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Impact of CST on Navy Programs

The CST Process for Technology Transition and Programmatic Change

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By:
D.A. Backes (RPI)

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Abstract

Since 1985 the Navy has conducted focused Advanced Technology Demonstration (ATD) programs to introduce Low Frequency Active Acoustics (LFAA) technology into the Fleet to improve antisubmarine warfare (ASW) capability against the quiet submarine threat. The Critical Sea Test (CST) Project tested LFAA and related technologies at sea in CST-Magellan tests, both independently and in combination with tests sponsored by the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Program, the Submarine Security Program, the Air Defense Initiative (ADI) Low Low Frequency Active (LLFA) Project, and Fleet Ship ASW Readiness/Effectiveness Measuring (SHAREM) Program and Air ASW Readiness/ Effectiveness Measuring (AIREM) Program exercises, among others. These tests were often conducted jointly with several of our Allies. Complementary environmental measurements were conducted with each test to ensure the technology transition process was complete, successful and timely. The CST Project ended on 30 September 1996. Has it been successful in transitioning the technologies developed? Through examination of Navy ASW program documentation, tracking of CST technical personnel interviews, and use of projections for future Fleet ASW system capability, the method and completeness of CST-generated technology transitions are assessed in this paper. This paper also provides a window into the technology transition process employed by the CST Project and the current programmatic status of those transitions. Lessons Learned and several recommendations regarding structure and transition strategies for future ATDs are also discussed.

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Executive Summary

In the mid 1980s the Navy experienced an antisubmarine warfare (ASW) risk ''psychic shock'' which resulted in a greatly heightened sense of urgency to implement ''solutions'' to the quiet submarine threat. The outcome was a firm commitment to develop new technology to defeat the new threat. The Critical Sea Test (CST) Project was initiated by Chief of Naval Operations (CNO) (OP-098) as a technical risk ''insurance policy'' to protect the Navy's proposed investment of some $6 billion dollars in new Low Frequency Active Acoustic (LFAA) systems.

The CST approach to risk-reduction was thought to be the most cost-effective, programmatic method of concurrently answering the LFAA issues from all ASW communities by using a single support organization with the responsibility to provide common assets, test planning and data analysis. Several programmatic goals for the CST Project were paramount: prove LFAA is a multi-platform and multi-environment solution, provide results rapidly to keep technology transition windows open, be big enough to plan and test for interoperability early, and address the new concerns of acoustic warfare as those issues emerged.

The CST process of test and analysis planning, at-sea technology demonstration, post-test technology transition, and continuous LFAA manager/scientist/engineer training resulted in several interesting programmatic outcomes. These outcomes followed from the group dynamics, committee-like methodology of the CST Project programmatic decision making, which was a forerunner of the Integrated Product Team (IPT) concept. This process included *consensus building* among the undersea warfare (USW) research and development (R&D) community, *confidence building* in the methodology and the technical results, *system implication payoff* for the recipient system developers, and *stakeholder development* among all participants in CSTs. Stakeholder development may have had the greatest programmatic impact in overcoming conflicting priorities and resolving the major impediments to technology transition (stovepipe development, budgetary ricebowls and the not-invented-here (NIH) syndrome).

While all the programs for LFAA development did not survive, the CST Project was successful in its overall goal of LFAA transition: i.e., the undersea surveillance community has its first operational system (SURTASS LFA); the submarine and surface ASW communities are committed to LFAA bistatic processing and are pursuing use of ''leave-behind'' and reduced-size ''on-board'' sources, respectively. The air community has taken technology tested during CST and developed an independent LFAA system concept with an interim operational capability in the Fleet today.

The CST Project ended 30 September 1996, and in the absence of the continual technology transition process and programmatic push provided by CST, the Navy needs to refocus its goals for exploitation of LFAA. Recent programmatic and organization initiatives to resurrect the ASW division in the CNO staff and to coordinate system command (SYSCOM) programmatic action through the Undersea Surveillance Executive Steering Group (U/S ESG) are important steps toward achieving this goal. A specific CNO point of contact on the ASW staff for LFAA integration is still required.

Introduction

In the mid 1980s the unexpected radiated noise reduction in the Soviet Victor III class attack submarine caused the Navy to experience an ASW risk "psychic shock" resulting in a sense of urgency to implement "solutions" to this quiet submarine threat. The programmatic result was a firm fiscal commitment to develop advanced technology to defeat the new threat. Several technical approaches developed in Navy 6.2 applied technology were funded for development and demonstration in the CNO Urgent ASW R&D Program (CUARP) (reference 1). Most promising among these approaches were those using LFAA technology.

The Navy validated the requirements for several new LFAA systems in a series of Mission Need Statements (MNSs) and Tentative Operational Requirements (TORs). By nature, TORs are temporary documents and none are currently active. The only surviving MNS is for Bistatic LFA, which was promulgated by CNO (OP-098) in 1990 (reference 2), and it remains an important justification of continued work in multistatic LFAA research. Several new acquisition programs were initiated in Program Objective Memorandum (POM) 88, which was the last funding growth wedge for many years. The CST Project was initiated by CNO (OP-098) as a scientific, technical and risk-reduction "insurance policy" to protect the Navy's proposed investment of some $6 billion dollars in new LFAA systems. Congress shared the Navy's concern regarding the new threat and consequently directed the Navy to produce an annual ASW Master Plan. These plans documented the acquisition strategy for LFAA as well as the need for a scientific and technological risk -reduction program embedded in the CST Project.

The CST Project cross-deck, risk-reduction approach was thought to be the most cost-effective programmatic method for concurrently answering the issues from all ASW communities. This was accomplished by using a single support organization and common assets, test planning, and analysis assignments (reference 3).

Several goals were paramount for the CST Project: prove LFAA was a multi-platform and multi-environment solution (with specific emphasis on LFAA-related scientific and technological goals supported by an improved environmental acoustics (EVA) understanding), provide rapid results to keep technology transition windows open, plan early for interoperability, and address the new concern of acoustic warfare as the Fleet operational issues emerged.

In the subsequent ten years of program execution, the CST Project conducted ten CST tests in seven operationally important areas of the world. It has examined LFAA-related issues in the three most significant acoustic environments (reference 4), and delivered to the Navy key scientific, system and operationally related LFAA hardware and software plus related technical reports, recommended operating techniques, at-sea evaluated environmental and acoustic models; and the latest LFAA sea testing in complicated oceanic environments (reference 5).

The overall workings of the CST Project will be reviewed to examine why it survived at all and then some observations will be made as to the programmatic effect it has had on Navy USW system acquisition, from its initial justification for the "modern times" LFAA program to the resultant support of LFAA Fleet introduction that exists within the funding justification for POM 98. The goal is to provide insight into the CST Project programmatic process, share some observations on why that process worked, offer some conclusions as to the effectiveness of that process, and make several recommendations of what it may take for the Navy to extract the maximum payoff from the demonstrated potential of LFAA as part the Navy program for ASW improvement.

Description

This paper documents some of the unique pieces of the technology transition process employed by the CST Project Office, and identifies the product, format and programmatic transition window for technologies developed or tested during the course of the project. It also discusses migration of the LFAA expertise into the Navy acquisition community and the resultant programmatic impact. This paper is written from the author's perspective as the CNO Requirements Officer assigned to CST (OP-951F1) and later as a member of the Deputy Assistant Secretary of the Navy Antisubmarine Warfare (DASN(ASW)) staff assigned to justify and coordinate funding and provide oversight for the Phase II follow-on to CST Phase I.

Sources of Information

Available sources for most of information about CST programmatic process lie in the personal experiences of participants in the process, the most recent summary reports from the CST Project, and the record of programmatic decisions reflected in budget justifications for LFAA-related programs that exist today. Therefore, it was decided to concentrate on gathering information from these sources.

