily relevant example of how a design-based approach was used to leverage the skills and abilities of millennial-generation Service members. The value of this research is to provide readers with a militarily relevant example of how a design-based approach was implemented and how this approach may serve to foster innovation and enhance warfighting capabilities.

E. RESEARCH QUESTIONS AND HYPOTHESES

The researcher investigated how a design-based methodology was used to leverage the innate skills and abilities of millennial-generation Service members and how this unique collaborative effort can be used to support effective program management in the DoD.

The researcher addressed these themes through the following two major research questions:

1. How can the DoD exploit design-thinking modalities?
2. How can a design-based methodology support defense acquisition?

F. RESEARCH METHODS

The researcher collected data through an extensive literature review and interview process. Interviews were conducted with individuals from the submarine sonar development community who participated in the transition to an open architecture model, those who are missioned with developing requirements for submarine sonar systems, and those who participated in the TANG Forum innovation effort. The researcher interviewed the PM who designed and developed the U.S. submarine forces open architecture strategy, members of the government contracting team who effected the transition to open architecture, members of academic and government laboratories who participated in and experienced the transition to open architecture, members of the submarine requirements groups, members of the submarine prototype team, the former naval officer that initiated the TANG project, the TANG Forum staff, the TANG business area experts, members of the IDEO design team, the submariners who collaborated with IDEO during the initial TANG event, and members of multiple research and development organizations.

G. DATA, OBSERVATION, AND ANALYSIS METHODS

Yin (2009) defined the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context and in which multiple sources of evidence are used. Case study research is the most appropriate approach for this thesis research in order to meet the goal of understanding the complex issues contained in the submarine scenario. In order to capture and represent the motivations of case participants, triangulation was used to define pivotal factors in the case. The researcher used a relativist approach to ensure credibility and to enable future readers to derive their own opinions from the multiple perspectives of the subjects (Stake, 1995). The purpose of this research was to produce a detailed contextual analysis of the circumstances surrounding the submarine scenario. This was accomplished by developing the multiple perspectives of the participants through a thorough examination of the scenario, situation, and relationships. The completed case study grants readers an opportunity to experience the innovation efforts and to draw comparisons between the evolution of the submarine scenario and current and future innovation efforts.

H. POTENTIAL BENEFITS, LIMITATIONS, & RECOMMENDATIONS

The limitations imposed by utilizing the case study method include the potential that the researcher's exposure to the case may prejudice the findings. In order to ensure the highest levels of objectivity, the researcher involved had neither a vested involvement with nor predisposed notions or general assumptions of the submarine community or the scenario under investigation. To further ensure complete objectivity, the researcher gathered data from multiple sources, which provided opportunities for triangulation.

I. ORGANIZATION OF THE THESIS

1. Chapter II: Literature Review

2. Chapter III: The Case

a. Part I—The Acoustic Dilemma

b. Part II—Acoustic Rapid COTS Insertion

c. Part III—Challenges in Managing Rapid Technology Change

d. Part IV—Tactical Advancements for the Next Generation

e. Part V—Conclusion

3. Chapter IV: Analysis of Findings

4. Chapter V: Conclusions & Recommendations for Future Research

5. Appendices

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II. LITERATURE REVIEW

The researcher gathered the information used in this chapter through an extensive literature review of the case study development process and the fields of organizational change management, human capital, requirements engineering, design, and design thinking.

A. CASE STUDY

In *Designing Interactions,* Moggridge (2007) presented a series of case studies that is a de facto record of digital technology's interactive development progress over the past 50 years. This work details the design of digital technology and the evolution of human interaction with that technology. Through these case studies, the reader is introduced to historical events that demonstrate how the design process inspires innovation. There is a striking lack of DoD-specific case studies available that investigate and detail organizational change, much less the evolution and implementation of new interactive technologies to augment warfighter capabilities.

In order to construct the case study used in this project, the researcher used Stake's *The Art of Case Study Research* (1995), which provides a qualitative approach to developing a scholarly case study. Stake (1995) provided a framework for developing the issues in the case and for analyzing the trends within interviews and observations in order to correlate the researcher's findings. In *Case Study Research: Design and Methods*, Yin (2009) provided insight into case study research and the methods of defining interview question sets. Yin's (2009) work also includes a source of institutional review board information to ensure the protection of research subjects. To guide the analysis and instructor's guide portion of the final case study product, Senge's *The Fifth Discipline* (1990) and Kotter's *Leading Change: Why Transformation Efforts Fail* (1996) each played vital roles. The works of both Yin (1990) and Kotter (1996) discussed in detail how to manage change and innovation efforts within organizations, and both delved into common causes for the failure of organizational changes.

B. ORGANIZATIONAL CHANGE MANAGEMENT

In *The Heart of Change* (2002), Kotter suggested that effecting change is an issue of "speaking to people's feelings" (p. x). Although a purely practical approach suggests that change should be derived from a reasoned and logical analysis of a problem, an evaluation of available options, a choice of the most beneficial course of action, and then execution of that action, Kotter (2002) put forth the idea that people are much more likely to alter their behavior if they are "shown a truth that influences their feelings" (p. 1). Logically, people tend to accept Option A when reasoned arguments demonstrate that the virtues of Option A exceed the virtues of Option B. Realistically, even when people rationally accept the argument that Option A has greater merit and possesses larger benefit, they still tend to choose Option B if they are more experienced and more comfortable with Option B. The action of selecting Option A is a non-starter in terms of creating behavioral change.

1. Kotter's Eight-Stage Organizational Leadership Change Process

Influencing behavioral change requires an emotional connection to both the change and the reason for making that change. In *Leading Change,* Kotter (1996) advocated an eight-stage organizational leadership change process:

- Establishing a sense of urgency
- Creating the guiding coalition
- Developing a vision and strategy
- Communicating the change vision
- Empowering broad-based action
- Generating short-term wins
- Consolidating gains and producing more change
- Anchoring new approaches in the culture

Kotter (1996) separated these eight stages of organizational change leadership into three functional groups to project and counter the inevitable resistance that comes with all efforts to create organizational change. Stages 1–4 exploit dissatisfaction with the status quo and create the "space" necessary to introduce change. Steps 5–7 are the areas in which the new direction is implemented. Step 8 is where the change is inculcated into the organizational culture.

- Establishing a Sense of Urgency

Increasing the urgency of change first requires that people be inspired to move. Newton's (1999/1687) first law of motion dictates that an object at rest will remain at rest unless acted on by an unbalanced force. The rule of inertia applies not only to matter but to the action and inaction of an organization's human assets. Establishing a sense of urgency is necessary to shake organizational complacency. Dissatisfaction must exist or must be created to initiate the change process and create a fertile environment to introduce a new vision.

- Creating the Guiding Coalition

From an outside perspective, most successful change efforts tend to attach themselves to a single person. Whether it is Apple's Steve Jobs or Virgin's Richard Branson or GE's Jack Welch or Ford's Lee Iacocca, the successful leaders of change are identified as the source of that change. The underlying reality is that effecting change requires a right-sized group of the right people to enact that change. Finding the right people in the right position, with the necessary skill set, and the requisite emotional commitment to change is vital to executing the change effort (Kotter, 1996).

- Developing a Vision and Strategy

According to Kotter (1996), the vision is necessary to "direct, align, and inspire actions on the part of large numbers of people" (p. 7). The coalition must establish a simple vision that paints the picture of the future state of the organization. The strategy focuses both on the need for change and defines the path to get there. Kotter (1996) stressed simplicity in corporate visions because "whenever you cannot describe the vision driving a change initiative in five minutes or less and get a reaction that signifies both understanding and interest, you are in for trouble" (p. 136).

- Communicating the Change Vision

According to Kotter (1996), communicating the essentials simply and elegantly appeals to people's needs. As many people as possible need to be informed of the change vision because the vision only reaches its maximum effect when all members of the organization have a common knowledge and understanding of it. Communicating the vision is the method by which people begin to embrace the change process.

- Empowering Employees for Broad-Based Action

Kotter (1996) described four barriers to empowerment for the people within an organization: structure, skill, system, and supervisor. The organization's structure can prevent employees from embracing change. Organizations are structured along different lines, but the purpose of any structure is to achieve the goals of the organization. The perspective through which people see their organization and its environment may not be conducive to instituting change. In a similar vein, the skill set of the employees may be a limiting factor. Whether under-qualified or over-qualified, the employee population may have a skill set that presents significant obstacles to introducing change. The current system under which the organization operates often presents a barrier, and organizational practices must be altered to change direction. This change of direction may not be well received. This lack of "cheerful obedience" often extends to both the rank and file as well as the organizations' supervisory-level members. Organizational leadership often presents itself as a barrier to change. Subordinate leadership often fails to embrace the new vision, which can, in turn, undermine the entire change movement. Kotter (1996) argued that in order to empower action, these obstacles must be identified and removed.

- Generating Short-Term Wins

The simple and elegant vision is a necessary motivator to initiate change, but the members of the organization need tangible results sooner rather than later. Kotter (1996) called this a necessity to "manage the current reality" (p. 118). Maintaining the momentum of the change effort requires establishing credibility. Short-term wins are relatively easy to achieve and create the requisite manifestations of the positive progress the change effort is making.

- Consolidating Gains and Producing More Change

Constant and consistent pressure is required to maintain the momentum of the change effort. A single short-term success can be misinterpreted to mean that the change has been initiated, instituted, and universally accepted. Small victories without follow-through send the message that the change effort is complete. While achievements need to be highlighted, future goals need to be set and acted upon.

- Anchoring New Approaches in the Culture

Kotter (1996) argued that the change effort must be persistently reinforced through inculcation of the change into the organizational culture. New champions need to be recruited, promoted, and retained, and the change must become internalized as part of the organizational ethos if the results are to become self-sustaining.

2. Resistance to Change

Effecting change within an organization is a constant battle against falling back into the status quo. Consistent effort and constant pressure are necessary to maintain the momentum of the change effort. Forces begin working against the change effort from the moment the effort is initiated and continue through the entire life cycle (Kotter, 1996).

Kotter and Schlesinger (2008) described four reasons that people fight the change effort:

- Parochial self-interest—people concerned with how change affects their own interests versus the positive effects on the organization
- Misunderstanding—inadequate understanding of the change effort
- Low tolerance for change—fear of loss of security or stability
- Different assessments of the situation—disagreement with the reasons for change.

Kotter (2002) further described four behavior types that commonly derail the change effort:

> The first is complacency, driven by false pride or arrogance. A second is immobilization, self-protection, a sort of hiding in the closet, driven by fear or panic. Another is you-can't-make-me-move deviance, driven by anger. The last is a very pessimistic attitude that leads to constant hesitation. (p. 17)

Kotter (1996) cited eight common reasons for resistance throughout the change's life cycle:

- inwardly focused cultures,
- paralyzing bureaucracy,
- parochial politics,
- low levels of trust,
- lack of teamwork,
- arrogant attitudes,
- lack of leadership in middle management, and
- general human fear of the unknown.

Kotter's (1996) organizational change leadership factors, Kotter and Schlesinger's (2008) reasons why people fight change, and Kotter's (2002) reasons for resistance throughout the change effort's life cycle serve as invaluable resources for implementing organizational change.

C. HUMAN CAPITAL

In order to develop the purpose and process of exploiting the millennial-generation assets available to the DoD, the researcher turned to Schultz's *Investment in Human Capital* (1961), in which Schultz argued for the validity of leveraging human capital to promote economic growth. The effective utilization of labor extends beyond seeing workers as simple tools who perform work that requires little knowledge or skill. Schultz (1961) made the argument for organizational commitment to human investment in several endeavors. In *Human Capital: A Theoretical and Empirical Analysis, With Special Reference to Education* (1993), Becker discussed human capital theory as an activity capable of raising worker productivity. Becker's argument is that an organization's investment in an individual's education and training is similar in value to that organization's investment in equipment, because both increase worker productivity. In *Intellectual Capital: The New Wealth of Organizations* (1997), Stewart discussed the practicality of leveraging the untapped knowledge of an organization into a competitive weapon. He argued that knowledge is the most important factor of production in the modern economy and the means to achieving competitive advantage. Stewart (1997) argued that knowledge—not natural resources, equipment, or financial capital—is the critical factor in economic success. These themes are central to the argument of this thesis research. The DoD invests a great deal of time, energy, and effort in management training, education, and leadership development. The goal of this investment is to promote well-informed decision-making and to exploit the DoD's strongest and most expensive assets: its personnel. The overarching purpose of this thesis research was to investigate a means to leverage the knowledge of millennial-generation Service members and to exploit this relatively untapped source of human capital to advance the DoD's development and acquisition efforts.

D. REQUIREMENTS ENGINEERING

The DoD's acquisition community relies on three principal decision-making support systems: the Planning, Programming, Budgeting, and Execution (PPBE) Process; the Defense Acquisition System; and the Joint Capabilities Integration and Development System (JCIDS; DAU, 2011a).

The PPBE is the strategic planning, program development, and resource determination process that the DoD uses to develop plans and programs that satisfy the demands of the national security strategy (DAU, 2012).

The Defense Acquisition System exists to manage the nation's investments in technologies, programs, and product support necessary to achieve the national security strategy and support the United States Armed Forces (DAU, 2011a). Department of Defense Directive (DoDD) 5000.01 (Under Secretary of Defense for Acquisition, Technology, & Logistics [USD(AT&L)], 2007) and Department of Defense Instruction (DoDI) 5000.02 (USD[AT&L], 2008a) are the documents that provide the basic guidance to implement the acquisition process.

The DoD's process for fulfilling operational capabilities exists as a framework of phases and milestone decision reviews. Each phase of the process progressively develops, produces, and fields material solutions to meet warfighter needs. These needs are addressed through the JCIDS. The JCIDS provides the capability documents that guide the various phases of the Defense Acquisition Management System (DAMS; see Figure 1) by providing stakeholder requirements in terms of performance, cost, and schedule (Chairman of the Joint Chiefs of Staff [CJCS], 2012b).

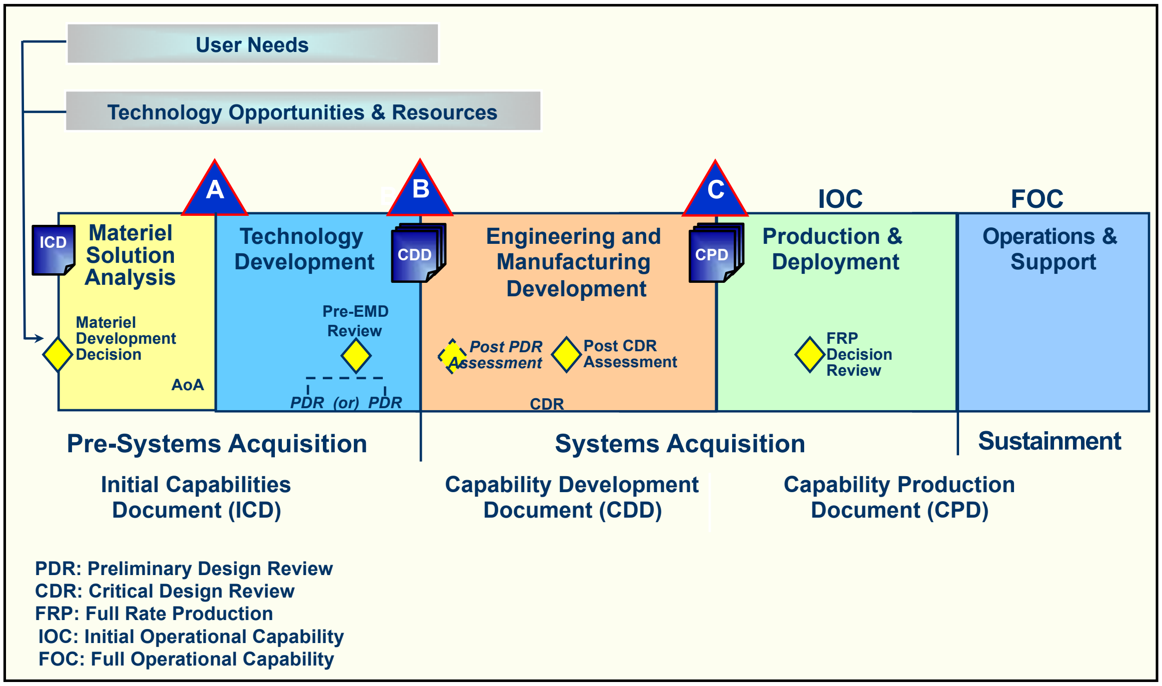

Figure 1. Defense Acquisition Management System
(B. S. Brown, 2010)

The JCIDS's focus is on requirements generation. The JCIDS identifies current warfighting strengths and weaknesses across all four military Services and conducts analyses to determine appropriate solutions to fill capability gaps (CJCS, 2012a). JCIDS documents are the link between validated capability requirements and the acquisition of material capability solutions (DAU, 2012).

When the question "What is wrong with acquisition?" is posed, inevitably, the dilemma of *requirements* development and management arises. The DAU hosts a semi-annual PM's forum. During each forum, over 20 major DoD PMs identify and rank their major concerns. Since 2007, each forum has listed some form of the term "requirement" in the top seven issues that PMs battle. In 2010 and 2011, the out-briefings listed "requirements and testing" as their number one issue (Mohney, 2011).

There are several definitions of the term *requirement.* Sailor (1990) defined requirements as identifiable capabilities expressed as performance measurables of functions that the system must possess to meet mission objectives. Chambers and Manos (1992) recognized requirements as the attributes of the final design that must be a part of any acceptable solution to the design problem. Davis (1993) defined requirements as a user need or necessary feature, function, or attribute of a system that can be sensed from a position external to that system. Grady (1993) identified requirements as an essential attribute for a system or an element of a system coupled by a relation statement with value and units information for the attribute. The military standard MIL-STD 499B (Joint OSD/Services/Industry Working Group, Department of Defense, HQ AFMC/EN, 1994) expected requirements to identify the accomplishment levels needed to achieve specific objectives. Harwell, Aslaken, Hooks, Mengot, and Ptack (1993) summarized requirements quite succinctly: "If it mandates that something must be accomplished, transformed, produced, or provided, it is a *requirement*—period" (p. 2).

Requirements generation is the cornerstone of the acquisition process because requirements define the problem. The term *requirement* resides at such a high level of abstraction and semantic imprecision that Jack Mohney (2011), a professor of requirements management at the DAU has written, "We in the DoD corporate structure often use this term to arbitrarily describe anything from a nuclear deterrent characteristic to a battlefield mission task to a contractual specification" (p. 20).

In its most basic form, a requirement is what a customer wants translated into a contractual document or interpreted through a specification. Requirements originate through an analysis of needs and current shortfalls to meeting those needs. This top-down analysis of capability needs develops into a broad set of top-level requirements called a mission needs statement (MNS). The user community then translates the MNS into an initial capabilities document. Capabilities are identified based on the tasks required to meet the capability. Once these tasks are defined, the most cost-effective and -efficient options to satisfy those requirements are identified and developed (International Defense Acquisition Research Management [IDARM] Program, 2013).

The Center for Civil Military Relations (IDARM, 2013) argued that while requirements always change and that requirements analysis must be continuous, fundamentally, a requirement consists of four basic components:

- It defines what is to be done (the function).
- It defines how well the function is to be performed.
- It defines the conditions (when and where) under which the requirement applies.

- It defines how the requirement is to be verified.

The requirements process is used in everything from determining force levels and manpower needs to establishing funding levels and acquisition priorities. The start of any procurement program begins with an identification of valid requirements. Requirements begin as broad concepts and objectives and are filtered down into specific organizations, tactics, and systems (IDARM, 2013). This filtering and refinement requires a high degree of contextual knowledge in order for the interpretation and translation process to be successful.

The Project Management Tyre Swing depicts a humorous representation of the exasperating reality of failed requirements communication during the acquisition process (see Figure 2).

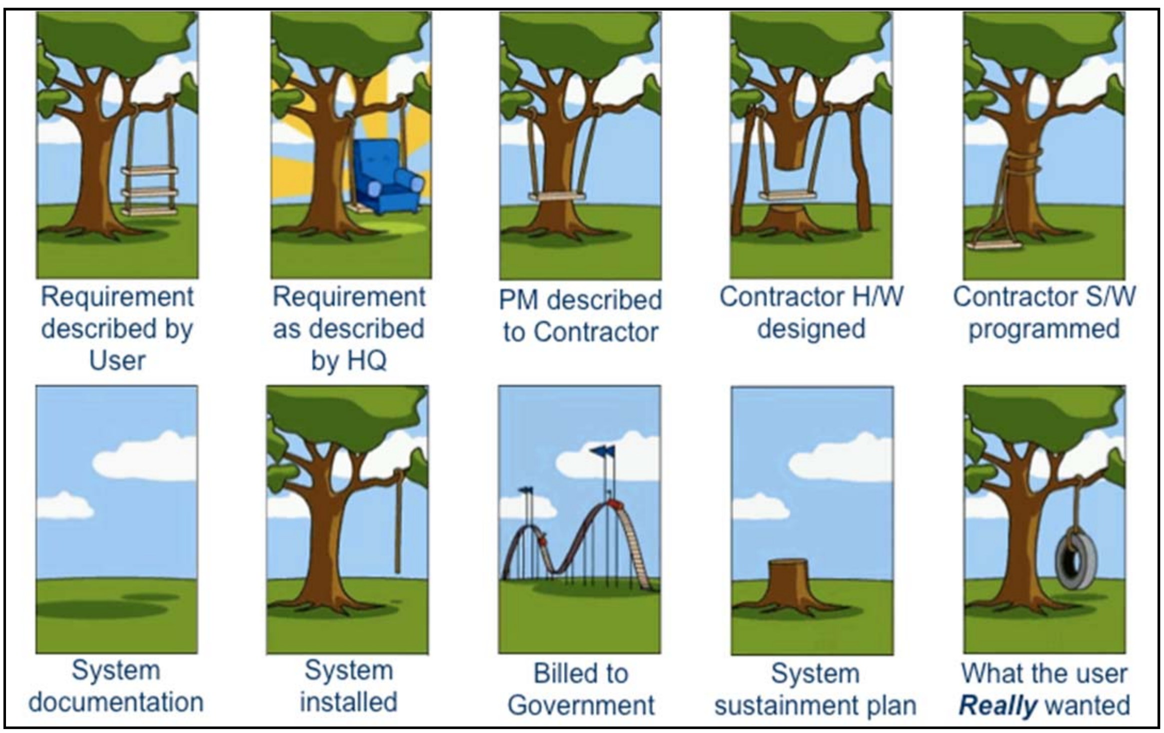

Figure 2. Project Management Tyre Swing
(Gilb, 1988)

Requirements errors are the most common errors in the acquisition process and are by far the most expensive to fix. Statistically, requirements errors consume 25–40% of the total project budget (Gallagher et al., 2005). Research has shown that requirements errors in software development account for 48% of all software problems (Hall, Beecham, & Rainer, 2002). A Standish Group Report listed unstable requirements as one of the top three reasons for project failure (Verner, Cox, Bleistein, & Narciso, 2005). The other two items on that list are a lack of user involvement and poor project management. Each of these concerns was identified as recurring and as the major cause of program failure.

Requirements engineering, the process of originating, documenting, and maintaining requirements, has developed into a separate and distinct profession (Defense Finance and Accounting Service [DFAS] Policy and Requirements Management Directorate, 2005). In an effort to remove the inherent threats of ambiguity and to decrease translation errors, there are several formal documentation requirements for every phase of the DoD acquisition process:

- DoD Directive (DoDD) 4630.5, Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS; Assistant Secretary of Defense for Networks & Information Integration [ASD(NII)], 2007)
- DoD Instruction (DoDI) 4630.8, Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS; ASD[NII], 2004)
- DoDD 5000.1, *The Defense Acquisition System* (USD[AT&L], 2007)
- DoDI 5000.02, Operation of the Defense Acquisition System (USD[AT&L], 2008a)
- Defense Finance and Accounting Service (DFAS) 8430, DFAS Life Cycle Management Policy (DFAS, 2003)
- Chairman, Joint Chief of Staff Instruction (CJCSI) 3170.01H, Joint Capabilities Integration and Development System (CJCS, 2012a)
- Chairman, Joint Chiefs of Staff Manual (CJCSM) 3170.01B, Operation of the Joint Capabilities Integration and Development System (CJCS, 2012b)
- DoD 8510.1-M, Department of Defense Information Technology Security Certification and Accreditation Process (DITSCAP) Application Manual (ASD[CCCI], 2007)
- DoD Architecture Framework (DoDAF) Volume I: Definitions and Guidelines (Department of Defense Chief Information Officer [DoD CIO], 2009a)
- DoD Architecture Framework (DoDAF) Volume II: Product Descriptions (DoD CIO, 2009b)

These references strive to remove risk in the acquisition process by establishing the attributes of well-defined requirements. Although the DoD literature abounds with references that describe how requirements should be written, the researcher has found very little DoD-specific literature that systematically delineates how requirements should be developed.

The literature surrounding the processes of requirements development may be found in the field of requirements engineering. Requirements engineering draws on the cognitive and social sciences to provide both theoretical grounding and practical techniques for eliciting and modeling requirements (Nuseibeh & Easterbrook, 2000).

The DFAS has published a *Requirements Engineering and Training Guide* (2005) to support acquisition personnel in the development of requirements. This DoD publication freely admits that it is not a "how-to" guide but is designed to provide exposure to the foundational concepts of requirements engineering, as well as a basic training and reference resource (DFAS, 2005).

The "how-to" guides exist mainly as a broad framework of critical phases that the requirements engineering process must progress through, but the method to move through these phases continues to reside at a high level of academic abstraction. Christel and Kang (1992) decomposed requirements engineering into the activities of requirements elicitation, specification, and validation. Nuseibeh and Easterbrook (2000) laid out a process of eliciting requirements, modeling and analyzing requirements, communicating requirements, agreeing upon requirements, and evolving requirements.

The DAU (2001) published *Systems Engineering Fundamentals,* which includes as Supplement 4-A, "A Procedure for Requirements Analysis." This supplement provides a list of 15 tasks that should be considered when planning and performing requirements analysis (DAU, 2001). Drawn from the Institute of Electrical and Electronics Engineers (IEEE) Systems Engineering Standard, the 15 necessary tasks are as follows:

- Customer expectations
- Project and enterprise constraints
- External constraints
- Operational scenarios
- Measures of effectiveness (MOEs)
- System boundaries
- Interfaces
- Utilization environments
- Life cycle

- Functional requirements
- Performance requirements
- Modes of operation
- Technical performance measures
- Physical characteristics
- Human systems integration (DAU, 2001)

This IEEE standard offers a process for identifying important tasks when performing requirements analysis (DAU, 2001). A more comprehensive "how-to" guide can be found in the INCOSE *Systems Engineering Handbook* (2010), which includes several considerations for successful requirements definitions. The handbook argues that requirements define the system and form the foundation for architectural design (INCOSE, 2010). This handbook is consistent with and heavily reliant on the International Organization for Standardization /International Electrotechnical Commission's Systems and Software Engineering—Systems Life Cycle Processes (ISO/IEC 15288:2008; INCOSE, 2010). ISO/IEC 15288:2008 establishes a common framework for describing the life cycle of human-created systems (Office of the Deputy Assistant Secretary of Defense [ODASD], 2012). In its discussions of requirements definition, ISO/IEC 15288:2008 (INCOSE, 2010) states,

> The purpose of the Stakeholder Requirements Definition Process is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment. It identifies stakeholders, or stakeholder classes, involved with the system throughout its life cycle, and their needs, expectations, and desires. It analyzes and transforms these into a common set of stakeholder requirements that express the intended interaction the system will have with its operational environment and that are the reference against which each resulting operational service is validated. There is near unanimous agreement that successful projects depend on meeting the needs and requirements of the stakeholder/customer. (p. 54)

INCOSE presented a context model to help illustrate its requirements definition process, as seen in Figure 3.

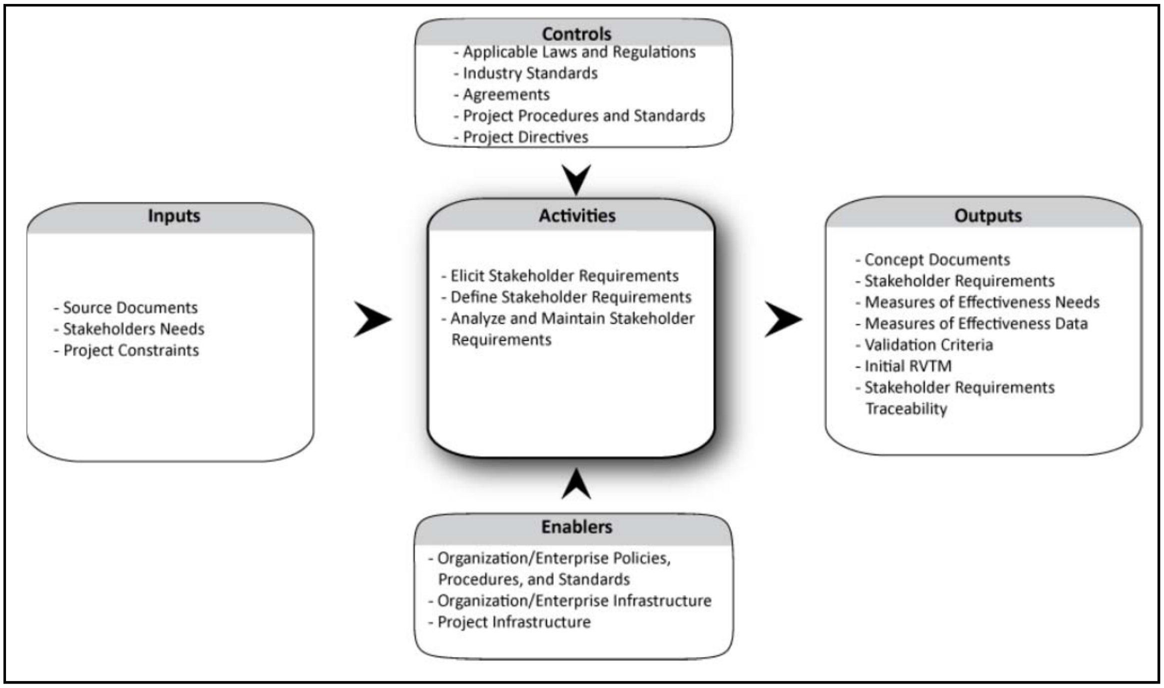

Figure 3. Context Diagram for Stakeholder Requirements Definition Process
(INCOSE, 2010)

Because stakeholder requirements are considered to govern all facets of any system's development, INCOSE offers a process by which to elicit and define those system requirements. Although not a veritable "how-to" manual for requirements generation, the INCOSE handbook offers several analytical considerations for pursuing requirements definitions.

Buede (2009) used a similar input/output trace model, as well as an application of the Integrated Definition for Function Modeling (IDEFO) to articulate his seven activities necessary to successfully define requirements:

- Develop the operational concept
- Define the system boundary
- Develop an objectives hierarchy
- Develop, analyze, and refine requirements
- Ensure requirements feasibility
- Define the qualification system requirements
- Obtain approval of requirements

Once again, this is not a veritable "how-to" manual, but Buede's (2009) contributions provide another analytical method to generate requirements. Effective requirements engineering requires establishing the proper context. Problem owners are people, and successful requirements engineering must take into account not simply what the stakeholders are saying but how those stakeholders perceive and understand the world around them (Nuseibeh & Easterbrook, 2000). Stakeholder interaction, cultural foundations, and the sociology of the organization have deterministic effects on their words and actions (Nuseibeh & Easterbrook, 2000). Establishing the contextual relationship between stakeholders requires more than simply developing a hierarchical wish list of stakeholder desires. For this thesis, the researcher investigated the applicability of a design-based approach to establish such a contextual relationship.

E. DESIGN

Design in the corporate world has traditionally been understood as product styling (Verganti, 2009). For corporate organizations, design is most often considered a functional area of creative image engineering. This form of design is an important business function but generally occurs post-product creation and is a calculated effort to generate a specific message to a targeted audience. In this context, designers are little more than the manufacturers of marketing schemes and branding strategies.

The design of physical objects has long been the central focus of professional designers (Kimbell, 2009a). Designing an object requires that the designers understand what message their design communicates and requires that the designers have the cultural fluency to embed that message (Cross, 2007). Design can then be viewed as a discipline of human intelligence and "design thinking" as the creative process of how designers think and work (Cross, 2011).

In *Notes on the Synthesis of Form*, one of the earliest authors discussing the process of design and design thinking was architect Christopher Alexander (1964). Alexander (1964) divided the world of design into form and context. Context defines the problem and form provides the solution to that problem. Attacking a problem through design thinking relies on determining where form and context meet.

In *The Sciences of the Artificial,* Herbert Simon (1996), a recipient of the 1978 Nobel Prize in economics and a professor of psychology at Carnegie Mellon University, moved away from the object-oriented focus of design. Simon (1996) discussed design in terms of "what-is and what-ought-to-be" and the design process as a rational set of procedures developed in response to a defined problem. Simon's (1996) idea of designing human activities rather than objects and his insights into the formal role of the designer stimulated research into the process and methods by which designers went about design activity (Kimbell, 2009a).

Simon's (1996) "design of human action" assumes that it is possible to determine a desired state of affairs. In this perspective of design, the design process can be viewed as a linear model that can be divided into two distinct phases: problem definition and problem solution. The linear model presents the design process as both logical and methodical:

> *Problem definition is an analytic sequence* in which the designer determines all of the elements of the problem and specifies all the requirements that a successful design solution must have. *Problem solution is a synthetic sequence* in which the various requirements are combined and balanced against each other, yielding a final plan to be carried into production. (Buchanan, 1996)

This linear model of design implies that all design problems are determinate. This implication that all problems are based on definite conditions casts the designer in the role of assessing conditions and calculating solutions (Buchanan, 1996).

University of California at Berkeley colleagues Horst Rittel (1972), a professor of the science of design, and Melvin Webber, an urban designer, coined the term "wicked problem." A problem is *wicked* as opposed to *tame* if its level of indeterminacy and complexity defies the formulation of either a comprehensive definition or inclusive solution (Rittel, 1972). Rittel (1972) identified 10 properties of wicked problems:

- Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution.
- Wicked problems have no stopping rules.
- Solutions to wicked problems cannot be true or false, only good or bad.
- In solving wicked problems, there is no exhaustive list of admissible operations.
- For every wicked problem, there is always more than one possible explanation, with explanations depending on the Weltanschauung (world-view) of the designer.

- Every wicked problem is a symptom of another “higher-level” problem.
- No formulation and solution of a wicked problem has a definitive test.
- Solving a wicked problem is a “one-shot” operation with no room for trial and error.
- Every wicked problem is unique.
- The wicked problem solvers have no right to be wrong—they are fully responsible for their actions.

Rittel (1972) argued that all but the most trivial of design problems are wicked problems because their very indeterminacy implies no definitive conditions or limits to the design problem (see also Buchanan, 1992). Rittel’s (1972) wicked problem approach was devised as an alternative to the linear model of the design process but left the question of why design problems are indeterminate, and by his own definition “wicked,” unanswered (Buchanan, 1992).

In *Wicked Problems in Design Thinking,* Richard Buchanan (1992), a professor of design, management, and information systems at Case Western University, built on Rittel’s (1972) description of the social reality of designing and began to formulate a grounded theory of design. Buchanan (1992) argued that design problems are indeterminate and wicked because “design has no special subject matter of its own apart from what the designer conceives it to be” (p. 98). The indeterminacy or wickedness of design problems directly influences the process of design thinking. Rittel’s (1972) properties of wicked problems show that there are countless ways to stalk, locate, bait, trap, and skin the proverbial cat. The specific execution of the design solution is determined by the unique approach of the designer. That unique design approach and the consequent design solution are derived from an application of the designer’s own knowledge, methods, and principles (Buchanan, 1992). Design thinking can then be understood as a practical demonstration of the designer’s own subject matter (Buchanan, 1992). This concept shifted the theory of design from a study of individual cognition to an approach that more fully acknowledges the social aspects of design and provides a method of design thinking that is applicable to any system (Kimbell, 2009b). This theory also serves to illustrate why the concepts of design thinking are defined and understood in so many different ways.

F. DESIGN THINKING

Much of the literature exploring design concepts is written at such a high level of academic abstraction that it is difficult to take away a practical application. This difficulty is compounded by the fact that much of the literature surrounding design is contradictory in nature. The very term *design thinking* is confusing, and much of the literature involves semantic debate over whether the terms *creativity*, *invention*, or *innovation* may be more appropriate (Collopy & Boland, 2004; Kimbell, 2009a, 2009b; Nussbaum, 2009;).

In *Beyond Design Thinking: Design-as-Practice and Designs-in-Practice,* Lucy Kimbell (2009b) demonstrated that there is no single authoritative definition or description of design or design thinking. Kimbell (2009b) constructed a chart (see Figure 4) that is by no means comprehensive but that highlights several of the key themes and contradictions that appear across the literature of design.

	Characteristic	Reference
Goal of design	To achieve fit between a form and its context	Alexander 1971
	Problem solving	Simon 1969
	The generation of new concepts and new knowledge; expandable rationality	Hatchuel and Weil 2009, Hatuchel 2001
	The resolution of paradoxes between discourses in a design situation	Dorst 2006
Modes of reasoning and thinking in design	Abductive	Cross 2006
	Inductive, deductive and abductive	Dunne and Martin 2006
	Balancing divergent and convergent thinking	Lawson 2006
	Designing new possibilities rather than selecting between alternatives	Boland and Collopy 2004
The nature of design problems	Determinate; ill-structured problems can be solved similarly to wll-structured problems	Buchanan 1992
	Paradoxes between discourses; design problems are not knowable and evolve during the process	Dorst 2006
	A design attitude sees problems as opportunities for the invention of new altenatives	Bolland and Collopy 2004
	Design and creativity are special case of problem solving	Simon 1969 (Hatchuel 2001)
	Problem solving is a subset of innovative design	Hatchuel 2001
The nature of design processes and activity	Dynamic mapping between functions and design parameters	Braha and Reich 2003
	Selecting and identifying constraints and applying guidelines	Lawson 2006
	Exploratory and emergent	Cross 2006
	Functional decomposition	Alexander 1971, Hubka 1982
	Reflection-in-action; making 'moves' to reframe problems	Schon 1983
	Design processes do not end	Lawson 2006
	Working at high levels of abstraction as well as detailed level	
	Co-evolution of problem and solution	Dort and Cross 2001
	Solution fixated	Cross 2006; Rowe 1987
	Experimentation	Brown 2008

[continued on next page]

	Characteristic	Reference
Designers' approach to knowledge production	Comfortable with ambiguity and uncertainty	Cross 2006, Michlewski 2008
	Integrating across knowledge domains	Hargadon and Sutton
	Consolidating multidimensional meanings	Michlewski 2008
	Empathy with users and stakeholders	Brown 2008; Dunne and Martin 2006;Michlewski 2008
	Design requires expanding concepts that are partly unknown	Hatchuel and Weil 2009
	Design requires designing learning devices	Hatchuel 2001
Emblematic practices	Sketching and drawing	Cross 2006; Lawson 2006
	Prototyping objects, experience prototyping	Kelley 2001, Fulton and Suri 2000
	Brainstorming	Sutton and Hargadon
	Tearing up a drawing of a possible solution	Boland and Collopy 2004
Approach to organizing work	Collaboration	Brown 2008, Dunne and Martin 2006
	Co-design with users	Bate and Robert 2007
	Project-based working	Dunne and Martin 2006
	Small group working	Kelley 2001

Figure 4. Research in Design and Design Thinking
(Kimbell, 2009b)

The varied understanding and interpretation of the tenets of design, the high level of academic abstraction in the literature, and the lack of a comprehensive procedural process for implementing design have made the practical application of design thinking a daunting challenge. This difficult and convoluted reality begs the question: How are design and design thinking valuable resources for business management? Design traditionally describes an object or end result, but design can also be understood as a protocol for solving problems and exploiting new opportunities ("Design Thinking," 2006). Design is a conceptual tool for addressing wicked problems and assessing the role of managers as not simply decision-makers, but as designers of solutions to ill-structured problems.

In recent years, several of the tenets of design and design thinking have been brought to the forefront of business-management efforts. The underlying belief is that these tenets have the power to spur innovation and drive organizational transformation. In *The Design of*

Business: Why Design Thinking is the Next Competitive Advantage, Roger Martin (2009), a professor of strategic management at the University of Toronto, detailed an argument for why organizations that have a proven record of success through the exploitation of reliable processes often neglect to explore available opportunities. Through a discussion of the reliability–validity trade-off, Martin (2009) explained how organizations doggedly rely on proven formulas rather than assume the risk of exploring new options. Reliability focuses on the effective management and control of clearly defined and proven processes. Validity focuses on searching for the next right answer through exploration. Many businesses, including the DoD, logically incentivize reliability by defining value through analytically based solutions. Martin (2009) argued for a greater emphasis on validity because design-based solutions hold greater potential for innovation and creativity.

In *Managing as Designing,* Case Western Reserve University colleagues Fred Collopy and Richard Boland (2004) put forth an argument that the focus of management practice and education is on the development of advanced analytical techniques. These techniques have demonstrably increased the ability to choose between alternatives, but they have also served to diminish the design skills necessary to shape new alternatives. Inside the DoD, management education and leadership development evolve through a decision-attitude toward problem solving where alternatives are displayed and the metric of managerial efficacy is determined through the selection of the best alternative. The decision-attitude assumes that the alternative courses of action are relatively simple to discover and the challenge of leadership is deciding between those alternatives. In "Managing as Designing: Lessons for Organization Leaders from the Design Practice of Frank O. Gehry," Boland, Collopy, Lyytinen, and Youngjin (2008) argued the merits of adopting a design-attitude toward problem solving where the challenge and focus of leadership effort is on designing a better course of action, not simply deciding between immediately available options.

Decision and design should serve as mutually supporting approaches to problem solving, but the overemphasis on decision over design has consistently failed to exploit available opportunities. In *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation,* the chief executive officer (CEO) and president of the design firm IDEO, Tim Brown (2010) introduced the collaborative process of design thinking that offers an approach for designing those alternatives.

In "Design Thinking for Social Innovation," Brown and executive director of IDEO.org Jocelyn Wyatt (2010) argued that design thinking is an approach that taps into capacities that are too often overlooked by conventional problem solving. Brown and Wyatt (2010) explained the design-thinking process as a system of overlapping spaces rather than an ordered sequence of steps. Brown and Wyatt (2010) identified these three spaces as follows:

- Inspiration—the problem or opportunity that motivates the search for solutions
- Ideation—the process of generating, developing, and testing ideas
- Implementation—the path that leads from the project stage into people's lives

For Brown and Wyatt (2010), design thinking is *human centered* and based on the human ability to be "intuitive, to recognize patterns and to construct ideas that have emotional meaning as well as being functional, and to express ourselves in media other than words or symbols" (p. 33). The "spaces" where the design-thinking process unfolds often occur non-sequentially and differ vastly from the traditional linear model and milestone-based processes of most organizations (Brown & Wyatt, 2010).

Human-centered design exists at the hub of technology, business, and human values (see Figure 5; d.school, 2013b). Human-centered design begins with a specific design challenge. Designers forge a path that begins with concrete observations about people, then moves to abstract thinking as insights and themes are uncovered, and then loops back to the concrete as tangible solutions are created (IDEO, 2009).

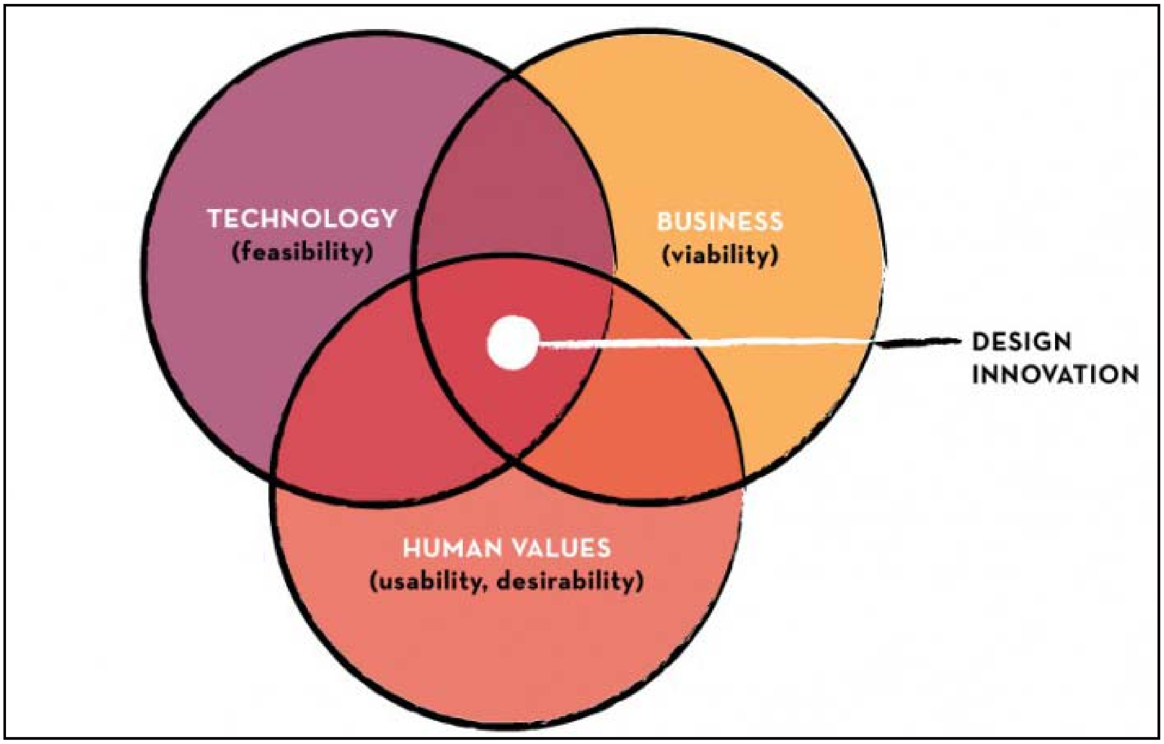

Figure 5. Hasso Plattner Institute of Design at Stanford Design Innovation Diagram
(d.school, 2013b)

The design firm IDEO approaches human-centered design through three main phases: hear, create, and deliver. In the *hear* phase, the design team prepares for field research by collecting stories and creating a contextual relationship between the users and their everyday life. In the *create* phase, the design team collaborates through a workshop format to translate what they heard into frameworks, opportunities, solutions, and prototypes (IDEO, 2009). In the *deliver* phase, the design team takes the ideas and prototypes generated in the create phase and develops them into tangible solutions.

The actual process of design thinking is a difficult concept to convey in print. Design thinking has proven to be an excellent approach to stimulate innovation, but much like the concept of design itself, different people undertake the process of design thinking in different ways. There are several different versions of and techniques to implement the design process. One of the more accessible and inclusive versions may be found in the *Bootcamp Bootleg* developed by the d.school (2013a) at the Hasso Platter Institute of Design at Stanford University.

G. THE STANFORD DESIGN-THINKING PROCESS

The d.school aptly explains itself through the *d.manifesto:* "all you need to know—on a napkin" (Figure 6). The d.school was founded in 2004 by Stanford professor and IDEO founder, David Kelley. The d.school (2013b) exists to provide a collaborative hub for innovators to "take on the world's messy problems together" and to reliably produce creative solutions.

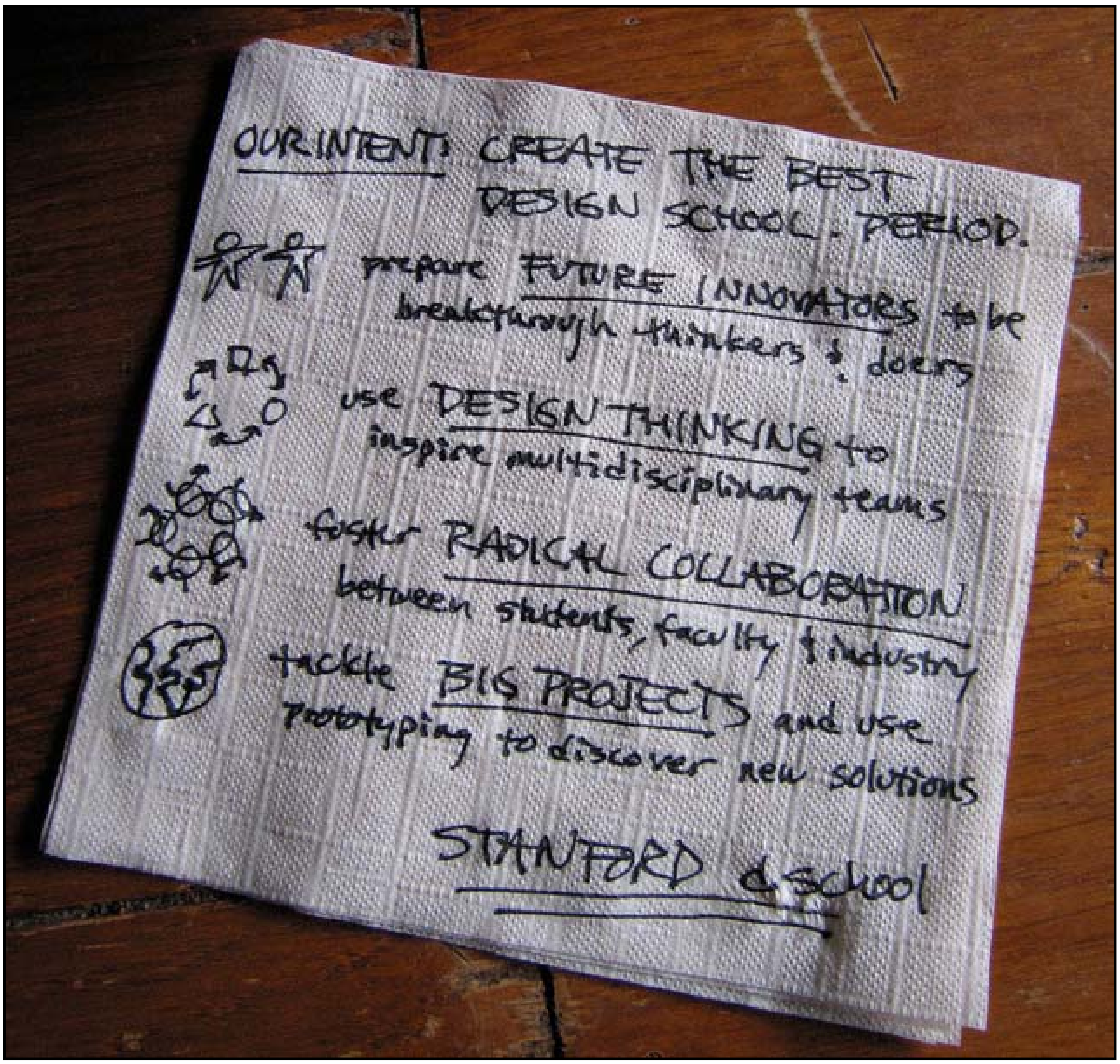

Figure 6. Hasso Plattner Institute of Design at Stanford d.manifesto "All You Need to Know—On a Napkin"
(d.school, 2013b)

The d.school's *Bootleg Bootcamp* (2013a) is a guide to the human-centered design process and an introduction to several of the methods to do design work. *Bootleg Bootcamp* is a free resource from the d.school and is licensed under the Creative Commons Attribution Non-Commercial-Share Alike 3.0 Unported License and is included as Appendix A. *Bootleg Bootcamp* (d.school, 2013a) outlines five modes or phases of the design-thinking process:

- Empathize
- Define
- Ideate
- Prototype
- Test

Empathy is the foundation of the human-centered design process and is undertaken by observing users and their behavior in the context of everyday life. By engaging and interacting with users through scheduled and "intercept" encounters, the designers can guide innovation efforts by immersing themselves in the user's experiences and uncovering the needs that the user may or may not be aware of. This process of empathizing with the user enables the designer to identify the right users to design for and to discover the underlying emotions that guide behaviors. Immersion in the design space allows the designer to better understand the situation that the users are in and to focus the design effort through a contextual understanding. Empathy is the first step to developing cultural fluency.

