FY 2007 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2006
Exhibit R-2

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602782N
PROGRAM ELEMENT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

COST: (Dollars in Thousands)

Project Number & Title	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	44,894	48,877	53,435	59,929	56,677	51,678	49,501

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: Provides technologies for Naval Mine Countermeasures (MCM), Expeditionary Warfare, U.S. Naval sea mining, Naval Special Warfare (NSW), and Joint Tri-Service Explosive Ordnance Disposal (EOD). This program 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. These efforts concentrate on the development and transition of technologies for the MCM-related and Urban Asymmetric/Expeditionary Warfare Operations (UAEO)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs). The Mine and Obstacle Detection/Neutralization efforts include technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting and neutralization/breaching. The UAO effort includes critical warfighting functions such as Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, etc. The Naval Special Warfare and Explosive Ordnance Disposal technology efforts concentrate on the development of technologies for safe near-shore mine detection, diver mobility and survivability, and ordnance disposal operations.

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

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B. PROGRAM CHANGE SUMMARY:

	FY 2005	FY 2006	FY 2007
FY 2006 President's Budget Submission	47,544	49,520	54,839
Congressional Action	0	100	0
Congressional Undistributed Reductions/Rescissions	-36	-743	0
Execution Adjustments	-2,287	0	0
FY 2005 SBIR	-327	0	0
Program Realignment	0	0	-1,457
Rate Adjustments	0	0	53
FY 2007 President's Budget Submission	44,894	48,877	53,435

PROGRAM CHANGE SUMMARY EXPLANATION:
Technical: Not applicable.

Schedule: Not applicable.

C. OTHER PROGRAM FUNDING SUMMARY:
Not applicable.

D. ACQUISITION STRATEGY:
Not applicable.

E. PERFORMANCE METRICS:
The overall metrics of this applied research program are the development of technologies which focus on the Expeditionary Warfare challenge of speeding the tactical timeline and increasing safe standoff from minefields. Individual project metrics include the transition of 6.2 technology solutions into 6.3 advanced technology programs.

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COST: (Dollars in Thousands)

Project Number & Title	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	44,894	45,777	53,435	59,929	56,677	51,678	49,501

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This project focuses on reducing the time involved in conducting Mine Countermeasures (MCM) operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and Urban Asymmetric/Expeditionary Warfare Operations (UAEO)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs). The MCM effort includes technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting, neutralization/breaching and clearance. The Littoral Warfare effort includes critical warfighting functions such as Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, etc. The sea mining effort emphasizes technologies for future sea mines. The Naval Special Warfare and Explosive Ordnance technology efforts concentrate on the development of technologies to enhance diver capabilities including: safe near-shore mine sensing, mobility and survivability, and ordnance disposal operations.

B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 2005	FY 2006	FY 2007
LITTORAL COMBAT	2,048	449	0

Within the Naval Transformation Roadmap, this investment supports achievement of transformational capabilities of Ship to Objective Maneuver (STOM), a key capability within Sea Strike. This activity develops and demonstrates prototype capability to enable Naval Expeditionary Forces to influence operations ashore. The goal of Littoral Combat is the application of technologies to enhance the ability of the Navy/Marine Corps team to execute the naval portion of a joint campaign in the littorals. This activity considers all the critical functions of warfighting: Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, force protection, and training.

FY07 funding for this activity moved to PE 0602131M.

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FY 2005 Accomplishments:

-Continued development of advanced sensing algorithms to derive maps using digital imagery from airborne ISR assets to support expeditionary maneuver. (Previous efforts funded by PE 0602131M; FY 06 effort funded by PE 0602131M)
-Continued development of advanced weapon materials technologies. (Previous efforts funded by PE 0602131M and PE 0602236N; FY 06 effort funded by PE 0602131M)
-Continued development of expeditionary warfare decision support tools for Marine ground forces in support of STOM. (FY 06 effort funded by PE 0602131M)
-Initiated development of organic light emitting diode (OLED) display technology for shipboard use.