Technology transition resources were principally within the context of the System's Implications Study (reference 6) and the relationship between the opportunities it addresses and the actual programs funded in POM 98, as documented in the Navy's congressional budget justification report (reference 7). Navy acquisition documentation and existing Platform/ Warfare Area Master Plans were reviewed to get current status. Key USW players were interviewed for insights on the latest process of technology transition. In order to get uninhibited openness as well as objective data, it was agreed that specific quotes would not be attributed. This was thought to be appropriate as focus was on the programmatic methodology and on gleaning some judgments on the resultant impact in the technology and management areas. Finally, findings and conclusions are summarized to put it all in perspective.

CST Objectives

To determine what the CST Project has accomplished, it is useful to first address the expected programmatic impact of CST activities and the process used by the CST Project to get that result. Recall the driving factors of the 1985 ASW investment decisions; based on the new threat and results from Navy 6.2 LFAA at-sea testing, CNO (OP-951) made a firm commitment to develop LFAA for air and surface tactical applications as well as the more mature surveillance application. Programmatically, this resulted in Budget Year adjustments to ASW science and technology (S&T) investment, creation of projects such as CUARP (which included the CST Project), focused war gaming to estimate the cost benefit of LFAA (in general, using counter-Soviet scenarios), and the forming of a cadre of ASW modelers and war gamers (both in and outside of the government) to support that process. A principal task was the formation and verification of the ASW Master Plans.

Within the Naval Operations (OPNAV) staff, this was accomplished using a steering committee known as Team Alpha, which directed the development of new ASW TORs based on the architecture resulting from the war gaming. LFAA systems development was consequently initiated in Navy POM 88. CNO (OP-098) provided part of Team Alpha's guidance and articulated the requirement to ensure investment decisions were based on scientific knowledge of the physics involved and that sea testing was adequate to demonstrate the applicability of previously tested experimental designs to real-world Fleet systems and operational scenarios. However, the urgency of the threat caused the CST Project to be initiated concurrently with acquisition initiatives to reduce the risks and protect the LFAA investment.

Serious past problems in getting the new Integrated Undersea Surveillance System (IUSS) Active Adjunct for Undersea Surveillance (AAUS) program through the budget intact testified to the programmatic wisdom of this method. Programmatically, the CST Project was to:

1. Increase confidence in the underpinning physics and EVA to support past 6.2 LFAA development results;
2. Test the entire LFAA band to encompass the proposed source technologies for air, surface and surveillance applications;
3. Be large enough and sufficiently funded to ensure at-sea testing in all key global areas and to support broad participation; and
4. Be ecumenical enough to test the overarching EVA, scientific, system and operational issues.

In the area of mission support, CST was to verify the performance assumptions modeled in war gaming the LFAA role in the Maritime Strategy. Using a single support organization and fewer assets to test the cross-platform common issues, the CST Project was also expected to reduce the cost by controlling overhead and consolidating sea-test requirements. Finally, the CST Project was to try to accommodate the cross-platform common goals and requirements, identify the technology transition paths, coordinate the research, and ensure the technology transition. One now has to determine if those expectations were met.

Measure of Effectiveness

CST and ADI-LLFA are, by definition, ATD projects with loosely defined transition paths based on requirements described in a Non-Acquisition Program Definition Documents (NAPDDs). They were programmatically only lightly cemented with formal and informal agreements between the Project Managers (PMs), resource sponsors, and related system development managers. Despite lower transition expectations with ATDs, **"Transition" remains the nature of the beast**. Programmatically and pragmatically, for each receiving acquisition program, technology transition is in the eye of the beholder; in this case the technology receiver (the acquisition PM).

Meeting the expectations of the acquisition PM who is working under the pressures of performance, cost and schedule can make technology transition a frustrating task. It often takes much more time and money and a great deal of negotiating skill to get S&T results into a mainline program and the new capability into the Fleet. Table 1 provides a list of product transition formats that have been used by the CST Project to get the tested technologies to the users. While some may be familiar (actual hardware, software codes, technical reports) (reference 6), others, such as verbal conversations and personnel transfers, have been somewhat outside the normal channels cited in the DoD 5000 series and supporting Navy acquisition instructions.

Table 1. Technology Transition Formats

Hardware	Technical Reports
Specifications	Ocean Models
Signal/Information Processors	EVA Models
Reusable Software Code	Performance Models
Integration Control Directives	Data Bases
Procedures	Data Sets
Techniques	Direct Personal Knowledge

Therefore, a strict one-for-one correspondence between CST successes and actual LFAA acquisition milestones was not expected to exist and indeed other programmatic forces often drove the decision process, making it problematic as to whether the CST Project insurance policy resulted in preservation of established LFAA acquisition programs or not. For that reason, an analytical measure of effectiveness for the CST Project was not pursued, but rather the overall situation was examined at the end of the program vis-à-vis the status of LFAA program acquisition decisions and subsequent LFAA transition into the Fleet.

CST Programmatic Process

The first step in determining the level of technology transition success was to examine the methods often used to ensure that transitions could occur. Several attempts have been made within the CST Project execution plan to formalize the transition process, with limited success. The reason is the concept of technology itself. While knowledge is the basis of technology, application is the grease by which it flows. Funding is required to provide the ‘‘voltage’’ or force to push it through the process, and management is required to direct the flow to the right transition window. Figure 1 describes the classic path for acquisition programs. Initializing or breaking into that path is not easy. With a technology such as LFAA that would significantly perturbate most ongoing Navy ASW programs and projects, there would be significant obstacles. The CST Project had to break down some very big barriers. Injection of LFAA technology was often handled in the same manner as an amendment to a Congressional Bill. An example of this process is the creation of the MNS for bistatic LFAA. It became the justification for early and enduring inclusion of bistatic and multistatic into CST testing. Programmatically, it was effectively a shoehorn that slipped LFAA into every USW sensor program's shoes (mainstream process). CSTs simply had to demonstrate it worked through the ATD process. These ATDs evolved and rarely entered the system as part of mainstream LFAA acquisition projects; but, more often, were subsumed into non-LFAA development through the Pre-Planned Product Improvement (P^3I). The ‘‘path of least resistance’’ was thus discovered and the nature of the majority of CST technology transitions defined (as shown inside the dotted line in).

