Naval Ocean Systems Center
San Diego, CA 92152-5000

(4)

DTIC FILE COPY

Technical Document 1448
November 1988

NOSC and Remotely Operated Vehicles (ROVs) and Autonomous Unmanned Vehicles (AUVs)

AD-A203 356

I. P. Lemaire

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152-5000

E. G. SCHWEIZER, CAPT, USN
Commander

R. M. HILLYER
Technical Director

ADMINISTRATIVE INFORMATION

This document was produced with in-house funds by Code 90 of the Naval Ocean Systems Center.

Released under authority of
I. P. Lemaire, Head
Engineering and Computer
Sciences Department

JJ

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NOSC TD 1448	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Ocean Systems Center 6b. OFFICE SYMBOL (if applicable) NOSC	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) San Diego, CA 92152-5000	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Ocean Systems Center 8b. OFFICE SYMBOL (if applicable) NOSC	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code) San Diego, CA 92152-5000	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	AGENCY ACCESSION NO.
In-house			

11. TITLE (include Security Classification)

NOSC AND REMOTELY OPERATED VEHICLES (ROVs) AND AUTONOMOUS UNMANNED VEHICLES (AUVs)

12. PERSONAL AUTHOR(S)

I. P. Lemaire

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM Oct 1988 TO Oct 1988	November 1988	9

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Remotely Operated Vehicles (ROVs)
Autonomous Unmanned Vehicles (AUVs)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This article briefly reviews the Naval Ocean Systems Center's (NOSC) ROV/AUV program and gives a glimpse of NOSC's present development efforts in hopes that developers within government and industry will take advantage of our expertise and achievements in deep-ocean engineering.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE PERSON I. P. Lemaire	22b. TELEPHONE (include Area Code) (619) 553-3900 22c OFFICE SYMBOL Code 90

DD FORM 1473, 84 JAN

83 APR EDITION MAY BE USED UNTIL EXHAUSTED
ALL OTHER EDITIONS ARE OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

Naval Ocean Systems Center
San Diego, California 92152-5000

NOSC

NOSC AND REMOTELY OPERATED VEHICLES (ROVs) AND AUTONOMOUS UNMANNED VEHICLES (AUVs)

INTRODUCTION

As the lead Navy laboratory in deep-ocean engineering, one of NOSC's principal responsibilities involves developing the systems needed by the Navy to perform Fleet missions down to great ocean depths. These operations include finding, surveying, recovering, and repairing objects underwater. The systems used for this are test-bed Remotely Operated Vehicles (ROVs) and Autonomous Unmanned Vehicles (AUVs)—sometimes jointly called Unmanned Undersea Vehicles (UUVs)—and are employed to advance deep-ocean technology, which is another NOSC responsibility. (NOSC also develops other unmanned vehicles for carrying out principal Navy missions; for example, mine neutralization.) The ROVs and AUVs have been developed for such host platforms as submarines, aircraft (helicopters), and surface ships. Over the past 26 years, the Center has developed 21 unmanned vehicles in-house. Additionally, ocean engineering has conducted applied research in marine materials (metals, plastics, and composites), as well as in acoustic and fiber optic communications links.

This article briefly reviews the Center's ROV/AUV program and gives a glimpse of NOSC's present development efforts in hopes that developers within government and industry will take advantage of our expertise and achievements in deep-ocean engineering.

HISTORY

Organizations that preceded NOSC pioneered important work in ocean engineering. For example, NEL concentrated on supporting the early generation of manned submersibles (TRIESTE and DEEPSTAR), while NOTS was concerned with operating underwater missile ranges off Long Beach and San Clemente Island. NOSC's involvement in ocean engineering, described in the following paragraphs, stemmed from these activities.

