

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2

DATE: February 2008

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

COST: (Dollars in Thousands)

Project Number & Title	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	56,035	70,504	47,869	45,234	47,016	51,308	60,597

**A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION:** The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board (Jan 2007). This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This PE 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 Urban Asymmetric Operation 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

UNCLASSIFIED

# UNCLASSIFIED

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Exhibit R-2

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BUDGET ACTIVITY: 02

PROGRAM ELEMENT: 0602782N

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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.

UNCLASSIFIED

# UNCLASSIFIED

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Exhibit R-2

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## B. PROGRAM CHANGE SUMMARY:

	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
FY 2008/FY 2009 President's Budget Submission	56,868	59,874	56,648
Congressional Action	0	11,600	0
Congressional Undistributed Reductions/Rescissions	0	-455	0
Execution Adjustments	-1	0	0
Program Adjustments	0	0	-8,592
Rate Adjustments	0	0	-187
SBIR Assessment	-832	-515	0
FY 2009 President's Budget Submission	56,035	70,504	47,869

## 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.

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	56,035	70,504	47,869	45,234	47,016	51,308	60,597

**A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION:** This project focuses on reducing the time involved in conducting MCM operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and UAEO-related FNC 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 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 2007	FY 2008	FY 2009
<b>MINE/OBSTACLE DETECTION</b>	28,697	41,663	32,817

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 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).

# UNCLASSIFIED

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Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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PROGRAM ELEMENT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

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The investment increase from FY 2007 to FY 2008 reflects critical navy MCM efforts supporting the following FNC products: Buried Mine Sensors and Processing; Undersea Cooperative Cueing (for Unmanned Underwater Vehicles (UUVs)); MCM Sensors for the LCS; and MCM Data Fusion. These 6.2 investment areas are maturing technologies such that they are ready for advanced tech development (6.3) and subsequent transition to acquisition programs. These are all high priority MCM investment areas and are reflected in the input to the FY 2008/FY 2009 MCM Master Plan submitted yearly to Congress. In FY 2009, funding programmed for new FNC ECs was realigned to reflect the priorities of the Navy's Technology Oversight Group (TOG).

## **FY 2007 Accomplishments:**

- Continued development of data fusion algorithms for underwater EO, magnetic and acoustic sensors to enhance probability of classification and probability of identification and reduce false alarm rate for proud and buried mine hunting.
- Continued development of long range, forward-looking Integrated Precision Underwater Mapping (iPUMA) sonar for small (12.75") UUVs.
- Continued at-sea testing of prototype Low Frequency Broadband (LFBB) acoustic scattering sonar focusing on multi-aspect mine classification/identification and characterization of clutter in various environments.
- Continued the development of a low-cost, 12.75" UUV-based EO sensor for mine identification.
- Continued 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 Mine Warfare Environmental Data Library (MEDAL) for improved mine detection and avoidance.
- Continued development of automatic mine detection and classification algorithms for integrated forward-looking iPUMA sonar and side-looking sonars.
- Continued phenomenology studies for improved mine detection algorithms for UAV sensors.
- Completed development of multi-static AUV-based minehunting integrating navigation, communication and sensor elements.
- Completed development of automated broadband, physics-based target recognition algorithms utilizing data collected by prototype sonar; and begun transition to Naval Sea Systems Command (NAVSEA) codes PMS-403 and PMS-495.
- Completed the development of active electromagnetic sensing for short-range mine classification.
- Completed development and field testing of 12.75" UUV platforms.
- Completed effort to define the interface between MEDAL and the SQS-53C Integrated Peer Review (IPS) required to support transition of this registration capability.
- Completed development of Over the Horizon (OTH) deployment concepts for UUVs.

R1 Line Item 14

Page 5 of 14

# UNCLASSIFIED

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

PROGRAM ELEMENT: 0602782N

PROGRAM ELEMENT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

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- Completed mine burial expert system and transition to the Naval Oceanographic Office (NAVOCEANO).
- Completed buried and proud mine target acoustic scattering measurements in the presence of bottom roughness using parametric and conventional sonars.
- Initiated large area search and survey based upon multiple, cooperating UUVs.
- Initiated technology development for MCM Mission Module systems for Advanced Flight LCS.
- Initiated technology development for a Tactical UAV (TUAV) buried minefield detection sensor.