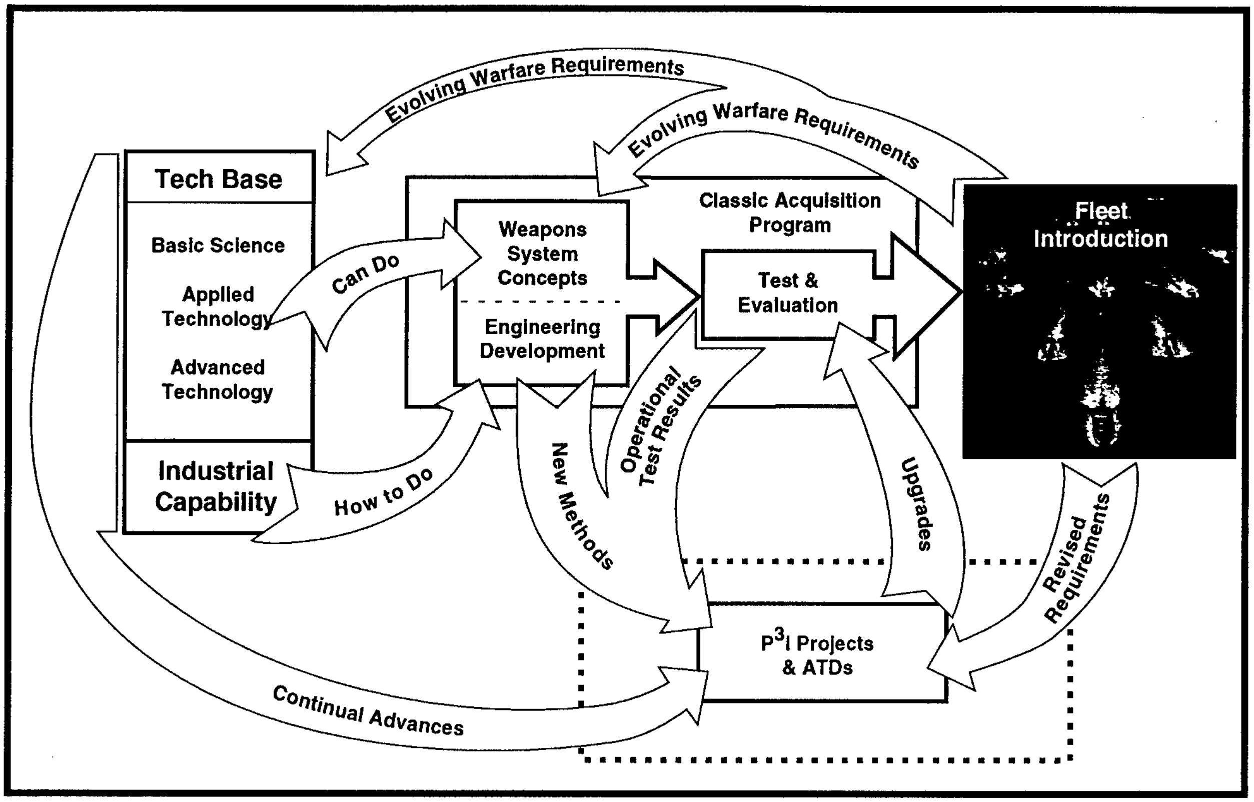

Figure 1. Technology Flow

Considering the above, the CST Project technology transition was anything but conventional in programmatic method. Rather than managing the technology transition to the classic technology acquisition program structure, CST Project management was run more like the IPT concepts of today; to ''improve'' a product rather than start from scratch. As the CST Project was managed much like a committee, CST operations resulted in a Navy programmatic decision process that generally followed group dynamic rules. While beneficial in general, this process caused several difficulties, including diluted focus, addressing all LFAA problems at once versus a step-wise priority approach, and some added cost due to the iterative nature of a ''negotiated'' planning process. However, it did continue to self correct and streamline in execution over the eight years of at-sea testing.

CST Programmatic Impact

The CST process consisted of basically four major activities and corresponding group dynamic programmatic impacts, as follows:

- Test planning and execution > > > > resulting in team **consensus building,**
- EVA understanding and technology demonstration > > > > resulting in team **confidence building**,
- Continual technology transition > > > > garnered participant **system implication pay-off**, and
- In-process LFAA Manager/Scientist/Engineer Training > > > > initiated the critical reaction of **stakeholder development.**

It is useful to examine each of these four major activities and their impacts in trying to understand the programmatic affect of the CST Project on Navy programs as a whole.

Consensus Building

Consensus building became a major hallmark of the CST participation process. Table 2 shows part of the relationship between CST test events and the broadening programmatic participation as a number of environments and scenarios were addressed. Items in bold indicate initial CST participation and initial focus on that test environment/scenario.

Table 2 Consensus Building

TEST #	PARTICIPATION	ACOUSTIC ENVIRONMENT / SCENARIO
CST 1	**CST / LFA**	**Blue Water CZ / Open ocean surveillance / EVA**
CST 2	CST / LFA	**Blue Water Duct /** Open ocean surveillance / EVA
CST 3	CST / LFA	Blue Water CZ / Open ocean surveillance / EVA
CST 4	CST / LFA / DESRON 31[(+)]–**SHAREM / Sub Security**	Blue Water Duct / Ocean surveillance / **Tactical Bistatics** / EVA
CST 5	CST / LFA / SHAREM **Sub Security**	Blue Water CZ to **Shallow Water Duct** / Bistatic Support / EVA
CST 6 / E-1	CST / **ADI (LLFA)** / SHAREM / **AIREM**	Blue Water CZ to **Shallow Water RBR Multistatic** Surveillance / EVA
CST 7	CST / LFA / SHAREM / Sub Security	Blue to Shallow Water Duct / **BG Support / EVA**
CST 8	CST / LFA / **CTF**[(+)] / IUSS /BDSs **Sub Security**	Shallow Water RBR / **Littoral BG Support** / EVA
CST 8 (East)	CST	**Very Shallow Water RBR /** Littoral Surveillance / EVA
CST 10	CST / LFA / SHAREM / AIREM **Sub Security**	**Sloped Bottom Interactive /** Littoral BG Support / EVA
LFA 13 / E-2	CST* / LFA / **JTF**[(+)] / LLFA / SHAREM	Shallow Water RBR / **Littoral JTF ISR Support / EVA**
Standard Eiger / E-3	CST* / LLFA **Sub Security**	Shallow Water RBR / **Multi Static Littoral Surveillance / EVA**

*CST Project supported ship costs.
[(+)]Non-LFAA related technologies added into increasingly complex, combined sensor searches directed by afloat and shore commanders.

Consequently, through the process of CST test planning and execution over the first three CST experiments, a core of participants was formed from all Navy laboratories, warfare centers staffs and Fleet command centers. This gained a strong consensus that LFAA was viable across the LFAA frequency band. Participants were able to refine priorities among the platforms' sponsors for LFAA development. Also, early involvement of our Allies under the auspices of The Technical Cooperation Program (TTCP); Information Exchange Programs (IEPs); the multilateral American, British, Canadian, Australian, and New Zealand Agreement No. 2 (ABCANZ-2); bilaterals C-30 and B-85; and international Fleet agreements for SHAREM and AIREM participants broadened both US and Allied Fleet interest. CNO (OP-951), Team Alpha and the

Connectivity and Interoperability Working Group (C&IWG) provided the needed budget protection and allowed technical participants to focus on requirements. Cooperation with other S&T efforts for USW operations (i.e., Submarine Security Program) and for littoral USW environmental support (Harsh Environment Program (HEP) and Acoustic Reverberation Special Research Project (AR SRP)) focused and improved the S&T content.

Confidence Building

In 1985 the Navy embarked on what is commonly referred to as a "full court press" across many technology approaches to counter the alarming quieting trend of the Soviet submarine threat. However low, the confidence that did exist and, consequently, the funding that was available, was concentrated on enabling technologies for reviving active sonar (particularly LFA sonar) as a search sensor and on passive sonar, non-traditional signal processing, for exploiting all submarine acoustic signature components. This discussion will concentrate on LFAA confidence building.

Programmatically, other than LFAA, there have been few technologies that have had such a pervasive impact on Naval forces since the advent of long-range, surveillance radar. The similarities between these technologies are not only in technical issues and tactical application and its consequence, but also in the realm of the programmatics for system acquisition. LFAA may be thought of as a mirror image of the over-the-horizon (OTH) surveillance radar in its beneficial result of enabling the long-range search capability. However, there is also a commensurate requirement to understand the medium in which it works and its potential for unintended exposure of friendly forces and/or possible interference with other sensors sharing the airwaves for OTH or sonar transmission paths for LFAA. Both were programmatically introduced as revived technology from earlier S&T programs. It is also interesting to note SURTASS LFA uses OTH-Gold message formats for contact reporting. This comparison is only used to impart a sense of scale and interdependency in considering the programmatic impact of CST. An excellent, unclassified summary of the technical challenges of developing LFAA systems, testing them at sea and understand the EVA issues associated with operating LFAA systems was published by Gordon Tyler, Jr., in the Johns Hopkins APL Technical Digest (reference 8). For the sake of brevity and retaining focus on the CST process and programmatic impact, those details are not included here. Reading Tyler's discussion of the emergence of LFAA as a critical ASW technology would be very helpful in appreciating the scope of the Navy's challenge in transitioning this technology, and is highly recommended.

