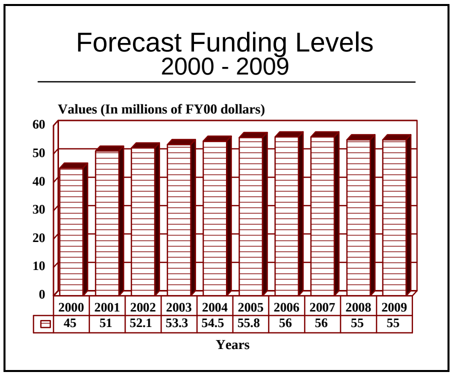
Mine Countermeasures, Mining and Special Warfare Technology - Archived 3/2001

Outlook

- A slow increase in funding expected over the forecast period
- Continued prototype production for proof-of-concept and technology development
- Increasing attention on clandestine minefield surveillance and reconnaissance
- Investigations into specific threats from weapons of mass destruction initiated



Orientation

Description. This program provides technologies for US naval mines, mine countermeasures (MCM), special warfare, and explosive ordnance disposal (EOD).

Sponsor

US Navy
Naval EOD Technology Center
Indian Head, Maryland (MD)
USA

Naval Surface Warfare Center
Bethesda, Maryland (MD)
USA

Naval Surface Warfare Center
Panama City, Florida (FL)
USA

Naval Surface Warfare Center
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Naval Research Laboratories
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Stennis Space Center, MS
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Status. Advanced technology development.

Total Produced. Limited prototypes for proof-of-concept and technology development.

Application. Technology development for US naval mines, MCM, special warfare, and explosive ordnance disposal (EOD) equipment. It is strongly aligned with the Department of Defense (DoD) Science & Technology Investment Strategy for Undersea Superiority, with particular emphasis on addressing the urgent technology needs of shallow water and surf zone MCM. All of these efforts are part of an integrated Department of Navy Science & Technology process, recently initiated by the Office of Naval Research.

Price Range. Indeterminable

Technical Data

Characteristics. Operational deficiencies in US Naval MCM capabilities, revealed during the tanker escort operations in the First Gulf War, were further highlighted by the damage to two US warships in 1991. This led the US Navy to review its MCM capabilities, technology development, and MCM operational concepts.

MCM Technology. Third World nations have the capability to procure, stockpile, and deploy all types of mines in all depths of water. The Second Gulf War demonstrated that the US Navy needs to counter the projected Third World threat. Advanced technologies are needed to rapidly detect and neutralize all mine types, especially in the shallow water and surf zone regions. The DoD has identified shallow water and surf zone MCM as major MCM efforts.

The shallow water MCM effort supports sweeping of mines in waters 40 ft to 200 ft deep. (Very shallow water is 10 ft to 40 ft deep and surf zone is 10 ft to the high water mark.) Advanced very shallow water acoustic and nonacoustic sensors, miniaturized warhead, real-time processing, and remote platform technologies will be developed and integrated.

The surf zone MCM effort will develop and perform critical technology demonstrations of distributed explosives, weapon deployment, and minefield obstacle clearance, as well as breaching technologies. Both efforts include high search rate sensor technologies integrated with advanced remote platform technologies for conducting rapid mine reconnaissance operations.

Mine Technology. The need for improved mine technology has actually diminished. This conclusion was reached when it was discovered that even archaic mines still floating around in the sea are highly effective when they come in contact with modern vessels. Yet, despite the lowered sophistication of the mine threat, it is imperative that the Navy maintains its critical mass effort and capabilities in mine sensors, environment, and systems performance analysis technology. Emphasis will be placed on potentially high-payoff advanced target detection sensors and low-cost mine system concepts with expanded weapon effectiveness for regional warfare.

Special Warfare Technology. Naval special warfare missions primarily support covert naval operations. The objective is to develop technology required to increase the combat range and effectiveness of special warfare units. The current focus is to develop technologies to enhance the Sea-Air-Land (SEAL) team mission of pre-invasion clearance of mines and obstacles in the very shallow water and surf zone approaches to the amphibious landing areas. Improvements to mission support equipment are needed to increase the probability of mission success, endurance, and SEAL team survivability.