FY 2006 Plans:

-Continue design and development of rocket propelled grenade (RPG) defensive systems. (Previous efforts funded by PE 0602131M; FY07 effort continues in PE 0603640M.)
-Complete development of organic light emitting diode (OLED) display technology for shipboard use.

FY 2007 Plans:

Realigned to PE 0602131M.

	FY 2005	FY 2006	FY 2007
MINE/OBSTACLE DETECTION	25,717	28,459	32,294

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. It supports Discovery and Invention (D&I) and Mine Countermeasure (MCM)-related FNC ECs. Efforts in Synthetic Aperture Sonar (SAS) technologies for longer range detection and classification of mine-like targets and magnetic gradiometer sensing and electro-optic (EO) technology for buried mine identification, and sensor integration onto Autonomous Underwater Vehicles (AUVs) are being addressed. EO 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. Efforts also support development of MCM Mission Modules for Littoral Combat Ships (LCS).

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The funding profile from FY06 to FY07 reflects the reorganization of Future Naval Capabilities (FNC) Program investments into Enabling Capabilities (ECs). As a result of this reorganization, the funding for each EC has been aligned to a Budget Activity 2 and Budget Activity 3 PE as appropriate. This Activity reflects the alignment of investments for the following ECs: Mine Countermeasures Capacity Spiral 1 and 2; and Mine Countermeasures for Maneuver Spiral 1 and 2.

FY 2005 Accomplishments:

-Continued development of automated broadband physics-based target recognition algorithms.
-Continued the development of active electromagnetic sensing for short-range mine classification.
-Continued buried and proud mine target acoustic scattering measurements in the presence of bottom roughness using parametric and conventional sonars.
-Continued development of sensor systems for crawling vehicles, focusing on surf zone (SZ) mine detection and identification.
-Continued development of multi-static AUV-based minehunting integrating navigation, communication and sensor elements.
–Continued development of 12.75” UUV technology; conducted field testing.
-Continued development of a directional transponder and the development of an acoustic smart marker/pinger for reacquisition of very shallow water (VSW) mines.
-Continued development of rapid overt airborne reconnaissance (ROAR) active/passive EO image processing for detection of mines/minefields in VSW, SZ, and the beach zone (BZ).
-Continued to optimize the data input-output capabilities of the mine burial expert system and participate in a fleet exercise to demonstrate operational utility.
-Continued blazed array obstacle avoidance sonar effort - integrate onto a UUV for testing.
-Completed development of prototype broadband acoustic scattering sonar and integration onto a 21 inch AUV.
-Completed development of SAS motion compensation and beamforming algorithm for long-range, multi-path environment.
-Completed development of the Real-time Tracking Gradiometer (RTG) for classification of buried mines.
-Completed integration of RTG and Bottom Object Search Sonar (BOSS) prototype wing onto a 12.75” UUV and executed initial at-sea testing of combined sensors.
-Completed development of the Laser Scalar Gradiometer (LSG).
-Completed development of a Surf Zone Index (SZI) to predict sensor performance for both active and passive airborne EO systems.

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-Completed development of multi-platform fusion of AV-15 Kingfisher contact data via registration with those from the Mine Warfare Environmental Decision Aids Library (MEDAL) for improved mine detection and avoidance.

