Secretary of Defense Report on Nuclear Attack Submarine Procurement and Submarine Technology

In Compliance With Section 131
Fiscal Year 1996 National Defense Authorization Act

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Executive Summary

The National Defense Authorization Act for Fiscal Year 1996 (Section 131) directs the Secretary of Defense to submit to the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives, a plan for the development of a program that will lead to the competitive production of a more capable, less expensive class of nuclear attack submarines. This report provides a plan that complies with the Authorization Act. Chapter 1 of this report sets forth the compliant construction plan, its funding, oversight, and impact on force structure. It will be difficult to fund the directed plan. To address this issue, the Department developed alternatives, which address the key requirements for competition, introduction of a second shipbuilder into the nuclear attack submarine program, quantity of submarines and technology insertion, but do not fund all of these requirements within the current Future Years Defense Program. Alternatives were also considered to correct a circumstance in the construction plan directed by the Authorization Act that could weaken one shipbuilder's ability to remain in the marketplace prior to the initiation of competition.

The baseline New Attack Submarine satisfies military requirements. However, chapter 2 of this report addresses the identification and development of advanced technologies and associated funding requirements. It provides for the establishment of an oversight council to integrate submarine technology management. The Navy used an Independent Submarine Technology Assessment panel in addition to its senior civilian and Flag-Level team to identify advanced technology needs and required investments. Not all of the advanced technology options described can be pursued within existing fiscal constraints. Three levels of research and development investment are identified which involve the submarine shipbuilders and shift technology development and transition from a cyclical to a steady, core investment approach.

The Navy has initiated the process to transfer New Attack Submarine design information from Electric Boat to Newport News Shipbuilding using Fiscal Year 1996 funds. The Navy, Newport News Shipbuilding, and Electric Boat Corporation have agreed in writing to a design transfer process which facilitates New Attack Submarine construction at Newport News Shipbuilding in fiscal year 1999. Advanced procurement of long lead components for both the Fiscal Year 1998 and the next submarine has begun using Fiscal Year 1996 funds. The Department's Fiscal Year 1997 budget submission includes $35 million to continue design transfer efforts.

The Department's Fiscal Year 1997 budget submission complies with the Authorization Act. The Department would face major near term affordability issues in pursuing the plan directed by the Congress or the alternatives presented in this report. The Department believes that these alternatives place disproportionate near term funding emphasis on one weapon system at the expense of other weapons systems across the Future Years Defense Program. The Department believes the baseline ship and program fully satisfies military requirements.

CHAPTER 1

SHIPBUILDING PLAN

Shipbuilding Plan

Background

In 1995, the Department of Defense presented a submarine construction program to the Congress that represented an affordable plan to build nuclear attack submarines which meet the Joint Chiefs of Staff mission requirements outlined in Appendix A, and maintains submarine superiority in the future.

During consideration of the Fiscal Year 1996 budget, the Committee on Armed Services of the Senate and the Committee on National Security of the House of Representatives criticized the Department of Defense's plan, arguing it failed to provide for competitive procurement and it produced a submarine class design with inadequate technological advantage over foreign submarines presently under construction or in design. Section 131 of the National Defense Authorization Act for Fiscal Year 1996 directs the Secretary of Defense to:

- submit to the Congress a plan that would lead to production of more capable, less expensive nuclear attack submarines;
- provide for the design, development, and procurement of four nuclear attack submarines to be procured in Fiscal Years 1998 through 2001;
- provide for construction in alternating years at two designated shipyards, using the New Attack Submarine design as a base;
- identify advanced technologies in various stages of research and development, to include commercially available technologies, that might be incorporated into subsequent designs;
- call upon each contractor to propose design improvements for each successive submarine so long as the improvements would result in more capable and more affordable submarines; and
- competitively award serial production contracts not earlier than Fiscal Year 2003 of a design incorporating the latest, best and most affordable technology;

The Department's Fiscal Year 1997 budget submission complies with section 131 of the National Defense Authorization Act for Fiscal Year 1996. This report responds to the requirements of the Authorization Act.

The Need For Alternative Approaches

It will be difficult to afford the plan directed by the Congress in the context of other modernization priorities. Consequently, the Department has developed alternative submarine construction programs that will allow for technology insertion, will provide for a two-yard production base, and will lead to competition. The alternatives achieve these goals while having a lower near-term funding impact than the Congressional plan. An alternative was also considered to correct a circumstance in the construction plan directed by the Authorization Act that could result in weakening one shipbuilder's ability to remain in the marketplace prior to the initiation of competition.

Shipbuilding Plan

Alternative Nuclear Attack Submarine Construction Plans

Chart 1 presents three alternative nuclear attack submarine construction plans and compares them to the Department's Fiscal Year 1997 budget submitted in March 1996. All of these alternatives preserve a two-yard production base, leading to the potential for competitive acquisition of nuclear attack submarines in the next century. Electric Boat Corporation requires at least one submarine every other year to sustain production skills and reasonable overhead absorption. The construction plan in the Fiscal Year 1996 Defense Authorization Act creates a two year gap for Electric Boat Corporation by allocating submarines in Fiscal Year 1998 and 2000, then starting serial production not earlier than Fiscal Year 2003.

Chart 2 shows the cost of each alternative through Fiscal Year 2001 and reflects the increased funding required per year for each alternative compared to the Department's Fiscal Year 1997 budget submission. The Shipbuilding and Conversion, Navy (SCN) costs in Chart 2 reflect only the funds necessary to construct nuclear attack submarines in accordance with the current New Attack Submarine design, which includes those technologies discussed in Appendix B. Chart 3 shows total submarine program SCN cost as a percentage of the SCN budget for the Fiscal Year 1997 President's Budget request and Alternative 3 (Congressional Plan).

These alternatives vary in their affordability and impact on the industrial base. Each alternative should be evaluated in terms of three criteria:

- cost and affordability
- military need
- impact on the industrial base

Each alternative will be discussed in turn.

Chart 1: Alternative Nuclear Attack Submarine Construction Plans

	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04
Budget Baseline (Milestone II Program)	1-EB	0	1-EB	0	2-EB	2-EB	2-EB
Alternative 1	1-EB	1-NNS	1-EB	0	1-EB 1-NNS	1	2
Alternative 2	1-EB	1-NNS	1-EB	1-NNS	1-EB	1-NNS	1-EB 1-Compete
Alternative 3 (Congressional Plan)	1-EB	1-NNS	1-EB	1-NNS	0	1-EB 1-NNS	2

Boxes connote two-year competitive packages with some ships directed as shown to maintain industrial base at both shipyards.
For the Budget Baseline, competition could potentially be introduced in FY03.
EB- Electric Boat Corporation
NNS - Newport News Shipbuilding

Chart 2
SCN Funding Requirements for Alternative Building Profiles
(Then Year $billions)

FY 1997 President's Budget FYDP

	FY97	FY98	FY99	FY00	FY01	Total*
Number of Ships	0	1	(1)**	1	(1)**	2 (2)
Shipbuilder		EB	NNS	EB	NNS	
SCN Funds Requested	$0.3	$2.7	$0.5	$1.9	$1.1	$6.6

Alternative 1 - Base Design Only

	FY97	FY98	FY99	FY00	FY01	Total*
Number of Ships	0	1	1	1	0	3
Shipbuilder		EB	NNS	EB		
SCN Funds Required	$0.8	$2.9	$2.5	$1.9	$0.9	$9.0

Alternative 2 - Base Design Only

	FY97	FY98	FY99	FY00	FY01	Total*
Number of Ships	0	1	1	1	1	4
Shipbuilder		EB	NNS	EB	NNS	
SCN Funds Required	$0.8	$2.9	$2.5	$2.1	$2.1	$10.4

Alternative 3 - Base Design Only
(Congressional Plan)

	FY97	FY98	FY99	FY00	FY01	Total*
Number of Ships	0	1	1	1	1	4
Shipbuilder		EB	NNS	EB	NNS	
SCN Funds Required	$0.8	$2.9	$2.5	$2.1	$2.1	$10.4

* See Chart 1 for profiles beyond Fiscal Year 2001. Differences in outyear building profiles influence earlier funding requirements.
**The ships in parantheses and their associated advance procurement and construction costs are unfunded, non-add items in the FY97 Budget.

Additional SCN costs above those listed in the table above can be anticipated for non-recurring design costs associated with incorporating new technologies selected for insertion in submarines in these alternative profiles.

Chart 3
Submarines as a Percentage of the SCN Budget

Fiscal Year 1997 President's Budget FYDP ($ in billions)

	FY97	FY98	FY99	FY00	FY01	Total
FYDP SCN	$4.912	$7.762	$5.182	$7.684	$8.090	$33.630
Submarine Programs	$0.995	$2.807	$0.544	$1.900	$1.137	$ 7.383
Submarines as a percentage of FYDP SCN	20.3%	36.2%	10.5%	24.7%	14.1%	22.0%

Alternative 3 ($ in billions)-Base Design Only

	FY97	FY98	FY99	FY00	FY01	Total
FYDP SCN	$4.912	$7.762	$5.182	$7.684	$8.090	$33.630
SCN Additional Required	$0.504	$0.203	$1.956	$0.200	$0.963	$3.826
Total SCN	$5.416	$7.965	$7.138	$7.884	$9.053	$37.456
Submarine Programs	$1.499	$3.010	$2.500	$2.100	$2.100	$11.209
Submarines as a percentage of FYDP SCN	30.5%	38.8%	48.2%	27.3%	26.0%	33.3%
Submarines as a percentage of Total SCN	27.7%	37.8%	35.0%	26.6%	23.2%	29.9%

Submarine Programs: Includes funding to complete construction of SSN 23, and design and construction funding for New Attack Submarine.

Budget Baseline

The Department's Fiscal Year 1997 budget, as submitted, conforms to the direction in section 131 of the National Defense Authorization Act for Fiscal Year 1996. The submarine in Fiscal Year 1999 and its associated ship set were not included in the budget as allowed in Section 131 (b)(2)(C) of the Authorization Act. The Department believes this baseline is acceptable in terms of cost and affordability, and the baseline ship and program fully satisfy military requirements. It would not, however, permit consideration of competition or expansion of the submarine industrial base to more than one yard until Fiscal Year 2003.