- Define

The define phase is the mode in which the designer synthesizes the empathy findings into needs and insights and focuses these to develop an understanding of the users and the design space. The goal of the define phase is to transform that understanding into an actionable problem statement that guides the innovation effort.

- Ideate

The ideate phase of the design process focuses on idea generation. Ideation is the transition from identifying problems to exploring solutions. There are several methods to conduct the ideate phase, but the goal of ideation is to explore a wide solution space and to develop a large quantity of diverse ideas. The fundamental principle that must be adhered to during this phase is that there is a difference between generating ideas and evaluating ideas, and the boundary between these two must be understood and only intentionally crossed.

- Prototype

Protoyping is the physical manifestation of the ideas generated in the ideate phase. A prototype can be anything that takes physical form and is important and necessary for participants to experience and interact with in order to dive deeper into empathizing, exploring, understanding, testing, and ultimately, shaping solutions.

- Test

Testing is an opportunity to refine solutions. Like each of the five phases, testing is iterative and it allows the designers to place low-fidelity artifacts into the context of the user's life to determine suitability. *Bootleg Bootcamp* (d.school, 2013a) advises designers to "prototype as if you know you're right, but test as if you know you're wrong" (p. 5).

These five phases of design thinking capture the broad framework of the design-thinking process and encapsulate the means by which designers create a contextual understanding of wicked problems and seek to develop a range of possible solutions (d.school, 2013b). This process is iterative in nature, and each cycle brings about stronger insights and a wider array of possible solutions. These possible solutions represent "big ideas" that exist to promote innovation and solve complex issues, but ideas alone cannot effect change. There must be a means to execute those ideas in order to implement the change that those "big ideas" suggest.

H. THE EXECUTION CHALLENGE

James March, professor emeritus at the Stanford University School of Education and a long-time collaborator of Herbert Simon, built off of Simon's (1996) argument that the limited cognitive ability of individuals and groups is "bounded by rationality" when confronted with complex or uncertain situations (March, 1981). According to March (1981), when individuals and groups approach complex problems, they base their decision-making solutions around the attainment of realistic goals. Because the goals of these individuals and groups inside the organization compete for available resources, they often have conflicting agendas (March, 1981). March (1981) argued that organizational behavior is the weighted sum of those conflicting agendas and that organizations must develop mechanisms to maintain the conflicts at an acceptable level.

In order to maximize cost/benefit ratios and maintain an acceptable level of internal conflict, successful organizations develop specialized skill sets that govern the performance of routine activities (Govindajaran & Trimble, 2010). These routine activities become the core processes of the organization. In “Exploration and Exploitation in Organizational Learning,” March (1991) expanded on the root of the resource conflicts through a discussion of the relationship between those in the organization who seek to exploit “old certainties” and those who seek to explore “new possibilities.” The root of the problem for March was the complication in allocating organizational resources between these groups. March (1991) concluded that the organizational emphasis on refining exploitation would offer greater short-term gains but that it was self-destructive in the long term because a lack of focus on exploration would lead to obsolescence in a competitive market.

In *The Other Side of Innovation,* Govindajaran and Trimble (2010) further developed this argument of exploitation versus exploration through the lens of organizational innovation initiatives. Govindajaran and Trimble (2010) discussed the conflict for limited organizational resources as the relationship between the “performance engine” and “idea generation” aspects of the organization. The performance engine aspect focuses on the exploitation of those mechanisms and specialized routines that maintain an organization’s operational capability. The aspect of idea generation is comprised of the innovators who focus their efforts on finding and developing new products and processes for the organization. Govindajaran and Trimble (2010) argued that the conflict between these two groups stems from the fact that ongoing operations are both repeatable and predictable, while innovation is non-routine and uncertain. The performance engine leadership is responsible for continuing the organization’s operations, while the innovation leadership’s responsibility to think differently about organizing and planning implicitly distracts from the core business norm. Govindajaran and Trimble (2010) argued that the performance engine that drives the core business processes is also the function that enables the execution of innovation. The relationship between the performance engine and the innovators is symbiotic: Without the innovators, the core processes of the performance engine suffer through stagnation; and without the performance engine, the innovator’s “big ideas” cannot manifest into actual products, services, or improvements (Govindajaran & Trimble, 2010).

This symbiotic relationship forms an innovation–execution process that enables organizations to leverage their internal conflicts to strengthen the firm and remain relevant in the ever-changing world. The current trend is to keep the two groups isolated in order to explore innovative avenues of attack without interrupting daily operations (Govindarajan, 2010). Govindarajan (2010) has argued that a more successful execution of the innovation approach would be to adopt a distinct-but-linked organizational model wherein an organization builds a dedicated team for the innovation initiative and then incentivizes a dedicated team of core business partners, so the performance engine teams with rather than fights the innovators. Govindarajan (2010) provided 10 methods to nurture such a healthy relationship between the big idea innovators and the core business personnel:

- Articulate a motivating vision of victory in which both the dedicated team and the performance engine win.
- Highlight the reality that the dedicated team and the performance engine are mutually dependent.
- Create a common enemy: the competition.
- Reinforce the values that the dedicated team and the performance engine share, even if they are simple and universal values, like a commitment to integrity.
- Make the division of responsibilities between the dedicated team and the performance engine as clear as possible.
- Anticipate resource constraints created when the shared staff must simultaneously handle the demands of innovation and ongoing operations.
- Gather data to understand whether fears about cannibalization are valid or unfounded.
- Alter incentives and specifically evaluate "ability to collaborate across organizational boundaries" on performance reviews.
- Use influential and collaborative insiders at points of interaction between the dedicated team and the shared staff.
- When the innovation initiative succeeds, share credit liberally, with both the dedicated team and the shared staff.

For Govindajaran and Trimble (2010), solving the execution challenge involves developing the natural conflict between exploitation and exploration into a healthy tension between the innovation team and the performance engine. Based on the premise that organizations cannot thrive without innovating, Govindajaran and Trimble (2010) argued that developing healthy tension in the innovation–execution process is the means by which organizations can implement wild ideas and maintain their innovative competitive edge.

I. LITERATURE REVIEW CONCLUSION

Based on the literature review, there is a strong link between the case that has been researched and the fields of organizational change management, human capital, requirements engineering, design, and design thinking. The lessons that this case research offers highlight the challenges of change management in the DoD and offer significant anecdotal insight into the challenges to innovation inside the strictures of the DoD's acquisition process. The literature review and the case research have demonstrated the potential of utilizing the principles of design in leveraging the DoD's millennial-generation human assets, as well as introducing an actionable design-thinking process to requirements engineering and an executable innovation paradigm to support program management inside the DoD.

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III. THE CASE STUDY

The case study presented in this chapter addresses three distinct yet interlocking narratives. The first concerns how the submarine sonar community transitioned to modular open source architecture and enabled the continuous and rapid delivery of advanced technology into submarine systems. The second concerns the challenges to managing such a rapid refresh of technology. The third concerns the unique method that was devised to address that challenge.

This chapter begins with the closing of the Cold War. Worldwide advances in submarine system technology had led to a degradation of U.S. submarine superiority. The post-Cold War loss of the U.S.'s symmetric adversary and dramatic cuts to the defense budget caused a realignment of the DoD's overall acquisition strategy from a threat-based to a capabilities-based development process. The loss of the Cold War competitive forcing function required an overarching change to the businesses models of many DoD components. What follows is a historical narrative of the U.S. Navy submarine forces' shift from a closed business structure to an open business model and the challenges that this transition imposed.

The model that subsumed the traditional acquisition process for submarine sonar system development was the Acoustic Rapid Commercial-Off-The-Shelf Insertion program (ARCI; pronounced *AR-kee*). The goal of ARCI is to improve U.S. submarines' abilities to detect and defeat other submarines. ARCI is both a business and technical strategy that capitalizes on the rapid improvements available through commercial-off-the-shelf (COTS) processing technologies. ARCI enabled the submarine community to update sonar system technology at an unprecedented rate. These rapid updates dramatically improved the submarine sonar systems, but the operational and support functions of the U.S. submarine community struggled to keep pace with the rapid rate of technology change.

The challenges to managing these rapid technology changes led the Commander, Submarine Forces, to look to the most junior members of the submarine force for a solution. In order to leverage the millennial-generation sailor's characteristic familiarity, proficiency, and skill with advanced technology, one of the nation's leading not-for-profit centers for sonar systems engineering, research, and development coordinated with a design consultancy firm to create the Tactical Advancements for the Next Generation (TANG). TANG used the principles of design thinking to create a collaborative endeavor to exploit the tacit knowledge of junior sailors in the design of sonar system technology.

While the target audiences for this case study are U.S. military Service members and DoD acquisition professionals, the narrative has been framed to accommodate the lay reader. An acronym guide and a glossary of relevant terms have been included to assist the reader through the narrative.

A. PART I: THE ACOUSTIC DILEMMA

1. Background

The United States Navy operates three types of submarines: SSBNs, SSGNs, and SSNs. The designation *SS* stands for submarine, *N* stands for nuclear-powered, *B* stands for ballistic missile, and *G* stands for guided missile (O'Rourke, 2012a). All U.S. Navy submarines are nuclear-powered, but a submarine's use of nuclear power as its energy source is not an indication of the submarine being armed with nuclear weapons.

The Ohio-class SSBNs are the ballistic missile submarines. SSBN "Boomers" are missioned to remain hidden at sea with their nuclear-armed submarine-launched ballistic missiles (SLBMs) and serve as the nation's strategic nuclear attack deterrence (Woolf, 2008). SSGNs are cruise missile and special operations forces (SOF) submarines. From 2002 to 2008, the four oldest Ohio-class SSBNs were converted to SSGNs to carry cruise missiles and SOF rather than SLBMs (O'Rourke, 2012b). The 42 Los Angeles–class, three Seawolf-class, and eight Virginia-class fast-attack SSN submarines perform a variety of peacetime and wartime missions that include Service-level and national-level covert intelligence, surveillance, and reconnaissance (ISR); anti-submarine warfare (ASW); anti-surface ship warfare; covert offensive and defensive mine warfare; and, on a smaller scale than the SSGNs, SOF insertion and recovery, and cruise missile strikes against land targets (O'Rourke, 2012a).

During the Cold War, the SSN mission was primarily ISR and ASW against the Soviet submarine force. In the early days of the Cold War, the newly nuclear-powered U.S. submarine force prided itself on its acoustic quieting capabilities: the techniques to dampen machine vibrations and prevent them from reaching an observer (Polmar & Moore, 2005).

Achieving an acoustic advantage consists of a combination of quieting and sonar system capability. In order to attain acoustic superiority, as an adversary's quieting capability increases, sonar systems need to become more capable. Being quieter than the enemy allowed U.S. submarines both to avoid detection. Having more capable sonar systems enabled U. S. submarines to more capably find, stalk, and expose Soviet submarines, which was the top priority for U.S. forces (Bratton & Tumin, 2012).

In 1962 at the height of the Cuban Missile Crisis, four of the relatively noisy Russian "Foxtrot" diesel submarines from the Soviet Northern Fleet were able to avoid the U.S. Naval Blockade and surface inside the quarantine line around Cuba (Blanton, Burr & Savranskaya, 2012). With 85% of the U.S. Atlantic Fleet on a wartime footing, the Soviet submarines, each carrying nuclear-tipped torpedoes, were able to evade U.S. forces and run the blockade (Bratton & Tumin, 2012; Blanton et al., 2012). This event and the ASW mission priority would see the U.S. Navy turn its focus of effort to develop and deploy a vast array of sonar technology.

The joint effort of naval land, air, surface, and submarine assets would produce an array of active and passive surveillance sonar that, throughout the Cold War, enabled the U.S. to enjoy a major acoustic advantage over the Soviets (Benedict, 2005). Through the 1970s and 1980s, the U.S. submarine force enjoyed great success in intelligence gathering and in the protracted tracking and trailing of Soviet missile subs (Sontag, Drew, & Drew, 2000). A significant factor in this success is that the Soviets remained ignorant of the U.S.'s decisive acoustic superiority. This advantage would be revealed to the Soviets through the Walker/Whitworth espionage ring, and the details of U.S. acoustic superiority would lead the Soviets to improve their quieting capabilities dramatically (Weir & Boyne, 2003).

Walker/Whitworth was uncovered in 1985, but the full ramification of their betrayal would not manifest for several years (Prados, 2010). From 1980 through the early 1990s, the U.S. submarine force battled the rapid reduction in Russian submarine noise levels (see Figure 7). The technological advances made by the Soviets were accompanied by changes in tactics and techniques that began to stymie U.S. submarine forces (Benedict, 2005).

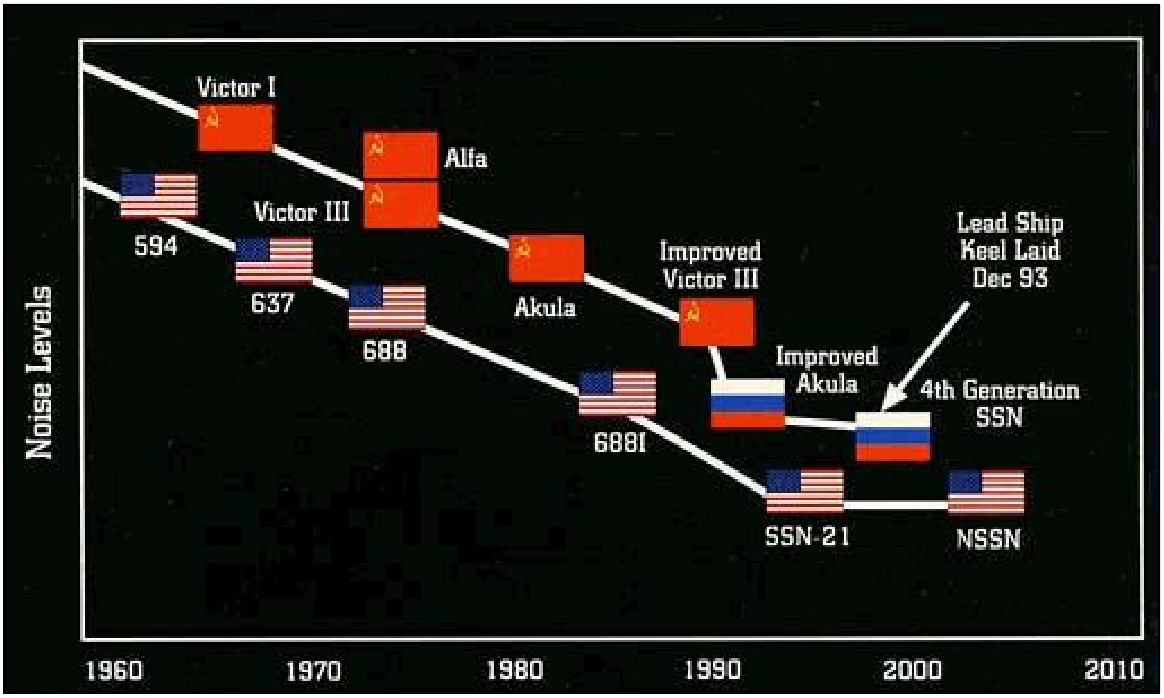

Figure 7. Broadband Quieting Comparison
(Federation of American Scientists [FAS], 1998)
Note. This figure depicts a comparison between the noise emitted by the multiple classes of U.S. and Soviet/Russian submarines. The U.S. maintained a decisive edge in acoustic quieting, but the increased quieting capability of the Soviet/Russian submarines would make them increasingly difficult to detect with the existing U.S. submarine sonar technology.

Some of the earliest indicators that the sonar equipment on U.S. submarines was falling into obsolescence were discovered during post-mission analyses. The U.S. submarines of the day had the ability to collect and store vast amounts of data, but they lacked the capability to efficiently process that data in real time. The more advanced processors available on shore for post-mission analysis revealed several key indicators of adversary submarine contacts that the mission had missed. The realization of this capability gap and the threats against U.S. undersea dominance demonstrated a definitive need for the U.S. to increase the acoustic advantage. Better acoustic sensing systems, stronger processors, and the ability to present the accumulated data to the submariner in a meaningful way were necessary for the U.S. to maintain undersea superiority. Post-Cold War Cuts to the Defense Budget

The post-Cold War loss of the U.S.' symmetric adversary would see dramatic cuts to the defense budget and would cause a realignment to the Department of Defense's overall acquisition strategy from a threat-based to a capabilities-based development process.

The Cold War acquisition professional's "traditional" threat-based approach to overcoming this "acoustic dilemma" would involve a decade-long multi-billion-dollar program designed to build a better system (Johnson, 2004). Development costs of an entirely new system built to the design of military standards (MIL-STD) and military specifications (MIL-SPEC) were projected to be $1.5 billion and installation costs an additional $90 million per boat to install (Gansler & Lucyshyn, 2008). The budget cuts at the end of the Cold War put the submarine force in a precarious position. Submarine research and development (R&D) funding dropped by 80% (see Figure 8). The fall of the Soviet Union and the de facto end of the Cold War put this traditional DoD acquisition response on hold.

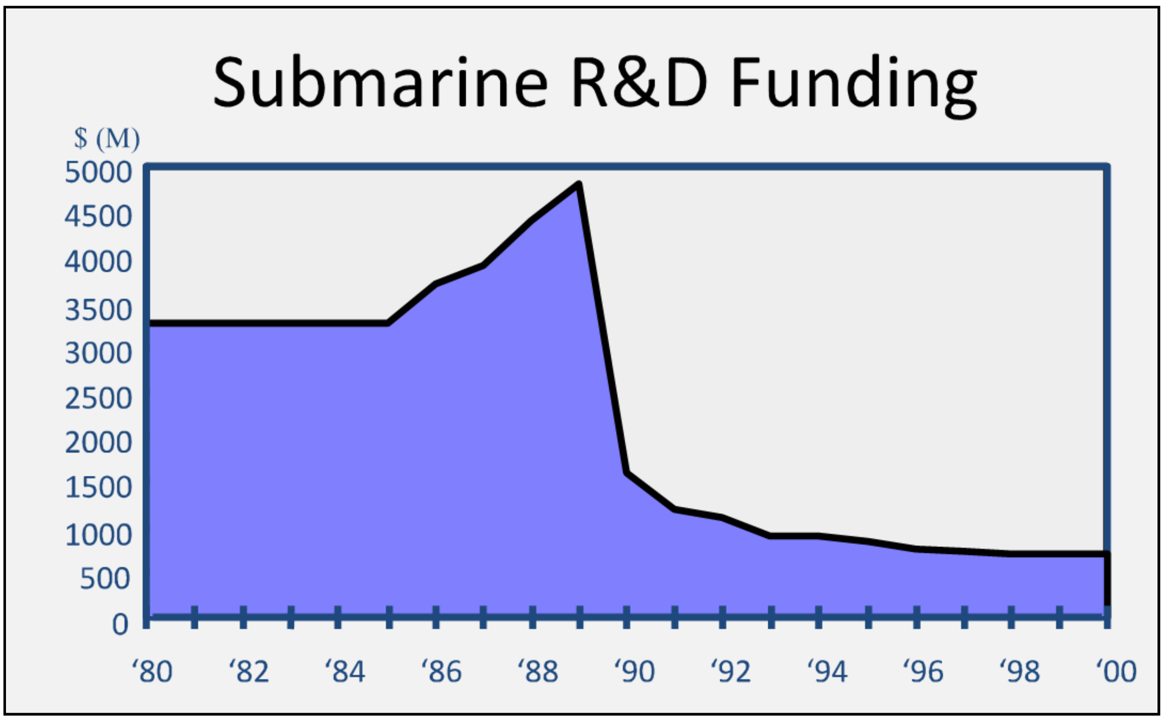

Figure 8. U.S. Submarine Research & Development Funding Profile
(Zarnich, 2000)

The U.S. submarine force could not introduce performance improvements at the pace of the 1970s or 1980s. The advanced development programs that conducted research and the engineering development programs that practically applied that research were decoupled (Johnson, 2013b). Conducting R&D efforts between these isolated programs was a lengthy, costly, and inefficient process. The processing capacity of the legacy system was exhausted so the only way to upgrade the antiquated system was to replace it, which was much too expensive (Maris, 2007).

With the Cold War over and the dismantling of the Soviet Bloc, the Red Threat competitive forcing function that drove the American military machine began to disintegrate. Although the Soviet, now Russian, navy was certainly in decline and would become a poorly maintained financially infeasible wreck by the early 2000s, in the years immediately following the 1991 fall of the Soviet Union, the Russian submarine navy was still a substantial force to be reckoned with.

The submariner's acoustic battle was further complicated by a sharp rise in the development efforts of the rest of the world's diesel submarine arsenal and these submarines' ever-increasing quieting capabilities (see Figure 9). The U.S. submarine force may have lost her primary Cold War adversary, but between budget cuts and the proliferation of other nations' submarines, the U.S. submarine Navy continued to lose ground in undersea dominance.

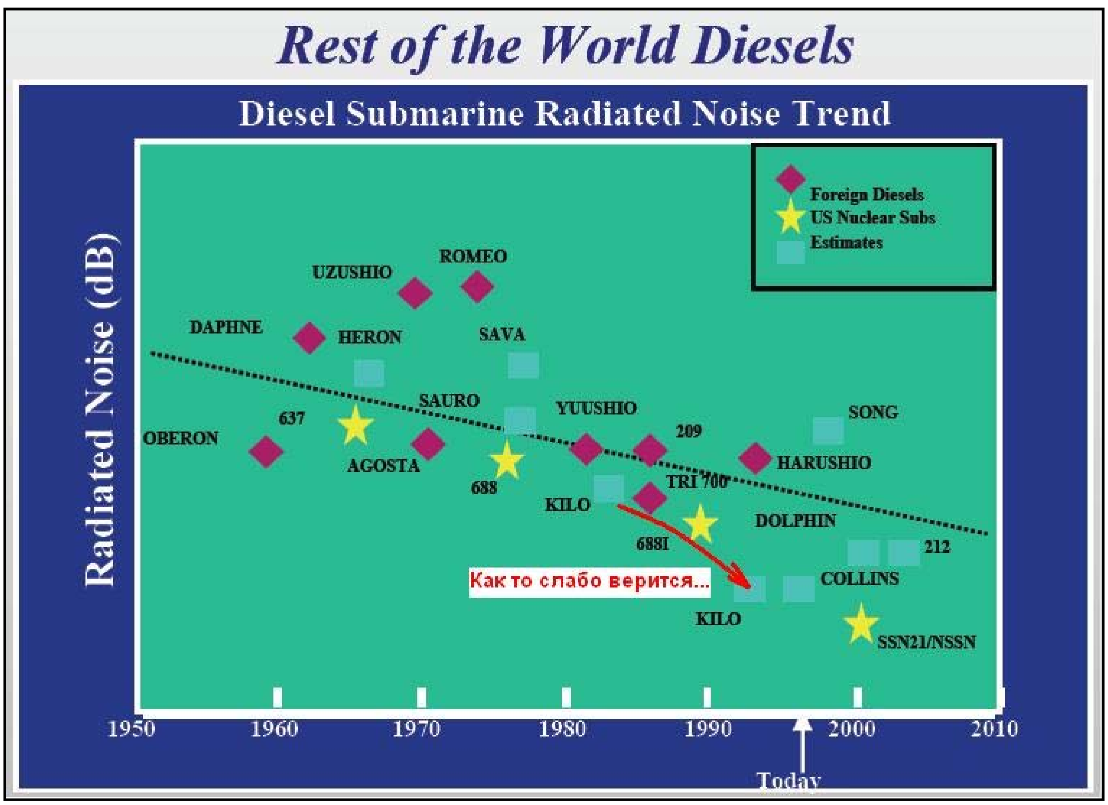

Figure 9. Rest of the World Diesels' Radiated Noise
(Zarnich, 2006)
Note. This figure depicts the radiated noise produced by the rest of the world's diesel submarines compared to the radiated noise of U.S. nuclear submarines.

In the 1990s, many U.S. submarine exercises with allied diesel submarines proved humbling (Benedict, 2005). Western diesel-electric submarines posing as adversary submarines in North Atlantic Treaty Organization (NATO) naval exercises had been able to penetrate ASW defenses of U.S. aircraft carrier battle groups (Kan, Bolkcom, & O'Rourke, 2000). South African Daphne-class, Chilean Type 209, and Australian Collins-class submarines penetrated battlegroup defenses and were able to conduct mock attacks before being counterattacked (Farrell, 2003).

The reduction of acoustic superiority and the reduced ability to track and detect adversary submarines represented a clear and present danger to the efficacy of the U.S. Navy's submarine force. Couple these factors with the 80% drop in investment funding and the inability to improve or replace obsolete fleet systems, and the very relevance of the U.S. submarine force would come into question over this acoustic dilemma.

2. Submarine Superiority Technical Panel

The submarine force commissions a blue ribbon panel of experts from government, industry and academia to explore solutions to the acoustic dilemma.

By 1995, the acoustic superiority crisis had reached critical mass. Confronted by grossly inefficient and starkly underfunded acquisition process, the U.S. submarine fleet could not afford to develop another legacy system, nor could it afford to buy new legacy ship-sets (Maris, 2007). The Cold War was over, the U.S. had won, but the Navy had lost much of its long-dominant undersea acoustic advantage.The rash of budget cuts saw severe changes to the U.S. strategic nuclear forces (Aspin, 1993), which included a drawdown of nuclear missile submarines from 36 to 18 (Bratton & Tumin, 2012). These factors combined to question not simply the effectiveness of the U.S. submarine force, but its very relevance in the post-Cold War world.

In 1995, Chief of Naval Operations Admiral Boorda's Submarine Acoustic Master Plans vision for the acoustic capability of Navy submarines was to "aggressively incorporate flexible, affordable and innovative technologies to restore and maintain acoustic advantage, ensuring tactical control, maritime battlespace superiority, and comprehensive undersea surveillance" (Rosenberger, Altizer, Odish, & Steed, 2005). Acting on this vision, in April 1995 the Director of Submarine Warfare, Rear Admiral Malcolm Fages, chartered a blue-ribbon investigative panel dubbed the Submarine Superiority Technical Panel to identify the reasons for, and to propose corrections to, the shortfalls in U.S. submarine acoustic superiority (Sonar Development Working Group [SDWG], 1999). This blue-ribbon panel was a working group comprised of representatives from government, industry, and academia. Led by John Schuster of the Chief of Naval Operations, Submarine Warfare Division and chaired by Ken Hawker of the MITRE Corporation, the panel undertook the challenge of solving the acoustic advantage dilemma (Bratton & Tumin, 2012; MITRE, 1999).

The Program Executive Officer, Submarines (PEO SUB), is the government entity responsible for developing, acquiring, modernizing, and maintaining the U.S. Navy's submarines (Assistant Secretary of the Navy, Research, Development, & Acquisition [ASN(RDA)], 2012b). At the time, the Submarine Combat System Program Office (PMS 425) was the division of the Program Executive Officer, Submarines responsible for developing and acquiring the sonar, combat and weapon control systems for both in-service and new construction boats (ASN[RDA], 2012b). In 1995, the lead civilian for submarine sonar from the Submarine Combat System Program Office and the blue-ribbon panel's de facto acquisition expert for submarine sonar systems was Bill Johnson.

3. Bill Johnson

Johnson was an electrical engineer out of Cornell University who started his career at the Georgia Institute of Technology Experiment Station designing electronic circuitry used in testing surface ship radar systems (Johnson, 2013a). In the early 1970s, Johnson joined the Navy and worked extensively on undersea surveillance (Johnson, 2013b). Having completed his active-duty service, Johnson returned to Cornell for graduate work in electrical engineering and then embarked on a career in engineering and program management with the organization that would become the Naval Sea Systems Command (NAVSEA; Johnson, 2013b). NAVSEA (pronounced *NAV-sea*) is the largest of the Navy's five system commands and is the entity that maintains overall responsibility for engineering, building, buying, and maintaining ships, submarines, and combat systems (NAVSEA, 2013). By 1980, Johnson had shifted from surface ships to submarines and became involved in designing and developing visual systems (Johnson, 2013a). Over the next 15 years, Johnson became an expert in all aspects of design, development, fielding, support, and acquisition of submarine combat systems (Johnson, 2013a).

When asked what type of person Bill Johnson is, one Navy Senior Chief described him as “a huge guy who used to work as a bar bouncer. ... He’s ‘one of those leaders.’ Very inspiring, visionary, and definitely wants to deliver systems for the fleet by the fleet” (F. M., personal communication, December 11, 2012). Although driving down costs is the acquisition industry’s standard measure of success, there is scant higher praise for an acquisition professional from the fleet than being considered “one of those leaders.” Johnson’s experience and expertise would open up a space for him on the blue-ribbon panel, but it was his force of character and fearless leadership that would serve to revolutionize the submarine sonar community.

During the blue-ribbon Submarine Superiority Technical Panel’s deliberations, Johnson came to several stark realizations. The first was that the feedback he had received on the operational performance of his sonar systems had been filtered through the Office of Naval Intelligence (ONI) or the Naval Undersea Warfare Center (NUWC; pronounced *NEW-ick*) in Newport, Rhode Island (Bratton & Tumin, 2012). First-hand knowledge of system performance derived from the operational experience of fleet end users would have to migrate through the naval hierarchy before reaching Johnson and the other decision-makers ultimately responsible for developing and acquiring the systems. This highly compartmentalized structure and lack of direct contact with the fleet would see information diluted to the point that Johnson was “in the dark about what had caused all the fuss” (Bratton & Tumin, 2012, p. 124).

The highly stratified organizational structure and the insular nature of the U.S. Navy had led to severe inefficiencies in U.S. sonar development. Stove-piped funding lines and closed business practices have led the Navy to develop unique systems for each class of ship (Johnson, 2013b). These duplicative efforts resulted in multiple expenditures on virtually identical organizations and infrastructures (Bratton & Tumin, 2012). The lack of cross communication between the disparate development and acquisition professionals is indicative of the strict “need-to-know” Cold War culture that helped spawn countless redundant and siloed legacy systems.

These parallel development processes led to Johnson’s next major realization: Even though the Russian submarines were getting significantly quieter, the U.S. was still having great success in detecting them. The submarine sonar systems were suffering, but the ocean floor surveillance systems were proving to be especially effective (Johnson, 2013b). Working with the varied membership of the blue-ribbon panel was the first opportunity that Johnson had to see the raw data. During one of the panel's meetings, they used an ocean floor surveillance system to process a recording of a Russian submarine and then put that same signal through the U.S. submarine-based system:

> The difference was astounding. Like a heart-rate monitor, the ocean-floor system showed a healthy straight line across the chart: it had maintained nearly continuous contact with the Russian sub. The submarine based system was on life support: nothing but dits, dashes, dots, and gaps—mostly gaps, mostly non contact. (Bratton & Tumin, 2012, p. 125)

The practical difference between the two systems was that the surveillance systems had been continuously and consistently improved by commercially developed technology and regular updates to software (Johnson, 2013b).

4. Adopting Commercial-Off-The-Shelf (COTS) Technology

The array of sensors developed for the U.S. Navy's acoustic surveillance systems was capable of accumulating massive amounts of data. The technology necessary to process such a large influx of data lagged significantly behind the data collection capability. This shortfall stimulated a small segment of the acoustic development community to look to commercial industry for a solution.

Since the 1950s, the U.S. Navy had relied on a network of strategically placed ocean floor sensors known as the Sound Surveillance System (SOSUS) as the long-range early warning asset for protecting the U.S. against the threat of Soviet ballistic missile submarines (Whitman, 2005). The ocean floor sensors enjoyed great success, but it was both technically and fiscally infeasible to blanket the entire ocean with sensors, so the reach of the surveillance systems were limited to a perimeter defense. In order to extend its reach, the Navy began deploying the Surveillance Towed Array Sensor System (SURTASS), which were mobile sensors towed behind surface ships that would collect acoustic data and then transmit that data to evaluation centers ashore for processing (Pike, 1999). Both the ocean floor sensors and the sensors towed behind surface ships used telemetry to acquire an accurate fix on Soviet submarines (Whitman, 2005). Collectively, these sensors accumulated vast amounts of data, but absorbing this data soon eclipsed the Navy's processing capability

(Bousquin, 2008). The technology mature enough to process such massive amounts of data simply was not available in the 1960s and 1970s.

In 1971, having recognized the data processing problem, Henry Aurand of the Naval Ocean Systems Center proposed an elegantly simple and extremely cost-effective solution: utilize the commercially developed technologies already in use by oil exploration companies (Bousquin, 2008). The oil companies' sensors were designed to isolate seismic movement but were fully capable of isolating submarine movement. Aurand's suggestion to modify commercially available seismic array technology developed into the Large Aperture Marine Basic Data Array program (LAMBDA; Bousquin, 2008). This seismic array approach gave the evaluation centers that were struggling to process the massive amount of sensor data an alternative method for tracking mobile Soviet submarines (Defense Advanced Research Projects Agency [DARPA], 1997). Although the submarine force would eventually return to the telemetry approach, the seismic array approach may be credited with keeping the ocean floor and towed array sensor programs alive by filling the detection capability gap and allowing processing technology the time to mature (Bousquin, 2008). Aurand's idea would set a precedent for the ocean floor and surface ship sonar development communities by introducing the innovative use of commercial technology. It would take the submarine community roughly 25 years to assimilate and accept the advantage of commercially developed solutions.

5. Traditional Submarine Sonar System Development

Traditional submarine sonar systems were based on the sole development efforts of the Navy laboratories of the Naval Undersea Warfare Center in Newport, RI, and their single long-term contractor, the Lockheed Martin Corporation in Manassas, VA. These large-scale proprietary systems were patently unique and developed from the ground up. This process would habitually require 5–6 years to progress from initial development to operational implementation.

The processing problem that the submarine community was facing in 1995 was similar to the problem that the ocean floor surveillance community had begun attacking in 1971: The signals from the sensors held information that the systems simply could not process. The blue-ribbon panel's demonstration of the differences in signal processing between the surveillance systems and the submarine system put the problem into context. The surveillance sonar community had taken advantage of the commercial advances in signal processing and microchip development and had reaped the benefits of decreased costs and increased performance while the submarine sonar community had remained tethered to the traditional five- to six-year development and acquisition process (Bratton & Tumin, 2012; Johnson, 2013b).

The submarine sonar systems were wholly dependent on the Navy laboratories of the NUWC (Johnson, 2013b). The Navy laboratories of NUWC were the submarine signal processing experts and had sole control over the design and development of all submarine sonar systems (Bratton & Tumin, 2012). While the Naval Sea Systems Command was the manager of the acoustic program, NUWC had historically developed all of the algorithms and processing techniques for the submarine community (Johnson, 2013b). In contrast, the surveillance community had long-standing relationships with diverse institutions such as the University of Texas, Johns Hopkins University, and a slew of small businesses. The Navy laboratories of NUWC were institutionally opposed to inviting or involving "outsiders" into their process (Johnson, 2013b). The egotism of this insular culture, its stubbornness against involving outsiders in the development process, and the five- to six-year refresh rate of the traditionally closed and controlled acquisition process had allowed submarine sonar systems to fall behind the rest of the acoustic development world.

In September 1995, the blue-ribbon panel commissioned to find solutions to the acoustic dilemma released its recommendations. Unsurprisingly, they recommended that the Navy adapt the surveillance systems to the submarine (Bratton & Tumin, 2012). The panel challenged each sonar community to, over time, standardize 80% of the infrastructure of all sonar platforms and to customize the other 20% based on specific platform needs (Bratton & Tumin, 2012). They would also make the strategic recommendation that the sonar communities adopt commercially available technology, institute an improvement program based on peer review and sea-data based evaluation, and update sonar systems annually (SDWG, 1999). Leveraging commercial technologies would save the Navy both time and money by taking advantage of the commercial sector's soaring advances in technology development. Peer review would open up development efforts to a larger audience of subject-matter experts (SME, pronounced *smee*) that had long been ignored by the closed world of submarine sonar development. Evaluating system performance on actual operational sea-data would be a means to verify that the developers had built the system correctly and to validate that the developers had built the right type of system. Annual updates would ensure that the sonar community kept pace with the changing threat and would restore the U.S.'s acoustic advantage.

6. From Recommendations to Reality

Bill Johnson would take the recommendations of the blue-ribbon Submarine Superiority Technical Panel and create a vision of change for the submarine community and formulate a plan to fix submarine sonar system development.

The recommendations put out by the blue-ribbon panel fit perfectly with the vision Bill Johnson had been developing (Bratton & Tumin, 2012). Johnson's experience with his sonar system compatriots had shown him the value of sharing talents and resources between disparate program offices (Johnson, 2013b). Leveraging state-of-the-art commercial technology seemed like a brilliant idea, but implementing that idea was a task easier said than done. The closed business practices of the traditional acquisition process and the long history of systems developed and built to unique military standards and specifications could not simply adopt or adapt commercial systems (Perry, 1994). Johnson's plan to implement a COTS-based approach would require a fundamental shift in the way the Navy did business and a complete overhaul of submarine sonar development (Bratton & Tumin, 2012).

Sole reliance on NUWC as the single provider of sonar systems inhibited innovation and the competition of ideas (Johnson, 2013b). Johnson (2010) wanted the development process open to both competition and new contributors. Commercial industries could provide a higher return on investment (ROI) on development dollars. Their technologies could increase processing capacity and reduce the cycle time for future upgrades. Johnson (2010) wanted to leverage commercial industry and take advantage of those affordable solutions. He wanted to engender fleet participation in the development process, which was too often completely detached from the traditional acquisition process (Johnson, 2010). He wanted to institute a peer group evaluation process to build interactive communication between the operators and the algorithm developers and to use real-world encounter data in the test and evaluation process so that system development would be truly data driven and not based on any institutionalized or politically motivated decision-making process (Johnson, 2013b).

Johnson (2013b) argued the value of implementing an open system approach that would integrate the business and technical areas of sonar system development. An open system business strategy reduces total system ownership costs by leveraging currently available technologies from multiple sources (Azani & Khorramshahgol, 2006). An open system technical strategy relies on large-scale collaboration between developers to share, discuss, and review a process so that they may continuously develop and refine that process (Scacchi, 2002). Under an open system, developers would have access to products and processes and would be able to freely replicate and redistribute the "source code" (Azani & Khorramshahgol, 2006). Rather than a single source proprietary development methodology, an open system strategy would allow multiple parallel development efforts. The access to information that an open source strategy provides would allow separate teams of developers to produce subsystems and components for the larger system. Johnson's (2013b) vision was to force development efforts to build flexibility into the system. The flexibility of an open system would help achieve enduring interoperability, integrability, affordability, adaptability, commonality, and supportability (Azani & Khorramshahgol, 2006). Johnson's vision was to create a modular system that would allow submarine sonar to leverage COTS technologies and to open development efforts to a larger audience of SMEs.

Johnson's plan to turn this vision into a reality would call for a complete overhaul of the way submarine sonar was developed. It was not just the technology Johnson set out to change, but the entire acquisition process (Johnson, 2013b). Johnson's vision was to reinvent the way the submarine sonar community conceived, designed, developed, and deployed sonar systems (Bratton & Tumin, 2012). The term for this initiative, coined by Johnson and the PMS 425 program manager Captain John "Jack" P. Jarabak was the Acoustic Rapid COTS Insertion (ARCI) Program (Bratton & Tumin, 2012).

ARCI was the idea that would embody Johnson's vision of a wholly transparent and peer-reviewed collaborative process. ARCI was Johnson's solution to leading the submarine Navy to solving its acoustic dilemma. The only things standing in the way were the firmly established traditional acquisition process, the embedded acquisition professionals whose personal authority and professional identity stemmed directly from that traditional system, the Navy leadership whose careers had risen and were inextricably linked to that traditional system, the proven experts from Navy laboratories of the NUWC, the vested interests of the long-term prime contractor, and 220 years of institutionalized naval tradition.

B. PART II: ACOUSTIC RAPID COTS INSERTION

1. Revolutionary and Controversial

The Acoustic Rapid Commercial-Off-The-Shelf Insertion program confronted and corrected four fundamental constraints of the traditional submarine sonar system acquisition process: the closed business model, lack of competition, lengthy development times, and the absence of end user participation from the Fleet.

The ideas behind the ARCI initiative were revolutionary because they directly confronted four fundamental constraints of the traditional acquisition process (Johnson, 2004). The first constraint was the closed business environment that had been long dominated by the Navy laboratories of the NUWC in Newport, RI, and the prime contractor, Lockheed Martin, in Manassas, VA. This domination excluded outside sources and inhibited the exploitation of commercially developed systems (Johnson, 2004). The second constraint, directly related to the first, is that operating inside a closed environment inhibits the competition of ideas (Johnson, 2004). A closed environment removes any incentive to share information and effectively punishes collaboration. Outsider participation would force the dominant entities of the closed business system to sacrifice sole ownership of their products and impinge on their monopolistic competitive advantage. The third constraint was the traditional timelines required to develop new sonar systems. The goal of rapidly refreshing technology and modernizing both software and hardware in a timely manner was inconsistent with the traditional development profiles (Johnson, 2004). The fourth constraint was the disconnection between the fleet operators and the acquisition process. In the conventional submarine sonar development model, there was very little solicitation of fleet participation beyond the requirements generation stage of the acquisition process. Direct feedback was virtually non-existent in concept development, design and engineering, test and evaluation, delivery, training, or logistics support (Johnson, 2004).

Johnson's vision was to redesign sonar development into a wholly *transparent*, *peer-reviewed,* and *competitive* process that would leverage the *tacit knowledge of the fleet* and test its solutions against ocean noise and encounter data taken directly from real-world operations. Johnson's vision directly challenged the traditional way of doing business and threatened the embedded insular culture. The ARCI initiative presented an opportunity to act on the recommendations of the blue-ribbon panel, but academic proposals alone were soft ground from which to launch an institutional heresy. Johnson and his team would have to engage a laundry list of long-entrenched forces if the ARCI vision were to turn into reality. Although the embedded institutional inertia was strong and the obstacles to implementing change were high, there were several key factors working in Johnson's favor.

2. The Legal Framework

The post-Cold War environment would see the Department of Defense realign its overall acquisition strategy and institute overarching changes to many of its business methods and models. The "Perry Memo," the Federal Acquisition Streamlining Act, and the Clinger–Cohen Act would serve as the legal framework to institute the changes governing the adoption of commercial specifications and standards.

The laws, regulations, and policies governing the use of COTS technologies in government acquisition had begun to emerge and mature. The "Perry Memo," drafted in 1994 by Secretary of Defense William Perry, called for a dramatic change in the DoD's organizational approach to acquisition. Perry (1994) argued that the DoD must make greater use of performance and commercial specifications and standards if the DoD was going to meet future military, economic, and policy objectives. Perry identified the root cause of the problem as the manner by which the acquisition community traditionally developed requirements. The traditional focus on generating requirements based on severe standards and highly granular specifications that were exclusive to the military customer was the major reason that any conventional answer to the submarine's acoustic dilemma would have required a decade-long, multibillion-dollar program designed to build a better system (Johnson, 2004). Perry shifted the focus from developing requirements based on rigid military specifications and military standards to developing them based on performance and commercial specifications. In the memo, Perry (1994) directed the DoD to use commercial items and to adopt commercial business practices. Perry recognized that there was a cultural problem inside the DoD and its organizational approach to acquisition (Gansler & Lucyshyn, 2008). Perry (1994) called for the establishment of the Standards Improvement Executive, which would be responsible for coordination, and for oversight of reform activities, as well as the standardization of specifications. This memo opened the door to the commercial marketplace and offered the submarine community an opening to radically change its approach to development and acquisition.

The tenet to use COTS to the maximum extent possible originally put forth in Perry's (1994) memo was enacted into law in 1994 as part of the Federal Acquisition Streamlining

Act. The Federal Acquisition Streamlining Act was also the first time that the concept of non-developmental items would be legally introduced into the acquisition vernacular (Gansler & Lucyshyn, 2008). Non-developmental items were defined as any commercial item or item previously developed exclusively for government purposes that would require only minor modifications in order to meet government requirements (Federal Acquisition Regulation [FAR], 2011, part 2). The Federal Acquisition Regulation would set the goal that the DoD should establish "acquisition policies more closely resembling those of the commercial marketplace and encouraging the acquisition of commercial items and components" (FAR, 2011, part 12).

The Clinger–Cohen Act of 1996 was focused on how the federal government acquires and manages information technology (IT). The Clinger–Cohen Act directly addressed the need to incorporate commercial technology and dramatically simplified the procedures for COTS purchases. This legislation represented a significant shift away from traditional development efforts that focused on unique systems for the exclusive use of a single military customer. This shift would help pave the way for rapid and dynamic innovation in the submarine world.

3. The ARCI Strategy

The vision Johnson had for the Acoustic Rapid Commercial-Off-The-Shelf Insertion program required a comprehensive strategy in order for that vision to be practically applied. The major arguments for implementing this strategy were the performance advantages the rapid refresh of sonar system technology offered the tactical operator and the cost savings and logistical improvements it would offer the U.S. Navy's submarine force.

These new laws and policies would give Bill Johnson and the ARCI initiative a statutory leg to stand on. Johnson's vision of ARCI as a wholly transparent and peer-reviewed competitive process was inspiring, but no idea survives without a performance engine to drive it. *Innovation* is the product of good *ideas* and *execution*, and the ARCI innovation effort would simply fail into obscurity if it could not be practically applied. The solution to the execution problem would manifest through the collaborative efforts of Johnson's Sonar Development Working Group (1999).

Chartered through the Naval Sea System Command's Undersea Warfare Executive Steering Group, the Sonar Development Working Group was established in 1996 to "develop and oversee the implementation of a coordinated set of development plans and processes aimed at resolving acoustic superiority issues” (SDWG, 1999, p. 1). Membership and protocols for the working group were developed through a partnership between Johnson’s ARCI program and the Advanced Systems Technology Office (SDWG, 1999).

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The strategy was designed around nine principal submarine sonar axioms (see Figure 10). These axioms were the ethos of the ARCI vision and would frame the ARCI strategy (Johnson, 2010).

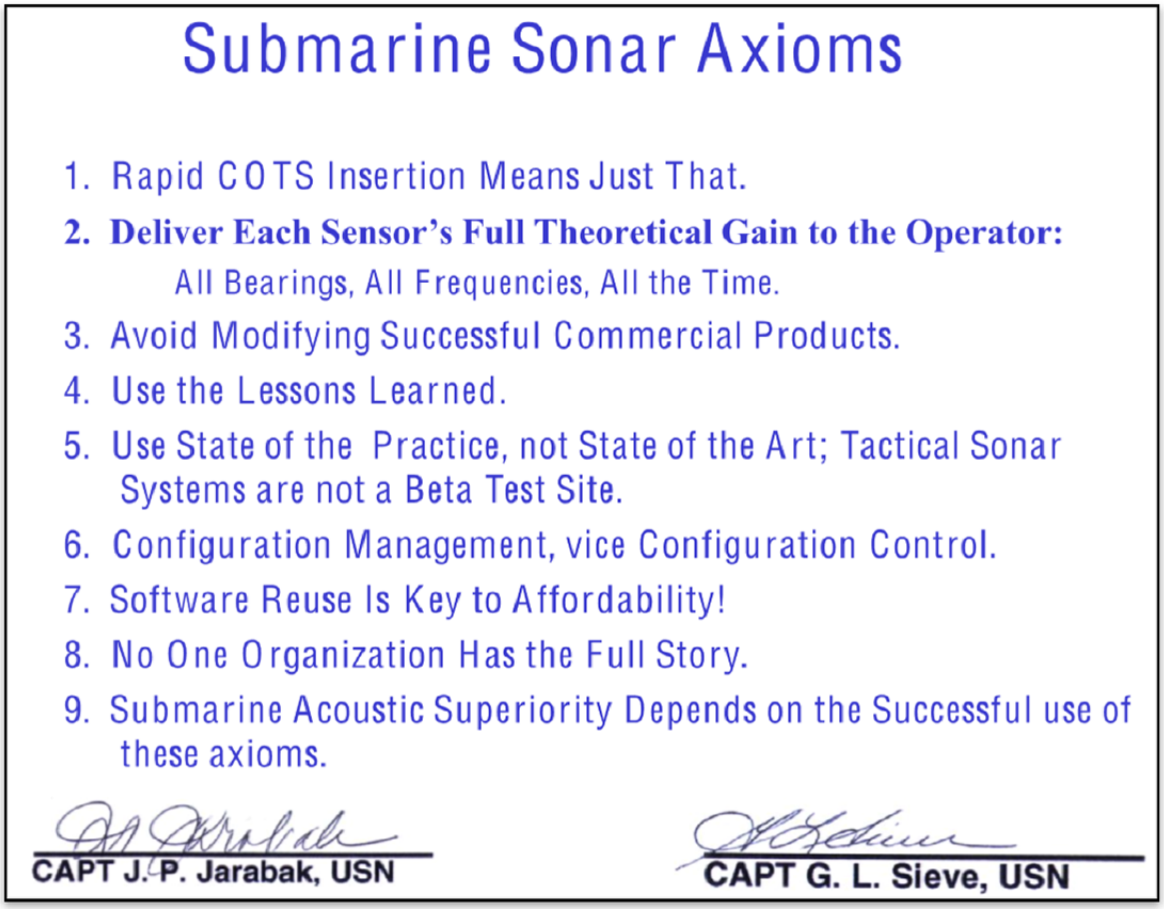

Figure 10. ARCI Submarine Sonar Axioms
(Johnson, 2010)

The overarching strategic goal was to develop a rapid technology transition process that would provide a cost-effective means to deliver rapid sonar improvements within a limited R&D budget (SDWG, 1999). This goal was audacious and could not be met within the constraints of the traditional development process, because the ARCI strategy was contrary to the standard acquisition model. ARCI's strategic goal challenged the established system and threatened the status quo. Johnson and his team would have to take a lot of arrows from the embedded establishment if they were to implement the real and necessary change that the ARCI strategy embodied. Johnson saw the keys to victory as threefold: performance, budget, and cover (Johnson, 2013).

