FY 2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2004
Exhibit R-2

BA: 02 PROGRAM ELEMENT: 0602782N
PROGRAM ELEMENT TITLE: Mine and Expeditionary Warfare Applied Research

COST: (Dollars in Thousands)

| Project Number & Title | FY 2003 Actual | FY 2004 Estimate | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate |
|---|---|---|---|---|---|---|---|
| Mine and Expeditionary Warfare Applied Research | 49,363 | 47,929 | 48,016 | 47,176 | 49,777 | 50,698 | 51,733 |

**A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION:** Provides technologies for Naval Mine Countermeasures (MCM), U.S. Naval sea mines, Naval Special Warfare (NSW), and Department of Defense (DOD) Explosive Ordnance Disposal (EOD). It is strongly aligned with the Joint Chiefs of Staff Joint Warfighting Capability Objectives through the development of technologies to achieve military objectives with minimal casualties and collateral damage. Within the Naval Transformation Roadmap, this investment will achieve one of three "key transformational capabilities" required by "Sea Shield" as well as technically enable the Ship to Objective Maneuver (STOM) key transformational capability within "Sea Strike" by focusing on technologies that will provide the Naval Force with the capability to dominate the battlespace, project power from the sea, and support forces ashore with particular emphasis on rapid MCM operations. The MCM efforts concentrate on the development and transition of technologies for the Organic Mine Countermeasures Future Naval Capability (OMCM FNC) supporting STOM. These include technologies for clandestine minefield surveillance and reconnaissance, organic ship self-protection, organic minehunting, neutralization/breaching and clearance. The sea mining efforts emphasize technologies for future sea mines. The NSW and EOD technology effort concentrates on the development of technologies for near-shore mine/obstacle detection and clearance, mobility and survivability, as well as explosive ordnance disposal.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

FY 2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2004
Exhibit R-2

BA: 02 PROGRAM ELEMENT: 0602782N
PROGRAM ELEMENT TITLE: Mine and Expeditionary Warfare Applied Research

**PROGRAM CHANGE SUMMARY:**

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| FY 2004-2005 President's Budget Submission | 55,531 | 47,490 | 48,315 |
| Cong. Rescissions/Adjustments/Undist.Reductions | 0 | -561 | 0 |
| Congressional Actions | 0 | 1,000 | 0 |
| Execution Adjustments | -5,315 | 0 | 0 |
| Inflation Savings | 0 | 0 | -154 |
| Rate Adjustments | 0 | 0 | -145 |
| SBIR Assessment | -853 | 0 | 0 |
| FY 2005 President's Budget Submission | 49,363 | 47,929 | 48,016 |

**PROGRAM CHANGE SUMMARY EXPLANATION:**
Technical: Not applicable.

Schedule: Not applicable.

FY 2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2004

Exhibit R-2a

BA: 02 PROGRAM ELEMENT: 0602782N PROGRAM ELEMENT TITLE: Mine and Expeditionary Warfare Applied Research

PROJECT TITLE: Mine and Expeditionary Warfare Applied Research

COST: (Dollars in Thousands)

| Project Number & Title | FY 2003 Actual | FY 2004 Estimate | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate |
|---|---|---|---|---|---|---|---|
| Mine and Expeditionary Warfare Applied Research | 49,363 | 47,929 | 48,016 | 47,176 | 49,777 | 50,698 | 51,733 |

**A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION:** This project focuses on reducing the time involved in conducting Mine Countermeasures (MCM) operations and removing personnel from minefields. The MCM project develops and transitions technologies for organic mine countermeasures and Future Naval Capabilities supporting Ship to Objective Maneuver (STOM). These include technologies for clandestine minefield surveillance and reconnaissance, organic ship self-protection, organic minehunting, neutralization/breaching and clearance. The sea mining effort emphasizes technologies for future sea mines. The Naval Special Warfare and Explosive Ordnance (EOD) technology effort concentrates on the development of technologies for near-shore mine/obstacle detection and clearance, mobility and survivability, as well as Explosive Ordnance Disposal (EOD).

**B. ACCOMPLISHMENTS/PLANNED PROGRAM:**

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| **Mine/Obstacle Detection** | 31,362 | 27,144 | 28,664 |

This activity focuses on applied research to enable longer detection ranges and precise mine location with fewer false alarms in a variety of challenging environments. For acoustic sensors, efforts in Synthetic Aperture Sonar (SAS) technologies, sensor integration onto Autonomous Underwater Vehicles (AUVs) and buried mine classification are being addressed. Electro-optic (E-O) sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Vehicle (UAV). Other processing, classification and data fusion techniques to reduce operator workload, and a mine burial prediction "expert system" are also being developed.