Alternative 1: Earlier Competition Alternative

Alternative 1 provides for an earlier base for competition between the two shipyards by building three submarines from Fiscal Year 1998 through 2001. This alternative would buy one ship earlier than planned in the budget baseline, and would direct that ship to a second shipyard. This alternative would procure an additional submarine sooner than required, would support production at two shipyards beginning in Fiscal Year 1999 and would begin competition in Fiscal Year 2002. The industrial base risk created by the gap in production in Fiscal Year 2001 is mitigated by nuclear aircraft carrier work at Newport News Shipbuilding.

Alternative 2: Directed Procurement Alternative

Alternative 2 builds four submarines from Fiscal Years 1998 through 2001 with production in alternating years at two designated shipyards. This alternative avoids a potential problem by directing a submarine to Electric Boat in Fiscal Year 2002 to preclude a two year production gap. As with Alternative 1, this plan buys submarines sooner than required, though the impact is reduced by buying only one submarine in Fiscal Year 2003. This alternative maintains two yards and begins competition in Fiscal Year 2003.

Alternative 3: Congressional Plan

Alternative 3 is the submarine construction plan mandated by Congress in section 131 of the National Defense Authorization Act for Fiscal Year 1996. This alternative purchases submarines sooner than required. While this alternative maintains two yards and begins competition in Fiscal Year 2003, it creates a two year gap in production at Electric Boat Corporation (fiscal years 2000 to 2003). Consequently, in order to sustain production capability at Electric Boat Corporation this plan would require additional industrial base funding in Fiscal Year 2002.

Competitive Submarine Program

To execute the program in section 131(c) of the National Defense Authorization Act for Fiscal Year 1996, the Navy would:

- Use the Fiscal Year 1998 New Attack Submarine design as the base design for both shipbuilders. As deemed prudent, the base design would be updated to incorporate producibility improvements and new technologies approved for each subsequent ship to enhance operational capability or cost effectiveness;

- Assure a sound, producible design by continuing the existing Integrated Product and Process Development effort at the lead shipyard, Electric Boat Corporation. For consistency and cost effectiveness, Electric Boat Corporation would retain lead design yard responsibility, including integrating any new technologies approved for each subsequent ship into the design;

- Transfer Navy design information to Newport News Shipbuilding as it becomes available to enable Newport News Shipbuilding to construct New Attack Submarines as early as Fiscal Year 1999;

- Establish Integrated Product and Process Development teams with Newport News to support efficient construction of nuclear attack submarines at Newport News Shipbuilding;

- Provide information regarding the Navy's submarine research and development programs being pursued by industry and government laboratories and research centers to both shipbuilders. Appendix C identifies emerging technologies that have potential for insertion in future ships;

- Call upon the shipbuilders to propose improvements to the base design that would reduce cost or improve capabilities to meet mission requirements at an affordable cost;

- Review proposals from the shipbuilders to determine which design changes to make to the base design. This process would be streamlined to ensure that cost, risk, and benefits of the proposed design changes would be addressed in an efficient manner;

- Decide upon changes and task the lead design yard to integrate the changes into the design for subsequent ships;

- Establish an up-to-date base design to compete serial production ships.

The transfer process for the New Attack Submarine design would be similar to that used for previous classes of submarines. The Navy, Newport News Shipbuilding, and Electric Boat have agreed to a design transfer process as follows to support construction of future nuclear attack submarines at Newport News Shipbuilding:

- Newport News Shipbuilding would be provided design deliverables in a manner generally consistent with that provided to follow yards in recent submarine projects;

- The Navy would coordinate and adjudicate the design deliverable transfer; and

- Follow ships would be built to the base design, with changes as approved by the Navy to reduce costs or to provide capability the Navy needs at an affordable cost.

Shipbuilding Plan

Program Oversight

The Navy's nuclear attack submarine program will be managed by the Navy under the oversight of the Under Secretary of Defense for Acquisition and Technology (USD(A&T)). This oversight will be executed by the Navy and USD(A&T) via Integrated Product Teams, which have been established by USD(A&T) for all major Acquisition Category (ACAT) programs. A Submarine Technology Oversight Council, co-chaired by USD(A&T) and the Assistant Secretary of the Navy for Research, Development and Acquisition, will ensure efforts to advance submarine technology from initial concept to production are coordinated within the Department of Defense. The Council will also ensure that the Special Submarine Review Panel, established under subsection 131(f) of the National Defense Authorization Act for Fiscal Year 1996, is informed of the status of the submarine modernization program and the status of submarine related research and development as required by the Authorization Act.

Integrated Product Teams have been used successfully by commercial companies to streamline the acquisition process. The use of Integrated Product Teams in the Navy's nuclear attack submarine program is ensuring effective oversight in a streamlined acquisition environment by satisfying the following objectives:

- Conveys timely program information to higher level acquisition managers within the Office of the Secretary of Defense, Navy and other staffs to facilitate timely decisions.
- Coordinates actions resulting from key cost, schedule, acquisition strategy and technical issues for the nuclear attack submarine program.
- Develops timely consensus for issue resolution.
- Sustains the focus on capable, affordable submarines.
- Identifies acquisition reform opportunities and implements program improvements to take advantage of these opportunities.

Shipbuilding Plan

Impact on Force Levels

Force Structure

The attack submarine force will reach 55 ships in Fiscal Year 1999 and remain between 45-55 ships, even if one of the alternative construction profiles were executed. The force goal in Fiscal Year 2001 for active and reserve surface combatants could range between 126 and 138 ships, depending on future funding priorities and operational requirements. The Department has not adopted the force structure in the Surface Combatant Force Level Study. The long-term surface combatant goal is currently under review as part of the Fiscal Year 1998 budget development. Funding additional submarines within the Future Years Defense Program could adversely affect the other high priority shipbuilding programs shown below.

The Fiscal Year 1996 maritime force structure is as follows:

SHIP TYPE	ACTIVE	RESERVE
Ballistic Missile Submarines	17	-
Aircraft Carriers	11	1
Attack Submarines	80	-
Surface Combatants	116	10
Amphibious Ships	42	2
Mine Warfare Ships	11	5
Logistic Force Ships	65	-
Total	**342**	**18**

Future Years Defense Program Shipbuilding Plan

Ship Type	FY97	FY98	FY99	FY00	FY01
Nuclear Attack Submarine (see note 1)	-	1	(1)	1	(1)
DDG 51 (Guided-Missile Destroyer)	4	2	3	3	3
Carrier Replacement Program	-	-	-	-	-
LPD 17 (Amphibious Transport Dock)	-	1	1	2	2
ADC(X) (Fast Combat Support Ship)	-	-	-	1	-
TAGS 60 (Oceanographic Research)	-	-	1	-	-
T-AGOS 23 (Ocean Surveillance Ship)	-	-	1	-	-

Note 1: The third and final SEAWOLF was authorized in Fiscal Year 1996 and requires an increment of funding in Fiscal Years 1997 and 1998. Additionally, the President's Fiscal Year 1997 FYDP includes funds the Fiscal Year 1998 and 2000 nuclear attack submarines. In accordance with guidance contained in subsection 131(b)(2) of the National Defense Authorization Act for Fiscal Year 1996, funding requirements for the Fiscal Year 1999 and

2001 submarines are identified in the Fiscal Year 1997 FYDP, but the advance procurement for the FY99 ship is not funded in the FY 1997 President's Budget request.

CHAPTER 2

SUBMARINE TECHNOLOGY

Submarine Technology

Submarine Technology Transition and Insertion

Background

The New Attack Submarine will be a highly capable, technologically robust warship that incorporates an affordable mix of technologies that meet all mission requirements established by the Joint Staff.

Current Technology Transition Process

Historically, submarine technology development, maturation, and transition have been performed on a cyclical basis. The cycle began as a preface to new submarine design. Funding for technology development, maturation, and transition was increased dramatically to provide technologies for inclusion in the new class design, only to be scaled back to subsistence levels during serial submarine production. This approach, used for the SSN 688, SSBN 726, and SEAWOLF classes, was successful mostly because there was continuity or overlap of multiple submarine class design or design upgrades. It produced blocks of technology that were available during designated periods, thereby achieving some measure of stability within the submarine development, engineering and design core. This approach was also successful for the New Attack Submarine, as all of the near-term technologies available to support its mission requirements have been included in its design.

Future Technology Transition Requirements

The transition from a high to a low production rate of submarines, coupled with an exponential increase in the rate of technology turnover, necessitates a more evolutionary approach to submarine technology development and transition. The submarine technology transition process must change from one that is cyclical in nature, to a more active, but steady approach. The New Attack Submarine design incorporates those technologies that support all mission requirements, and features dramatic new approaches that will accommodate in a cost effective way new technologies as they mature and are needed to satisfy new military requirements.

Core Technology Development and Transition

To finish development of the technologies identified by the Defense Advanced Research Projects Agency (DARPA) and other sources, the Navy is evaluating core technology investment options. The Navy's preliminary estimate is that an increase of $60 million per year in Research, Development, Test, and Evaluation might be required.

Optional Levels of Technology Insertion

Appendix C provides a prioritized listing of technologies that are candidates for insertion in New Attack Submarines. Although these technologies are not mandatory to meet the mission requirements of the submarine, they could further enhance performance or affordability. They are grouped into three categories, which represent optional levels for investment

- **Category I:** Technologies that have the highest military priority. These technologies could enhance submarine acoustic superiority in the near term, at relatively low added cost.

- **Category II:** Technologies that have moderate priority. These technologies could enhance submarine producibility or contribute to affordability.

- **Category III:** Technologies that have lower near term military priority and are collectively more expensive. These technologies could enhance performance, or provide additional capabilities beyond those needed to meet mission requirements.

Submarine Technology

Submarine Technology Management

Background

The current technology management approach, which worked adequately for the cyclical technology development and transition process of the past, must change to a new, steady, evolutionary process. To guide this transition, the Department has established an oversight council. As a continuing part of its planning and programming development process, the Navy established a Flag-level panel and multiple working groups to identify and recommend priorities for new technology development from early assessment to operational insertion. To ensure no technology was overlooked, independent experts evaluated submarine technology suggestions from the private and academic sectors.

Submarine Technology Oversight Council

The Submarine Technology Oversight Council will oversee the technology development and transition process, and ensure efforts to advance submarine technology from initial concept to production are coordinated within the Department of Defense. The Council will also ensure that the Congressional Special Submarine Review Panel, established under subsection 131(f) of the National Defense Authorization Act for Fiscal Year 1996, is informed of the status of the submarine modernization program and submarine related research and development as required by the Authorization Act. The Council will be co-chaired by the Under Secretary of Defense for Acquisition and Technology and the Assistant Secretary of the Navy for Research, Development and Acquisition. Members will include:

Director, Defense Advanced Research Projects Agency
Deputy Chief of Naval Operations for Resources, Warfare Requirements and Assessment
Commander, Naval Sea Systems Command
Director of Naval Intelligence
Program Executive Officer for Submarines
Director, Naval Nuclear Propulsion
Director, Defense Research and Engineering
Director, Strategic and Tactical Systems

Chief Executive Officers from Electric Boat Corporation, Newport News Shipbuilding, and the New Attack Submarine C3I System Prime Contractor will participate with the Council as appropriate.