With the 80% decrease in funding, there was no new money coming into the program office. Johnson had an $80 million budget, which was too small to launch a complete system overhaul. From everyone's perspective, an $80 million allocation fell well short of the funding necessary to address even the acoustic superiority problem. For Johnson (2013b), $80 million was just enough to produce a baseline ARCI product. Johnson retargeted the available funds and turned this presumed liability into an asset. By leveraging the R&D efforts of the commercial sector, the ARCI strategy made available high-performance technology at a fraction of the traditional costs. Johnson explains the rationale,

> I decided that I was going to leverage other smart people, their products and the people themselves and their ideas. Instead of making the wave, I am going to ride the wave. What are the best ideas and how do we find them? How do we determine that they are the best? How do we do it in a way that is even handed so people really believe that the decisions are based on analysis and not based on positioning within the political spectrum? (Johnson, 2013b)

This revolutionary idea of inviting "outsiders" into the development world would enable the submarine community to take advantage of the leaps in cutting-edge technology and to deflect significantly high R&D costs onto the private sector. The ARCI strategy was rooted in this idea of collaborative development and relied on rapidly introducing these technologies to the fleet.

By deliberately opening up development efforts to a larger professional audience, ARCI introduced a modular open systems approach to sonar system development. A modular open systems approach design breaks systems down into functional components by developing an adaptable architecture that incorporates widely supported industry standards to ensure compatibility between those components (Flowers & Azani, 2004). As a technical strategy, the modular open systems approach aligns independent development efforts and enables major systems to be comprised of "plug-and-play" components that can be removed, updated, improved, or replaced without impacting the other components (Boudreau, 2006). Employing a modular open systems strategy avoids the need to redesign the entire system in order to upgrade that system, which was the fundamental problem of the traditional submarine sonar development approach. While the colloquial "plug-and-play" paradigm does not precisely translate to simple interchangeability for complex submarine system components, ARCI's open system approach would enable an unprecedented degree of hardware independence.

In 1965, Gordon Moore observed that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. Based on this observation, Moore (1965) predicted that this trend would continue for the foreseeable future. The simplified version of what became known as Moore's law is that processor speeds and overall processing power effectively doubles every 18 months (see Figure 11).

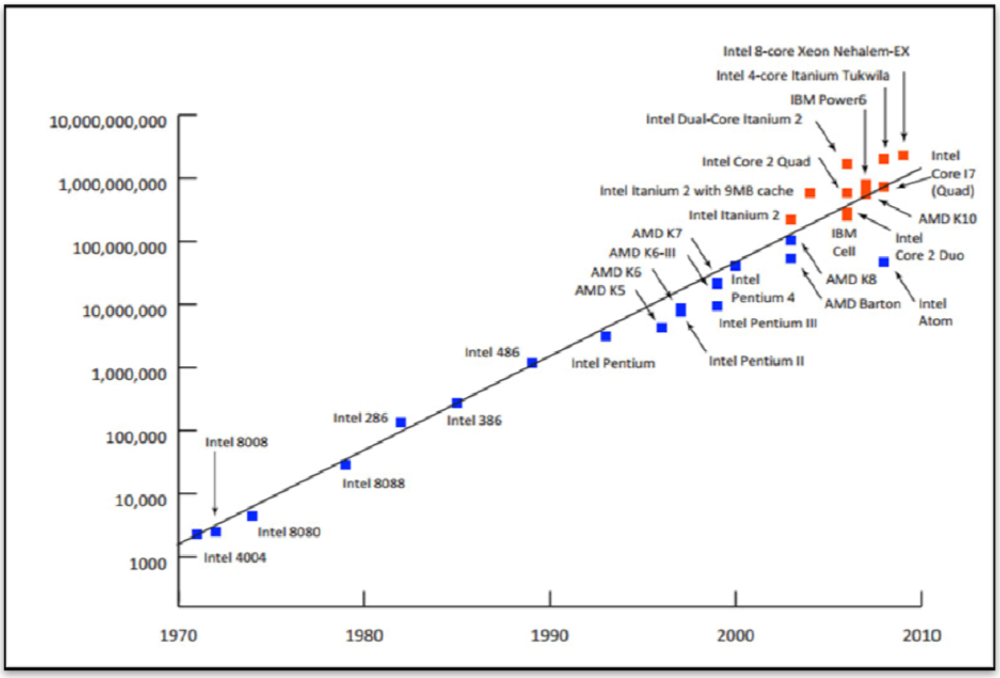

Figure 11. Microprocessor Complexity as Represented by Transistor Count
(Nilsen, 2012)
Note. Moore's prediction is shown as a black line, single core as blue boxes, and multi-core as red boxes.

The prospect of implementing an ARCI strategy carried with it the benefit of constantly and continuously refreshing sonar systems with the latest technology upgrades. The ARCI strategy acknowledged Moore's law and would take advantage of the availability of increased processing power by planning on exchanging outdated sonar system components on an annual basis (Johnson, 2013b). This rapid refresh rate of technology promised to deliver state-of-the-art equipment to the operator quickly and to dramatically reduce systems' costs. The potential to drastically reduce the warehousing of parts alone promised to deliver significant cost savings to the Navy. When put into context, in 1995, the 23 oldest Los Angeles–class submarines required the Navy to habitually stockpile over $600 million worth of spare sonar processors (Bratton & Tumin, 2012). The ARCI model projected an annual replacement schedule, which negated the need to warehouse a high volume of spare parts. ARCI offered to eliminate the existing large and wasteful logistics tail.

ARCI pushed a healthy chunk of R&D costs away from the government and onto the commercial sector. ARCI leveraged available advances in technology that unique and isolated government programs could not. ARCI's collaborative open source architecture ensured that systems were developed modularly and that functional components could be upgraded independently. ARCI's rapid refresh rate brought the best available solution to the warfighter and made the stockpiling of parts unnecessary. The ARCI strategy had the powerful combination of driving down costs while driving up performance. The strategic design of ARCI presented a strong argument for fulfilling NAVSEA's mission to develop an acoustic system based on commercially available hardware and software (Gansler & Lucyshyn, 2008). In June 1996, the ARCI strategy convinced the NAVSEA commander, Vice Admiral George R. Sterner, to approve the ARCI plan (Bratton & Tumin, 2012).

4. The Apple Cart

The implementation of the Acoustic Rapid Commercial-Off-The-Shelf Insertion program would upset the long-standing status quo. The dramatic change from the traditional closed business process to an open system encountered significant resistance from the executives of the Naval Undersea Warfare Center in Newport, RI.

Johnson's ARCI argument promised to meet the requirements of performance and budget, and the ARCI strategy fit well with the new laws coming out of Capitol Hill and was well covered by the policies emerging from the DoD and the Department of the Navy (DoN). Unfortunately, history is replete with examples of bureaucracies that enact new rules to drive change that the entrenched establishment notoriously fails to apply. The demonstration that had compared the commercially influenced ocean floor signal processing system to the traditionally designed submarine-based signal processing system had clearly shown the inferiority of the submarine system. The facts of this demonstration, though, did not negate the reality that NUWC was still the submarine community's signal processing expert and that they were not simply going to give away the franchise nor gracefully cede control of their domain.

NUWC's initial resistance posture manifested as a semantic repackaging of its traditional processes. NUWC executives argued that they had long ago incorporated commercial systems into their development programs and that they had even fielded one of those systems into the fleet: the Automatic Fleet-Towed Array Sensor. In a brief presented to the commander of the Program Executive Office for Submarines, Rear Admiral Dugan Shipway, NUWC's Senior Executive Service member for Combat Control and Sonar, along with one of NUWC's senior engineers, argued their long-standing experience integrating commercial systems. The NUWC executives contended that they were already implementing commercial solutions and that the wisest course of action would be to slow ARCI down. They conceded that ARCI had its merit but that rapidly implementing ARCI would cause more problems than it would solve. The executives argued that their commercial variant was working well and that ARCI should be slowed down to "a more reasonable pace" (Johnson, 2013b) and that "we should take our time with ARCI and do it right" (Bratton & Tumin, 2012, p. 128).

While the NUWC senior executive's plan was to intentionally exclude Johnson from the brief, Johnson's military partner Captain Jack Jarabak had caught wind of the circumvention and quickly grabbed Johnson from his desk and hauled him up to the eighth floor conference room (Johnson, 2013b). After sitting in silence for 30 minutes as the NUWC representatives detailed to Rear Admiral Shipway why ARCI was flawed and why funds planned for ARCI should be diverted to NUWC's home-grown, commercially based signal processor, Johnson finally had enough (Johnson, 2013b). Johnson, the huge guy who used to be a bar bouncer, rose up and snatched the pointer from the senior engineer's hands (Bratton & Tumin, 2012). While the senior executive and the engineer stood mouth agape, Johnson systematically debunked NUWC's claims (Johnson, 2013b). To the appalled NUWC representatives, Johnson tore their brief apart piece by piece. When Johnson was finished, the engineer was noticeably shaken and the senior executive was visibly angry (Johnson, 2013b). Captain Jarabak, despite a slight smile, remained silent and almost jovial. Rear Admiral Shipway blithely remarked on how it was healthy for a family to disagree behind closed doors (Johnson, 2013b).

Johnson summed up the encounter and the fundamental problem: "They [NUWC] had a lot of good ideas. They just didn't have all the good ideas. And some were incapable of being objective when it came to comparing their own ideas with somebody else's" (Bratton & Tumin, 2012 p. 128). Later that afternoon, the shaken engineer approached Johnson to apologize for the end-run and for not first discussing the brief with him (Johnson, 2013b). NUWC executives were obstinately fighting the ARCI initiative and its threat to their domain. NUWC managers and engineers, however, had slowly but surely begun to quietly support Johnson and his ARCI program (Bratton & Tumin, 2012).

5. Too Delicate for the Harsh Realm

The traditional system development process designed and built ruggedized systems that could serve and survive hostile combat operations in the unique operational environment of the U.S. submarine Navy. Commercial-off-the-shelf systems are designed specifically for commercial use and the presumption is that they are too delicate to meet the high standard required to conduct military operations.

Having lost the semantic argument, the NUWC establishment shifted gears and argued against the feasibility of using delicate COTS systems in the harsh realm of the submarine environment. The premise was simply that commercial gear on a combat ship is not ruggedly designed and is destined to fail when the sailor needs it most. This presented a very convincing argument against following a COTS policy. Johnson himself was reluctant to tackle a COTS solution because of the threat it implied to ships' safety. The means to confront and defeat this argument occurred during a serendipitous elevator conversation between Johnson and Dr. Robert M. Snuggs (Stapleton, 2013).

Snuggs, a pioneer in digital underwater sensor technology and the man who led the move from analog to digital sonar, was the technical director and chief engineer for the Integrated Undersea Surveillance Systems (IUSS; Johnson, 2013b). Snuggs had been working on the ocean floor surveillance system and had been aggressively pursuing COTS solutions (Johnson, 2013b). Before the Perry (1994) memo redefined the role of COTS in government programs, Snuggs' program had been required to purchase Enhanced Militarized Signal Processors that were designed to strict military standards and programmed using a custom language called Processing Graph Methodology. Snuggs was frustrated with the limitations imposed by the enforced system development profile. The constraints of using a custom programming language, which required long lead times and exorbitantly high initial costs, were exacerbated by the fact that only a handful of programmers were qualified to write the code. To challenge these constraints, Snuggs turned to the Digital Equipment Corporation.

Digital Equipment Corporation, a Massachusetts-based technology manufacturer, made its name by creating a line of low-cost computers for use in laboratories and research institutions (Hall, 2013). Snuggs reached out to the company, procured a number of their products, and took them out to sea to run comparative parallel tests with the ruggedized processors. On one side of the boat were all of the approved hyper-expensive ruggedized processors with their huge cooling fans, limited processing capability, and customized code. On the other side of the boat, in a comically smaller rack, were the commercial computers that were a tenth of the cost and running C code. An analysis of the encounter data enabled Snuggs to show that, for a dramatically decreased cost, he could provide a higher reliability system that not only used simpler and more accessible coding but also provided a more adaptive framework for experimentation and innovation (Stapleton, 2013).

When Johnson and Snuggs met in the elevator, Snuggs regaled Johnson with the success of the commercial system and the potential it afforded. This encounter offered Johnson an opportunity to promote ARCI and to foster collaborative efforts between the surveillance sonar community and the submarine sonar community. To engender this effort, Johnson turned to the chief engineer for the Submarine Acoustics Programs, Victor Gavin (Johnson, 2013b).

Gavin had been the on-site government representative at Lockheed Martin in Manassas, VA, from 1988 to 1996 (ASN[RDA], 2012a). Lockheed Martin, Manassas was the Navy's long-term acoustic programs prime contractor. Victor Gavin was well grounded in submarine sonar technology, and his experience as the on-site government representative at Manassas made him well familiar with both the personnel involved and the dynamics of the test bays (Johnson, 2013b). To foment the collaborative effort between the surveillance community and the submarine sonar development community, Gavin embarked on one of the boats where Snuggs had set up the comparative tests between the ruggedized processors and those that had been commercially developed.

During this voyage in the North Atlantic, the boat on which Gavin sailed met with an abnormally severe sea state, near gale force winds, and was tossed about by the rough 15-foot-high waves. The civilian personnel on board hugged the rails and did their best not to spray vomit onto the decks. In all the commotion, as the civilian testers fought down the fear that they would never see land again, the commercial equipment was merrily humming along and performing without any failures or any faults. This evolution provided a very convincing demonstration that COTS gear may just be rugged enough to hold up in the extreme submarine environment.

Although an eye-opening experience, this demonstration alone would not create universal acceptance or fundamentally shift the community norm from militarized computers to commercial computers. It did, however, present a proof-of-concept argument against the claims that COTS gear was too delicate to be relied upon and cracked opened the door for new commercial competition.

The major benefit of Gavin's wild ride was that this collaboration provided an opportunity for a long-term and influential member of the Manassas submarine sonar development community to witness firsthand how the surveillance community was going to places like the University of Texas and Johns Hopkins University and leveraging the technologies from small businesses (Johnson, 2013b). Bringing outsiders into the submarine sonar development community had upset NUWC's apple cart because it threatened NUWC's sole control of algorithm development and processing technologies. Bringing small businesses into the mix would aggravate the other major power in the traditional closed business environment, the long-term prime contractor: Lockheed Martin, Manassas.

6. The Contractor

Lockheed Martin, Manassas, had been the long-term prime contractor for submarine acoustic systems since the 1960s. The closed business relationship between the NUWC and Lockheed Martin, Manassas, had given them both a monopolistic advantage. Bill Johnson's introduction of the ARCI program into the equation, combined with the utilization of the Small Business Innovation Act, would serve to unseat this monopoly.

The Manassas facility had been housing the primary effort of submarine acoustic development projects since the late 1960s. The facility first belonged to Industrial Business Machines (IBM). In 1967, IBM acquired the Manassas site for its Federal Services Division, which was IBM's internal organization that developed military products (Garner, 2012). In Manassas, the Federal Services Division specialized in developing software products for antisubmarine warfare (Mills, 1993). In 1994, the New York-based Loral Corporation acquired IBM's Federal Services Division for $1.58 billion (Joyce, 2006). Loral specialized in software and hardware that could be used to modernize older equipment (Mills, 1993). In 1996, the Loral Corporation's defense electronics and system integration business sold its interests, which included the Manassas site, to the Lockheed Martin Corporation for $9.1 billion ("Lockheed Martin," 1996). Lockheed Martin's Maritime Systems and Sensors business unit still resides in the Manassas site and continues to develop and manufacture sonar systems to this day. While the Manassas site went through a number of corporate mergers and acquisitions over the years, most of the personnel working at the Manassas site on sonar systems remained the same (Latham, 2012).

The Small Business Innovation Development Act of 1982 established the Small Business Innovation Research program. This program encourages domestic small businesses to engage in federal R&D through the investment of federal research funds (Small Business Innovation Research/Small Business Technology Transfer [SBIR/STTR], 2013). The program was a way to give small businesses an opportunity to get a foot in the door with the DoD and for the DoD to access the innovative opportunities small business can create. Every DoD program that has an R&D budget contributes to a pool of funds for this federal program. A qualifying small business can apply for those funds by submitting a proposal. The program relies on a teaming approach. Small businesses often do not have the organic capabilities to successfully bid a government project or the necessary infrastructure to pursue that project all the way through commercialization. To overcome these shortfalls, the program matches small businesses with larger companies that have the requisite experience and infrastructure (SBIR/STTR, 2013). One such company that took advantage of the program was Digital Systems Resources (DSR).

Digital Systems Resources was a small firm in Fair Lakes, VA. They employed a number of very talented engineers, but they had never built a product that stood on its own (Johnson, 2013b), until, that is, they were contracted through the Small Business International Research program to develop the Multi-Purpose Processor for the submarine force (Johnson, 2013b). The Multi-Purpose Processor provided a physical architecture that made it possible to develop system software on a wide variety of processing platforms and operating systems (Small Business Innovation Research [SBIR], 2013). The Multi-Purpose Processor offered the technical backbone necessary to implement ARCI's rapid refresh plan, and Johnson wanted to use that processor as the central core for the ARCI program. Although Digital Systems Resources had been awarded the contract, its partner through the Small Business Innovation Research program was Lockheed Martin, Manassas (Johnson, 2013b).

Since the 1970s, IBM had been the submarine sonar systems prime contractor until Loral bought the Manassas sector, which was in turn bought out by Lockheed Martin (Johnson, 2013b). The names had changed, but the people had not. That IBM heritage was firmly rooted in Manassas. They were not just software people; they were also the hardware people who built the computers and the operating systems from the ground up. Digital Systems Resources owned the controlling interest in the Multi-Purpose Processor contract, but Lockheed became very interested in gaining control of that contract when it was decided that the Multi-Purpose Processor would be the core processor of the ARCI program (Johnson, 2013b).

Lockheed's senior vice president and general manager of their Undersea Systems Division soon approached Johnson with her demands. Because Lockheed had recently won a contract to build the Navy's New Attack Submarine's combat and sonar systems, and because they had already been contracted to build the combat and sonar systems for the Seawolf-class submarine, she looked at the Multi-Purpose Processor as a third-party developed product (Johnson, 2013b). This executive's argument was that Digital Systems Resources was simply incapable of handling the technical load (Johnson, 2013b). From a business perspective, Lockheed's reluctance to adopt commercial products is understandable because it would replace a large part of Lockheed Martin, Manassas' business profile. This executive strongly suggested that Johnson novate Digital Systems Resources' contract. Because Lockheed owned all of the sonar development contracts except this one, the Lockheed executive wanted to take over Digital Systems Resources' contract and turn the small company into a sub-contractor answerable to Lockheed Martin (Johnson, 2013b).

Johnson's answer was vehement: "No! We are not going to continue that way" (Johnson, 2013b). In Johnson's opinion, the acoustic superiority issue had arisen from the closed business model that forced the submarine Navy to rely solely on the efforts of Lockheed and NUWC. There was no competition in the old system, and the Navy was not getting the best ideas or the best products. The Lockheed Martin executive responded, "Well, when you run into problems and we start having overruns or additional features that you want, we have deep pockets. We can keep the program going while you and the Navy go out and secure additional funds" (Johnson, 2013b). That was precisely the wrong thing to say to Johnson. Johnson's retort was,

> If you fall down on this, I am going to transfer your work to DSR [Digital Systems Resources]. You just won a huge contract in the New Attack Submarine Combat System. One of the features that won you that contract was your claim that you could take third party products and seamlessly, SEAMLESSLY, integrate them into the rest of your system. This is your chance to prove it! (Johnson, 2013b)

Lockheed's president of the Undersea Systems Division was, to say the very least, not happy with Johnson's terse reply. Johnson's defense of Digital Systems Resources and the Small Business Innovation Research program was a game changer that sparked bitter opposition from the executives at Lockheed Martin. Because Johnson had the foresight to draft the Lockheed Martin and Digital Systems Resources contracts based on a win-win or lose-lose team construct and had intentionally omitted any win-lose option, Lockheed had little recourse to counter Johnson's position directly (Johnson, 2013b). Although Lockheed was publicly touting a mantra of good corporate citizenship and emphasizing its ability to effectively collaborate and support small businesses, its corporate executives were discreetly visiting Navy and congressional leaders with the message that adopting an ARCI approach would put them out of business (Johnson, 2013b).

Johnson had made adversaries of the two most powerful executive entities in sonar systems development: NUWC and Lockheed Martin. If the ARCI initiative was to succeed, the ARCI team needed to get a product into the field as soon as possible. In order to accomplish this feat, the ARCI team would need to transform their strategy into an operational reality.

7. Operationalizing ARCI

From a business perspective, the Acoustic Rapid Commercial-Off-The-Shelf Insertion strategy provided an elegant argument against the weaknesses inherent in the closed business model of the traditional development process. From a technical perspective, the Acoustic Rapid Commercial-Off-The-Shelf Insertion strategy presented a similarly elegant argument against dogmatic adherence to sequential system development. While the traditional system followed a waterfall model, which emphasized up-front requirements

and design activities, the Acoustic Rapid Commercial-Off-The-Shelf Insertion strategy would follow a spiral model of iterative design and development.

The first steps to operationalizing ARCI had been effected by initiating an open business environment and forcing collaboration with outside industry. The Small Business Innovation Research program had opened the door to Digital Systems Resources, a small company outside of the traditional closed business model, and allowed them to competitively develop the Multi-Purpose Processor (SBIR, 2013). The Multi-Purpose Processor provided the physical backbone onto which ARCI could mount cost-effective and state-of-the-market COTS processing elements (SBIR, 2013). Digital Systems Resources would capitalize on the success of the Multi-Purpose Processor with development of an associated product, the Multi-Purpose Transportable Middleware (SBIR, 2013). The Multi-Purpose Transportable Middleware would facilitate migration and reuse of older system software. Combined, the Multi-Purpose Processor and Multi-Purpose Transportable Middleware enabled the integration of system software from a wide variety of processing platforms and operating systems (SBIR, 2013). These innovative efforts would preserve the Navy's investments in legacy software while enabling the seamless integration of independently developed software products.

Both the Multi-Purpose Processor and Multi-Purpose Transportable Middleware were representative of ARCI's new and explicit conceptual architecture that would enable engineers to segment new systems along natural and logical boundaries. The ability to decompose new systems at the functional string and thread level enabled engineers to execute development efforts via a focused, iterative design and assessment process (Johnson, 2004). Johnson explained,

> The application software was segmented along natural and logical boundaries, and then isolated into functional modules. Each functional module can stand alone or be re-used and installed in anther system application. The result is that modules of software developed for nuclear attack submarines can readily be used on different computer processing hardware for surface ship ASW functions and shore based acoustic intelligence analysis, even though the hardware and specific end applications are different. (Johnson, 2004, p. 100)

This field-leveling plug-and-play architecture was the vehicle through which submarine sonar systems could be competitively developed through the collaboration of disparate entities. This was the shift from the closed business model that needed a multi-year, multi-billion-dollar development process to generate a unique stand-alone sonar system towards an open business model that could be developed and improved modularly.

These first steps towards operationalization provided answers to the "who can build" and "how to build" framework of the ARCI process. The next steps in ARCI development would answer the questions of "what to build" and "when to build."

The traditional sonar system development process answered the "what to build" question through a rigorous and time-consuming requirements elicitation and documentation process. The goal of the process was to transform the fleet's end user desires into actionable requirements that would be developed into a producible sonar system. The simplest model by which to develop a system is the waterfall model (see Figure 12).

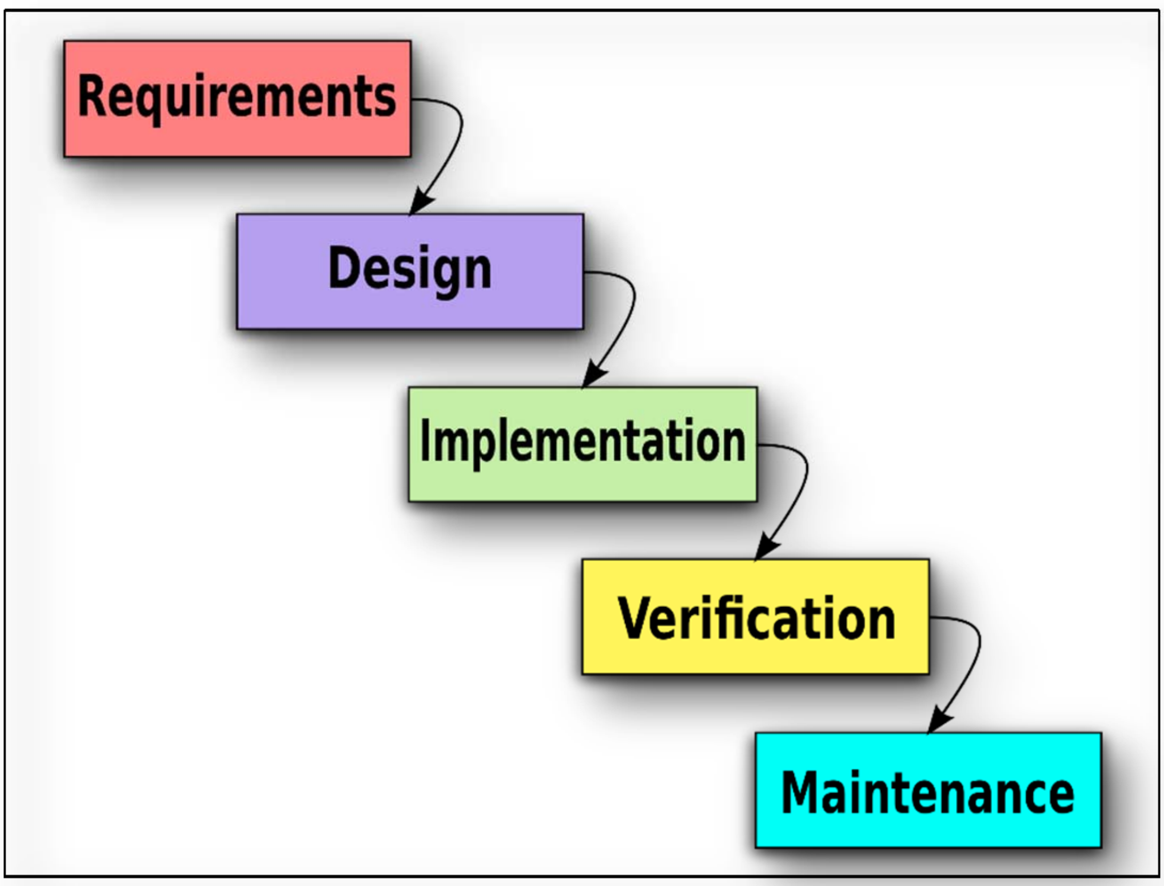

Figure 12. Waterfall Model
(Royce, 1987)

The waterfall model is a sequential development process that emphasizes up-front requirements and design activities (Department of the Air Force, Software Technology Support Center, 2000). In its simplest form, the waterfall model follows the following path:

- Requirements specification
- Design
- Implementation
- Integration
- Testing
- Installation
- Maintenance

The fatal flaw of the waterfall model is that it doggedly progresses sequentially through its phases, and any attempt to retreat a phase in order to manage a problem or correct a deficiency has major implications to both cost and schedule (Department of the Air Force, Software Technology Support Center, 2000). The traditional sonar system development model followed a sequential path. This accounts for the enormous front-loading of explicit requirements definition and documentation and the inflexible nature of the traditional development process. In the waterfall model, each stage is a prerequisite for succeeding activities and any unforeseen eventuality or change to requirements or unpredictability can cause grievous harm to the program. For traditional sonar system development, fleet involvement ended once the requirements phase was completed. There was very limited capability to change once the program moved past the requirements phase, because passage through the requirements phase assumed that the developers fully understood the fleet's needs and had successfully documented those needs as requirements. The waterfall model is extremely effective if requirements are well known, unchanging, and relatively simple. Sonar system development encompassed none of those traits.

ARCI's approach to system development was to break the system down into functional modules and then make incremental improvements to the system through component upgrades (Boudreau, 2006). ARCI had established an adaptive architecture necessary for complex system development. Johnson and the ARCI team had recognized the shortfalls and limitations of the traditional waterfall approach to sonar system development and had designed ARCI along an entirely different model (Johnson, 2010). ARCI's approach to system development would follow a spiral development process (see Figure 13; Boudreau, 2006).

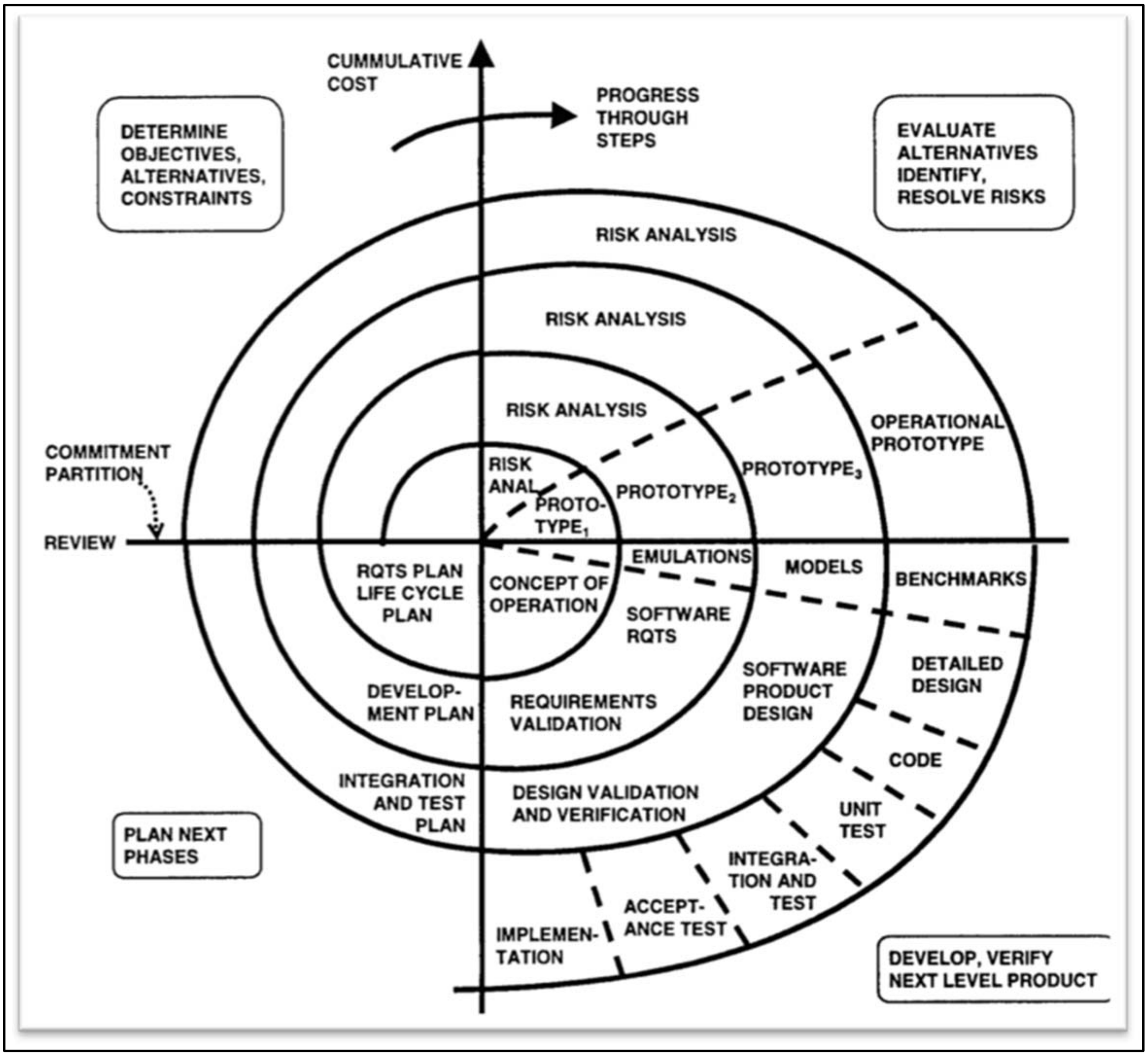

Figure 13. Spiral Model
(Boehm, 1988)

The spiral method is an adaptable methodology that engages end users and developers in an iterative and incremental development process. The spiral method makes use of repetitive development cycles as user needs and requirements are continuously refined through demonstration and risk management (Department of the Air Force, Software Technology Support Center, 2000). The continuous dialogue between developers and end users allows each increment of the spiral development process to deliver the best possible capability. Spiral development does not suffer the fatal flaw of the waterfall model because the spiral model is specifically designed to quickly reengage development phases in order to continuously capture and adapt to changes in requirements (Department of the Air Force, Software Technology Support Center, 2000). Spiral development is best suited for situations where the desired capability is understood, but the end-state requirements are not fully known (Department of the Air Force, Software Technology Support Center, 2000). ARCI would follow a data-driven build-test-build methodology that would identify sonar system shortfalls, select the best solutions, and through a persistent feedback process, enable continual system performance improvement (SDWG, 1999). This development process was hinged entirely on the continual interactions between developers and fleet operators.

The traditional system had provided for minimal fleet operator involvement (Johnson, 2004). Johnson and the ARCI team recognized that complex system development would be better served through an iterative design and development approach that could solicit fleet operator involvement through every stage of the development process (Johnson, 2004). In order to accomplish this task, a collaborative work environment known as advanced processing builds (APB; see Figure 14) was established to develop system software (Johnson, 2004).

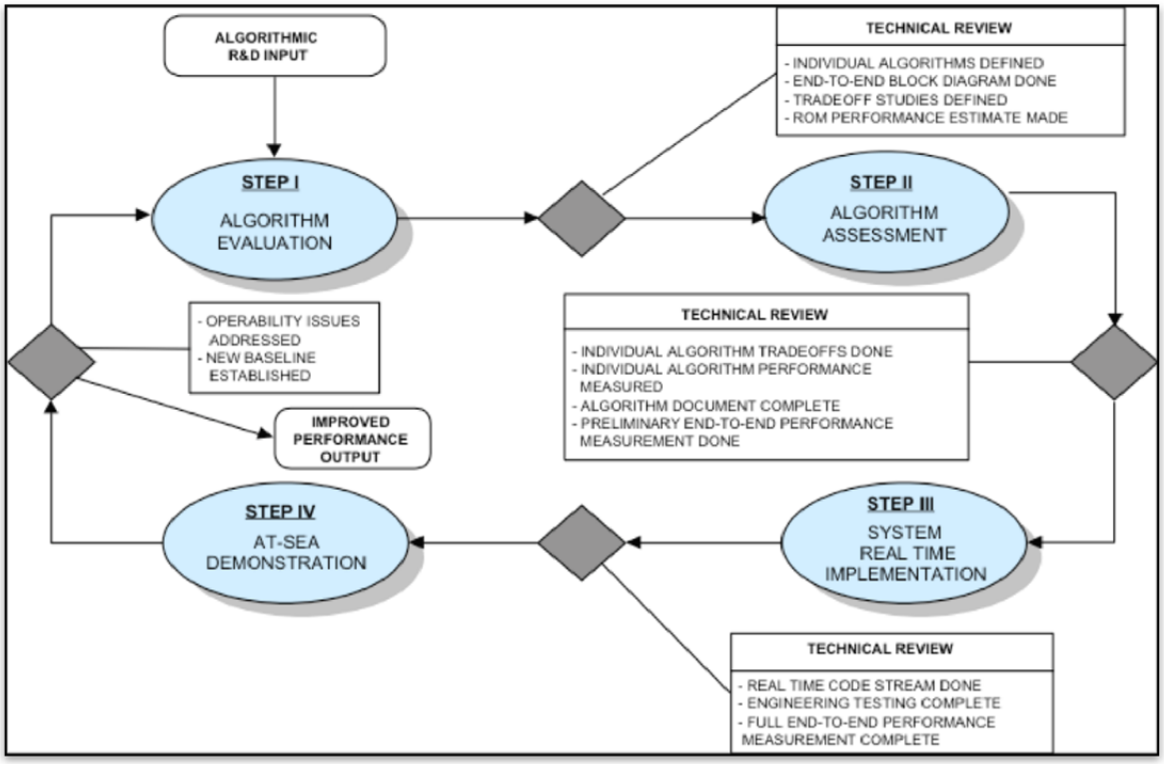

Figure 14. The Advanced Processing Builds Process
(SDWG, 1999)

8. Advanced Processing Build

Advanced Processing Builds are software improvements to submarine systems. "APB" refers to both the development process as well as the system end product (Wilson, 2009). APBs are hardware independent software builds designed to create or improve functionality of submarine systems (Program Executive Office Integrated Warfare Systems 5A [PEO IWS5A], 2003).

APBs are software builds that have been developed under a systematic four-step approach. The four-step APB process creates the beta software for the specific ARCI upgrade (SDWG, 1999). The four basic steps of APB development depicted in Figure 14 are explained as follows:

Step 1—Algorithm Survey: Step 1 considers the entire array of available algorithms. Step 1 evaluates the most promising algorithms based on tactical importance, maturity, expected performance, and computational resource requirements (SDWG, 1999). The algorithms under consideration had been developed by government agencies such as the Office of Naval Research, the Defense Advanced Research Projects Agency, and the Integrated Undersea Surveillance Systems. Other algorithms had come from industry, independent research and development, or through broad area announcements.

Step 2—Algorithm Testing: Step 2 is designed to validate the functionality of the algorithms selected during Step 1. Step 2 tests the most promising algorithms using real-world ocean noise and encounter data recorded by operational submarine sonar systems (SDWG, 1999). Testing the algorithms against real-world data rather than synthetic data provided a means to evaluate performance. Perhaps the most important facet of Step 2 was that the metrics against which performance was judged were developed through a dynamic collaborative effort between engineers, developers, and fleet representatives.

Step 3—String Testing: Step 3 tests the algorithm in a systems context with a fleet operator. The transition to Step 3 occurs when the best-in-breed algorithms from Step 2 are incorporated into the Multi-Purpose Processor baseline. Step 3 independently tests system performance by having a fleet operator evaluate the performance enhancement. This method of having fleet representatives test and evaluate new features provides for immediate fleet feedback and serves the dual purpose of ensuring the enhancement is ready for at-sea testing and assures those who contributed to the system's development that their ideas have been properly implemented (SDWG, 1999).

Step 4—At-Sea Testing: Step 4 provides the opportunity to verify algorithm performance at sea. This test demonstrates how the fleet sonar team interacts with the APB performance enhancement before that enhancement is incorporated into the system baseline. Step 4 of the APB provides the requisite data set to test the enhancement in the real world while still providing the time and the means for corrective action. At the completion of Step 4, the APB is delivered to the program office for certification via separate testing and full integration into the baseline system (SDWG, 1999).

Operationalizing the ARCI strategy through the APB process developed both the architecture and the mechanisms to progressively solve the acoustic dilemma. The four-step evolutionary APB process represented a fundamental change in Navy acquisition strategy by seamlessly coupling advanced development with engineering development (SDWG, 1999).

The APB process adhered to the basic principles shown in Figure 15, considered the keys to APB success (SDWG, 1999).

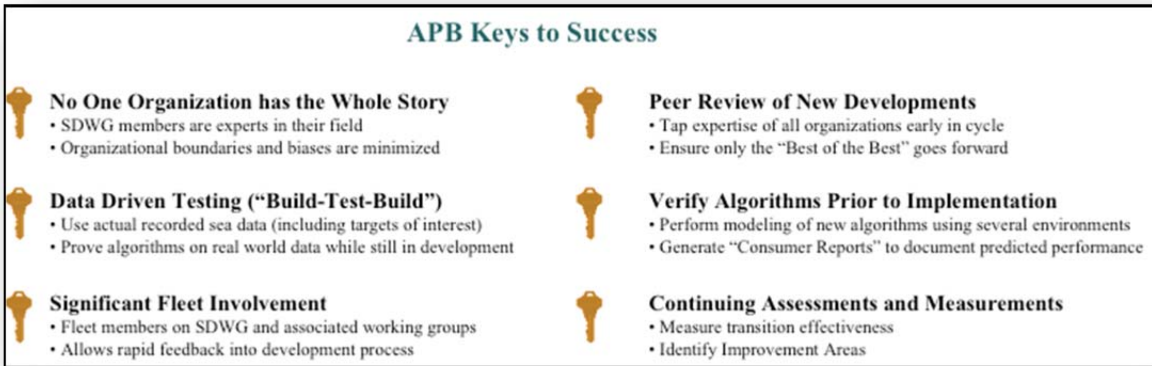

Figure 15. The Advanced Processing Builds Keys to Success
(SDWG, 1999)

9. Introducing ARCI to the Fleet and Generating a Small Win

ARCI is both a business and technical strategy designed to revolutionize submarine sonar system development and solve the acoustic dilemma. The ARCI team had formed their vision, pushed their strategy, and taken steps to operationalize that strategy through the APB process. In order to cement ARCI into the submarine culture and prove the merit of the programs, the ARCI team needed to demonstrate to the submarine community a physical product and produce a visible "win."

Innovation is a combination of good ideas and the ability to execute those ideas. The ARCI strategy and the APB process combined to provide both the *idea* and *execution* elements in the *innovation equation*. Johnson and his ARCI team understood that if the ARCI initiative was going to succeed, it would need to quickly generate a win to quiet the embedded majority (Johnson, 2013b). Johnson crafted a plan to create that win and made his pitch during one of the periodic reviews by the resources and requirements sponsor, the Office of the Chief of Naval Operations, Submarine Warfare Division (Johnson, 2013b).

During the presentation, Johnson asked the forum of captains representing the Submarine Warfare Division for permission to take some surveillance software and run it on the ARCI computer and take it out to sea (Johnson, 2013b). The collection of NUWC executives in attendance quite literally jumped from their seats and argued, "No. We don't need to take this to sea. All we need is a good engineering study. We should have an answer in a year or two" (Johnson, 2013b). Johnson's counterargument was, "We can spend two years working this thing and all we're going to have at the end of two years is a stack of paper. We need to take this thing out to sea and do a side-by-side comparison" (Johnson, 2013b).

The Submarine Warfare Division representatives were both confused and confounded by the exchange, confused because they could not understand why the NUWC executives were vehemently against the proposal and confounded because of the obvious animosity that NUWC had for Johnson and the ARCI program (Johnson, 2013b). Johnson and the ARCI team won the argument. The decision was made to go forward and put the surveillance software onto a submarine to determine whether it was possible to replicate the static system's performance at sea.

In November 1997, a scant 18 months after Vice Admiral Sterner had given the ARCI plan the go-ahead, the ARCI group had developed, tested, and certified an ARCI system and readied it for sea trials (Bratton & Tumin, 2012). Before the sea trials commenced, a senior NUWC representative who happened to be a personal friend of Bill Johnson reached out at the 11th hour and said, "Listen Bill, if you put this on the submarine, the sailors will like it. Then where will we be?" (Johnson, 2013b). This ludicrous plea was a watershed moment for Johnson (Johnson, 2013b). Here was a good man and a good friend who had allowed insecurity and the loss of control to cloud his judgment to the point that the mission to support the warfighter had become less important than maintaining NUWC's majority control. This exchange embodied the NUWC executives' fear that their organization was going to be cut out of the development equation and that they would have to surrender absolute control.

In January 1998, the submarine USS *Augusta* set sail equipped with the ARCI sonar system and ran the algorithms from the ocean floor sonar community on commercially available software (Bratton & Tumin, 2012). The ARCI team was elated. The pre-deployment workup had drawn rave reviews from the engineers who had developed the system. The engineers' reports had shown that the new sonar algorithms had provided enormous gains and would let the sonar operators see things that they had never seen before (Bratton & Tumin, 2012). When the *Augusta* returned from its 90-day deployment, however, the crew's report was disturbingly underwhelming. There had been no observable performance improvement. The crew's opinion was, "Nice job on the new sonar, but 'no change.' We don't see anything different" (Bratton & Tumin, 2012, p. 128).

Johnson and the ARCI team were flabbergasted. Their ARCI gear had been the product of the four-phase testing process and had demonstrated enormous gains for the engineers in pretrial reports. Why had it not performed for the sailors? How had ARCI missed the target? For the answers to these questions, Johnson turned to his fleet SMEs who had participated in the development effort and had helped configure the new sonar displays.

10. Small Win Turns Into Big Flop

Bill Johnson and the ARCI team had won the fight to take their systems to sea. The systems performed beyond expectations in the lab but left much to be desired during the at-sea trials. To investigate how the lab successes were followed by operational failure, Johnson would turn to his group of senior enlisted advisors.

Johnson's group of senior enlisted advisors quickly identified the shortfall as a combination of training gaps and the limitations of the legacy system displays. Simply put, the new sonar system was processing an exponentially larger amount of data, but the operators could not recognize what it was they were looking at. The legacy displays could not handle the new signal, and the submariners could not accurately interpolate the data as it was presented to them. To test this theory, the senior enlisted advisors evaluated over 200 sonar operators on the system. The results: expert-level operators were able to correctly answer the question "What is this thing I'm looking at?" 76% of the time, but average operators were missing the target 75% of the time (Bratton & Tumin, 2012).

Johnson's ARCI effort had focused on developing the hardware and software elements of sonar (Johnson, 2013b). Training programs were under an entirely separate sphere of influence and far beyond Johnson or ARCI's purview. Johnson explains the issue:

> When I developed this system, I was thinking of it in terms of hardware and software. The people part of the equation was really somebody else's to deal with. … Here we are pouring hundreds of millions of dollars into these sonar systems that extracted the last decibel of information out of the ocean, and it's all falling on the floor because these guys don't recognize what they're seeing. (Bratton & Tumin, 2012, pp. 128–129)

The root of the problem was that no matter how elegant a product the ARCI system could develop, without adequate training, the performance potential of the product would never be realized. When Johnson approached those responsible for training with the problem, they refused to budge on the issue (Bratton & Tumin, 2012). In a hauntingly familiar situation, the trainers argued that they were the SMEs and were not about to be lectured on how they do their job by the ARCI office. Not one to let the ARCI initiative suffer from an obstinate institution like Training, Johnson formed his group of senior enlisted advisors into the Concept of Operations and Operator–Machine Interface Support Group (COSG; SDWG, 1999). The COSG (pronounced *CO-sig*) would serve as the primary voice of the fleet for prioritizing APB improvements in acoustic signal detection, system automation, and tactical information management (SDWG, 1999). The senior enlisted advisors of the COSG redesigned the sonar operator's system interfaces with flat screen displays that made the signals easier to read (Bratton & Tumin, 2012). Following a four-hour training session on the new screens, the junior, less-experienced operators actually outperformed the experienced operators who were accustomed to the legacy custom monitors (Bratton & Tumin, 2012). Armed with such overwhelming evidence, Johnson took this data to the fleet admirals, and the Training piece was swiftly shamed into compliance (Bratton & Tumin, 2012).

The initial APB had provided ARCI the win it needed. By March 1998, Johnson and the ARCI team were busy retooling the baseline ARCI platform from the *Augusta* in preparation for the first wave of operational installations. The fleet expected operational installs by the spring of 1999 and installed new APBs every year for the next four years (Bratton & Tumin, 2012). This unprecedented timeline set the standard for introducing system upgrades into the fleet in terms of months rather than years and was the key to resolving the acoustic dilemma. Johnson speaks to the success of the program:

> The initial result was delivered to the fleet in eighteen months. There was a seven-fold increase in performance and a sixty-fold decrease in real processing costs. Within the first four years this capability was installed on two-thirds of the sub's fleet. After five years, four major improvements had been fielded. This revolution applied to logistics as well. Factory conversion training was reduced from twenty to four weeks. Spares inventory was reduced from hundreds of millions of dollars to hundreds of thousands of dollars. The fleet became the program's biggest advocate. (Johnson, n.d.)

11. The New Standard

The Acoustic Rapid Commercial-Off-The-Shelf Insertion program is the spiral acquisition process that transformed legacy submarine sonar system development. Advanced Processing Builds are software improvements to submarine systems. The acronym APB refers to both the development process as well as the system end product. The ARCI program and the APB development process would usurp the traditional acquisition and development processes to become the new standard.