EOD Technology. Technology development for EOD addresses the Navy's Joint Service and interagency responsibilities in EOD. These responsibilities include countering and neutralizing various mines. The new technologies being developed are practically mandatory for locating, rendering safe, and disposing of conventional and nuclear mines. EOD operations typically occur in shallow water. The technologies being developed in this area are expected to be transitioned to the Joint Services EOD Program or to the DoD Technical Response Group.

Variants/Upgrades

This section is not applicable to this report.

Program Review

Background. The US Navy conducts mine countermeasures research under PE#0602315N Mine Countermeasures, Mining, and Special Warfare Technology (originally titled Mine and Special Warfare). During FY89 the Navy demonstrated magnetic-acoustic mine detector discrimination against background noise clutter. They also completed mine burial prediction techniques and developed generalized hydrodynamics models for complex mechanical sweep systems simulations.

The Navy held TECHEVAL contractor demonstrations and began OPEVAL on the ALQ-166 in FY89. The service also began limited production of the A/N37U-1, with full-scale engineering development of the ASQ-182, and advanced acoustic system demonstrations. Efforts in the Neutralization System included environmental, safety and contractor demonstrations. Additionally, the AQS-20 underwent critical component tests.

Further development of the ALQ-166 magnetic sweep was suspended in FY90 and has not been restarted. During FY90-91, surface MCM efforts included the completion of SQQ-32 OPEVAL, shock tests and environmental tests leading to approval for full-scale production. A production SLQ-48 system underwent shock tests.

NOTE: *For additional information,* **A/N37U-1** and **SQQ-32** *are covered as separate reports.*

By the end of FY92, MCM technology development accomplishments included: prototype fabrication for minehunting demonstration; design and fabrication of moored mine Hardkill attachment device; and completion of very shallow water acoustic characterization measurements against proud (mine warfare slang for a visibly exposed mine) and buried mines to determine optimum frequency, processing, and sonar design.

Much of the activity within this program was finally declassified in FY93 when the program was restructured with greater emphasis placed on the following individual projects: Surf Zone MCM, Shallow Water MCM, Mining, and Special Warfare/EOD.

Surf Zone MCM. The Distributed Explosive Performance analytical model, including sand characterization for the line charge and Distributed Explosive Technology (DET), was completed in FY93. Other accomplishments consisted of completing a coarse rocket deployment model for predicting in-flight characteristics of DET (the model was validated by a series of rocket motor/net array deployment tests) and evaluating alternative concepts for obstacle clearance. Subscale tests above and below the waterline of the Flying Sword concept were conducted with encouraging results. An analytic model of the Flying Sword concept was also developed.

Laboratory testing was conducted during FY94 to determine the dynamic behavior of wet sand as a function of porosity and degree of saturation. Additional project efforts focused on the following: validating, testing, and transitioning DET array hydrocode development and explosive formulation to PE#0603555N Sea control and Littoral Warfare Technology Demonstration; enhancing the rocket Deployment Computer Model used to predict rocket deployment of DET; and continuing design and development of a large-scale Flying Sword warhead.

Mine vulnerability testing of available threat mines to update kill criteria and expand threat mine database was conducted during FY95. Testing efforts focused on developing a multiphase model in a coupled hydrodynamic/structural code for simulation of explosive shock propagation through wet sand. Survey techniques to accurately measure explosive shock pressures in wet sand were also developed.

The investigation for alternative DET array deployment concepts continued, as did proof-of-concepts tests for the Thunder Road deployment concept. Under the Flying Sword effort, a single-plate Explosively Formed

Projectile (EFP) technology for a surf zone environment was demonstrated. A dual-plate EFP warhead for underwater obstacle clearance was also designed. Additionally, development was started on high-speed image processing algorithms for airborne minefield reconnaissance under the Overhead Laser Image Detection and Ranging (LIDAR) technology concept. Other work focused on assessing the effectiveness of power blade technology to clear anti-invasion mines on the beach.