D&I Efforts (ONR followed by NRL):

ONR

- Continued development of UUV-based extended range electro-optic identification sensors and supporting meteorology and oceanography and planning systems.
- Continued design and development of Broadband interferometric SAS.
- Continued evaluation of Littoral Remote Sensing (LRS) algorithm development requirements utilizing data streams available from national and organic sensors.
- Continued the development of multi-static acoustic sensing and processing for cooperating, unmanned vehicles.

NRL

- Continued the primary sub-system design efforts to extend mine identification using acoustic color concept to longer ranges. (NRL)
- Continued development of UltraWideBand (UWB) Synthetic Aperture Radar (SAR) imaging algorithms and design, and construction of SAR breadboard experimental system. (NRL)
- Continued the development of a numerical simulation capability for exploring SAS system sensitivities to seafloor sediment parameters. (NRL)
- Completed evaluation of sediment poro-elastic and elastic propagation models to understand high-frequency acoustic-bottom interactions. (NRL)
- Initiated model prediction verification for acoustic interactions with ocean bottoms containing configurations of inclusions, multiple scattering from clusters, rough surface shadowing effects and layers to improve model performance in buried mine identification. (NRL)

## **FY 2008 Plans:**

- Continue all efforts of FY 2007 less those noted as completed above.
- Complete the development of a low-cost, 12.75" UUV-based EO sensor for mine identification and conduct initial sea testing of sensor performance.
- Complete development of long range, forward-looking iPUMA sonar for small (12.75") UUVs and begin at-sea

R1 Line Item 14

Page 6 of 14

UNCLASSIFIED

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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

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testing.

-Initiate integration of iPUMA and SAS systems in a single vehicle to obtain 100% area coverage.

D&I Efforts (ONR followed by NRL):

ONR

-Continue all efforts of FY 2007.

-Complete design and development of Broadband interferometric SAS - and complete at-sea testing.

-Initiate development of algorithms exploiting broadband acoustic transmit waveforms for improved automatic classification of buried mines from clutter.

NRL

-Continue all efforts of FY 2007 less those noted as completed above.

-Complete the primary sub-system design efforts to extend mine identification using acoustic color concept to longer ranges. (NRL)

-Complete development of UWB SAR imaging algorithms and design, and construction of SAR breadboard experimental system. (NRL)

-Initiate development of Multiple Input Multiple Output (MIMO) UUV communications by determining channel capacity and extending use to moving platforms. (NRL)

-Initiate demonstration of flapping fin propulsion on an inexpensive, stealthy undersea vehicle to enable new mine warfare mission capabilities. (NRL)

-Initiate development of an ultrafast silicon carbide (SiC) avalanche transistor and a SiC drift step recovery diode. (NRL)

## **FY 2009 Plans:**

-Continue all efforts of FY 2008 less those noted as completed above.

-Complete development of multi-platform fusion of data from high-resolution mine hunting systems (e.g. AN/AQS-20 and submarine-launched MIW UUVs) via registration with those from the MEDAL for improved mine detection and avoidance.

-Complete 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.

D&I Efforts (ONR followed by NRL):

ONR

# UNCLASSIFIED

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Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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

PROJECT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

- Continue all efforts of FY 2008 less those noted as completed above.
- Complete the development of multi-static acoustic sensing and processing for cooperating, unmanned vehicles.
- Complete evaluation of LRS algorithm development requirements utilizing data streams available from national and organic sensors.
- Complete development of algorithms exploiting broadband acoustic transmit waveforms for improved automatic classification of buried mines from clutter.
- Investigate and develop signal processing algorithms in areas of research such as environmentally adaptive channel estimation/equalization, multi-carrier modulation techniques, and spatial diversity exploitation to enable reliable, high-rate communication between fixed and/or mobile nodes in an ad hoc underwater acoustic communication network.