Flag-Level Team

To emphasize the ongoing process of advancing technology from development to operational status, the Navy has an integrated team of senior leaders from the science and technology, research and development, acquisition, and operational communities, including

the Defense Advanced Research Projects Agency. Under the joint direction of the Office of the Chief of Naval Operations and the Naval Sea Systems Command, the role of the team is to establish and recommend priorities for technology investment and to leverage submarine research and development programs, emphasizing transition to operational status at an affordable cost.

Supporting the senior leadership team, ten submarine system-oriented working groups will assess science, technology, research, and development efforts against current requirements and desired future capabilities to identify technologies for potential submarine application. These working groups include participation by the Defense Advanced Research Projects Agency, Office of Naval Research and representatives from a broad spectrum of the submarine technology community. The working groups provide recommendations for an integrated submarine technology development and transition strategy which are reviewed by the leadership team. The strategy is used to formulate the Navy's submarine program plan, develop the Department's Future Years Defense Plan, and to provide information to the Defense Advanced Research Projects Agency and the Office of Naval Research on submarine technology needs. This team approach is enhancing communication and cooperation among organizations engaged in submarine-related research and development.

Independent Submarine Technology Assessment

The Navy contracted for an independent study to assess existing and emerging technological advances that have potential to increase the capability and affordability of submarines. This assessment was performed by independent experts representing a broad spectrum of industry, academia and the military communities. Study participants collectively were knowledgeable in a wide variety of technology and submarine research, design, construction, operations and maintenance areas

The independent study identified advanced technologies that are in various phases of research and development, as well as those that are commercially available off-the-shelf. To support the study, an announcement in the Commerce Business Daily was issued in December 1995, requesting suggestions regarding future technologies for the Navy to consider incorporating in the New Attack Submarine design. Over 250 inputs from industry, academia, and government laboratories were received in response to this announcement. The study included discussions with many of the respondents, and assessed all suggestions with respect to military utility, capability improvement, cost, risk, and affordability. The study participants then identified candidate technologies and conducted an in-depth analysis of each candidate, resulting in a recommendation regarding the potential benefits and drawbacks of incorporating these technologies into the New Attack Submarine base design. In addition to briefings provided by witnesses who testified at the September 7, 1995 special hearing of the House of Representatives National Security Committee, the study participants received briefings from the Defense Advanced Research Projects Agency, Office of Naval Research, Naval Sea Systems Command, New Attack Submarine Program Office, Office of the Chief of Naval Operations, Center for Naval Analysis, Electric Boat and Newport News Shipbuilding.

Submarine Technology

Funding Implications of Technology Enhancement Program

The RDT&E appropriation funding needed to accelerate the transition of technologies identified in Appendix C for incorporation in the New Attack Submarine are indicated below. This funding is in addition to that included in the Fiscal Year 1997 President's Budget request.

Additional RDT&E Funding to Insert Appendix C Technologies (Then Year $millions)

Investment Level	RDT&E (Total over the next 7 years)
Low	$585
Moderate	$797
High	$2,053

Appendix C provides a prioritized listing of technology areas that have potential for insertion in future submarines. In the table above, the Low Investment Level inserts first priority (Category I) technologies, the Moderate Investment Level inserts first and second priority (Category I and II) technologies, and the High Investment Level inserts all of the potential technologies (Category I, II and III). These estimates include $60M/year ($420M over seven years) to increase the core capability to mature and transition technologies from the research and development stage.

Introduction to Appendices

Appendix A to this report provides a definition of submarine mission area requirements as established by the Joint Requirements Oversight Council of the Joint Chiefs of Staff.

Appendix B provides an overview of the New Attack Submarine and a description of the technologies incorporated into the base design of the New Attack Submarine, which will be implemented in the Fiscal Year 1998 ship.

Appendix C provides information regarding emerging technologies that have potential for insertion in the future.

The study included a review of all technology areas identified in section 131 of the National Defense Authorization Act for Fiscal Year 1996, including electric drive, hydrodynamic quieting, ship control automation, solid-state power electronics, wake reduction technologies, superconductor technologies, torpedo defense technologies, advanced control concepts, fuel cell technologies, and propulsors. A review of technologies relating to combat and weapons systems, hull, mechanical, and electrical systems, and command, control, communications and information (C3I) systems, as well as habitability and environmental technologies was also performed. In conducting their assessment, the study participants did not limit themselves to domestic technologies, but also looked at foreign applications of several technology areas.

Recommendations from the Independent Submarine Technology Assessment include:

- Proceed with the New Attack Submarine but commit to continuous evolution;
- Define a single product manager for all attack submarines responsible for acquisition, life cycle support and technology maturation/insertion;
- Establish a significant, stable, continuing R&D program under the product manager that supports and matures major advances, reflects technology base opportunities, and responds to future missions;
- Address the maturation of technologies specifically identified in the report (hydrodynamic program, alternative sail designs, advanced arrays, electric drive, external weapons and active controls and mounts); and
- Ensure that the technology base community understands the performance needs identified by the product manager, involves the shipyards as performers, performs utility analysis before pursuing evolutionary improvements, and has the courage to pursue potentially revolutionary technologies.

Appendix A

Submarine Missions

Appendix A

Submarine Mission Areas, Established by the Joint Chiefs of Staff

Covert Strike Warfare:

Conduct strike warfare (independently or a coordinated strike) in support of a Joint Task Force. This includes the ability to receive targeting data, target a salvo of missiles, and successfully conduct a cruise missile launch within a specified time window.

Antisubmarine Warfare:

Detect, classify, track and localize multiple threat diesel and nuclear submarines with acoustic sensors and destroy, at maximum effective weapons range in all ocean environments.

Covert Intelligence Collection and Surveillance/Covert Indication and Warning, and Electronic Warfare:

Covertly monitor intelligence targets to sense, record, classify and localize electromagnetic, visual, infrared and acoustic data in potentially hostile areas. Be able to communicate this data real time to other units in the Joint Task Force. Be able to augment the nominal installed shipboard equipment for specialized intelligence collection capability.

Antisurface Ship Warfare:

Detect, classify, track through acoustic, electromagnetic and visual means and destroy threat surface forces and interdict the flow of other nations' maritime commerce in order to accomplish national objectives. Be capable of surviving any datum provided to the enemy by the launch of weapons.

Special Warfare:

Covertly deploy, control, coordinate and recover a Special Operations Forces vehicle, surfaced or submerged, with associated equipment, in a crisis region to provide the element of surprise.

Covert Mine Warfare:

Offensive Mine Warfare. Mine planting in threat areas, including littoral areas (e.g., ports, waterways, and/or amphibious operating areas) allowing the submarine to dominate a larger battlespace than would otherwise be possible with a similar naval force.

Defensive Mine Warfare (minefield avoidance/penetration): Maneuver to avoid and safely transit to a designated operational area beyond a minefield. This is an enabling capability that

allows the submarine to perform other missions such as Covert Indications and Warning and Electronic Warfare, Covert Strike Warfare, Special Warfare, and shallow water Antisubmarine Warfare in the littorals.

Battle Group Operations:

Operate in a battle group with sufficient covert connectivity to maximize warfighting effectiveness. Be able to send and receive over-the-horizon targeting information on the tactical network employed by the Joint Task Force. Be fully interoperable on all tactical circuits required with reliability and throughput to be fully integrated into the joint task force.

Battle Space Preparation:

A hallmark of the submarine is its multi-mission capability to prepare the battle space. Unlike any other single asset, its stealth, covert posture and wide variety of missions capabilities enable it to be present before all others. These capabilities include intelligence collection, monitoring of naval and ASW forces, mine laying, mine field mapping, and communications interception. The submarine can covertly insert special forces teams in squads and platoons to conduct a variety of missions and then clandestinely extract them. When directed, the submarine can launch a surprise surgical strike with a salvo of land attack or antiship missiles to suppress communications grids, air defenses and naval forces. The submarine can then monitor and destroy threat submarines as they leave port to intercept other combat and logistic forces.

Appendix B

Overview of the New Attack Submarine Design and Technology Initiatives for the Lead New Attack Submarine

Introduction

Part 1 of this Appendix describes the military capability of the New Attack Submarine. It also describes how affordability is being factored into the design and construction process, and explains how the design approach provides flexibility for future technology insertion.

Part 2 of this Appendix is a matrix which shows the relationship between the submarine mission areas established by the Joint Chiefs of Staff, and each technology initiative incorporated into the lead New Attack Submarine.

Part 3 of this Appendix is a narrative description of each technology initiative, in alphabetical order, incorporated into the lead New Attack Submarine. These initiatives also are included in the matrix in Part 2.

Part 1
Overview of the New Attack Submarine

Military Capability

The Joint Requirements Oversight Council of the Joint Chiefs of Staff determined that a submarine must be able to carry out the following seven specific missions, described in *Appendix A:*

- Covert Strike Warfare
- Antisubmarine Warfare
- Covert Intelligence Collection/Surveillance, Covert Indication and Warning, and Electronic Warfare
- Antisurface Ship Warfare
- Special Warfare
- Covert Mine Warfare
- Battle Group Support

The New Attack Submarine is a highly capable, technologically robust warship, designed to perform the seven missions identified above. The New Attack Submarine is the Navy's first submarine designed to satisfy a broad spectrum of regional and littoral mission requirements while retaining blue-water undersea battlespace dominance. With added emphasis on expeditionary warfare in the littoral environment, it will surpass the warfighting and peacetime performance of any current or projected threat submarine. Compared with previous classes of ships, the New Attack Submarine will have improved electromagnetic stealth, sophisticated surveillance capabilities, and special warfare enhancements. The ship will carry advanced-capability, heavy-weight torpedoes, and all land-attack and anti-ship cruise missiles and mines in the present and planned inventory.

The sonar system will include a bow mounted spherical active/passive array, high-frequency chin and sail arrays, both thin-line and fat-line towed arrays, and a lightweight wide aperture array. The sail will house two new photonics masts for improved imaging functions, an improved electronic support measures mast, and multi-function masts that cover the frequency domain for full-spectrum communications. The design includes extremely high frequency and super-high frequency communications masts as well as accommodations for a special "mission-configurable" mast.