Mine vulnerability testing continued in FY96. Under the Standoff Deployment effort, a critical component and initial full-scale testing of Thunder road, providing an alternative approach to delivery which does not require a naval craft, was conducted. Other alternatives continued to be investigated. A full-scale underwater test of dual late EFP warhead against surf zone obstacles for Flying Sword was also slated to be conducted during this time period.

The Overhead LIDAR work planned to refine airborne laser-based image processing algorithms for detection of anti-invasion minefields in a high-clutter environment. The effort hoped to accomplish an 80 percent false alarm rate reduction. Additionally, a high frame rate camera for rapid, wide area coverage rate airborne minefield detection systems began development.

A database of mine neutralization criteria (pressure, impulse, and energy) for threat mines through testing and analysis was developed during FY97. During this period, the multiphase coupled code mode for simulation of explosive shock propagation through wet sand was to be validated and the results used to update surf zone mine neutralization analytical models. Development of improved techniques for accurate shock pressures measurements were also expected to be completed. Also in FY97, full-scale testing of Thunder Road was scheduled to be completed and the airborne image processing demonstrated.

The FY98 agenda called for establishing through precise tests and measurements the importance of relative flow between sand and mine-like targets on shock transmission and mine kill predictions in the Surf Zone. Efforts continued on expanding the database of mine neutralization criteria (pressure, impulse, energy) for threat mines through testing and analysis.

Plans for FY99 included the establishment of expanded databases on the vulnerability of mines and experimentation to determine the effects of shaped charges on varying types of surf zone mines. An attempt to investigate innovative concepts for energetic neutralization of Surf Zone mines was also planned.

<u>Shallow Water MCM</u>. Shallow water MCM development has been very active over the last few years. Past program efforts have included fabricating a polymer toroidal volume search sonar (TVSS) and a ceramic TVSS. The TVSS is effective against volume and close tethered mines, and potentially provides four times the current search rate capability. A limited capability prototype synthetic aperture sonar (SAS) was tested using multi-aspect imaging in shallow water. All mines, proud and partially buried, were detected and imaged. Data from this test will be used for continuing the design of SAS hardware and software, motion compensation, and signal processing.

Other work consisted of a successful test of the Moored Mine Hardkill concept. This eliminates the creation of a floating mine during the mechanical sweep operation and provides verification of neutralization. A broadband spark gap acoustic generator for acoustic minesweeping was demonstrated. Based on the preliminary test analysis, it appeared that the acoustic signal can be sustained and the required output level can be achieved. This will provide a small, lightweight, low-power, low-drag, acoustic influence sweep capability that is compatible with small sized platforms.

The validation of the Biot-Stoll Acoustic Penetration Model was completed. This is the only current model that accurately computes acoustic penetration at subcritical angles; an important capability for detecting buried mines. When this development is fully implemented it should improve the capability of existing and future sensor systems.

Shallow water MCM work during FY94 centered around completing towed testing of the TVSS from a small surface vessel; completing development of the experimental side-looking sonar, which includes fabrication of the arrays and a fiberglass tow body section to house them, and modifications to the sonar controller hardware and software; and demonstrating the feasibility of using a supercavitating projectile as an anti-mine munitions for rapid airborne mine clearance. Additional work included conducting oblique water entry, explosive detonation, and sand penetration tests.

TVSS was reconfigured as a helicopter dipping sonar for mine detecting/classification in shallow water in FY95, during which time a sea test of long-range side-looking sonar (SLS) for detection of bottom and close tethered mines from unmanned undersea vehicles was also conducted. Additionally, laboratory tests of shallow water and very shallow water (SW/VSW) high-resolution, option-compensated synthetic aperture aide scan sonar for detection/classification/identification of bottom mines in very shallow water were conducted as well.

