FY 2008/2009 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2007
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 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	45,394	56,868	59,874	56,648	58,480	58,718	60,422	62,131

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: 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 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 2006	FY 2007	FY 2008	FY 2009
FY 2007 President's Budget Submission	48,877	53,435	59,929	56,677
Congressional Action	0	6,650	0	0
Congressional Reduction	0	-3,000	0	0
Congressional Undistributed Reductions/Rescissions	36	-217	0	0
Execution Adjustments	-2,907	0	0	0
Non-Pay Inflation Adjustments	0	0	-163	132
Program Adjustments	0	0	622	-3,498
Program Realignment	0	0	-542	3,273
Rate Adjustments	0	0	28	64
SBIR Assessment	-612	0	0	0
FY 2008/FY 2009 President's Budget Submission	45,394	56,868	59,874	56,648

PROGRAM CHANGE SUMMARY EXPLANATION:
Technical: A reduction of $3M by congressional action in each of the past two years (FY 2006 and FY 2007) adversely affected critical technology development and insertion opportunities in two Mine Warfare areas within the Mine and Obstacle Detection R-2 activity. Core Discovery and Invention (D&I) investments addressing acoustic (sonar) interaction with the environment, mine-like objects and natural clutter to support and advance sensor processing were reduced. Also, the cuts have eliminated opportunities to conduct advanced experimentation in support of the Littoral Combat Ship Flt 0 Battlespace Preparation Autonomous Underwater Vehicle (BPAUV) Mission Module which develops and assesses tactics of employment and refines the design of the BPAUV system.

Schedule: Not applicable.

C. OTHER PROGRAM FUNDING SUMMARY:
Not applicable.

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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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Project Number & Title	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
MINE AND EXPEDITIONARY WARFARE APPLIED RESEARCH	45,394	56,868	59,874	56,648	58,480	58,718	60,422	62,131

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 UAEO-related 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, Communications, 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 2006	FY 2007	FY 2008	FY 2009
LITTORAL COMBAT	449	0	0	0

Within the Naval Transformation Roadmap, this investment supports achievement of transformational capabilities of 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: C4ISR, fires, maneuver, sustainment, force protection, and training.

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FY 2006 Accomplishments:

-Continued design and development of Rocket Propelled Grenade (RPG) defensive systems. (Previous efforts funded by PE 0602131M; FY 2007 effort continues in PE 0602131M.)
-Completed development of organic light emitting diode display technology for Marine Corps use.

FY 2007 Plans:

FY 2007 and outyear funding for this activity moved to PE 0602131M.

	FY 2006	FY 2007	FY 2008	FY 2009
MINE/OBSTACLE DETECTION	24,620	29,102	42,297	36,335

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 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).

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 approved by the Navy’s Technology Oversight Group (TOG) and are reflected in our input to the FY 2007/FY 2008 MCM Certification Plan to Congress.

FY 2006 Accomplishments:

-Continued development of automated broadband-Low Frequency Broadband (LFBB) physics-based target recognition algorithms.

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-Continued the development of active electromagnetic sensing for short-range mine classification.
-Continued development of multi-static AUV-based minehunting integrating navigation, communication and sensor elements.
-Continued the optimization of the data input-output capabilities of the mine burial expert system and participated in a fleet exercise to demonstrate operational utility.
-Continued effort to define the interface between Mine Warfare Environmental Data Library (MEDAL) and the SQS-53C Integrated Peer Review (IPS) required to support transition of this registration capability.
-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 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 Over the Horizon (OTH) deployment concepts for UUVs.
-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 MEDAL for improved mine detection and avoidance.
-Continued buried and proud mine acoustic scattering measurements in the presence of bottom roughness using conventional and parametric sonars.
–Continued development and field testing of 12.75” UUV platform.
-Completed, at-sea, UUV based testing of blazed array obstacle sonar.
-Completed development of sensor systems for crawling vehicles, focusing on Surf Zone (SZ) mine detection and identification.
-Completed testing and evaluation of a common control language for AUVs.
-Completed development of a directional transponder and the development of an acoustic smart marker/pinger for reacquisition of Very Shallow Water (VSW) mines.
-Completed development of rapid overt airborne reconnaissance active/passive EO image processing for detection of mines/minefields in VSW, SZ, and Beach Zones (BZs).
-Demonstrated multi-platform fusion of SQS-53C IPS contact data via registration with those from the MEDAL for improved mine detection and avoidance.
-Initiated development of automatic mine detection and classification algorithms for integrated forward-looking iPUMA sonar and side-looking sonars.

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-Initiated phenomenology studies for improved mine detection algorithms for UAV sensors.

D&I Efforts (ONR followed by Naval Research Lab (NRL)):
ONR
-Continued development of prototype Remote Sensing EO sensors for Tactical UAV (TUAV) applications.
-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) SAR imaging algorithms and design, and construction of SAR breadboard experimental system. (NRL)
-Completed development and testing of the Integrated Mine Burial Model and transition to Naval Oceanographic Office (NAVOCEANO). (NRL)
-Initiated 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)
-Initiated the development of a numerical simulation capability for exploring SAS system sensitivities to seafloor sediment parameters. (NRL)

FY 2007 Plans:

-Continue all efforts of FY 2006 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 the development of active electromagnetic sensing for short-range mine classification.
-Complete development and field testing of 12.75” UUV platforms.
-Complete effort to define the interface between MEDAL and the SQS-53C IPS required to support transition of this registration capability.
-Complete development of OTH deployment concepts for UUVs.
-Complete mine burial expert system and transition to the NAVOCEANO.

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-Complete buried and proud mine target acoustic scattering measurements in the presence of bottom roughness using parametric and conventional sonars.
-Initiate large area search and survey based upon multiple, cooperating UUVs.
-Initiate technology development for MCM Mission Module systems for Advanced Flight LCS.
-Initiate technology development for a TUAV buried minefield detection sensor.