The New Attack Submarine will feature an integral lock-out/lock-in chamber for special operations, and is designed to host vehicles to deliver Navy special warfare forces. The torpedo room design will permit reconfiguration to host special operations personnel and their equipment.

Part 2 of this appendix is a matrix which lists the New Attack Submarine technology initiatives and relates them to the specific mission areas listed above. Part 3 of this appendix

is a narrative description, listed in alphabetical order, of each technology initiative incorporated in the lead New Attack Submarine.

Affordability

With a focus on affordability, the Department of Defense examined available and potentially available technologies for inclusion on the New Attack Submarine to satisfy current and future warfighting requirements. In addition to aggressive incorporation of leading edge technology, the New Attack Submarine capitalizes on previous submarine advances, incorporates commercial off-the-shelf technologies, and introduces simplified, revolutionary design techniques.

The New Attack Submarine Program is applying the lessons learned from other successful government and industry programs. Integrated Product and Process Development (IPPD) teams bring the combined experience of the shipbuilder, major vendors, the Navy Program Office, and submarine operators and maintainers to bear on the ship design. For example, the early involvement of trades personnel is ensuring the design is optimized to shipbuilder construction processes and facilities. This design/build approach will allow a smoother transition from design to manufacturing, and reduce the number of changes typically encountered during lead ship construction.

The enhanced modular construction approach has significant cost advantages; it will facilitate "off-hull" assembly, integration and testing, which can be performed more economically when maximum access is available. The modular approach permits incorporation of mission-specific hull sections into the design and provides a more affordable method of enhancing ship capability in selected warfare areas during new construction.

Flexibility for Technology Insertion

The New Attack Submarine design provides flexibility for affordable insertion of new technology to respond to changing missions, threats, and resources. Innovations such as open systems architecture electronics and the modular isolated deck structure, permit affordable incorporation of new technology as it becomes available.

The submarine design has developed in a state-of-the-art electronic design environment. This permits all members of the integrated teams to work collaboratively from a single design database. Electronic visualization tools provide team members with virtual three-dimensional mock-ups during the design process. These visualization tools allow engineers and designers to affordably and accurately review, assess and incorporate design changes.

The New Attack Submarine Command, Control, Communications, and Intelligence (C3I) system design will employ open systems architecture, and a fiber optic network. This will enable the expanded use of non-developmental items and commercial components for connectivity among the sonar, fire control, navigation, electronic support measures, and

communications systems. Integrated electronic systems with commercial components will allow state-of-the-art technology insertion throughout the lifetime of the class. Consequently, the submarine's electronics design can benefit from the rapid advances being made in the commercial electronics industry.

The Modular Isolated Deck Structure (MIDS) is the innovative design feature which provides the necessary shock and acoustic isolation for commercial grade electronics. MIDS is a key part of the ship's enhanced modular approach. This approach facilitates technology insertion in follow ships of the class since individual modules can be redesigned and constructed without unnecessarily impacting the whole ship's design. The enhanced modular approach will cut construction costs and permit the incorporation of mission-specific hull sections during future new construction. This allows the Navy to more easily and cost-effectively insert new technologies and incorporate improvements to existing components and systems on individual ships throughout it's service life.

Appendix C lists and describes technologies, not included in the lead New Attack Submarine, which have the potential for insertion in follow ships.

Summary

The New Attack Submarine design will yield a cost-effective ship, providing the nation with technologically robust, highly capable, multi-mission submarines which meet 21st Century operational requirements. A submarine which costs significantly less would lack sufficient warfighting performance to counter projected threats, and would lack flexibility to affordably accommodate future technology upgrades. The New Attack Submarine will sustain the nation's ability to design and build advanced nuclear attack submarines and will ensure our margin of superiority in submarine warfare. The New Attack Submarine design balances military performance and affordability, while providing flexibility for future technology insertion.

Part 2
Technology Initiatives for the Lead New Attack Submarine and the Mission Area Each Supports
(in alphabetical order)

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES **	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Advanced Display System								X
Advanced Submarine Tactical Electronic Warfare Support Measures Combat System and Integrated Electronics Mast		X	X					X
Advanced Two Operator Ship Control		X		X	X			X
Air Turbine Pump	X	X		X		X		
Anti-Fouling Coatings								X
Battery Electrolyte Agitation Blower								X

* See Appendix A for the description of each mission area.
** See Appendix B, Part 3, for the description of each technology initiative.
*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/Operability* ***
Brushless Direct Current Motors for Towed Array Handling Systems		X		X				
Doppler Sonar Velocity Log								X
Electromagnetic Silencing System	X	X	X	X	X	X		
Fiber Optic Cable System								X
High Data Rate Communications Antenna	X		X	X			X	X
High Frequency Arrays			X			X		
High Speed Direct Current Ship Service Turbine Generator		X		X				X
High Speed Emergency Diesel Generator								X

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Hovering System Components	X	X		X	X	X		
								X
Hull Penetrators								
Impressed Current Cathodic Protection System								X
								X
Integrated Interior Communications System								
Integrated Low Pressure Oxygen Generating Plant	X	X		X	X	X		X
								X
Isolated Deck Structures	X	X	X	X	X	X		
Lightweight Wide Aperture Array		X	X	X				
Main Propulsion Unit	X	X		X	X	X		
								X
Main Shaft Seal								

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Main Storage Battery and Automatic Battery Monitoring System								X
Main Thrust Bearing	X	X		X	X	X		X
Mechanically Attached Fittings								X
Navigation Sensor System Interface								X
New Design Electric Plant								X
Non-Tactical Data Processing		X	X		X		X	X
Onboard Team Trainer								X
Open Systems Architecture Computer Resources								X
Photonics Mast Imaging		X	X		X		X	X

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Propulsion Plant								X
Propulsion Shaft		X						X
Propulsor	X	X		X	X	X		X
Quiet Electro-Mechanical Actuator	X	X		X	X	X		X
Quiet Non-Ozone Depleting Air Conditioning and Refrigeration								X
Quieted Torpedo Tubes	X	X		X	X	X		
Reconfigurable Weapons Shipping and Handling Module	X	X		X	X	X		X
Reverse Osmosis Desalination Plant	X	X		X	X	X		X
Ring Laser Gyro Navigator	X					X		X

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Single Element Hangers								X
Sonar Signal Processing		X		X		X		
Special Hull Treatment	X	X		X	X	X		X
Structurally Integrated Enclosures								X
Submarine Communications Support System	X	X	X	X	X		X	
Submarine Defensive Warfare System		X		X				
Total Ship Monitoring System	X	X	X	X	X	X		X
Undermatched Welding (Advanced Welding Process)								X

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

SUBMARINE MISSION AREA, DEFINED BY THE JOINT CHIEFS OF STAFF*

TECHNOLOGY INITIATIVES**	*Covert Strike Warfare*	*Anti-Submarine Warfare*	*Covert Surveillance, Indication/ Warning & Electronic Warfare*	*Anti-Surface Ship Warfare*	*Special Warfare*	*Covert Mine Warfare*	*Battle Group Support*	*Affordability/ Operability* ***
Universal Modular Masts								X
Vacuum Sanitary & Quiet Sanitary Blow								X
Variable Speed Secondary Propulsion Motor					X	X		

* See Appendix A for the description of each mission area.

** See Appendix B, Part 3, for the description of each technology initiative.

*** Affordability/Operability is not a mission area, but includes design objectives such as affordability, flexibility, habitability, and environmental compliance.

Part 3
Description of Technology Initiatives for the Lead New Attack Submarine
(in alphabetical order)

Advanced Display System

- The Advanced Display System provides standard commercial off-the-shelf (COTS) hardware and software to meet the New Attack Submarine's Command, Control, Communications, and Intelligence (C^3I) System display and workstation requirements. This Navy-standard Advanced Display Workstation will reduce New Attack Submarine procurement and life cycle costs and help ensure compatibility with Navy-wide computer technology initiatives.

Advanced Submarine Tactical Electronic Support Measures (ESM) Combat System (ASTECS) and Integrated ESM Mast (IEM)

- ESM provides detection, identification, direction finding, and exploitation of radar and communication signals from ships, aircraft, submarines, and land facilities and is used for self-protection, situation awareness, and intelligence gathering for battle group and Joint Task Force support. ASTECS is a new ESM electronics suite, that process and display an expanded range of modern, complex radar and communications radio-frequency signals, as well as laser light detection and ranging (LIDAR) signals. ASTECS and IEM will automatically detect, localize, and identify signals, and warn the combat system of potential threats. ASTECS and IEM are companion programs that will provide improved system performance compared to existing submarine ESM suites.

Advanced Two-Operator Ship Control System

- The Ship Control System is critical to ship safety and precisely maneuvering the ship to perform its missions. The New Attack Submarine Program is incorporating multiple automation technologies to introduce a robust, flexible, affordable, state-of-the-art Ship Control System. The advanced, two operator system will require fewer operators than previous submarines, reduce maintenance requirements, meet demanding safety and performance requirements, and, because it uses "fly by wire" technology, minimize impact on the ship's layout.

Air Turbine Pump

- The quieted MK 20 Air Turbine Pump (ATP) System is a less-expensive weapon launch system, derived from the OHIO (SSBN-726) class MK 19 ATP. However, the New Attack Submarine design has the flexibility to substitute either the reduced-cost Elastomeric Ejection System, currently under development, or the Modified MK 21

SEAWOLF Air Turbine Pump System, should future threats require a greater reduction in weapons launch signature.

Anti-Fouling Coatings

- Non-polluting, biodegradable, environmentally safe anti-fouling coatings will be applied over the submarine's Special Hull Treatment. The new coatings will extend the service life of the underwater hull coating system and reduce maintenance requirements, with minimal environmental impact.

Battery Electrolyte Agitation Blower

- Commercial blower technology is being incorporated into the submarine's Battery Electrolyte Agitation System, used to circulate battery electrolyte. The new, less-costly Battery Agitation Blower will obviate the need for a low-pressure air compressor and associated air distribution system, resulting in cost savings during new-construction and lifetime maintenance of each New Attack Submarine.

Brushless Direct-Current Motors for Towed Array Handling Systems

- An electric motor drive and control system for towed sonar array handling will be installed to reduce the risk of damage to the towed arrays during their deployment and retrieval. This system will eliminate the need for the hydraulics supply and the specially quieted hydraulic motors traditionally used for this purpose, reducing ship acquisition and life-cycle costs.