–Initiated effort to define the interface between MEDAL and the SQS-53C Integrated Peer Review (IPS) required to support transition of this registration capability.
-Initiated at-sea testing of prototype broadband acoustic scattering sonar focusing on multi-aspect mine classification/identification and characterization of clutter in various environments.
-Initiated the development of a low-cost, 12.75” UUV-based EO sensor for mine identification.
-Initiated development of long range, forward-looking Integrated Precision Underwater Mapping (iPUMA) sonar for small (12.75”) UUVs.
-Initiated development of data fusion algorithms for underwater electro-optic, magnetic and acoustic sensors to enhance probability of classification (Pc) and probability of identification (Pid) and reduce false alarm rate for proud and buried mine hunting.
-Initiated testing and evaluation of a common control language for AUVs.
-Initiated development of Over the Horizon (OTH) deployment concepts for UUVs.
-Initiated development of multi-platform fusion of data from high-resolution mine hunting systems (e.g. AN/AQS-20 and submarine-launched Mine warfare (MIW) UUVs via registration with those from the MEDAL for improved mine detection and avoidance.

Following are Discovery and Invention (D&I) efforts (ONR followed by NRL):
ONR
-Continued prototype Remote Sensing EO sensors for Tactical Unmanned Aerial Vehicle (TUAV) applications.
-Continued the development of multi-static acoustic sensing and processing for cooperating, unmanned vehicles.
-Completed an at-sea demonstration of Broadband SAS detection/classification of buried and proud mines at Sediment Acoustics Experiment 2004 (SAX04).
-Completed the development of underwater sensor prediction tools to support development, system design, and Tactical Decision Aids (TDA) efforts.
-Initiated evaluation of Littoral Remote Sensing (LRS) algorithm development requirements utilizing data streams available from national and organic sensors.
-Initiated design and development of broadband interferometric SAS.
NRL
-Continued development and testing of the Integrated Mine Burial Model and transition to the Naval Oceanographic Office (NAVOCEANO). (NRL)
-Completed analysis and reporting of scanning focused acoustic fields using time-reversal acoustics. (NRL)

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-Initiated the primary sub-system design efforts to extend mine identification using acoustic color concept to longer ranges. (NRL)
-Initiated development of a concept of operations for generating geotechnical data inputs to the impact mine burial prediction model. (NRL)
-Initiated development of Ultrawideband (UWB) SAR imaging algorithms and design, and construction of SAR breadboard experimental system. (NRL)

FY 2006 Plans:

-Continue all efforts of FY05 less those noted as completed above.
-Complete, at-sea, UUV based testing of blazed array obstacle sonar.
-Complete at-sea testing of the RTG and BOSS wing prototype on a 12.75” UUV.
-Complete buried and proud mine acoustic scattering measurements in the presence of bottom roughness using conventional and parametric sonars.
-Complete development of sensor systems for crawling vehicles, focusing on SZ mine detection and identification.
–Complete development and field testing of 12.75” Unmanned Underwater vehicle (UUV) technology.
-Complete testing and evaluation of a common control language for AUVs.
-Complete development of a directional transponder and the development of an acoustic smart marker/pinger for reacquisition of VSW mines.
-Complete development ROAR active/passive EO image processing for detection of mines/minefields in Very Shallow Water (VSW), SZ, and the BZ.
-Demonstrate multi-platform fusion of SQS-53C Integrated Peer Review (IPS) contact data via registration with those from the Mine Warfare Environmental Decision Aids Library (MEDAL) for improved mine detection and avoidance.
-Initiate development of automatic mine detection and classification algorithms for integrated forward-looking iPUMA sonar and side-looking sonars.
-Initiate technology development for a Tactical UAV buried minefield detection sensor.

Following are D&I efforts (ONR followed by NRL):
ONR
-Continue all efforts of FY05 less those noted as completed above.
-Complete development of prototype Remote Sensing EO sensors for TUAV applications.
NRL

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-Continue all efforts of FY05 less those noted as completed above.
-Complete development and testing of the Integrated Mine Burial Model and transition to NAVOCEANO. (NRL)
-Initiate analysis of at-sea experimental results and sediment poro-elastic and elastic propagation models to investigate the high frequency acoustic bottom interaction for various seafloor sediment properties. (NRL)
-Initiate the development of a numerical simulation capability for exploring synthetic aperture sonar (SAS) system sensitivities to seafloor sediment parameters. (NRL)