**FY 2003 Accomplishments:**

-Completed integration of non-imaging SAS hardware onto an AUV.

-Initiated at-sea testing to begin to quantify performance and collect data to refine non-imaging SAS

processing techniques.
-Continued development of AUV obstacle avoidance sonar and real-time path-planning algorithms.
-Continued development and performance assessment of long-range SAS motion compensation and beamforming techniques using existing SAS field data.
-Continued SAS algorithm development for long-range, multi-path environment.
-Continued development of buried mine classification sensors and began to address AUV integration issues.
-Updated E-O mine/minefield detection system performance models for UAV sensor.
-Continued the refinement of real-time E-O image processing algorithms for UAV multi-spectral minefield detection.
-Performed a significant 3D Light Detection and Ranging (LIDAR) data collection in the Surf Zone (SZ) for UAV sensor algorithm development.
-Initiated a first order UAV optical Surf Zone Index (SZI) passive E-O imaging database to predict system performance in SZ.
-Completed and validated underwater electro-optic identification (EOID) system performance models.
-Completed refinement of automated underwater mine identification algorithms to AQS-20A mine countermeasures program.
-Continued the development of underwater sensor prediction tools to support development, system design, and Tactical Decision Aid (TDA) efforts.
-Began development of long-range, automated, physics-based target recognition algorithms for underwater SAS.
-Began integration of enhanced mine burial predictive sub-models into a mine burial expert system and conducted limited demonstration of the expert system.

**FY 2004 Plans:**
-Continue data collection to refine non-imaging SAS processing techniques.
-Continue development of compact non-imaging SAS projector, receiver, and post mission analysis tool for AUV system integration.
-Continue development of AUV obstacle avoidance sonar and continue to develop path-planning algorithms.
-Complete development of long-range SAS motion compensation and beamforming techniques.
-Continue SAS algorithm development for long-range, multi-path environment.
-Continue development and integration of buried mine classification sensors into an AUV.
-Demonstrate autonomous reconnaissance and mine hunting technologies focused on multiple cooperating UUVs during Fleet exercises.
-Initiate development of multi-static techniques for multiple, cooperating AUVs.
-Continue the development of UAV Rapid Overt Airborne Reconnaissance (ROAR) active/passive electro-optic image processing and modeling.
-Develop a reconfigurable 3D LIDAR test bed for data collection for UAV sensor algorithm development.

-Continue development of a UAV SZI to predict sensor performance for both active and passive E-O systems.
-Demonstrate utility of underwater EOID system performance models and diver visibility models during a fleet exercise.
-Continue development of SAS long-range, automated, physics-based target recognition algorithms.
-Continue the development of underwater sensor prediction tools to support development, system design, and Tactical Decision Aid (TDA) efforts.
-Begin to optimize the data input-output capabilities of the mine burial expert system to provide predictions in an acceptable operational format and begin evaluating its operational utility during selected fleet exercises.
-Begin the development of a Computer-Aided Detection/Computer-Aided Classification (CAD/CAC) evaluation framework to use in the development and testing of various algorithms.

**FY 2005 Plans:**
-Complete development of a compact broadband projector, an improved broadband SAS receiver and post mission analysis tool for evaluating AUV system integration of broadband projector and receiver.
-Complete data collection to refine non-imaging SAS processing techniques.
-Complete development of a compact non-imaging SAS projector, an improved non-imaging SAS receiver and post mission analysis tool for evaluating AUV system integration of non-imaging projector and receiver.
-Complete development of real-time path planning algorithms for AUVs.
-Complete development of SAS algorithm for long-range, multi-path environment.
-Continue development of AUV obstacle avoidance sonar.
-Continue development of multi-static AUV-based minehunting integrating navigation, communication and sensor elements.
-Complete integration of buried mine classification sensors into AUV and demonstrate during field trials.
-Demonstrate autonomous reconnaissance and minehunting technologies, specifically non-imaging SAS, during fleet exercises.
-Initiate evaluation of technological capabilities for ROAR UAV sensor buried mine detection in the Beach Zone.
-Continue development of UAV SZI and 3D LIDAR technology test bed for data collection and demonstration of airborne detection of minefields in the VSW and SZ.
-Transition underwater EOID system performance models and sensors for on-scene assessment of diver visibility.
-Continue the development of underwater sensor prediction tools to support development, system design, and TDA efforts.
-Continue development of SAS long-range, automated, physics-based target recognition algorithms.
-Continue the development of a CAD/CAC evaluation framework to use in the development and testing of various algorithms.

-Continue to optimize the data input-output capabilities of the mine burial expert system and participate in a fleet exercise to demonstrate the utility of the mine burial expert system.
-Transition mine burial expert system to the Naval Oceanographic Office.
-Begin the development of survey sensor suites for manned and unmanned platforms.
-Initiate effort to fuse data from underwater magnetic and acoustic sensors to enhance Probability of classification (Pc) and reduce false alarm rate for buried minehunting.