Other work focused on demonstrating acoustic image processing algorithm capable of a 50 percent reduction in false alarms per target detected for anti-invasion minefields in high-clutter environments, demonstrating optical mine identification sensor in shallow water from unmanned undersea vehicles, designing experimental nitrogen-cooled superconducting gradiometer for detection/classification of buried mines, and demonstrating stable supercavitating projectile dynamics through air, oblique water entry, and underwater. The Hamlet's Cove effort to explore multi-source data fusion methods to detect obstacles, mines, and mine laying activities before hostilities was also initiated during FY95.

Additional at-sea trials of TVSS were scheduled for FY96. The Navy hopes to integrate TVSS and SLS in a small-diameter underwater vehicle. Sea tests of SW/VSW low-frequency and high-frequency Synthetic Aperture Sonar (SAS), including beamforming and motion compensation technology developments, were also planned for FY96. Additional shallow water MCM work focused on evaluating the effectiveness of using resonance signal processing algorithms (using acoustic backscatter returns from mines) for mine classification. Data fusion sea tests with a total field magnetometer and SAS on a small diameter underwater vehicle were planned as well.

Sea tests of laser-enhanced electro-optic sensors to identify sea mines in murky littoral waters were slated for FY96. Additional work in this area focused on the development of the Rapid Airborne Mine Clearance System (RAMICS) concept. During this time frame, technology issues associated with targeting and fire control for RAMICS were investigated. An integrated system-level evaluation and static demonstration of the RAMICS target acquisition, fire control, gun, and anti-mine projectile performance were conducted. Also conducted was a technical analysis regarding feasibility and effectiveness of creating focused underwater shock waves to implement standoff mine destruction.

NOTE: *For specific details on this program, please refer to the report titled* **Rapid Airborne Mine Clearance System (RAMICS)** *in the Anti-Submarine Warfare binder service.*

Fabrication of a field-deployable nitrogen-cooled superconducting gradiometer and algorithms for Hamlet's Cove were developed and evaluated; they are intended to exploit multi-source data fusion methods for obstacle and minefield surveillance.

A new effort scheduled in FY96 centered on developing a marine mammal neural network target classifier for incorporation into an acoustic response monitor. This would collect a mammal's mine detecting characteristic activities and correlate them with the location of a minefield.

At-sea trials of long-range TVSS integrated with real aperture SLS in a small-diameter underwater vehicle were on the agenda for FY97. Data fusion sea tests with integrated total field magnetometer, SAS, and electro-optic sensors on a small-diameter underwater vehicle were also planned. Fabrication of a field-deployable nitrogen-cooled superconducting gradiometer for the detection of buried mines was expected to be completed during this time frame. This was set to be followed by dockside operability testing prior to at-sea trials. Hamlet's Cove work was expected to demonstrate the capability to use multi-source data fusion by the end of the year. Development of the mammal neural network was slated to be completed as well. New concepts were planned to be developed for neutralizing mines in amphibious assault areas.

At-sea experiments to verify assessment effectiveness of a new mine destruction concept using focused underwater shock waves were also expected be conducted during FY97.

Project plans for FY98 called for developing design options to implement focused underwater shock wave generator for standoff mine neutralization, as well as the transition development and testing of anti-mine projectile for RAMICS to an Advanced Technology Transition project. Other efforts included conducting tests and analyses of target acquisition, fire control, gun, and anti-mine projectile subsystem components to predict integrated system performance.

By the end of FY99, selection of a generator design option and establishment of full-scale test for demonstration of focused underwater shock wave mine neutralization was under way. Additional efforts will also be made to initiate the development of technology to sweep pressure influence mines by focusing on the characterization of pressure signatures of surface ships in ocean swells.

<u>Mining</u>. Project activity during FY93 focused on conducting laboratory testing and evaluating work on neural network-based mine control processing algorithm. Within the span of one year (FY94), project accomplishments consisted of evaluating probability of detection and probability of false alarm for acoustic identify friend or foe (IFF) for mines, and verifying approach for an active acoustic mine to counter surface targets in shallow water by using high-frequency sonar to discriminate ships from the surface water.

