FY 2001 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2000

Budget Activity: 2

PROGRAM ELEMENT: 0602314N
PROGRAM ELEMENT TITLE: Undersea Warfare Surveillance Technology

(U) COST: (Dollars in Thousands)

PROJECT NUMBER & TITLE	FY 1999 ACTUAL	FY 2000 ESTIMATE	FY 2001 ESTIMATE	FY 2002 ESTIMATE	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	TO ESTIMATE	TOTAL COMPLETE	PROGRAM
Undersea Warfare Surveillance Technology	46,143	51,123	52,488	53,978	52,801	52,733	51,896	CONT.	CONT.	

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: All of the Navy's applied research in undersea target detection, classification, localization, and tracking is funded through this Program Element (PE). In countering the troubling proliferation of quiet diesel submarines to third world countries and Russia's continued investment in submarine technology, work within this PE provides an enabling capability for power projection and force sustainability. Associated research directly supports the Department of Defense Joint Warfighting Science and Technology Plan and the Defense Technology Area Plans. Within the Navy the effort supports the following Navy Joint Mission Areas (JMAs): Littoral Warfare; Intelligence, Surveillance, and Reconnaissance; and Strategic Mobility. The approach protects the country's capital investment in submarine, surface ship and Air Antisubmarine Warfare (ASW) assets both by developing commercial off-the-shelf (COTS) upgrade options for today's ASW suites and by exploring those high risk/high payoff technologies that promise to provide capabilities of exceptionally high military value in five to fifteen years.

(U) Intelligence, Surveillance, and Reconnaissance includes research and technology issues associated with reliable undersea target detection and tracking to enable on-command application of precision offensive military force. Programs include undersea sensors and arrays to provide robust shallow water surveillance and reconnaissance, and to detect undersea threats to the surface battleforce. This effort also includes Navy unique research and technology issues associated with creating a timely and intelligible tactical picture of the undersea battlespace.

(U) Littoral Warfare includes research and technology issues associated with dominating the undersea battlespace to enable timely execution of joint/combined operations and to ensure joint force sustainability. Programs include advanced sensors and arrays for both improved ASW surveillance and enhanced battleforce self-defense, ASW data fusion for better tactical control, and low frequency active sonar and rapidly deployable surveillance systems for covert/non-covert indication and warning.

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(U) Strategic Mobility includes research and technology issues associated with reliable undersea target detection and tracking, enabling joint battleforce sustainability. Programs include the entire spectrum of technology development undertaken in support of other JMAs.

(U) These efforts support the naval portion of the Joint Warfare Strategy as expressed in "Forward...From the Sea". Programs in this PE are primarily service (Navy) unique.

(U) Applied research funded by this PE in many cases transitions to advanced development projects in undersea warfare advanced technology (PE 0603747N).

(U) Due to the sheer volume of efforts included in this PE the programs described in the Accomplishments and Plans sections are representative selections of the work included in this PE.

(U) The Navy Science and Technology program includes projects that focus on or have attributes that enhance the affordability of warfighting systems.

(U) JUSTIFICATION FOR BUDGET ACTIVITY: This program is budgeted within the APPLIED RESEARCH Budget Activity because it investigates technological advances with possible applications toward solution of specific Naval problems, short of an advanced development effort.

(U) PROGRAM ACCOMPLISHMENTS AND PLANS:

1. (U) FY 1999 ACCOMPLISHMENTS:

- (U) ACOUSTIC SENSOR TECHNOLOGY:
  (U) Initiated:
  - (U) Development of low frequency, three-axis, acoustic velocity sensors aimed at dramatically improving the ability to passively detect quiet submarines. The basis for this effort is a comprehensive analysis that indicates that this technology will enable a significant improvement of detection ranges for some of the most challenging targets.
  - (U) Development of an affordable, high-pulse power, high-energy density, ambient temperature battery for use in A-size active sonobuoys and in off-board and deployable sensors and sources intended for wide-

area surveillance operations. The goal of this effort is to extend the lifetime of active sonobuoys by 50% and to power future autonomous surveillance arrays for up to 90 days.