Doppler Sonar Velocity Log

- The New Attack Submarine will use the Doppler Sonar Velocity Log (DSVL) speed sensing system developed for surface ships. The transducer has been adapted for use at operational depths, and commercial technology has been incorporated into the system design. The DSVL will be more reliable and have lower life cycle costs than the Electromagnetic Log system used on previous submarines.

Electromagnetic Silencing System

- In the past decade, technologies to reduce submarine electromagnetic signatures have advanced significantly. Research efforts from Navy activities and the Advanced Research Projects Agency are being advanced to provide a complementary set of sub-systems which will significantly reduce the New Attack Submarine's electromagnetic signature.

Fiber-Optic Cable System

- The fiber-optic cable system design, adapted from similar systems already installed on Navy ships, is a key component of the New Attack Submarine's internal communications infrastructure. The fiber-optic cable system will provide significant growth potential in signal bandwidth to accommodate future technologies and systems as they become available. Fiber-optic hull penetrators will also be installed to allow optical transmission of data from outboard sensors. Optical signal transmission offers extensive space, weight, and installation cost savings compared to traditional electrical signal transmission media

High Data Rate Communications Antenna

- A Super High Frequency/Extremely High Frequency (SHF/EHF) dual-band high data rate mast-mounted communications antenna will allow real-time receipt of off-board imagery, resulting in dramatic improvements in the received rate of message, data, and voice transmissions. High data rate communications will permit the New Attack Submarine to participate effectively in joint battle group operations.

High-Frequency Array Sonar Suite

- The high-frequency acoustic array suite will complement enhancements to associated processors and displays, enabling the New Attack Submarine to operate in littoral waters with reduced vulnerability to floating, moored, bottom, and near-bottom mines. This suite incorporates the results of research and demonstration conducted in the High Frequency Sonar and the Advanced Mine Detection Sonar programs.

High Speed Direct-Current Ship Service Turbine Generator

- The Ship Service Turbine Generator set being designed for the Direct-Current Ship's Electrical Distribution System incorporates technologies such as advanced solid state power electronics, high speed turbine machinery, and advanced bearings and control systems. In addition to improving ship performance, these enhancements reduce the generator's weight and volume.

High-Speed Emergency Diesel Generator

- The New Attack Submarine's emergency diesel generator incorporates a commercial marine high-speed diesel engine. Modern commercial diesel engines have a lower initial cost and a lower overall life-cycle cost than the specially designed engines used on previous U.S. submarines. Commercial diesel engines are significantly smaller than those used on existing submarines, providing a reduced footprint, saving weight, and improving flexibility in the ship's internal arrangement.

Hovering System Components

- Quiet depth control components designed for SEAWOLF submarines will be re-engineered to meet the New Attack Submarine's rapid ballasting requirements. Valve quieting technologies being developed will satisfy specific ballasting rates and differing acoustic transmission paths. A new hovering recycle pump will minimize high-pressure air use during hovering.

Hull Penetrators

- Pressure hull penetrations capable of transmitting more powerful electrical currents will be installed on the New Attack Submarine. This will reduce the number of penetrations required, resulting in lower fabrication and maintenance costs.

Impressed Current Cathodic Protection System (ICCP)

- This active system will replace traditional zinc-based corrosion control with automated control of galvanic corrosion currents using an extensive array of anodes exterior to the hull and in the ballast tanks. Better "localized" control of corrosion currents will minimize the ship's vulnerability to electric field detection sensors, and will lower the life-cycle maintenance cost for ship components that are susceptible to corrosion. Improved corrosion control also offers the potential for extending the time between ship dry-docking periods.

Integrated Interior Communications System

- This integrated voice, alarm, and announcement system uses commercial technology, including a wire-free communication system, within the ship. This communications system significantly reduces acquisition and life cycle cost savings, while offering enhanced performance.

Integrated Low-Pressure Oxygen Generating Plant and Gas Management System

- This system incorporates lower pressure electrolysis cells than the units installed on existing submarines. The system will improve operation and maintenance safety, eliminate separate high-pressure oxygen storage, and reduce ship manning requirements. The system also reduces cost by integrating components from the oxygen generator and the Gas Management System into a single package. More affordable and lower maintenance control electronics are being used in this system.

Isolated Deck Structures

- Isolated Deck Structures are a new type of deck construction introduced on the New Attack Submarine. The deck structures and associated high-capacity isolation mounts will provide better shock and acoustic protection, allowing commercial off-the-shelf hardware to be used without costly shock hardening modification. These modular structures will allow "off-hull" equipment installation and testing. These structures reduce ship acquisition and life cycle cost.

Light-Weight Wide Aperture Array

- The Light-Weight Wide Aperture Array (LWWAA) sonar improves anti-submarine and anti-surface ship warfare capabilities, improves situational awareness, and supports rapid acoustic contact detection and localization. The LWWAA used on the New Attack Submarine features corrosion resistant materials and improved reliability, and will provide a significant reduction in the weight of outboard components, as well as a life-cycle cost savings. The results of the successful Light Weight Planar Array Advanced Technology Demonstration (ATD) are being used for production design and development of the outboard arrays.

Main Propulsion Unit

- The Main Propulsion Unit consists of two main propulsion steam turbines and the main reduction gear. The unit features the same state-of-the-art technologies as those used in SEAWOLF submarines, but is scaled to the horsepower requirements of the New Attack Submarine. The unit will provide advanced performance, quieting, and reliability, at a lower cost.

Main Shaft Seal

- The Main Shaft Seal will be lighter and less expensive than those used on previous submarines. Two designs are being considered: a design used on SEAWOLF submarines that has been re-engineered and scaled to meet New Attack Submarine performance and acoustic requirements, and a British design used on current Royal Navy submarines

Main Storage Battery and Automatic Battery Monitoring System

- The New Attack Submarine will use the latest high-capacity storage battery technology to increase expected battery life, reduce future life cycle costs, and reduce weight. The associated Automatic Battery Monitoring System is smaller, more automated, and less costly than those used on previous submarines. Fiberglass wedges will replace hand-tailored wooden wedges, reducing the time required to install or remove the battery.

Main Thrust Bearing

- The New Attack Submarine will use re-engineered SEAWOLF submarine advanced bearing technology, resulting in significant quieting enhancements over earlier systems. The Main Thrust Bearing will incorporate new materials for the internal bearing wear surfaces that enhance long-term durability, resulting in lower life-cycle costs..

Mechanically Attached Fittings

- Having passed qualification testing, commercial fittings that do not require welding or brazing will be used to join low-pressure and low-temperature piping systems. This reduces installation times, and eliminates hot work and weld inspections, resulting in significantly lower construction and life-cycle costs

Navigation Sensor System Interface

- The New Attack Submarine C^3I System will use the Navigation Sensor System Interface (NAVSSI) developed for surface ships. NAVSSI distributes time-referenced navigation, provides digital nautical charts, and automated navigation. NAVSSI uses commercial off-the-shelf technology to carry out automated navigation functions. Digital nautical charts eliminate the requirement to carry and update paper charts. Using commercial technology and digital charts provide significant life-cycle cost savings and reduce space and weight requirements.

New-Design Electric Plant

- The new-design electric plant is advancing commercial high-power solid state devices. It will provide improved electrical harmonic isolation and be readily adaptable to a variety of specially conditioned electrical power requirements.

Non-Tactical Data Processing

- The New Attack Submarine will feature a commercial off-the-shelf-based hardware and software network for non-tactical shipboard administrative data processing applications. The network is a key element of the "paperless ship" concept for the New Attack Submarine, and will substantially reduce the amount of paper and number of operating manuals onboard each ship. Open System Architecture standards and protocols are being used to provide flexibility to accommodate future technological upgrades.

Onboard Team Trainer

- A commercial off-the-shelf-based Onboard Team Trainer (OBTT) processor will be an important part of the New Attack Submarine C^3I System. The OBTT processor will allow for use of onboard resources to satisfy team training requirements, thereby minimizing costly and time-consuming shore-based crew training assignments.

Open System Architecture Computer Resources and Commercial Off-the-Shelf Hardware and Software

- An Open System Architecture (OSA), compatible with existing and projected commercial off-the-shelf (COTS) hardware and software is an integral part of the New Attack Submarine C^3I System design. The New Attack Submarine will feature a modern information management system that links functional subsystems over a scaleable, modular, low latency, high data rate network. The OSA permits compatibility with emerging commercial technologies, and will provide flexibility for affordable and adaptable solutions to meet current and future mission performance requirements. The *Non-Tactical Data Processing System, Onboard Team Trainer, Navigation Sensor System Interface, Advanced Display, Sonar Signal Processing systems,* and the *Fiber-Optic Cable Subsystem* all use COTS-based products.

Photonics Mast (Non-Penetrating) and Imaging

- The Photonics Mast is a non-hull penetrating, multi-sensor replacement periscope that will provide advanced all-weather visual and infrared imaging capabilities. Based on the latest commercial color and high-resolution black-and-white camera technology, the system will incorporate data collection and image enhancement techniques that will improve target identification and classification capabilities. Sensors include:

    1. Infrared (IR) imaging, based on a new-technology 3-5 micron, high resolution (640x480 pixel) staring array detector.
    2. UHF antennas for communications
    3. Radar and communications intercept
    4. Radio frequency navigation, such as the Global Positioning System (GPS)
    5. Marine band transceiver support.
    6. Laser range-finding

- Sensors are mounted on non-penetrating masts, which allow unprecedented ship design flexibility. For example, the sail can be positioned where it can best benefit the ship hydrodynamically and hydroacoustically. In addition, elimination of inboard periscope wells provides significant volumetric savings and internal arrangement flexibility.

Propulsion Plant

- The new propulsion plant is smaller and simpler than any recent U.S. submarine reactor, but has a greater energy density. Moreover, it is the first propulsion plant designed for a life-of-the-ship reactor core, which will obviate the need for a mid-life refueling, saving hundreds of millions of dollars in refueling and waste disposal costs for each New Attack Submarine.

Propulsion Shaft

- The propulsion shaft will be re-engineered to use the latest material technology for metal alloys, resulting in greater long-term corrosion resistance

Propulsor

- The propulsor is a key ship acoustic signature driver, particularly when the ship is traveling at higher speeds. The New Attack Submarine propulsor builds on advances from the Defense Advanced Research Projects Agency (DARPA) and incorporates hydroacoustics research performed by the Office of Naval Research (ONR). The New Attack Submarine will feature a quieter, more affordable propulsor based on a more producible design, reducing material and machining costs.