The following year (FY95), project efforts concentrated on completing at-sea technology demonstrations of acoustic and electromagnetic sensors for the Littoral

Sea Mine application, as well as completing a neural network target classification algorithm for bottom mine target detecting devices.

The schedule for FY96 called for developing advanced processing techniques for detecting and localizing all surface targets, including fast patrol boats. Other efforts focused on developing reliable underwater message transmission techniques for remote control applications.

Bi-Static active target motion analysis and motion compensation models for moored Littoral Sea Mine (LSM) with low-cost mobile warheads were planned to be developed during FY97. During this time period, measurement of target advanced gradient signatures, theory and performance model development, and a feasibility decision were expected to be completed. Additional at-sea experiments to verify assessment effectiveness of new mine destruction concept using focused underwater shock waves were scheduled to be conducted.

Mining efforts for FY98 called for developing DADS mobile shallow water mines concept and a covert deployment concept based upon SLMM. Additional development work focused on guidance sensors and signal processing for DADS mobile shallow water mines. The Mine Field Command and Control project was slated to develop a concept for command and control of DADS weapons, as well as assessing the incorporation of prior year development of IFF and RECO into DADS. Development concept for intra-field guidance of DADS weapons after launch using node and weapon sensors were also explored.

Efforts undertaken in FY99 focused on developing hardware and software to demonstrate feasibility of DADS weapon concept in the area of Intelligent Mine Network. Guidance sensors and signal processing for DADS weapons were be tested, and a simulation for testing the command and control of DADS weapons was conducted. An examination of shallow water bottom mines was initiated in an assessment of the application of sensors and command and control concepts development in prior years. As in previous years much efforts was placed in developing and enhancing the C4 network that monitors and controls minelaying operation.

<u>Special Warfare/EOD</u>. A great deal of the Special Warfare effort remains classified; however, beginning in FY93, the Navy began to make some of its accomplishments known in the hope of deterring potential adversaries by the sheer existence of overwhelming technology. Project advancements during FY93 included: collecting water-entry load and acceleration data for SEAL teams; developing robotic serpentine manipulator with end effectors for safer EOD examination and identification of explosive devices; developing micro mechanical hydrophone array for acoustic imaging; transitioning oxygen sensor technology to product improvement program for the Mk 16 Underwater Breathing Apparatus; and transitioning diver-held acoustic lens technology to the program management office for use in the development of a new EOD diver hand-held sonar. Acoustic lens technology will provide a high spatial resolution sensor that has all the salient features required by a diver engaged in the neutralization of underwater explosive ordnance in highly turbid waters.

By FY94, development had reached the level of incorporating real-time correlator with hand-held sonar for improved mine detection in very shallow water, as well as the demonstration of several classified MCM technologies.

While much of the FY95 special warfare activity was still classified, known work included the following: conducting laboratory tests of prototype clandestine underwater electro-optic imaging system for mine identification; developing a prototype diver rebreather incorporating a carbon dioxide separator; conducting laboratory tests of shock mitigation technology components for Naval Special Warfare high-speed boats; testing and transitioning autonomous work package for EOD underwater vehicle containing controller, navigation, and target classification sections; and demonstrating diver hand-held imaging sonar capability for very shallow water operations.

Mission mobility technology was scheduled to be tested and demonstrated using a full-scale Naval Special Warfare (NSW) high-speed boat hock mitigation system in FY96. A prototype near UV imaging system for mine detection was expected to be completed before the end of the period. A portable multi-spectral reconnaissance imager using an optical parametric amplifier laser, and an NSW with underwater standoff obstacle clearance capability, started development. Other work concentrated on responses to Improvised Explosive Devices/Special Improvised Explosive Devices (IED/SIED) incidents through providing real-time, high-resolution images of underwater targets using high-frequency acoustics, assessing robotic arm performance, and demonstrating the ability to remove unexploded ordinances (UXO) from areas using subsumptive robotic techniques.