NRL

- Continue all efforts of FY 2008 less those noted as completed above.
- Complete the development of a numerical simulation capability for exploring SAS system sensitivities to seafloor sediment parameters. (NRL)

	FY 2007	FY 2008	FY 2009
<b>SPECIAL WARFARE/EOD</b>	11,079	11,199	10,360

The goal of this effort is to develop technologies to extend stand-off of special operations and EOD forces in clandestine hydrography, mine clearance and port security missions while increasing the range and effectiveness of divers. 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.

The reduction in FY 2009 represents a change in NRL categorization of investment between the R-2 activities of Mine and Obstacle Detection and Special Warfare/EOD. It does NOT represent a reduction in the priority of this activity.

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

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BUDGET ACTIVITY: 02

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PROGRAM ELEMENT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

PROJECT TITLE: MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH

## **FY 2007 Accomplishments:**

ONR

- Continued development of dual-mode visible sensor for clandestine tracking of near-shore craft and other objects.
- Continued development of technology to detect, monitor, and disrupt operation of 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 Swimmer Delivery Vehicle (SDV) low-observable periscope.
- Continued development of buried ordnance identification sensor.
- Completed development of a diver heating system for SDV.
- Initiated development of metal-hydride based thermal control technology for combat divers.
- Initiated assessment of x-ray fluorescence technologies for the detection of bulk explosive compounds in containers and vehicles.

NRL

- Continued all efforts.
- Completed prototype of an AUV using a deformable fin by performing self-propulsion tests on a working vehicle and provided a demonstration. (NRL)

## **FY 2008 Plans:**

ONR

- Continue all efforts of FY 2007 less those noted as completed above.
- Complete development of robotic manipulators, actuators and control algorithms based on artificial muscle materials.
- Complete development of an SDV low-observable periscope.
- Initiate development of technologies for portable hand-held detection of concealed Improvised Explosive Devices (IEDs).
- Initiate development of tactile-feedback robotic manipulators.

NRL

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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

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- Continue all efforts of FY 2007 less those noted as completed above.
- Initiate design of an underwater riverine autonomous surveillance system that uses multiple small sensor nodes to provide persistent surveillance. (NRL)

## **FY 2009 Plans:**

- Continue all efforts of FY 2008 less those noted as completed above.

	FY 2007	FY 2008	FY 2009
<b>MINE/OBSTACLE NEUTRALIZATION</b>	9,509	5,918	4,500

Activity includes applied research to support selected MCM related FNC 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 for FY 2007 reflected the initiation of important UUV Neutralization products addressing autonomous neutralization of sea mines. This technology, when developed over the Future Years Defense Plan will remove the necessity for divers to perform these dangerous missions and reduce the time necessary for such missions by an order of magnitude. This effort also has NAVSEA transition sponsors. The investment decrease from FY 2007 to FY 2008 reflects the completion and transfer of a major program at the end of FY 2007. In FY 2009, funding programmed for new FNC ECs was realigned to reflect the priorities of the Navy's TOG.

## **FY 2007 Accomplishments:**

- Continued development of models to assess performance of bombs against mines in Very Shallow Water (VSW).
- Continued development of advanced computational models for high speed water entry and penetration.
- Continued development of advanced computational tools for predicting soil penetration by countermine darts.
- Completed development of platform concepts for autonomous mine neutralization by AUVs.
- Completed assessment of dart dispenser concepts using computational tools and engineering level models.
- Completed mine jamming development efforts with a demo on a steel-hulled combatant ship.
- Completed development of a tool to assess mine jamming effectiveness on future ship designs.
- Initiated technology development for autonomous neutralization of sea mines in VSW areas.

R1 Line Item 14

Page 10 of 14

# UNCLASSIFIED

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

DATE: February 2008

BUDGET ACTIVITY: 02

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- Initiated development of stand-off, assault breaching warhead fuse to extend effectiveness of unitary warheads to greater water depths.
- Initiated development of precision navigation capability for targeting, safe navigation through assault lanes including lane marking.

### **FY 2008 Plans:**

- Continue all efforts of FY 2007 less those noted as completed above.
- Initiate development of AUV technologies for neutralization of littoral sea mines.
- Initiate acoustic organic mine jamming investigations as a follow-on to FNC work in electromagnetic organic mine jamming.