This revolutionary change in acquisition and sonar system development was fraught with battles against the entrenched institution. Prior to ARCI, NUWC was the sole owner of technical sonar solutions and was the single technical voice to the program office (Maris, 2007). In the traditional process, NUWC would issue the program office a technical memorandum that stated its position on requirements. The program office would then forward the technical memorandum to the contractor to build. Since the initiation of ARCI, NUWC's role has changed significantly. Under the ARCI management structure, technical matters were confronted and settled by integrated product teams (SDWG, 1999). Integrated product teams consist of multidisciplinary groups of people that assume collective responsibility for product delivery ("Integrated Product Team," 2012). NUWC remained an integral part of the development process, but its role shifted from sole controlling voice to participative representative with the team.

The team's structure stressed frequent peer-to-peer contact and communication. Technical decisions were developed jointly by team members through a collaborative effort to find the best solutions versus the solution immediately available to a single stakeholder. Multiple teams working in parallel flattened the organization of sonar system development (Maris, 2007). The program office incentivized the flattening of the organization by pushing decision-making down to the team level. The overall responsibility for the process would still reside with the cognizant program offices (SDWG, 1999), but the collaborative effort of the teams would be the genesis of answers and options.

Prior to ARCI, Lockheed Martin, Manassas, was the prime contractor and owned the entire system. Each system was developed "from scratch," and unique high performance systems were favored over open modular systems (Maris, 2007). Since ARCI, Lockheed Martin, Manassas, has been twice awarded the role of prime systems integrator through contract competitions. Once the executive-level obstructions to ARCI were removed and the stubbornness of traditional corporate mindsets was overcome, it was the long-standing personnel of Lockheed Martin, Manassas, who embraced the revolutionary ARCI ideas and quickly adopted the ARCI model. The Lockheed Martin, Manassas, business managers and engineers embraced this model and became the focal point for innovative solutions from academia, big and small businesses, and the fleet. Lockheed Martin, Manassas, underwent a cultural shift away from the big business model of exclusionary competition and proprietary development and created a unique environment that had a healthy respect for products "not invented here" and became one of the most successful "big brothers" of the Small Business Innovation Research program.

Bill Johnson provided the vision and strategy for ARCI. He provided the leadership necessary to kick open the door held shut by the entrenched establishment and to garner the necessary support from both the fleet admirals and congressional leaders. ARCI has become the DoD's prototypical model of innovation and modular open source architecture. The DAU teaches the ARCI model as the premier example of how to implement open architecture business and technical models into the military establishment.

The first APB had proven the efficacy of development through a *transparent* and *peer-reviewed competitive* process that leveraged world-class signal processing experts from across the wide-ranging sonar community. The APB process exploited the *tacit knowledge of the fleet* and had displaced decades of custom systems through its "fleet-sourced design" (Bratton & Tumin, 2012). The ARCI program established itself and introduced a new APB to the fleet every year. The exhausting pace of APB delivery was precisely what Johnson and ARCI had envisioned. Creating a collaborative environment where members of the scientific community, engineers, contractors, and the fleet itself could coalesce ideas and contextualize requirements in a competitive but mutually supporting environment was the essence of the ARCI initiative. The fast-changing pace of technology had offered an opportunity, and Bill Johnson's leadership embraced that opportunity, confronted the insular establishment, and changed the face of the Navy's acquisition processes.

C. PART III: CHALLENGES IN MANAGING RAPID TECHNOLOGY CHANGE

The ARCI program tackled the acoustic dilemma that had questioned the relevance and very existence of the submarine Navy in the post-Cold War world. In an era of severe budget cuts and military drawdowns, the submarine Navy regained acoustic superiority and revolutionized the acquisition process along the way. ARCI's philosophy of the rapid insertion of technology upgrades proved to be so successful that it was soon implemented into submarine combat control systems (SDWG, 2003). Bill Johnson moved from his position as assistant program manager for sonar to become the deputy program manager for combat systems in an effort to recreate the ARCI process (Johnson, 2013b). The Navy was so impressed with ARCI that it began to reorganize the warfare systems development and acquisition offices in order to emulate the APB process (SDWG, 2003).

The ARCI program demonstrated its utility and effectiveness to the naval establishment and could count the U.S. Congress among its greatest of allies (Johnson, 2013b). This fact can be attributed in part to those members who had a small business agenda and were pursuing a meaningful niche inside the DoD for smaller high-tech companies (Johnson, 2013b). Congressional support was also bolstered by the new capabilities that ARCI provided, and members stayed well informed of these capabilities by one of ARCI's strongest supporters, the Director of Submarine Warfare for the Chief of Naval Operations, Vice Admiral Edmund Giambastiani (Johnson, 2013b).

Vice Admiral Giambastiani kept ARCI on the forefront on the Hill by briefing members and their staffs on the latest deployments of the submarine community and the successful new capabilities that ARCI had brought to the table (Johnson, 2013b). Giambastiani, who had been a stalwart proponent of the ARCI initiative from the outset, outlined the program:

> The business case decision to adopt that [ARCI] procurement model is very important. What we did in the form of this is create a program based on a business case decision, deploy the first phase of installments across all our submarines, around 70 of them in the government, in 18 months, the first solution in 18 months, and essentially complete the entire fleet in five years. That is unprecedented, frankly, and it also was the single largest application of a small business initiative research proposal in the history of the federal government. Even more important are the built-in tech refresh aspects of this program, both hardware and software. The warfighting benefit was significant, a significant increase in sonar performance and sonar operating performance. In other words, sonar operator training and their performance. Also a model for collaboration between uniformed personnel—that's sonar technicians, for example—and the industry, software engineers who write and build advanced program builds in about 18- to 24-month cycles. (Giambastiani, 2007)

1. Submarine Tactical Requirements Group & the Sonar Development Working Group

The Submarine Tactical Requirements Group is a forum of senior submarine officers responsible for defining and prioritizing the submarine force's tactical requirements (SDWG, 2003). The group consolidates the submarine fleet's tactical needs through an annual requirements letter, which effectively directs the development goals for the following year's Advanced Processing Build. The Sonar Development Working Group is the organizational structure through which the details of the requirements letter are translated and acted upon.

The collaborative environment Giambastiani regaled as pivotal to the success of the ARCI program was supported by the Sonar Development Working Group's strategy of using integrated product teams (see Figure 16). Each team, chartered by the program offices, was chaired by SMEs and consisted of a cross section of members from across the fleet, Navy laboratories, university laboratories, and industry (SDWG, 2003).

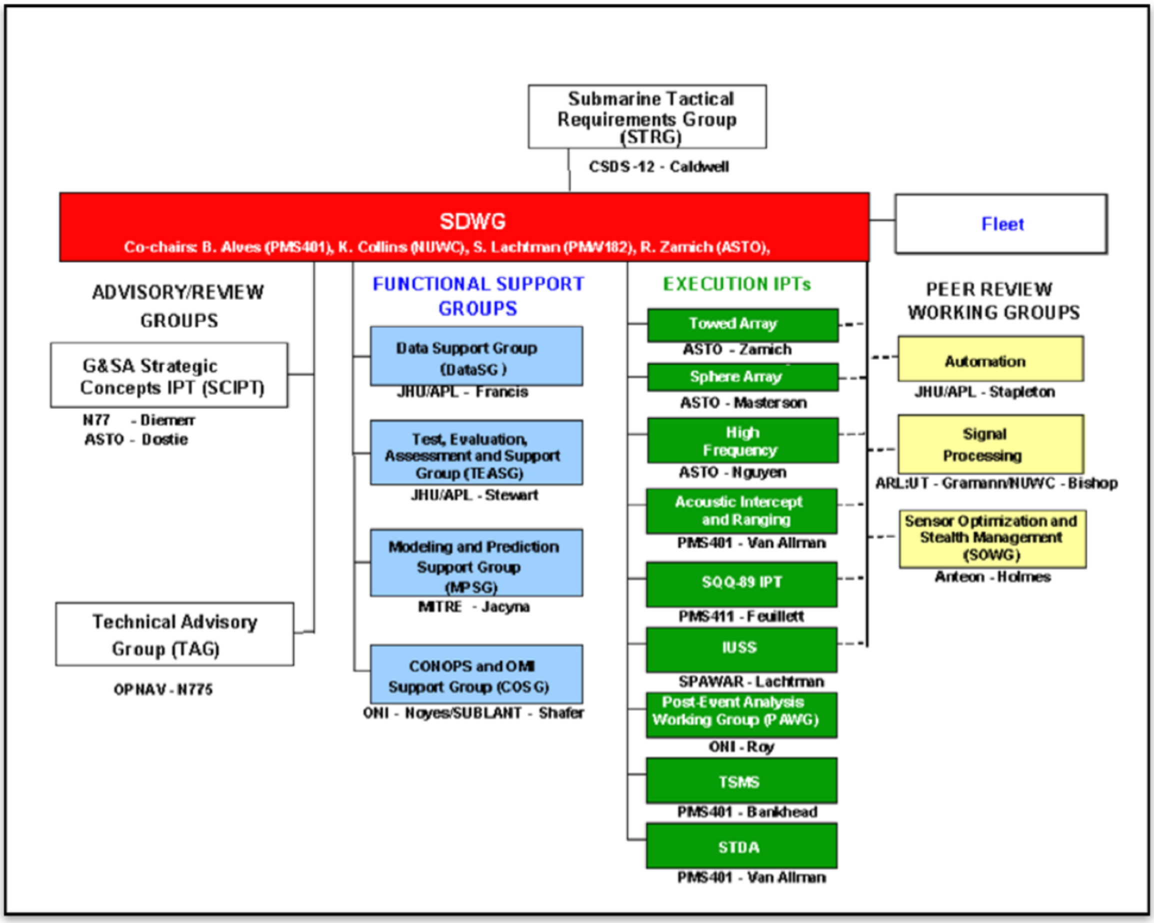

Figure 16. Organizational Chart of the Sonar Development Working Group
(SDWG, 2000)

The starting point for this collaborative process was the Submarine Tactical Requirements Group. The Submarine Tactical Requirements Group is the entity responsible for defining and prioritizing the submarine force's tactical requirements (SDWG, 2003). This group is a forum of senior submarine officers under the leadership of the Commodore of Submarine Development Group-Twelve and is responsible for identifying and consolidating the submarine fleet's tactical needs through an annual requirements letter. Once the requirements letter is endorsed by the Commander Submarine Force, U.S. Pacific Fleet, and the Commander, Submarine Forces, the requirements are forwarded to the submarine Navy's resources and requirements sponsor, the Director, Submarine Warfare. The Director, Submarine Warfare, releases the annual requirements letter to the Program Executive Office, Submarines and Program Executive Officer, Integrated Warfare Systems, which effectively directs the development goals for the following year's APB. Armed with the requirements letter, the technical community begins development of those requirements and advises the Navy on how to attain the requirements capability (Stevens, 2008).

The Sonar Development Working Group would take the requirements letter and, through a forum of monthly meetings, collaboratively discuss updates and issues related to the APB process. This monthly forum was designed to provide a clearinghouse for communication across the working groups for the presentation of recommendations and works in progress (SDWG, 2003). This format offered the integrated product teams a means to "sync-up" deliberations (Johnson, 2013b). It was also a means to ensure that the teams were cross-pollinating and understanding what was going on in all of the different areas. This was a clean break from the traditionally isolated way of doing business. In the old way of doing things, there was a strict stay-in-your-lane mentality. For example, the people in science and technology who had been working on processing algorithms for years never received feedback on how their ideas were being incorporated (Johnson, 2013b). These people never knew whether their work was actually being used, much less whether it had resulted in something positive for the warfighter. The collaborative structure of the Sonar Development Working Group ensured constant and consistent participative involvement throughout the development and acquisition process. This structurally enforced involvement served to mitigate the translation errors inherent in requirements determination and definition.

2. Concept of Operations and Operator–Machine Interface Support Group

The Concept of Operations and Operator–Machine Interface Support Group was the team of senior enlisted advisors responsible for designing display schemes and controls (Boudreau, 2006). They served as the primary voice of the fleet for sonar system development. They would take responsibility for prioritizing improvements in the areas of acoustic signal detection, system automation, and tactical information management (SDWG, 2000) and would shoulder the responsibility of both developing and conducting crew familiarization training for Advanced Processing Build system upgrades (Boudreau, 2006).

One of the most important and influential integrated product teams was the Concept of Operations and Operator-Machine Interface Support Group (COSG). This team was comprised of a group of handpicked senior enlisted sonar specialists. This was the group that had solved the problems discovered during ARCI's initial at-sea testing on the *Augusta*. By transforming the decades-old custom displays into the slick flat screens that made signals easier to read for less experienced operators, this team had been responsible for developing the first user-configured component of the ARCI initiative (Bratton & Tumin, 2012). This group would be charged with designing the operator–machine interfaces of the APBs and would strongly influence how the systems would be utilized operationally (SDWG, 2000). Most important, this team provided direction on what it was that the typical fleet operator would want to see in the new displays and would serve as the focal point for defining the system's interface (Johnson, 2013b).

ARCI had removed the barriers to fleet involvement so common in the traditional acquisition process and enabled a collaborative environment for the fleet, the developers, and the contractors to openly communicate and fully cooperate on how the systems could be improved. As the fleet's voice for determining the priority of APB improvements in acoustic signal detection, system automation, and tactical information management, the COSG would undertake the responsibility of developing and conducting crew familiarization and installation training for APB system upgrades (SDWG, 2000).

Membership in the COSG became a prestigious duty inside the sonar community. While membership was principally comprised of active-duty senior enlisted personnel and acoustic intelligence specialists drawn directly from the fleet, it would come to include civilian representatives from the program offices, the Navy laboratories, and system development contractors (SDWG, 2003). Because they were the team with the de facto responsibility to actualize the concepts put out in the annual requirements letter, this team would drive the development efforts that shaped the future of the sonar community

The team had taken ownership of the process from end to end. Retired Master Chief Don Noyes, a former co-chair of the COSG, explained,

> The COSGs [Concept of Operations Support Group] were small groups of Chiefs for Sonar and a group of Chiefs and Officers for the combat systems. Based on the STRG [annual requirements] letter, we would collaborate and brainstorm ideas and then carry the message forward into the development cycle. We would also support the TEASG [Test, Evaluation, Analysis Support Group] during the test cycle. We would develop the CONOPs [Concept of Operations] and training for the APB. We would take the product out on the boats, do the installation training, and get the crews up to speed. This worked very well because the COSGs were made up of SUBPAC [Submarine Forces, Pacific Fleet], SUBLANT [Submarine Forces, Atlantic Fleet], TRE [Tactical Readiness Evaluation], CSDS-12 [Commodore, Submarine Development Squadron Twelve], ONI ACINT [Office of Naval Intelligence Acoustic

> Intelligence specialists], and SLC [Submarine Learning Center]. So you had a core gambit of senior enlisted developing operator type combat systems. (Noyes, 2012)

The function of the COSG was to provide guidance and recommendations for what the development community needed to focus on for the man–machine interface (Johnson, 2013b). The man primarily responsible for constructing the initial group was retired Navy Captain Rocky English. English has been described as "one of those guys that taught the Admirals how to drive submarines" (Johnson, 2013b). He was well respected and responsible for handpicking the fleet's best and brightest to serve on the team. This niche group of elites contributed significantly to the success of the ARCI program but soon drew criticism for developing operator-centric versus command-centric displays.

During the Sonar Development Working Group meetings, the working groups addressed the functional and technical issues of what the engineers could build into the systems (SDWG, 2003). Armed with that information, the integrated product teams collaborated on drafting a proposal of what they envisioned should be built (Noyes, 2012). Those proposals were briefed at each Submarine Tactical Requirements Group meeting for approval. Over time, the process would become dysfunctional because the over influence on display development focused on supporting the operator rather than the command decision-maker. This fixated focus is natural when one considers that the COSG was composed primarily of SME *operators*. The dysfunctional nature of the relationship stemmed from the fact that the requirements were generated by a collection of senior officers whose focus obviously leaned toward *command and control*. Former Commodore of Submarine Development Squadron Twelve Captain John M. Richardson addressed the problem:

> It is imperative that systems be designed to support command level decisions. We must fight the tendency to design displays and interfaces that are solely optimized for the operator. While it's important that the operator can use his display, at some level the system must serve the CO [commanding officer], otherwise it may prevent the most important decisions from being made. (Richardson, 2005)

3. Human Systems Integration

In order to resolve the disconnect between operator focused and command focused displays, the Commodore, Submarine Development Squadron Twelve, the organization responsible for developing and evaluating submarine tactical systems, would commission a

study into how system displays and interfaces could more fully support the overall efforts of the submarine force.

In an effort to fully understand the problem and to shift the fixated focus on operator displays to include command and control functionality within those displays, Richardson turned to the field of human systems integration. Richardson commissioned Dr. Gary Klein to conduct a study of how the displays could support command decision-making. Klein was a renowned research psychologist who specialized in how humans make decisions in complex real-world settings (Klein & Klinger, 1991). Klein became a research pioneer by using cognitive task analysis methods to study decision-making in naturalistic settings (Klein, 2005).

The goal of Klein's research was to understand the decision requirements of submarine commanding officers (CO) by looking at the cognitive challenges that the systems would need to support and to develop design recommendations for displays that could support the CO's decision-making process (Klein, 2005). What Klein determined was that the current display designs supported the specialized operator's tasks well, but the COs had only passive access to the present data or to data from the immediate past (Klein, 2005). This limited access to information was not well suited to developing the "big picture" that the COs needed in order to make informed decisions. The CO needed to absorb and integrate information to formulate that "big picture," and displays that could not be actively engaged could not support the decision-making process. Klein recommended several design directions through which the submarine community could improve the displays that would continue to serve the operator but would also support the CO's decision-making process.

Richardson identified a significant shortfall in the way displays were being developed. There was a disconnect between the way COs made command decisions and the way the systems were being designed (Klein, 2005). By refocusing system design efforts on a decision-centered paradigm versus a purely functional paradigm, the systems could be engineered to foster intuitive decision-making (Klein, 2005). Richardson's elegant solution was to design systems and displays that supported the intuition of commanders rather than force those commanders to adapt to the system (Klein, 2005). This decision-centered approach to design had the potential to revolutionize the tactical systems of the submarine Navy.

The work on what would be commonly referred to as the original "command display" began to be developed for incorporation into the APB for 2007. Richardson, a forward-thinking leader, had set the course for change, but his tour as the Commodore of Development Squadron Twelve had ended, and effecting that change would fall into the hands of his successors. The execution of this new design strategy could have embraced the in-place collaborative effort of the existing development structure by fomenting and exploiting a healthy tension between the functional tasks and the decision-making process. Unfortunately, with Richardson's departure, several factors combined to obfuscate this new strategy and design direction.

4. Dismantling the Fiefdom of the Concept of Operations Support Group

The senior enlisted sonar specialists that comprised the Concept of Operations Support Group (COSG) had drawn significant criticism for fixating on operator-centric displays. One senior submarine officer saw the power held by this group of elites as a dangerous force degrader and set out to marginalize the group's influence.

One of the more significant factors that inhibited the strategy proposed by Richardson emerged through the adversarial response of one particular senior submarine officer toward the COSG. This senior submarine officer remarked, "The sonar men were sent to the Beltway and co-opted the system" (F. H., personal communication, December 11, 2012). That senior officer was frustrated that the team of senior enlisted sonar specialists had assumed and usurped the responsibility to set requirements and direct display development efforts (F. H., personal communication, December 11, 2012). In that senior officer's opinion, the senior enlisted team's design influence had served to undermine rather than support the efforts of the submarine commander (F. H., personal communication, December 11, 2012). In an attempt to mitigate the problem, an effort was made to systematically disempower the group and marginalize their influence. These efforts would lead to a complete restructuring of the participative development process.

This institutional power play could not have occurred at a worse time for the ARCI program. ARCI had lost one of its most influential and charismatic leaders when Bill Johnson transitioned from sonar to combat systems. Johnson had championed the consistent participative involvement of the teams in the Sonar Development Working Group structure. The loss of Johnson's direct support saw a lapse in team participation and a decrease in scheduled meetings (Johnson, 2013b). The apathy that ensued allowed the senior officer who wanted to shift the influence held by the COSG to move forward with his disestablishment plans, unopposed.

Senior leadership would establish a separate officer-specific group inside the team dynamic and would assume overall control of both teams. Under this leadership, the participative element of the team dynamic began to falter. Suddenly, the senior enlisted team members who had been carefully hand-selected to participate in the working group often found more pressing business elsewhere. Active enlisted member participation in the COSG quickly fell off. Through pure attrition, the once tightly selected and prestigious positions on the team became just another delegated collateral duty that would be filled by someone with the minimum qualifications rather than a handpicked fleet superstar.

Senior leadership would also reorganize the COSG functional authority. This reorganization would shift the responsibility for developing training programs from the support group to the submarine schoolhouses. While there had always been a schoolhouse representative as part of the team architecture, the COSG had maintained overall responsibility both to develop training plans and to conduct crew familiarization training for APB system upgrades. The submarine schoolhouses were not as familiar with systems under development and the sudden responsibility to develop training programs for these systems created a significant knowledge gap between the development community and the training community. This lack of direct participation in the development process by the schoolhouses would lead to significant difficulties in the APB program.

5. The Problem Matures

ARCI provided a means to rapidly and cost effectively introduce state-of-the-art commercial technologies into the submarine fleet. The development community understood system capability to be the standard measure of success. The fleet would measure success as the amount of capability the operators could pull from the system. A means to adequately train sailors on the new systems and provide guidance on how to operationally employ new system features could not keep pace with the rapid rate of system introduction.

By 2007, every single U.S. submarine had been converted to ARCI-based sonar, with most submarines having undergone upwards of five upgrade cycles (Bratton & Tumin, 2012). The ARCI process had morphed through the years to accommodate the rapidly changing pace of technology and had adapted to fit the ever-changing development environment. The software developed for the APBs continued along an annual implementation schedule but, in order to avoid hardware obsolescence, ARCI implemented a process known as technology insertions (TI) to leverage available hardware advances in processors and sensors (Wilson, 2009). Unlike the APB software updates, which were introduced every year, TI hardware updates were originally provided every two years and served to reestablish the hardware baseline for future upgrades. APBs and TIs are referenced by the year they are developed. TI-06/APB-07 would be indicative of a submarine that had undergone a refit to the technical insertion developed for 2006 and the APB developed for 2007.

The APB and TI processes are designed to revamp tactical systems using the most advanced technology available. The rapid changes of scheduled annual software updates and biennial hardware upgrades created changes to both the means and methods by which the affected systems were employed. Changes in operational employment necessitated constant updates to guidance, training, and operations. The personnel involved in the ARCI program had become the Navy's experts in developing, testing, and installing new systems but, as the process matured, the need for greater collaboration between system developers, installers, doctrine writers, and trainers began to surface as the submarine crews encountered significant challenges in employing the new systems (K. Perry, 2008).

The performance upgrades delivered in the software of the APBs and more capable hardware of the TIs are designed to offer greater capability to the sailor and to the submarine. The problem was that the advantages offered through the technology advances were wholly contingent on the operator's ability to effectively employ that technology. ARCI had revolutionized the acquisition process and enabled a cost-effective, rapid-technology refresh rate, but the fleet was not fundamentally equipped to absorb those fast pace changes. The rapid rate of change began to take its toll.

Scott Tupper, a former submarine officer and director of advanced development for Submarine Development Squadron Twelve explained the circumstances:

> Each submarine platform gets an entirely new hardware build every six to eight years. The process was set up such that, in a sailor's five-year tour onboard his submarine, he would probably see one modernization cycle. For example, he could go from having a build that was put to sea in 2002 to a 2008 build. On the most basic level those changes could be something as small as how you select a target of interest to how you zoom in and out on the

> display or where the information was located on the screen. On a broader level, there could be entirely new tools or displays that just didn't exist before. That individual sailor, during his first tour on a submarine, may only have to worry about one change, which, by itself, is manageable. But, there were unintended consequences that have been very challenging. When you talk about the squadron waterfront staffs, the inspection teams, the operational test teams and the training and doctrine communities that support those sailors and boats, those guys need to know five or six different configurations and how each configuration should be trained, operated, and tactically employed. … What we really didn't recognize at the time was that when you modernize each boat every six to eight years, that sailor who finished his first tour on submarine number one with system X goes to shore duty for three or four years and comes back as a Chief or a Senior 1st Class Petty Officer or that Junior Officer who comes back as a Department Head, comes back to a system that's completely new to him. He is no longer the system expert but is expected to train his guys on a system that he has never seen before. In effect, we took away the system expertise of those senior enlisted and returning officers. (S. A. Tupper, personal communication, February 15, 2013)

One of the ARCI program's greatest strengths was its ability to keep pace with the rapid advances in commercial technology. These rapid advances, however, posed an enormous challenge to the sailors and to the support crews who had to constantly build and re-build operational proficiency on new systems (K. Perry, 2008). The software and hardware engineering upgrades were designed to increase the capability of the system. The fleet measured success not on how much capability was built into the new systems but on how much capability the crew could get out of that new system (K. Perry, 2008). Former Commodore of Submarine Development Squadron Twelve, Captain Ken Perry explains,

> Every commanding officer (CO) returning from a successful mission credits a measure of his crew's effectiveness to the enhanced capabilities made possible by well-designed new gear. The fleet has voiced concerns about the APB process. Reliability of new processors; interface issues between new tactical equipment and existing ship systems; unclear or incomplete employment guidance or technical documentation; and lack of training support for newly installed gear are some of the gaps that keep crews from realizing the full capabilities of new hardware or a new program build. (2008)

The rate of change in technology required that procedures and support publications be developed at a matching pace. Technology, documentation, doctrine, and training needed to be coordinated to support system employment and crew readiness. Accomplishing this necessitated greater collaboration between system developers, doctrine writers, trainers, and operators to manage the waves of change. Coordinating their efforts was exceedingly difficult and often clumsy, imbalanced, and mistimed. To promote a properly balanced approach, the modernization scheduling would need to synchronize the following elements before the system could be properly installed and effectively operated:

- appropriate documentation to support maintenance, logistics, information assurance, and other compliance requirements;
- system employment guidance; and
- training resources to build crew proficiency on the new capabilities. (K. Perry, 2008)

In 2007, the Commander of Submarine Forces issued a doctrinal strategy, which aimed to make system documentation both tactically sound and user friendly. The strategy specified the development of a System Employment Manual and a complementary Interactive Electronic Technical Manual (K. Perry, 2008). The System Employment Manual, which was authored by Submarine Development Squadron Twelve, served as a reference guide for system operations under diverse conditions and tactical situations. The Interactive Electronic Technical Manual, authored by the system developer, provided the system operator with detailed information and procedures for operations, troubleshooting and maintenance (K. Perry, 2008). These employment and technical manuals were designed to ensure that system documentation kept pace with the changes in technology and would provide the guidance necessary to enable submarine crews to squeeze every bit of capability from their new systems.

Fleet concerns over the burden of tactics, training, and procedural changes incurred by the rapid and aggressive upgrade schedule were addressed by deliberately slowing the process down. Capability-based APBs shifted to delivery every odd year and TIs to every even year. Software upgrades that were necessary to support new hardware were explicitly designed to be transparent to the operators before they were installed. This more conservative delivery model saw each submarine receive a TI with the preceding year's APB approximately every four years (Stevens, 2008). This 2/4 schedule was further modified to account for individual submarine's deployment schedules. Once a submarine received a new APB, there would be no more software or hardware upgrades until after that submarine completed the deployment cycle (Stevens, 2008).

Slowing down the process provided a bit more breathing room to coordinate the intricate dance of technology advances and the supporting efforts necessary to effectively employ those advances. Slowing down the process, however, did not fully alleviate the burden of the technology management problem. A new solution was needed. This solution would be shaped, as so many government programs often are, by yet another looming round of budget cuts.

6. The Japanese Model

The challenge to effectively manage the rapid rate of technology change led to a suggestion that the U.S. submarine force adopt the Japanese model for submarine operations. Rather than rely on regular systems upgrades, the strategy utilized by the Japanese submarine force relies on sailors achieving subject-matter expertise of systems that do not change for almost a decade. This argument would be bolstered by the fact that not all system upgrades had proven either effective or necessary and would beg the question: "When is enough, enough?"

The budget cuts anticipated for fiscal year 2007 required the submarine Navy to reevaluate many of its spending priorities. Vice Admiral Munns, then Commander of Submarine Forces, had entertained a reduction in the manning levels onboard submarines and directed a feasibility study to determine where the cuts could be made. Eliminating billets would certainly cut costs, but rarely do reductions in available personnel coincide with a reduction in mission requirements.

The stress of these impending cuts threatened the security of the now 10-year-old ARCI program. One of the most dramatic suggestions was to abandon the current implementation schedule and revert to the Japanese model. The Japanese submarine force does not regularly upgrade its systems and instead relies on its sailors' operational expertise of the existing systems. This strategy enables submarine sailors to become true SMEs on the existing systems and to fully understand and consistently employ the range of systems' capabilities. The rationale behind this model is that the submarines have an acceptable level of capability and, by manning the boats with sailors committed to long-term enlistments, those sailors can attain absolute mastery of the static submarine systems. Long-term enlistments on a submarine whose systems do not change for the better part of a decade preclude exorbitant training and technology investment costs. Shifting to the Japanese model would allow the U.S. Navy to reduce costs and to eliminate the constant training and support burden. The justification for adopting the Japanese model was primarily financial but was bolstered by the challenge of effectively managing the rapid technology change cycle. The argument was that the sailors were unable to extrude every capability that had been built into the existing systems, so the Navy would be better served by taking a strategic pause and halting the implementation of any additional changes to the system (Stapleton, 2013).

Transitioning to the Japanese model could have mitigated the challenge of managing rapid technology changes but would have resulted in a reversion to the traditional development and acquisition process. ARCI has been hailed as the cornerstone of innovation in the DoD's acquisition process, but not every system upgrade has been resolutely successful, nor has the program become immune to the threat of budget cuts. In point of fact, the APB program represents the largest unfenced R&D budget line inside the submarine Navy (Stapleton, 2013).

In the realm of DoD budget guidelines, a "fence" represents funds that are protected from being used for other purposes (Potvin, 2012). The submarine Navy has several large-ticket items on its budget line. Items such as naval reactors and shipbuilding are going to be funded. When Congress changes the submarine Navy's budget, the APB's unfenced funds are at a high risk of being diverted to a higher priority. Maintaining a successful product track record is vital to the APB's survival because a misstep can quickly see the APB being overwhelmed by budget priorities (Stapleton, 2013).

Not every APB has been deemed a success; the APB for 2006 was considered to be exceptionally unstable. There were serious questions over whether it should have even been fielded into the fleet. In 2006, Vice Admiral Carl V. Mauney, then the Director of Submarine Warfare, demanded that every APB deliver a significant ROI, or the program would be subject to cancellation (Stapleton, 2013). In light of the management challenges that the rapid technology changes had incurred, and in consideration of the rippling effects the system upgrades had on each facet of the submarine community, Mauney's decision was understandably sound. The challenge, however, lay in determining how to effectively measure ROI.

7. Watch Section Task Analysis

Evaluating the return on investment delivered by the introduction of system upgrades would be accomplished through the innovative use of a submarine simulation device. This simulation enabled comparative testing between the older and upgraded versions of

submarine systems. This simulation environment would serendipitously create an interactive laboratory to encourage participative involvement in development efforts that would stimulate the creation of a user-developed command-centric display.

The man who took up the challenge to effectively measure ROI was Dr. John Stapleton. Stapleton, the director of technology and strategy at the Johns Hopkins University Applied Physics Lab, had been involved with the APB program from the beginning (Stapleton, 2013). The biggest obstacle to meeting Mauney's demands was that nobody had genuinely defined ROI. After a decade of rapidly introducing system upgrades, there were plenty of opinions on which upgrades were quality products and which were suspect, but there was no quantitative measure or established qualitative reasoning to gauge ROI. ROI is a nebulous animal that calls to mind Supreme Court Justice Potter Stewart's pornography analogy: "I could never succeed in intelligibly [defining] it, but I know it when I see it" (*Jacobellis v. Ohio*, 1964).

Stapleton and the APB program supporters had to make a convincing case that the upgrades were delivering significant ROI to the submarine force, but first they had to design something compelling that would be able to demonstrate ROI. Stapleton found the answer to this dilemma through the human-systems-integration process of task analysis (Stapleton, 2013). Task analysis explores how tasks are accomplished and details the manual and mental activities that are devoted to completing tasks (Kirwan, 1992). Stapleton saw the value of applying task analysis methods to submarine watch teams. Submarine crews are organized into three watch sections. A watch team is comprised of the sailors in each section that operate the submarine during a duty period. In order to understand and evaluate the different tasks of each person on the watch team and to map watch team information flows, Stapleton made use of the submarine multi-mission team trainer (SMMTT; pronounced *smit-TY*).

SMMTT is a high-fidelity simulator used to train submarine crews in sonar and combat systems. The SMMTT is used primarily in pre-deployment training to hone the mission skill set of the crews (see Figure 17; Haines, Lee, Beatty, & Tavares, 2009).The SMMTT was built in response to the ARCI program and is capable of replicating various system configurations (Haines et al., 2009). It was designed to synchronize tactical development with the system upgrade delivery cycle by immersing crews in complex scenarios that could simulate deployed operations (see Figure 18; Haines et al., 2009).

Figure 17. The Submarine Multi-Mission Team Trainer
(Photo taken by William Kenny; Haines et al., 2009)

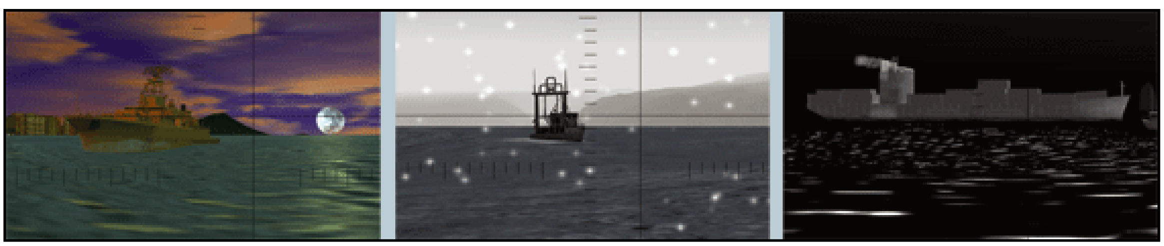

Figure 18. SMMTT Images
(Images courtesy of the Submarine Learning Center; Haines et al., 2009)
Note: Simulated high-contact density environments in the SMMTT consist of optical and infrared signatures projected on small, high-resolution displays.

Stapleton's team designed a Watch Section Task Analysis (WSTA; pronounced *WAS-ta*) program that would observe watch teams as they went through a simulated tactical evolution scenario using a prior year's APB installation. The watch team would then run through a similar simulated tactical evolution scenario using the following year's APB installation. The scenario that had been developed for the initial comparative evaluation tested Vice Admiral Munns' theory of reduced manning. A smaller-than-usual watch team underwent the tactical scenarios that evaluated the previously installed version and then the beta version of the APB. The WSTA program served to develop both subjective and objective measurements of how the watch team performed through a comparison of the team's performance using the old system with their performance using the new system (Stapleton, 2013). Stapleton explained WSTA:

> We would bring whole watch teams in to run a tactical scenario. We run these scenarios with the prior APB and the new APB and we would measure if and how they are more effective with the new tools. That seems to scratch the itch. There is a lot of value in having these watch teams come. We can gauge how difficult it is to learn, because these guys have to learn the new APB on the spot. We can talk to the CO and the watch team about what they actually thought about the system. That is the subjective piece, but WSTA [Watch Secion Task Analysis] provided objective measures like faster speed of advance with fewer close encounters or more times when you have sat[isfactory] placement with a torpedo. All these subjective and objective measures allowed us to say, "This is what you are getting for your money." (Stapleton, 2013)

The first WSTA event was launched in February 2007 and was a soaring success. Not only had they developed a standard for ROI, but the WSTA program had also serendipitously created a forum for collaborative design that gave voice to the end users in the fleet. Using the watch teams to test the performance of the new system upgrade based on the performance of the old system provided data for evaluation of the differences between iterations, but it also crowd sourced the knowledge and opinions of fleet operators as they worked with the beta version of the new system. In this interactive laboratory, the system developers and the operators undertook a meaningful conversation that created context between the capability the developer put into the system and the functionality that the operator pulled out. It was the creation of this contextual relationship that reinvigorated the development of the command-centric display.

8. Interactive Battle-Space Awareness Layer

The first Watch Section Task Analysis endeavor had enabled system developers and operators to create a shared understanding of the available capability and desired functionality of a system display. This contextual conversation would lead into the development of the first command-centric display design: the Interactive Battle-Space Awareness Layer.

The APB for 2007 was the first iteration of former Commodore Richardson's direction to develop a command display (Richardson, 2005). The development community was tasked specifically to develop a decision-centered design. This was the system display that would be developed for the command element and follow Dr. Gary Klein's study recommendations on how to design displays that support CO decision-making. Unfortunately, the development of this command-focused display design had encountered significant obstacles. The collaborative effort that had pushed the design of system displays and interfaces for the past decade had begun to wane. Between the budget threats and restructuring of the COSG, the intentionally limited fleet operator involvement had begun to take its toll.

The restructuring of the COSG had caused the pendulum of influence to swing from solely senior enlisted involvement to solely senior officer involvement. Sole utilization of senior enlisted in the design process had led to displays optimized for the operator but had failed to effectively support command-level decision focus. Switching to solely senior officer involvement would create entirely different problems for the design process. Inside the DoD, management education and leadership development evolve through a decision-attitude toward problem solving where alternatives are displayed and the metric of managerial efficacy is determined through the selection of the best alternative. Leaders are trained to create a single right plan and then execute it. This pervasive philosophy of command does not lend itself well to collaboration. If 10 commanding officers were sent into a room to answer the command display question, the most probable outcome is that they would deliver 10 equally correct but dramatically different answers. This fact does not disparage the creative capability of senior officers but reflects the challenge of conducting collaboration and innovation between strong senior personalities. Collaboratively designing a command display that all of the commanding officers were going to agree upon was unlikely.

The WSTA event had provided a format to include fleet operators in the command-centric display design effort. The collaborative environment of the simulation had introduced formal cognitive engineering approaches into the planning, analysis, development, and testing of the system under development (Cooley & McKneely, 2012). The post-event analysis coupled subjective feedback and objective measurements to provide statistically based data on which to develop the Command Display (Cooley & McKneely, 2012). This analysis provided developers with a contextual understanding of operator interactions and refined the conceptual notion of designing displays that would provide commanding officers with an intuitive and actionable tactical picture (Cooley & McKneely, 2012). Based on this contextual understanding, developers were able to transform the concept into a working prototype: the Interactive Battle-Space Awareness Layer (I-BAL; see Figure 19).

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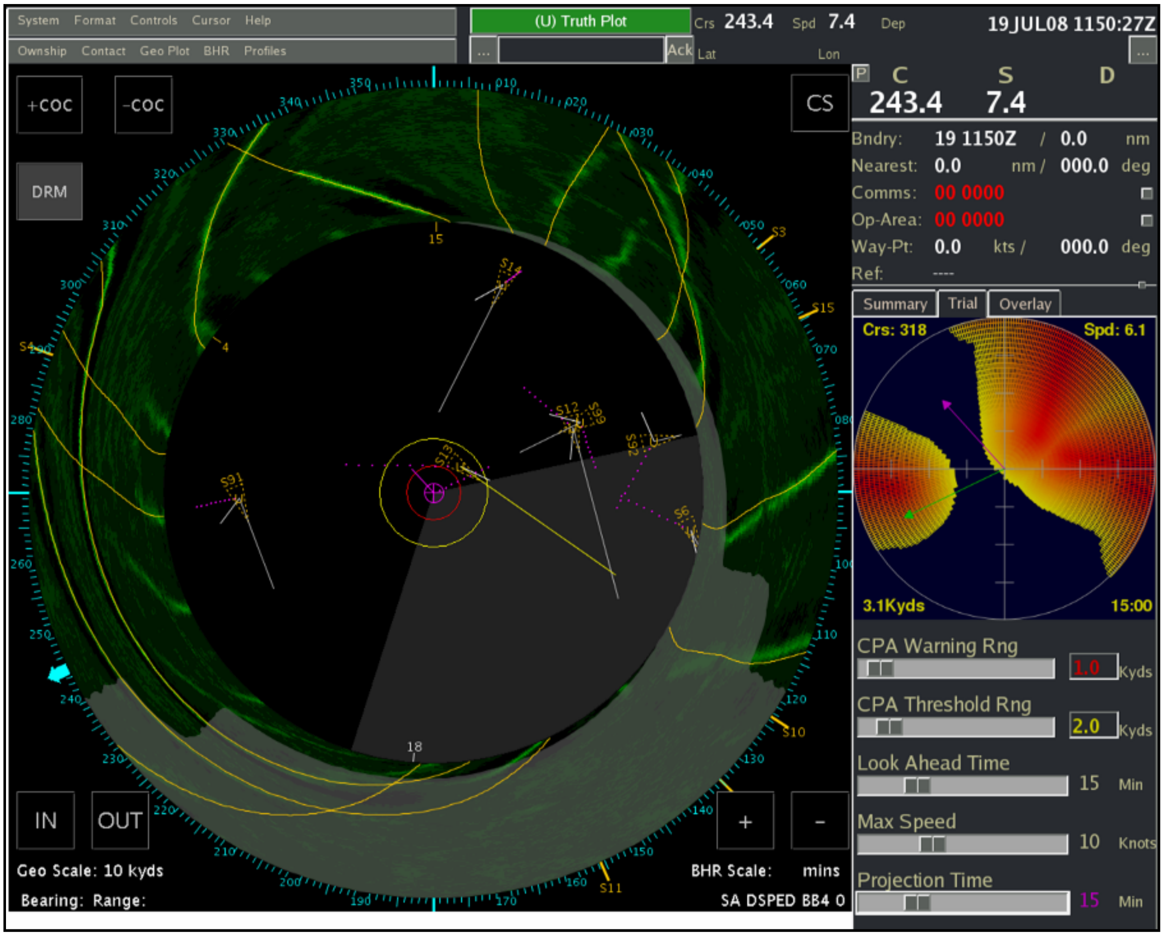

Figure 19. Interactive Battle-Space Awareness Layer
(Smith, 2012a)

FOR OFFICIAL USE ONLY

I-BAL (pronounced *EYE-ball*) was developed through a design process that fully integrated hardware, software, and human performance (Cooley & McKneely, 2012). It was quickly launched as part of the next year’s system upgrades. Captain Ken Perry, then the Commodore of Submarine Development Squadron Twelve, lauded I-BAL as the “great example of fleet-enterprise partnership, to address top tactical priorities” of commanding officer decision-making and situational awareness (K. Perry, 2008). I-BAL was a first-of-its-kind display that fused real-time data with active solutions and provided the decision-maker with a more intuitive, coherent, and actionable picture (K. Perry, 2008).

9. Enough is Enough

The Interactive Battle-Space Awareness Layer had been developed through a collaborative effort of fleet operators and the development community. Unfortunately the promises offered by this command-centered display would fail to live up to operator expectations. Combined with the ever-present challenge of managing the rapid technology changes to submarine systems, the decision was made to strategically halt any changes to future display or interface designs.

When I-BAL hit the fleet, it was received with mixed reviews. The I-BAL display had issues with reliability and longevity. The system habitually locked up and crashed. I-BAL had been highly praised, but when it made it into the hands of the operator, it failed to live up to its glorified promise. One fleet instructor explained,

> They named this thing I-BAL because it looks like an eyeball. It didn't look like anything we ever had before, so I had to wrap my head around it. The first time I saw it, even though this was my job [to train sailors on the system], all I could think was, "This is useless to me." There was one tool on there that I liked and I thought, "Okay, I can sell that because I like it." It was actually very good, and then I started getting used to the rest of the display and realized that there was some utility in there that I can use. Problem was, the implementation was terrible. It would lock up constantly. Just constantly fail. It was a very useful tool, once you wrapped your head around it and understood what you were looking at. But it doesn't work, so you just say, "[expletive deleted] it!" It's taking too much time to learn and then it doesn't work. It's a $40 million dollar doorstop. Why are we going to spend time on it? (J. L., personal communication, November 28, 2012)

I-BAL underwent significant rework to improve its reliability, but to a certain extent, the damage was done. When a new piece of technology fails to deliver on its promise of performance, it is human nature to ascribe that poor reputation and subsequent negative connotations to each subsequent version of that product. Sociologist Dr. Everett Rogers (1995) coined the phrase "failed diffusion," which helps explain the phenomenon. Diffusion is the process of social change by which an innovation is communicated into the social system (Rogers, 1995). When a new technology is introduced to a community, even if the utility of the technology can deliver positive results, the cultural belief system will rail against the adoption of a system that carries a stained reputation.

The implementation of I-BAL was met with a prototypical response to failed technology. Fleet operators expected I-BAL to fail, so it was marginalized on the operator level. These reliability and dependability issues, combined with the continued training and support burden of the rapid changes in technology, had finally reached critical mass In December 2009, the decision was made to strictly limit any change to the operator machine interface component of future system upgrades (Commander, Submarine Development Squadron Twelve [COMSUBDEVRON], 2009). Changes to the interface design would only be entertained if the new design could demonstrate a convincing return on investment. I-BAL was a new concept and a new way of looking at things. Until the bugs were worked out and until the training and support functions on the waterfront caught up to the implementation process, the submarine force would not accept any change to common displays or operator–machine interfaces (COMSUBDEVRON, 2010).

D. PART IV: TACTICAL ADVANCEMENTS FOR THE NEXT GENERATION

The U.S. submarine force had successfully addressed the challenge of modernizing the fleet through the innovative efforts of the ARCI program (Gansler & Lucyshyn, 2008). The rapid rate of technology updates created a cascading effect of challenges on the submarine Navy's training and support structures. The challenge of managing these changes would be addressed through a series of decisions that focused on retarding the rapid rate of change. The solutions to slow down the system update process would culminate in a decision where the submarine Navy would resolutely refuse any changes to the existing common display design or to operator–machine interfaces. This abrupt answer was less a solution to the problem than a conservative coping mechanism.

1. Fast Following and Digital Natives

The newly appointed Commander, Naval Submarine Forces, strives to leverage the research and development efforts of the commercial world and to exploit the submarine Navy's organic millennial-generation assets.

In 2010, John Richardson, the forward-thinking former Commodore of Submarine Development Squadron Twelve, had progressed in the naval hierarchy to become a vice admiral and the Commander, Naval Submarine Forces. Richardson was the man who in 2006 had commissioned the Klein study and shifted development priorities from operator-centric to command-centric displays. Richardson explained his vision of the current challenge the submarine force faces:

> We've gone from a single mission with a geographic focus in World War II, to the extended submerged periods during the Cold War, where the subsurface is our home, to the dawn of a new era in access, where we can reach out and touch you from long range, whether through cyber attacks or by long range missiles. The missions have grown from ASW [anti-submarine warfare] centric, to ISR [intelligence, surveillance and reconnaissance], strike, SOF [special operation forces], and now unmanned fixed and mobile systems, with each new mission adding to rather than replacing other missions. We have expanded our sensors to cover the breadth of the electromagnetic and acoustic spectra, and added off-board sensors, leading to an avalanche of information on the watch team. (Richardson, 2012)

This avalanche of information was the next generation's version of the 1990s "acoustic dilemma." Richardson saw the solution to this dilemma in effectively managing information through intuitive interfaces. Unfortunately, since his departure as the Commodore of Submarine Development Squadron Twelve, the efforts into developing an intuitive design have struggled (i.e., the I-BAL).

In preparation for his role as the Commander, Submarine Forces, Richardson would come across several signs that his vision of displays that supported command decision-making had not fully matured nor had the institutional Navy quite grasped the notion of intuitive design. Richardson illustrates the struggles with intuitive design through a story about a Navy leadership course he once attended. When the course began, the participants were provided with course materials and on their desks were a briefcase, some books, and an Apple iPod.

> What was really interesting was underneath the iPod was this six-page, stapled together pile of papers. You look in that pile of papers. Here's the iPod. It's in this brand new case, and they'd actually loaded it up with some business books and that sort of thing. The Navy felt the need to provide us with this six-page Navy instruction manual on how to use the iPod, which I thought was really a good indication of how we're dealing with stuff. Here's a device. First of all, they've sold probably billions of these things by now, certainly millions of these iPods. You could take this thing and drop it out of an aircraft into the middle of the Kalahari Dessert and before you know it those folks would pick it up. It's just so intuitive that they'd be downloading music and listening to it in no time without any instructions at all. Here we were with this six-page manual on how to use it. That little arrow, that means play, all those

> sorts of things. It was hysterical. It got me thinking about how we might be missing an opportunity to really harness what's out there. (Richardson, 2012)

Vice Admiral Richardson wanted to reinvigorate the emphasis on human systems integration and the design of intuitive decision-centered displays, but an organization that devises a six-page instruction manual for an iPod has, at best, a tenuous grasp on intuitive design. An example of this disconnect occurred during a conference where the next version of the submarine digital navigation system was on display. The 2010 system had left quite a bit to be desired. By all accounts, it was slow, difficult to manage, and counterintuitive (Richardson, 2012). When Richardson examined the navigation system that would replace it, the new system did prove to be a bit faster and could show digital charts a bit better, but Richardson began to think about products like Google Maps and Google Earth (Richardson, 2012). Richardson reasoned that if users walked up to a digital navigation system that had the same controls, look, and feel as Google Earth or Google Maps, they could be up and running in no time and there would be no need to send a sailor to a multi-week school just to learn how to navigate the system (Richardson, 2012). This idea of intuitive interfaces easing the training burden and improving performance would resonate with many in the submarine world, but none so much as the newest members of the submarine community.

The current generation is a demographic cohort immersed since birth in an explosion of access to information and new technology. These members of the aptly named millennial generation think and process information fundamentally differently from their predecessors (Carr, 2011). The average millennial college graduate has spent fewer than 5,000 hours of their lives reading, but over 10,000 hours playing video games and 20,000 hours watching TV (Prensky, 2001). American author and educator Marc Prensky (2001) coined the term "digital native" to describe the millennial generation and their ability to naturally understand the digital language of computers, video games, and the Internet. Vice Admiral Richardson saw the digital natives of the millennial generation come into the submarine force with "well-honed skills in modern information management inherent in gaming interfaces, multi touch devices, smart phones and tablet computers" (2012).