The agenda for FY97 called for completing and transitioning high-speed boat shock mitigation systems, the portable multi-spectral imager prototype, and demonstrating NSW underwater standoff obstacle clearance capability. A laboratory demonstration of method for identifying underwater SIEDs through use of biological sensor to recognize secondary emissions was also slated to be conducted, as was a demonstration of standoff method for making safe electronically-safed/ armed fusing. Additional laboratory experiments to identify environmentally safe methods for disposal of explosives in field environments were planned as well. The prototype UV imaging system for mine identification was scheduled to be integrated and demonstrated during FY97.

Other efforts on the agenda included development of a two-kilowatt laser diode stack for the neutralization of surface unexploded ordnance. A 10,000-element high-frequency acoustic imaging array to provide centimeter resolution images in turbid water environment at a 20-frame-per-second rate was to be tested. Experiments with a pulsed electro-magnetic induction technique for detecting and classifying buried and deeply buried unexploded ordnance were also planned.

The agenda for FY98 focused on completing the development of components of low signature diver propulsion system and integrating, testing and evaluating prototype with the transition of technology for incorporating micro Phase Change Materials into dive suits for passive, thermal protection. Mission Support Technology centered on fabricating, evaluating, and demonstrating prototype of passive multi-spectral optical parametric amplification laser imager with a field test of the sensor. This cumulated with a transitioning of the clandestine ultra short range gage laser technology for underwater obstacle localization and identification.

Eforts undertaken during FY99 were directed towards the development of low signature diver propulsion technology and the development of NSW signature reduction technologies. Mission support technology development were conducted through integrating sensors into a diver-portable multisensor buried mine-hunter prototype and evaluated and demonstrated under realistic field conditions. Transition of multi-spectral optical parametric amplification laser imaging technology were scheduled to take place during this time.

The changing tenor of the times was underlined by efforts aimed towards the development and testing of an analysis sensor. This sensor was intended to detect and localize the use of a Weapon of Mass Destruction (WMD) within the maritime environment. Other than the fact that they have occurred, additional efforts in this area remain classified. However, it has been revealed that efforts during FY00 and subsequently will be expanded to cover studies of the interaction between radiation and sea water; a suggestion that the possibility of facing nuclear mines is now taken seriously.

Testing. In May 1997, the US Navy announced testing of Australia Defence Industries (ADI) Dyad Influence Minesweep systems was a success. The Dyad Influence Minesweep uses dyad technology similar to the ADI Minesweeping and Support System (AMASS) currently in service with the Royal Australian Navy and a number of other countries. The US Navy's Coastal System Station in Panama City, Florida, conducted the test and evaluation over a ten-month period as part of the Foreign Comparative Test Program. Tests were conducted in the Gulf of Mexico as a simulation to meet the Navy's requirement for such a system. Deployed in a distributed array to sweep sophisticated mines, dyads are buoyant, permanently magnetized cylinders. The evaluation tests were conducted with high-speed surface craft making sweeps consisting of dyads and the Mk 104 acoustic sweep towed at high speeds over a minefield that included the Versatile Exercise Mine System.

Funding

US FUNDING

	FY98		FY99		FY00 (Req)		FY01 (Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E US Navy PE#0602315N MCM, Mining, & Special Warfare Technology(a)	-	35.2	-	45.5	-	45.0	-	51.0

	FY02 (Req)		FY03 (Req)		FY04 (Req)		FY05 (Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E US Navy PE#0602315N MCM, Mining, & Special Warfare Technology	-	52.1	-	53.3	-	54.5	-	55.8

All $ are in millions.