- (U) Development of an ultra-lightweight, ultra-low power air-, surface ship- or submarine-deployable, Autonomous Drifting Line Array (ADLA) to be used in conjunction with or in place of conventional towed arrays when additional sensing resources are needed in forward areas. These arrays will make maximum use of in-sensor passive and active signal processing and will communicate with tactical support centers via low-bandwidth RF paths such as commercial cellular channels.
- (U) Development of active and passive acoustic signal processing detection, localization and classification techniques that can be executed in battery-powered, drifting and fixed autonomous air ASW and undersea surveillance sensors and arrays. Two separate Broad Agency Announcements (BAAs) were published to address this topic.
- (U) Development of a family of ultra-lightweight, ultra-low power air-, surface ship- or submarine-deployable, Matched Field Tracking Arrays to be used for barrier (Hydra) or area (Kelp) surveillance or as organic off-board sensors for submarines. These arrays will classify on depth from matched field tracking as well as other means, will have telesonar communications and be compatible with the overall Deployable Array Technology (DAT) system concept.
- (U) Development of a broadband acoustic projector array using electroactive polymer as the driver. This development utilized existing copolymer material available. Future planning includes the use of a new class of high strain irradiated electrostrictive polymer currently in 6.1 development.

(U) Continued:

- (U) Development of a large aperture, bottom-mounted array and associated signal processing aimed at exploring the feasibility of achieving the very large gains promised by matched field signal processing.
- (U) Development of a signal processing method that enables rapid and accurate differentiation between transient noises that come from man-made sources and those that emanate from biologic sources. The method reduces the high false alarm rate and performs at a level that is very near the theoretical optimum.
- (U) Development of an affordable, high-pulse power, high-energy density, thermal battery for A-size active sonobuoys. The goal is to increase energy density and lifetime to meet requirements of Air Deployed Low Frequency Projector (ADLFP) program. Began a related 24-month Small Business Innovation Research Phase II effort.

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- (U) The assessment and report on the role of Air ASW Surveillance in plausible FY 2015 regional and global conflicts. Began a similar assessment of bottom-moored shallow water acoustic and non-acoustic surveillance methods.
- (U) Development of signal processing algorithms which, when used in conjunction with a volumetric towed array, can provide improved localization estimates. This technology will transition to PE 0603504N, Advanced Processing Build Block for integration and delivery to hull two of the Virginia class submarine.
- (U) Development of a first-generation brassboard version of an off-board, acoustic, multi-static source and associated on-board signal processing techniques. FY 1999 work focused on conducting an over-the-side engineering test of a brassboard, off-board source transducers and electronics utilizing low frequency, slotted cylinder projectors, and a sea test to obtain target-in-the environment data. The sea-test and engineering test of the off-board source transducers and electronics were successfully completed. Following analysis of the data, development of multi-static processing and shallow water classification algorithms will be initiated.
- (U) Development of critical sensor and signal processing technologies required to autonomously detect and classify submarines with a family of deployed systems. The focus of the FY 1999 work is on integrating acoustic communications links into an uncabled network of undersea sensors and subsequently demonstrating an ability to pass a series of preprogrammed communications in a shallow water environment.
- (U) Development of a capability to exploit unique classification clues provided by coherently processing active sonar data collected by two widely spaced, relatively moving sensors. The focus of the FY 1999 work is on analyzing at-sea data and computer simulations to evaluate the payoffs and limitations of this approach.
- (U) Development of technical approaches for automating the configuration of a sonar system in response to a real-time analysis of the acoustic field and relevant (measured) environmental parameters. The FY 1999 work is focused on an exploration of alternative adaptive signal processing/modeling techniques.
- (U) Development of electrostrictive relaxor ceramics for use in high power, low frequency projector arrays. Continue engineering and manufacturing efforts to complete development of a class of lead magnesium niobate (PMN) relaxor materials.

(U) Demonstrated:

- (U) That forward-scattered acoustic energy is detectable at tactically useful ranges in a tactically significant acoustic environment at sea as part of the Littoral Warfare Advanced Development (LWAD) 99-3 Sea Test (P.E. 0603747N).
- (U) Performance of a Bragg grating-based optical towed array. This is a risk reduction effort that was initiated in FY 1996. The intent is to provide an alternative optical technology in the event the approach selected in the Affordable Array Technology Advanced Technology Demonstration (PE 0603792N) does not work as hypothesized.

(U) Completed:

- (U) Development of a signal processing algorithm that, based on in-situ environmental information and the tactical scenario, automatically selects the appropriate advanced tracking method for improved detection and classification of stationary or slowly-moving submarines. This effort was initiated in FY 1998.
- (U) Development of common signal processing algorithms for a surface ship's SQS-53C and the SH-60R helicopter's Airborne Low Frequency Sonar (ALFS). This effort, which was initiated in FY 1997, is aimed at significantly reducing the false alarm rate, especially when operating in shallow water. The technologies will transition via software upgrades to ALFS and the SQS-53C.

- (U) NON-ACOUSTIC SENSOR TECHNOLOGY:

  (U) Initiated:

  - (U) Design and construction of two laser based, sensor Exploratory Development Models. This development is in support of a joint US/UK program that will significantly expand the utility of a Laser Induced Differential Absorption Radar (LIDAR) system as a standoff sensor.
  - (U) Extremely Low Frequency Electromagnetic (ELFE) sensor installation and associated sensor algorithm development in support of the next generation Magnetic Anomaly Detection (MAD) system.

  (U) Completed:

  - (U) Development and laboratory evaluation of a miniature, low cost, low power, magnetometer together with electromagnetic feature extraction and tracking algorithms. This effort is in support of a deployable autonomous distributed system. Transition to Advanced Deployable System, P.E. 0604784N.

- (U) DATA FUSION TECHNOLOGY:

  (U) Demonstrated:

- (U) The capability of the Deployable Autonomous Distributed System to autonomously detect, classify, and track a threat target and, using data fusion techniques, to develop a fire control quality track suitable for weapon employment.

(U) Completed:

- (U) Development of the multi-sensor, acoustic and non-acoustic Data Fusion algorithm. Transition this technology to Program Executive Officer, Undersea Warfare Advanced Systems Technology Office and Naval Sea Systems Command PMS-400.

2. (U) FY 2000 PLAN:

- (U) ACOUSTIC SENSOR TECHNOLOGY:

(U) Initiate:

- (U) Development of active acoustic arrays that will conform to the shape of the hull for follow-on surface ship programs and for inclusion into the Virginia class Integrated Bow Conformal (IBC) effort for high frequency use. The objective is to explore system issues that could lead to the elimination of large spherical bow arrays on these ships. Affordability, reliability and service life considerations will drive this development.
- (U) Development of an advanced version (Super ADAR) of the Advanced Deployable Acoustic Receiver (ADAR) sonobuoy that includes the Global Positioning System (GPS), in-buoy active, passive and transient signal processing, satellite data and command telemetry, and has a 5 day semi-autonomous lifetime.
- (U) Development of single crystal materials suitable for use in a high power, broadband, acoustic projector. This is a high risk/high pay-off effort that leverages a massive investment in this technology by Defense Advanced Research Projects Agency. The initiative is applicable to surface ships and submarines. It could lead to a common ASW and mine avoidance system.
- (U) Development of all-optical heading, depth, and temperature sensors (engineering sensors) for use with all-optical towed arrays. The focus of the FY 2000 work will be on developing an approach for an all-optical heading sensor with sufficient sensitivity to replace conventional magnetic sensors.

(U) Continue:

- (U) Development of critical sensor and signal processing technologies required to autonomously detect and classify submarines with a family of deployed systems. The focus of the FY 2000 work will be on integrating the technologies required to link a series of fully functional, autonomously

deployable sensors to each other with acoustic communications and to the shore via low profile gateway buoys employing radio frequency communications.

- (U) Development of low frequency, three-axis, acoustic velocity sensors to dramatically improve the ability to passively detect quiet submarines. The FY 2000 work will focus on preparations for an in-water test at Lake Seneca to validate performance.
- (U) Development of an electroactive polymer broadband acoustic source. The aim of this initiative is to enable the under-ice and mine avoidance sonar on an attack submarine to be embedded in the submarine bow or sonar dome as a conformal array.
- (U) Development of a high-energy density, ambient temperature battery for use in A-size active sonobuoys and in off-board and deployable sensors and sources intended for wide-area surveillance operations. The focus of the FY 2000 work will be on testing a prototype battery in the laboratory.
- (U) Development of an ultra-lightweight, deployable, ADLA to be used in conjunction with, or in place of, conventional towed arrays. An over-the-side hydrodynamic and acoustic test of a 300-meter long array will occur in FY 2000.
- (U) Development of active and passive acoustic signal processing detection, localization and classification techniques that can be executed in battery-powered, drifting and fixed autonomous air ASW and undersea surveillance sensors and arrays.
- (U) Development of technical approaches for automating the configuration of a sonar system in response to a real-time analysis of the acoustic field and relevant (measured) environmental parameters. The FY 2000 work is focused on application of adaptive signal processing/modeling techniques.
- (U) Development of a first-generation, brassboard version of an off-board, acoustic, multi-static source and associated on-board signal processing techniques. The focus of the FY 2000 work will be on a more advanced demonstration utilizing an integrated version of the brassboard source and at-sea testing of multi-static processing algorithms in two other littoral areas. Development of multistatic processing algorithms will be continued.
- (U) Development of a family of ultra-lightweight, ultra-low power air-, surface ship- or submarine-deployable, Matched Field Tracking Arrays to be used for barrier (Hydra) or area (Kelp) surveillance or as organic off-board sensors for submarines. An acoustic feasibility test of both array concepts, Hydra and Kelp, will occur in FY 2000.
- (U) Development of a signal processing method that will enable rapid and accurate differentiation between transient noises that come from man-made sources and those that emanate from biologic sources. These works will transition to the Advanced Processing Build program in PE 0603504N.

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- (U) Development of signal processing algorithms which, when used in conjunction with a volumetric towed array, can provide improved localization estimates. The work in this project has been redirected from volumetric towed array processing to single line towed array processing at the request of the Advanced Systems and Technology Office. This technology will transition to PE 0603504N, Advanced Processing Build Block for integration and delivery into the Acoustic Rapid COTS Insertion Program.

(U) Conduct:
- (U) Report analysis of sea test for Acoustic Ray Anomaly. Initiate transition planning with PMA-264 and the NAVAIR Advanced Extended Echo Ranging (AEER) Program Office.

(U) Demonstrate:
- (U) The performance of a large aperture, bottom-mounted array and associated signal processing aimed at exploring the feasibility of achieving the very large signal processing gains promised by matched field signal processing.
- (U) The capability to exploit unique classification clues provided by coherently processing active sonar data collected by two widely spaced, relatively moving sensors using at-sea data. This demonstration will be conducted using data collected at-sea in an acoustically challenging environment.
- (U) The advantages of employing novel feedback control techniques in powering transduction array concepts. An offshoot will be to initiate the integration of efficient power amplifiers directly into the transducer array. This initiative is specifically aimed at reducing the life-cycle cost of active acoustic systems.

(U) Complete:
- (U) Development of innovative, low frequency, multi-static signal processing algorithms. These technologies will transition to PE 0603747N Project X1933 for evaluation in an end-to-end Low Frequency Active/Surveillance Towed Array Search System testbed.
- (U) Assessment and report on the role of bottom-moored shallow water acoustic and non-acoustic surveillance methods. Begin and complete a similar assessment of the role of submarine-deployed off-board sensors.

- (U) Development of an affordable, high-pulse power, high-energy density, thermal battery for A-size active sonobuoys. The goal is to increase energy density and lifetime to meet requirements of the ADLFP program. Complete a related 24-month Small Business Innovation Research Phase II effort.

• (U) NON-ACOUSTIC SENSOR TECHNOLOGY:
(U) Conduct:
- (U) An airborne demonstration of an uncompensated, Extremely Low Frequency MAD system. The goal is to show that the new development system will perform as well as a compensated MAD system.

(U) Complete:
- (U) Construction of LOTUS and Emerald Exploratory Development Model hardware and initiate at-sea shakedown testing.

• (U) DATA FUSION TECHNOLOGY:
(U) Initiate:
- (U) Development of advanced concepts for inter-platform/system data fusion.

(U) Conduct:
- (U) An advanced simulation of intra-field data fusion and field level control of a Deployable Autonomous Distributed System.

3. (U) FY 2001 PLAN:

• (U) ACOUSTIC SENSOR TECHNOLOGY:
(U) Initiate:
- (U) Development of a new "fishline" fiber optic acoustic sensor technology for future application to towed and deployed sonar arrays. The objective is to explore sensing and interrogation concepts for a very small diameter, single fiber, multiplexed acoustic sensor system. Acoustic sensitivity and noise issues of "fishline" will be assessed.
(U) Continue:
- (U) Development of active acoustic arrays that will conform to the shape of the hull for follow-on submarine and surface ship programs. The work in FY 2001 will focus on nested and sparse array

concepts for both mid and high frequency application requirements and on approaches for integrating projector arrays with large passive arrays and with submarines coatings.