### **FY 2009 Plans:**

- Continue all efforts of FY 2008.
- Complete development of models to assess performance of bombs against mines in VSW.
- Complete development of advanced computational models for high speed water entry and penetration.
- Complete development of advanced computational tools for predicting soil penetration by countermine darts.
- Complete assessment of stand-off, assault breaching warhead fuse to extend effectiveness of unitary warheads to greater water depths.

	FY 2007	FY 2008	FY 2009
<b>MINE TECHNOLOGY</b>	194	198	192

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

### **FY 2007 Accomplishments:**

- Continued assessment of sea mine technologies in order to maintain a level of expertise in naval mines.

### **FY 2008 Plans:**

- Continue all efforts of FY 2007.

# UNCLASSIFIED

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Exhibit R-2a

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BUDGET ACTIVITY: 02

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## FY 2009 Plans:

-Continue all efforts of FY 2008.

## CONGRESSIONAL PLUS-UPS:

	FY 2007	FY 2008
AUTONOMOUS UNDERWATER VEHICLE (AUV) DOCKING AND RECHARGING STATION	1,749	2,783

FY07: This project initiated support for the concept, design, and development of a large, mobile, unmanned, underwater vehicle to provide docking and energy-refresh capabilities for smaller AUVs.

FY08: This project supports the continued development and demonstration of the AUV docking and recharging station, which will consist of a mobile, unmanned, undersea vehicle capable of docking and replenishing smaller AUVs.

	FY 2007	FY 2008
CENTER FOR DETECTION AND NEUTRALIZATION OF ELECTRONICALLY INITIATED IMPROVED EXPLOSIVE DEVICES (IEDS)	1,644	2,384

FY07: This project initiated support for the concept, design, and development of an effective and reliable means of detecting and neutralizing IEDs through exploration of a magnetic pulse system developed under ONR funding and management.

FY08: This project supports the continued development and demonstration of an effective and suitable IED detection and neutralization system through use of a magnetic pulse system. The system will also provide a viable means of neutralization verification.

# UNCLASSIFIED

FY 2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET  
Exhibit R-2a

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BUDGET ACTIVITY: 02

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	FY 2007	FY 2008
ELECTROMAGNETIC SIGNATURE ASSESSMENT SYSTEM USING MULTIPLE AUTONOMOUS UNDERWATER VEHICLES	0	1,987

This project develops algorithms needed to control a fleet of small autonomous underwater vehicles through integration of inexpensive, easily deployable electromagnetic and possibly acoustic measurement systems to be trained to work together to assess the electromagnetic or acoustic signature of a forward deployed vessel.

	FY 2007	FY 2008
NAVY SPECIAL WARFARE (NSW) UNATTENDED SENSOR NETWORK	2,192	1,589

FY07: This project initiated support for the conceptual design and development of an unattended sensor network for use by NSW forces for covert Sea-Air-Land missions throughout the littorals and across the nearshore.

FY08: This project supports the continued development, testing, and refinement of the unattended sensor network for covert use by NSW forces during littoral and nearshore Sea-Air-Land missions.

	FY 2007	FY 2008
NMSU WATER SECURITY PROGRAM	971	795

FY07: This project initiated the development of a database of technologies for inland desalinization. Additional assessments will provide detailed economic assessments on where additional research funding should be spent. The analysis will determine the costs of the main components of treating brackish water.

FY08: This project continues to develop a comprehensive inland desalinization technologies database. The analysis will determine the costs of the main components of treating brackish water and will provide detailed economic assessments on where additional research funding should be spent.

	FY 2007	FY 2008
REMOTE CONTROLLED SURVEILLANCE SONAR SYSTEM (RCSSS)	0	994

This project supports the development of low-cost, high resolution, remote controlled Side Scan Sonar for

# UNCLASSIFIED

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underwater threats and port protection.

	FY 2007	FY 2008
VIRTUAL ONBOARD ANALYST (VIRONA) FOR MULTI-SENSOR MINE DETECTION	0	994

This project supports development to provide greater diversity in data covering the wide range of phenomenology needed to remove clutter and improve false alarms with regard to base and operate littoral mine countermeasure systems.

#### 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

#### OTHER PROGRAM FUNDING SUMMARY - 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:

Not applicable.