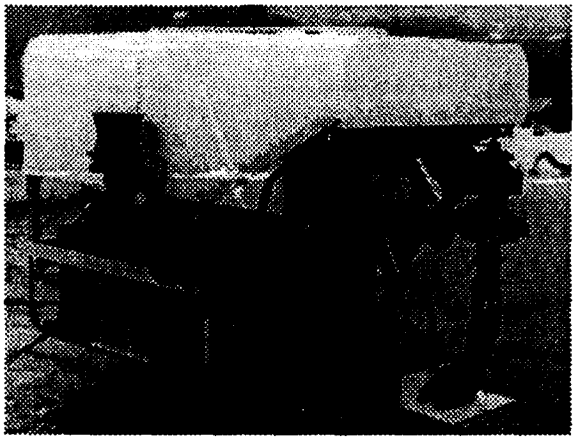
Cable-Controlled Underwater Recovery Vehicle (CURV)

(SDW)

Cable-Controlled Underwater Recovery Vehicle (CURV III)

During the early 1960s, NOTS engineers developed the Navy's first ROV, CURV, which, by 1965, could retrieve sunken ordnance from depths of 800 feet. CURV, a surface-powered, cable-controlled, underwater system that integrated TV, sonar, still cameras, and a variety of manipulators and grabbers, successfully validated the concept of an underwater work system. Successive versions of CURV could reach even greater depths (ultimately, 10,000 feet) and perform additional, more complex missions. Due to its air-transportability, CURV I was used to recover the H-bomb lost off Palomares, Spain, in 1966; and CURV III was used to rescue the operators of the bottomed PISCES IV manned submersible off Ireland in 1973. NOSC supported CURV III for the Supervisor of Salvage until FY 85, when the system became part of the salvage equipment pool. Presently, NOSC operates a modernized CURV II to recover expended test ordnance in the San Diego/San Clemente Island area.

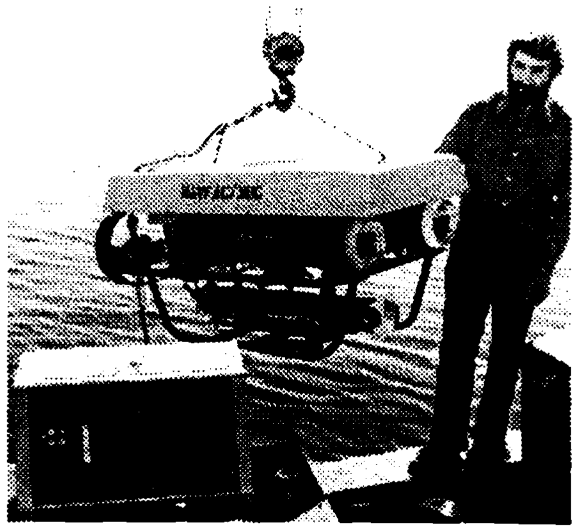
Remote Unmanned Work System (RUWS)/Advanced Tethered Vehicle (ATV)



Advanced Tethered Vehicle (ATV)

NOSC engineers in Hawaii have pursued extending cable-powered ROV work systems for deep-ocean operations. Initial work on RUWS began in 1968, culminating in a series of successful demonstration dives in the mid-1970s. This initial work required advances in cables, connectors, work systems, and teleoperator and telemetry technology; and was followed by the present-day ATV development. During 1985, the ATV completed a series of test dives off Hawaii, reaching depths of 12,000 feet. The ATV system is considerably lighter than the RUWS and can be transported by C-130 aircraft. Instead of the conventional metal conductor cable* used on RUWS, the ATV cable incorporates fiber optic elements for transmitting data—and command and control signals. Unlike RUWS, which was used strictly as a test bed, the ATV will be further developed and tested, and will become operational in the Fleet during 1989/1990.