- (U) Development of an electroactive polymer, broadband, acoustic source. The focus of the work in FY 2001 will be on testing prototype broadband partial arrays encompassing multi-octave operation and broadband signal transmissions. This effort will include a validation of array models and an assessment of the interactions between array elements.
- (U) Development of the air-deployable Super-ADAR sonobuoy that includes GPS, in-buoy active and passive signal processing, satellite data and command telemetry, and has a 5 day, semi-autonomous lifetime. Deploy a testable unit in FY01.
- (U) Development of high-energy density, extended operation, ambient chemical battery for wide area air ASW drifting and fixed surveillance operations. Transition the technology to PE 0603747N Project R2142 for an advanced development demonstration of integrated deployable system technologies.
- (U) Development of critical sensor and signal processing technologies required to autonomously detect and classify submarines with a family of deployed systems. The focus of the FY 2001 work will be on signal processing associated with a short vertical line array sensor.
- (U) Development of all-optical heading, depth, and temperature sensors (engineering sensors) for use with all-optical towed arrays. The focus of the FY 2001 work will be on demonstrating all-optical heading sensor performance and developing an approach for multiplexing all engineering sensors on a single fiber.
- (U) Development of a family of ultra-lightweight, ultra-low power air-, surface ship- or submarine-deployable, Matched Field Tracking Arrays to be used for barrier (Hydra) or area (Kelp) surveillance or as organic off-board sensors for submarines. Advanced array construction methods, engineering sensors for self location, and improved processing will occur in FY2001.
- (U) Development of a first-generation, brassboard version of an off-board, acoustic, multi-static source and associated on-board signal processing techniques. FY 2001 work will focus on further analysis of sea test data, development of robust multistatic processing algorithms for use in difficult littoral areas and improvements to multistatic performance prediction models.
- (U) Development of acoustic arrays that conform to the shape of the hull for follow-on submarine and surface ship programs. The FY 2001 focus is to design and evaluate conformal sensor designs of double-curvature arrays. Acoustic performance of the conformal acoustic arrays will be assessed relative to ship design implications.

- (U) Evaluation of performance of low frequency, three-axis, acoustic velocity sensors and scalar pressure sensors through in-water tests at Lake Seneca. In addition, develop plans for full-scale evaluation on a 688-I class submarine.

(U) Demonstrate:
- (U) Capability of automated active signal processing techniques for detection and classification of diesel electric submarines in littoral environments. These techniques will allow reduced manning of future sonar systems.

(U) Complete:
- (U) Development of technical approaches for automating the configuration of a sonar system in response to a real-time analysis of the acoustic field and relevant (measured) environmental parameters. Transition environmentally adaptive sonar technology signal processing techniques, concepts of operation and measures of effectiveness to an advanced development demonstration effort in PE 0603747N Project R2142.

• (U) NON-ACOUSTIC SENSOR TECHNOLOGY:
- (U) Conduct sea tests of LOTUS and Emerald standoff sensor system.
- (U) Complete ELFE algorithm development and data analysis from flight tests. Develop and publish a final report. These technologies will transition to the Shallow Water Localization and Attack System, P.E. 0603254N, Project H1292.

• (U) DATA FUSION TECHNOLOGY:
- (U) Develop inter-platform/sensor data fusion algorithms to produce a Common Tactical Picture and perform a Situation Assessment.

(U) Complete:
- (U) Analysis of results from simulation tests and publish final report. Transition to PD-18.
- (U) Analysis of results from the FY 00 sea test and publish final report. Transition to PD-18.

B. (U) PROGRAM CHANGE SUMMARY:

	FY 1999	FY 2000	FY 2001

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(U) FY 2000 President's Budget:	49,710	51,406	51,213
(U) Appropriated Value:	-	51,406	-
(U) SBIR/STTR Transfer:	-593	0	0
(U) Minor Program Adjustments	0	0	686
(U) Execution Adjustment:	-2974	0	0
(U) Congressional Rescissions	0	-283	0
(U) Various Rate Adjustments	0	0	589
(U) FY 2001 OSD/OMB Submission:	46,143	51,123	52,488

(U) CHANGE SUMMARY EXPLANATION:

(U) Schedule: Not Applicable.

(U) Technical: Not Applicable.

C. (U) OTHER PROGRAM FUNDING SUMMARY:

(U) RELATED RDT&E:

- (U) PE 0601153N (Defense Research Sciences)
- (U) PE 0602315N (Mine Countermeasures, Mining and Special Warfare Technology)
- (U) PE 0602435N (Ocean and Atmospheric Technology)
- (U) PE 0603254N (Anti-Submarine Warfare Systems Development)
- (U) PE 0603504N (Advanced Submarine Combat Systems Development)
- (U) PE 0603747N (Undersea Warfare Advanced Technology)
- (U) PE 0603792N (Advanced Technology Transition)
- (U) PE 0604212N (Anti-Submarine Warfare and Other Helicopter Development)
- (U) PE 0604784N (Advanced Deployable System)

D. (U) SCHEDULE PROFILE: Not applicable.