The LFAA technologies developed or tested by CST are well documented in recent summary reports, particularly System Implications of Critical Sea Test Phase II Environmental Acoustics Measurements (U) (reference 6). Table 3 lists some of the more recognized technologies and several ancillary technologies participating with CST assets during the final series of tests.

Table 3. Technologies Demonstrated During CST

LFAA Sources	Test Program Management
LFAA Receivers	Test Planning
LFAA Monostatic Processing	Multistatic Operations Planning
LFAA Bi/Multistatic Processing	Multistatic C^4I Integration
LFAA Performance Modeling	*Joint Surveillance Planning
LFAA Environmental Acoustics	*Supporting Electronics, EW and Electro-Optic Sensors
LFAA Environmental Measurement Systems	*ISR Data Fusion
LFAA Environmental Mitigation	UAV and USV Operations

* The CST Project funded CORY CHOUEST operations in Arabian Sea Joint Task Force (JTF) demonstration - 1995

While LFAA system hardware and software lead the list, less direct supporting technologies are also important to ensure the technology is effective in its intended environment, and is user friendly in its application and operation in the natural and integrated battle group (BG) environments. Principal among these support technologies is the new understanding of the EVA medium in which the LFAA systems must operate; including the effects those environments have on the systems themselves; the new devices necessary to measure critical environmental parameters to develop performance estimation, prediction and optimization; and the Tactical Decision Aids (TDAs) needed to use these systems in an operational setting. An equal but somewhat parallel transition product was the training and subsequent migration of qualified CST personnel to other projects, which turned out to be an optimum method to transition a technology having the magnitude of LFAA.

Near the end of the CST Project, SPAWAR used the Research Vessel (R/V) CORY CHOUEST as an ATD for littoral USW operations. This demonstration began to explore the possibility of integrating surveillance in the radio frequency (RF) and optical bands with LFAA surveillance operations. Leveraging off R/V CORY CHOUEST availability, several new RF, infrared (IR), visual surveillance and advance vehicle technologies were demonstrated. Unfortunately these experiments did not enjoy peer review and consensus and confidence building within the acquisition community, and only a few of these 6.2 efforts have received 6.3/6.4 funding for advanced development and acquisition.

Identifying the Payoff

Tasked with reducing technical risk in developing the direct application of LFAA as an ASW search sensor across all USW platforms, the CST Project was also charged with developing an understanding of the interoperability/mutual interference consequences. It was in this way that CST underwrote its insurance policy status for the Navy's full court press. The CST Project's programmatic content secured solid support for transition of 6.2 projects that had shown potential high payoff against a quiet submarine. This included new LFAA technologies being developed under CUARP and under new LFAA-based acquisition programs with the charter to transition LFAA technology to ASW system development, acquisition and fielding. This was particularly successful for the emerging LFAA surveillance technology and system concepts.

It is important to reiterate here that the CST Project differed programmatically from classic acquisition programs in its technology transition methodology. This resulted in equal weighting being applied across all formats (Table 1) of technology transition vice the single integrated system approach most often used.

Clearly, the hardware format was aimed at surveillance applications. Processors for bistatic active processing, however, were more universal with tactical applications in roll-on-roll-off (RO-RO) configurations. Transition from the Navy's 1980s ASW shoe box data archives to today's Internet access and electronic exchange of data was somewhat driven by the wealth and breadth of CST technical and scientific data and analysis products. This affected data formats and issues of interoperability among LFAA developers. The best examples of cross-platform transition is the Transmit-Receive Subsystem (TX) active processing developed by SURTASS LFA that will become the baseline of bistatics active prosecution across all towed arrays.

During the later sea tests (1991-1995), the CST Project refined issues and determined the best formats for technology transition. Model verification, modification and validation occurred as a synergistic spinoff of CST testing and resulted in stabilization of the format for standard models with multiple platform-specific TDAs. The CST Project provided issue resolution outside (beyond) the programmatic threshold of the LFAA acquisition program, thus providing multi-purpose data sets and direct knowledge to the S&T community.

Three major acoustic environments tested in seven operationally significant locations produced the following technology demonstration results:

- Issues of interoperability (mutual interference, BG control, multistatics and US submarine security) could be handled.
- The following additional technologies were integrated into LFAA testing and acoustic/non-acoustic warfare fusion:
  - New oceanographic measurement techniques, integrated test planning processes, acoustic models, electronic warfare (EW) technologies, integrated electro-optic, and non-acoustic sensors on Unmanned Aerial Vehicles (UAVs) and Unmanned Surface Vehicles (USVs), and new OTH and line-of-sight (LOS) communications.
  - Integrated shore command participation (Commander Task Force (CTF) 12, 59 and 67).
- Rapid feedback was provided to the Fleet and Acquisition staffs through quicklook reports and Journal of Underwater Acoustics (JUA) articles. Use of CST-tested models were sufficiently robust to show utility of vertical source concept over other configurations for surface ship use, causing a major redirection in Surface Source Development Programs.

However, the following the CST Project programmatic deficiencies were also noted:

- Selection of the slow, commercial R/V CORY CHOUEST limited the flexibility needed to meet tactical LFAA test requirements, slowing the move to use variable depth LFAA vertical arrays for surface ship ASW.
- Full LFAA bandwidth source configurations were tested, but not in all tests. Later tests were limited to planned surveillance/air applicable sources.
- Early focus on coherence limits of processing long waveforms turned off interest in potential bistatic air systems using shorter, more tactical waveforms.

- Ecumenical committee approach, and the sheer number of different experiments on each test, slowed results on several known specific LFAA issues (bottom reverberation, clutter rejection).

Despite these negatives, eight years of sea testing has resulted in Initial Operational Capability (IOC) of a surveillance LFAA system [SURTASS LFA] using the CST principal test asset, R/V CORY CHOUEST. Also, the continued validation by the Joint Requirements Oversight Council (JROC) of the MNS for bistatic LFA (applies across all US Navy ASW sonar equipped platforms) speaks strongly for the use of LFAA to meet the continued threat of the ever quieting modern nuclear and diesel submarines. The very success of the recent Seawolf SSN 21 "Alpha" sea test (reference 9) is "quiet proof" that there is no clear end to the technology for this quieting trend.

Navy 6.2 successes and CST Phase I testing have demonstrated that the physics support LFAA concepts in deep water. However, risk was still well off the chart in meeting any performance goals in littoral, shallow water environments. Models did not support performance prediction in any known alternative configuration of the deep water system design for littoral, shallow water environments. Confidence had to be established to complete the transition.

Programmatically, without broad support by the acquisition community and the Fleet, the first cost, schedule or performance envelope nick in a program involved in the Navy's Planning, Programming and Budgeting System (PPBS) process is often fatal. As a programmatic tool, Navy confidence support building by dictum has not worked in the past. Fortunately for most LFAA acquisition programs, the CST Project was in the conflict resolution and confidence building business. The CST Project established the paradigm for LFAA development and convinced people that LFAA has great potential. This function was carried out several ways: first through the normal functioning of the CST process of conducting broadly attended technical reviews before and subsequent to each sea test; second, publication of numerous technical reports and white papers; third, by direct liaison among the many participants; and fourth through the LFAA information exchange in directed briefings to Navy leaders and in the normal operation of Team Alpha and the C&IWG or as some would believe, the "seeing eye" working group. At the completion of the CST Project, few of these natural methods will exist, neither will the impetus be there to continue this liaison. The base realignment dictated by base realignment and closures (BRAC) will make easy face-to-face coordination almost impossible between the major SYSCOMs. Consequently this technology transition methodology will be much more difficult to achieve.