Source: US Department of Defense FY1998/1999 Biennial RDT&E Descriptive Summary

[a]FY1995 decrease resulted from reduced program requirements. FY1996 change resulted in a reduction for the Jordanian F-16 financing recession. The FY1997 increase resulted from congressional plus-up for Lithium Battery Technology and from congressional undistributed reductions. The FY1998 decrease was due to NWCF and minor adjustments and from inflation adjustment. The FY1999 reduction resulted from NWCF and minor adjustments, and transferred from this PE to Advanced Technology Demonstrations PE to fund higher Navy priorities, and from inflation adjustment.

Recent Contracts

While many of these research and development programs are not fully classified, much of the information pertaining to them, including contracts, is heavily censored and difficult to determine. The following contracts are most likely involved with this particular program to some degree:

Contractor	Award ($ millions)	Date/Description
Westinghouse	12.5	Aug 1994 — Contract for a Near-term Mine Reconnaissance system (NMRS) and demonstration. (N00024-94-C-6168)
Loral Federal	5.1	Sep 1994 — Modification to previously awarded contract N66604-92-C-0196 for an additional receiver system inboard processing subsystem for the Advanced Mine Detection System. (N66604-92-C-0196)
Harrop Construction	6.7	Nov 1994 — FFP contract for construction of a Fleet Mine Warfare Center at the Ingleside Naval Station, Texas. (N62467-94-C-0679)

Contractor	Award ($ millions)	Date/Description
Westinghouse	43.4	Feb 1995 — CPAF contract for the Near-term Mine Reconnaissance System operational prototype. (This amount includes $12.5 million previously announced for a maximum priced contract.) Contract was expected to be completed by January 1998. (N00024-94-C-6168)
Applied Research Lab	47.8	Feb 1995 — A modification to a previously awarded contract for mine warfare, fire control, undersea countermeasures, coastal/special warfare, and communications research and development. (N00039-91-C-0082)
Alliant Techsystems	7.4	Aug 1995 — FFP contract for a Forward Area Combined Degaussing and Acoustic Range (FACDAR). The FACDAR is designed to analyze mine countermeasure capabilities of the US Navy by determining whether Navy ships meet magnetic signature requirements, and to analyze the vulnerability of ships to mines. Contract completed May 1997. (N00167-95-D-4010)
Lockheed Martin	11.9	Aug 1996 — A CPAF contract for engineering and manufacturing development of the Remote Minehunting System (RMS) (V) 3 which uses acoustic sensors to detect, classify, and localize mine-like objects and will be capable of over-the-horizon operations. Contract is expected to be completed by September 2001. (N00024-96-C-6322)
EDO	8.1	Jul 1996 — FPI contract for two Mk 105 Mod 4 Magnetic Minesweeping system upgrade kits and engineering services. Contract was expected to be completed by August 1998. (N00024-96-C-6332)
ARINC/Annapolis	16.6	May 1997 — CPFF contract for MCM engineering support services. Contract is expected to be completed by May 2002. (N61331-97-D-0031)
Hughes	12.5	Sep 1997 — CPFF contract for RAMICS for the advanced technology development program. Contract is expected to be completed by September 2000. (N61331-97-C-0046)
Northrop Grumman	9.5	Oct 1997 — Modification to previously awarded contract for the follow-on procurement of the detailed design for the Long-Term Mine Reconnaissance system and related data. Contract is expected to be completed by August 1999. (N00024-96-C-6121)
Boeing	9.8	Oct 1997 — Modification to previously awarded contract for the follow-on procurement of the detailed design for the Long-Term Mine Reconnaissance System and related data. Work is expected to be completed by August 1999. (N00024-96-C-6122)
Arete Associates	7.8	Dec 1997 — CPFF contract for the development of a ruggedized version of the Streak Tube Imaging LIDAR (STIL) for mine identification. Contract is expected to be completed by January 2001. (N00014-88-C-0006)