The intuitive design of products like Google Maps, Google Earth, and the Apple iPod are the result of billions of dollars in research and development (R&D) investments by commercial industries (see Figure 20). These R&D efforts have pushed technology into the market and seen consumers move exponentially forward with new tools to access and manage information. The commercial sector has moved from mainframe to desktop to laptop to tablet, from Internet connectivity to mobile connectivity, and from trackball and mouse to multi-touch and Kinect (Richardson, 2012).

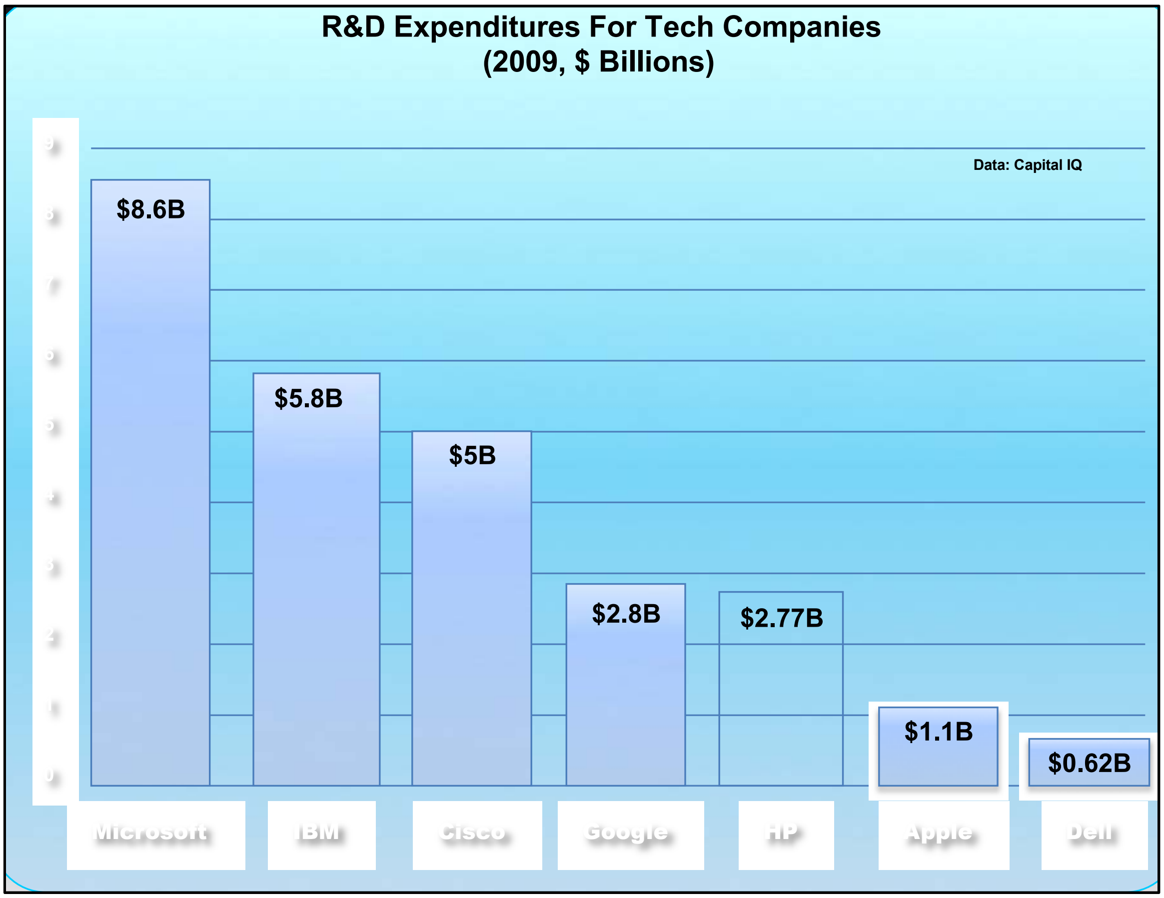

Figure 20. Research & Development Expenditures for Tech Companies
(Richardson, 2012)

Consumer-oriented companies’ R&D investments shoulder both the costs and the risks involved in introducing intuitive interface designs into the marketplace. Richardson wanted to find areas where the submarine Navy could “fast follow” industry and take advantage of these commercial R&D investments and risk reductions by adapting commercial designs to submarine systems (Richardson, 2012). The ARCI program had been fast following commercial trends in processing horsepower and computer development for almost 15 years. They had taken advantage of Moore’s Law and pushed signal-processing capability as far and as fast as possible. Richardson championed developing partnerships with industry leaders to leverage their advances in technology and apply those advances to the submarine Navy (Richardson, 2012).

In May 2011, Richardson attended a seminar hosted by Corning Glass at Stanford University. At this seminar were the chief technology officers from industry leaders like Corning, Microsoft, IBM, CISCO, Adobe, Google, Verizon, and Sharp Technologies (Richardson, 2012; Stapleton, 2013). These companies had proven innovative processes that were both agile and more capable than the institutional Navy's could ever hope to be. Richardson soon discovered that many of these U.S. industry leaders were excited to share their discoveries and eager to find ways they could help the submarine Navy apply commercial solutions to their problems (Richardson, 2012).

In order to leverage the opportunities offered by fast following industry and to exploit the submarine community's organic digital-native assets, Richardson would challenge the Advanced Development community to incorporate commercial designs into the submarine's tactical systems and to access the millennial generation's innate proficiency with technology (Richardson, 2012).

2. Leading the Charge

The Commander, Submarine Forces' challenge to leverage industry and exploit the organic millennial-generation assets of the submarine community was answered through a proposal drafted by a former submarine junior officer. The answer was simply to conduct a forum that would give voice to the ideas of young submariners. This simple idea matured into the Tactical Advancements for the Next Generation Forum.

Even before Richardson's call to action, several members of the submarine community had been looking to exploit the innate skill sets that millennial-generation sailors brought with them when they joined the Navy. One of the biggest proponents was the newly appointed Commodore of Development Squadron Twelve, Captain Bill Merz. Merz would take up the charge of leveraging the sailors' experience with commercial products to develop the next generation of tactical systems interfaces. Merz summarized the problem as follows:

> I looked at our sonar and combat system displays then looked at the interface on my iPhone and my son's XBOX360 and said to myself, what are we [the submarine force] doing to take advantage of the years of "training" that your [the millennial-generation sailors] experience with iPhones and gaming systems provide? (B. Merz, personal communication, November 1, 2011)

As the head of the Submarine Tactical Requirements Group, the entity responsible for prioritizing requirements for the APBs, Merz was in an ideal position to implement Richardson's strategic direction. Merz' challenge lay in turning that strategic vision into an operational reality. Unknown to Merz at the time, a plan for that transition had been hiding in plain sight at Johns Hopkins Applied Physics Lab in Laurel, MD.

The Applied Physics Lab (APL) is a division of the world-renowned Johns Hopkins University. APL is a not-for-profit center for engineering, research, and development that was organized in 1942 to develop critical technologies for World War II (Johns Hopkins Applied Physics Lab [JHU/APL], 2013). APL has a long history of tackling complex research problems for many government agencies. Their contributions to the submarine Navy are both long and storied. APL was a lead agency in the blue-ribbon Submarine Superiority Technical Panel that was commissioned in the mid-1990s and was pivotal to the success of the ARCI program. APL's Dr. John Stapleton was responsible for the WSTA program that had defined the measure of ROI for the submarine system upgrades.

The APL facility in Laurel, MD, is a beautiful campus that sprawls across 399 acres and holds more than 20 buildings (JHU/APL, 2013). In Building 9's labyrinth of white-painted cinder block halls that could only be described as "bunker-chic," sits the cramped offices of the co-chairs of the Program Executive Office for Integrated Warfare Systems Advanced Development (PEO IWS5A) Operator–Machine-Interface Working Group, Josh Smith and Don Noyes. Smith, a former submarine lieutenant and Noyes, a retired acoustic intelligence master chief petty officer, would soon add to APL's long list of innovative and revolutionary accomplishments.

Noyes had retired from active service and joined APL in April 2005. Smith had left active service and joined APL in 2008. The two had first met in February 2007 during the initial WSTA evolution. At the time, Noyes was heading APL's operator–machine-interface working group and had participated in the simulation as a SME. Smith, an active duty lieutenant at the time, was serving as an instructor at the Submarine Learning Center in San Diego, CA (Smith, 2012a). Smith (2012a) had been drafted to serve as a watch station officer in the simulation by his former USS *Corpus Christi* commanding officer, Captain Marc Denno.

In 2007, Denno was serving as the Submarine Development Squadron Twelve Chief of Staff. Denno was one of the forward-thinking leaders in the submarine community who had been looking for ways to exploit the innate skill set of the millennial-generation sailors (Smith, 2012a). A brutally honest and direct man, Denno is an engaging and charismatic leader with a firm grasp on the potential of the millennial generation. From as far back as his days as commanding officer of the *Corpus Christi*, Denno had been arguing that the younger generation has grown up accustomed to a massive influx of information, and they not only expect access to that information, but they expect that information to grow (Smith, 2012a). Denno had been preaching the idea that displays that are hard to teach just waste people's time and that "innovation is a young man's game" (Denno, 2013).

In April 2010, Smith sent Denno a draft of an idea that Smith believed would address Denno's concerns and answer the problems that the submarine development community was wrestling with (Smith, 2010a). By June 2010, Smith had published his argument that outlined how the Navy should capitalize on the ideas of its junior members (included as Appendix 2). Smith proposed a forum comprised of hand-selected junior officers (JO) and junior enlisted submariners to tap into their recent tactical experience and to "obtain ideas for training, technology, task flows, system deficiencies, lessons learned, and other concepts from their perspective" (Smith, 2010b, p. 1).

A "JO" is defined as the lowest three ranks of the Navy's Officer Corps: Ensign (O-1/Ens), Lieutenant, Junior Grade (O-2/LTjg), and Lieutenant (O-3/LT). The junior naval enlisted members are comprised of the Non-Rates (E-1–E-3), Third Class Petty Officers (E-4/PO-3), Second Class Petty Officers (E-5/PO-2), and First Class Petty Officers (E-6/P-O1). Smith's (2010b) argument contended,

> The Navy invests a great deal of time, money, and energy to train Junior Officers, and after acquiring some tactical experience, Junior Officers develop a great understanding of current issues. JOs are the "barometer of the health of the future force," they have recent tactical experience, and are prime candidates for understanding how the development community can leverage today's technologies, but we are not tapping into them as a resource to understand where the Navy and combat systems can improve in the future. (Smith, 2010b)

Smith would go on to argue that the millennial-generation submariners were constantly interacting with iPhones, Facebook, Twitter, SMS, XBOX360, iMacs, iPads, and a laundry list of other commercial products. If the Navy could combine this interaction experience with the junior submariners' recent operational and deployment experiences, these junior members of the submarine community would make ideal candidates for explaining to the development community how the submarine Navy could leverage today's technologies (Smith, 2010b).

While the argument had gained traction in the halls of APL, the idea of a conference devoted to junior officers and junior enlisted sailors was regarded with a great deal of skepticism. Geoff Brown (2012), a public affairs specialist for APL explained,

> Navy leaders were about to ask the sailors an unusual question: "What do you think?" of junior officers (lieutenant or below) and enlisted sailors (petty officer first class and below). This would be like the CEO of a Fortune 500 company asking junior executives how they thought the company could be improved. (2012)

In 2010, absent the forcing function necessary to devote the time, energy, effort, and funding to convene a Junior Officer Conference, Smith's paper was just another good idea waiting to be noticed. That idea would surface when APL presented Smith's paper as an answer to Vice Admiral Richardson's May 2011 call to action.

In June 2011, Dr. John Stapleton would brief Smith's idea of a Junior Officer Conference to Vice Admiral Richardon, Commodore Merz, and Mr. Pete Scala, the Integrated Warfare System Director for Advanced Development (S. A. Tupper, personal communication, February 15, 2013). Smith's idea was well received, and Merz and Scala agreed to co-sponsor the plan (Stapleton, 2013). Smith and Noyes were given the green light to execute what would become the Tactical Advancements for the Next Generation (TANG) Forum.

3. Coordinating Tactical Advancements for the Next Generation

Through a series of cold calls to industry leaders, the plan for conducting the TANG Forum began to emerge. The most fortuitous connection made through these cold calls was to the design consultancy firm of IDEO. IDEO would come aboard and introduce the principles of design thinking into the TANG initiative.

Combining Smith's ideas with Richardson's call to action, the TANG planning process was initiated through a series of cold calls to industry leaders. One of the first calls was to the host of the May 2011 Stanford University seminar, Corning Glass. In a serendipitous turn of events, the man the APL team would reach was Corning Glass Director of Commercial Technology Paul Tompkins. Earlier that week, Wendell Weeks, the chief executive officer of Corning Glass, had directed Tompkins and his team to "go find something patriotic to do" (Stapleton, 2013). This corporate directive served the needs of both Corning and the TANG initiative and was clear evidence of Richardson's claim that industry leaders were excited to share their discoveries and eager to find ways they could help the submarine Navy apply commercial solutions to their problems.

The next cold call went out to Microsoft, and they were even more excited to support the Navy in its efforts (Stapleton, 2013). Microsoft volunteered to send a representative to the TANG Forum to display its current technologies and to present the technologies that were under development (Smith, 2012a). A series of additional cold calls to industry leaders resulted in the TANG Technology Expo. This Expo was designed to kick off the TANG Forum and introduce the TANG participants to what was already available in the commercial world and what these industry leaders were currently developing. This introduction would invite the TANG participants into what Smith and Noyes had termed, "the art of the possible" (Smith, 2012a). APL was developing the partnerships with industry that Richardson had understood to be so vital to advance the submarine systems.

Perhaps the most fortuitous and impactful industry partnership of the entire TANG Forum occurred through a referral made by APL Undersea Warfare Business Area Executive Lisa Blodgett (Brown, G., 2012). Blodgett had been following the TANG evolution and recalled a book published by former Disney creative leader Eric Hazeltine. *Long Fuse, Big Bang: Achieving Long Term Success Through Daily Victories* was Hazeltine's (2010) treatise on how our short-term, "put-out-the-fire" mentality makes us miss opportunities that come from long-term thinking. Hazeltine, who had recently left the National Security Agency (NSA), sat down with Blodgett, Stapleton, and the government sponsors to discuss innovation and the TANG project (Blodgett, 2012). Hazeltine recommended that the TANG coordinators explore the field of industrial design and suggested that they reach out to the innovation and design consultation firm, IDEO (Blodgett, 2012).

IDEO is a pioneer in the world of design thinking. IDEO defines design thinking as "a generative approach to innovation that constantly drives toward tangible, human centered outcomes" (IDEO, 2009). IDEO CEO Tim Brown and IDEO.org Executive Director Jocelyn Wyatt explain design thinking as follows:

> Design thinking is a deeply human process that taps into abilities we all have but get overlooked by more conventional problem-solving practices. It relies on our ability to be intuitive, to recognize patterns, to construct ideas that are emotionally meaningful as well as functional, and to express ourselves through means beyond words or symbols. Nobody wants to run an organization on feeling, intuition, and inspiration, but an over-reliance on the rational and the analytical can be just as risky. Design thinking provides an integrated third way. (Brown & Wyatt, 2010)

For IDEO, design thinking is *human centered* and the "spaces" where the design-thinking process unfolds occur non-sequentially and differ vastly from the traditional linear model and milestone-based processes of most organizations (Brown & Wyatt, 2010). Human-centered design exists at the hub of technology, business, and human values (see Figure 21; d.school, 2013b). Human-centered design begins with a specific design challenge. Designers forge a path that begins with concrete observations about people, then moves to abstract thinking as insights and themes are uncovered, and then loops back to the concrete as tangible solutions are created (IDEO, 2009).

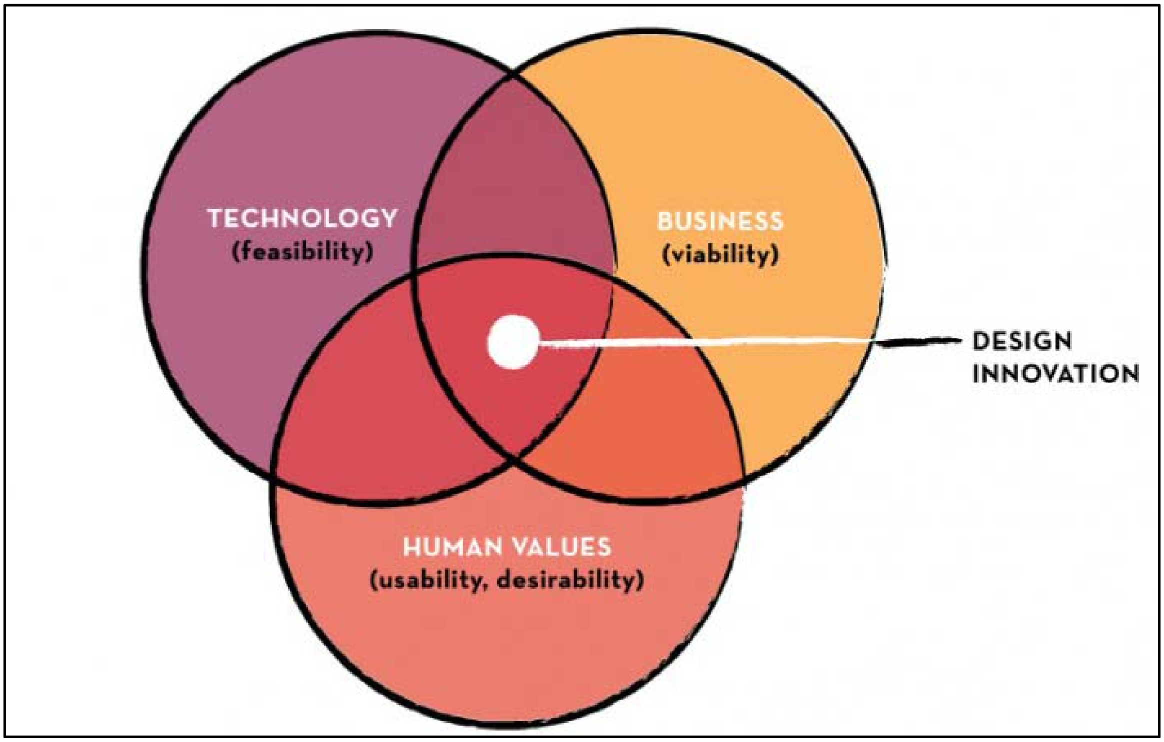

Figure 21. Hasso Plattner Institute of Design at Stanford Design Innovation Diagram
(d.school, 2013b)

The design firm IDEO approaches human-centered design through three main phases: *hear*, *create*, and *deliver*. In the *hear* phase, the design team prepares for field research by collecting stories and creating a contextual relationship between the users and their everyday life. In the *create* phase, the design team collaborates through a workshop format to translate what they had heard into frameworks, opportunities, solutions, and prototypes (IDEO, 2009). In the *deliver* phase, the design team takes the ideas and prototypes generated in the create phase and develops them into tangible solutions.

Engaging IDEO and their design-thinking methodologies to facilitate the TANG Forum was met with a mixed response by the establishment. There were several people involved in organizing the TANG Forum that were intrigued by IDEO's unique approach to problem solving. Others, however, were extremely skeptical of both the abstract notions of the design-thinking approach and of IDEO itself. When the tried-and-true standard of the rational, empirically driven, and analytical engineering approach is compared with the ephemeral notions of design, both design thinking and IDEO's methodologies were legitimately called into question.

This questioning, combined with persistent grumblings over the utility of using junior sailors to design submarine systems, came very close to ending IDEO's involvement in the TANG Forum before it even started. Amidst this skepticism and negativity, the APL took a leap of faith and reached out to IDEO by cold calling their New York offices. What followed was a series of meetings between IDEO and the APL. According to IDEO Vice President of Client Advocacy David Haygood, during these meetings, the IDEO representatives would introduce the principles of design thinking and explain how their methodologies could address the solutions the submarine force was looking for (Haygood, 2012). These meetings provided the clarity that would mollify the fears the resistors had been grumbling in the sponsors' ears about and serve to establish a high level of faith, trust, and confidence in both IDEO and their design-thinking process. Dr. John Stapleton explains,

> We had a great first meeting with IDEO. They were completely unpretentious, they were confident about what they could and couldn't do, very willing to learn about our problem space, and very interested in a partnership that played to everyone's strengths. (Haygood, 2012)

In August 2011, the decision was made to hire IDEO and on September 1, 2011, IDEO received the necessary security clearance for their design team to participate in the TANG initiative. This decision to engage IDEO was endorsed by the APL coordinators, the upper management of APL, the leadership at Submarine Development Squadron Twelve, the leadership of the Integrated Warfare System Director for Advanced Development, and Vice Admiral Richardson. The decision to move forward and bring the IDEO consultancy aboard would further invigorate the already-energized planning behind the TANG Forum.

4. Hear—Create—Deliver

IDEO conducts ethnographic research of the submarine community and introduces the principles of design thinking to develop the TANG Forum. The design-thinking process utilizes an iterative approach. In order to design the conduct of the TANG Forum, IDEO and the TANG coordination team would execute a dry run of the TANG Forum.

IDEO was engaged to consult on ways to improve the situational awareness of submarine watch teams and to leverage the technological acumen of the submarine forces' millennial-generation assets. From September 7–16, 2011, IDEO conducted ethnographic research that consisted of interviews and a tour of the Lockheed Martin facility in Manassas, VA, as well as tours of the waterfront and a Virginia-class submarine. As they conducted this research, the design team continuously refined its interview methodology. This iterative process was driven by the design team's growing insights into how submariners interacted with their systems and one another. The process evolved as the team's contextual understanding of the submarine culture deepened.

During this research evolution, the IDEO team was introduced to several handpicked SMEs involved in the submarine development community. The design team engaged these SMEs and trained them in IDEO's unique brainstorming process and its seven simple rules (see Figure 22).

TIP

SEVEN BRAINSTORMING RULES

» **Defer judgment**
There are no bad ideas at this point. There will be plenty of time to judge ideas later.

» **Encourage wild ideas**
It's the wild ideas that often create real innovation. It is always easy to bring ideas down to earth later!

» **Build on the ideas of others**
Think in terms of 'and' instead of 'but.' If you dislike someone's idea, challenge yourself to build on it and make it better.

» **Stay focused on topic**
You will get better output if everyone is disciplined.

» **Be visual**
Try to engage the logical and the creative sides of the brain.

» **One conversation at a time**
Allow ideas to be heard and built upon.

» **Go for quantity**
Set a big goal for number of ideas and surpass it! Remember there is no need to make a lengthy case for your idea since no one is judging. Ideas should flow quickly.

Figure 22. Seven Brainstorming Rules
(From IDEO's HCD Toolkit; IDEO, 2009)

Adherence to these rules creates the space necessary for individual participants in the brainstorming session to express and expound on their ideas and for everybody else in the group to positively support one another through an active listening and engagement process. In order to ensure the free flow of ideas is captured, IDEO makes extensive use of Post-It notes. Post-It notes provide an excellent mechanism for recording and retaining ideas as they are presented during the brainstorming session. They also serve as a modular framework that can help reveal patterns. Conducting a post-brainstorming synthesis of the ideas and the patterns that arise during the brainstorm enables designers to develop insights into the core elements of the problems (see Figure 23).

Figure 23. TANG Forum Synthesis
(Smith, 2012a)

This training of SMEs in brainstorming served the dual purpose of introducing SMEs to the design-thinking process and of preparing these technical experts for a future role as co-facilitators during the TANG Forum. The selection of the SMEs for the TANG Forum was conducted through a joint effort of IDEO, APL, and Submarine Development Squadron Twelve. IDEO recommended an interdisciplinary team with T-Shaped people (IDEO, 2012). Being T-Shaped describes an individual with a deep knowledge base in a specific critical area (the stem of the "T") and a broad base of both experience and generalizable knowledge, which includes the high degree of empathy necessary to understand and pursue a focus on human-centered design (the crosspiece of the "T").

The four SMEs that fit the bill and would be tagged to facilitate the TANG Forum were TANG Coordinator Don Noyes; Andy Leal, a retired submarine officer with extensive APB experience and a senior systems engineer with the Lockheed Martin Corporation; Ray Rowland, the director for advanced information design at the NUWC; and Josh Hausbach, an active junior officer who was assigned to the Schoolhouse in Groton as part of the submarine Modernization Training Team (Smith, 2012a).

IDEO, the TANG coordinators, and the newly identified SMEs worked diligently to prepare for the forthcoming TANG event. This preparation, like the interviews, the visits, and the selection of the SMEs had followed IDEO's design-thinking rubric. This immersion in design-thinking methods served to familiarize the event organizers with the IDEO process and to formulate the plan to execute TANG. Part of that plan would be to host a dry run for the TANG event to shake out event details and to create space for the continuing iterative refinement of the TANG process.

The dry run took place on September 20, 2011, and was hosted on the Naval Submarine Base in Groton, CT. The nine junior officers and enlisted sailors who participated in the dry run were culled from the boats on the waterfront. This small-scale version of the TANG Forum drove the participants through the design-thinking process by having them learn the brainstorming rules, conduct brainstorming sessions, and then produce low-fidelity prototypes of their solutions with simple arts-and-crafts materials like Post-It notes, markers, popsicle sticks, cardboard, foam core, scissors, and yarn (Smith, 2012a).

Prototyping is an essential part of the design-thinking process. Prototypes allow participants to turn ideas into physical constructs and interact with them in a visceral way (see Figure 24). Evaluating possibilities through prototyping allowed the participants to visualize what their ideas would look like, how they would behave, and how they could work. People respond to tangible objects and experiences on a much deeper level than they can with just expository writing (IDEO, 2012).

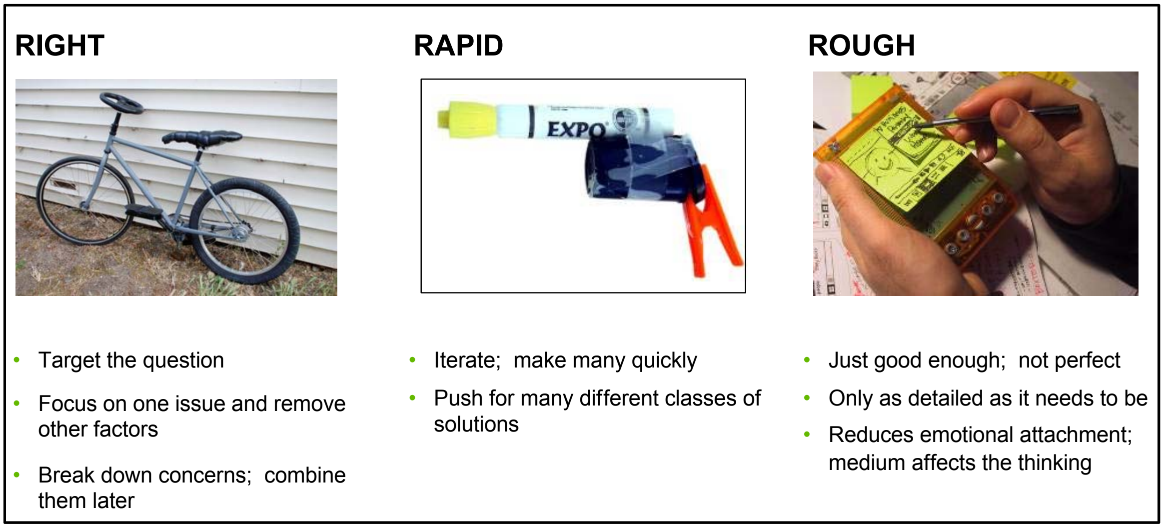

Figure 24. What Makes a Good Prototype
(IDEO, 2012)

Neither the TANG planners nor the commanding officers of the boats these nine sailors had come from had informed the sailors about what they were reporting for or why. As would be expected, when the sailors checked into the TANG dry run, there was a great deal of initial skepticism from the participants. Pulling sailors off their boats and telling them to have kindergarten arts-and-crafts time is a dubious proposition. The problems matured when the sailors were told why they were involved and what they would be doing. The entire idea that they were being invited to help "fix" the problems of the submarine force was almost impossible to believe. Their exasperated replies would argue, "What makes you think they will listen to us?" "What can we do?" and "This is not going to go anywhere" (Smith, 2012a).

Once again, the design-thinking process and the IDEO methodologies would transform apathy into excitement and exasperation into wonder. Once the sailors underwent the design-thinking process of the dry run, their imaginations began to define and address the underlying problems the submarine Navy was facing. This prototype dry run event stimulated an even-broader understanding for the TANG planners and served to further refine their method to engage participants in the TANG Forum.

One of the unique aspects included in the design of the dry run was the "plenary room." TANG coordinators Josh Smith and Don Noyes were fully aware of the creeping skepticism and continued grumblings of resistance to IDEO and the TANG project (Smith, 2012a; Noyes, 2012). Having experienced several of the epiphanies that had converted skeptics into believers, Smith and Noyes contrived to have a one-way closed-circuit observation room for the TANG dry run. This "plenary room" was provided so senior leadership could witness the dry run without running the risk of having them interfere directly with the conduct of the design-thinking process. This "plenary room" concept would serve to not only turn skeptics into champions but also stir the senior leadership witnessing the event to begin brainstorming ideas and adopting the design-thinking approach themselves (Noyes, 2012; Smith, 2012a). This "plenary room" concept was such a success that it was incorporated for use in the official TANG Forum.

One of the biggest ideas generated during the dry run was mirrored in a comment made by Vice Admiral Richardson to the Naval Warfare Development Command:

> Our challenge was that the complexity is increasing but our form factor is not. Our submarines are not getting bigger. We are not getting more people. In fact it's probably trending the other way. This is just the world. It would be great if you could simplify it, but the enemy and the world gets a vote and this is just the facts of our life. (Richardson, 2012)

The big idea was to construct a model that outlined the confines of a Virginia-class nuclear submarine command room for the TANG participants to interact with during the forum. The encouragement of wild ideas could stimulate the conversation, but it could not change the size of the submarine. This model was a means to focus the TANG participants on the displays rather than attempting to rebuild the submarine structure. This physical model was constructed of nothing more complicated than PVC pipe, string, and foam core (Figure 25) but would serve as a contextual constraint for the TANG participants to flesh out and present their ideas.

Figure 25. TANG Forum Control Room Mock-Up
(Smith, 2012a)

The dry run would add to the TANG planners' general fund of knowledge and refine the conduct of the TANG event. The dry run also served to create insights into which arts-and-crafts prototyping materials could best serve the participants' needs (Smith, 2012a). One of the biggest lessons gleaned from the dry run was the role of the SME as co-facilitator. The major role of the SME as co-facilitator was to ensure that the participants' conversations were steered away from a purely technical focus in order to maintain the discussion around human-systems interactions (Noyes, 2012; Rowland, 2012). This redirection would need to be subtle enough to not interfere with the participants' brainstorming efforts but direct enough to keep the participants from drilling down to such a high level of technical granularity that the human part of the system would be subsumed. In an analytical- and engineering-focused culture like the submarine community, this was an extremely easy rabbit hole to fall down. Armed with the insights gleaned from the ethnographic research and the results of the dry run, the TANG team was ready to undertake the challenge of the TANG Forum.

5. Tactical Advancements for the Next Generation Forum 2011

Vice Admiral Richardson and Rear Admiral Caldwell, the Commander, Submarine Forces Pacific Fleet, called on the submarine squadron commanders to nominate their best and brightest young officers, sonar men, and fire control operators to participate in this innovation workshop (Richardson, 2012). The participants in the forum were lieutenants and junior enlisted operators with recent deployment experience that had been hand selected by the Commodore, Development Squadron Twelve, and by the respective squadron commodores of the operational fleet (Richardson, 2012).

In total, 27 sailors representing all of the different submarine platforms, homeports, and software builds would be invited to San Diego, CA, to participate in the inaugural TANG Forum (Smith, 2012a). Commodore Merz sent out a welcome letter to the invitees that concluded,

> You're going to participate in a series of workshops and brainstorming sessions designed to wring out new ideas for "how might we" better design, use and operate our tactical systems. We've brought in a group of innovation experts from IDEO, a leading design consulting firm, to help the brainstorming process. We've brought in demonstrations and exhibits from Microsoft and other commercial leaders to demonstrate the "next generation" of commercial capabilities to stretch your horizon on the "art of the possible." And most importantly, we've brought in you, away from the boat distractions, to help create fresh ideas. You were specifically chosen because of your unique balance of motivation, experience, and connection with the digital generation—hopefully to bridge the gap between what we have and what you want. Next week will be unlike any military event you've been through before. Next week there are no wrong answers. Next week there are no uniforms. Next week is about new ideas. (B. Merz, personal communication, November 1, 2011)

This motivating message would set the stage for the TANG event. Of particular note was that the participants were told to report in civilian attire. This may seem inconsequential to the civilian population, but the civilian attire was indicative of the fundamentally different atmosphere and environment that the TANG participants were entering.

Much of the planning and logistics coordination conducted by Smith and Noyes would revolve around making the participants feel comfortable and, for lack of a more suitable term, “special” (Smith, 2012a). Smith and Noyes’ attention to detail included having the non-local participants greeted individually at the airport by support staff holding placards bearing the participant’s name. From the airport, participants were chauffeured to the Hilton Hotel in the Gaslamp District of San Diego, CA, where they would stay for the duration of the event. This is a far cry from the usual procedure of arriving at the airport in the middle of the night and either paying out of pocket for a cab that takes unfamiliar Service members on a 25-mile tour of a10-mile route or running through airport terminals in a desperate search for Terminal 2’s Uniformed Service Organization and, hopefully, sharing a seat on a discounted shuttle to one of the half dozen naval facilities in the San Diego area. This and other subtle “special treatment” was carefully designed to ingrain in the participants that they were, indeed, part of something new and uniquely different (Smith, 2012a).

The TANG Forum officially began on the evening of Monday November 7, 2011, with a social gathering of the TANG participants at the San Diego Hilton Hotel. TANG was structured as a three-day event and was conducted in the meeting spaces of the Submarine Learning Center. On Tuesday morning, November 8, 2011, the first speaker for the TANG Forum was Bruce Harris, a technical evangelist in Microsoft’s Institute for Advanced Technology in Government. Harris kicked off the event with a talk about how government agencies needed to consider today’s young workforce and how this generation was far more digitally advanced than the older generations and had a dramatically different learning style (Smith, 2012a). This speech reinforced the theme of the participants’ “specialness” and served to set the tone for the entire event. Harris was followed by the welcoming remarks of Vice Admiral Richardson. Richardson outlined the mission of the TANG Forum:

> I challenge you to arrive at better ways to synthesize the data from around the ship and come up with some displays that will allow us to be better decision makers. (Richardson, 2011)

IDEO took the stage and talked to innovation and introduced their brainstorming process. The participants were divided into three teams of nine and were ushered into separate breakout rooms with the IDEO facilitators and the SME co-facilitators to begin their first brainstorming session. A fourth room was dedicated to an executive session where, just like the "plenary room" of the dry run, a closed-circuit one-way video feed allowed the senior leadership to monitor progress without interfering in the process.

The breakout teams took the titles: Team Barb, Team Tautog, and Team Parche in honor of the famous World War II submarines that bore those names (see Figure 26; Smith, 2012b).

Figure 26. TANG Forum Team Structure
(Smith, 2012b)

Outside of the breakout rooms, the Tech Expo was set up for all three days of the event (Smith, 2012a). After completing their first brainstorm session, each group was taken in turn through the Tech Expo to interact with the industry gear. Microsoft had brought an array of multi-touch technology and the latest of their Kinect developments. A particular highlight from the Microsoft display was a flight simulator software application that could control the aircraft via the Kinect interface. Metron, a defense consulting company with expertise in graphical interfaces, displayed a series of tablet applications and the versatility of data mobility. In Depth, an industry leader in software development with strong ties to ARCI, displayed multi-touch tables and an astounding array of possibilities available to manipulate navigation data (Smith, 2012a).

The planned composition of the teams and the original schedule of TANG morphed as the iterative design of the TANG process found new insights and new opportunities to explore. The changing team composition and changing schedule addressed the central insights that were being developed as the forum unfolded (Noyes, 2012; Smith, 2012a). The TANG Forum generated several innovative ideas using the design-thinking process (Richardson, 2012).

The teams prototyped their idea using foam core, glue guns, construction paper, and tape and presented their ideas in a physical form and shared their concepts with the other teams in a forum-closing skit event. This creative outlet enabled the teams to turn kindergarten supplies into future displays and innovative concepts. The TANG Forum produced a stream of "big ideas" on which the submarine Navy would build tomorrow's designs. A few of the most popular conceptual ideas to emerge from the TANG Forum are included as Figures 27 through 30.

6. TANG Outcomes

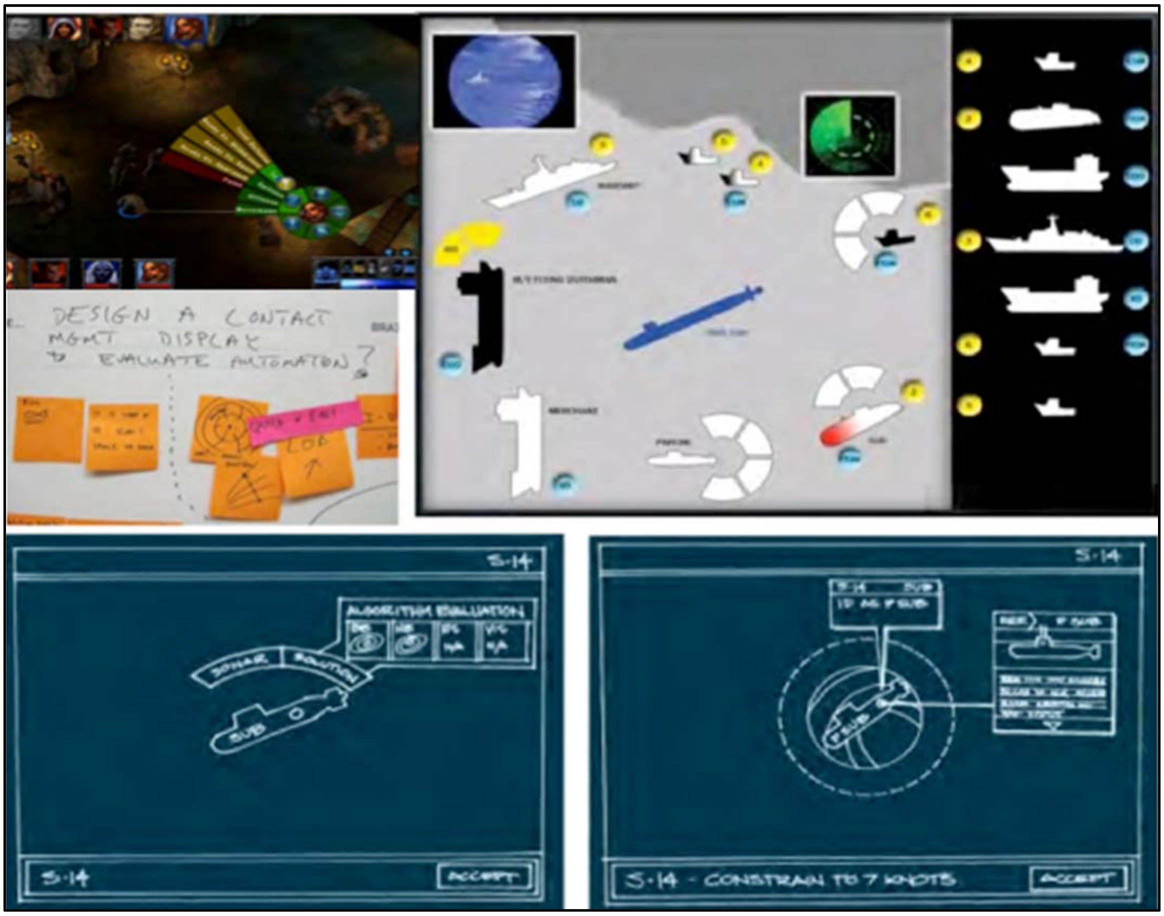

Figure 27. TANG Forum Common Object Oriented Layered Geo

Note. Rather than the existing multitude of disparate system displays, the TANG participants devised a single system that would layer information and provide data-rich icons with radial menus borrowed from the gaming industry (Smith, 2012b).

Figure 28. TANG Forum Data Mobility: Go-Anywhere Tablet (GAT)

Note. The TANG Forum's image of a Go-Anywhere Tablet would allow the operator to unchain himself from his work station console and grant him the freedom to move throughout the boat while maintaining continued access to information and displays (Smith, 2012b).

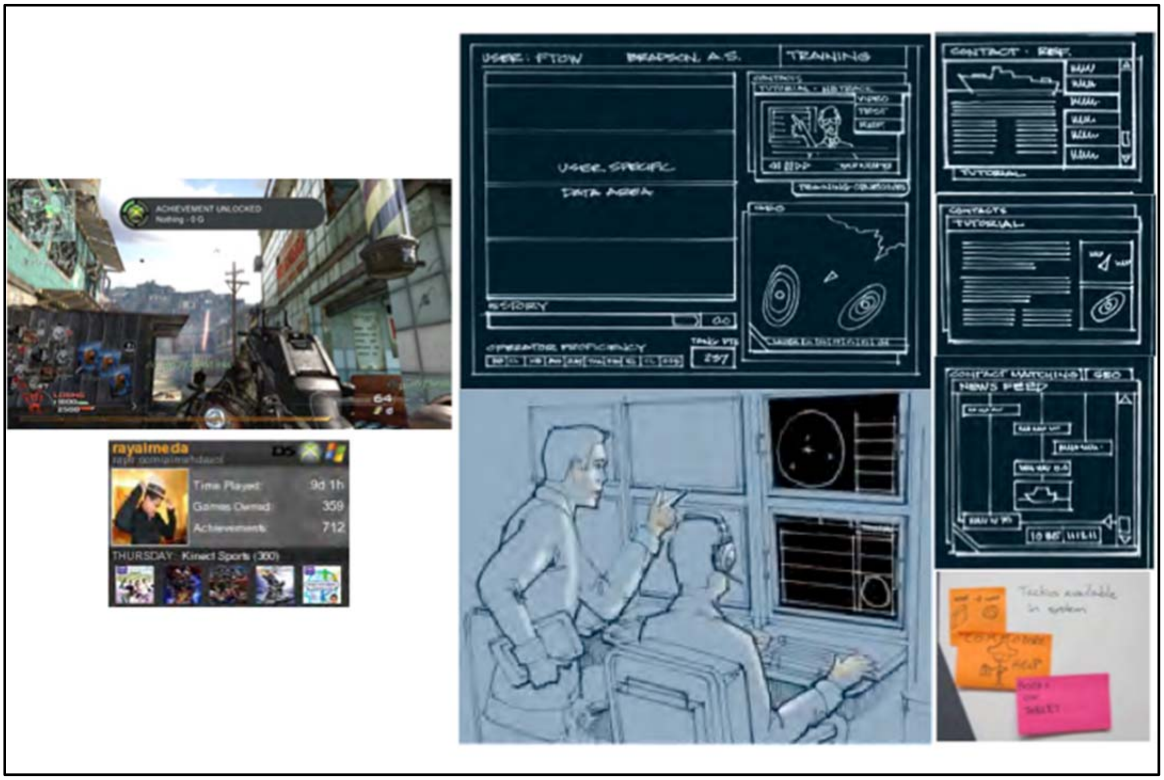

Figure 29. TANG Forum Proficiency and Training Tracking System

Note. One of the most time-consuming functions in the military is the hours of necessary qualification training. One of the most frustrating occurrences is when a military member completes a duty cycle performing a specific job and then must report for training on the very task he had spent the past eight hours performing. The TANG Forum developed a system that would allow them to accrue points for completing training modules or guided work flows or for successfully carrying out certain real-world missions. The operator would also achieve similar "experience points" for other qualifications throughout his career. Being able to take credit for completing different tasks on duty would immerse the operator in an environment that created a system where operators would truly "train like they fight" (Smith, 2012b).

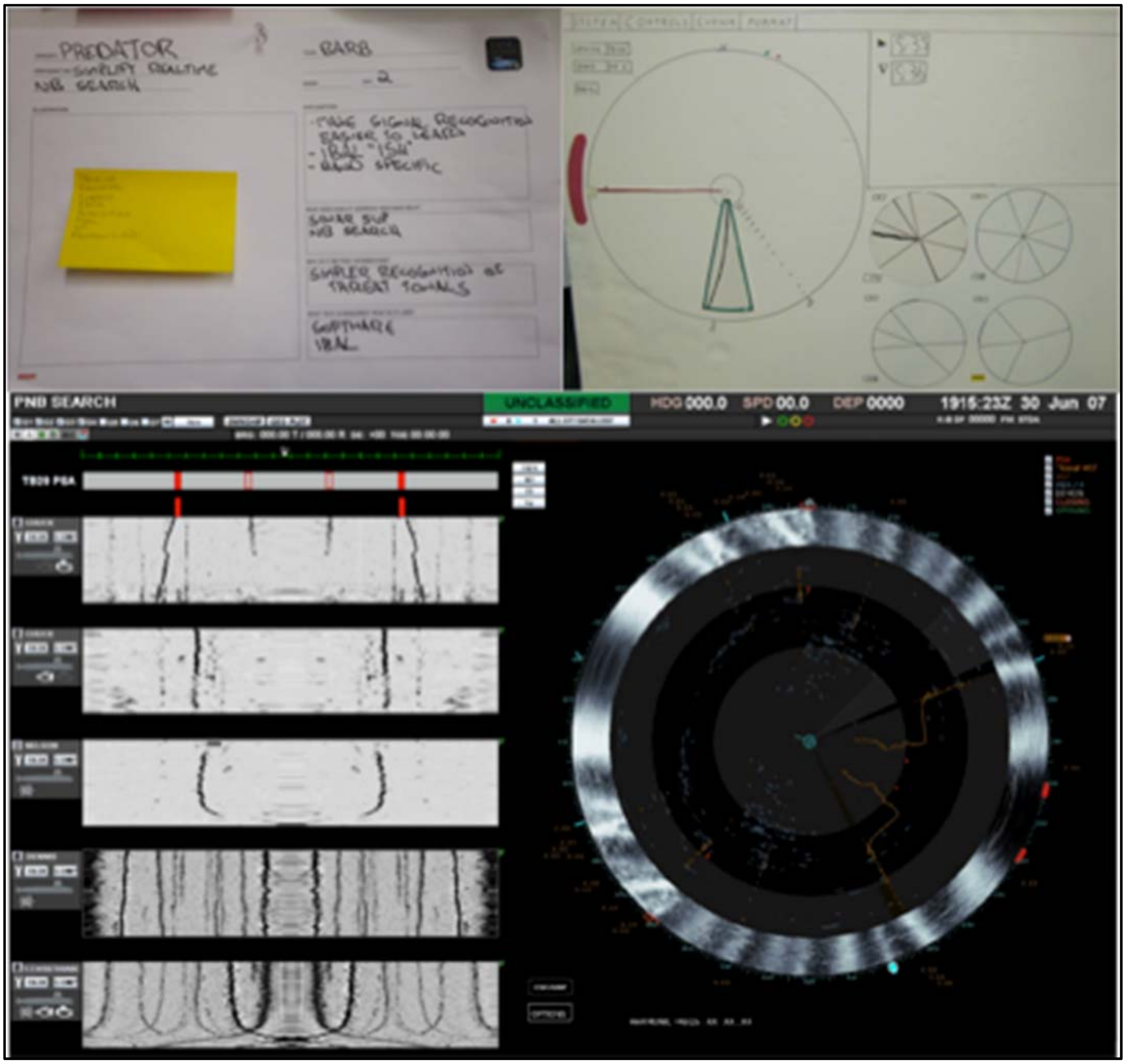

Figure 30. TANG Forum Predator Display

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Note. The ideas for displays that emerged from the TANG Forum married the needs of the operator to the needs of the decision-maker. In a groundbreaking discovery unearthed by the TANG Forum, the simple idea of presenting data in an intuitive radial format emerged in the Predator Display (Smith, 2012a). This display is by far the most striking outcome of the TANG Forum. This concept was so compelling that by January 2012 developers from PEO IWS5A would take the conceptual idea from its literal origins as a pizza box prototype to a physical construct running real sonar data in Step 2 testing (Richardson, 2012; Rowland, 2012).

7. Concept User Experience Events

In order to transform the conceptual ideas that had emerged from the TANG Forum, the team of Josh Smith and Don Noyes used the principles of design thinking to create a series

of contextually rich mini-TANG events to develop and mature the concepts into physical constructs. These Concept User Experience events were a participative effort between the fleet, the developers, the test team, the training team, and the human-factors experts.

The TANG Forum had created a forum where the tenets of design thinking were used to give voice to the fleet's digital natives. The TANG initiative had enabled the creative capacity and innate skill set of the millennial-generation operators and elicited from them soluble needs and desires to attack what Vice Admiral Richardson had called the "avalanche of information" (Richardson, 2012). The TANG outcomes had given the APB development teams new insights into their design of operator–machine interfaces. The TANG Forum had created a new level of excitement and energy for the operator community and granted them an actionable stake rather than a limited evaluative role in the development process. The TANG participants had generated the "big ideas" necessary for innovation, but those big ideas needed to be put into the appropriate context to foment true understanding between the fleet operators, the system developers, the test teams, the training community, and the human-factors experts (Smith, 2013).

Smith and Noyes, now well trained by IDEO and experienced in human-centered design methodologies, created a process to move the TANG Forum's "big ideas" from concept to reality. Smith and Noyes constructed a methodology to foster contextual understanding between multiple stakeholders. This design-thinking process came to be called Concept User Experience Events (CUE2). CUE2 (which is colloquially pronounced by adding an extra "e" as *QUEUE-e-two*) used the design-thinking process to conceptualize, refine, and iterate operator–machine interface design ideas for inclusion in APB for 2013 (Smith, 2013). The CUE2 process follows an iterative path that can be best equated to the conduct of multiple mini-TANG events and has been modeled off of a "Double Bubble" concept (see Figure 31).