Table 4 is a subjective estimate of transition confidence factors attained by CST by the end of Phase II. It reflects estimates based on discussions with PMs and Technical Directors (TDs) in each of the applicable ASW systems areas. Past experience in dealing with transition suggests that a confidence rating greater than 75 percent on an overall, subjective scale is needed to convince PMs to budget and plan for the transition. For surveillance and applicable submarine applications, that confidence level has been reached. At this time, the surface community is unwilling to commit to transition to LFA source technology. The air community is independently pursuing advanced development of the selected Air LFA sources with a consequently narrowed need for any bistatic processing other than for Air LFA sources.

Table 4. System Issue Resolution for Transition

Application	Configuration Of Transmitter	Configuration Of Receiver	Wave Form	Type Signals	Platform Operational Envelope	Overall Confidence
Surveillance	.9	.8	.8	.9	.8	0.84
Air *	.8	.5	.3	.5	.2	0.46
Surface *	.2	.8	.6	.75	.5	0.57
Submarine *	N/A	.8	.8	.7	.8	0.78

* Current configuration of tactical receive sensors.

Technology Transition and Programmatic Impact

When looking at CST in terms of testing events and demonstrated capabilities versus some resultant Navy acquisition programmatic action as a means to measure technology transition, it is difficult to draw defendable conclusions. Figure 2 demonstrates this enigma.

LFAA Transition Roadmap

CST/LFA Tests	CST 1	CST 2	CST 3, 4	CST 5, 6 E-1	CST 7	MAG I CST 8	MAG II CST 10	LFA 13 E-2, E-3 CST 11
* Demonstrated capability	Fixed Bistatics	Volume Scatter issue revealed	Deep Water LFAA proven, initial tactical Bistatics	LFA Deep-to-Shallow Bistatics through edge reverb.	Shallow Water Bistatics, multi-platform prosecution	Shallow Water Monostatics, BG Control, Shallow Distributed Sensor Bistatics	BG/CTF control, Multi-statics, Acoustic/ Non-Acoustic hand-off	JTF control, Acoustic/ Non-Acoustic fusion, IOC Surveillance/ LFAA
Coincident Programmatic actions	CUARP, MSS & AAUS start	SQY-1 starts, MSS canc.	CUARP completes DSS starts	SQY -1 canc. EER, PoP start	MSS PoP stops, AAUS dropped, SURTASS LFA MSII	DSS canc. SALFAS starts new environmental safety and health rqts.	SALFAS canc. T-23 Class reduced, SWAC starts	Fixed Bistatics dropped, LELFAS starts, Compact LFA starts

* In addition to monostatic LFAA

Figure 2. CST Events Vs Navy LFAA Programmatic Actions

Why was the CST Project frustrated in meeting some of its originally planned LFAA transitions? One interviewee stated ''Its hard to keep the [transition] windows in-place and open when the houses keep burning down.''

No doubt, the downsizing of the Navy had a tremendous programmatic impact at least equal and opposite to that of the CST Project success. For example, while about 90 percent of the envisioned at-sea testing needed to support 6.4 development was completed successfully, only about 50 percent of the participating programs survived the budget crunch to complete the transition.

On the positive side, as some projects died, new S&T has germinated and grown strong on CST results. Initiatives for lower acquisition category (ACAT) backfits and new, more affordable offboard sensors are now in place and provide new goals for LFAA transition (new sources, receivers and processors). In addition, not all the larger programs were killed. Figure 3 illustrates the programmatic survivors combined with the new S&T projects.

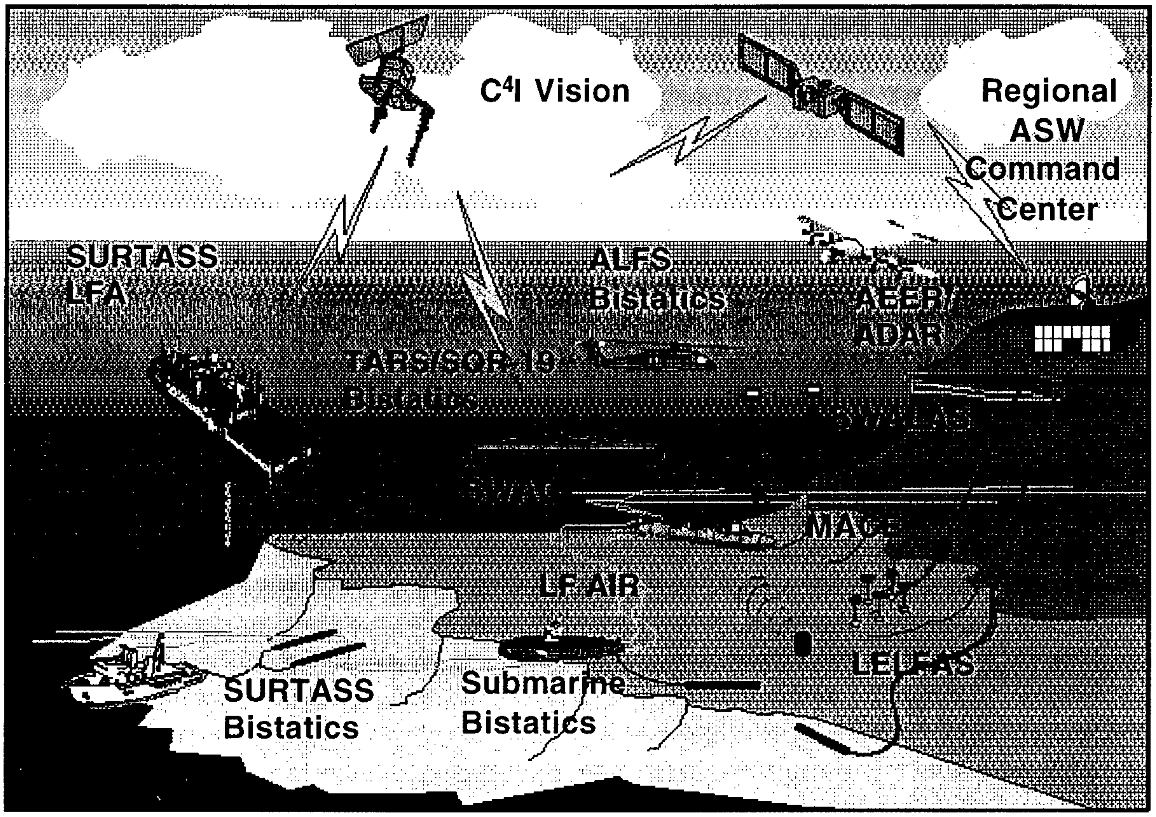

Figure 3. New LFAA Applications Demonstrated or Proposed

By far the most successful transition has been to the SURTASS LFA program. From the use of the CST platform (R/V CORY CHOUEST) by the Fleet in the Pacific theater to the integrated active acoustic prediction TDAs, the CST Project has assisted Space and Naval Warfare Systems Command (SPAWAR) PMW 182 field an ASW capability that is unmatched by any other navy. Besides providing the R/V platforms, the CST Project contributed strongly to both the system design and the supporting technologies that define operational suitability in the gamut of ocean environments from deep ocean to littoral, shallow water environments. It also answered key suitability questions of operations in a BG environment, in concert with other sensor systems, and during broader scope surveillance missions.