Timetable

Year	Major Development
FY89	AQS-20 began critical components evaluation; SQQ-32 OPEVAL completed
FY90	Completed SSN-2 software code and test Phase III; ALQ-166 work suspended
1990	Magic Lantern deployed to Gulf for tests
1992	Magic Lantern ML-90 engineering models delivered to Navy
1992	Awarded A/N37U-1 engineering & manufacturing development contract
FY93	Awarded A/A25E-24 engineering & manufacturing development contract; awarded contract for advanced development model for Buried Mine Detection System; Modular Influence Minesweeping System (MIMS) Milestone IIIA approval scheduled; Single Ship Deep Sweep Milestone III approval; developed TVSS model
1995	SQQ-32 Milestone III approval; conducted at-sea testing of shallow water and very shallow water high-resolution side-scan sonar, and developed underwater diver rebreathing apparatus for those working on underwater EOD
1996	Magic Lantern Advanced EMD procured by US Navy
1997	AQS-20 development terminated with FY99 budget
1998	Buried Mine Detection System Milestone II approval scheduled

Worldwide Distribution

This **US Navy** program adheres to the US Tri-Service Reliance Agreements on EOD, with coordination provided by the Joint Directors of Laboratories. Other selected mine warfare technology issues are coordinated with efforts addressed by the Mine Warfare Panel of the Technical Cooperation Program with Australia, Canada, New Zealand, and the United Kingdom. Coordination is also maintained with data exchange arrangements involving Italy, France, Denmark, the Netherlands, Germany, Norway, Spain, Belgium, South Korea, and Japan.

Forecast Rationale

Combating mines in shallow water continues to be one of the most difficult problems faced by sea forces around the world. This situation is unlikely to change in the near future and shallow water mines will remain a serious threat to littoral naval operations. This ever-present danger demands that better mine detection and disposal technologies must continue to be developed.

New technology is also needed to facilitate suppression of modern submarines like the Russian Kilos and the German Type 209s now in the hands of several Third World nations. These subs are quite capable of laying mines in littoral areas for both offensive and defensive missions.

Current technology emphasis is on sensors, mine delivery and advanced minefield concepts. In the area of MCM, emphasis is being placed on the detection and neutralization of mines, especially in the shallow water area. A new aspect with unpleasant implications is the growing attention being paid to weapons of mass destruction as payloads for shallow-water mines. This includes consideration of the special dangers of nuclear-tipped mines. An early form of strategic weapons, these were considered to be an especial threat to port and harbor facilities in the 1950s.

Notable attention has been paid to special warfare technology. US Naval special warfare missions are primarily clandestine in character. They support naval operations by: reconnaissance and clearing of amphibious landing beaches; underwater attacks against enemy shipping and port installations; raids against targets in coastal areas; intelligence collection through reconnaissance and capture of personnel; and counter-terrorism with emphasis on recovery of captured ships and aircraft. The principal special warfare goal is to develop technology required to increase the combat range and effectiveness of units such as the US Navy SEALs.

The Navy, in its effort to combat the growing use of mines and, indeed, mine warfare technology, has launched an aggressive campaign of research and development to contend with the problem of locating, identifying, and neutralizing mines in all kinds of ocean conditions, from deep water to beachheads.

Funding for the US Navy's Mine Countermeasures, Mining and Special Wafare Technology program is expected to increase from US$45 million to a possible US$55 million throughout the forecast period until the US Navy brings these areas up to efficient combat readiness – which may take some time, since mine warfare was not a high priority in the past.

NOTE: *Funding totals begin with the year 1989, when the US Navy started to re-evaluate its mine warfare and MCM capabilities, and began to invest considerable money into research and development. Prior to this period, funding was nominal.*

Ten-Year Outlook

ESTIMATED CALENDAR YEAR FUNDING ($ in millions)

			High Confidence Level				Good Confidence Level			Speculative			
Designation	**Application**	**Thru 99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**Total 00-09**
MCM TECHNOLOGY	MINE WARFARE TECHNOLOGY DEVELOPMENT (US NAVY)	339.300	45.000	51.000	52.100	53.300	54.500	55.800	56.000	56.000	55.000	55.000	533.700