Small Inspection and Light Work Vehicles



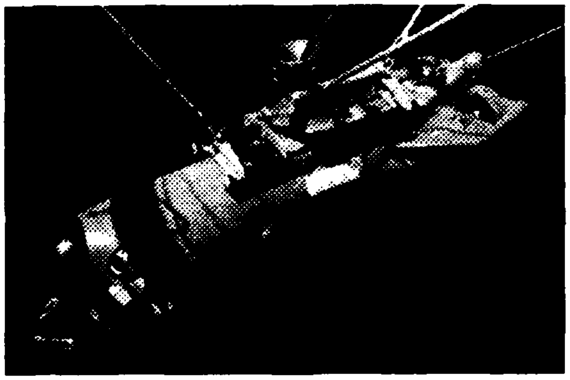
NAVFAC SNOOPY

Concurrent with the development of RUWS, NOSC pioneered the development of a series of small, light work and inspection vehicles for use in shallow waters. These vehicles were needed for simpler, shallower tasks, for which the large CURV/RUWS type machines proved too cumbersome or expensive.

The SNOOPY series of small ROVs started in 1970 with the original SNOOPY, essentially a swimming TV camera, that could dive to 200 feet and inspect and recover small objects. Subsequently, the more capable Electric SNOOPY could operate to 1500 feet; and finally, NAVFAC SNOOPY, completed in 1978, included a small scanning sonar system and was delivered to the Naval Facilities Engineering Command (NAVFAC) for use in their construction work.

* However, this cable, itself, was a breakthrough development in using Kevlar as a strength member.

Mine Neutralization System (MNS)

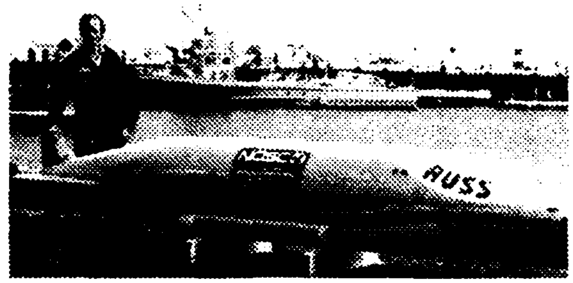


Mine Neutralization System (MNS)

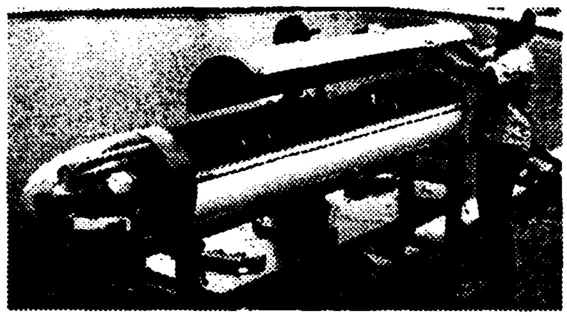
In 1971, NOSC demonstrated with CURV and SNOOPY that a cable-controlled vehicle could be used for mine inspection and neutralization. Commencing in 1972, NOSC engineers designed and built, in-house, the Advanced Development Model (ADM) of the MNS. This effort culminated in 1977 with the successful completion of deep-water OPASSIST testing from a fleet minesweeper (USS *Pluck*) off St. Croix, VI. The ADM design data, together with valuable at-sea experience, was incorporated into a NAVSEA procurement package for the ensuing competitively procured Engineering Development Model (EDM). NOSC was named Technical Direction Agent to oversee the contractors. TECH/OPEVAL was successfully completed in 1982, and a production contract was awarded a year later. Presently, 14 systems (including 27 vehicles) of this unique, militarized ROV system are being delivered for installation on all of the new class mine-countermeasures ships (MCM and MHC).

Free-Swimming Vehicles

NOSC recognized in the mid to late 1970s that surface-powered ROVs had limitations caused by the cable itself. The newly emerging artificial intelligence and robotics technologies, coupled with advances in component miniaturization, led to the development of free-swimming ROVs, also known as Autonomous Unmanned Vehicles (AUVs). The Experimental Autonomous Vehicle (EAVE) West, developed originally as a shallow-water test bed for the Mineral Management Service (formerly part of the U.S. Geological Survey) is now a test bed for Navy projects and is known as the Free Swimmer (FS). This AUV is used to investigate advanced communications links (e.g., expendable fiber optic microcable); onboard computer architectures aimed at providing autonomy; mechanical configurations; and incorporation of state-of-the-art sensors.