It is clear that the greatest difficulty for the CST Project was the closing of the transition windows that were available or planned to receive the LFAA technology products. Examples of this phenomena were the demise of Multistatic Sonar System (MSS), SQY-1, Stand-Alone Low Frequency Active Sonar (SALFAS), AAUS (Bistatic activation of Sound Surveillance Undersea

System (SOSUS), Fixed Distributed System (FDS) and Ariadne (in addition to the SURTASS passive ships)), and AAA (Bistatic activation of the Tactical Surveillance Sonobuoy (TSS), Sparse Tactical Random Array Processing (STRAP) and Horizontal Line Array (HLA)). There was also some direct technical backlash from the system configuration implications of real-life testing of a mid LFAA band vertical array using optimized vertical beam forming versus performance predicted for hull-mounted planar or conformed array sonars in the same environment. This comparison of real data to not too dependable modeled performance contributed to the end of SQY-1 and the rise of Proof-of-Principle (PoP), SALFAS, and Shallow Water Active Classification (SWAC). This is not a judgment on the relative worth of SQY-1 but just points out the need for real data "right now" when defending the Navy budget.

Stakeholder Development

There is additional insight to be gained into this technology transition process by looking at the personnel involved in CST. Based on review of records of at-sea participants in CST testing, review of the current mailing list for the CST Symposium, and recollections of the principal program and technical managers of the CST Project:

- Over 1000 government personnel have directly participated in CST operations over the past eight years.
- Over 500 government, civilian, academic, and industry scientists/engineers are still, directly or indirectly involved in CST analysis and/or development of CST tested technologies.
- A significant number of U.S. and Allied Fleet personnel are now familiar with surveillance and air/surface/submarine LFAA strategies.
- USW acquisition management personnel take LFAA as a "done deal" for future ASW system concepts.

A large number of the people involved in LFAA technology and its acquisition are in positions that enable day-to-day transition of LFAA technology to related USW projects. This broad base also provides an educated working pool able to implement LFAA acquisition tasks without additional training or unnecessary S&T development time. Actually conducting research at sea in the company of your peers (such as was done during CST testing) provides the best possible type of training of the next generation of researcher in the processes and techniques for testing USW systems. This is programmatically important today due to the reduced funding for future sea testing which reduces both the number and scale of tests to be conducted. The CST Project also developed a sound methodology for resolution of environmental issues and promotional cross-community test coordination and execution. Unfortunately, like all learned skills, this knowledge is perishable, and while the technical information is documented, the experienced CST participants may soon be gone except for those directly involved in follow-on LFAA developments.

The CST Project activities also provided the means to overcome some of the common technology transition impediments to achieving the programmatic goals for LFAA across all platforms. The impediments, their common result, and how they related to the CST Project were as follows:

- Stovepipe Development: No Outside Participation
  - With a new technology, the CST Project did not fit into existing program development road maps for sponsors other than surveillance.

- Budgetary Ricebowls: Unrealized Cost Benefit
  - The Navy's PPBS process required a single resource sponsor for the CST Project. Funding the CST Project was viewed as a tax away from other resource sponsors' ASW programmatic goals, not as an investment toward a common ASW goal.
  - Specifically, the ATD process was fairly new, and CST was viewed more as an extension of the SURTASS LFA vision than a common solution to all LFAA development risks.
- Not-Invented-Here: No Laboratory Commitment
  - The new LFAA paradigm was a threat to alternative ASW R&D projects. LFAA had significant, demonstrated potential, yet lack of sponsor confidence in the LFAA system implications implied to laboratory leadership that programmatic fiscal punishment from their sponsors would be incurred if laboratory focus was changed based on this "outside" information.

The CST Project was unique in its organization and approach to overcoming the programmatic resistance to transition created by stovepipe development, budgetary ricebowls and NIH. Inter-laboratory competition was somewhat muted by handling logistics through one technical agent already at the forefront of LFAA technology, Johns Hopkins University Applied Physics Laboratory (JHU/APL), and soliciting participation in the management of the technology development from all of the Naval warfare centers, as well as academic research centers and knowledgeable contractors. In effect, developers of specific platform ASW systems also became stakeholders in CST management and technology demonstrations. This programmatic mix resulted in a deep current of technology transition not immediately apparent in the acquisition documentation during the early 1990s, but more amenable and strongly evident today in the changing acquisition climate where the above barriers are being broken down.

The Director of the SPAWAR Intelligence, Surveillance and Reconnaissance (ISR) directorate (PD18) has initiated a new U/S ESG (reference 10). However, without the natural CST Project consensus building process available, a more structured measure such as Team Alpha may be required to enable agreement on the bistatic LFA MNS requirements and resourcing the exploitation of the full potential of LFAA technology.

> Note: While there are good altruistic programmatic, budgetary and practical technology development reasons for SPAWAR to continue to share its technology with other SYSCOMs and warfare centers, it should be pointed out that the CNO Staff looks to SPAWAR to coordinate the implementation of LFAA technology transition to other platforms.

Table 5 gives some indication of the strength of this stakeholder development process. It is a partial list, yet it clearly points out several LFAA-related Navy development programs and projects where CST-experienced personnel are now in key management or technical positions. Part of this is from in-place distribution of participants during the CST tests and part from recent migration of CST participants to new projects.

Table 5. Stakeholder Development Process

Program	Developer	Phase	CST Personnel
SURTASS LFA	PMW 182	6.4	5
Compact LFA	PMW 182	6.3	2
LLFA	NRaD	6.3	4
Fixed Bistatics	PD 18	6.3	2
SQQ 89I	PMS 411	6.4	4
IEER, AEER	PMA 264	6.4	2
SWALAS	NAWC	6.3	3
SWADC	NUWC	6.2	2
ADLFP	NAWC	6.2	3
ARS	NAWC	6.3	3
ALFS	PMA 299	6.4	2
ATOC	DARPA	Academia	4
Submarine Security	CNO N871	6.3	5

There are also many CST-experienced managers and technologists now in LFAA-related industry positions. Examining the invitation list for the final CST Symposium provides an appreciation of this expansion of the LFAA technology base. CST-experienced personnel are promulgating both technical and corporate knowledge of CST and are currently:

- In development management in all warfare centers, laboratories and SYSCOMs,
- Producing research, development, test and evaluation (RDT&E) plans that incorporate CST-derived LFAA and/or other CST-tested technology and test methods, and
- Convincing leadership outside of USW that LFAA is integral to future Battle Force system development, integration and Fleet suitability plans.

While today this distribution is a powerful programmatic factor in influencing Navy programmatic actions, the benefit could be lost over the next few years due to government service attrition BRAC actions (re-assignments), and loss of ASW requirement focus (a leadership issue).

The above almost osmosis-like processes makes it impossible to document the specific instances of CST technology transition to all the Navy SYSCOMs, warfare centers, laboratories, and the national defense industry. Additionally, the flow of technology transition was not always forward up the acquisition path of systems development. Often the results of CST testing flowed back to the academic and research communities to provide a validated baseline to guide future research toward other applications from LFAA. This feedback loop was provided by the active participation of Navy 6.1 and 6.2 managers in the CST process from the very beginning, and there are some very good examples that can be discussed.

As mentioned earlier, The CST Project offered an early example for use of Total Quality Management (TQM) and other methods for streamlined acquisition, especially when you consider the following CST accomplishments:

- Cross-platform application of commercial-off-the-shelf (COTS) - non-developmental items (NDI);
- Transition from blue water to littoral, USW, shallow water environment operations in meeting the new threat;

- Integrated at-sea testing, data sharing and reporting, seamless transition of technology from S&T to RDT&E to Fleet introduction and multi-discipline stakeholder development for the new technology (for example, LFAA playing in Joint Task Force concepts for ISR operations); and
- Fusion of acoustic, non-acoustic and non-organic data at the platform for common tactical picture generation.