Quiet Electro-Mechanical Actuator (EMA)

- An electro-mechanical weapons cradle lock actuation system which meets the noise and safety goals for operation of the weapons stowing and handling system will be installed on the New Attack Submarine. The EMA will reduce the ship's cost and weight by replacing high pressure, quieted hydraulic actuators and associated hydraulic piping with quieted electrically controlled and powered EMAs derived from those used extensively in modern aircraft.

Quiet Non-Ozone Depleting Air Conditioning and Refrigeration

- Quiet, environmentally safe HFC-134a air conditioning units and refrigeration plants will be installed on the New Attack Submarine. The new air conditioning and refrigeration system will comply with the 1990 Montreal Protocol and other environmental regulations, and will use commercial technology.

Quieted Torpedo Tubes

- The New Attack Submarine's 21-inch diameter torpedo tubes and firing system are derived from SEAWOLF's 30-inch, large bore tube design and will include re-engineered quieting and shock survivability technologies. The new tubes will be less expensive and easier to install than those used on previous submarines.

Reconfigurable Weapons Shipping and Handling Module

- The weapon stowage and handling system on the New Attack Submarine will be completely reconfigurable, providing a large, open, easily rearranged space to carry a variety of weapons and support non-traditional missions such as hosting Special Operations forces or Unmanned Undersea Vehicles (UUVs). This reconfigurable module, unique to the New Attack Submarine, is a key feature of the ship's mission-flexible design.

Reverse Osmosis Desalination Plant

- The New Attack Submarine will use a reverse osmosis desalination plant, rather than steam-powered distillers used by current submarines. Commercial technology will be adapted to produce high-purity water while providing for quiet operations at varying seawater supply pressures. This system reduces the amount of auxiliary steam required by the ship, and costs significantly less to acquire and maintain than the steam-powered distillers used on previous submarines.

Ring Laser Gyro Navigator

- The inertial navigation system which will be used on the New Attack Submarine is a modified version of the Ring Laser Gyro Navigator (RLGN) developed and used by NATO navies. The RLGN offers significant life cycle cost reduction and reliability improvements compared to the Electrically Suspended Gyro Navigator (ESGN) system used in current submarines.

Single Element Hangers

- Single Element Hangers are resilient hanger assemblies for piping isolation which incorporate advances in materials technologies and in the reduction of acoustic energy propagation. Pipe hanger components used on current submarines constrain the design of the ship's internal arrangement and are expensive to install. The new Single Element Hangers reduce volume requirements and provide more effective assemblies, resulting in both weight and cost savings.

Sonar Signal Processing

- A multi-purpose processor will use commercial computing hardware and software for sonar subsystem applications. The New Attack Submarine will perform sonar signal processing functions, previous performed by military-specification based systems, using commercial off-the-shelf hardware and software. This will result in significant performance improvements, acquisition cost savings, and arrangement flexibility than in previous submarines

Special Hull Treatment

- Special hull treatments help improve submarine quieting and reduce susceptibility to active sonar detection. The New Attack Submarine takes advantage of advances made in the SEAWOLF class special hull treatment, and will use an improved industrialized Mold-In-Place (MIP) installation process that will significantly reduce installation time and cost. The new Special Hull Treatment is complemented by the development of new, environmentally friendly Anti-Fouling Treatments (described above).

Structurally Integrated Enclosures (SIEs)

- The majority of the New Attack Submarine's C^3I System will be housed in Structurally Integrated Enclosures. The SIEs reduce overall C^3I System space and weight requirements, minimize and simplify the number of platform-to-C^3I System interfaces, and provide a recurring cost savings. SIEs will improve access to electronic chassis and drawers, allowing easy replacement of circuit card assemblies. SIEs will permit the easy modernization of electronics, while the submarine is operational, avoiding the need for lengthy industrial availabilities.

Submarine Communications Support System

- The Submarine Communications Support System will provide exterior communications system processing and display equipment, required for secure and non-secure voice, video, imagery, and narrative record messages. This system will provide the New Attack Submarine with full interoperability with joint warfare forces of the future.

Submarine Defensive Warfare System (SDWS) and Countermeasure Launch Control

- SDWS detects and localizes incoming weapons and controls the launch of countermeasures to neutralize threat weapons. This system will provide earlier warning and greater self-protection against current and projected threats.

Total Ship Monitoring System (TSMS)

- The TSMS monitors the ship's acoustic signature and supports localization of acoustic anomalies. TSMS also provides the data processing capabilities for condition-based monitoring of the ship's machinery to enhance maintenance of its quiet running condition. This system will provide extensive noise monitoring of hull, deck structure, and machinery to improve acoustic stealth performance of the New Attack Submarine. The system will incorporate commercial-based processors and displays and uses the ship's Fiber-Optic Cable System (discussed above) for signal transmission.

Undermatched Welding (Advanced Welding Processes)

- Undermatched welding is a new welding technique that results in high-strength joints for less cost than traditional methods and materials. The process yields significant recurring cost savings by reducing the lengthy preheating time and eliminating the post-weld soaks previously required for welding high yield steels used in the ship's hull and major structures.

Universal Modular Masts

- The New Attack Submarine's mast-mounted electronic sensors and antennas will be housed in a common-design mast cell that will provide a standard mechanical interface to the ship and to the sensors. This permits parts standardization and reduces installation and life-cycle costs. The modular mast permits the sensor suite to be tailored for special missions, and is flexible to accommodate future sensor designs..

Vacuum Sanitary and Quiet Sanitary Blow

- The New Attack Submarine will be the first submarine to have a Vacuum Collection, Holding, and Transfer System for waste disposal. The new system replaces the old water gravity drain system with technologies originally developed by the Navy for surface ships. This new design reduces water use and cuts holding tank volume requirements; simplifies pipe design and layout; improves ship arrangements flexibility; and reduces total ship acquisition and life-cycle cost.

Variable Speed Secondary Propulsion Motor

- Precision slow-speed maneuvering is critical for special warfare missions. The New Attack Submarine Program is adapting the SEAWOLF Secondary Propulsion Motor in conjunction with a variable frequency motor controller to permit variable speed operation.

Appendix C

Emerging Technologies which have Potential for Future Insertion

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This appendix consists of a table of emerging submarine technologies grouped by technical areas with estimates of Research and Development (R&D) costs, risk, and Ship Conversion, Navy (SCN) cost impact, followed by a brief written description of the specific technologies. The table includes the full range of technologies that could be inserted into the New Attack Submarine that are currently unfunded as well as technologies identified as part of the recent Navy review of submarine technologies.

The table headings are defined below:

Column 1, Cat (Category)-This column lists the priority of the technology based on a high level consideration of submarine military needs. Category I (first priority) consists of those technologies which will increase the margin of submarine acoustic superiority. Category II (second priority) lists those technologies which are expected to provide improved submarine affordability or producibility. Category III (third priority) are those technologies which could provide enhanced performance or new capabilities over the baseline design.

Column 2, Technical Areas/Technology Listing-This column lists the emerging technologies considered, grouped by technical areas. Specific descriptions of these technologies follow the table.

Column 3, Missions-This column identifies the submarine mission areas applicable to each technical area. A definition of each mission area is provided in Appendix A.

Column 4, Maturity-This column provides an estimate of the time required to develop each technology for installation. For each technology, an "x" is placed in the column(s) corresponding to the Fiscal Year the technology can be considered for installation.. These estimated dates assume that the R&D funding in column 5 and a core investment increase of $60M per year are both provided.

Column 5, R&D Total Cost-This column provides an estimate of the total Fiscal Year 1997 and POM 98 R&D funding (above current controls) required to mature technologies in each technical area for installation. This total takes into account technology development that is currently funded in the Navy and the Defense Advanced Research Project Agency (DARPA) and assumes that this funding will continue at planned levels. Note that technologies targeted for Fiscal Year 2002 and beyond may require additional R&D funding after Fiscal Year 2003.

Column 6, SCN Cost Impact-This column estimates the ship construction cost impact of each technology if it were to be installed on the New Attack Submarine. "L" indicates low impact (less than $10 million), "M" indicates moderate impact ($10 million to $100 million), and "H" indicates high impact (greater than $100 million). Note that there are two types of SCN costs to be considered, the non-recurring (costs associated with installation of the technology in the first ship), and recurring ship costs (costs associated with installation of the technology on each subsequent ship).

Column 7, R&D Risk-This column indicates the estimated level of risk to develop each technology for insertion in the earliest hull in Column 4. ("L" - Low, "M" - Moderate, "H" - High).

Column 8, Acceleration Risk-This column indicates the estimated risk associated with accelerating each technology to insert it on an earlier hull. (Note that any funds necessary to achieve such an acceleration have not been determined).

Emerging Technologies with Potential for Future Submarine Insertion

Cat	Technology Areas/Listing	Missions	Maturity Year					Estimated R&D Total Cost ($M)	SCN Cost Impact	R&D Risk	Accel Risk
			FY98	FY99	FY00	FY01	FY02				
I	Advanced Passive Sonar Processing	ASW,ASUW, BG, I&W						$58			
	Passive Ranging/TMA		X	X	X	X	X		L	L	N/A
	Large Aperture Processing		X	X	X	X	X		L	L	N/A
	Matched Environmental Processing				X	X	X		L	M	M
	TSMS Improvements		X	X	X	X	X		L	L	N/A
I	Advanced Acoustic Sensors	ASW,ASUW, BG,I&W						$107			
	Near Term MLTA		X	X	X	X	X		L	L	N/A
	High Gain MLTA						X		M	H	H
	LWAA Fiber Optics				X	X	X		L	M	H
	High Gain Hull Array						X		H	H	H
II	Affordability & Maintainability	ALL						$212			
	EMA/EHA						X		M	L	M
	Welding				X	X	X		L	L	M
	Power Electronics						X		M	H	H
	Advanced Propulsor Fabrication						X		L	M	H
	Advanced Hybrid Propulsor				X	X	X		L	M	H
	Advanced Coatings			X	X	X	X		M	M	H
	Rim Driven Motors						X		M	L	M
	Elastomeric Ejection System (EES)				X	X	X		M	M	H
III	Advanced Hydro & Maneuver Control	MIN,SOF,I&W						$87			
	Advanced Sail						X		M	M	H
	Advanced Control Surfaces						X		M	M	M
	Low Speed Maneuvering			X	X	X	X		L	M	H
III	Advanced Combat Systems	ALL						$80			
	Data Fusion		X	X	X	X	X		L	L	N/A
	Advanced Command & Control Workstation			X	X	X	X		L	L	M
	Situational Awareness		X	X	X	X	X		L	L	N/A
	Advanced TDAs (ISSIPS)		X	X	X	X	X		L	L	N/A
	Advanced Covert Navigation					X	X		M	M	H
	Advanced Tactical Scene Generation (TSOA)					X	X		M	H	H
III	Self-Defense	ALL						$221			
	Anti-Torpedo Torpedo						X		L	H	H
	Electro-Fiber Optic Guided (EFOG) Missile						X		L	M	H
	Exposed Mast Detectability						X		M	M	H