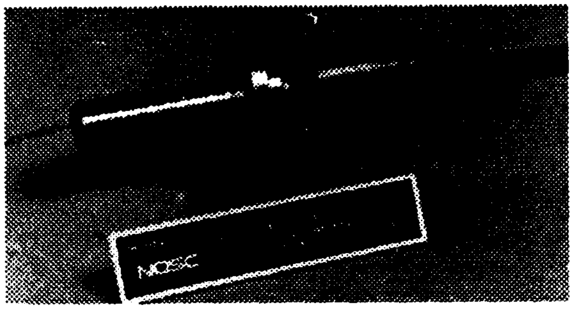
Advanced Unmanned Search System (AUSS)



Free-Swimming AUV

As a companion system to the ATV, NOSC is developing the Advanced Unmanned Search System (AUSS). This unique, acoustically controlled free-swimming vehicle system will search the deep-ocean sea floor and, perhaps, someday replace the heavier and slower surface-towed search systems. This advanced-technology AUSS is undergoing extensive at-sea testing and, if proven successful, will become operational in the early 1990s.

SUPPORTING TECHNOLOGY



Optical Connector

In addition to the UUV systems development just discussed, Center scientists and engineers have made significant contributions and hold many patents in related technologies. Some noteworthy examples include: head-coupled TV; stereo-TV; hydraulic and electric drive manipulators; cable-cutters and other tools; fiber optic microcable and winding techniques; pressure-resistant optical connectors; acoustic underwater communication links; oil-filled cable harnesses; launch and recovery systems; Kevlar used as a cable strength member; graphite composite and ceramic housings; supervisory-controlled computer architectures; and sensors for acoustic links.

TRANSITION

For nearly 30 years, NOSC has prosecuted the development of a variety of unmanned undersea vehicles. Throughout this period, considerable effort has been devoted to ensuring timely technology transfer to industry and academia. Industry incorporated much of the early work on the heavy work vehicles into systems designed for offshore oil field support (e.g., oil-filled cable assemblies, tether management, vehicle layout, and so on). Likewise, the burgeoning commercial unmanned vehicle industry has incorporated the Kevlar and fiber optic cable technology and remote presence systems, pioneered by the Center. And, of course, successfully completing the advanced development model of the MNS resulted in totally disclosing the NOSC design for the succeeding competitive procurement of the engineering development models and present day production system. Today's proliferation of smaller vehicles also had its beginnings at the Center, and much of the current work on ATV, AUSS, and FS is also anticipated to be adopted by industry. Close technical liaison with United States and foreign vehicle developers is maintained by active involvement and leadership in several technical societies, most notably the Marine Technology Society (MTS). The highly successful series of ROV conferences (held in San Diego and foreign cities on alternate years) are heavily supported by Center employees. This involvement ensures maximum data exchange and enables NOSC engineers and scientists to remain current in this rapidly evolving area.

TESTING

NOSC, by virtue of its location on Point Loma, San Diego, has excellent year-round at-sea test facilities. Ships with special equipment are used for testing UUVs off the southern California coast and at San Clemente Island. In addition to the extensive at-sea testing support, the Center has machining and welding shops, as well as environmental test facilities.

CONCLUSION

NOSC has an 80-person Division dedicated to ocean engineering, plus an additional 15 ocean engineers in Hawaii. This is the largest Navy laboratory group engaged in ROV/AUV development, test, and evaluation. NOSC's commitment to continuing "hands-on" ocean engineering development assignments, through in-house and DoD sponsor funding, assures the Navy of capable, unbiased engineering expertise in the important and rapidly growing UUV area.

For further information, please contact either Mr. Norm Estabrook at (619) 553-1862 or Mr. Ivor Lemaire at (619) 553-3900.

October 1988