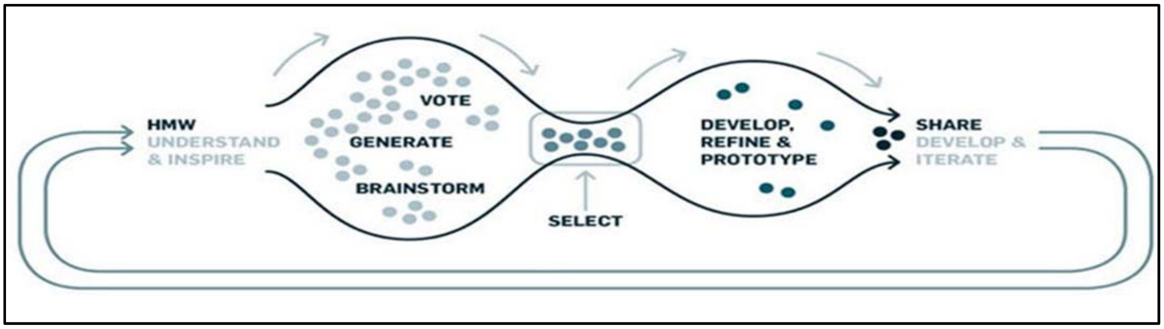

Figure 31. The "Double Bubble" Concept

Note. Borrowed from IDEO, the CUE2's "Double Bubble" is a model that traces the path of divergent thinking to foster new ideas, a convergence of those ideas to select the most viable options, a second divergence to further refine those viable ideas, and then a second convergence to materialize the concepts (IDEO, 2012; Smith, 2012b).

The CUE2s were formed to focus on the ideas created during the TANG Forum and to brainstorm ways to improve upon and instantiate those concepts through a collaborative effort of stakeholders. CUE2 membership was comprised of small groups of hand-selected representatives from the various stakeholder communities (Smith, 2012b). The initial CUE2 session commenced with an introduction to the design-thinking principles, followed by an overview of the broad outcomes of the TANG Forum and the rules of the brainstorming process (Smith 2012b). The CUE2 members then executed a brainstorming session that incorporated design-thinking skills and applied those skills to constructing "How Might We" (HMW) questions. The groups were segmented into teams and used physical props like Post-It notes, foam core, markers, glue, and other simple arts-and-crafts materials to visualize the operator–machine interface design. The primary purpose of the initial CUE2 brainstorm session was to lead participants into what Smith (2012) and Noyes (2012) had termed, "the realm of the possible." Experimenting with low-fidelity prototypes built by the operators offered the developers direction in constructing their own physical prototypes for the follow-on CUE2 sessions. The fleet operators needed to interact with the developers' prototypes in order to provide meaningful feedback. This collaborative interaction helped ensure that all of the participants had a cooperative and shared understanding of what they were trying to build.

Before the CUE2, operator–machine interface designs were developed based on a list of static requirements (Noyes, 2012). Those requirements were generated by the Submarine Tactical Requirements Group and APL's Operator–Machine Interface Working Group and then acted on by the Operator–Machine Interface Working Group whose task it was to translate the requirements list to the rest of the development community. While both the

Submarine Tactical Requirements Group and the Operator–Machine Interface Working Group consisted of highly experienced and talented individuals, the legacy process was compartmentalized and rife with miscommunications and translation errors. The CUE2's design-thinking approach to operator–machine interface design transformed the generally static and, by all accounts, antagonistic requirements meeting into a mutually supportive and collaborative event (Smith, 2013). Proof of this change lay in the fact that more ideas were generated during the first CUE2 brainstorm session than had occurred during the entire previous year of legacy operator–machine interface meetings (Smith, 2013).

The concepts derived from the initial brainstorming sessions were prototyped quickly using adaptable computer languages like Java, HTML, and MATLAB. This rapid prototyping enabled participative interaction and a format to effect timely and cost-effective changes to the developing product (Smith, 2013). The traditional alternative was to fully integrate the product into the system and then solicit operator feedback during the evaluation process. The CUE2's method of fully integrating stakeholder interaction in the earliest stages of the development process staved off the tendency of miscommunication, mistranslation, and misunderstanding between the development community, the support community, and the operator end users.

The next stage of the CUE2 focused on refining the operator–machine interface conceptual design. The fleet operators were given time to free play with the developers' prototypes. Each member of the team was tasked to develop feedback for those prototypes. Again using Post-It notes and foam core, the participants captured the comments and suggestions made during their hands-on interactions. This multi-user method ensured the ideas and comments made by the team were immediately captured and put on display for group consideration. Following the free-play session, the participants reengaged with another brainstorm. During this brainstorming session, the team focused on either a specific feature of the prototype or a more generalized "How Might We make this prototype better?" topic (Smith, 2013). The participants' recent interaction and intimate experience with the prototypes tended to spark a great many ideas for changing and improving the prototype (Smith, 2013). These ideas and comments were organized by theme and then put to a vote by the CUE2 participants. Groups were then subdivided into smaller teams to transform the ideas with the most votes into physical form using the available arts-and-crafts materials (Smith, 2013).

This process included all of the CUE2 participants. Teams consisted of a mixed bag of operators, developers, testers, trainers, and, human-factors experts, all of whom participated in the prototyping effort (Smith, 2013). These prototypes granted the operators a vehicle to rapidly express their ideas and to give the developers a contextual understanding of the operators' vision of the design. This conversation was primarily focused on the operators and developers, but the inclusion on the teams of testers, trainers, and human-factors experts facilitated contextual understanding of the design intent and enabled early refinements to the measurement and analysis plans and the training development plan and led to modifications to the display concepts and operator task flows (Smith, 2013).

Following this prototyping session, the individual teams presented their concepts to the larger group. This sharing session allowed the team members to role-play their concepts through different scenarios. The larger group audience members were then able to share this contextual explanation and use this shared understanding to further refine the presented concepts as well as to improve upon their own designs (Smith, 2013).

The CUE2 process explored multiple options to develop operator–machine interface design for APB for 2013. CUE2s were two-day evolutions that allowed operators to interact with prototypes, brainstorm new ideas, and collaborate with members of the larger stakeholder community. The CUE2 concluded with a presentation by the developers during which they articulated to the entire group their understanding of design priorities in terms of functionality and conceptual improvements that had been derived during the CUE2 process. The fleet operators then took the developers' list and reprioritized the items on it based on what they wanted to see for the next CUE2 evolution (Smith, 2013). Prioritizing these items focused the developers and managed the expectations of the operators.

CUE2s were scheduled monthly to allow developers the requisite time to refine prototypes before reengaging with the larger group (Smith, 2013). When the CUE2 recommenced, the developers reviewed the prioritized list with the group and provided status updates on what actions had been accomplished and what actions had been interrupted or delayed due to time, complexity, or unforeseen factors (Smith, 2013). Each focus area would ultimately undergo four rounds of the CUE2 process. In the final round, the groups verified that the prototypes had captured the published concept of operations and design intent, that the metrics and task flows had been completed, and that the prototypes were ready for inclusion in the Advanced Processing Build Four-Step testing process in the Step 2 testing phase (Smith, 2013).

The CUE2 methodology provided the development community with an operator–machine interface construct that had been designed and vetted at the earliest stages of the process by the fleet, the developers, the test team, the training team, and the human-factors experts. This participative effort, conducted early in the design phase, served to maximize capability and minimize communication and translation errors.

The CUE2 process created an invaluable contextual understanding between multiple stakeholders. The TANG Forum created the figurative design space that enabled the CUE2 process. The merits of design thinking exhibited through the TANG Forum and the CUE2 process would combine to motivate the long-term prime integrator to create a literal design space in order to further advance the contextual understanding between stakeholders.

8. Area 51

Influenced by the excitement generated by the TANG Forum, the long-term contractor for submarine sonar systems, Lockheed Martin, Manassas invests internal funds to create an interactive laboratory that supports innovative design efforts,

The TANG and the Concept User Experience events generated enthusiasm from the fleet and the development community. That enthusiasm motivated Lockheed Martin, Manassas, the prime integrator for submarine sonar systems, to invest its internal funds and create an interactive demonstration bay known as Area 51 (see Figure 32).

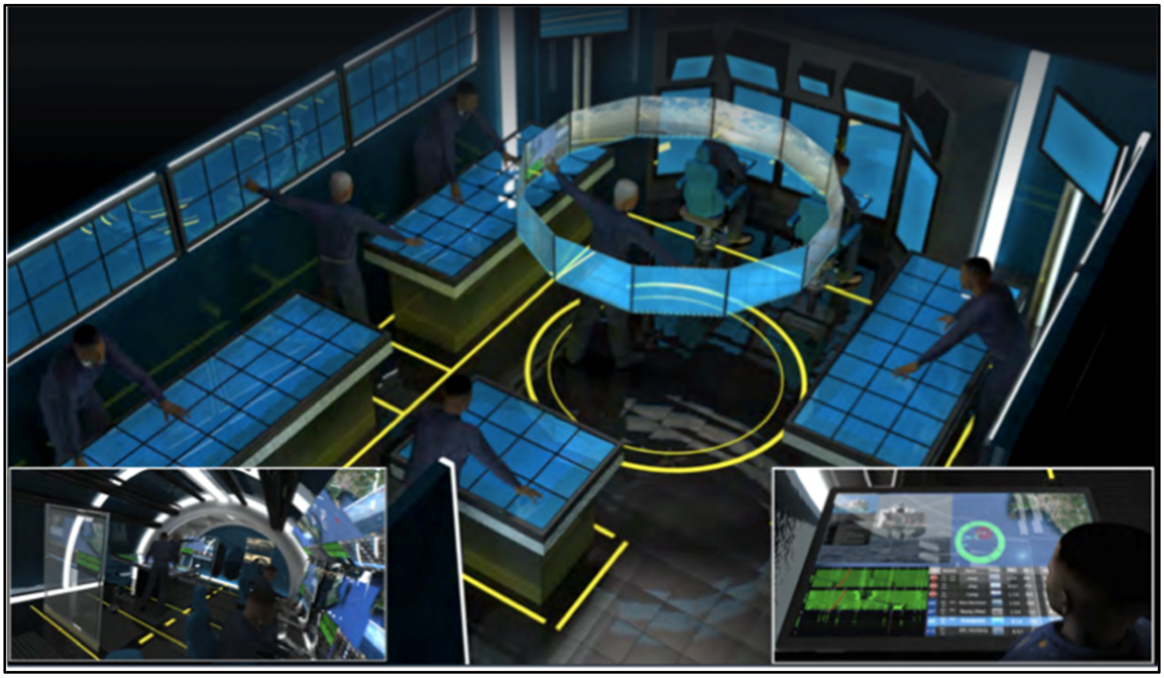

Figure 32. Lockheed Martin, Manassas Area 51 (Conceptual)
(Smith, 2012b)

Opened on April 9, 2012, Area 51 is a configurable movie-style set that can replicate the dimensions of either the Los Angeles-class or Virginia-class control room. This set provides a fully interactive model that can host commercial-sector technologies with live data from the latest variant of the APB (Richardson, 2012). Area 51 provides a physical design space in which operators, designers, psychologists, engineers, and analysts can collaborate (Latham, 2012). Area 51 is, for all intents and purposes, an immersible prototype in which collaborators can see and feel how today's submarine workstations can be utilized by watch teams and how they can positively affect hardware and software updates. Vice Admiral Richardson explained,

> Area 51 is a way to quickly shake out what is real and ready from what is vision. ... Instead of trying to predict the future, the goal is to be agile and flexible in the design of the control room, so we are well positioned to fast follow industry trends. (Richardson, 2012)

Area 51 has been a resounding success. The brainchild of Lockheed Martin's Dave Latham, this interactive format has taken the "art of the possible" to new heights. The site has introduced cutting-edge technologies to the community and has created a fertile design space where contextual understanding between stakeholders can flourish.

Area 51 consists of the control room and a separate built-to-scale wardroom and a to-scale model of the submarine conning tower (see Figure 33.). Not one to rest of their laurels, Dave Latham and Lockheed Martin have begun construction of Area 52, which will become an interactive model of the shore-based sonar surveillance floor and future plans include an Area 53 for surface ships and Area 54 for the Navy's P3 and P8 programs (Latham, 2012).

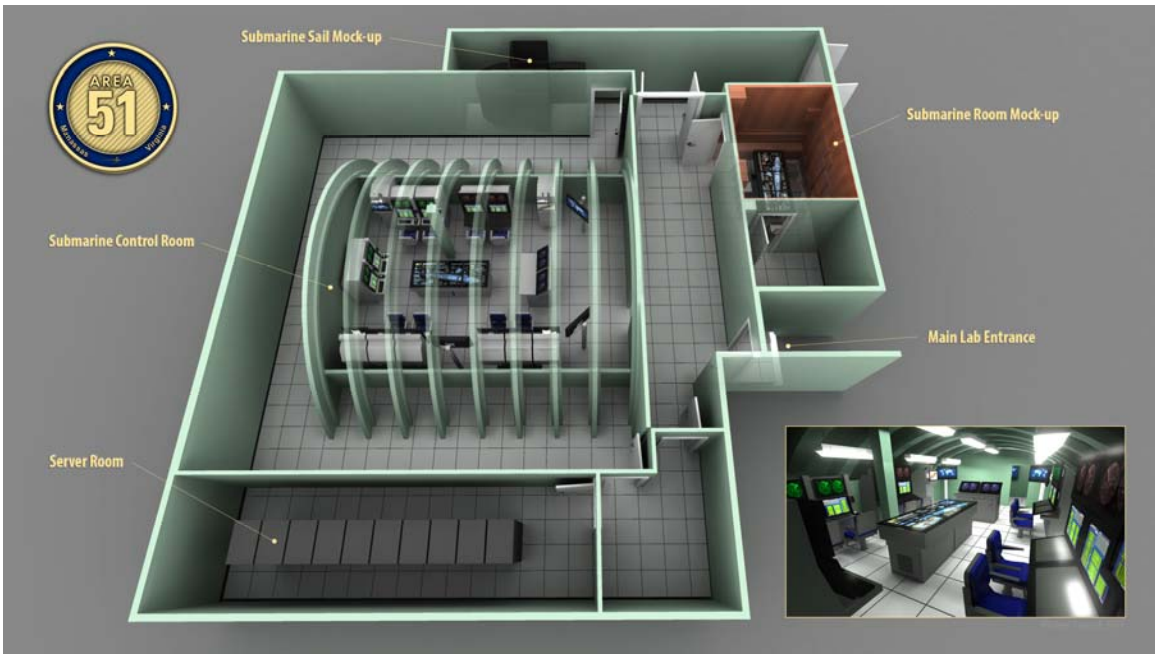

Figure 33. Lockheed Martin Manassas, Area 51 Layout

E. PART V: CONCLUSION

During the Cold War, the mission of the U.S. submarine Navy was primarily ISR and ASW against the Soviet submarine force. The U.S. submarine force prided itself on its acoustic quieting capabilities. Being quieter than the enemy allowed U.S. submarines both to avoid detection and to more capably find, stalk, and expose Soviet submarines (Bratton & Tumin, 2012). Throughout the Cold War, the U.S. enjoyed a major acoustic advantage over the Soviets (Benedict, 2005). A significant factor in this success is that the Soviets were ignorant of the U.S.'s decisive acoustic superiority. This advantage was revealed to the Soviets through the Walker/Whitworth espionage ring and the details of U.S. acoustic superiority led the Soviets to dramatically improve their quieting capabilities (Weir & Boyne, 2003). The loss of acoustic superiority and the inability to track and detect adversary submarines represented a clear and present danger to U.S. interests. The traditional Cold War threat-based solution to this "acoustic dilemma" was a decade-long multi-billion-dollar program designed to build a better system (Johnson, 2004). The collapse of the Soviet Union and the de facto end of the Cold War incurred severe budget cuts throughout the DoD that precluded this traditional approach.

The U.S. submarine force saw an 80% drop in investment funding and an inability to revamp its submarine systems through the traditional acquisition process. With an inability to improve or replace obsolete fleet sonar systems, the very relevance of the U.S. submarine force came into question. In this era of severe budget cuts and military drawdowns, the submarine Navy regained acoustic superiority and revolutionized its acquisition process through an open systems architecture approach of the ARCI program. ARCI unseated the traditional sonar system development process and provided a *transparent*, *peer reviewed,* and *competitive* process capable of leveraging the *tacit knowledge of the fleet*.

ARCI provided a solution to modernizing the fleet and solved the acoustic dilemma by creating a process that could rapidly improve or replace technologies aboard U.S. submarines. ARCI's rapid refresh rate created a cascading effect of challenges on the submarine Navy's training and support structures. The challenge of managing these changes was addressed through a series of decisions that surrounded retarding the rapid rate of technology change.

In 2011, Vice Admiral John Richardson called on the submarine community to "fast follow" the soaring advances in commercial technology by leveraging the submarine forces' millennial-generation "digital natives." Richardson's call to action was put into effect through a revolutionary forum of junior submarine officers and enlisted men known as the TANG Forum.

The submarine Navy has created an acquisition process capable of rapidly introducing software and hardware upgrades onto the submarine platform. They have created partnerships with industry that leverage the immense research and development efforts and innovative power of the commercial world. They have created an innovative forum that gives voice to the needs of the fleet and demonstrated how fleet operators can be effectively exploited to participate in the design of complex technologies. In a scant 12 months, the submarine Navy transformed Vice Admiral Richardson's vision statement though the TANG Forum and then integrated the design concepts produced by that forum into their baseline systems. The excitement and energy created by this revolution led to a contractor-funded interactive laboratory capable of hosting the latest hardware and software systems. This powerful combination has demonstrated how anything commercially available can be integrated into the submarine and ready for use within one software update cycle.

Innovation is the combination of good ideas and the capability to implement those ideas. The submarine Navy has created a mechanism that solves the equation of innovation. They have created a design-thinking forum to generate "big ideas" and have built the performance engine to effectively implement those ideas.

IV. ANALYSIS OF FINDINGS

A. OVERVIEW

The overarching intent of this thesis research was to develop a teachable case study for students attending DoD corporate universities such as the Naval Postgraduate School, the DAU, and the Air Force Institute of Technology. Case studies present an opportunity to analyze events in the context of real-life situations and offer students greater insight into how solutions to complex problems were derived. One of the larger frustrations for military students attending corporate universities is that the preponderance of case studies provided for analysis are drawn from the corporate world. Institutions such as the Harvard Business Review have a vast array of useable case study material, but there are very few case studies drawn directly from military-specific situations or from a military member's point of view. This lack of militarily relevant case studies requires that military students perform the mental calculus to transform the lessons of the corporate world into military terms. While this may seem a trivial inconvenience at first glance, when one considers that military students studying business have a dramatically different interpretation of simple terms like profit and loss or cost and revenue than their civilian counterparts, the lack of military-specific case studies presents a significant shortfall in effectively educating military students through the case study analysis method.

One of the areas in which there is a dearth of recorded history, much less any teachable case study material, surrounds how the DoD manages IT. The DoD has undergone several changes in how it acquires, employs, and relies on IT assets. There have been innumerable successes and failures in IT acquisition and IT management, but the tale of those events too often resides only in the memory of those who lived through it. The failure to commit the details of those events to paper only ensures that IT managers will continue to relive through trial and error the same mistakes and the same failures of their predecessors. The details of the case study presented in this thesis provide a military-specific business case and a narrative, which describes a relevant and recent IT innovation initiative inside the DoN.

B. THE CASE STUDY

The case study presented in this thesis addresses three distinct yet interlocking narratives. The first concerns how the submarine sonar community transitioned to the ARCI program. The second concerns the challenges to managing the rapid technology refresh rate enabled by ARCI. The third concerns the design-thinking methodologies that were introduced by the TANG initiative.

The case study presented discusses the emergence of ARCI mainly from the point of view of the submarine program office. Within the narrative, Bill Johnson serves as the focal point for the vision and strategy that became the ARCI program. Johnson's formidable leadership and internal championing of the program are significant factors to the successes of ARCI, but it would be disingenuous to suggest that it was Johnson alone that enabled the transition from the traditional program. As it is with all major organizational changes, there were several contributing forces that facilitated the creation, adoption, and maturation of ARCI. Any under-representation of those individual contributions to the advancement of ARCI is solely the responsibility of the author. The accomplishments of ARCI occurred through the concerted efforts of a number of individuals and several organizations. While the narrative portrays a distinctly adversarial relationship between the ARCI proponents and certain segments of the Navy laboratories of the NUWC and the Lockheed Martin, Manassas, facility, both organizations have members who significantly contributed to the implementation of ARCI. The intent of the narrative is not to villainize these organizations but to invite, through the case study analysis method, student discussion of how institutional inertia often stymies innovation and resists organizational change.

The theme of managing change is continued with a discussion of ARCI's rapid technology refresh rate and the challenge it created for the submarine force's operational and support structures. The cascading repercussions caused by the massive influx of new information technology serve to illuminate several of the barriers to effective technology management. Techniques to answer this challenge are explored in the narrative through a comparison of the traditional analytical approach to problem solving with the design-thinking approach employed by the TANG Forum.

The case study this thesis provides describes in detail a militarily relevant narrative of how the submarine Navy developed the capability to effectively and rapidly project, plan, develop, test, and deploy high-performance technology into the fleet. On this premise, this case study may be used to conduct an *analysis of organizational change* within the DoD. Additionally, this case study details how a small segment of the DoD has introduced the principles of design thinking into their acquisition efforts and how these efforts may serve to support effective program management. This thesis addressed these themes through two major research questions:

- How can the Department of Defense exploit design-thinking modalities?
- How can a design-based methodology support defense acquisition?

C. ORGANIZATIONAL CHANGE MANAGEMENT

The case study presented in this thesis provides students with material for an in-depth discussion of how the U.S. submarine community experienced organizational change when faced with the acoustic dilemma. In *Leading Change,* Kotter (1996) argued for an eight-stage organizational leadership change process:

- Establishing a sense of urgency
- Creating the guiding coalition
- Developing a vision and strategy
- Communicating the change vision
- Empowering broad-based action
- Generating short-term wins
- Consolidating gains and producing more change
- Anchoring new approaches in the culture

Kotter (1996) separated these eight stages of organizational change leadership into three functional groups to project and counter the inevitable resistance that comes with all efforts to create organizational change. Stages 1–4 exploit dissatisfaction with the status quo and create the “space” necessary to introduce change. Steps 5–7 are the areas in which the new direction is implemented. Step 8 is where the change is inculcated into the organizational culture.

The details of the acoustic dilemma can be applied to this eight-stage model as the loss of U.S. acoustic superiority, combined with the massive budget cuts induced by the end of the Cold War, necessitated a drastic change in the way the U.S. submarine Navy conducted sonar system acquisition. This forcing function established a genuine sense of urgency for the U.S. submarine force generally and for the sonar system development community specifically. While the underlying reality is that effecting change requires a right-sized group of the right people to enact that change, from an outsider's perspective, the guiding coalition may be ascribed to Bill Johnson. Johnson served as the focal point for developing the vision and the strategy of what became the ARCI program. In a similar vein, Johnson, Captain Jack Jarabak, and Vice Admiral Giambastiani may be credited with successfully communicating the change vision to the larger U.S. submarine community, the DoN, and the U.S. Congress. Their communication of the change vision kept the radical idea of ARCI alive as it evolved and matured and as the change process began to be embraced by the community at large.

From its inception, ARCI challenged the status quo. As ARCI began to mature, it confronted several institutional barriers to change. Kotter (1996) described four "barriers to empowerment" for the people within an organization: structure, skill, system, and supervisor. By empowering employees for broad-based action, the ARCI initiative laid roots that could combat the structural obstinacy of the closed business system. ARCI would offer access to an entirely new employee base that opened up a new and wide-ranging skill set from diverse SMEs. ARCI altered the traditional system and enabled a cultural revolution by confronting the status quo and by converting skeptics into believers through either garnering their support or by simply co-opting senior leadership.

Johnson and the ARCI initiative doggedly pursued the opportunity to test their ideas and turned that testing into generating the necessary short-term wins to prove the merit of the program and the vision of change the ARCI team had been championing. The ARCI team took that first win and began a cycle of iterative development that consolidated those initial gains. Those gains multiplied, leading to constant and consistent production of quality products, which combined to promote a generalized acceptance of the ARCI model. This fervent and continued attack cemented the ARCI approach into the U.S. submarine sonar system development culture.

The resistance to change manifests clearly in the case study narrative and is easily applied to the evolution of ARCI. Effecting change within an organization is a constant battle against falling back into the status quo. Consistent effort and constant pressure are necessary to maintain the momentum of the change effort. Forces begin working against the change effort from the moment the effort is initiated and continue through the entire life cycle (Kotter, 1996). Kotter and Schlesinger (2008) described four reasons that people fight the change effort:

- Parochial self-interest—people concerned with how change affects their own interests versus the positive effects on the organization
- Misunderstanding—inadequate understanding of the change effort
- Low tolerance for change—fear of loss of security or stability
- Different assessments of the situation—disagreement with the reasons for change

The case study discusses at length how the closed business structure of traditional sonar system development had encouraged parochial self-interest. The entrenched forces from the NUWC and the old guard from Lockheed Martin, Manassas, were certainly concerned with how ARCI would affect their interests rather than the positive effects ARCI could have on the submarine community as a whole. The case study is rife with examples of this dynamic. This attitude is perhaps summed up best by the remark made by the NUWC representative and close friend of Bill Johnson on the eve of the initial ARCI pre-sea trials: "Listen Bill, if you put this on the submarine, the sailors will like it. Then where will we be?" (Johnson, 2013b). This comment demonstrates how the establishment had allowed insecurity and the loss of control to cloud its collective judgment to the point that the mission to support the warfighter had become less important than maintaining that control.

This obfuscation of the "warfighter-first" mission priority may be seen as evidence that there was either deliberate misunderstanding of the change effort or that the fear of losing the long-term security and stability of the traditional process had created severe intolerance for change. While there was a consensus that a change was required for the U.S submarine community to effectively address the acoustic dilemma, there was drastic disagreement on the means and measures on how to execute that change. Where the traditionalists saw the answer to the dilemma as simply finding a new product built by the old process, the ARCI proponents saw the answer as a new strategy that would change the entire business model.

The acoustic dilemma and the ARCI sections of the case study are designed to foment student discussion of organizational change management. Kotter (1996) cited eight common reasons for resistance throughout the change's life cycle:

- inwardly focused cultures,
- paralyzing bureaucracy,
- parochial politics,
- low levels of trust,
- lack of teamwork,
- arrogant attitudes,
- lack of leadership in middle management, and
- general human fear of the unknown.

Examples of these reasons for resistance resound throughout the case study and may be used to both educate and prepare students to recognize the pitfalls of introducing change into their respective military communities. Kotter's (1996) organizational change leadership factors, Kotter and Schlesinger's (2008) reasons why people fight change, and Kotter's (2002) reasons for resistance throughout the change effort's life cycle serve as invaluable resources for organization's implementing organizational change. Material that addresses organizational change management as it applies specifically to the TANG initiative may be found in the supporting thesis work of LCDR Thomas Hall, *A Case Study of Innovation and Change in the U.S. Navy Submarine Fleet* (2012). Hall's (2012) research investigated the TANG event through the multiple lenses of barriers to change, the methods utilized by the internal champion, the relationships between the disparate participating groups, the perceptions of the innovation effort, and the utility the innovation effort of the TANG initiative offered the submarine community.

1. How Can the Department of Defense Exploit Design-Thinking Modalities?

Both Hall's (2012) case study and the case study presented in this thesis are designed to support the education efforts of DoD institutions in the realm of organizational change. The case study in this thesis additionally offers an opportunity for student discussion of information technology management and has significant implications for effective program management. These areas are addressed in the case study through the cascading repercussions caused by the ARCI solution to the acoustic dilemma and the events that led into and followed the TANG Forum.

ARCI created a method to rapidly deliver cutting-edge technology to the warfighter. The submarine community adopted the ARCI model and embraced its immediate positive effects. The effects of managing these dramatic and dynamic changes produced a ripple of management challenges throughout the submarine community. These changes placed a high demand on both the operational and support structures. The rational answer endemic to the analytical decision-making management model so common to the military establishment, was to intentionally halt that rapid change. Halting the change would enable the operational and support structures to assess the implications of the technology changes and institute the necessary procedural changes to manage the new technologies. This solution to the challenge of managing the rapid influx of advanced technology offers the case study readers an appropriate comparative analogy between an analytic approach and a design approach to problem solving.

The advantages of "design thinking" have been floating around military circles since late 2008 when U.S. Army Major Ketti Davison (2008) published "From Tactical Planning to Operational Design" in the *Military Review*. Davison (2008) presented an elegant argument for developing a coherent framework for operational design. Her argument has gained slight traction inside the DoD, but the elusive concepts of design and design thinking are difficult to resolve with the traditional models of military decision-making.

Military leaders are groomed to attack problems analytically. The focus of management practice and education is on the development of advanced analytical techniques (Collopy & Boland, 2004). Mastering these analytical techniques demonstrably increases the leader's ability to choose between alternatives but has also served to diminish the design skills necessary to shape new alternatives. Inside the DoD, management education and leadership development evolve through a decision-attitude toward problem solving where alternatives are displayed and the metric of managerial efficacy is determined through the selection of the best alternative. The decision-attitude assumes that the alternative courses of action are relatively simple to discover and the challenge of leadership is deciding between those alternatives. Leaders are trained to create a single right plan and then execute it.

This concept is clearly demonstrated through the U.S. submarine community's decision to simply halt all technology refreshes in order for the traditional operations and support structures to catch up. Analytically, this is the most correct decision to defeat the identified problem. The author contends that the events that led up to the TANG Forum created the necessary environment to reengage the problem through a design-thinking methodology.

Design thinking is a difficult concept to convey in print. Commercial industry consistently lauds the tenets of design thinking to stimulate innovation, but that praise is difficult to effectively translate to the military community. The military culture tends to either force the concepts of design thinking to match preconceived decision models or to simply deride the elusive concepts of design as abstract and academic nonsense. This dismissive attitude is quickly adopted because much of the literature exploring design concepts is written at such a high level of academic abstraction that it is difficult to take away a practical application.

This difficulty is compounded by the fact that much of the literature surrounding design is contradictory in nature and that there is no single authoritative definition or description of design or design thinking (Kimbell, 2009b). The very term *design thinking* is confusing, and much of the literature involves semantic debate over whether the terms *creativity*, *invention*, or *innovation* may be more appropriate (Collopy & Boland, 2004; Kimbell, 2009a; 2009b; Nussbaum, 2009).

The varied understanding and interpretation of the tenets of design, the high level of academic abstraction in the literature, and the lack of a comprehensive procedural process for implementing design have made the practical application of design thinking in the DoD a daunting challenge. This difficult and convoluted reality begs the question, How are design and design thinking valuable resources for the military?

Design traditionally describes an object or end result, but design can also be understood as a protocol for solving problems and exploiting new opportunities ("Design Thinking," 2006). Design is a conceptual tool for addressing wicked problems and assessing the role of managers as not simply decision-makers, but as designers of solutions to ill-structured problems. The author contends that the design-thinking methodology outlined in the case study may be used as an example of how the U.S. submarine community has introduced design thinking to effectively support the functions of requirements engineering in the acquisition process.

The case offers an example of how a design thinking methodology was successfully executed in a niche DoD community. The case demonstrates how a design thinking modality was used to address the complex problems presented in the development of operator–machine interface displays. The design thinking approach discussed in the case proved advantageous, but in order for the DoD as a whole to capitalize on this success, and effectively exploit design thinking, then the tenets of design thinking would need to be culturally accepted as a viable alternative to the standard analytic approach. This is an exceptionally daunting challenge when one considers the abstract nature of "design thinking" and how deeply the analytical approach to problem solving is ingrained in the DoD culture. While it is beyond the scope of this thesis to address how the DoD could fully implement design thinking into its operations, the case study offers readers a comparative analogy between an analytic approach and a design approach to problem solving. This militarily relevant and teachable case study may serve as a vehicle to introduce the tenets of design thinking to DoD students and create an opportunity for the DoD to more fully understand and exploit design-thinking methods.

2. How Can a Design-Based Methodology Support Defense Acquisition?

The DoD's acquisition community relies on three principal decision-making support systems: the PPBE Process; the Defense Acquisition System; and JCIDS (DAU, 2011a).

The PPBE is the strategic planning, program development, and resource determination process that the DoD uses to develop plans and programs that satisfy the demands of the national security strategy (DAU, 2012).

The Defense Acquisition System exists to manage the nation's investments in technologies, programs, and product support necessary to achieve the national security strategy and support the United States Armed Forces (DAU, 2011a). DoDD 5000.01

(USD[AT&L], 2007) and DoDI 5000.02 (USD[AT&L], 2008a) are the documents that provide the basic guidance to implement the acquisition process.

The DoD's process for fulfilling operational capabilities exists as a framework of phases and milestone decision reviews. Each phase of the process progressively develops, produces, and fields material solutions to meet warfighter needs. These needs are addressed through the JCIDS. The JCIDS provides the capability documents that guide the various phases of the DAMS by providing stakeholder requirements in terms of performance, cost, and schedule (CJCS, 2012b).

The JCIDS's focus is on requirements generation. The JCIDS identifies current warfighting strengths and weaknesses across all four military Services and conducts analyses to determine appropriate solutions to fill capability gaps (CJCS, 2012a). JCIDS documents are the link between validated capability requirements and the acquisition of material capability solutions (DAU 2012).

When the question "What is wrong with acquisition?" is posed, inevitably, the dilemma of *requirements* development and management arises. The DAU hosts a semi-annual Program Manager's (PM) forum. During the course of each forum, over 20 major DoD PMs identify and rank their major concerns. Since 2007, each forum has listed some form of the term "requirement" in the top seven issues that PMs battle. In 2010 and 2011, the out-briefings listed "requirements and testing" as their number one issue (Mohney, 2011).

Requirements generation is the cornerstone of the acquisition process because requirements define the problem. The requirements process is used in everything from determination of force levels and manpower needs to the establishment of funding levels and acquisition priorities. The start of any procurement program begins with an identification of valid requirements. Requirements begin as broad concepts and objectives and are filtered down into specific organizations, tactics, and systems (IDARM, 2013). This filtering and refinement requires a high degree of contextual knowledge in order for the interpretation and translation process to be successful. A continued challenge for any acquisition effort is the translation errors that occur as requirements move through stakeholder groups.

Requirements errors are the most common errors in the acquisition process and are by far the most expensive to fix. Statistically, requirements errors consume 25–40% of the total project budget (Gallagher et al., 2005). Research has shown that requirements errors in software development account for 48% of all software problems (Hall et al., 2002). A Standish Group Report listed unstable requirements as one of the top three reasons for project failure (Verner et al., 2005).

Requirements engineering, the process of originating, documenting, and maintaining requirements, has developed into a separate and distinct profession (DFAS, 2005). In an effort to remove the inherent threats of ambiguity and to decrease translation errors, there are several formal documentation requirements for every phase of the DoD acquisition process The DoD has created policies for certification training that address requirements management (USD[AT&L], 2008b). The DAU (2001) has published *Systems Engineering Fundamentals,* which includes as Supplement 4-A, "A Procedure for Requirements Analysis." This supplement provides a robust task list of concerns that should be considered when planning and performing requirements analysis (DAU, 2001). Although the DoD literature abounds with references that describe how requirements should be written and what factors should be included in deliberations, the author has found little DoD-specific literature that systematically delineates a method for how requirements should be developed.

The events discussed in the case offer an example of how the submarine community introduced a design thinking methodology to coordinate stakeholder interactions at the earliest stages of the requirements development process. The author contends that the design-thinking methodology discussed in the case study presents a reproducible means to foment contextual understanding between stakeholders. A reproducible framework that can generate innovative ideas and then develop those ideas into unambiguous and actionable requirements would be a significant force multiplier for the DoD's requirements engineering efforts.

TANG created a forum where the tenets of design thinking were used to give voice to the fleet's digital natives. U.S. author and educator Marc Prensky (2012) coined the term "digital-native" to describe the millennial generation and its ability to naturally understand the digital language of computers, video games, and the Internet. By virtue of their advanced technology skill sets, the millennial-generation members of the Armed Services represent a significant and untapped force multiplier. This group's pervasive technological knowledge, savvy, and comfort level represents an unexploited opportunity for the DoD. The TANG initiative enabled the creative capacity and characteristic skill set of the millennial-generation operators and elicited from them soluble needs and desires on which developers could determine and define requirements. The TANG outcomes gave the system development teams new insights into how they would design operator–machine interfaces. The TANG Forum created a new level of excitement and energy for the operator community and granted them an actionable stake rather than a limited evaluative role in the development process.

Estimating the ROI of the TANG Forum is a complex issue. The cost to research, develop, and execute the entire process of the TANG Forum was roughly $400,000. Ascribing an accurate cost–benefit analysis to the far-reaching effects of the TANG Forum is beyond the scope of this thesis, but it is appropriate to offer some small evidence of how TANG has influenced the submarine sonar development community and how the community is changing its methodologies in response to TANG.

The participants in the TANG Forum generated the "big ideas" necessary for innovation. The CUE2 developed by Josh Smith and Don Noyes took those big ideas and put them into the appropriate context to foment true understanding between multiple stakeholders (Smith, 2013). The CUE2 methodology provided the development community with an operator–machine interface construct that is designed and vetted at the earliest stages of the process by the fleet, the developers, the test team, the training team, and the human-factors experts. This participative effort conducted early in the design phase served to maximize capability and minimize communication and translation errors.

Economic evidence of this assertion may be seen in a comparison between the costs of the CUE2s and the historical costs incurred by operator–machine interface development. From January 1, 2012, through February 28, 2013, one of the small businesses contracted by the submarine community expended $594,277.54 on operator–machine interface development costs. Historically, 20–40% of an operator–machine interface product needs to be reworked following its initial encounter with end user operators. The inclusion of the CUE2 collaboration in the development process served to produce the same product at the end of a single development cycle that would have historically taken two to three cycles to produce using the old method. The cost of the rework done in the traditional way would have been between $77,646.08 and $155,292.16 per cycle. The rough cost of the CUE2 was

$75,000. In the worst-case scenario, the CUE2 incurred costs no greater than the traditional method, and in the best case, the inclusion of CUE2 saved approximately $75,000 per iteration.

The CUE2 was the first step to operationalize the concepts that were birthed by the TANG Forum. The cost estimates listed in the previous paragraph concern only one of the concepts to come out of the TANG Forum. When one considers the additional concepts that arose from the initial TANG Forum and the potential concepts to emerge from follow-on TANG events, the TANG Forum presents a formidable force multiplier for the DoD.

The case study presented in this thesis demonstrates how a subcomponent of the DoD used design-thinking modalities to leverage its organic millennial-generation assets to successfully elicit system capability requirements. This case study presents a relevant example of how design-based methodologies can support effective program management.

D. FURTHER CONSIDERATIONS

Every acquisition program is unique, and there is no single-source solution or one-size-fits-all full proof method that will guarantee success. Employment of a modular open systems architecture is not feasible for every program, nor is an evolutionary acquisition approach always the best possible course of action. These particular solutions have served to promote success for the ARCI program, but the author contends that the ARCI model is unlikely to be reproduced.

ARCI evolved through the concerted efforts of several individuals and organizations but also had several unique advantages that many acquisition programs do not have. ARCI evolved in response to a threat against the effectiveness and relevancy of the U.S. submarine force. This fact invited significant external pressure from senior leadership. Uncharacteristically, this external pressure did not result in an overbearance of legislative or bureaucratic oversight from an external agency. The fact that neither Congress nor the Office of the Secretary of Defense (OSD) sought to impose itself on the program served to alleviate ARCI from the burdens of restrictive supervision. This freedom of action resulted primarily from the fact that ARCI was a relatively small and relatively low-cost program, which kept it below the dollar threshold classification as a Major Defense Acquisition Program. ARCI also benefited from advantageous timing. The program evolved during a time of limited funding due to severe budget cuts and at a pivotal point in history when the entire acquisition process was being reformed. These facts combined to ensure that decision-making authority for the ARCI program would remain the purview of the DoN. While ARCI was not completely unfettered, the ability to avoid heavy-handed bureaucratic constraints cannot be discounted in the ARCI success story.

ARCI's ability to leverage the Small Business Innovation Program and exploit the competitive advances in commercial processing technology allowed the program to rapidly adopt or adapt competitively constructed products. This dramatic change away from the traditional custom-built systems was a major factor in the ARCI success story. The transition to a modular open system architecture enabled the integration of independently developed components. While this "plug-and-play" architecture is of enormous benefit to creating capability for the warfighter, the process of integration would require the individual small company to sacrifice proprietary ownership of the products they developed. This requisite sacrifice questions the sustainability of long-term small business partnerships with a DoD customer who simply assumes control of the product. ARCI built strong relationships with its small business partners and established significant levels of trust and confidence. Reproducing such a feat and encouraging small businesses to make similar sacrifices is a significant obstacle for any program attempting to implement an open systems strategy.

A similar uncharacteristic advantage enjoyed by the ARCI program was the inordinately high levels of trust and confidence imbued by the fleet in the APB development teams. While one of ARCI's tenets was to continuously engage and involve fleet operators, the requirements constraints under which the APBs operated essentially consisted of "build me the best product you can." This mandate is not a typical indulgence from a stakeholder. This practice of malleable requirements definitions granted APB development the unique option of continuously redefining system requirements as the development process progressed. The APBs are, in many ways, completely absolved from any responsibility to provide traceability between the stated requirement and the capability delivered.

It is the author's opinion that the unique and trusting collaborative and cooperative culture that ARCI engendered is the crux of the program's success. Whether strategically devised or serendipitously exploited, the unique advantages enjoyed by ARCI and the risks inherent in this seemingly "fast-and-loose" strategy make it extremely difficult for the ARCI program to be reproduced outside of the submarine community.

The design-thinking methodology utilized by the TANG Forum, however, is entirely reproducible and, as previously discussed, could serve as an effective tool for creating contextual understanding between stakeholders. The DoD has created several policies and published extensive doctrine concerning the proper conduct of requirements analysis. This literature provides an extensive framework for tasks that should be included in the analysis process but lacks a modality capable of supporting the development of a shared mental model between the disparate stakeholders. The design thinking methodology presented in this case study offers an alternative to the traditional analytical approach towards executing requirements analysis. The example presented in this case study demonstrates how a design-thinking modality can foster collaboration between stakeholders and help to create a shared contextual understanding that would more effectively pursue requirements analysis.

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V. CONCLUSIONS & RECOMMENDATIONS

A. CONCLUSIONS

The DoD has recognized a need to leverage the skills and abilities of its human resources. By virtue of their advanced technology skill sets, the millennial-generation members of the Armed Services represent a significant and untapped force multiplier. This group's pervasive technological knowledge, savvy, and comfort level represent an unexploited opportunity for the DoD.

The overarching intent of this thesis research was to develop a teachable case study for students attending DoD corporate universities such as the Naval Postgraduate School, the DAU, or the Air Force Institute of Technology. The purpose of this thesis was to investigate the submarine community's recent efforts to exploit the technological acumen of its millennial-generation assets and to develop a pertinent case study of those efforts and events. The details of the case study demonstrate how the U.S. submarine community used design-thinking modalities to leverage its organic millennial-generation assets and successfully elicit system capability requirements. This case study presents ample evidence and a strong argument for how the DoD's acquisition community may use design-based methodologies to support effective program management. This case study provides readers with a militarily relevant example of how a design-based approach may serve to foster innovation and enhance warfighting capabilities.

The case study offers a militarily relevant narrative on which to base discussions of organizational change management in the DoD. The details of the case study present readers with an opportunity to explore the principles of design and the applicability of design thinking to leverage millennial-generation human assets. The case study offers significant anecdotal insight into the challenges to innovation inside the strictures of the DoD's acquisition process.

B. RECOMMENDATIONS FOR FUTURE RESEARCH

The case study presented in this thesis covers a 17-year history of sonar system development. There are several areas that bear additional research. The APB has become a hallmark of open systems architecture and has been adopted by the surface Navy as the

Advanced Capabilities Build (ACB) program. An investigation into how the surface Navy is adopting and adapting this program into the fleet could present great insight into the reproducibility of the open systems approach.

The author recommends an in-depth study of the WSTA program. Research into this program could include the details of how effective it has been for the submarine force and how the surface Navy is currently implementing a similar task analysis evaluation.

The case study presented in this thesis discusses the emergence of the ARCI program mainly from the point of view of the submarine program office. The ARCI program managed to reach its success through the concerted efforts of a number of individuals and several organizations. Future research should be conducted into the contributions of these additional agents and agencies that made ARCI a success. One organization, in particular, that should be researched is the sonar system development contractors at Lockheed Martin, Manassas. While beyond the scope of this thesis research, the cultural shift that occurred inside this organization as it adopted ARCI and the individuals that effected that cultural shift would prove enormously beneficial to understanding how such a revolutionary change occurred. Additional material for inclusion in any research of Lockheed Martin, Manassas, should include an in-depth study of Area 51. Topics could include the story of its origins and a discussion of how Area 51 is changing the interactions between the contractor and the end user and how such a design space could benefit the larger acquisition community.

In the near future, the TANG initiative is projected to tackle an Executive forum, a Surface Ship forum, and an Electronic Warfare forum. The author believes that a directed study of the planning and execution of these events would be highly advantageous for both the DoD's academic and acquisition communities. Included in this research should be a concentration on IDEO's design-thinking process and the role a design consultancy firm plays in spurring innovation in government organizations. Additional topics should include a TANG program ROI profile. This profile should not focus simply on how the TANG initiative or design thinking can save the DoD money but should include an investigation into the value of producing multiple low-fidelity failures to produce one quality product, and the missed opportunity costs of failing to conduct a TANG-like event.

The U.S. submarine sonar development community has created a unique system capable of rapidly introducing cutting-edge technologies into the submarine fleet. The TANG event established a method to leverage millennial-generation assets to develop new and creative ideas. Innovation is the combination of good ideas and the capability to implement those ideas. The submarine Navy has created a mechanism that solves the equation of innovation. It has created a design-thinking forum to generate "big ideas" and has built the performance engine to effectively implement those ideas. It is the author's opinion that the most important and beneficial future research would be to investigate the reproducibility of this dynamic within the DoD.

A single case cannot indisputably establish the validity of the design thinking approach for effective requirements engineering. It is the author's opinion that a design thinking approach and the design thinking methodology discussed in the case should be respectively viewed as a tool and as a technique for establishing context during stakeholder analysis. Future research should be conducted to validate the design thinking tool and technique and, if proven effective, further research should be conducted into how the DoD may institutionalize design thinking in the acquisition process.

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APPENDIX A. GLOSSARY OF ACRONYMS & TERMS

Acoustic Rapid Commercial-Off-The-Shelf [COTS] Insertion Program (ARCI)
ARCI is the spiral acquisition process applied to naval sonar systems. ARCI is a four-phase program that transformed legacy submarine sonar system development into one that uses a more capable and flexible commercial-off-the-shelf and modular open system approach (Gansler & Lucyshyn, 2008). The modular open source architecture enables ARCI to leverage the development efforts of independent sources and ensure that the best-in-class components can be installed on the submarine as they become available. The ARCI approach breaks the system down into hardware and software modules and then makes incremental improvements to the system through upgrading the various hardware and software components (Boudreau, 2006). Hardware and software used within an ARCI system are independent of one another. Improvements can be made to software applications independent of changes to hardware and vice versa. The software improvements made to submarine systems are called Advanced Processing Builds (APB). The hardware improvements made to submarine systems are called Technology Insertions (TI).

Acquisition
The conceptualization, initiation, design, development, test, contracting, production, deployment, logistics support, modification, and disposal of weapons and other systems, supplies, or services (including construction) to satisfy DoD needs, intended for use in, or in support of, military missions (DAU, 2011b).

Advanced Processing Builds (APB)
APBs are software improvements to submarine systems. APBs refer to both the development process as well as the system end product (Wilson, 2009). APBs are managed by the Program Executive Office for Integrated Warfare Systems 5A. APBs are hardware-independent software builds designed to create or improve functionality (PEO IWS5A, 2003). APBs are developed on an 18- to 24-month cycle and provide biennial deliveries to the fleet. APBs are identified according to the year for which they are developed. For example, APB 09 identifies the software baseline for the submarine system that was completed for 2009.

Architecture
The organizational structure of a system or component, its relationships, and the principles and guidelines governing its design and evolution over time (Open Systems Joint Task Force [OSJTF], 2004).

Capability Gap

The inability to execute a specified course of action. The gap may be the result of no existing capability, lack of proficiency or sufficiency in an existing capability solution, or the need to replace an existing capability solution to prevent a future gap (CJCS, 2012b).

Closed Interfaces
Privately controlled system/subsystem boundary descriptions that are not disclosed to the public or are unique to a single supplier (OSJTF, 2004).

Commercial-Off-The-Shelf (COTS)
A commercial item sold in substantial quantities in the commercial marketplace and offered to the government under a contract or subcontract at any tier, without modification, in the same form in which it was sold in the marketplace (FAR, 2011, subpart 2.101).

Commodore, Submarine Development Squadron Twelve (CSDS 12)
The Commodore, Submarine Development Squadron 12 (DEVRON 12), responsible, among other things, for the Submarine Tactical Requirements Group (STRG; United States Navy [USN], 2013).

Component
A product that is not subject to decomposition from the perspective of a specific application (OSJTF, 2004).

Concept of Operations and Operator–Machine Interface Support Group (COSG)
The COSG defines the operator–machine interface (notional control and display schemes) and operational utilization of the processing algorithms. It would serve as the primary fleet voice for determining the priority of APB improvements in the areas of acoustic signal detection, system automation, and tactical information management. The COSG also develops and conducts crew familiarization training for platforms receiving the APB system upgrades (Boudreau, 2006).