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| **Special Warfare/EOD** | 7,832 | 8,655 | 10,239 |

Naval Special Warfare (NSW) missions primarily support covert near-shore naval operations. The goal is to develop technology to increase the combat range and effectiveness of Special Warfare units. A major focus is to develop technologies to enhance the Sea-Air-Land mission of pre-invasion detection for clearance/avoidance of mines and obstacles in the very shallow water (VSW) and surf zone (SZ) amphibious landing areas. Explosive Ordnance Disposal (EOD) operations typically occur in deep, poor-visibility water, with high background noise, and in areas contaminated by a variety of unexploded ordnance (UXO). Advanced technologies are needed to gain access to areas contaminated by area-denial sensors and/or booby traps. These technologies will transition to the Joint Service EOD Program, the Naval EOD Program, or the DOD Technical Response Group. This activity includes applied research in sensor technology for NSW and EOD autonomous and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include mission support technology improvements for Autonomous Underwater Vehicles (AUVs) and human divers – such as communications, navigation and life support.

**FY 2003 Accomplishments:**
-Completed development of technologies to enable coordinated behavior and mission execution by unmanned underwater vehicles (UUV).
-Completed development of underwater imaging polarimeter.
-Completed development of a pulsed neutron elemental analysis system for identification of filler material in improvised explosive devices.
-Completed development of small Synthetic Aperture Sonar (SAS) for AUV deployment.
-Performed field tests on dual frequency lens sonar.
-Completed development of virtual environment-based training.
-Continued development of digital beamformer architecture for high frequency imaging sonar.
-Continued development of hyperspectral polarimeter prototype.
-Continued development of short range sensors for UUV reconnaissance of surf zone.

-Initiated development of technology to detect, monitor, and disrupt operation of Explosive Safe and Arming (ESA) devices.
-Initiated development of standoff detection and classification sensors for surface and buried UXO using multi-dimensional electro-magnetic (EM) methods.
-Continued development of robotic manipulators, actuators and control algorithms based on artificial muscle materials.
-Continued development of life support equipment technologies, a miniature CO2 sensor, and a passively controlled rebreather.
-Continued development of extended lifetime underwater adhesives.
-Initiated investigation of technology alternatives for next generation Seal Delivery Vehicle.
-Initiated development of Low Probability of Intercept/Low Probability of Detection (LPI/LPD) underwater communications.
-Initiated development of UUV technologies for autonomous inspection of ship hulls.

**FY 2004 Plans:**
-Complete development of digital beamformer architecture for high frequency imaging sonar.
-Complete development of hyperspectral polarimeter prototype.
-Complete extended lifetime underwater adhesive development.
-Continue development of short range sensors for UUV reconnaissance of SZ.
-Continue development of technology to detect, monitor, and disrupt operation of ESA devices.
-Continue development of standoff detection and classification sensor for surface and buried UXO using multi-dimensional EM methods.
-Continue development of robotic manipulators, actuators and control algorithms based on artificial muscle materials.
-Complete development of passively controlled rebreather.
-Continue development of a miniature CO2 sensor.
-Continue effort for next generation Seal Delivery Vehicle - develop design alternatives.
-Continue development of LPI/LPD underwater communications.
-Continue development of UUV technologies for autonomous inspection of ship hulls.
-Initiate development of hand-held scannerless range imaging sensor.
-Initiate development of a diver heating system for Swimmer Delivery Vehicle (SDV) deployment.
-Initiate development of a composite garment to provide diver insulation.

**FY 2005 Plans:**
-Complete development of short range sensors for UUV reconnaissance of SZ.
-Continue development of technology to detect, monitor, and disrupt operation of ESA devices.

-Continue development of standoff detection and classification sensors for surface and buried UXO using multi-dimensional EM methods.
-Continue development of hand-held scannerless range imaging sensor.
-Complete development of CO2 sensor.
-Continue development of LPI/LPD underwater communications.
-Continue development of UUV technologies for autonomous inspection of ship hulls.
-Continue development of a diver heating system for SDV deployment.
-Continue development of a composite garment to provide diver insulation.
-Initiate analysis of Naval Special Warfare (NSW) equipment signatures.
-Initiate development of buried ordnance identification sensor.

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| **Mine/Obstacle Neutralization** | 9,969 | 4,941 | 8,913 |

Activity includes applied research in technologies for rapid mine and obstacle neutralization and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes various lethality, vulnerability and dispensing computational tools, as well as models and assessments to support the various far-term Surf Zone (SZ) and beach zone (BZ) mine and obstacle breaching concepts in PE 0603782N.