D&I Efforts (ONR followed by NRL):
ONR
-Continue all efforts of FY 2006 less those noted as completed above.
NRL
-Continue all efforts of FY 2006 less those noted as completed above.
-Complete development of prototype Remote Sensing EO sensors for TUAV applications.
-Complete evaluation of sediment poro-elastic and elastic propagation models to understand high-frequency acoustic-bottom interactions. (NRL)
-Initiate 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 at-sea testing of prototype LFBB acoustic scattering sonar focusing on multi-aspect mine classification/identification and characterization of clutter in various environments.
-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 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 UUV-based extended range electro-optic identification sensors and supporting

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meteorology and oceanography and planning systems.
-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)

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.
-Develop and apply emerging technologies that support delivery of TOG approved FNC enabling capabilities structured to close operational capability gaps in mine and expeditionary warfare.

D&I Efforts (ONR followed by NRL):
ONR
-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.
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 2006	FY 2007	FY 2008	FY 2009
SPECIAL WARFARE/EOD	11,146	11,270	11,370	11,420

Naval Special Warfare (NSW) missions primarily support covert near-shore naval operations. The goal of this

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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.

FY 2006 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 diver heating system for Swimmer Delivery Vehicle (SDV).
-Continued development of an SDV low-observable periscope.
-Completed analysis of NSW equipment signatures.
-Completed development of standoff detection and classification sensors for surface and buried UXO using multi-dimensional electro-magnetic methods.
-Initiated development of buried ordnance identification sensor.
NRL
-Continued efforts in the design of a prototype deformable fin for AUVs. (NRL)
-Completed prototype device of a portable liquid crystal underwater imager and perform a prototype demonstration. (NRL)

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FY 2007 Plans:

ONR
-Continue all efforts of FY 2006 less those noted as completed above.
-Complete development of a diver heating system for SDV.
-Initiate development of metal-hydride based thermal control technology for combat divers.
-Initiate assessment of x-ray fluorescence technologies for the detection of bulk explosive compounds in containers and vehicles.
NRL
-Continue all efforts of FY 2006 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)

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

FY 2009 Plans:

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

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	FY 2006	FY 2007	FY 2008	FY 2009
MINE/OBSTACLE NEUTRALIZATION	5,991	9,673	6,007	8,693

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 SZ and BZ mine and obstacle breaching concepts.

The funding profile from FY 2006 to FY 2007 reflects 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 FY 2008 to FY 2009 increase reflects the phasing of MCM FNC products as per the TOG-approved Program of Record.

FY 2006 Accomplishments:

-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.
-Continued development of models to assess performance of bombs against mines in 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.
-Continued assessment of mine jamming using impressed current cathodic protection system on a steel-hulled combatant.
-Initiated development of tools to assess mine jamming effectiveness on future ship designs.

FY 2007 Plans:

-Continue all efforts of FY 2006.
-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 mine jamming development efforts with an exist demo on a steel-hulled combatant ship.

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-Complete development of tool to assess mine jamming effectiveness on future ship designs.
-Initiate technology development for autonomous neutralization of sea mines in VSW areas.
-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 2008 Plans:

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

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.
-Develop and apply emerging technologies that support delivery of Technology Oversight Group approved FNC ECs structured to close operational capability gaps in mine and expeditionary warfare.

	FY 2006	FY 2007	FY 2008	FY 2009
MINE TECHNOLOGY	185	198	200	200

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

FY 2006 Accomplishments:

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

FY 2007 Plans:

-Continue all efforts of FY 2006.

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FY 2008 Plans:

-Continue all efforts of FY 2007.

FY 2009 Plans:

-Continue all efforts of FY 2008.

CONGRESSIONAL PLUS-UPS:

	FY 2006	FY 2007
AUV DOCKING AND RECHARGING STATION	0	1,793

This effort supports the initial concept and preliminary design for a large, mobile, unmanned vehicle which will perform docking and energy-refresh for smaller autonomous unmanned undersea vehicles. Initial efforts will concentrate on developing a concept of operations and engineering analysis.

	FY 2006	FY 2007
COORDINATED, HETEROGENEOUS TEAMS OF UNMANNED VEHICLES	2,040	0

This effort supported the development of technology that combines different classes of autonomous vehicles into a coordinated heterogeneous team - each class of vehicle can provide a complementary capability that greatly enhances the operational effectiveness and the utility of autonomous vehicles for military operations. Initial deliverables were the definition and implementation of inter-vehicle communication standards and development of a platform to support experimentation goals.

	FY 2006	FY 2007
DETECTION AND NEUTRALIZATION OF ELECTRONICALLY INITIATED IEDS	0	1,644

This effort supports the development of a suitable means of effecting IED detection and neutralization through the exploration of the magnetic pulse system developed under ONR and will provide a means to verify neutralization.

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	FY 2006	FY 2007
HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN	963	0

This activity supported the development of a hyperspectral scanner suitable for near-Earth orbit observations of the global coastal ocean, the characterization of the hyperspectral scanner under controlled laboratory conditions and testing in the field (coastal waters of Hawaii) from airborne platforms. The deliverable was a new, compact, robust hyperspectral scanner optimized for coastal ocean applications.

	FY 2006	FY 2007
NMSU WATER SECURITY PROGRAM	0	996

This effort supports the development of a concept for a water security program under New Mexico State University sponsorship.

	FY 2006	FY 2007
NSW UNATTENDED SENSOR NETWORK	0	2,192

This effort supports development, testing, and refinement of an unattended sensor network for use by Naval Special Warfare for covert Sea-Air-Land missions in the littorals and across the nearshore.

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:
Not applicable.