Emerging Technologies with Potential for Future Submarine Insertion

Cat	Technology Areas/Listing	Missions	Maturity Year					Estimated R&D Total Cost ($M)	SCN Cost Impact	R&D Risk	Accel Risk
			FY98	FY99	FY00	FY01	FY02				
	LIDAR Intercept Receiver				X	X	X		L	L	M
	Accelerate EM Silencing (Closed loop)		X	X	X	X	X		L	L	N/A
	Advanced Electromagnetic Silencing				X	X	X		L	M	H
	Advanced CM Launchers						X		M	M	H
	Impv. Int'l CM Launchers				X	X	X		L	L	M
	Improved Countermeasures						X		L	H	H
III	Advanced Communications	ALL						$76			
	Subsurface Antennas						X		L	M	H
	Acoustic Communications						X		L	H	H
	Hullborne ELF Antenna						X		L	L	M
	Global Broadcast Service						X		L	L	H
III	Advanced Propulsors	ALL						$100			
							X		H	H	H
III	Structural Acoustics	ALL						$230			
	Integrated Deck Structures						X		H	M	H
	Advanced Mounting				X	X	X		L	M	H
	Active Control				X	X	X		L	L	M
	Advanced VR (AVR &Passive VR)					X	X		M	M	H
	Active Control						X		H	H	H
III	Wake Detection	ASW						$60			
	Wake Detectors						X		M	H	H
III	Advanced Weapons	ASW,ASUW, BG,STW,MIN						$516			
	Half-Length Torpedo						X		L	M	H
	Dual Warhead Mine						X		L	M	H
	Advanced Wide Area Submarine Mine						X		L	M	H
	Tomahawk Upgrades-TBIP		X	X	X	X	X		L	L	N/A
	Advanced Strike Weapons						X		H	M	H
III	Off Board Sensors	I&W,STW, MIN,BG,SOF						$120			
	Advanced UUV						X		L	M	H
	UAV Command, Control & Communications		X	X	X	X	X		L	L	N/A
	Submarine Launched UAV						X		M	L	M

Emerging Technologies with Potential for Future Submarine Insertion

Cat	Technology Areas/Listing	Missions	Maturity Year					Estimated R&D Total Cost ($M)	SCN Cost Impact	R&D Risk	Accel Risk
			FY98	FY99	FY00	FY01	FY02				
III	Advanced Active Sonar	ASW,ASUW, BG,MIN						$68			
	Deployable Bi-Static Source						X		L	M	H
	Bi-Static Signal Processing		X	X	X	X	X		L	L	N/A
	MF Processing Improvements		X	X	X	X	X		L	L	N/A
III	Advanced Electronic Warfare	I&W,BG, STRIKE,ASUW						$48			
	New Threat Signal Measurement		X	X	X	X	X		L	M	N/A
	Non-Acoustic Sensors (Bi-static Radar, Air Acoustics)				X	X	X		L	M	M
	Advanced Photonics				X	X	X		L	L	M
	Advanced ESM				X	X	X		L	M	H
III	HF Sonar	ASW,MIN, SOF,BG						$40			
	Advanced Mine Detection Processing		X	X	X	X	X		L	L	N/A
	Weapons & Shipboard Sonar Interoperability				X	X	X		L	M	H
	Advanced HF Receiver						X		H	H	H
	HF Image Processing		X	X	X	X	X		L	L	N/A
III	Mission Specific Hull	STW,MIN,SOF						$30			
	Sections Feasibility & Concept Designs						X		L	L	L
							Total	$2,053			

Technical Areas/Technology Listing

Advanced Passive Sonar Processing

- Passive Ranging/TMA-Develops integrated passive localization algorithms and incorporates them directly in processing software. Allows rapid and accurate range estimation as a natural part of passive sonar processing.

- Large Aperture Processing-Applies advanced beamforming and detection techniques to large aperture arrays (TB-29 and WAA). Includes integration and use of large Commercial Off-the-Shelf (COTS) parallel processing capability to support required throughput and I/O loads.

- Matched Environmental Processing-Implements improved passive processing based on environmentally realistic predicted signal propagation rather than idealized single plane waves. Exploits vertical aperture to provide improved sensor discrimination in range and depth.

- TSMS Improvements-Expands capability of existing Total Ship Monitoring System (TSMS) by extending frequency coverage of sensors and improvements to the supporting processing. Includes direct estimation of own ship composite acoustic vulnerability in real time.

Advanced Acoustic Sensors

- Near Term MLTA-Develops small Multi-Line Towed Array (MLTA) to replace the TB-16 array. Provides improved performance and operability in shallow water littoral environments. New array designed to operate within envelope of existing flushing tube and TB-16 handling system.

- High Gain MLTA-Develops large, high gain Multi-Line Towed Array (MLTA) to improved detection performance over TB-29. Includes modified handling system design capable of supporting MLTA and incorporation of fiber optic sensing technology to maintain array affordability. Array of choice for supporting matched environmental processing approaches described above.

- LWAA Fiber Optics-Completes the production improvement to the lightweight, fiber-optic based wet end replacement for WAA. Revised design reduces array weight, complexity and cost while maintaining current WAA system performance.

- High Gain Hull Array-Develops "smart skin" conformal acoustic array based on CAVES (Conformal Array of Velocity Element Sensors) technology. Single hull array design integrated directly into planned hull coatings would provide significant cost, performance and design flexibility improvements over existing sphere and WAA wet end designs.

Affordability & Maintainability

- Electrohydraulic/Electromechanical Actuators-Development of actuation mechanisms that replace hydraulic fluid with electric machines. This will result in reduced size and complexity of the hydraulic plant and potential weight savings.

- Welding-Development of material systems and procedures to eliminate high cost fabrication constraints imposed upon submarine pressure hull and structures. This includes HSLA-80 and HSLA-100 steels for pressure hull, development of low carbon bianetec welding consumables, electrodes that allow high quality welding with less defects and elimination of sensitive pre-heating in the joining process

- Power Electronics-Development of next generation solid state power converter technologies to maximize power density and minimize related acoustic signature while reducing cost. Power circuit technologies which support increased performance at reduced cost will be identified and limited scale demonstrations will be performed.

- Advanced Propulsor Fabrication-Development of methods to reduce the fabrication cost of propulsors. The program will explore techniques which include superplastically formed diffusion bonded titanium blades for weight reduction and treatment enhancement, the use of leachable core casting and injecting treatments, and low cost polyurethane encapsulation/cast coating of propulsor blades in lieu of high cost, numerically controlled machining of high tolerance blades.

- Advanced Hybrid Propulsor-Development of a low cost alternate to compound propulsors that will lead to reduced weight and cost (fabrication and maintenance) with improved acoustic signature and propulsion performance.

- Advanced Coatings-Development of ships coating systems with improved target strength properties, reduced impact upon ship systems, and reduced installation costs.

- Rim Driven Motors-Development of motors using permanent magnet technologies that will enhance acoustic stealth, survivability, and readiness. The technology will be demonstrated in a shaftless pump, which has the motor windings contained in the pump housing with the impellers functioning as rim-drive rotors. The benefit is improved maintainability due to a simplified pipe loop and elimination of rotating mechanical seals.

- Elastomeric Ejection System-This system replaces the weapon ejection turbine pump with an elastomeric bladder. The system launches a weapon by releasing energy stored in an elastomeric bladder. The EES will be less complex and costly than a turbine pump and will substantially reduce weapon launch acoustic transients.

Advanced Hydro & Maneuvering Control

- Advanced Sail-Development of advanced hydrodynamic shaped sail that would support high speed maneuvering and improved acoustic and non-acoustic stealth. The program will assess advanced materials such as composites that would have acoustic absorber materials, Radar Absorbing Material, and sensors embedded into the material system.

- Advanced Control Surfaces-Development of control surfaces to support missions requiring station keeping or low speed maneuvering and increased responsiveness during high speed operations. The program will explore technologies that integrate stealth technologies and reduce ships hydraulic plant requirements. The goal is to reduce the size of the hydraulic plant resulting in smaller, faster ships. These technologies include articulated control surfaces, which consist of a flexible skin over an articulated robotic control structure, and composites that will incorporate acoustic absorbing materials, RAM, and sensors into the material system.

- Low Speed Maneuvering-Development and validation of hydrodynamic analytical codes to support all missions requiring station keeping or low speed maneuvering.

Advanced Combat Systems

- Data Fusion-Collection, integration and formatting of contact data from multiple sensors in a single composite set of displays. Improves ability to make timely accurate decisions in stressful tactical situations. Implemented as software capability on standard COTS workstation hardware (TAC-X).

- Advanced Command & Control Workstation-Use of emergent flat panel technology to improve the display of integrated combat control information. Implemented with ruggedized COTS display capabilities and supporting display software. Situational Awareness: Sensor, data base and processing technology to detect and identify enemy, friendly and neutral assets (planes, helicopters, small patrol craft, ships and submarines). This effort would be a transition of SSN Security Programs efforts.

- Situational Awareness-Sensor, data base and processing technology to detect and identify enemy, friendly and neutral assets (planes, helicopters, small patrol craft, ships and submarines). This effort would be a transition of SSN Security Program efforts.

- Advanced Tactical Decision Aids (TDAs)-Information and processing technologies to create a vulnerability assessment, what if scenarios and route planning based on the fusion of all available information including data bases, own ships sensors, data from other DOD assets and information derived from situational awareness sensors and tactical scene generation technologies. This effort would transition from DARPAs Integrated Submarine Stealth Information Processing System (ISSIPS) Program.

- Advanced Covert Navigation-This area addresses the development of a gravity navigation system that can accurately measure depth and estimate terrain variations around a submarine.

This is an enhancement of gravity measurement systems currently on Trident submarines including miniaturization of mechanical components.