The CST Project's early use of cross-platform sponsors, CNO (OP-951 and OP-981) and DASN(ASW), and an integrated process vision, turned out to be a forerunner to the IPT concept and acted as the glue to hold the technology transition together, particularly in the areas of: cross-platform standards for analysis (several CST area working groups), regular applications reviews, a continuous feedback loop with the PMs at all stages of development, and early addressing of "in-service" type issues generated by Fleet participants. This widened the critical issues list and engendered larger tests which got designers, builders and logisticians together early.

Conclusions and Implications

How has the CST process of consensus building, confidence building, system implication and transition, and stakeholder development contributed to the CST Project ultimate level of success? What does the current level of Pentagon commitment to LFAA development mean in terms of meeting the programmatic goals for CST and LFAA technology transition on a whole? Well, despite the tough times in getting there, the CST process contributed to its success and many of the CST Project goals were accomplished, which will enable further development. For instance:

- Achievable performance is much better understood:
  - Current Navy POM ASW wargames model LFAA capabilities to be developed for multiple platforms. One may now think of "ASW on Demand" as a programmatic goal.
  - New Tactical Doctrine addresses both USN Allies and potential adversary LFAA capability in planning for future Navy USW architectures.
- PMs have been convinced of low technical risk (reference 7):
  - Follow-on LFAA is in the R&D of every ASW sponsor's development roadmap.
  - Transition windows are again identified and documented for additional LFAA technology insertion into 6.4 acquisition.
- The CST Project's ASW technology transition effort netted about 50% of its top-level programmatic goals. The CST Project enabled:
  - Surveillance LFAA - Operational SURTASS LFA capability achieved (albeit delayed 4 years); bistatic Bottom Distributed System (BDS) delayed but achievable.
  - Surface ASW - Intentions of the bistatic LFA MNS have been demonstrated, surface bistatics will happen for the SQR-19, and new LFAA active classification components are coming into place. SURTASS LFA TX processing is the basis of combatant bistatic processing architecture.

However, no organic surface combatant 6.4 LFAA program has survived to date. (Littoral, shallow water environment performance is the issue.)

- Air ASW - Air stand-alone LFAA vision is in 6.4 (Improved Extended Echo Ranging (IEER)). Bistatic LFAA processors are available. However, bistatic air LFAA still awaits reliable high gain receiver development for littoral, shallow water environment use (reference 11).
- Submarine ASW - Bistatic MNS guidance is used. Consideration of potential LFAA offboard sources are in the Underwater Unmanned Vehicle (UUV) Master Plan.

- Insuring the LFAA investment:

  Lack of funding limited many of the originally planned programmatic actions, however, those with the highest payoff have survived. CST was a good policy but it did not cover all perils.

Limitations on Further Transition

So what might be done programmatically to complete the CST Project transition process? Acquisition decisions are still being made on an individual program basis versus a system-of-systems approach (no overall plan). As the research and development projects created to usher in the LFAA system approaches for restoring the Navy's acoustic advantage reach maturity, there must be a focused programmatic response to ensure the technology transition results in an integrated plan to achieve the promised Fleet capability (reference 12).

Focusing on the Future

Programmatically, coordination between CNO and Assistant Secretary of the Navy (ASN) staffs is vital for LFAA integration. Within the organization of the new ''ASW Czar'' there must be a CNO (N84) Action Officer responsible for LFAA requirements. A ''system-of-systems'' approach to LFAA integration is required. Within the ASW Czar's charter there needs to be a directive to re-examine littoral USW performance requirements using Team Alpha methodology and CNO/Fleet guidance. This effort must be supported by the U/S ESG (SYSCOMs/warfare centers) charted by DASN(ASW) (reference 10). A focus group for LFAA RDT&E should be created under Chief of Naval Research (CNR) to support that vision with new S&T, particularly in coordination of the myriad of at-sea testing being conducted by ONR (reference 13), including follow-on LFAA testing. The CNO (N84) Action Officer is also needed to address the emerging acoustic warfare and environmental issues associated with the use of LFAA. A continuing, serious problem is the lack of programmatic backing for the surface ASW community. Today there are fewer platforms to perform the task and no good sensor alternatives to LFAA, even for close-in ASW defense. Most important is to recapture the common vision which is the glue which holds LFAA technology transition together.

For the above organizations there are three key tasks that must be accomplished to attain a common vision. First, requirements must be redefined; the existing MNSs and ORDs for the ASW performance must be reevaluated and validated, and new operational and system requirements are needed now to cover the work being done today in the ATD arena and pull it together into an integrated plan. Second, for those applications not previously covered by CST, the risk in selecting an applicable technical approach must be reduced to an acceptable level through selective operational performance demonstrations to cover the highest priority issues. Third, there must be organizational consensus to dedicate the assets and shepherd the funds necessary to get the LFAA technologies into Fleet use.

Part of this has already been done through the CST Project and related LFAA development programs. The recent decision by the CNO to reestablish a Director for ASW Requirements is the enabler for the first step and will lay the foundation for the third. Concentrating our risk-reduction efforts on the surface and air ASW application of the LFAA technologies will complement and continue the risk reduction achieved by the CST Project.

It is no coincidence that the CST Project completion co-dates these events. Overall, through the CST process, the consensus for LFAA development has been established, the technology proven, and the stakeholders are in place to pull ASW out of the downward spiral that now threatens the Navy's ability to sail in harm's way. There would be no need for the new CNO (N84) organization if there were no ''solutions'' available to meet the quiet submarine threat. The CST Project can take much credit for providing the ready tools the Navy Director of ASW can use to answer the challenge.

Summary: There and Back

The blizzard of technical reports and white papers goes well beyond this programmatic overview to address science and system-level implications for the CST technologies. There is real meat in those pages to apply to achieve the ''solutions'' sought from the 1985 beginning of CST's programmatic quest. Programmatically, the CST Project has completed the majority of its mission.

- CST risk-reduction sea testing supported a multi-billion dollar investment in LFAA technology that spans across all ASW platforms and committees.
- Most EVA and technical issues have been answered in deep water; however, threat reduction and consequent budget/programmatic decisions significantly reduced the Navy LFAA investment.
- Secondary effects of familiarization and training have resulted in consensus, confidence and stakeholder support for LFAA.
- New acquisition rules have created a second opportunity for LFAA technology transition.

However, new focused management is needed to regain original programmatic vision.

Post Script

A survey was conducted during the CST and LLFA Symposium to capture broader audience knowledge and opinion; however, at the end of the symposium, only 6 completed survey forms were collected from over 150 attendees. This is both good news and bad news. The good news is the responses were genuine and provided helpful comments to focus future action for LFAA technology transition, and there were no ''raspberries'' regarding the CST Projects. The bad news is there were no ''raspberries'' regarding the CST Project; this is in spite of a number of deficiencies known to exist in CST testing, particularly addressing the key issues for tactical platforms. This may indicate a feeling of apathy, or perhaps more precisely, a sense of job completion where, in fact, there is still much to be done. A good starting point to correct this would be to ponder the "remaining issues" side of the coin when going through the CST Final Reports and other summations of CST accomplishments. If the new ASW organizations and working groups can view the big picture in a "system-of-systems" approach, the LFAA technology transition impetus from the CST Project could provide part of the foundation for the new ASW Master Plan.

Follow-on action plans to correct deficiencies in ASW technology development, transition and training must also take a commensurate "Team ASW" approach to acquisition requirements.

In the interview process for this paper, the interviewees often stated that their application (air, surface, submarine or surveillance) of LFAA technology must perform to some impossible stand-alone standard in every conceivable scenario or environment. To the author this produced a resonant chord that sounded like that of a gold-plated rice bowl filled with plans for a stovepipe development that excluded all technologies that were not invented here. Take care not to lose what took so long to gain!