FY 2007 Plans:

-Continue all efforts of FY06 less those noted as completed above.
-Complete development of automated broadband, physics-based target recognition algorithms utilizing data collected by prototype sonar; and begin transition to Naval Sea Systems Command (NAVSEA) codes PMS-403 and PMS-495.
-Complete development of long-range, forward-looking sonar for small (12.75”) UUVs and begin at-sea testing.
-Complete the development of active electromagnetic sensor for short range mine classification.
-Complete development of data fusion algorithms for underwater electro-optic, magnetic and acoustic sensors to enhance Pc and Pid and reduce false alarm rate for proud and buried mine hunting.
-Complete the development of a low cost, 12.75” UUV based electro-optic sensor for mine identification, integrate onto a UUV, and conduct initial at-sea tests of sensor performance.
-Complete mine burial expert system and transition to the NAVOCEANO.
-Initiate large area search and survey based upon multiple, cooperating UUVs.
-Initiate technology development for MCM Mission Module systems for Advanced Flight LCS.

Following are D&I efforts (ONR followed by NRL):
ONR
-Continue all efforts of FY06 less those noted as completed above.
-Complete development of broadband interferometric SAS and begin at-sea testing.
-Continue evaluation of Littoral Remote Sensing (LRS) algorithm development requirements utilizing data streams available from national and organic sensors.
NRL
-Continue all efforts of FY06 less those noted as completed above.
-Complete evaluation of sediment poro-elastic and elastic propagation models to understand high-frequency acoustic-bottom interactions. (NRL)

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	FY 2005	FY 2006	FY 2007
SPECIAL WARFARE/EOD	11,500	11,146	11,270

Naval Special Warfare (NSW) missions primarily support covert near-shore naval operations. The goal of this effort 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 VSW and SZ amphibious landing areas. Explosive Ordnance Disposal (EOD) operations typically occur in shallow, 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. Developed 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 AUVs and human divers – such as communications, navigation and life support.

NRL investment in Special Warfare/EOD decreases in FY07.

FY 2005 Accomplishments:

ONR
-Continued development of dual-mode visible sensor for clandestine tracking of near-shore craft and other objects.
-Continued development of standoff detection and classification sensors for surface and buried UXO using multi-dimensional Electro-Magnetic (EM) methods.
-Continued development of technology to detect, monitor, and disrupt operation of explosive safe and arming Explosive Safe and Arming (ESA) devices.
-Continued development of low probability of intercept/low probability of detection (LPI/LPD) underwater communications.
-Continued development of AUV technologies for autonomous inspection of ship hulls.
-Continued development of robotic manipulators, actuators and control algorithms based on artificial muscle materials.
-Continued development of a diver heating system for swimmer delivery vehicle (SDV).
-Completed development of CO2 sensor.
-Completed development of a composite garment to provide diver insulation.

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-Completed development of man-portable impulse radar system for sense-thru-the-wall applications.
-Initiated analysis of NSW equipment signatures.
-Initiated development of an SDV low-observable periscope.
NRL
-Continued efforts in the design of a prototype deformable fin for AUVs. (NRL)
-Continued assembly of a prototype portable liquid crystal underwater imager by integrating the liquid-crystal cells with an acoustic lens. (NRL)

FY 2006 Plans:

ONR
-Continue all efforts of FY05 less those noted as completed above.
-Complete analysis of NSW equipment signatures.
-Complete development of standoff detection and classification sensors for surface and buried UXO using multi-dimensional EM methods.
-Initiate development of buried ordnance identification sensor.
NRL
-Continue all efforts of FY05.
-Complete prototype device of a portable liquid crystal underwater imager and perform a prototype demonstration. (NRL)

FY 2007 Plans:

ONR
-Continue all efforts of FY06 less those noted as completed above.
-Complete development of a diver heating system for SDV.
-Continue development of dual-mode visible sensor for clandestine tracking of near-shore craft and other objects.
NRL
-Continue all efforts of FY06 less those noted as completed above.
-Complete prototype of an AUV using a deformable fin by performing self-propulsion tests on a working vehicle and provide a demonstration. (NRL)

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	FY 2005	FY 2006	FY 2007
MINE/OBSTACLE NEUTRALIZATION	5,441	5,538	9,673

Activity includes applied research to support selected Mine Countermeasures (MCM)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs) 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, models and assessments to support the various far-term Surf Zone (SZ) and beach zone (BZ) mine and obstacle breaching concepts.