- Advanced Tactical Scene Generation-Information processing and display technologies which utilize situational awareness sensors and processing to provide a Commanding Officer with a tactical scene which includes enemy, friendly and neutral target positions, speed and bearing. The effort also reduces the number of operators required to process incoming tactical data thereby reducing the life cycle cost of submarines. This effort would be a transition of the Defense Advanced Research Projects Agency's (DARPA) Tactical Scene Operator Associate (TSOA) Program.

Self Defense

- Anti-Torpedo Torpedo-Six inch diameter very high speed, very maneuverable vehicle with warhead and homing capabilities designed to track, target and kill incoming torpedoes as a final defensive measure in the close-in region surrounding a submarine. Weapon might also be used against small enemy patrol craft and mine layers. The effort would transition technologies being demonstrated in an ongoing Navy Advanced Technology Demonstration (ATD).

- Enhanced Fiber Optically Guided (EFOG) Missile-Submarine application of the Army EFOG missile to provide defensive capabilities for submarines operating in the littoral against small patrol craft, helicopters and planes as well as an offensive capability against tactically significant targets. Effort takes advantage of the Army program and does not build a new missile but looks to resolve issues surrounding the launch, and command and control of the missile from a submarine.

- Exposed Mast Detectability-Technologies to reduce the radar cross section, visual, and infrared signatures of exposed masts as well as the hydrodynamic wake of the mast. Technology application would allow for increased use of communication and electronic intercept receiving equipment in a littoral environment. Effort has been proposed to DARPA.

- LIDAR Intercept Receiver-Receiver to detect enemy Laser Detection and Ranging (LIDAR) transmissions to alert a Commanding Officer that a possible enemy asset is in the area and using LIDAR technologies for Anti Submarine Warfare (ASW) purposes. This technology deals with an emerging LIDAR ASW threat stemming from the development and sale of Canadian and Swedish LIDAR bathemetry and ASW systems.

- Accelerate EM Silencing (Closed Loop)-Enhancement over current open loop, non-feedback electromagnetic (EM) silencing systems via closed loop systems. With the new system, EM feedback sensors at various locations along the ships hull are tied to processing equipment to monitor and continually keep at a reduced level, the ships EM signature.

- Advanced Electromagnetic Silencing-Effort which builds upon closed loop silencing efforts to further reduce EM signatures via advanced degaussing techniques and damping systems.

- Advanced Counter Measure (CM) launchers-New, quiet external CM launcher system which ameliorates the need for noisy gas generation launch devices. The system utilizes technology developed by the Elastomeric Ejection System Program in which a bladder is filled with liquid and the liquid at high pressure is discharged to push a CM device out of the tube.

- Improved Internal Counter Measure Launchers-Technology which builds upon the Advanced Counter Measure Launcher System effort previously described and applies that technology to internal CM launch tubes.

- Improved Countermeasures (CMs)-New mobile CM devices which more fully produce the acoustic and magnetic signatures of own ship to defeat enemy torpedoes.

Advanced Communications:

- Subsurface Antennas-Fiber optic buoyant cable antenna (FO-BCA) which allows the submarine to communicate at both low and high frequencies (with other naval assets), and receive Global Positioning System (GPS) location data updates while the submarine is at speed and depth.

- Acoustic Communications-Provides modem level acoustic communications capability (2-10 kbps) at tactically significant ranges for moving platforms. Integrated into existing active sonar designs as an add-on processing capability.

- Hullborne ELF Antenna-Extremely Low Frequency (ELF) antenna which is placed just aft of the sonar sphere array in the wet area inside the hull. The system provides the ship with the ability to communicate at extremely low frequencies without the need to deploy a buoyant cable antenna and move in a specific direction, often away from the battle group. The system does not address the need for HF communications.

- Global Broadcast Service (GBS)-Current submarine communication systems are limited in data rate due by the size of an antenna aperture which can be placed inside a mast radome. The new GBS system will ameliorate much of the aperture problem by providing stronger spotlight beam transmissions covering much of the earth s surface. The technology envisioned here would allow the submarine to receive and deal with these very high data rates via a very compact communications support system in the radio room.

Advanced Propulsors

- Advanced Propulsors-Development of an advanced propulsor system that incorporates external electric drive motor fully integrated with impellers functioning as a rim-driven motor, advanced control surfaces, power electronics and ship control system.

Structural Acoustics

- Integrated Deck Structures-Development of design technologies and methods that increase shock and acoustic isolation performance by optimizing internal structural designs and mounting arrangements. Increases affordability by reducing the shock hardening requirements for all equipment and maximizes off-hull construction, outfitting and testing.

- Advanced Mounting-Development of alternate mounting system technologies such as active isolation, highly damped materials, advanced truss structures including DARPA sponsored cradle efforts and air cushioning for acoustic isolation of deck systems. These would be form, fit, function replacement for passive mounts with the goal of reduced size and weight.

- Active Control (Project F)-Project is classified.

- Advanced Vibration Reducers (AVR and Passive VR)-The Advanced Vibration Reducer (AVR) program develops vibration reduction techniques for submarine quieting. Serves as insurance policy in meeting the NEW SSN noise goals in the event that the specified NEW SSN propulsor design quieting goals are not meet. The Passive Vibration Reducer (PVR) will potentially reduce the acoustic signature for reduced fabrication cost and with reduced size and weight.

- Active Control (Project M)-Project is classified.

Wake Detection

- Wake Detectors-This technical area addresses non-acoustic hydrodynamic sensors that can be used to detect submarine wakes. It includes the development of advanced acoustic or optical sensors that can detect wakes with large vertical stand-off from the depth of the submarine creating the wake.

Advanced Weapons

- Half Length Torpedo-System developed would augment the current torpedo inventory and would provide a limited number of weapons which are physically one half the length of the current torpedo. The weapon developed would increase loadout by providing two weapons per rack where there was once one and improve firepower of ships carrying other tube launched devices (UUV, Mines, etc).

- Dual Warhead Mine-Technology consisting of utilizing the large inventory of MK48 torpedo afterbodies and placing two warheads in a new weapon. The mine would be covertly launched from the submarine and deploy two warheads at two different locations. The technology would double the current mine warhead loadout on submarines and ameliorate obsolescence issues with current submarine launched mobile mines.

- Advanced Wide Area Submarine Mine-A new mobile mine with significantly greater detection and kill range to allow a submarine to mine a much larger area with available stowage space.

The device would be launched from a submarine, deploy and then sit in the middle of a very large sensor array and await an enemy detection.

- TOMAHAWK Upgrades (TBIP)-Technology is being pursued to add GPS capability and infrared targeting images to tomahawk cruise missiles to improve the missiles probability of kill and reduce collateral damage. This effort would provide for that capability by installing the appropriate data handlers and communications support equipment onboard submarines.

- Advanced Strike Weapons-This effort would provide ship modifications to deploy the Army ATACM missile or the Navy s standard missile from submarines.

Offboard Sensors

- Advanced Unmanned Undersea Vehicles (UUVs)-UUVs are being developed by the Navy for deployment from submarines to conduct covert mine reconnaissance. This effort would transition technologies being developed by the Office of Naval Research and DARPA to increase the vehicles endurance, search swath, communications capability, stealth and navigational accuracy to provide for a more robust mine reconnaissance capability.

- Unmanned Aerial Vehicle (UAV) Command, Control and Communications-A demonstration of the C3 by a submarine with a UAV to support special operations forces is scheduled for this summer. This effort would provide for the miniaturization of the equipment presently housed in the torpedo room such that it could be placed in the communications center and would add capability to down link video and synthetic aperture radar data as well as provide for secure transmissions between the submarine and UAV.

- Submarine Launched UAV-This effort would provide the submarine with its own expendable, cheap UAV to be launched from the submarine. The UAV would be housed in a canister and launched from a torpedo tube. It would possess all the sensor capabilities of current UAVs but would be limited in endurance due to its size.

Advanced Active Sonar

- Deployable Bistatic Source-Provides a long endurance off-board active source that can be deployed through the torpedo tube. Allows submarine exploitation of bistatic active sonar capabilities without requiring availability of supporting source platform.

- Bistatic Signal Processing-Provides adjunct capability for existing and planned passive sonar arrays to detect, classify and localize targets through exploitation of offboard acoustic sources. Implemented as an add-on processing capability to planned COTS-based passive processing system.

- MF Processing Improvements-Improves performance of existing mid-frequency active sonar through application of advanced processing techniques developed in the surface ship

community to submarines. Enhanced processing with integrated autodetect and classify algorithms implemented in COTS processing hardware.

Advanced Electronic Warfare

- New Threat Signal Measurement-Includes sensor and processing technologies to expand the bandwidth of third party signals which can be collected, the utilization of full spectrum processing techniques vice the processing of only certain narrow band signals as is done today, and the application of advanced processing techniques to intercept and decode LPI signals.

- Non-Acoustic Sensors-Technologies that include bi-static radar receivers, in-air acoustic receivers, and LIDAR receivers. These sensors support situational awareness efforts and provide the necessary detection data to determine if enemy, neutral or field platforms are present.

- Advanced Photonics-Includes technologies to upgrade and automate the Photonics capabilities demonstrated previously including the automatic digitization, compression, transmission, receipt, storage and retrieval of photographic information.

- Advanced ESM-Combines efforts to measure threat signals such as RADAR and LIDAR, communications interceptions, acoustics from all sources, for close in defense and IFF. the technology envisioned would involve the use of phased array antenna technology being developed under Navy ATD funds in addition to DARPA efforts.

HF Sonar-Provides improved high resolution active sonar capabilities to support enhanced mine avoidance, restricted water navigation and near ship battle space dominance.

- Advanced Mine Detection Processing-Enhances performance of current mine avoidance sonars through improved autodetection and classification, improved beamforming, and nulling of boundary returns. Implemented as software upgrades to existing high frequency sonars.

- Weapons and Shipboard Sonar Interoperability-Enhances weapon attack capabilities by allowing joint operation and data exchange between weapon sonars and shipboard sonars operating in the same frequency range. Provides capability to link weapon sonar acoustic data back to ship.

- Advanced HF Receiver-Integrates selected HF receive apertures into a CAVES technology conformal hull array. Improves HF wet end affordability and design flexibility while simultaneously allowing coverage of all azimuths around the ship.

- HF Image Processing-Develops processing techniques to allow display of high resolution HF sonar data directly as a visual image for the operator. Intended to improve the transfer of information to the warfighter during.

Mission Specific Hull R&D support required to evaluate mission specific hull packages. Possible mission specific packages include, strategic missile section, special operating forces, and tactical strike missiles.