Acknowledgments

The author thanks PMW-182-2 for supporting this work; Mr. Mark Waggoner of PSI for assistance in obtaining CST personnel lists and advance copies of the CST reports; the CST participant scientists, engineers, managers, contractors and the authors of CST reports without whose effort there would have been no programmatic process and impact to write about.

A Note From the Author

As the CNO (OP-951) requirements officer assigned to CST in 1985, I strongly believed in the requirement for the CST Project and had the privilege to work with many of the mid-1980s leaders of the ASW community in developing the program plan and cobbling together the budget to get it going. In 1989 I returned to the Pentagon from a sea tour with the IUSS community and learned how important the results from the CSTs were to the future of ASW. At the direction of the DASN(ASW), I was assigned the duty of articulating the budget justification and crafting a strategy to justify and fund a follow-on "Phase II" of the CST Project which would focus on the mission requirements laid out in the Navy white paper "From the Sea" (reference 14). In that process, with the budget year restart support of Congress and consequent execution year Navy reprogramming and refocusing of ongoing related programs, there was some not so gentle encouraging of financial participation. These things happen often in Navy programmatic activities. For those affected adversely in those action, there may be some comfort in the realization that your participation made the positive programmatic effect of the CST Project possible and moved the Navy much further along the power curve of addressing the quiet submarine threat. In these times of DoD downsizing, I am happy to see that the LFAA technology transition effort was not folded like a high-risk hand of poker and may actually realize its potential as the cornerstone of the new "ASW Master Plan."

References

1. J. D. Watkins, ''CNO Urgent ASW R&D Program (CUARP),'' Ser 00/6U300181, 16 June 1986.

2. J. S. Reynolds, Mission Needs Statement (MNS) for Bistatic LFAA (U), (Secret), CNO, 2 February 1990.

3. A. C. Biondo, et al., ''An Overview of the Critical Sea Test Program Phase One (U),'' (Secret), U.S. Navy Journal of Underwater Acoustics (U), April 1992.

4. W. T., Ellison, D. A. Backes, and S. J. Labak, "LFAA Shallow-Water at-Sea Performance Assessment to Date (U),'' (Secret), U.S. Navy Journal of Underwater Acoustics (U), (Secret), January 1996.

5. J. D. Zittel, et al., ''System Implications of Critical Sea Test Phase II Environmental Acoustics Measurement (U). (Secret), U.S. Navy Journal of Underwater Acoustics (U), (Secret), January 1996.

6. M. Stripling, et al., ''CST/LLFA Systems Implications Final Report(U),'' (Secret), SPAWAR CST/LLFA-R-USWAC-15, July 1996.

7. Department of the Navy FY 1997 Budget Estimates: Justification of Estimates; Research, Development, Test & Evaluation Budget Activities 1-3, Science and Technology (S&T), March 1996.

8. Tyler, Gordon D., Jr., The Emergency of Low-Frequency Active Acoustics as a Critical Antisubmarine Warfare Technology, Johns Hopkins APL Technical Digest, Volume 13, Number 1 (1992).

9. ''Seawolf Completes Sea Trials With a Clean Sweep,'' The Observer, Naval Sea Systems Command, 22 July 1996.

10. Charter for the Undersea Surveillance Executive Steering Group (U/S EST), Memorandum From the Deputy Assistant Secretary of the Navy for Mine and Undersea Warfare (DASN-MUW), 17 April 1996.

11. A. D. Ravitz, ''Low-Frequency Active Air bistatics (U),'' (Secret), U.S. Navy Journal of Underwater Acoustics (U), January 1996.

12. P. W. Bulkeley, CAPT, USN, ASW CEB Brief, 1 December 1995.

13. ''R&D At-Sea Program Synopses—Bi-Annual Report,'' Ocean, Atmosphere and Space Science & Technology Department (OAS), ONR (Code 32), 30 June 1996

14. F. Kelso, et al., ''From the Sea,'' September 1992.

Acronyms

AAA	Air Active Adjunct
AAUS	Active Adjunct for Undersea Surveillance
ABCANZ-2	American, British, Canadian, Australian, and New Zealand Agreement No. 2
ACAT	acquisition category
ADAR	Air Deployed Active Receiver
ADI	Air Defense Initiative
AEER	Advanced Extended Echo Ranging
AIREM	Air ASW Readiness/Effectiveness Measuring
ALFS	Airborne Low Frequency Sonar
AR SRP	Acoustic Reverberation Special Research Project
ASN	Assistant Secretary of the Navy
ASW	antisubmarine warfare
ATD	Advanced Technology Demonstration
BDS	Bottom Distributed System
BG	battle group
BRAC	base realignment and closures
C&IWG	Connectivity and Interoperability Working Group
C^4I	Command, Control, Communication, Computing and Information
CNO	Chief of Naval Operations
CNR	Chief of Naval Research
COTS	commercial-off-the-shelf
CST	Critical Sea Test
CTF	Command Task Force
CUARP	CNO Urgent ASW R&D Program
CZ	Convergence Zone
DASN(ASW)	Deputy Assistant Secretary of the Navy Antisubmarine Warfare
DESRON	destroyer squadron
DSS	Decision Support System
EVA	environmental acoustic
EW	electronic warfare
FDS	Fixed Distributed System
HEP	Harsh Environment Program
HLA	Horizontal Line Array
IEER	Improved Extended Echo Ranging
IEP	Information Exchange Program
IOC	Initial Operational Capability

IPT	Integrated Product Team
IR	infrared
ISR	Intelligence, Surveillance and Reconnaissance
IUSS	Integrated Undersea Surveillance System
JROC	Joint Requirements Oversight Council
JTF	Joint Task Force
JUA	Journal of Underwater Acoustics
JHU/APL	Johns Hopkins University Applied Physics Laboratory
LELFAS	Long Endurance Low Frequency Acoustic Source
LFA	Low Frequency Active
LFAA	Low Frequency Active Acoustics
LLFA	Low Low Frequency Active
MACE	Multistatic ASW Capabilities Enhancement
MNS	Mission Need Statement
MSII	Milestone II
MSS	Multistatic Sonar System
NAPDD	Non-Acquisition Program Definition Document
NDI	non-developmental item
NIH	not-invented-here
OPNAV	Naval Operations [staff code]
OTH	over-the-horizon
P^3I	Pre-Planned Product Improvement
PM	Program Manager
POM	Program Objective Memorandum
PoP	Proof-of-Principle
PPBS	Planning, Programming and Budgeting System
R&D	research and development
R/V	Research Vessel
RBR	Refracted, Bottom Reflected
RDT&E	research, development, test and evaluation
RF	radio frequency
RO-RO	roll-on-roll-off
S&T	science and technology
SALFAS	Stand-Alone Low Frequency Active Sonar
SHAREM	Ship ASW Readiness/Effectiveness Measuring
SOSUS	Sound Surveillance Undersea System
SPAWAR	Space and Naval Warfare Systems Command

STRAP	Sparse Tactical Random Array Processing
SURTASS	Surveillance Towed Array Sensor System
SWAC	Shallow Water Active Classification
SWALAS	Shallow Water Active Localization and Attack System
SYSCOM	system command
TARS	Towed Array Receiver System
TD	Technical Director
TDA	Tactical Decision Aid
TOR	Tentative Operational Requirement
TQM	Total Quality Management
TSS	Tactical Surveillance Sonobuoy
TTCP	The Tactical Cooperation Program
TX	Transmit-Receive Subsystem
U/S ESG	Undersea Surveillance Executive Steering Group
UAV	Unmanned Aerial Vehicle
USV	Unmanned Surface Vehicle
USW	undersea warfare
UUV	Underwater Unmanned Vehicle