Concept User Experience Events (CUE2)
The design-thinking process developed by Josh Smith and Don Noyes to transform the ideas generated during the initial TANG Forum from concept to reality. CUE2s are intended to foster contextual understanding between multiple stakeholders and to further conceptualize, refine, and iterate operator–machine interface designs. The model of the CUE2 traces the path of divergent thinking to foster new ideas, a convergence of those ideas to select the most viable options, another divergence to further refine those viable ideas, and then another convergence to materialize the concepts (IDEO, 2012; Smith, 2012b).

Human-Systems Integration (HSI)
The integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for system manpower, personnel, training, safety and occupational

health, habitability, personnel survivability, and human-factors engineering (DoDI 5000.02; USD[AT&L], 2008a).

Information Technology (IT)
Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the executive agency. IT includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources, including National Security Systems (CJCS, 2012c).

Interface
The functional and physical characteristics required to exist at a common boundary or connection between systems or items (DoD 4120.24-M; USD[AT&L], 2000).

Interface Standard
A standard that specifies the physical, functional, and operational relationships between various elements (hardware and software), to permit interchangeability, interconnection, compatibility and/or communications (OSJTF, 2004).

Integrated Product Team (IPT)
Team composed of representatives from appropriate functional disciplines working together to build successful programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision-making. There are three types of IPTs: overarching IPTs (OIPTs) that focus on strategic guidance, program assessment, and issue resolution; working-level IPT (WIPTs) that identify and resolve program issues, determine program status, and seek opportunities for acquisition reform; and program-level IPT (PIPTs) that focus on program execution and may include representatives from both government and industry after contract award (DAU, 2011b).

Integrated Undersea Surveillance System (IUSS)
IUSS is the multi-faceted organization that encompasses the operations of detection, localization, and tracking of submarines, and the collection of acoustic and hydrographic information as well as the maintenance of processing and communications equipment necessary to carry out the operational mission. IUSS is missioned to support antisubmarine warfare command and tactical forces by detecting, classifying, and providing timely reporting of information on submarines and other contacts of interest; to provide command of Naval Ocean Processing Facilities to include direct tactical control of associated Surveillance Towed Array Sensor System (SURTASS) ships; to gather long-term acoustic, oceanographic, and hydrographic information (COMSUBFOR, 2013).

Interoperability

The ability of systems, units, or forces to provide data, information, materiel, and services to and accept the same from other systems, units, or forces, and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together (DoDD 5000.1; USD[AT&L], 2007).

Modular Design
A design where functionally is partitioned into discrete, cohesive, and self-contained units with well-defined interfaces that permit substitution of such units with similar components or products from alternate sources with minimum impact on existing units (OSJTF, 2004).

Modular Open Systems Approach (MOSA)
An integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industry standards organization (OSJTF, 2004).

Naval Sea Systems Command (NAVSEA)
NAVSEA is comprised of command staff, headquarters directorates, affiliated Program Executive Offices, and numerous field activities who engineer, build, buy and maintain ships, submarines, and combat systems that meet the fleet's current and future operational requirements (NAVSEA, 2013).

Naval Undersea Warfare Center (NUWC)
NUWC is a shore command of the U.S. Navy within the Naval Sea Systems Command (NAVSEA) Warfare Center Enterprise, which engineers, builds, and supports the U.S. fleet of ships and combat systems. As the Navy's premier research, development, test and evaluation (RDT&E) engineering, and fleet support center for submarine warfare systems and other systems associated with the undersea battlespace, NUWC is charged with meeting the undersea warfare (USW) requirements of the 21st century (NAVSEA, 2013).

Office of the Chief of Naval Operations (OPNAV)
The Chief of Naval Operations (CNO) is the senior military officer in the Navy. The CNO is a four-star admiral and is responsible to the Secretary of the Navy for the command, utilization of resources and operating efficiency of the operating forces of the Navy and of the Navy shore activities assigned by the Secretary (DoN, 2007a).

Office of the Chief of Naval Operations, Director, Submarine Warfare (OPNAV N87)
The Director Submarine Warfare Division (N87) of the Office of the Chief of Naval Operations is the resource sponsor for programs related to submarines and submarine warfare (DAU, n.d.).

Office of Naval Intelligence (ONI)

ONI is the leading provider of maritime intelligence to the U.S. Navy and joint warfighting forces, as well as national decision-makers and other consumers in the Intelligence Community. Established in 1882, ONI specializes in the analysis, production, and dissemination of vital, timely, and accurate scientific, technical, geopolitical, and military intelligence information to key consumers worldwide (ONI, 2012).

Office of Naval Research (ONR)
ONR is an executive branch agency within the Department of Defense. ONR supports the president's budget and provides technical advice to the Chief of Naval Operations and the Secretary of the Navy. ONR reports to the Secretary of the Navy through the Assistant Secretary of the Navy for Research, Development and Acquisition. Led by the Chief of Naval Research, its senior leadership oversees a portfolio of investments ranging from immediate, quick-turnaround technologies to long-term basic research (ONR, 2012).

Open Architecture
An architecture that employs open standards for key interfaces within a system (OSJTF, 2004).

Open Standards
Standards that are widely used, consensus based, published, and maintained by recognized industry standards organizations (OSJTF, 2004).

Open System
A system that employs modular design, uses widely supported and consensus-based standards for its key interfaces, and has been subjected to successful validation and verification tests to ensure the openness of its key interfaces (OSJTF, 2004).

Program Executive Officer (PEO)
A military or civilian official who has responsibility for directing several Major Defense Acquisition Programs and for assigned major system and non-major system acquisition programs. A PEO normally has no other command or staff responsibilities within the component and only reports to and receives guidance and direction from the DoD component acquisition executive (DAU, 2011b).

Program Executive Office for Integrated Warfare Systems Advanced Development (PEO IWS5A)
PEO IWS5A is the organization responsible to align development, procurement and delivery of advanced undersea technologies for the fleet. PEO IWS5A has life-cycle responsibilities for analysis of combat system performance, system planning, design management, systems engineering, integration, installation, test, maintenance, and disposal. PEO IWS5A is the cognizant authority responsible for the ARCI, APB, and TI programs (PEO IWS5A, 2003).

Program Executive Office, Submarines (PEO SUB)

PEO SUB focuses on the design, construction, delivery, and conversion of submarines and advanced undersea and anti-submarine systems, including Special Operations Forces delivery systems; submarine rescue systems; torpedoes; towed acoustics sensors; and unique submarine sonar, control, imaging, and electronic warfare systems (NAVSEA, 2013).

Proprietary Standard
A standard that is exclusively owned by an individual or organization, the use of which generally would require a license and/or fee (OSJTF, 2004).

Small Business Innovation Research (SBIR) Program
The SBIR program is a highly competitive program that encourages domestic small businesses to engage in federal research/research and development that has the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs (SBIR/SBTT, 2013).

Sonar Development Working Group (SDWG)
The SDWG was charged to provide a monthly forum for discussion of topics, updates, and issues related to the APB process. It provides a clearinghouse for communication across the working groups and a forum to brief recommendations and works in progress from the various working groups. Meetings are held monthly and agenda items are developed based on priorities established by the fleet and the sponsor (Chief of Naval Operations [CNO] N87) with inputs from the program offices and working-group constituents (Boudreau, 2006). Group no longer exists.

Sound Surveillance System (SOSUS)
Born of a three-way marriage of early Cold War strategic necessity, World War II progress in underwater acoustics, and an extraordinary engineering effort, the Navy's pioneering Sound Surveillance System—SOSUS—became a key, long-range early-warning asset for protecting the United States against the threat of Soviet ballistic missile submarines and in providing vital cueing information for tactical, deep-ocean, anti-submarine warfare (Whitman, 2005).

Spiral Development
A process for implementing evolutionary acquisition within which the end-state requirements are not known at program initiation but are refined through continuous user feedback, demonstration, and risk management so that each increment provides the user the best possible capability (OSJTF, 2004).

Stakeholder
An enterprise, organization, or individual having an interest or a stake in the outcome of the engineering of a system (OSJTF, 2004).

Submarine Combat System Program Office (PMS 425)
Organizations inside Program Executive Office, Submarines, responsible for development and acquisition of the combat and weapons control systems for both in-service and new construction submarines (NAVSEA, 2013).

Submarine Development Squadron Twelve (DEVRON-12)
DEVRON 12 is a submarine squadron missioned to support the Navy's vision of the future by developing and evaluating submarine tactics, both warfighting and forward presence, and disseminating those tactics to the operating forces. Using seven submarines, it provides operational insight into the development of new technology and equipment. DEVRON-12 is commanded by the Commodore, Submarine Development Squadron 12 (CSDS-12), and is responsible for the Submarine Tactical Requirements Group (STRG; USN, 2013).

Submarine Multi-Mission Team Trainer (SMMTT)
SMMTT is the submarine force's premier ashore combat system team trainer; it provides team training for the entire submarine attack party. This trainer, used primarily in pre-deployment training, hones submariners' skills in strike warfare; anti-submarine warfare; anti-surface warfare; Navy special warfare; mine warfare; intelligence, surveillance and reconnaissance; navigation; and command, control, communications, computers and intelligence. To ensure mission success, SMMTT allows for the officer of the deck and his sonar, combat control, weapons launch, electronic warfare support, imaging, and ship control teams to execute complex scenarios in a high-fidelity, realistic simulation that replicates forward-deployed operations (Haines et al., 2009).

Submarine Superiority Technology Panel (SSTP)
Following an internal Navy operational assessment, the Office of the Chief of Naval Operations commissioned the Submarine Sonar Technology Panel to assess the technology development and transition process associated with submarine acoustic signal processing. The primary conclusion of the SSTP was that the current passive sonar (sonar capable of receiving signals but not transmitting them) advanced development process was not effectively transitioning new technology to engineering development. It was determined that systemic process and product changes could enhance the current technological advantage the submarine force enjoyed over other submarine forces (MITRE, 1999).

Submarine Tactical Requirements Group (STRG)
The STRG is the entity responsible for defining and prioritizing the submarine force's tactical requirements (SDWG, 2003). The STRG is a forum of senior submarine officers under the leadership of the Commodore of Submarine Development Group Twelve. The STRG is responsible for identifying and consolidating the submarine fleet's tactical needs through an annual requirements letter. This letter is routed through the Commander Submarine Force, U.S. Pacific Fleet (COMSUBPAC) and the Commander Submarine Forces (COMSUBFOR) to the submarine Navy's resources and requirements sponsor, OPNAV

N97. This requirements letter effectively directs the development goals for the Advanced Processing Build (APB).

Surveillance Towed Array Sensor System (SURTASS)
SURTASS is an element of the Integrated Undersea Surveillance System (IUSS), providing mobile detection, tracking, and reporting of submarine contacts at long range. SURTASS was developed and deployed in the early 1980s as the mobile, tactical arm of the IUSS, providing long-range detection and cuing for tactical weapons platforms against both diesel- and nuclear-powered submarines. With the SOSUS Arrays being placed in a standby status (data available but not continuously monitored), SURTASS must provide the undersea surveillance necessary to support regional conflicts and sea-lane protection (FAS, 1999).

Tactical Advancements for the Next Generation (TANG)
A forum for the submarine force's next-generation operators and officers to collaborate and conceptualize ideas for future interfaces and information management. The first-ever TANG Forum was a three-day workshop for our nation's next-generation submarine operators and officers (COMSUBFOR, 2012).

Technology Insertions (TI)
Technology insertions are hardware updates to submarine sonar systems. TIs are provided every two years and establish a new hardware baseline for future upgrades. TIs take advantage of the increased processing capacity afforded by commercial advances. TIs are managed by the Program Executive Office, Submarines. TIs are identified according to the year for which they are developed. For example, TI 06 identifies the hardware baseline for the submarine system that was completed for 2006.

Weapon System
An item or set of items that can be used directly by warfighters to carry out combat or combat support missions to include tactical communication systems (DoDI 5000.02; USD[AT&L], 2008a).

Watch Section Task Analysis (WSTA)
WSTA is an evaluation conducted in the Submarine Multi-Mission Team Trainer. The WSTA is a method to observe watch teams as they progress through a simulated tactical evolution scenario using a prior year's Advanced Processing Build installation. Following the scenario, the watch team is then run through a similar simulated tactical evolution scenario using a following year's APB installation. The WSTA program served to develop both subjective and objective measurements of how the watch team performed through a comparison of the team's performance using the old system with its performance using the new system (Stapleton, 2013).

APPENDIX B. SELECTED BIOGRAPHIES

Victor Gavin

Mr. Victor Gavin currently serves as Program Executive Officer for Enterprise Information Systems (PEO EIS). In this role, he oversees a $2+ billion portfolio of information technology projects and programs designed to enable common business processes and provide standard information technology capabilities to the Department of Navy. The PEO EIS programs include Naval Enterprise Networks, Navy Enterprise Resource Planning, Global Combat Support System-Marine Corps, Sea Warrior Program, Security Cooperation Enterprise Solution, and DoN Enterprise Software Licensing.

Mr. Gavin's most recent position was Deputy, PEO EIS. Prior to his time at the PEO EIS he was Deputy for the Program Executive Officer for Littoral and Mine Warfare (LMW). PEO LMW executes the Navy's acquisition for Mine Warfare, Unmanned Maritime Vehicles, Explosive Ordnance Disposal, Antiterrorism Afloat, Naval Special Warfare, Maritime Surveillance Systems, and the Mission Modules for the Littoral Combat Ship.

Mr. Gavin was appointed to the Senior Executive Service in February 2007 while serving as Technical Director, PEO Submarines. He was responsible for all Submarine Combat Systems acquisition and PEO directed Research and Development. His responsibilities included modernization of all in-service submarines and support of foreign sales to the Royal Australian Navy Collins Class submarine and the Brazilian Navy Scorpene class submarine.

Over the span of his Navy career, he has held positions as the Systems Engineer with the Naval Underwater Warfare Center, as an on-site government representative with Lockheed Martin, Deputy Program Manager, Submarine Acoustic Systems and as the Program Manager for Submarine Combat Systems.

Mr. Gavin holds a Bachelor of Science degree in electrical engineering from North Carolina AT&T State University and a Master of Science degree in systems engineering from Virginia Polytechnic Institute.

William Johnson

Mr. William M. Johnson is an independent consultant and sole proprietor of WMJ Associates LLC advising government and industry on management and leadership matters involving the acquisition of complex systems. He is retired from 37 years of federal government service. Prior to retiring, he was Deputy for Future Combat Systems Open Architecture in the Program Executive Office for Integrated Warfare Systems. Throughout his career, he has developed and successfully pioneered innovative methods for providing the U.S. Navy's fleet with the best possible products in a timely and affordable manner. He has been widely acclaimed as a key leader in business process transformation and is a recipient of the Navy Distinguished Civilian Award, its highest civilian honor.

Mr. Johnson graduated from Cornell University where he received the Bachelor of Science in electrical engineering in 1970 and the Master of Engineering (Electrical) in 1975. In addition, he is a graduate of the Program Managers Course at the Defense Systems Management College, Ft. Belvoir, VA, in 1989 and the Senior Officials in National Security Program at Harvard University, Cambridge, MA, in 1994. He has maintained ties with academia and has been the subject of case studies at both Harvard and the Naval Postgraduate School.

After completion of undergraduate school, Mr. Johnson embarked on his career at the Georgia Institute of Technology Experiment Station, Atlanta, GA, where he designed electronic circuitry used in testing of surface ship radar systems. Mr. Johnson subsequently volunteered for active duty in the U.S. Navy where he served three years as an officer in undersea surveillance. As a junior officer, he led efforts related to training and operational readiness that were twice recognized by the Commander Ocean Systems Pacific as the best under his command. After leaving the Navy and completing graduate school, he embarked on a career in engineering and program management with the Department of the Navy. Mr. Johnson is experienced in all aspects of design, development, fielding, support and acquisition of surface ship and submarine combat systems. Since 1980, Mr. Johnson has had significant responsibility for many of the Navy's submarine sonar and combat control systems programs. More recently, he led business process transformation efforts at the Naval Enterprise level. These efforts aimed to greatly increase the Navy's ability to take advantage of leading edge technologies and innovations.

He is most proud of the team awards, including the National Performance Review "Hammer" Award (twice), won by programs which he led. He was awarded the Meritorious Civilian Service Award (twice) and is the recipient of the NDIA Bronze Medal for his leadership in Submarine Combat Systems. In addition, he was presented with the Superior Civilian Service Award by his Fleet sponsor for his pioneering of the highly acclaimed Acoustics Rapid COTS Insertion (ARCI) program. Fifteen years after its conception, ARCI continues to be heralded as the "poster child" model for technical and business process transformation within the Navy as well as Department of Defense. His role in this effort is featured in the book "*Collaborate or Perish!: Reaching Across Boundaries in a Networked World*" published by Random House.

Don Noyes

Mr. Don Noyes is the Operator Machine Interface Working Group co-chair for the Submarine Advanced Processing Build Program (APB) in the JHU/APL Laurel Office. In this position, he works to further the development and implementation of a submarine technology innovation vision that fast follows information management designs led by commercial industry. He manages the execution of innovative interface concepts and sponsors fleet and industry interactions applying design-thinking principles to enable user-centric design. He assists in the concepts and development for APB emerging interface technologies to answer critical challenges facing today's warfighter. His extensive background in submarine operations and system interfaces uniquely positions him to bridge the gap with signal processing automation engineers and the warfighter.

Prior to joining JHU/APL in 2005, he retired from the U.S. Navy as a Master Chief Petty Officer and Acoustic Intelligence Specialist (ACINT). His naval career spanned 25 years, completing 26 special operations. He joined the Navy under the advanced electronics program learning to repair and operate all sonar systems on the ship. His first tour was on the USS New York City (SSN 696) in Pearl Harbor, HI. He was then accepted and qualified as an ACINT specialist. IN his 20 years as an ACINT specialist he completed tours in Pearl Harbor, HI, the Office of Naval Intelligence (ONI), Washington DC, and the Submarine Learning Center Detachment in San Diego, CA. He was the ACINT training coordinator, Research and Development Liaison, Concept of Operations Support Group Co-Chair and ACINT Submariner Leading Chief Petty Officer. ACINT specialists are experts in the acoustics, tactics, and operational capabilities of naval ships worldwide, and they advise the commanding officers of submarines and surface ships on tactics during missions. The program was created in 1962 during the Cold War.

Don is married to Laura Hirsch of Bethesda, MD, and they have two children, Jennifer and Jack. In his spare time, Don enjoys fishing, vacationing in Maine, driving and maintaining a pair of vintage Corvettes.

Josh Smith

Mr. Josh Smith is the Assistant Program Manager for Technology Innovation, in the Advanced Processor Build (APB) Submarine Program in the JHU/APL Laurel office. He is passionate about applying design principles and innovative technologies to challenging military problems to empower today's warfighter. His work as the Operator Machine Interface Working Group Co-Chair has spanned a variety of capabilities and submarine software builds leveraging multiple organizations. His background in submarine operations and systems engineering makes him versatile in system interface and concept design.

His other role is the creator and director of the Tactical Advancements for the Next Generation (TANG) Forum initiative. Josh believes in empowering our junior leaders in designing the systems of the future. The TANG Forum brought together a diverse group of experts, end-users, and industry leads for a revolutionary shift in submarine system design. The success of the TANG Forum has created a strong desire for follow on Design Thinking and TANG events for other design areas. His effort has made him a subject of a Naval Postgraduate School case study.

Before joining JHU/APL, he was a submarine officer in the U.S. Navy. His tours included the USS City of Corpus Christi (SSN-705) in Guam and the Submarine Learning Center detachment San Diego, CA. Josh studied at the United States Naval Academy, where he earned a BS in Systems Engineering. Upon receiving his officer commission, Josh reported to the Nuclear Power training pipeline in Charleston, SC. He received a master's degree in engineering management from Old Dominion University while in the Navy.

Dr. John Stapleton

Dr. Stapleton has 27 years of experience in sonar and combat control system engineering, signal processing, information processing, and performance evaluations. He serves on the Principal Professional Staff at the Johns Hopkins University Applied Physics Laboratory. He currently directs technology strategy for the PEO IWS5A submarine Advanced Processing Build (APB) Program, an open architecture open business process. He led the establishment of the PEO-SUB ARCI Engineering Measurement Program, for data collection and measurement of sonar system performance under operational conditions. The program serves as a model for the Combat Control, Imaging, and Surface Ship Engineering Measurement Programs. He has chaired the APB Automation Working Group and co-chaired the Data Fusion Working Group, and he advises on the extension of the APB process to surface ships, the Integrated Undersea Surveillance System, Homeland Security, and biomedical applications. He recently provided direction in the planning and execution of the Tactical Advancements for the Next Generation (TANG) forum, driving a high level of innovation into best practices for leveraging intuitive commercial interfaces and information management approaches for use on the submarine. His expertise areas include user centered design and automated algorithms for active and passive sonar and combat control. He has taught graduate courses for the Johns Hopkins University Whiting School of Engineering graduate program in the areas of Digital Signal Processing and Applied Probability.

APPENDIX C. JUNIOR OFFICER CONFERENCE WHITE PAPER

6/1/2010

JHU/APL
NSTD/STA

JUNIOR OFFICER WATCH TEAM INNOVATION CONFERENCE

By: Joshua D. Smith
Co-authors: Brad Wolf, Don Noyes, Mandy Natter

Junior officer retention within select communities remains a priority, as junior officer retention is the barometer of the health of the future force. In FY09, the overall loss rate for junior officers decreased from 7.8 percent to 6.6 percent. Additionally, the surface and submarine warfare communities met their retention goals, representing the strongest junior officer retention in five years. Due to high operational demand for support of operations in Afghanistan and Iraq, the retention of junior officers within critical skills sets such as special warfare/special operations, explosive ordnance, intelligence, and civil engineering, remains a priority. -

STATEMENT OF
VICE ADMIRAL MARK E. FERGUSON III, U.S. NAVY

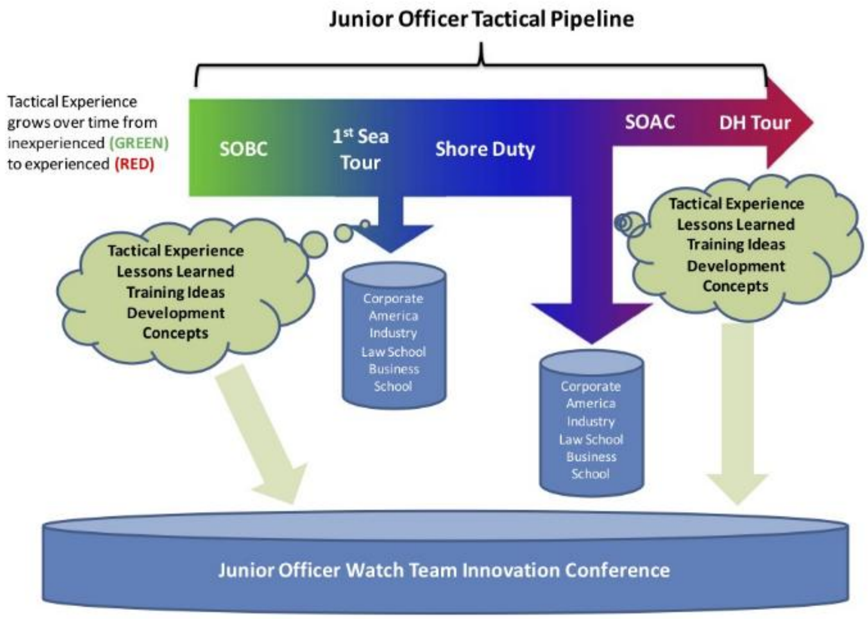
CHIEF OF NAVAL PERSONNEL

AND
DEPUTY CHIEF OF NAVAL OPERATIONS
(MANPOWER, PERSONNEL, TRAINING & EDUCATION)
BEFORE THE
SUBCOMMITTEE ON MILITARY PERSONNEL
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
MILITARY PERSONNEL LEGISLATIVE PRIORITIES
MARCH 17, 2010

Problem Statement: The Navy invests a great deal of time, money, and energy to train Junior Officers, and after acquiring some tactical experience, Junior officers develop a great understanding of current issues. JOs are the "barometer of the health of the future force," they have recent tactical experience, and are prime candidates for understanding how the development community can leverage today's technologies, but we are not tapping into them as a resource to understand where the Navy and combat systems can improve in the future. The attrition rate for Junior Officers in the Submarine Force has been a constant obstacle to overcome in order to maintain the tactical proficiency throughout the wardrooms. Many SSN Junior Officers leave the Submarine Force to pursue jobs in Corporate America and Industry or enroll in Law, Medical, and Business School. A large part of these officers are top performers with a wealth of RECENT tactical experience. The amount of time, money, and energy spent to train these officers is staggering and is lost with their separation from the Navy. Some JOs do stay in the Reserves, but their tactical proficiency drops drastically each day away from the operational fleet.

There needs to be a way to tap into this wealth of RECENT tactical experience to obtain ideas for training, technology, task flows, system deficiencies, lessons learned, and other concepts from their perspective. These Officers of the Decks are more influenced by commercial technology than any generation of junior officers before them.

"Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new." - Machiavelli



Proposal: Host a Junior Officer Watch Team Innovation Conference. Any officer that is ***eligible*** is invited to the conference either on the West or East Coast. The nominated officer would be instructed to ***select a FT and ST*** to attend the conference. The JO, FT, and ST from each boat can provide much needed insight into the boat's perspective on their boat specific APB, training methods, watch team tasks/organization, and their ideas for possible solutions to the submarine forces' problems. The technology curve is increasing exponentially, but the aptitude for younger members of the submarine force to keep pace is influenced by their daily interaction with technology. The JOs daily interaction with iPhones, Facebook, Twitter, texting, XBOX360, iMac, iPAD, and other commercial products make these three sailors/officers prime candidates for understanding how the development community can leverage today's technologies.

Attendee Criteria for Officers:

- **Nominated (one of the following)**
  - **as JO of the Year**
  - **#1 Department Head for the Squadron**
  - **Top Tactics JO/MTT at each Submarine Learning Center**
  - **Top SOAC student**

"Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new." - Machiavelli

- **Highest rank is LCDR[1]**
- **SSN or SSGN Background**

Two main points in this paragraph: 1) generalize what the navy really needs because not one boat- have a closer to representative sample of the watch team (with JO plus FT and ST), 2) JOs don't have the opportunity to honestly speak their minds because of command pressure- the ability to honestly collaborate does not currently exist outside of informal methods- especially amongst the boat (FT and STs), 3) Younger officers- brought up in slightly different culture are more open to change- IMPORTANT- (APB) can't make necessary changes without a willingness to be open to the potential and try.

As the APB process continues to move down the development chain, there are few opportunities for the testers and developers to understand what the sailors use and don't use, like and don't like, and want and don't need. Instead of grabbing a few sound bytes during a sea or in-lab test for ONE boat, why not hold a conference in which multiple sailors/officers can provide their perspective in a comfortable (i.e., no command pressure) environment amongst their peers from other commands and coasts? This would establish a method of collaboration throughout the JO community that does not exist today. The power of networking has already been demonstrated with such venues as Facebook and Twitter. The ability to share ideas and concepts throughout the fleet is limited to the senior officers which is necessary, but could also limit innovative thinking with the more technological advanced members of the submarine community. We have already observed younger sailors and officers' success with new capabilities and technology during countless sea tests and Watch Section Task Analysis events.. Their dependence on "the way we've always done it" does not exist; instead it is replaced with an open mind and a desire to learn something new. Why is it that when new installments of the Madden Football Game are released with a different look and feel, you don't hear complaints amongst the gaming community? (Instead, there is enthusiasm and anticipation of the new version.) The gamer can usually adjust to these new controls and is up and running before the end of the day.

Allowing the Junior Officer to select an FT and ST to bring to the conference can enable a larger sense of collaboration throughout the conference. We will be able to get multiple perspectives on the "this is how we did this on mission" concepts. Instead of only hearing what the CO thinks or what ONE officer thinks, we can understand what the Watch Team thinks.

What's in it for the attendees?

- Unique experience
- Team building
- Networking across the community
- Take ideas/concepts back to the boat
- Impact development of their future systems when they are DHs, XOs, and COs
- Exposure to where APB is going

[1] Similar to war game direction issued by the CNO to RADM Wendy Carpenter NWDC

"Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new." - Machiavelli

- Exposure to industry/advanced development
- Navy Exposure (Article in Base Paper, IWS5A Coin, Letter of Appreciation, etc)
- Resume Building
- Time off the boat

What's in it for Industry?

- Opportunity to show off new technology
- Chance to receive feedback from the deck plate level
- Participate in forward thinking discussions
- Access to the Submarine Force's Top Watch Teams
- Advertising

What's in it for IWS5?

- Dry run some new technology concepts
- Receive unbiased feedback from the JOs, FTs, and STs
- Chance to go beyond the one or two comments from and operator
- Opportunity to tap into a currently UNTAPPED forward thinking group that are heavily influenced by commercial technology (MAC, XBOX, Facebook…etc)
- Access to the Submarine Force's Top Watch Team
    - Future COSG Members?
    - New Hires?
    - WSTA watch teams?
- Great publicity to the fleet
    - These watch sections will go back to their boat and share with the wardroom and crew what they saw and learned
    - Truly Feeding back to the "Fleet"
- Be able to brief what was learned from this conference to the TCSG and STRG (Conference Coordinator will generate a report)
- Outside of the box thinking
- Could develop into an NDIA level annual or semiannual conference.
    - East Coast and West Coast conference

Possible Conference Structure:

- **One Week (East coast in DC and West coast in PH or SD)**
- **Keynote Speaker (N87?)**
- **Developer concept briefs 1 or 2 a day**
- **Hands on Demos**
- **Workshops**
    - **Small group discussions with a facilitator (HSI rep?)**

"Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new." - Machiavelli

  - Break groups up by rate or squadron or some other method (by APB build?)
  - Discuss
    - Task Flows
    - What works/doesn't work on their boat
    - How are they successful
    - What would they change and why?
    - What's missing
    - Training Ideas
  - Future Configuration Concepts (APB 23?)
  - Commercial Products that could be leveraged?
- Have 1 or 2 hand selected senior officers in the audience (not in uniform) in case the discussions go too far off track or are missing a key element of experience
- Social Hours once or twice…enable discussions in a more relaxed environment
- Breakfast and Lunch Catered
- Hotel and Flights Paid For

WHO PAYS FOR THIS?

- Co-Sponsored by Developers/Industry/IWS5/N87/SUBFORCE?

"Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new." - Machiavelli

APPENDIX D. BOOTLEG BOOTCAMP

Check this out —
It's the d.school bootcamp bootleg.

This compilation is intended as an active toolkit to support your design thinking practice. The guide is not just to read – go out in the world and try these tools yourself. In the following pages, we outline each mode of a human-centered design process, and then describe dozens of specific methods to do design work. These process modes and methods provide a tangible toolkit which support the seven mindsets — shown on the following page – that are vital attitudes for a design thinker to hold.

The bootleg is a working document, which captures some of the teaching we impart in "design thinking bootcamp," our foundation course. An update from the 2009 edition, we reworked many of the methods based on what we learned from teaching and added a number of new methods to the mix. The methods presented in this guide are culled from a wide range of people and organizations who have helped us build the content we use to impart design thinking. Think of this guide as a curation of the work of many individuals, who hail both from the d.school and also from other far-reaching areas of the design world. We thank all the people who have contributed to the methods collected in this guide.

We welcome your reactions to this guide. Please share the stories of how you use it in the field. Let us know what you find useful, and what methods you have created yourself – write to: bootleg@dschool.stanford.edu

Cheers,
The d.school

HASSO PLATTNER
Institute of Design at Stanford

Show Don't Tell

Communicate your vision in an impactful and meaningful way by creating experiences, using illustrative visuals, and telling good stories.

Focus on Human Values

Empathy for the people you are designing for and feedback from these users is fundamental to good design.

Craft Clarity

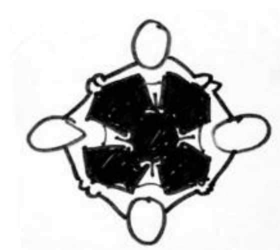
Produce a coherent vision out of messy problems. Frame it in a way to inspire others and to fuel ideation.

Embrace Experimentation

Prototyping is not simply a way to validate your idea; it is an integral part of your innovation process. We build to think and learn.

Be Mindful Of Process

Know where you are in the design process, what methods to use in that stage, and what your goals are.



Bias Toward Action

Design thinking is a misnomer; it is more about doing that thinking. Bias toward doing and making over thinking and meeting.

Radical Collaboration

Bring together innovators with varied backgrounds and viewpoints. Enable breakthrough insights and solutions to emerge from the diversity.

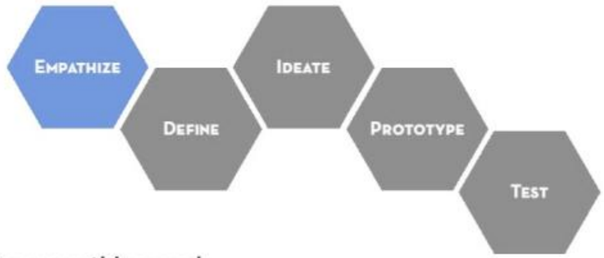
D.MINDSETS

d.

HASSO PLATTNER
Institute of Design at Stanford

MODE

Empathize



WHAT is the empathize mode

Empathy is the foundation of a human-centered design process. To empathize, we:
- **Observe.** View users and their behavior in the context of their lives.
- **Engage.** Interact with and interview users through both scheduled and short 'intercept' encounters.
- **Immerse.** Experience what your user experiences.

WHY empathize

As a human-centered designer you need to understand the people for whom you are designing. The problems you are trying to solve are rarely your own—they are those of particular users; in order to design for your users, you must build empathy for who they are and what is important to them.

Watching what people do and how they interact with their environment gives you clues about what they think and feel. It also helps you to learn about what they need. By watching people you can capture physical manifestations of their experiences, what they do and say. This will allow you to interpret intangible meaning of those experiences in order to uncover insights. These insights will lead you to the innovative solutions. The best solutions come out of the best insights into human behavior. But learning to recognize those insights is harder than you might think. Why? Because our minds automatically filter out a lot of information in ways we aren't even aware of. We need to learn to see things "with a fresh set of eyes" – tools for empathy, along with a human-centered mindset, is what gives us those new eyes.

Engaging with people directly reveals a tremendous amount about the way they think and the values they hold. Sometimes these thoughts and values are not obvious to the people who hold them. A deep engagement can surprise both the designer and the designee by the unanticipated insights that are revealed. The stories that people tell and the things that people say they do—even if they are different from what they actually do—are strong indicators of their deeply held beliefs about the way the world is. Good designs are built on a solid understanding of these kinds of beliefs and values. Engage to:
- Uncover needs that people have which they may or may not be aware of
- Guide innovation efforts
- Identify the right users to design for
- Discover the emotions that guide behaviors

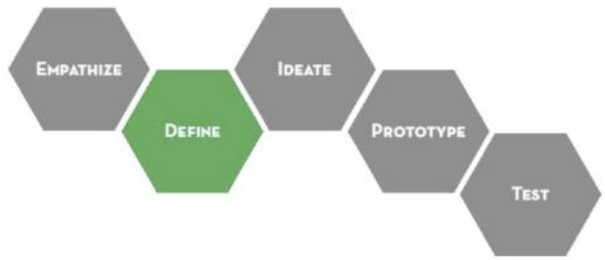
In addition to speaking with and observing your users, you need to have personal experience in the design space yourself. Find (or create if necessary) experiences to immerse yourself to better understand the situation that your users are in, and for which you are designing.

:: 1 ::

d.

MODE

DEFINE



WHAT is the define mode

The define mode is when you unpack and synthesize your empathy findings into compelling needs and insights, and scope a specific and meaningful challenge. It is a mode of "focus" rather than "flaring." Two goals of the define mode are to develop a deep understanding of your users and the design space and, based on that understanding, to come up with an actionable problem statement: **your point of view**. Your point of view should be a guiding statement that focuses on specific users, and insights and needs that you uncovered during the empathize mode.

More than simply defining the problem to work on, your point of view is your unique design vision that you crafted based on your discoveries during your empathy work. Understanding the meaningful challenge to address and the insights that you can leverage in your design work is fundamental to creating a successful solution.

WHY define

The define mode is critical to the design process because it explicitly expresses the problem you are striving to address through your efforts. In order to be truly generative, you must first craft a specific and compelling problem statement to use as a solution-generation springboard.

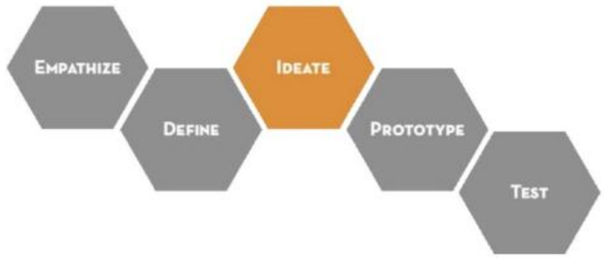
As a test, a good point of view (POV) is one that:
• Provides focus and frames the problem
• Inspires your team
• Provides a reference for evaluating competing ideas
• Empowers your team to make decisions independently in parallel
• Fuels brainstorms by suggesting "how might we" statements
• Captures the hearts and minds of people you meet
• Saves you from the impossible task of developing concepts that are all things to all people
• Is something you revisit and reformulate as you learn by doing
• Guides your innovation efforts

:: 2 ::

d.

MODE

IDEATE



WHAT is the ideate mode

Ideate is the mode during your design process in which you focus on idea generation. Mentally it represents a process of "going wide" in terms of concepts and outcomes—it is a mode of "flaring" rather than "focus." The goal of ideation is to explore a wide solution space - both a large quantity of ideas and a diversity among those ideas. From this vast depository of ideas you can build prototypes to test with users.

WHY ideate

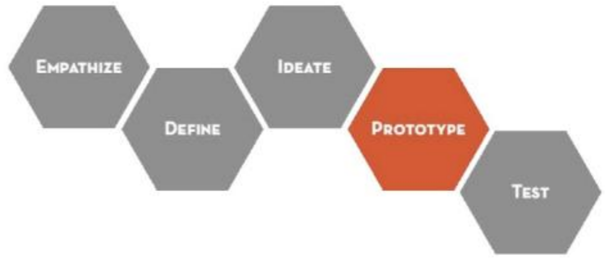
You ideate in order to transition from identifying problems into exploring solutions for your users. Various forms of ideation are leveraged to:
• Step beyond obvious solutions and thus increase the innovation potential of your solution set
• Harness the collective perspectives and strengths of your teams
• Uncover unexpected areas of exploration
• Create fluency (volume) and flexibility (variety) in your innovation options
• Get obvious solutions out of your heads, and drive your team beyond them

Regardless of what ideation method you use, the fundamental principle of ideation is to be cognizant of when you and your team are generating ideas and when you are evaluating ideas - and mix the two only intentionally.

d.

MODE

Prototype



WHAT is the prototype mode

Prototyping is getting ideas and explorations out of your head and into the physical world. A prototype can be *anything* that takes a physical form – be it a wall of post-it notes, a role-playing activity, a space, an object, an interface, or even a storyboard. The resolution of your prototype should be commensurate with your progress in your project. In early explorations keep your prototypes rough and rapid to allow yourself to learn quickly and investigate a lot of different possibilities.

Prototypes are most successful when people (the design team, the user, and others) can experience and interact with them. What you learn from those interactions can help drive deeper empathy, as well as shape successful solutions.

WHY do we prototype

Traditionally prototyping is thought of as a way to test functionality. But prototyping is used for many reasons, including these (non-mutually-exclusive) categories:

• **Empathy gaining:** Prototyping is a tool to deepen your understanding of the design space and your user, even at a pre-solution phase of your project.
• **Exploration:** Build to think. Develop multiple solution options.
• **Testing:** Create prototypes (and develop the context) to test and refine solutions with users.
• **Inspiration:** Inspire others (teammates, clients, customers, investors) by showing your vision.

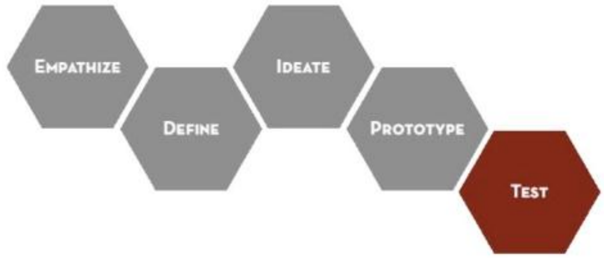
Many of the goals of prototyping are shared across all four of the above categories.
We prototype to:
Learn. If a picture is worth a thousand words, a prototype is worth a thousand pictures.
Solve disagreements. Prototyping is a powerful tool that can eliminate ambiguity, assist in ideation, and reduce miscommunication.
Start a conversation. A prototype can be a great way to have a different kind of conversation with users.
Fail quickly and cheaply. Creating quick and dirty prototypes allows you to test a number of ideas without investing a lot of time and money up front.
Manage the solution-building process. Identifying a variable to explore encourages you to break a large problem down into smaller, testable chunks.

:: 4 ::

d.

MODE

TEST



WHAT is the test mode

Testing is the chance to refine our solutions and make them better. The test mode is another iterative mode in which we place our low-resolution artifacts in the appropriate context of the user's life. Prototype as if you know you're right, but test as if you know you're wrong.

WHY test

To refine our prototypes and solutions. Testing informs the next iterations of prototypes. Sometimes this means going back to the drawing board.
To learn more about our user. Testing is another opportunity to build empathy through observation and engagement—it often yields unexpected insights.
To test and refine our POV. Sometimes testing reveals that not only did we not get the solution right, but also that we have failed to frame the problem correctly.

METHOD

Assume a Beginner's Mindset

WHY assume a beginner's mindset

We all carry our experiences, understanding, and expertise with us. These aspects of yourself are incredibly valuable assets to bring to the design challenge – but at the right time, and with intentionality. Your assumptions may be misconceptions and stereotypes, and can restrict the amount of real empathy you can build. Assume a beginner's mindset in order to put aside these biases, so that you can approach a design challenge afresh.

HOW to assume a beginner's mindset

Don't judge. Just observe and engage users without the influence of value judgments upon their actions, circumstances, decisions, or "issues."
Question everything. Question even (and especially) the things you think you already understand. Ask questions to learn about how the user perceives the world. Think about how a 4-year-old asks "Why?" about everything. Follow up an answer to one "why" with a second "why."
Be truly curious. Strive to assume a posture of wonder and curiosity, especially in circumstances that seem either familiar or uncomfortable.
Find patterns. Look for interesting threads and themes that emerge across interactions with users.
Listen. Really. Lose your agenda and let the scene soak into your psyche. Absorb what users say to you, and how they say it, without thinking about the next thing you're going to say.

METHOD

What? | How? | Why?

concrete ↔ emotional

WHAT (what are they doing in the photo?)	HOW (how are they doing it?)	WHY (why are they doing it this way? Take a guess!)
-little girl picking root vegetables	-she's smiling, even though it looks bigger than her, it looks fun	-somehow it's been made into a game...gardening is fun...getting messy is fun to her?

WHY use What? | How? | Why?

During observation mode, What? | How? | Why? is a tool that can help you drive to deeper levels of observation. This simple scaffolding allows you to move from concrete observations of the happenings of a particular situation to the more abstract potential emotions and motives that are at play in the situation you're observing. This is a particularly powerful technique to leverage when analyzing photos that your team has taken into the field, both for synthesis purposes, and to direct your team to future areas of needfinding.

HOW to use What? | How? | Why?

Set-up: Divide a sheet into three sections: What?, How?, and Why?

Start with concrete observations:
What is the person you're observing doing in a particular situation or photograph? Use descriptive phrases packed with adjectives and relative descriptions.

Move to understanding:
How is the person you're observing doing what they are doing? Does it require effort? Do they appear rushed? Pained? Does the activity or situation appear to be impacting the user's state of being either positively or negatively? Again, use as many descriptive phrases as possible here.

Step out on a limb of interpretation:
Why is the person you're observing doing what they're doing, and in the particular way that they are doing it? This step usually requires that you make informed guesses regarding motivation and emotions. Step out on a limb in order to project meaning into the situation that you have been observing. This step will reveal assumptions that you should test with users, and often uncovers unexpected realizations about a particular situation.

:: 7 ::

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METHOD

User Camera Study

WHY do a user camera study

In empathy work, you want to understand your users' lives, and specific tasks within the context of their lives. A User Camera Study allows us to understand a user's experience by seeing it through their eyes. It will also allow you to understand environments to which you might not normally have access.

HOW to do a user camera study

1. Identify subjects whose perspective you are interested in learning more about.

2. Briefly explain the purpose of the study, and ask if they would be willing to take photographs of their experiences. Get permission to use images they take.

3. Provide a camera to your subject and instructions such as: "We would like to understand what a day in your life feels like. On a day of your choosing, take this camera with you everywhere you go, and take photos of experiences that are important to you." Or you could try: "Please document your [morning routine] experience with this camera." Or, "Take pictures of things that are meaningful to you in your kitchen." Frame your request a little broader than what you believe your problem space might be, in order to capture the surrounding context. Many insights can emerge from that surrounding space.

4. Afterwards, have your subject walk you through the pictures and explain the significance of what they captured. Return to a good empathetic interviewing technique to understand the deeper meaning of the visuals and experience they represent.

:: 8 :: d.

METHOD

Interview Preparation

WHY prepare for an interview

Time with users is precious, we need to make the most of it! While we always must allow room for the spontaneous, blissful serendipity of a user-guided conversation, we should never abdicate our responsibility to prepare for interviews. Especially in following up with users (after testing, etc.), it is imperative to plan your interviews. You may not get to every question you prepare, but you should come in with a plan for engagement.

HOW to prepare for an interview

Brainstorm questions

Write down all of the potential questions your team can generate. Try to build on one another's ideas in order to flesh out meaningful subject areas.

Identify and order themes

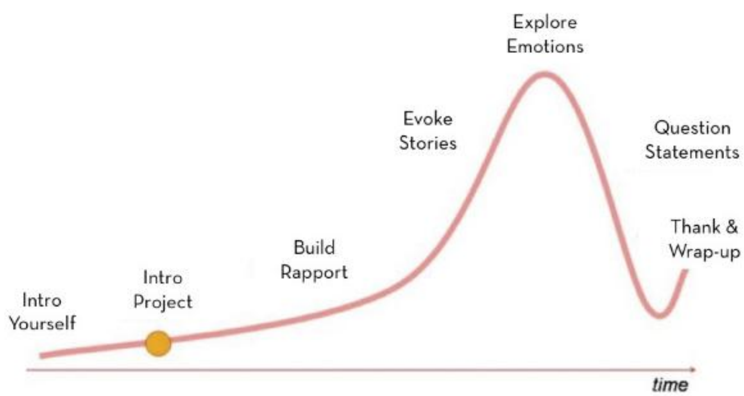
Similar to "grouping" in synthesis, have your team identify themes or subject areas into which most questions fall; once you've identified the themes of your question-pool, determine the order that would allow the conversation to flow most naturally. This will enable you to structure the flow of your interview, decreasing the potential for hosting a seemingly-scattershot interaction with your user.

Refine questions

Once you have all the questions grouped by theme and order, you may find that there are some redundant areas of conversation, or questions that seem strangely out of place. Take a few moments to make sure that you leave room in your planning to ask plenty of "why?" questions, plenty of "tell me about the last time you ___?" questions, and plenty of questions that are directed at how the user FEELS.

METHOD

Interview for Empathy



WHY interview

We want to understand a person's thoughts, emotions, and motivations, so that we can determine how to innovate for him or her. By understanding the choices that person makes and the behaviors that person engages in, we can identify their needs and design for those needs.

HOW to interview

Ask why. Even when you think you know the answer, ask people why they do or say things. The answers will sometimes surprise you. A conversation started from one question should go on as long as it needs to.
Never say "usually" when asking a question. Instead, ask about a specific instance or occurrence, such as "tell me about the last time you ___"
Encourage stories. Whether or not the stories people tell are true, they reveal how they think about the world. Ask questions that get people telling stories.
Look for inconsistencies. Sometimes what people say and what they do are different. These inconsistencies often hide interesting insights.
Pay attention to nonverbal cues. Be aware of body language and emotions.
Don't be afraid of silence. Interviewers often feel the need to ask another question when there is a pause. If you allow for silence, a person can reflect on what they've just said and may reveal something deeper.
Don't suggest answers to your questions. Even if they pause before answering, don't help them by suggesting an answer. This can unintentionally get people to say things that agree with your expectations.
Ask questions neutrally. "What do you think about buying gifts for your spouse?" is a better question than "Don't you think shopping is great?" because the first question doesn't imply that there is a right answer.
Don't ask binary questions. Binary questions can be answered in a word; you want to host a conversation built upon stories.
Only ten words to a question. Your user will get lost inside long questions.
Only ask one question at a time, one person at a time. Resist the urge to ambush your user.
Make sure you're prepared to capture. Always interview in pairs. If this is not possible, you should use a voice recorder—it is impossible to engage a user and take detailed notes at the same time.

:: 10 :: Visual adapted from Michael Barry, Point Forward

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METHOD

Extreme Users

WHY engage with extreme users

Designers engage with users (people!) to understand their needs and gain insights about their lives. We also draw inspiration from their work-arounds and frameworks. When you speak with and observe extreme users, the needs are amplified and their work-arounds are often more notable. This helps you pull out meaningful needs that may not pop when engaging with the middle of the bell curve. However, the needs that are uncovered through extreme users are often also needs of a wider population.

HOW to engage extreme users

Determine who's extreme
Determining who is an extreme user starts with considering what aspect of your design challenge you want to explore to an extreme. List a number of facets to explore within your design space. Then think of people who may be extreme in those facets. For example, if you are redesigning the grocery store shopping experience you might consider the following aspects: how groceries are gathered, how payment is made, how purchase choices are made, how people get their groceries home, etc. Then to consider the aspect of gathering groceries, for example, you might talk to professional shoppers, someone who uses a shopping cart to gather recyclables (and thus overloads the cart), product pullers for online buyers, people who bring their kids shopping with them, or someone who doesn't go to grocery stores.

Engage
Observe and interview your extreme user as you would other folks. Look for work-arounds (or other extreme behaviors) that can serve as inspiration and uncover insights.

Look at the extreme in all of us
Look to extreme users for inspiration and to spur wild ideas. Then work to understand what resonates with the primary users you are designing for.

:: 11 :: photo: flickr/bitchcakesny

d.

METHOD

Analogous Empathy

WHY use analogous empathy

During empathy work, analogies can be a powerful tool for developing insights that aren't obvious in a direct approach. Analogous needfinding spaces can offer up inspiration, a way to get unstuck, a fresh perspective on a space, or a useful work-around when direct observation is difficult.

HOW to use analogous empathy

Identify specific aspects of the space that you're interested in
Get your team together to talk about what aspects of the empathy space you're exploring are particularly interesting. If you're looking at hospitals, for example, you may be focusing on extreme time pressures, very high stakes decisions or perhaps long wait times. Look for spaces that are tangential to your design challenge, but share enough attributes that there may be insight cross-over.

Brainstorm opportunities for analogous spaces
If, for example, you think customer service is an important aspect of the space you're looking at, brainstorm places you might go to find particularly strong (or weak) customer service. You may also want to brainstorm specific people you could interview about these analogous spaces, or how you might do a quick observation.

Make an analogous inspiration board
Saturate a space with photos and quotes from your analogous space; this can help the team share inspiration, or bring in the analogous insight later in the process.

:: 12 :: photos: flickr/xcode, flickr/watt_dabney

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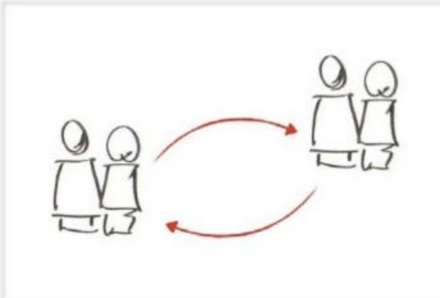
METHOD

Story Share-and-Capture



WHY story share-and-capture

A team share serves at least three purposes. First, it allows team members to come up to speed about what different people saw and heard in the field. Even if all the team members were present for the same fieldwork, comparing how each experienced it is valuable. Second, in listening and probing for more information, team members can draw out more nuance and meaning from the experience than you may have initially realized. This starts the synthesis process. Third, in capturing each interesting detail of the fieldwork, you begin the space saturation process.

HOW to story share-and-capture

Unpack observations and air all the stories that stick out to you about what you saw and heard during your empathy fieldwork. Each member in the group should tell user stories and share notes while other members headline quotes, surprises, and other interesting bits – one headline per post-it. These post-its become part of the team's space saturation, and can also be physically grouped to illuminate theme and patterns that emerge (See "Saturate and Group" method card). The end goal is to understand what is really going on with each user. Discover who that person is and what that person needs in regard to your problem space.

METHOD

Saturate and Group

WHY saturate and group

You space saturate to help you unpack thoughts and experiences into tangible and visual pieces of information that you surround yourself with to inform and inspire the design team. You group these findings to explore what themes and patterns emerge, and strive to move toward identifying meaningful needs of people and insights that will inform your design solutions.

HOW to saturate and group

Saturate your wall space (or work boards) with post-its headlining interesting findings (see "Story Share-and-Capture") plus pictures from the field of users you met and relevant products and situations.

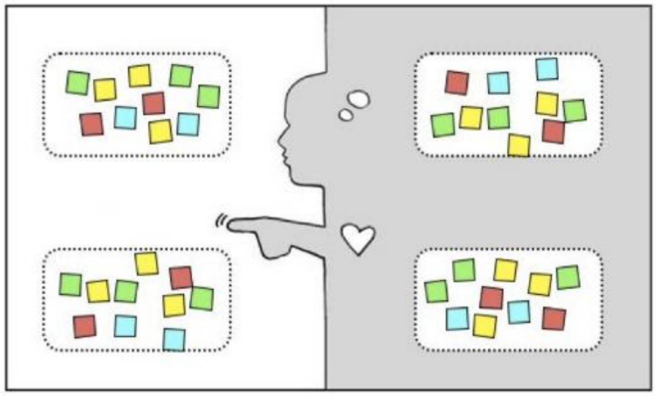
In order to begin to synthesize the information, organize the post-its and pictures into groups of related parts. You likely have some ideas of the patterns within the data from the unpacking you did when producing the notes. For example, you may have seen and heard many things related to feeling safe, and many things regarding desire for efficiency. Within the group of 'safety', go beyond the theme and try to see if there is a deeper connection that may lead to an insight such as "Feeling safe is more about who I am with than where I am". Maybe there is a relation between groups that you realize as you place items in groups – that safety is often at odds with users' desire for efficiency. Try one set of grouping, discuss (and write down) the findings, and then create a new set of groups.

The end goal is to synthesize data into interesting findings and create insights which will be useful to you in creating design solutions.

It is common to do the grouping with post-its headlining interesting stories from fieldwork. But grouping is also useful to think about similarities among a group of products, objects, or users.

METHOD

Empathy Map



WHY use an empathy map

Good design is grounded in a deep understanding of the person for whom you are designing. Designers have many techniques for developing this sort of empathy. An Empathy Map is one tool to help you synthesize your observations and draw out unexpected insights.

HOW to use an empathy map

UNPACK: Create a four quadrant layout on paper or a whiteboard. Populate the map by taking note of the following four traits of your user as you review your notes, audio, and video from your fieldwork:

SAY: What are some quotes and defining words your user said?
DO: What actions and behaviors did you notice?
THINK: What might your user be thinking? What does this tell you about his or her beliefs?
FEEL: What emotions might your subject be feeling?

Note that thoughts/beliefs and feelings/emotions cannot be observed directly. They must be inferred by paying careful attention to various clues. Pay attention to body language, tone, and choice of words.

IDENTIFY NEEDS: "Needs" are human emotional or physical necessities. Needs help define your design challenge. Remember: Needs are *verbs* (activities and desires with which your user could use help), not *nouns* (solutions). Identify needs directly out of the user traits you noted, or from contradictions between two traits – such as a disconnect between what she says and what she does. Write down needs on the side of your Empathy Map.

IDENTIFY INSIGHTS: An "Insight" is a remarkable realization that you could leverage to better respond to a design challenge. Insights often grow from contradictions between two user attributes (either within a quadrant or from two different quadrants) or from asking yourself "Why?" when you notice strange behavior. Write down potential insights on the side of your Empathy Map. One way to identify the seeds of insights is to capture "tensions" and "contradictions" as you work.

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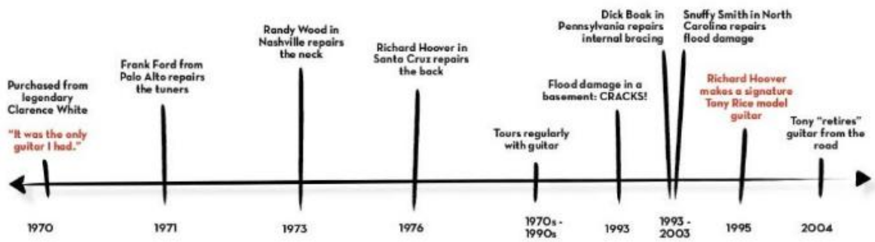
METHOD

Journey Map



WHY use a journey map

To gain empathy for a person or understanding of one's process through an experience, consider the details of that process to illuminate areas of potential insights. Creating a journey map is an excellent way to systematically think about the steps or milestones of a process. A journey map can be used for your own empathy work, or to communicate your findings to others.

HOW to use a journey map

Create diagrams that capture multiple observations, e.g. a map of a user's day, a map of a user's experience, or a map of how a product moves through space and time (from manufacturing to store shelf to user's hands). Consider a process or journey that is relevant, or even tangential to, your problem space. For example, you could consider your user's morning breakfast routine. You could capture every event of one person's exercise in a month – and consider who she was with, where she came from, where she exercised, and where she went afterwards. Or perhaps you are developing a dating service website; you could document every communication between two people before the first date. One important concern is to be comprehensive within the variables you choose to capture. (Don't overlook the opening of the window shades in the morning breakfast routine.) What seems meaningless, could actually be the nugget that develops into a stunning insight. You can create a journey map based on observation and interview – or you might ask a user to draw a journey map and then explain it to you.

Organize the data in a way that makes sense: a timeline of events, a number of parallel timelines that allows for easy comparison, a series of pictures, or a stack of cards. Then look for patterns and anomalies and question why those themes or events occurred. Push yourself to connect individual events to a larger context or framework. It is often the pairing of an observation with the designer's knowledge and perspective that yields a meaningful insight.

d.

METHOD

Composite Character Profile

Franklin

- 38 years old
- Divorced
- 2 kids
- Diabetic
- Free-clinic care-giver
- Has extreme tendencies in consumption and preparation of food.
- Balances his health and that of others, favoring the health of others.

WHY use a composite character profile

The composite character profile can be used to bucket interesting observations into one specific, recognizable character. Teams sometimes get hung up on outlying (or non-essential) characteristics of any of a number of particular potential users, and the composite character profile is a way for them to focus the team's attention on the salient and relevant characteristics of the user whom they wish to address. Forming a composite character can be a great way to create a "guinea pig" to keep the team moving forward.

HOW to use a composite character profile

The composite character profile is a synthesis method whereby the team creates a (semi)-fictional character who embodies the human observations the team has made in the field. These might include "typical" characteristics, trends, and other patterns that the team has identified in their user group over the course of their field work.

In order to create a composite character profile, a team needs to have unpacked its field observations and saturated its team space. After this is done, a team should survey across the individual users it encountered in the field to identify relevant dimensions of commonality and/or complementarity – these dimensions could be demographic information, strange proclivities and habits, or sources of motivation, to name only a few. After several dimensions of commonality have been identified, list these features of the user; if there are any dimensions of complementarity (those which may not be shared by all users, but are interesting to the team and not necessarily mutually exclusive), the team should add these as well. Last, give your character a name, and make sure every member of the team buys into the identity and corresponding characteristics that the team has created.

:: 17 :: d.

METHOD

Powers of Ten

WHY use powers of ten

Powers of Ten is a reframing technique that can be used as a synthesis or ideation method. It allows the design team to use an intentional approach to considering the problem at varied magnitudes of framing.

HOW to use powers of ten

The concept of Powers of Ten is to consider one aspect over increasing and decreasing magnitudes of context. Let's take two examples to illustrate how Powers of Ten could be used during a design process:

POWERS OF TEN FOR INSIGHT DEVELOPMENT: In this example, imagine you are designing a checkout experience, and you are trying to understand a user's motivation and approach to an aspect of her life. You are thinking about how she makes buying decisions. You made the observation that she read a number of customer reviews before making a purchase and are developing an insight that she values her peers' opinions when making purchases. Consider what her behavior might be for buying various items over a wide range of costs, from a pack of gum, to a pair of shoes, to a couch, to a car, to a house. Capture this in writing. Probe for nuances in your insight and see where it breaks down. Perhaps this could develop into a framework, such as a 2x2 (see the 2x2 Matrix method card).

POWERS OF TEN FOR IDEATION: During brainstorming groups idea generation lulls from time to time. One way to facilitate new energy is to use Powers of Ten. Continue with your brainstorming topic, but add a constraint that changes the magnitude of the solution space. "What if it had to cost more than a million dollars to implement?," "What about under 25 cents?," "What if it was physically larger than this room?," "Smaller than a deck of cards?," "Had no physical presence?", "Took more than four hours to complete the experience?", "Less than 30 seconds?". More power to you.

:: **18** :: image: Charles and Ray Eames, www.powersof10.com

d.

METHOD

2X2 MATRIX

WHY use a 2x2 matrix

A 2x2 matrix is tool to scaffold thinking and conversation about your users and problem space. Use it during your synthesis process to help you think about relationships between things or people. The hope is that insights or areas to explore more deeply will come out from using a 2x2. 2x2 matrices are also a great way to visually communicate a relationship you want to convey.

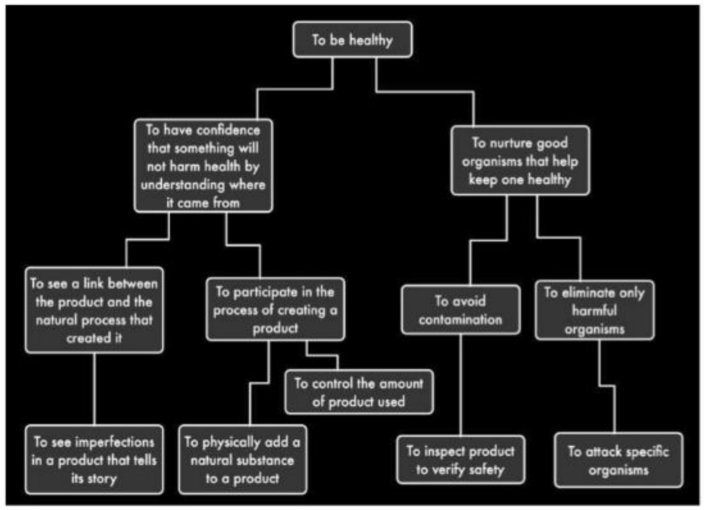
HOW to use a 2x2 matrix

Pick two spectra (one on each axis), draw a 2x2 matrix, and plot items in the map . The items could be product, objects, motivations, people, quotes, materials – any group of things that would be useful to explore. Put opposites on either end of each axis. For example, you might place different people on a matrix of passion for their career (low-to-high) vs. technology adoption (early-adopter-to-late-adopter). Look for relationships by seeing where groups start to form. See what quadrants are very full or empty; where does the assumed correlation break down? The discussion that is spurred by trying to place items on the matrix is often more valuable than producing the map itself. You may need to try a number of combinations of spectra to get one that is meaningful and informative. Try some combinations, even if you are not sure which is right – the first attempts will inform the ones to follow.

One common use for a 2x2 matrix is a competitive landscape. In this case, an empty quadrant could signal a market opportunity (or a very bad idea).

METHOD

Why-How Laddering



WHY why-how ladder

As a general rule, asking 'why' yields more abstract statements and asking 'how' yields specific statements. Often times abstract statements are more meaningful but not as directly actionable, and the opposite is true of more specific statements. That is why you ask 'why?' often during interviews – in order to get toward more meaningful feelings from users rather than specific likes and dislikes, and surface layer answers. Outside an interview, when you think about the needs of someone, you can use why-how laddering to flesh out a number of needs, and find a middle stratum of needs that are both meaningful and actionable.

HOW to why-how ladder

When considering the needs of your user, start with a meaningful one. Write that need on the board and then ladder up from there by asking 'why'. Ask why your user would have that need, and phrase the answer as a need. For example, "Why would she 'need to see a link between a product and the natural process that created it'? Because she 'needs to have confidence that something will not harm her health by understanding where it came from'." Combine your observations and interviews with your intuition to identify that need. Then take that more abstract need and ask why again, to create another need. Write each on the board above the former. At a certain point you will reach a very abstract need, common to just about everyone, such as the 'need to be healthy'. This is the top of that need hierarchy branch.

You can also ask 'how' to develop more specific needs. Climb up ('why?') and down (how?) in branches to flesh out a set of needs for your user. You might come up to one need and then come back down. In the previous example, you climbed up to the 'need to understand where a product came from'. Then ask 'how' to identify the 'need to participate in the process of creating a product'. There will also be multiple answers to your 'whys' and 'hows' – branch out and write those down.

The result (after some editing and refining) is a needs hierarchy that paints a full picture of your user or composite user. Alternatively, you can use this tool to hone in on one or two particularly salient needs.

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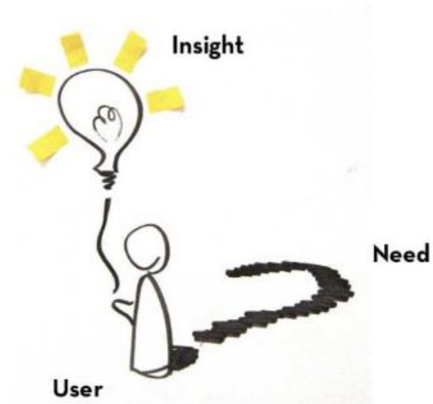
METHOD

Point-of-View Madlib



WHY use a POV madlib

A point-of-view (POV) is your reframing of a design challenge into an actionable problem statement that will launch you into generative ideation. A POV Madlib provides a scaffolding to develop your POV. A good POV will allow you to ideate in a directed manner, by creating How-Might-We (HMW) questions based on your POV (see "Facilitating Brainstorms"). Most of all, your POV captures your design vision – your responsibility and opportunity as a designer is to discover and articulate the meaningful challenge.

HOW to use a POV madlib

Use the following madlib to capture and harmonize three elements of a POV: user, need, and insight.

[USER] needs to [USER'S NEED] because [SURPRISING INSIGHT]

Use a whiteboard or scratch paper to try out a number of options, playing with each variable and the combinations of them. The need and insight should flow from your unpacking and synthesis work. Remember, 'needs' should be verbs, and the insight typically should not simply be a reason for the need, but rather a synthesized statement that you can leverage in designing a solution. Keep it sexy (it should intrigue people) and hold the tension in your POV.

For example, instead of "A teenage girl needs more nutritious food because vitamins are vital to good health" try "A teenage girl with a bleak outlook needs to feel more socially accepted when eating healthy food, because in her hood a social risk is more dangerous than a health risk." Note how the latter is an actionable, and potentially generative, problem statement, while the former is little more than a statement of fact, which spurs little excitement or direction to develop solutions.

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METHOD

Point-of-View Analogy

WHY use a POV analogy

A point-of-view (POV) is your reframing of a design challenge into an actionable problem statement that will launch you into generative ideation. A POV Analogy can be a concise and compelling way to capture how you define the design challenge (your POV!). A good analogy will yield a strong directive of how you go about designing the final solution.

HOW to use a POV analogy

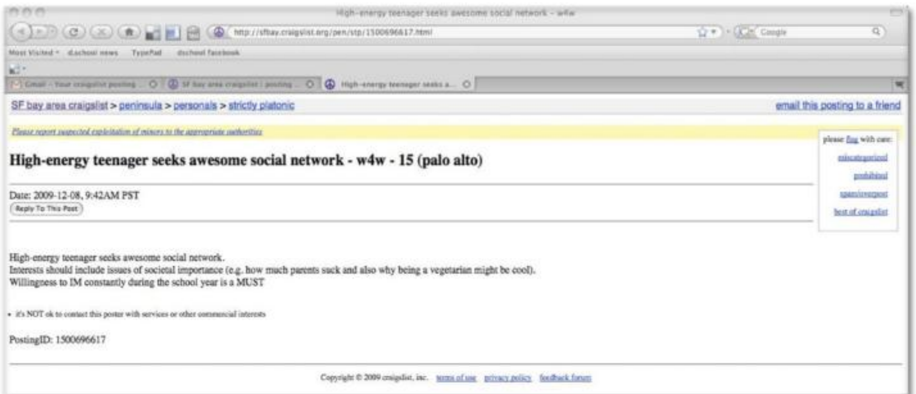
Use concise analogies to distill ideas. Metaphors and similes can encapsulate your insights in a rich picture. Discover metaphors from the work you do in synthesizing information, and looking at analogies between your user's situation and other areas.

For example, one metaphor from industry is:
"Personal music player as jewelry,"
which provides the directive for creating the iPod. Looking at the headset as jewelry, rather than simply speakers, allows the designer to create a product that users will enjoy as a projection of themselves, rather than merely a utilitarian device. You can imagine this could have been seeded by an insight about how a user views her music collection – that "her identity is linked to the bands she listens to, and her relationships are bolstered by shared music taste."

A metaphor can also be embedded into a more comprehensive POV.
For example you may create the following POV:
"A works-hard-plays-hard young professional needs to be motivated at work with a job that is more like a first-person-shooter than Tetris."

METHOD

Point-of-View Want Ad



WHY use a POV want ad

A point-of-view (POV) is your reframing of a design challenge into an actionable problem statement that will launch you into generative ideation. A POV Want Ad can be a good way to express your distilled findings in an intriguing format. The want ad format tends to accentuate a specific user, and her important character traits.

HOW to use a POV want ad

Embed your user, his or her need, and your insights within the format of a want ad. This way of expressing a POV is often more playful and nuanced than the simple USER+NEED+INSIGHT madlib, but should still have a clarity about how you have reframed the problem.

Try this format:
Descriptive characterization of a user,
followed by "seeks" an ambiguous method to meet an implied need,
plus additional flavor to capture your findings.
For example: "High-energy teenager seeks awesome social network. Interests should include issues of societal importance (e.g. how much parents suck and also why being a vegetarian might be cool). Willingness to IM constantly during the school year is a MUST!"

d.

METHOD

Critical Reading Checklist

Critical Reading Checklist

1.) What's the point?

2.) Who says?

3.) What's new?

4.) Who cares?

WHY use a critical reading checklist

The Checklist is a tool used to determine whether a team has arrived at a meaningful, unique Point of View (POV). The original "Critical Reading Checklist" tool was developed by David Larabee, of the Stanford School of Education, and repurposed in the context of a design process to evaluate POVs.

Use this Checklist to ensure that your team's POV is valid, insightful, actionable, unique, narrow, meaningful, and exciting. While this method is not in itself sufficient to address the deficiencies of a POV, it is a great tool to think through and evaluate the usefulness of the POV.

HOW to use a critical reading checklist

We ask ourselves four basic questions about our Point of View:

1. **What's the point?** – What is your team's angle?
• What is your team's framework in stating a POV?
• Is it User-centered, Need-based, and Insight-driven?
2. **Who says?** – How valid is your team's POV?
• Is your position supported by findings from users?
• Is it a distillation of findings? Is this applicable outside of one colorful interview?
3. **What's new?** – What is the value-add of your POV?
• Have you articulated your findings in a new way?
• Are they placed in the context of a user?
• If your POV doesn't feel new, try being more specific.
4. **Who cares?** – How is your POV significant?
• Your team should be excited at this point!
• Is this work *worth doing? If not, ask yourself why?*
• Reframe/rephrase until you get it right.

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d.

METHOD

Design Principles

WHY use design principles

Design principles are strategies to solve a design challenge independent of a specific solution. You, as the designer, articulate these principles, translating your findings – such as needs and insights – into design directives. These principles give you a format to capture abstracted, but actionable, guidelines for solutions, and communicate your design intentions to others.

HOW to use design principles

Develop a list of statements – using imperative phrasing – that outlines essential guidelines to create successful design solutions. The guidelines should distill your understanding of the design space and user. That is, you define what would be the meaningful challenge to solve, based on your empathy work, and then create the design principles to outline what's necessary to achieve that success.

You develop design principles in a number of ways. You can translate your point of view, needs, and insights into design principles by stating your findings in terms of solutions rather than the user, while maintaining the focus on the user-centered needs and insights you discovered. For example, a user's "need to feel instrumental in creating a gift" could become a design directive that the solution should "involve the user in creating the final gift outcome." You can also back out design principles from potential solutions that you and users find compelling. Ask yourself what aspects of the solution resonated with users, and those aspects may be abstracted and formed into design principles.

Design principles should be independent of a specific solution – i.e. useful guidelines regardless of the particular solution. However, it is helpful to identify the broad solution context to help you develop design principles. For example, you may know that you are designing a physical space – that would help you understand how to phrase your principles. In another case, you might know you are creating a gift – but not know whether it will be physical, digital, or experiential. Still, that context would allow you articulate the meaningful principle mentioned above to "involve the gift-giver in creating the final outcome."

:: 25 :: d.

METHOD

"How Might We" Questions

WHY create how might we questions

"How might we" (HMW) questions are short questions that launch brainstorms. HMWs fall out of your point-of-view statement or design principles as seeds for your ideation. Create a seed that is broad enough that there are a wide range of solutions but narrow enough that the team has some helpful boundaries. For example, between the too narrow "HMW create a cone to eat ice cream without dripping" and the too broad "HMW redesign dessert" might be the properly scoped "HMW redesign ice cream to be more portable." It should be noted, the the proper scope of the seed will vary with the project and how much progress you have made in your project work.

HOW to generate how might we questions

Begin with your Point of View (POV) or problem statement. Break that larger challenge up into smaller actionable pieces. Look for aspects of the statement to complete the sentence, "How might we..." It is often helpful to brainstorm the HMW questions before the solutions brainstorm. For example, consider the following POV and resulting HMW statements.

USER	+	NEED	+	INSIGHT
An overworked husband	(needs)	to feel good about recycling		When things pile up he feels behind. And ultimately the big pile on the curb feels more like generating waste than doing good

1. How to reduce the size of the recycling pile?
2. How to make the husband feel good about a big pile?
3. How to reduce the amount of work involved in gathering all the house piles?
4. How to eliminate overflowing recycling bins?
5. How to make the husband feel ahead of the game?
6. How to make the husband feel less overworked?
7. How to make recycling feel less like waste?

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METHOD

Stoke

WHY stoke

Stoke activities help teams loosen up and become mentally and physically active. Use stoke activities when energy is wavering, to wake up in the morning, to launch a meeting, or before a brainstorm.

HOW to stoke

Do an activity that gets your creativity going and increases your team members' engagement with each other. A good stoke activity not only increases energy but also requires each person to actively engage, listen, think, and do. For example, when playing Pictionary you must watch a teammate drawing, listen to other teammates guessing the answer (allowing you to build on those ideas), think of what the answer might be, and call out guesses yourself. Keep the activity brief (5-10 minutes) and active so you can jump into your design work after. Many improv games are good stoke activities. Try one of these:

Category, category, die! Line folks up. Name a category (breakfast cereals, vegetables, animals, car manufacturers). Point at each person in rapid succession, skipping around the group. The player has to name something in the category. If she does not, everyone yells "die!!" and that player is out for the round.

Sound ball Stand in a circle and throw an imaginary ball to each other. Make eye contact with the person you are throwing to, and make a noise as you throw it. The catcher should repeat the noise while catching, and then make a new noise as he throws to next person. Try to increase the speed the ball travels around the circle. Add a second ball to the circle to increase each person's awareness.

"Yes, Let's" Everyone walk around the room randomly, and then one person can make an offer: "Let's act like we're all at a cocktail party," "Let's be baby birds," or "Let's act like we don't understand gravity." Then everyone should shout in unison the response, "Yes, let's" and proceed to take the directive by acting it out. At anytime someone else can yell out the next offer. The answer is always, "Yes, let's!"

:: 27 :: photo: flickr/James Willamor

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METHOD

Brainstorming

One Conversation at a Time

Go for Quantity

Headline!

Build on the Ideas of Others

Encourage wild ideas

Be Visual

Stay on Topic

Defer Judgement - NO Blocking

WHY brainstorm

Brainstorming is a great way to come up with a lot of ideas that you would not be able to generate by just sitting down with a pen and paper. The intention of brainstorming is to leverage the collective thinking of the group, by engaging with each other, listening, and building on other ideas. Conducting a brainstorm also creates a distinct segment of time when you intentionally turn up the generative part of your brain and turn down the evaluative part. Brainstorming can be used throughout a design process; of course to come up with design solutions, but also any time you are trying to come up with ideas, such as planning where to do empathy work, or thinking about product and services related to your project – as two examples.

HOW to brainstorm

Be intentional about setting aside a period of time when your team will be in "brainstorm mode" – when the sole goal is to come up with as many ideas as possible, and when judgment of those ideas will not come into the discussion. Invest energy into a short period of time, such as 15 or 30 minutes of high engagement. Get in front of a whiteboard or around a table, but take an active posture of standing or sitting upright. Get close together.

Write down clearly what you are brainstorming. Using a How-Might-We (HMW) question is a great way to frame a brainstorm (e.g. HMW give each shopper a personal checkout experience?). (See more on the "'How Might We'" Questions" method card.)

There are at least two ways to capture the ideas of a brainstorming:

1. Scribe: the scribe legibly and visually captures on the board ideas that team members call out. It is very important to capture every idea, regardless of your own feelings about each idea.
2. All-in: Each person will write down each of his or her ideas as they come, and **verbally share it** with the group. It is great to do this with post-it notes, so you can write your idea and then stick it on the board.

Follow and (nicely) enforce the brainstorming rules – they are intended to increase your creative output.

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METHOD

Facilitate a Brainstorm

WHY facilitate a brainstorm

Good facilitation is key to a generative brainstorm. You brainstorm to come up with many, wide-ranging ideas; a good facilitator sets the stage for the team to be successful doing this.

HOW to facilitate brainstorm

ENERGY – As the facilitator it is your task to keep the ideas flowing. Perhaps the most important aspect of a successful brainstorm is the seed question that you are brainstorming about (see the "How Might We" method card for more information). During the brainstorm keep a pulse on the energy of the group. If the group is slowing down or getting stuck, make an adjustment. Create a variation to the "How-might-we?" (HMW) statement to get the group thinking in another direction (prepare some HMW options ahead of time). Or have a few provocative ideas in your back pocket that you can lob in to re-energize the team.

CONSTRAINTS – Add constraints that may spark new ideas. "What if it had to be round?," "How would superman do it?," "How would your spouse design it?," "How would you design it with the technology of 100 years ago?" Additionally you can create process constraints. Try putting a time limit on each how-might-we statement; shoot for 50 ideas in 20 minutes.

SPACE – Be mindful about the space in which you conduct a brainstorm. Make sure that there is plenty of vertical writing area. This allows the group to generate a large number of potential solutions. Strike a balance between having a footprint that is big enough for everyone, but also is not so large that some people start to feel removed. A good rule of thumb is that all members of the group should be able to reach the board in two steps. Also, make sure each person has access to sticky notes and a marker so they can capture their own thoughts and add them to the board if the scribe cannot keep up with the pace. (See more about scribing on the "Brainstorming" method card.)

METHOD

Selection

WHY brainstorm selection is important

Your brainstorm should generate many, wide-ranging ideas. Now harvest that brainstorm, so those ideas don't just sit there on the board. Harvesting is straight forward for some brainstorms (pick a couple of ideas), but when ideating design solutions give some thought to how you select ideas. Carry forward a range of those ideas, so you preserve the breadth of solutions and don't settle only for the safe choice.

HOW to select

In the selection process, don't narrow too fast. Don't immediately worry about feasibility. Hang on to the ideas about which the group is excited, amused, or intrigued. An idea that is not plausible may still have an aspect within it that is very useful and meaningful.

Different selection techniques can be used, including these three:

1. Post-it voting – each team member gets three votes and marks three ideas that he or she is attracted to. Independent voting allows all team members to have a voice.
2. The four categories method – the method encourages you to hang onto those crazy but meaningful ideas. Elect one or two ideas for each of these four categories: the rational choice, the most likely to delight, the darling, and the long shot.
3. Bingo selection method – like the four categories method, this is designed to help preserve innovation potential. Choose ideas that inspire you to build in different form factors: a physical prototype, a digital prototype, and an experience prototype.

Carry forward multiple ideas into prototyping. If an idea is so far out there that it seems pointless to test, ask yourselves what about that solution was attractive, and then test that aspect or integrate it into a new solution.

METHOD

Bodystorming

WHY bodystorm

Bodystorming is a unique method that spans empathy work, ideation, and prototyping. Bodystorming is a technique of physically experiencing a situation to derive new ideas. It requires setting up an experience - complete with necessary artifacts and people - and physically "testing" it. Bodystorming can also include physically changing your space during ideation. What you're focused on here is the way you interact with your environment and the choices you make while in it.

We bodystorm to generate unexpected ideas that might not be realized by talking or sketching. We bodystorm to help create empathy in the context of possible solutions for prototyping. If you're stuck in your ideation phase, you can bodystorm in the context of a half-baked concept to get you thinking about alternative ideas. Designing a coffee bar? Set up a few foam cubes and "order" a coffee! Bodystorming is also extremely useful in the context of prototyping concepts. Have a couple concepts you're testing? Bodystorm with both of them to help you evaluate them. Developing any sort of physical environment demands at least a few bodystorms.

HOW to bodystorm

This a straight-forward method, but one that is only useful if you fully engage with it. Get physical! If you are trying to ideate in the context of hospital patients, try walking through the experience to come up with new ideas. If you are designing products for the elderly, rub some Vaseline on your glasses to view the world through older eyes. Bodystorm by moving around and becoming aware of the physical spaces and experiences related to your solutions. Pay close attention to decision-making directly related to your environment and related emotional reactions. Dig into the "WHY"!

:: 31 :: photo: Deb Meisel and Francisco Franco

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METHOD

Impose Constraints

WHY impose constraints

It is a bit counterintuitive, but imposing constraints with intention can actually increase your creative potential. Try it: Think of as many white things as you can in ten seconds. Now think of white things in your kitchen. Did the more constrained prompt spark more ideas?

HOW to impose constraints

There are many times throughout the design process when imposing constraints can help you be a more successful designer. However, being conscious of what filters you place on your design process, and when, is very important. Imposing a specific constraint on your idea generation is different than rejecting ideas because of pre-conceived notions of what you are trying to make.

Three areas where imposing constraints can be useful are in ideation, in prototyping, and with time:
IDEATION: During a brainstorm, or when you are ideating with a mindmap, temporarily add a constraint. This constraint might be "What if it were made for the morning?" or "How would McDonald's do it?". Keep this filter on the ideation for as long as it is useful. (For more, see the "Facilitate a Brainstorm" card.)
PROTOTYPING: In prototyping, particularly in early stages, you build to think. That is, you reverse the typical direction – of thinking of an idea and then building it – to using building as a tool to ideate. You can increase the output of this process by imposing constraints. Constrain your materials to push toward faster, lower resolution prototypes and increase the role of your imagination. Developing a checkout service? Prototype it with cardboard, Post-its and a Sharpie. Making a mobility device? Do it with cardboard, Post-its and a Sharpie. Designing an arcade game? Cardboard, Post-its, Sharpie.
Additionally, as with brainstorming, put constraints on the solution itself.
How might you design it . . . for the the blind? Without using plastic? Within the space of an elevator?
TIME: Create artificial deadlines to force a bias toward action. Make two prototypes in an hour. Brainstorm intensely for 20 minutes. Spend three hours with users by the end of the weekend. Develop a draft of your point-of-view by the end of the hour.

:: 32 :: photo: flickr/vvvracer d.

METHOD

Prototype for Empathy

WHY prototype for empathy

It is common practice to test prototypes with users to evaluate solutions, but you can also gain empathy through prototyping, exposing different information than simple interviewing and observation might. Of course, *whenever* you test with a user you should consider both what you can learn about your solution and what you can learn about the person – you can always use more empathetic understanding.

But you can also develop prototypes or create situations specifically designed to gain empathy, without testing a solution at all (or even having a solution in mind). This is sometimes called "active empathy" because you are not an outside observer, you are creating conditions to bring out new information. In the same way a solution prototype helps you gain understanding about your concept, an empathy prototype helps you gain understanding about the design space and people's mindsets about certain issues.

HOW to prototype for empathy

These empathy prototypes are often best used when you have done some work to understand the design space, and want to dig deeper into a certain area or probe an insight you are developing. Think about what aspect of the challenge you want to learn more about. Then discuss or brainstorm ways you might investigate that subject. You can create prototypes for empathy to test with users or with your design team.

Some ideas:
- Have your user draw something (for example, draw how you think about spending money, or draw how you get to work) and then talk about it afterward.
- Create a game that probes issues you want to explore (for example, you could make a simple card game which forces users to make choices related to your design challenge).
- Simulate an aspect of what users are going through to better understand it yourself (for example, if your users plant seeds while carrying a baby, get a sling and carry ten pounds while planting seeds).

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METHOD

Prototype to Test

WHY prototype to test

Prototyping to test is the iterative generation of low-resolution artifacts that probe different aspects of your design solution or design space. The fundamental way we test our prototypes is by letting users experience them and react to them. In creating prototypes to test with users you have the opportunity to examine your solution decisions as well as your perception of your users and their needs.

HOW to prototype to test

Think about what you are trying to learn with your prototypes, and create low-resolution objects and scenarios which probe those questions. Staying low-res allows you to pursue many different ideas you generated without committing to a direction too early on. The objective is not simply to create a mock-up or scale model of your solution concept; it is to create experiences to which users can react. Bring resolution to the aspects that are important for what you are trying to test, and save your efforts on other aspects. You also need to think about the context and testing scenario you will create to get meaningful feedback. It is not always the case that you can just hand an object to someone on the street and get real feedback. Test in the context that your solution would actually be used (or approximate the important parts of that context). For example, if you are creating a consumer food storage system, let users test it in their kitchens at home - some of the nuanced but important issues will only emerge there.

Some tips for prototyping to test:
Start building. Even if you aren't sure what you're doing, the act of picking up some materials (paper, tape, and found objects are a good way to start!) will be enough to get you going.
Don't spend too long on one prototype. Move on before you find yourself getting too emotionally attached to any one prototype.
Build with the user in mind. What do you hope to test with the user? What sorts of behavior do you expect? Answering these questions will help focus your prototyping and help you receive meaningful feedback in the testing phase.
ID a variable. Identify what's being tested with each prototype. A prototype should answer a particular question when tested.

METHOD

Testing with Users

WHY test with users

Testing with users is a fundamental part of a human-centered design approach. You test with users to refine your solution and also to refine your understanding of the people for whom you are designing. When you test prototypes you should consider both their feedback on your solution and use the opportunity to gain more empathy. You are back in a learning and empathy mode when you engage users with a prototype.

HOW to test with users

There are multiple aspects to be aware of when you test with users. One is your **prototype**, two is the **context and scenario** in which you are testing, three is **how you interact** with the user during testing and four is how you **observe and capture** and consider the feedback.

In regard to the first two aspects, you need to test a prototype in a context that give you the best chance for meaningful feedback; think about how the prototype and the testing scenario interact. If the prototype is a scenario, think about how to find the proper people (i.e. users relevant to your point-of-view) and get them in the right mindset so that you get genuine feedback.

Roles
During the testing itself, use intentional team roles, as you would with empathy work:
Host: You help transition the user from reality to your prototype situation and give them the basic context they need to understand the scenario (don't over-explain it, let the user discover through the experience). As the host, you will also likely be the lead questioner when the time comes.
Players: You often need to play certain roles in the scenario to create the prototype experience.
Observers: It is very important to have team members who are solely observers, watching the user experience the prototype. If you don't have enough people to run the prototype and observe, videotape the testing.

Procedure
Use a deliberate procedure when you test.
1. Let your user experience the prototype. Show don't tell. Put your prototype in the user's hands (or your user in the prototype) and give just the minimum context so they understand what to do. Don't explain your thinking or reasoning for your prototype.
2. Have them talk through their experience. For example, when appropriate, as the host, ask "Tell me what you are thinking as you are doing this."
3. Actively observe. Watch how they use (and misuse!) what you have given them. Don't immediately "correct" what your user tester is doing.
4. Follow up with questions. This is important; often this is the most valuable part of testing. "Show me why this would [not] work for you." "Can you tell me more about how this made you feel?" "Why?" Answer questions with questions (i.e "well, what do you think that button does").

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METHOD

Prototype to Decide

WHY prototype to decide

Often during the design process, it's unclear how to proceed forward, particularly when a team reaches a fork in its decision tree. A prototype can frequently resolve team disagreements and help a team decide which design direction to pursue without having to compromise. The best way to resolve team conflicts about design elements is to prototype and evaluate them with users. Making and evaluating a prototype can be the best way to inform design decisions. If an idea has been prototyped and passes muster with the group, it's a good sign that the idea is worth pursuing further.

HOW to prototype to decide

Staying as low-resolution as possible, develop models of potential design candidates. Be sure to distill the design problem down to discrete elements so you can isolate and be mindful of the variable you are testing. Then try out the prototypes within your team, outsider peers, or, even better, take your prototypes to users and get their feedback.

METHOD

Identify a Variable

WHY identify a variable

Identifying a variable you want to test helps you understand what kind of prototype you are going to create. Most prototypes should not simply be mock-ups of a solution you have in mind. Instead, create prototypes – which may not look like or wholly represent your solutions at all – that help you learn about specific aspects of your solution or mindsets of your users. When you identify a variable you can save energy in not creating all the facets of a complicated solution, and, more importantly, the results of testing with users will often be more conclusive and nuanced.

Incorporating too many variables into one prototype can water down the feedback you'll get from your users – what was it were they responding to? You might never find out. Identifying a variable also gives you the opportunity to create multiple prototypes, each varying in the one property. Giving a user tester a choice and the ability to make comparisons often results in more useful feedback because that person is encouraged to promote one option over another (rather than a less useful "I like it" response you might get with one prototype).

HOW to identify a variable

Prototype with a purpose; think about what you are trying to learn by making a prototype. Identify one variable to flesh out and test with each prototype you build. Bring resolution to that aspect of the prototype. Remember a prototype doesn't have be, or even look like the solution idea. You might want to know how heavy a device should be. You can create prototypes of varied weight, without making each one operable. In another example, you may want to find out if users prefer getting delivery or picking up themselves – you may not even need to put anything in the box to test this.

METHOD

User-Driven Prototyping

WHY create a user-driven prototype

Whenever you engage a user with a prototype, you are trying to better understand him and perhaps his reaction to your solution-in-progress. Often with prototypes, we ask the user to experience something we created, and we gain insight by observing their reaction and by talking to them about the experience. The intention with a user-driven prototype is to gain understanding by watching the *user* create something, rather than try something that you developed.

The value of a user-driven prototype is that different assumptions and desires are revealed when the user is asked to create aspects of the design, rather than just evaluate or experience the prototype. The goal is not to take what they made and integrate it into your design, but rather to understand their thinking and perhaps reveal needs and features that you may not have thought of.

User-driven prototypes are often useful in early empathy work, as a way to facilitate a different kind of conversation. User-driven prototypes are also useful after you have determined the context and form-factor of your solution, to help think about some of the features and details of that solution.

HOW to create a user-driven prototype

The approach to creating a user-driven prototype is to set up a format for your users to create something which leads to your understanding of how they are thinking. As an example, if you were creating a website to allow users to create custom t-shirts, a traditional early-stage prototype might be a mock-up of the webpage with the features and buttons that you think might be appropriate. A *user-driven* prototype could be to give your user a blank piece of paper and ask her to draw what she thinks the features should be. You might provide a light scaffolding to get her going, such as a piece of paper with boxes in the layout of a possible website, and then ask her to create the content for those boxes. Of course, there is an entire spectrum of how much you provide and how much you ask your user to create. You need to find the balance, depending on your project progress, for a prototype that is scaffolded enough that the user feels that she can be generative, but open enough that you learn outside of your own biases and assumptions.

Other examples of user-driven prototypes include: asking a user to draw something ("draw how you think about going to the doctor"), to make an object with simple materials ("make a bag for diapers and baby supplies, using this paper and tape"), or to compile things ("tear out pictures from these magazines that represent your ideal mall shopping experience").

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METHOD

Wizard of Oz Prototyping

WHY create a Wizard-of-Oz prototype

You use a Wizard-of-Oz prototype to fake functionality that you want to test with users, thus saving you the time and resources of actually creating the functionality before you refine it through testing. Just like the small man behind the curtain faked the power of the wizard of oz, your design team can fake features that you want to test. Wizard-of-Oz prototypes often refer to prototypes of digital systems, in which the user thinks the response is computer-driven, when in fact it is human controlled.

HOW create a Wizard-of-Oz prototype

Creating a Wizard-of-Oz prototype starts with determining what you want to test or explore. It is often the case that you want to test something that requires great effort to create, like coding a digital interface, but you need to learn more before it makes sense to invest that effort. Figure out how to fake the functionality you need to give the user an authentic experience from their viewpoint. Often leveraging existing tools can be very powerful: Twitter, email systems, Skype, instant messengers, Powerpoint to fake a website, projectors, computer screens repurposed in a new skin, etc. Combine tools such as these with your human intervention behind the scenes, and you can create a realistic prototype. The concept can certainly be extended beyond the digital realm, to create physical prototypes. For example, you could prototype a vending machine without creating the mechanics and use a hidden person to deliver the selected purchases.

A good example of a wizard-of-oz prototype is from the company Aardvark. Aardvark connects people with questions with people best-qualified to answer via a digital interface over the internet. To create the network and algorithm to do this would require significant coding, but the team wanted to test user's reaction to the interface well before the coding was completed. They used an instant messaging system and a team of people behind the scenes to physically reroute questions and answers to the right people. The result is they learned a lot and developed their concept notably without investing coding resources.

:: 39 :: photo: flickr/kaptainkobold

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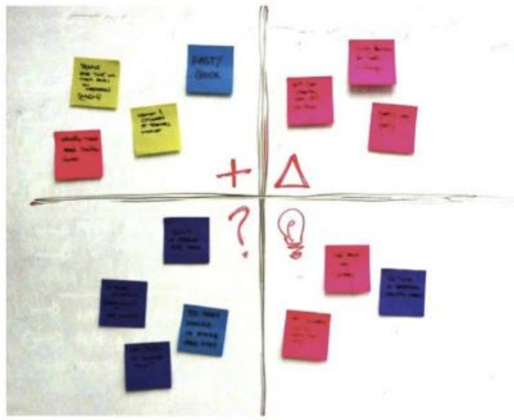
METHOD

Feedback Capture Grid



WHY use a feedback capture grid

Use a feedback capture grid to facilitate real-time capture, or post-mortem unpacking, of feedback on presentations and prototypes – times when presenter-critiquer interaction is anticipated. This can be used either to give feedback on progress within the design team or to capture a user's feedback about a prototype. You use the grid because it helps you be systematic about feedback, and more intentional about capturing thoughts in the four different areas.

HOW to use a feedback capture grid

1. Section off a blank page or whiteboard into quadrants.
2. Draw a plus in the upper left quadrant, a delta in the upper right quadrant, a question mark in the lower left quadrant, and a light bulb in the lower right quadrant.

It's pretty simple, really. Fill the four quadrants with your or a user's feedback. Things one likes or finds notable, place in the upper left; constructive criticism goes in the upper right; questions that the experience raised go in the lower left; ideas that the experience or presentation spurred go in the lower right. If you are giving feedback yourself, strive to give input in each quadrant (especially the upper two: both "likes" and "wishes").

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METHOD

Storytelling

WHY storytelling over other forms of communication

It seems stories are hard-wired into our psyche. People have been passing information along via storytelling for as long as humans have had a rich language to draw from. Stories are a great way to connect people with ideas, at a human level. A well-told story – focused on sharing pertinent details that express surprising meaning and underlying emotions – effects the emotions and the intellect simultaneously.

HOW to design a story

What's the point? Know what you intend to convey both narratively and emotionally. You should be able to describe the essence of the transformation of your character in one sentence & the tone of the story in a couple of words. Be able to articulate the emotional tone in a couple of words.

Be Authentic: Stories are more powerful when they include a little bit of you. Honest expression is stronger and more resonant than cliché .

Character-Driven: Characters are a great vehicle through which to express deep human needs and generate empathy and interest from your audience. Focus on character.

Dramatic Action: Your story should have 3 components: Action, Conflict, and Transformation.
Action: What is the character trying to do? What actions are they taking to achieve it?
Conflict: What is in her way? What questions linger beneath the surface?
Transformation: What is the big insight? How do the action & conflict resolve?

Details: "Behind all behavior lies emotion." What details can you share about your character and their situation that will suggest the emotions that lie beneath?

Design Process is a Built in Story: Use what you've learned during the design process.
Empathy maps well to Character. Needs map to Conflict, Insights + Solutions map to Transformation.

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METHOD

Shooting Video

WHY video

Video is a powerful medium for communicating ideas, insights & stories. Planning ahead, but staying open to possibility will give you the best chance of stumbling on a magical moment. Know what you are trying to do and be aggressive about communicating it in the frame. If it's not in the frame, it doesn't exist.

HOW to shoot video

Tips:

Direct Attention:
1. Know your intention. What are you trying to highlight? How do you want it to feel?
2. Bias toward tight framing.
3. Figure Ground: Get a good contrast between the subject & the background.
4. Be conscious of light sources & shadows on your subject.
5. Follow the rule of thirds, frame off-center.

Plan to Improvise: Know what you want, be flexible about how you get it.
1. Plan Ahead: Storyboard out your idea. Iterate!
2. Get Lucky: Follow your curiosity on the day of your shoot.
3. Overshoot! Get more than you think you need! More stuff gives you more options when editing. Longer takes allow you some wiggle room for transitions.

Audio is Important!!! Remember the 2 rules:
1. Mic close to the subject.
2. Point away from (undesired) noise.

METHOD

Video Editing

WHY video, why quick editing

Video is a powerful medium for communicating ideas, insights and stories; editing can make or break a video: the story is supported or undermined by the way a video is sequenced, paced, & scored. Editing can also be very time consuming so how you work is important in maintaining progress.

HOW to edit quickly & create compelling videos

Tips:

Make rough cut of the whole film then go into details. Iterate.

Keep it simple; avoid superfluous animated transitions.

Shorter is almost always better.

Sound is more important than picture.

Cut early: when in doubt, edit shorter cuts.

Critical eye: don't fall in love with it.

Choose a style that works with quick cuts – don't get swallowed up by the mechanics.

Music is very powerful: use it wisely.

METHOD

I Like, I Wish, What If

WHY use I Like, I Wish, What if

Designers rely on personal communication and, particularly, feedback, during design work. You request feedback from users about your solution concepts , and you seek feedback from colleagues about design frameworks you are developing. Outside the project itself, fellow designers need to communicate how they are working together as a team. Feedback is best given with I-statements. For example, "I sometimes feel you don't listen to me" instead of "You don't listen to a word I say."
Specifically, "*I like, I wish, What if*" (IL/IW/WI) is a simple tool to encourage open feedback.

HOW to use I Like, I Wish, What if

The IL/IW/WI method is almost too simple to write down, but too useful not to mention. The format can be used for groups as small as a pair and as large as 100. The simple structure helps encourage constructive feedback. You meet as a group and any person can express a "Like," a "Wish," or a "What if" succinctly as a headline. For example you might say one of the following:
"I like how we broke our team into pairs to work."
"I wish we would have met to discuss our plan before the user testing."
"What if we got new team members up to speed with a hack-a-thon?"

The third option "What if. . ." has variants of "I wonder . . ." and "How to . . ."
Use what works for your team.

As a group, share dozens of thoughts in a session. It is useful to have one person capture the feedback (type or write each headline). Listen to the feedback; you don't need to respond at that moment. Use your judgment as a team to decide if you want to discuss certain topics that arise.

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