**FY 2003 Accomplishments:**
-Completed analysis of the effectiveness and development of segmented rod warhead against light and medium beach obstacles.
-Initiated development of computational tools and engineering level models for prediction of dart dispenser performance.
-Continued development of dart and fragment sand penetration model.
-Expanded mine vulnerability database to include damage from reactive and chemical darts against SZ mines.
-Continued assessment of dart lethality against SZ and BZ mines with an emphasis on chemical, reactive, and explosive fills.
-Continued assessment of mine jamming concepts utilizing ship-degaussing coils.

**FY 2004 Plans:**
-Complete development of dart and fragment sand penetration model.
-Continue development of computational tools and engineering level models to assess dart dispenser concepts.
-Continue development of mine vulnerability database - emphasis on kinetic damage, shock, blast and thermal effects.

-Continue assessment of mine jamming concepts utilizing ship-degaussing coils on steel hulled vessels.
-Continue development of advanced computational model to simulate guided bombs in the BZ and SZ against mines and obstacles.

**FY 2005 Plans:**
-Continue assessment of dart dispenser concepts using advanced computational tools and engineering level models.
-Continue development of the mine vulnerability database for kinetic damage, shock, blast and thermal effects.
-Conduct demonstration and assessment of mine jamming utilizing ship-degaussing coils during a fleet exercise.
-Complete development of an advanced computational model to simulate guided bombs in the BZ and SZ against mines and obstacles.
-Initiate development of a mine vulnerability code for SZ and BZ mines.
-Initiate assessment of precision-guided bombs for mine neutralization in Very Shallow Water (VSW).

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| **Mine Technology** | 200 | 200 | 200 |

This activity assesses advanced sea mine technologies to maintain expertise in this Naval Warfare area.

**FY 2003 Accomplishments:**
-Completed development of mining assessment tools.
-Initiated assessment of advanced sea mine technologies focusing on remote control and warhead concepts.

**FY 2004 Plans:**
-Continue assessment of advanced sea mine technologies.

**FY 2005 Plans:**
-Continue assessment of advanced sea mine technologies, focusing on remote control and warhead concepts for increased effectiveness.

| | FY 2003 | FY 2004 | FY 2005 |
|---|---|---|---|
| **Assault Breaching System** | 0 | 6,000 | 0 |

Assault Breaching System concepts will lead to a future mine and obstacle breaching capability. The employment of air and surface strike weapon systems will minimize exposure to service personnel, enable amphibious landing forces to maintain an unencumbered operational tempo from the sea to the objectives ashore, and reduce total ownership costs and logistics requirements. It supports the future naval warfare directions of power projection, operational maneuver from the sea, Ship-to-Objective Maneuver, and sea-based logistics.

**FY 2003 Accomplishments:**
Not applicable.

**FY 2004 Plans:**
-Accelerate the development and demonstration of a reconnaissance system for detecting minefields on the beach.
-Develop a systems level model to support the planned tradeoff analysis of Assault Breaching Systems. The 6-Degrees of Freedom (DoF) model will integrate system/platform level guidance algorithms, accurate aerodynamics, and dispenser concepts to assess the performance of countermine dart delivery concepts.

**FY 2005 Plans:**
Not applicable.

**CONGRESSIONAL PLUS-UPS:**

| | FY 2003 | FY 2004 |
|---|---|---|
| MOBILE UNDERWATER COASTAL SURVEILLANCE SYSTEM | 0 | 989 |

The objective of this effort is to develop control algorithms to effect cooperative behavior among multiple autonomous underwater vehicles in specific, extended duration mission scenarios. Duration will be achieved through the use of vehicles capable of harvesting solar energy from the environment.

**C. OTHER PROGRAM FUNDING SUMMARY:**

NAVY RELATED RDT&E:
PE 0601153N (Defense Research Sciences)
PE 0602131M (Marine Corps Landing Force Technology)
PE 0602435N (Ocean Warfighting Environment Applied Research)
PE 0603502N (Surface and Shallow Water Mine Countermeasures)
PE 0603640M (USMC Advanced Technology Demonstration (ATD))
PE 0603654N (Joint Service Explosive Ordnance Development)
PE 0603782N (Mine and Expeditionary Warfare Advanced Technology)
PE 0604654N (Joint Service Explosive Ordnance Development)

NON-NAVY RELATED RDT&E:
PE 0602712A (Countermine Systems)
PE 0603606A (Landmine WF and Barrier Advanced Technology)
PE 1160401BB (Special Operations Technology Development)
PE 1160402BB (Special Operations Advanced Technology Development)

**D. ACQUISITION STRATEGY:**

Not Applicable.