The funding profile from FY06 to FY07 reflects the reorganization of Future Naval Capabilities (FNC) Program investments into Enabling Capabilities (ECs). As a result of this reorganization, the funding for each EC has been aligned to a Budget Activity 2 and Budget Activity 3 PE as appropriate. This Activity reflects the alignment of investments for the following ECs: Mine Countermeasures Capacity Spiral 2; Mine Countermeasures for Maneuver Spiral 1 and 2. The increase in FY 07 is due to expansion of Autonomous Mine Neutralization and Lane Navigation Efforts.

FY 2005 Accomplishments:

-Continued assessment of mine jamming using the advanced degaussing systems of the LPD-17 and DDG-76.
-Continued development of platform concepts for autonomous mine neutralization by AUVs.
-Continued assessment of dart dispenser concepts using advanced computational tools and engineering level models.
-Completed development of mine vulnerability database for SZ mines neutralized by pressure and impulse.
-Completed development of the mine vulnerability database for kinetic damage, shock, blast and thermal effects.
-Completed development of an advanced computational model to simulate guided bombs against SZ and BZ mines.
-Completed investigation of mine jamming effect on “dumb” mines.
-Initiated development of models to assess performance of bombs against mines in Very Shallow Water (VSW).
-Initiated development of advanced computational models for high speed water entry and penetration.
-Initiated development of advanced computational tools for predicting soil penetration by countermine darts.
-Initiated assessment of mine jamming using Impressed Current Cathodic Protection (ICCP) system on a steel-hulled combatant.

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FY 2006 Plans:

-Continue all efforts of FY05 less those noted as completed above.
-Initiate development of tool to assess mine jamming effectiveness on future ship designs.

FY 2007 Plans:

-Continue all efforts of FY06.
-Complete development of platform concepts for autonomous mine neutralization by AUVs.
-Complete assessment of dart dispenser concepts using computational tools and engineering level models.
-Complete development of models to assess performance of bombs against mines in VSW.
-Complete development of mine jamming effectiveness tool.
-Complete assessment of mine jamming using ICCP; and complete mine jamming effort with exit demonstration on representative mine field using a representative steel-hulled combatant ship.
-Initiate development of an expendable, autonomous underwater vehicle neutralizer, initially focused on neutralization of moored influence sea mines in very shallow water.
-Initiate development of stand-off, assault breaching warhead fuse to extend effectiveness of unitary warheads to greater water depths.
-Initiate development of precision navigation capability for targeting, safe navigation through assault lanes including lane marking.

	FY 2005	FY 2006	FY 2007
MINE TECHNOLOGY	188	185	198

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

FY 2005 Accomplishments:

-Continued assessment of advanced sea mine technologies, focusing on remote control and warhead concepts for increased effectiveness.

FY 2006 Plans:

-Continue all efforts of FY05.

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FY 2007 Plans:

-Continue all efforts of FY06.

CONGRESSIONAL PLUS-UPS:

	FY 2005	FY 2006
COORDINATED, HETEROGENEOUS TEAMS OF UNMANNED VEHICLES	0	2,100

This effort supports coordinated, heterogeneous teams of unmanned vehicles research.

	FY 2005	FY 2006
HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN	0	1,000

This effort supports hyperspectral imager for the coastal ocean research.

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)

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

D. ACQUISITION STRATEGY: