



Calhoun: The NPS Institutional Archive
DSpace Repository

Institutional Publications

Institutional Publications (Other)

1995-04

Mine Lines topics in the art of mine warfare,
awareness precedes preparedness, Vol. 2, No.
2, April 1995

Naval Postgraduate School (U.S.)

Monterey, California: Naval Postgraduate School.

<http://hdl.handle.net/10945/44488>

Downloaded from NPS Archive: Calhoun



Calhoun is a project of the Dudley Knox Library at NPS, furthering the precepts and goals of open government and government transparency. All information contained herein has been approved for release by the NPS Public Affairs Officer.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

<http://www.nps.edu/library>

MINE LINES
 TOPICS IN THE ART OF MINE WARFARE
 Awareness Precedes Preparedness

Vol 2, No. 2

April, 1995

Published at the U.S. Naval Postgraduate School, Monterey, CA 93943
 to Enhance Communication about Mine Warfare

- [Quick-Look Summary of April Symposium](#)
- [Too Many Munitions, Not Enough Time - Chris O Donnell](#)
- [Formation of the Mine Warfare Association](#)

TECHNICAL SYMPOSIUM ON AUTONOMOUS VEHICLES IN MINE WARFARE
 APRIL 4-7, 1995

MINE WARFARE ASSOCIATION (MINWARA)
 ORGANIZED TO PROMOTE EDUCATION AND AWARENESS
 ABOUT MINE WARFARE AND RELATED TOPICS

SYMPOSIUM A
 RESOUNDING SUCCESS

WATCH THESE PAGES
 FOR FOLLOW-UP ACTIVITIES

The content of the discussions at the symposium left little doubt that the entire spectrum of activities that involve dealing with hazardous materials and environments is one that is very appropriate for robotic applications. A major purpose of the symposium was to demonstrate the similarities of the technical problems that arise in civilian as well as military applications. Identification of common areas of interest and common needs for solutions is a first step in organizing focussed funding that crosses Federal Agency jurisdictional lines.

THREAT NOTE

IRAN HAS OBTAINED A VERSION OF THE RUSSIAN "RISING MINE" AND THUS HAS A DEEP-WATER MINING CAPABILITY EMERGING.

CHALLENGE TO THE SYMPOSIUM

This symposium took the form of a top-down design review to lay out prescriptive actions required to bring autonomous vehicles into operational use in mine countermeasures applications by the year 2000. The vision is to field a family (or families) of affordable units (about \$5000 per unit in production quantities of 100,000).

DESIRED OUTCOMES
 FOR SYMPOSIUM REACHED

TECHNOLOGIES ARE WITHIN GRASP;
 COMMAND ATTENTION AND
 FUNDING STABILITY NECESSARY;
 CHOICES ABOUND

For each class of autonomous vehicle - airborne, land mobile (rolling, tracked, walking), amphibious and in-water crawler or walker, and swimming on or in the water - the technical sessions identified the developments that, if achieved, will make possible the fulfillment of the vision. In identifying the requisite developments, the technical sessions were as prescriptive as possible in enumerating necessary steps, pacing areas of knowledge, and possible developmental time lines (assuming adequate and stable funding).

Tethered and teleoperated vehicles are the zeroeth generation. Such vehicles can also be extremely useful as test beds. Any mission-capable autonomous vehicle that can be obtained in quantity by the year 2000 is a member of the first generation of such vehicles. It is not necessary for the vehicles to do all of the tasks associated with mine countermeasures. The operational tasks are reconnaissance, classification and identification, marking, neutralization (destruction or disarming), and physical removal. These tasks have analogous applications in the remediation of areas contaminated with chemical, biological, or radiological materials or areas containing unexploded ordnance.

ACKNOWLEDGEMENTS

Every individual and organization who attended or supported the preparations for this symposium deserves our thanks. This includes many who, though unable to attend themselves, passed the word to others who did attend.

Both the Vice Chairman of the Joint Chiefs of Staff, ADM William A. Owens, USN, and the Chief of Naval Operations, ADM Jeremy M. (Mike) Boorda, USN, expressed their early interest and support for the objectives of the Symposium. The press of duties prevented both from attending.

Thus, we are extremely grateful to the former Commandant of the Marine Corps, GEN Alfred M. Gray, USMC, for stepping in as featured speaker.

The distinguished military and civilian officials provided thrust and contexts for the symposium as well as providing that sense of urgency so necessary to overcoming setbacks and funding uncertainties. Similarly, our guests from Europe and the Pacific Rim enriched the discussions and underscored the world-wide nature of the mine problems. The Session Chairs and Co-Chairs, the Invited Speakers, and those contributing papers provided the working substance of the symposium.

The U.S. Navy provided some display mines and a visit by an MCM Helicopter. Mr. Chick Mixter of EOD World Services, Inc., provided a display of anti-personnel and vehicle mines from Kuwait. There were several displays/demonstrations of robots under development as well as video presentations of land systems under Army-Marine Corps-Air Force consideration, notably the JAMC and the Clausen Power Blade.

Without the support of the Office of Naval Research, the Marine Corps Systems Command, and the Navy's Mine Warfare Command, as well as the outstanding support of the Naval Postgraduate School Superintendent, Faculty, and Staff. It is particularly appropriate to recognize the outstanding efforts of LCDR Howard Bayless, USN, for his meticulous attention to the details and needs of the symposium and its participants.

SYMPOSIUM PROCEEDINGS

Symposium PROCEEDINGS will be mailed in May to all registrants. Additional copies at \$50 will be available to those desiring them. Names, affiliations, addresses, and e-mail information will be provided for all registrants.

MINE LINES

This issue of MINE LINES goes to the whole symposium mailing list. Future issues can go only to those who are paid members of MINWARA (The Mine Warfare Association) as this must be a revenue-neutral activity.

TOO MANY MUNITIONS, NOT ENOUGH TIME
CHRIS O DONNELL
TECHNOLOGY PROGRAM MANAGER
NAVAL EXPLOSIVE ORDNANCE DISPOSAL
TECHNOLOGY DIVISION, INDIAN HEAD, MD

The advent of Improved Conventional Munition (ICM) systems; MLRS, Rockeye, etc., have greatly complicated the job of the Explosive Ordnance Disposal (EOD) Technician. Standard EOD blow-in-place or render safe techniques designed for one man, one munition operations are no longer operationally effective. An 8 man team can clear approximately 150 ICMs in an 8 hour period. A more expedient method is picking-up-and-carrying-away (PUCA). PUCA provides a rate of 250 ICMs a day but is a much more dangerous operation, due to the sensitivity and unknown state of the ICM duds. Accidents during PUCA operations involving ICM have resulted in the deaths of a number of EOD Technicians in the last few years. Two promising techniques for the clearance of surface scattered ICM are high power lasers and subsumptive robotics. The laser speeds the render safe operation, while the robotics eliminates the risk to the EOD Technician associated with PUCA.

The Air Base Operability Office at Eglin Air Force Base has been developing a two kilowatt laser system based on an armored personnel carrier (APC) for rendering safe ICM from a distance of up to 250 meters. The laser beam causes a localized heating of the munition casing and main charge. The heating of the main charge causes a low order detonation or deflagration which fractures the heated and weakened case. This procedure can be accomplished in ten to thirty seconds for ICMs.

EOD Technicians around the world have used remotely operated robotic vehicles for rendering safe terrorist devices for many years. These platforms are designed for standard surface EOD missions to render safe one device at a time. The speed, cost (\$50K+) and operator interface for these systems do not allow the EOD Technician to clear the large numbers and areas contaminated by ICM. . An operationally effective means for robotically removing the technician from the hazards associated with PUCA is the use of a number of small, single tasks robots. A Basic Unexploded Ordnance Gatherer (BUG) based on subsumptive control principals can be used to perform the PUCA task for a large number of ICM. The BUG would be guided to the general area of the munition by either a pinger dropped by an EOD Technician or by a local navigation network. Position of the munitions in the local navigation network can be determined by a EOD Technician or a separate reconnaissance platform. The BUG would carry the ICM to a predetermined location for disposal. The BUGs would work together as a group of 5 to 10 robots.

QUICK-LOOK SUMMARY
AN OVERVIEW OF THE SYMPOSIUM

Awesome was the expression repeatedly employed to describe the arrays of technology, the varieties of approaches, and the magnitude of the mine countermeasures/humanitarian demining problems that confront the U.S. and its allies. All involved with the symposium recognize the urgency of the tasks, the many technological opportunities that are available now, in the near term, and that are emerging for the mid-term. The practical result of recognition that there are no "silver bullets" is the recognition that

technologies are within grasp for tethered, teleoperated, and autonomous systems applications in operational "niche" environments. Man is at last learning from nature and from the analogies with biological systems.

In vitiating minefields, objectives are to map the extent of the dangerous areas, to avoid of mines and minefields, assault breaching of the minefields that cannot be avoided, and demining of mined areas. In the contexts of military operations time is a dominant consideration; in humanitarian demining contexts the challenge is to devise affordable approaches that result in assurance that the mine risks have been removed. The tasks of mine countermeasures are minefield reconnaissance; the detection, discrimination, and identification of objects as mines; marking the contacts for revisit or avoidance; and actions such as leaving a destructive charge, recovery, or rendering safe (in situ disassembly).

The objective is to reduce or remove the hazard to the human.

The "tool chest" of mine countermeasures includes Specialized People and their support; Heavy Construction Elements such as Seabees and Army/Marine Combat Engineers; and (futuristically) a remotely operated/autonomous vehicle brigade that might include in various proportions Air Assets, Surface (land) Assets; and Assets capable of operating in the water environments. These environmental "niches" are conjointly considered with the developmental epochs (present, near-term, and mid-term) to define the acquisition windows of opportunity. Adoption of the concepts of evolutionary acquisition assures capabilities growth in each of the niches.

Defining a conceptual Autonomous MCM Company provides a means of classifying potential candidate systems that were offered in the Technical Sessions of the Symposium. Such definition also permits identification of holes in the desired or needed capabilities package. The analogy is with an Infantry Company. The privates/scouts are units with limited capabilities. Squad leader corporal/specialist autonomous vehicles may have greater capabilities (sensor packages, etc) for object identification, marking, or other tasks.

In the mid-term or far-term one can imagine carrying the analogy with a company or battalion still further with classes of supervisory/communications/reporting/controlling robotic elements that might correspond to sergeants and officer robotics vehicles. Conceptually, human override is possible at every step, "man-in-loop" . In loop but not at the point!

Findings: For each of the environmental niches and domains (air, land, in and under the water, and for the surf zone) and for each of the epochs (present, near-term, and mid-term) there exist candidate vehicles, sensors, control and navigation techniques, some mission work packages, and power packs. Present and near-term vehicles are tethered or teleoperated; growth to semi- or total autonomous (rule-based or programmed) operation appears feasible. The unit costs range, potentially, from several hundred to several hundred thousand dollars with the more expensive vehicle and mission sets having correspondingly greater capabilities. There appears to be a rich menu of sensors; however, size and power requirements may rule out some applications.

In the class of land/surf zone/ estuarine environments rakes, plows, and a novel device, the Clausen Power Blade provide some immediately available approaches. The same statements are true for airborne reconnaissance and detection packages. There are several potential approaches to vehicle/sensor/mission packages for use in deep, shallow, and very shallow water. Throughout the present and near term power sources will limit independent vehicle endurance. The papers presented at this symposium indicate that there is sufficient information to develop at least one

Advanced Technology Concept Demonstration (Phase III) for domains of high interest.

Prescriptive Actions:

- * Form Working Group(s) to develop Phase III ACTD (COMINEWARCOM)
- * Identify Planning Groups to develop Workshops and Session Plans for Fall 1996 Mine Warfare Symposium.
- * Besides the Technical Session subjects covered in this symposium plan for classified workshops in Mining and Mine Technology and Minefield Theory as well as unclassified workshops and sessions on such topics as Minewatching, Passive MCM, Rules of Engagement and the Law of the Sea.
- * Through Mine Warfare Association (and other groups) maintain networking, outreach, and communications with Industry, Academe, and Government Agencies.

MAINTAIN THE MOMENTUM
AND
ENTHUSIAM OF THE SYMPOSIUM

OPERATIONAL TRUTHS AND NECESSITIES

GEN ALFRED M. GRAY,
USMC(Ret)
Former Commandant of the
Marine Corps
(During DESERT STORM)

CALLS FOR FOCUS, VISION,
COOPERATION, INVOLVEMENT
OF USERS, AND
STRONG LEADERSHIP
FOR MINE WARFARE

FORCE DOWNSIZING
WITHOUT MODERNIZATION
EQUIVALENT TO
"EATING OUR SEED CORN"

CITES REVOLUTION IN
MILITARY AFFAIRS;
BELIEF IN TECHNOLOGY;
MUST BE EVOLUTIONARY

The needed vision comes from thinking. It costs nothing to think. Are we really doing wide-open, developmental (6.2) thinking? We must bring people in from industry, the other services, the labs and industry. Sharing must be the rule. Are we doing that?

Is anyone listening to the military users? What do they need in these new threat environments? The key is proper planning. Do we have a "campaign plan"? Does it fit together?

If you have something that works, focus on making it work!

Fix C4I now! Do not tolerate schedule slippage!

Learn from other military communities and problem areas. Look at what was achieved through focus in Anti-submarine Warfare. Today we can do what we

only dreamed of 20 years ago. There is a message there for both the technical community and the military management/resource community.

Bottom line: FOCUS. Do we have it? If not, why not?

(Editor's Note: The addresses by General Gray, Dr. Saalfeld, and Mr. Lynn were in resonance. These talks were complemented by those from the military user communities; Col Greenwalt, RADM Pearson, MGEN Richwine, USMC, RADM Williams, and RADM Zerr. As the Mine Warfare Center-without-Walls, the Naval Postgraduate School is pledged to assist all in meeting the challenges put before the technical community), AMBottoms

VERNE L. (LARRY) LYNN
Deputy Under Secretary of Defense for Advanced Technology and
Director of the Advanced Research Projects Agency

MAJOR PROBLEM IN DEFENSE
SYSTEMS DEVELOPMENT IS
TRANSITIONING FROM
LABORATORY TO USER

ADVANCED TECHNOLOGY CONCEPTS
DEMONSTRATIONS (ATCD)
DESIGNED TO ACCELERATE
ADOPTION/EMPLOYMENT OF
EMERGING TECHNOLOGIES IN
OPERATIONAL SYSTEMS

NEED PHASE III ACTD

AVOID THE COUNSELS OF
PERFECTION; PUT 70% SOLUTIONS
IN USER'S HANDS - BUT, FIND OUT
THE WAR FIGHTER'S PROBLEM

Mr. Lynn actually experienced minesweeping in the Korean War. He noted the systemic improvements that have been added to mine countermeasures since 1952. He also noted the explosive proliferation of mines in potentially hostile countries and to rogue groups who understand the military leverage that can be given a militarily inferior (size, equipment, etc) force through use of mines.

The knowledge/technology "explosion" exacerbates the conflict between systems development/acquisition cycles that run to decades and the appearance of successive generations of technologies such as computers that may occur yearly. The answer lies in the policy of "evolutionary acquisition" in which projected product/capabilities improvements are anticipated and planned for. Capture of a temporally-fleeting "niche" market can be facilitated by adoption of "almost" solutions. To do otherwise is to get nothing.

The two funded ATCD's relevant to Mine Warfare are the Land and Beach (Army-1997) and the Shallow-water-surf zone (Navy - 1998). The highest near-term payoffs are expected in surveillance and C4I. As with all defense systems the question of affordability is a driver. Early industry involvement in design for production and avoidance of exotic or mil spec components is a necessity.

DR. TAMARA MELIA SMITH

Naval Historian (Author of "DAMN THE TORPEDOES", A History of U.S. Navy Mine Countermeasures, Dr. Smith was with the MCM Forces in the Persian Gulf during the operations in the "Tanker War" and during DESERT STORM).

In historical counter-point to the demands for action, vision, and focus; Dr. Smith cites the history of U.S. Navy mine countermeasures that has caused too many to despair of achieving solutions. Mine countermeasures have been adjudged to be just too hard and too resource-intensive.

This whole symposium - even the stimulus for it - is testimony to the thesis that mine countermeasures is a very difficult aspect of the military art. Difficult, yes; impossible, no!

Dr. Smith believes that history proves that we must use our full historical experience to accurately communicate the needs of the mine force to the military leadership and to properly educate naval officers concerning our mine warfare capabilities. Dr. Smith points out that the first, dazzlingly successful mine countermeasures operation was at Mobile Bay in the Civil War. Commodore Farragut breached the minefield because several nights of reconnaissance in small boats had revealed the positions of the torpedoes (mines). Hence, his exhortation to the doubting ship captain "Damn the torpedoes, full speed ahead".

General Gray says "Go where the mines aren't". Recce and the availability of precise navigation such as GPS, offer the possibility of being able to carry out operational maneuver from the sea. Dr. Smith calls for tempered confidence. She certainly calls for avoiding the policies of neglect and of problem denial that can lead to loss of sea control when and where the U.S. Navy needs it. The minefields at Wonsan during the Korean War spoiled MacArthur's strategic timeline. Those at Kuwait were not tested but could have caused serious tactical delays and casualties to major elements of the landing force.

That tempered confidence in mine countermeasures is possible is borne out by the many accounts of individual resourcefulness in Korea, Vietnam, and at Kuwait.

The story of American proficiency in mining has yet to be fully told. (It needs to be). We have used the naval mine as a strategic weapon to achieve national objectives (Haiphong) as well as an economic weapon in the Blockade of Japan during World War II.

Dr. Smith calls for confidence; the technical community can confer the tools that will instill and support that confidence. There is a common message from our senior military and civilian leaders, Seize the opportunity, now.

HUMANITARIAN DEMINING AND
OPERATIONS OTHER THAN WAR (OOW)

Mr. Harry (Hap) Hambric
U.S. Army, Ft. Belvoir, VA

(Under the Aegis of the Asst. Sec. of Defense for Low- Intensity Conflict, the U.S. Army is the Executive Agent for Humanitarian Demining Programs).

HUMANITARIAN DEMINING
NOT AN OFFICIAL ARMY MISSION
AS OPPOSED TO OOW

MUST KNOW WHERE MINES ARE NOT
WITH HIGH ASSURANCE

OPERATIONAL OBJECTIVES AND
NEEDS WELL UNDERSTOOD;
MEANS TO MEET REQUIREMENTS
NOT IN HAND

The magnitude of the problem in nearly every undeveloped region of the world where there has been fighting is stupefying. Mines in place estimated to number over 100 million; being put in place at rates that far exceed the removal/neutralization rates. Removal activities are slow, manpower and capital intensive, and far more costly than is practicable for these mine-plagued countries and people. Annual personnel casualties exceed 10000 - many farmers, women, and children. Anti-personnel mines maim thus inflicting staggering economic burdens on the people and the communities of the innocent.

U.S. Army Special Forces units advise indigenous demining personnel in many cases. Much demining work is conducted by contractors such as EOD World Services, Inc. When U.S. Government people are involved, the only allowable actions under various MOUs is to blow the mine in place - clearly impossible if the mine is next to a fuel storage tank.

Demining in Cambodia proceeds at the rate of about 15 square miles per day; associated costs are about \$1000 per mine neutralized. The figures will vary with the nature of the geological provinces as well as with the minefield densities. (Cost per mine is not a particularly good figure of merit).

There is currently \$10 million allocated by OSD to the Army for Humanitarian Demining. Mr. Hambrick is attempting to leverage other programs. He has lists of needs, tools, and planned procurements.

OPERATIONAL NEEDS OF THE JOINT EXPEDITIONARY FORCES
(See also the comments of MGEN Richwine, USMC)

Preparations for the Landing Force

REAR ADMIRAL JOHN D. PEARSON,
United States Navy
Commander, Mine Warfare Command

ADM Pearson provided a review of the current state of mine countermeasures as it applies to the expeditionary mission and a vision of how autonomous vehicles can help facilitate operations in the future. Realities: Threat: Moored Mines, Bottomed Mines, Drifting Mines, and weapons/obstructions designed to embarrass an amphibious assault. Naval mines can be contact mines or influence mines. Most modern mines have counter-countermeasures features such as ship counts, arming delays, sophisticated firing logics, and stealth shapes and materials.

MCM Systems: Ships, helicopters, and divers or swimmers are the backbone of the present MCM forces. The divers are used in recovery for exploitation or for attaching explosive destructors after they have verified that an object detected by other means is a mine. Minehunting systems, principally acoustic, attempt to reconnoiter, locate, and classify mines and the extent of mined areas. Helicopters can employ visual and electro-optical sensors as well as magnetometers and laser radar in their search. Dolphins have been successfully used to locate and classify buried mines. Brute force methods such as carpet bombing and the use of plows, rakes, and adaptations of heavy, earth-moving equipment are under consideration by the Navy-Marine Corps.

Remote MCM Systems: The Navy uses a tethered device, the Mine Neutralization System, and a teleoperated device, the Self-propelled Acoustic-Magnetic Sweep.

Environment: As with the land domains, there are many operational environments, characterized by widely different physical and biological features, that strongly affect the performance of the MCM systems. These environments are classified as riverine and estuarine, surf zone, very

shallow water, shallow water, and deep water. Visions:

Enhanced Threats: Coated, self-burying, and/or walking mines are already present or in some inventories. Sensors and firing logics promise near-term capability to discriminate among targets and against countermeasures efforts. Surveillance and Recce: Reference to the ideas of Operational Maneuver from the Sea (Gen. Richwine) will motivate the needs for both overt and covert capabilities.

Autonomous Systems: The Navy expresses great interest in the potentials of autonomous systems to provide organic MCM capabilities to fleet units, and to operate overtly and covertly to carry out a variety of MCM tasks. The challenge is to expeditiously apply technology.

Breaching. "Engineers to the Front!"

COL. ROBERT J. GREENWALT
United States Army
Director of Combat Developments,
U.S. Army Engineer Center

(Force XXI is the Army of the Twenty-First Century)

Threat to Force XXI

High Technology Mines
Side/Top Attack (on armor)
Discriminating Sensors
Coordinating Attack

Millions of "Legacy" Mines

Home-built Mines

In seizing a lodgement the decision alternatives are Bypass or Breach

Breaching carried out by maneuver forces very tightly controlled in time and space. Speed and the massing of fire essential. Exploit natural and artificial cover (smoke).

Present and Near-term capabilities dependent upon "man-at-the-point"; Detection techniques rely on metal detectors, probes, and "first vehicle" and are slow and dangerous - want standoff capability in future.

Breaching and Marking rely on hand-placement and on mine plows and rollers or line charges that are severely limited. Need speed and all-fuse capability as well as capability to detect non-metallic mines with stand-off detectors.

(Editor s Note: The Engineer Center is a part of the Army s Training and Doctrine Command. The Army has historically used concept-based requirements setting processes in each of its combat arms and services).

(Editor s Note: A directory of the activities that are concerned with Mine Warfare in each of the Military Departments would be very useful to the community as a whole. Assembly of such a directory is an objective task for the MINE WARFARE ASSOCIATION)

DISPLAYS AND DEMONSTRATIONS

INTRODUCE PARTICIPANTS
TO CAPTURED ORDNANCE, TO THE CH-53e MCM HELO,
TO SOME AUTONOMOUS VEHICLES AND ROBOTIC COMPONENTS,
AND TO AN INGENIOUS ADAPTATION OF EARTH-MOVING EQUIPMENT,
THE CLAUSEN POWER BLADE

CONTRIBUTED PAPER AND
 POSTER SESSIONS
 STIMULATED DISCUSSION
 AND PROVIDED
 OPPORTUNITY TO DESCRIBE
 RESEARCH APPROACHES

PROCEEDINGS WILL BE AVAILABLE
 AT COST AND WILL CONTAIN
 ALL PAPERS THAT WERE SUBMITTED

Adoption of the linear format for the Symposium severely limited the opportunities for presentation to plenary sessions. By adopting use of contributed paper sessions and through the exploitation of the technique called "poster boarding", contributors were given opportunity to discuss their work in an informal manner.

In the analogy with the design review and a project work breakdown structure, the discussions at the plenary sessions focussed on the systems and assembly levels whereas the contributed papers and the poster sessions represented component development at exploratory development stages.

Inquiries about the PROCEEDINGS should be directed to Visiting Professor Albert M. Bottoms, 104 Reynard Dr., Charlottesville, VA 22901.
 Tel. (804)296-3080; e-mail amb2m@virginia.edu.

DEMONSTRATION OF THE NPS
 UUV AND OF VIRTUAL REALITY IN RDT&E

Development costs skyrocket in each of the phases of the weapons systems development cycle. The NPS activity in virtual reality is intended, in part, to reduce costs of engineering development and test. Demonstrations in the NPS pool show also the great utility of differential GPS. A major objective of this work is to reduce the time for development as well as the costs.

HARDWARE
 DISPLAYS AND
 VIDEO PRESENTATIONS
 HEIGHTENED AWARENESS;
 INTRODUCED REALISM

U.S. NAVY MINES AND A DISPLAY
 OF LAND MINES RECOVERED FROM
 KUWAIT WERE SOMBER REMINDERS OF THE THREATS

The symposium is indebted to the Navy and to Mr. Chick Mixter, President of EOD World Services Incorporated for providing display mines. The land mines, anti-personnel and anti-tank, were recovered during the demining operations in Kuwait and are representative of the 100 million such mines in place around the world.

HM-15 based in Alameda provided a MCM Helo with the AQS-14 Minehunting Sonar. Discussions with the aircrew provided insight into the capabilities of Airborne Mine Countermeasures.

THE CLAUSEN POWER BLADE

This proven earth-moving device is under study and evaluation by the Department of Defense for a number of potential military applications in land and expeditionary warfare. The bull-dozer upon which the Clausen Power Blade is mounted has potential for teleoperation and is thus a present member of the zeroeth generation of autonomous vehicles. The results of tests by the Marine Corps and the Army indicate that this system is a

strong claimant for inclusion in the MCM "bag-of-tricks"- not a "silver bullet" but a part of the armamentarium of Mine Warfare.

JOINT AMPHIBIOUS MINE-COUNTERMEASURES SYSTEM (JMAC)

Under development and test at Eglin Air Force Base, JMAC is another mechanical contender that appears to meet some of the stringent weight restrictions on amphibious equipment.

WORD FROM THE SPONSOR
AND THE FEATURED SPEAKERS

PROVIDE PRODUCTS
PAY ATTENTION TO USER NEEDS
DON'T WAIT FOR PERFECTION
THINK SYSTEMS, AFFORDABILITY,
AND SOFTWARE VERIFICATION/VALIDATION

NAVY MINE WARFARE SYSTEMS ACQUISITION

DR. FRED SAALFELD
Dep. CNR and Tech. Director
Office of the Chief of Naval Research

ONR CONFIGURED TO
SUPPORT JOINT WARFARE
AND WARFARE SUPPORT AREAS
WITH MISSION-ORIENTED RESEARCH,
EXPLORATORY DEVELOPMENT, AND
TECHNOLOGY DEMONSTRATIONS

CAPABILITIES HAS BECOME THE
COMMON LANGUAGE
VICE TECHNOLOGIES

SETS OF ADVANCED CAPABILITIES
DEMONSTRATIONS (ACD)
SUPPORT THE 7 WARFARE AND
4 JOINT WARFARE SUPPORT AREAS

Scientific Officers from the Science and Technology
Directorate in Attendance

Dr. Saalfeld traced the evolution of the Office of Naval Research from the end of World War II to its present configuration. In the evolutionary process ONR has broadened its purview from almost pure research focus to focus on enabling technologies and systems capabilities.

At the same time, ONR preserves strong programs designed to elucidate understanding of such areas as biological sensors such as dolphin sonars and neural network applications that replicate processes that occur in nature.

The focus on capabilities complements the thrusts outlined by Mr. Lynn. Capabilities focus also encourages close cooperation among the performers of research and development in academe and industry and the users who are represented by the PEO-Mine Warfare and comparable acquisition officials in the other Military Departments.

MGEN DAVID A. RICHWINE, USMC
Deputy for Expeditionary Forces Programs
Office of the Assistant Secretary of the Navy
(Research, Development, and Acquisition)

(General Richwine represented both the Director, Expeditionary Warfare in the Office of the Chief of Naval Operations and the Commanding General of the Marine Corps Combat Development Command as neither MGEN Myatt, USMC, nor LTGEN Charles A. Wilhelm, USMC, were able to attend as they had planned).

OPERATIONAL MANEUVER IS
MOVEMENT WITH PURPOSE

MANEUVER FROM THE SEA IS
DESIGNED TO INFLICT TACTICAL
SURPRISE; PREVENT CONCENTRATION
OF ENEMY ASSETS

MINE WARFARE PROGRAM
MUST BE "CONCEPT BASED";
MILITARY USERS MUST PROVIDE
THE CONCEPTS AND NEEDS
DERIVATIVE THEREFROM

General Richwine notes that the Services must provide the concepts of operation based upon Service Doctrine. There must be an Executive Agent to get near-, mid-, and long-term recommendations. We must empower people to do creative thinking. We must make the Navy-Marine Corps Acquisition System and Processes clear to the technical community.

Mine Warfare is Joint Warfare. We need Joint Focus. Gen. Richwine suggests application of the "Joint CID Management Architecture" to Mine Warfare with appointment of an Executive Steering Committee. This group assists in configuration control and in defining needs in technical terms.

SYSTEMS ACQUISITION LEADERS (Continued)

RADM RICHARD D. WILLIAMS, III,
United States Navy
Program Executive Officer, Mine Warfare

NAVY ACQUISITION REALITIES

NAVY FORCE STRUCTURE,
MODERNIZATION GOALS,
RECAPITALIZATION NEEDS
NOT MET BY DEFENSE BUDGETS

Little Hope for Financial Relief
Must Depend on Cost-Savings Initiaves

RADM Williams listed the needs of Mine Warfare as

- * Knowledge of the Battlespace - Intelligence, Surveillance, reconnaissance, communications connectivity (Maneuver Enabler)
- * Surf Zone - Ability to overcome mines and obstacles
- * Mine Countermeasures capabilities organic to the Battle Group and to its assets
- * Ability to conduct an amphibious operation "in stride"

A suggested division of resources - Half to the war fighters for inexpensive mine hunting systems, C4I, improved sensors, mapping systems, and neutralization systems. and half to the exploratory development (laboratory) community for robotic swarms, mother/daughter unmanned,

underwater vehicles, and underwater networks.

The program executives in each program often find specific Congressional direction during the development and acquisition phases. Such direction does not necessarily reflect Service priorities. This is reality.

CAPT DAVID DURFREE, USN
Defense Aerial Reconnaissance Office
(Representing MGEN Kenneth R. Israel, USAF)

CAPT Durfree described current approaches and families of fixed and rotary-wing aircraft and examples of sensor systems in use or under development. Many of the systems are currently capable of teleoperation.

This class of mine countermeasures components is unlikely to fit in the vision of low-cost in production quantities.

Those who visited the MH-53E Helicopter MCM system in Monterey saw the world's largest rotary-wing work vehicle. Its lift and thrust are necessary to overcome the drag of the MCM sleds and future "rake" applications.

REAR ADMIRAL JOHN J. ZERR
United States Navy
Commander, Test and Evaluation Force

THE DEVELOPING PARTNERSHIP
OF OPERATIONAL TEST AND EVALUATION WITH
DISTRIBUTED MODELING AND
SIMULATION

THE PARTNERSHIP IS BUDDING

INFORMATION TECHNOLOGY AND
ACQUISITION REFORM ARE CHANGING

THE BASIC APPROACH TO
OPERATIONAL TESTING

NEED TO DEVELOP AND USE
SOFTWARE TESTING TOOLS;
TODAY, UNCERTAIN AS TO HOW
TO TEST AND EVALUATE SOFTWARE

ADM Zerr, laid out some needs - primarily needs for "people skills" :

- * People who can see beyond the glamour of the futuristic vision business;
- * People who are disciplined; who understand the need for disciplined software processes;
- * People who are dedicated to implementing a disciplined approach to developing and managing models and simulations;
- * People to study and develop testing methodologies; and
- * People to study and develop methodologies for distributing and linking models to help us solve our current and future problems.

There are those who see software intensive solutions as the elusive "free lunch". We need to impose discipline on people who say they are too busy writing code to subject themselves to discipline. This lack of discipline manifests itself in a lack of configuration control and safeguards. To

paraphrase the Admiral, the question is using test models in which we are uncertain to evaluate other models whose configurations and functionality are unknown.

ADM Zerr pointed out that removing the animosity between the testing community and that of the software developers has resulted in a much higher fraction of successful operational evaluations. This is clearly an important problem the solution to which can result in considerable cost - avoidance.

DESIRED PERFORMANCE IN THE MCM MISSIONS

The technical sessions of the symposium define the major subsystems that come together to give the system that is termed an autonomous mine countermeasures vehicle. The concept for the mine countermeasures system as a whole may include ensembles of vehicles or may include a hierarchical set of single (or limited) purpose vehicles that operate in a sequential, rule-based manner to achieve the desired operational goals. It is important for each of the sessions to keep in mind the potential operational concepts for use of the systems under consideration. Also, some of the military applications place a premium on speed of clearance or other task execution. This gives rise to sets of operational (as opposed to developmental) time lines.

PROGRAM HIGHLIGHTS

This symposium took the form of a top-down design review that addressed the challenge to field by the year 2000 a family (or families) of autonomous vehicles for mine countermeasures and related operations. An objective is to achieve unit costs in the order of \$5000 per unit in production quantities.

The eight technical sessions addressed the major functional components of the units and the systems or ensembles of units. The parallel sessions address application of current systems acquisition policy and the appropriateness of mission support analytical methodologies.

Each technical session establishes:

- *the 1995 benchmark
- *issues and barriers to goal achievement
- *milestones
- *human and financial resource needs

Addresses by senior officials helped to define the scope and urgency of the problem and the parameters of the systems design requirements.

The long term desired outcomes of this symposium are communication, new partnerships, and new approaches to funding.

THE ENVIRONMENTS OF MINE WARFARE

Dr. Robert C. Spindel, Director,
Applied Research Laboratory
University of Washington
Prof. James Miller, NPS

One needs only to look at geologic, topographical, and bathymetric charts or to consider the great variety of physical and biological environments to realize that the families of autonomous vehicles for mine countermeasures and related activities will, of necessity, have to occupy environmental "niches". Many, otherwise promising, approaches to detection and

classification of mines and similar objects have foundered on the hard realities of environmental parameters and characteristics.

One of the purposes of this session was to acquaint scientists and engineers from the civilian sector with the nature of the working environments. The very multiplicity of such environments lays to rest the idea that there is, or can be, a "silver bullet" for mine countermeasures.

Session Overviews:

Characterization of the Surf Zone

Prof. Edward Thornton, Naval Postgraduate School

Characterization of the Ground Environment: Soil

Electromagnetic Properties and the Sensor Clutter Problem
Charles Amazeen, Mine Detection Division, U.S. Army Night Vision and Electronic Sensors Directorate

Presented Papers:

Mapping Shallow Water Variability With an Autonomous Underwater Vehicle
Dr. Ed Levine, Naval Undersea Warfare Center Division, Newport

The "ORCA" Hydrographic Survey Vessel
Dr. Brian Bourgeois, Naval Research Laboratory

A Reactive Walking Robot Architecture for Operation in Current and Surge
Dr. Joseph Ayers, Marine Science Center, Northeastern Univ.

Environmental Science in the Coastal Zone
Dr James G. Bellingham, MIT Sea Grant Prog.

Panel Discussion: Requirements for Future Operational Environments

Moderator: Dr. Robert C. Spindel, Director, Applied Research Lab., Univ. of Washington

Panelists: Prof. Edward Thornton, Charles Amazeen, Dr. Ed Levine, Dr. Brian Bourgeois, Dr. Joseph Ayers, Dr James G. Bellingham

Summary of Findings:

On land and in the ocean or littoral the environments serve to define the niche areas for which different vehicle/sensor/work packages have to be designed. There is a lesson to be learned from nature.

POWER SOURCES

Mr. Dan Kiely, ARL, Penn State
Prof. Knox Millsaps, NPS

The design challenge is for families of affordable, possibly sacrificial, autonomous vehicles that are capable of carrying out a variety of tasks. Mission length and the demands for energy above that required for mobility (for work packages, communication, and so forth) appear to place a premium on power density. The trade-offs are among endurance, size (equated to expense), and nature of the mission-packages.

The objective for this session was to show whether or not power considerations are now limiting on the design objective; and, if power is limiting, what steps are required (at what cost) to remove a power source barrier. Conventional as well as unusual approaches to powering systems

will be topics.

Session Overviews

Power Sources for Undersea Autonomous Vehicles

Dr. Thomas G. Hughes, Applied Research Lab., Penn. State Univ.

Power Sources for Land-Based Autonomous Vehicles

Dr. Robert P. Hamlen, Dir., Power Sources Div., Army Research Lab.

Presented Paper

The Aluminum Fuel Cell: The Enabling Technology for Long-Range UUV's in Minehunting and Mapping Applications

Steven L. Sinsabaugh, Loral Defense Systems-Ackron

Findings:

Power sources may become limiting for light-weight autonomous aircraft and for many of the sub-surface and bottom-crawling applications of autonomous vehicles in the water. Research should focus on improved power densities.

At present there is no good way to estimate the required energy budget for an autonomous system. To obtain such a budget, one must know - in addition to the mission/vehicle envelopes - the power requirements of sensors, navigation, control, and reporting systems, and those of the mission work packages.

SENSORS

Dean William Lord, Prof. Satish Udpa
Iowa State University
Prof. Don Walters, NPS

This session dealt with sensors to detect, classify as mine-like, and identify as a mine (or other class of object of interest). Sensors for navigation and control are covered in that session. The subject of sensor fusion is included in this session.

"Machine vision" is properly dealt with in this session and/or in the session on Mission Work Packages. Which place is probably determined by the operational intent.

The scope of this session covers sensors for surveillance/reconnaissance of minefields (or other hazardous areas) on land or in the water. Sensors appropriate for use from the air (including space), from land vehicles, and from vehicles in the water. Any of these vehicles can be tethered, remotely operated, cued, or completely autonomous.

The problem in minefield reconnaissance and individual mine hunting is classification - false (mine- like) targets that are not mines. Otherwise promising schemes founder on this problem. It is essential that discussions of the competing and complementary sensor techniques and applications address the "false target problem".

No sensor applications design review can be complete without addressing such aspects as power requirements, potential for miniaturization, and potential for use in "cooperating" groups of independently operating vehicles. What limitations do potential operating environments - physical, chemical, or biological - impose?

The session adopted a panel format that captures the state of development and forecast of potentials for each of the classes of sensors. The topic sequences, each embodying an invited paper and discussants, led to

conclusions or findings in each segment of the session as well as for the session as a whole. Areas addressed include (1) where we are, (2) what the potentials are, (3) scientific and development issues, including interface issues such as power, size, and weight and (4) recommended actions.

Electromagnetic Sensors: Techniques and Limitations
Prof. John Young, Dept. of Electrical Eng., Ohio State Univ.

Pulsed Electromagnetic Sensors: Buried Mine
Detection Using Ground Penetrating Impulse Radar

Paul Sargis, Lawrence Livermore Nat. Lab.

Electro-optical Sensors: Electro-Optical Detection of Mines
Dr. R. Norris Keeler, Kaman Diversified Technologies

Acoustic Sensors: Acoustic Sensors for Mine Hunting
Dr. Chester Mckinney, Director Emeritus Applied Research Lab., Univ. of
Texas and Honorary Chair of the Symposium

Chemical/Radiological/Biological Based Sensors: Best
Type of Sensors for the Detection of Buried Mines
Dr. Divyakant Patel, Countermine Division, U.S. Army
Night Vision and Electronic Sensors Directorate

Mammal Based Sensors: The Bottlenose Dolphin
Dr. Patrick Moore, U.S. Navy Naval Command Control and Ocean Systems
Command

Sensor Fusion: Sensor Fusion for Mine Countermeasures
Dean William Lord, Iowa State Univ.

Panel Discussion: Future Sensor Developments and Limitations in Mine Warfare

Moderators: Dean William Lord, Iowa State Univ., Prof. Don Walters, NPS
Panelists: Dr. John Young, Mr. Paul Sargis, Dr. R. Norris Keeler, Dr.
Chester Mckinney, Dr. Divyakant Patel, Dr. Patrick Moore,

Findings:

On land and in the sea the varied operational environments call for domain-specific approaches to sensors. This, in turn, argues for modularization of the sensor packages for autonomous vehicles (as well as for miniaturization of the sensors and ancillary equipment).

There is considerable promise for acoustic sensor improvements in the exploitation of the contents and structure of the echo from the target. There are also efforts underway to use other biologically-based signal processing techniques.

MISSION WORK PACKAGES

Richard Blidberg,
Northeastern University
Dr. Don Brutzman, NPS
Advisor: Prof. Bob McGhee, NPS

The considerations about Mission Packages are similar to those about sensor applications. We must address such aspects as power requirements, potential for miniaturization, and potential for use in "cooperating" groups of independently operating vehicles as well as limitations imposed by potential operating environments - physical, chemical, or biological. As with the other sessions the papers in this session lead to understanding of (1) where we are, (2) what the potentials are, (3) scientific and

development issues, including interface issues such as power, size, and weight , and (4) Recommended Actions.

Mission work packages emerge as a class of activity that must be regarded as pacing and critical to the achievement of the vision of bringing autonomous vehicles into prominence in mine countermeasures.

The focus in this session was on robotic work packages. On display during the symposium were examples of currently available innovations, such as the CLAUSEN POWER BLADE, that can move large quantities of earth (and mines) out of the way of breaching forces.

Session Overview (Undersea)
CAPT Alan Beam, USN(Ret.)

Session Overview (Land)
Dr. David Weaver, U. S.Army NVESD

Off-Route Smart Mine Clearance ATD Program
Ricky W. Stanfield, Ricardo Gonzalez, Sean P. Burke, and Jason J. Regnier,
NVESD

Energetic Charged Beams for Disablement of Mines
Dr Craig R. Wuest, Lawrence Livermore National Laboratory

"Transformer" UUV for Surf Zone MCM
Dr. Robert Mons, Westinghouse Electric Corp.

Joint Amphibious Mine Countermeasures (JAMC) System
John P. Wetzell and Allen D. Nease,Wright Lab./Airbase Systems Branch

A System for Performing Site Characterization and Remediation for Test Ranges Containing Unexploded Ordnance
H Edward Brown and Dr. Carl Crane, Wright Lab./Airbase Systems Branch

Panel Discussion:Future Needs

Moderators: Dick Blidberg, Northeastern Univ. Don Brutzman,NPS
Panelists: Dr. David Weaver, NVESD CAPT Alan Beam, USN, Major Hamm, USMC,, Amphibious Warfare Technical Center Dr. Dana Yoerger, Woods Hole Ocean. Inst.

Findings: The technologies are available for the kinds of mission work packages needed. Whether the size and power requirements are compatible with potential vehicles is another question but is a question of focussed development effort rather than the need for new science.As the complexity of the work needs increases, it may become necessary to make the sensor(s) organic to the working tools. There are analogies with the NASA experience with the Space Shuttle and with the uses of remote devices in surgery and in radiological environments.

VEHICLES

Dr. Claude Brancart, Draper Labs
Prof. Tony Healey, NPS

The design challenge that gives rise to this symposium, the vision, is the quest for a family or families of autonomous platforms capable of carrying out some or all of the tasks of mine countermeasures or demining. Unit costs should be in the order of \$5000 in production quantities. Can this be accomplished this decade? Next?

The sessions that precede this one sketched the possibilities of mission systems and work packages. This session presented platform some current

designs.

Unit cost is of great importance. Approaches that address military mine countermeasures scenarios on land or in the water stress speed and a reasonable logistics tail. The needs for the humanitarian mission of demining, on the other hand, must clear to a high degree of confidence vast and uncharted areas. No approach at present begins to be economically feasible for the humanitarian demining and area remediation missions.

This session addresses the feasibility of developing affordable, rather small unit components. Such components are envisioned as complementing such heavy equipment as rakes, plows, and large bulldozers.

Overview of Underwater Vehicles for MCM Operations
Dr. Claude Brancart , ARPA/MSTO.

Overview of Land Vehicles for MCM Operations
COL Jeffrey Kotora,USMC, Unmanned Ground Vehicles Systems JPO.

Presented Papers:

Teleoperation of a HMMWV for Countermine Applications (High Mobility Multipurpose Wheeled Vehicle)
Francis N. Fisher, Army Research Lab.

Lemmings: A Swarming Approach to Mine Detection and Neutralization in the Very Shallow Surf and Beach Zones
Arnis Mangolds,Foster Miller Inc.

Autonomous Legged Underwater Vehicles For Near Land Warfare
Dr.Richard Elsley, Gary Bane, Rockwell., Colin Angle, Helen Greiner, IS Robotics

BUGS -Basic UXO Gathering System
Chris O'Donnel,Craig Freed,Tuan Nugyen, NAVEODTEHCEN., A. J. Healey, R.B.McGhee, S.McMillan, NPS

Walking Machine Theory and Practice
Prof. D. Orin, Ohio State Univ.

Advanced Remotely Operated Vehicles in Mine and Ordnance Intervention
Gary M. Trimble, Lockheed Martin

PANEL DISCUSSION:

IDENTIFYING CRITICAL ROADBLOCKS AND A TIME HORIZON FOR AFFORDABLE MCM
Moderators: Tony Healey, and Claude Brancart

Panelists: Jeffrey Kotora, USMC, Francis N. Fisher, Arnis Mangolds, Dr.Richard Elsley, Chris O'Donnel, D. Orin, Gary M.Trimble, Joseph Ayers, Northeastern Univ., Tom McKenna, ONR, David Kang , Draper Labs, J.D. Nicoud, LAMI-EPFL, Swiss Federal Institute of Technology

Findings: The roadblocks to achieving the families of vehicles are mostly of our own making. To date, vehicle development has been a highly ideosyncratic effort by groups interested in following specific paradigms. Development of concept-based requirements could help focus on the choices that are offered by walking, swimming, or crawling vehicles. Understanding of the niches can also assist in the making of these choices. From the Carnegie-Mellon experience with DANTE to the IS Robotics experience with walking robots for the NASA Mars Mission the conclusion arises that the technologies are here. What must be decided is what do we want?

NAVIGATION AND CONTROL

Prof. Ruzena Bajcsy,

Univ. of Pennsylvania
Prof. Bob McGhee, NPS

This session addressed the technology and the potential of "off-board" and "on-board" techniques for navigation and control of individual autonomous units or ensembles of such units. The starting point is the technology of remote piloting or "man-in-loop".

There is a natural flow from the architecture of individual platforms to the architecture for a systems of such platforms. In the applications that we are considering, the "system" may be composed of identical units or of components that have different forms and functions. There may be strong experiential reasons for preferring that the "on-board" control systems also be those that interface with "off-board" control.

Issues that exist are those dealing with the capacity of on-board computers and communications that will potentially allow a cooperative, rule-based dialogue between and among cooperating units and the control nodes. What failure modes can be programmed so as to prevent catastrophic system failure?

This external systems architecture must take into account the complexities of the missions and tasks as well as the environmental variety and complexity.

Session Overviews:

Land Vehicle Navigation and Control
Dr. James Albus, NIST

Underwater Vehicle Navigation and Control
Gary Trimble, Lockheed Martin

Presented Papers:

Cooperative Agents: Machines and Humans
Prof. Ruzena Bajcsy, Univ. of Penn.

Tri-level Control Architecture for NPS Phoenix AUV
Prof. Anthony Healey, Naval Postgraduate School

An Integrating Architecture for Robust Autonomous Robots
Marc G Slack and David P Miller, MITRE Corp.

Many Robot MCM Search Systems
Dr. Douglas W. Gage, NCCOSC RDTE DIV

Dual-Use Applications Using A "Flotilla" of Smart Mobile Mine Sensors
Christiane N. Duarte and Donald Gomez, Naval Undersea Warfare Center
Division Newport, U.S. Navy Laboratory

A Virtual World For An Autonomous Underwater Vehicle
Prof. Donald P. Brutzman, Naval Postgraduate School

Panel Discussion: Assessment and Projection
Moderated by: Prof. Rengeng Su, Colorado Univ.

Panelists: Prof. Ruzena Bajcsy, Dr. James Albus, Gary Trimble, Dr. Douglas W. Gage, Christiane N. Duarte, Donald Gomez, and Dr. David P. Miller

Findings:

The conclusion of the vehicle session applies here also with some conditions. Implementation of the Autonomous Company or Brigade is in the

future; but the building blocks for rule-based systems are within grasp.

ANALYTICAL MISSION SUPPORT

Prof. Alan Washburn, NPS
 Prof. George Carrier
 T. Jefferson Coolidge Professor of Applied
 Mathematics, Emeritus, Harvard University

This is one of two parallel sessions that took place on April 7, 1995.

Analytical tools are used in minefield planning, in support of tactical decision aids in mine countermeasures operations, in force level studies, and in the comparative analysis of mines and mine countermeasures components and equipments. The individual analytical approaches and simulations are increasingly being used in netted simulations and in conjunction with test and evaluation.

T.J. Horrigan makes the observation that the overwhelming activity in Mine Warfare analysis concerns the refinement of models and analytical techniques such as introducing increasing detail into simulations in the hope of obtaining greater realism and thus predictive qualities. Virtually no effort has been expended to elucidate the underlying physical theory. Most of the stochastic approaches assume (without proof) statistical independence of events. Although theoretically possible with modern simulation techniques, computer simulations rarely consider the geometric configurations and the resulting contributions that result from these "edge" effects.

Paul Davis of RAND approaches the issues from a background in statistical mechanics and addresses the fundamental questions of when and how to aggregate.

There is question about the adequacy of the theory and the analytical practice to support the applications.

The objectives of this session were to address the adequacy of the theories, methodologies and analytical practice in Mine Warfare both on land and at sea. Although not specifically addressed at this symposium, it is clear that demining and other range remediation actions also require a body of theory and models if there is to be confident assessment of alternative courses of action.

Session Keynote:

Dr. Herb Puscheck, Former Deputy for General Purpose Forces, OSD Office of Program Analysis and Evaluation

Presented Papers:

Tactical Platform Mine Warfare Thrusts
 Dr. David G. Olson, NUWC, Newport

Comparison of Swarming Vehicle Motion Patterns for
 Very Shallow Water/Surf Zone Minefield Clearance
 C.A. Guillebeau, Costal Systems Station, Naval Surface Warfare Center

Battle Managers, Naval Simulation, and Virtual Reality: MCM as a Testbed
 Joseph J. Molitoris, Center for Naval Analysis

Tactical Decision Aids, Minefield Penetrability and Configured Minefield Theory
 T.J. Horrigan, Horrigan Analytics

Mine Countermeasures Tactical Models
F.P Sutter, Costal Systems Station, Naval Surface Warfare Center

Panel Discussion: Needs in Mine Warfare Analysis and Simulation

Moderator: Prof. George Carrier, Harvard Univ.

Panelists: Prof. Alan Washburn, Dr. Herb Puscheck, Dr. David G. Olson, C.A. Guillebeau, Joseph J. Molitoris, T.J. Horrigan, F.P Sutter, and Paul A. Davis, RAND

Findings: There was some division in the extent to which panelists thought that the theory of the minefield supported the needs for analytical support to Mine Warfare. There was little disagreement with the fact that the Tactical Decision Aids and the Force Structure models are lacking in verification and difficult to apply.

Resources, people and money, for research in minefield theory and the models and simulations derivable therefrom has been spotty and uncertain for decades. The comments of Admiral Zerr on the need for methodological tools to evaluate software-intensive systems open new dimensions to the need for a multi-year focussed program on the analytical underpinning of Mine Warfare - mining and mine countermeasures.

MANUFACTURING TECHNOLOGY,
DUAL-USE TECHNOLOGY,
AND ACQUISITION STRATEGY

Mr. Ric Trotta, Industry Consultant
Prof. Michael Sovereign, NPS

This is the second of the parallel sessions that were held on Friday, April 7, 1995.

Participants: The Honorable Jay Sculley, CEO Allied Research, and former Assitant Secretary of the Army for Research, Development, and Acquisition - Session Keynote and Overview; Col. Joseph Muckerman, USA (Ret) and Former Director of Emergency Planning, OSD - the acquisition and Industrial Environment; Dr. Jack Yost, Vice President for Development and Technology Transfer, Penn State University - Competitiveness; Dr. Kathe Robertson, ARPA TRP - Commercial Leverage; Dr. Erick Hendricks, ONR Prog. Mgr. - Dual-Use; Dr. Joann Langston, Director, U.S. Army Model Improvements - Acquisition; Dr. David Strip, SANDIA Corp. - Manufacturing Technology; Prof. Michael Sovereign, NPS - Acquisition Policy.

Session Outline:

- * Overview - To set the stage
- * The Industrial Base
- * Competitiveness - The world stage
- * Leverage - Commercial, Dual-Use
- * Acquisition Reform - Commercial Components
- * Policy - Government Actions
- * Application to Mine Countermeasures Systems

This session explored how development and acquisition policies can leverage commercial markets and products so as to provide reliable, high technology components and systems. This is a particularly important consideration as we face the downsizing of the defense industrial base.

The preceding 3 days of the symposium explored a large number of cutting-edge technological developments and systems designs. It is clear from the start that the first generations of autonomous systems will only partially fulfill the systems requirements. A process of evolutionary acquisition will come into play. It is also clear that the demands of

affordability and reliability demand maximum use of technologies that have matured in the marketplace, the so-called dual- use technologies. Thus, there are implications to both the development community and the acquisition community. An important question revolves around the health of the U.S. industrial base, the ability to design for production, and the extent to which development and acquisition policy can leverage the availability of the requisite technologies.

Findings:

- * Need concept of operation and service directive
- * Assign Executive Agent to develop near-, mid-, and long-term recommendations
- * Use Joint CID Management Architecture as Mine Warfare management model
- * Appoint Executive Steering Committee to report to OSD
- * Clarify acquisition environment for technical community
- * Streamline Mil-Spec/Mil Stnd processes and rules
- * Empower people-encourage creativity
- * Get more industry involvement
- * Schedule "process" sessions early in major conferences and symposia

Actions:

Acquisition Issues Planning Group consisting of Mr. Trotta, Col. Muckerman, and Dr. Yost (Al Bottoms ex officio) will develop plans/proposals for follow on workshops and activity for Fall, 1996, Mine Warfare Symposium.

CALL FOR
SUGGESTIONS FOR
THE SEPT., 1996,
MINE WARFARE SYMPOSIUM

MINWARA and the Mine Warfare Chair at the Naval Postgraduate school welcome suggestions and observations about next year's program. Would you like to see some preparatory workshops? If so, what topics should be covered. Do we need sessions on the art and practice of offensive mining? On operational concepts?

ANNOUNCING THE FORMATION OF
THE MINE WARFARE ASSOCIATION (MINWARA)

The Mine Warfare Association is a not-for-profit organization that is devoted to education and the raising of awareness concerning mines. The purpose is to strengthen the national security of the United States and to assist in the attainment of international security and humanitarian objectives of the United States as set forth by the President of the United States.

The Mine Warfare Association has the following objectives:

1. To provide education and training and to increase awareness about the the military arts of mine warfare and the impacts of mines during and after hostilities;
2. To enhance communication among individuals and organizations who are concerned about all aspects of mine warfare - mining and mine design, mine countermeasures and counter-mine activity, demining and remediation of areas contaminated by mines, unexploded ordnance, or hazardous chemical, biological, and radiological materials.
3. To provide focus in the United States and abroad to efforts such as the development of international protocols that seek to control the spread and proliferation of mines and mine technologies to nations, factions, and

agencies who are indiscriminate and irresponsible in the use of mines and related weapons.

4. To promote the application of appropriate technology to expedite minefield neutralization in both military and humanitarian civilian contexts.

It shall be a policy and an objective of the Association to establish areas of joint and mutual interest with existing defense and technically - oriented organizations and associations.

Mine warfare in the contexts of the Charter and By-Laws of the Association and the activities of the Association includes the use of mines and mine-like weapons in space, on land, and in the sea. The idea of mine warfare extends also to mines used in accordance with traditional military practice as well as mines and booby traps used as weapons of terror.

MINE LINES

Published Periodically by the MINE WARFARE ASSN
as an unofficial vehicle for the exchange of
information and views concerning Mine Warfare and
Related Military and Civilian Areas

This issue of MINE LINES is being published at the Naval Postgraduate School in partial fulfillment of the obligations to communicate broadly on the planning and execution of the Symposium on Autonomous Vehicles in Mine Countermeasures.

Arrangements are being developed to maintain a relationship with the Naval Postgraduate School so that it is possible that future issues will continue to be published by that institution. The Editor, Mr. Bottoms, expects to retain affiliation with the school although his permanent home is in Charlottesville, Va.

The membership dues in the MINE WARFARE ASSOCIATION are the sources of funds to continue publication of MINE LINES after Mr. Bottoms returns to Virginia. There will be 4 or 5 issues per year if the membership response and the availability of material so warrant.

CALL FOR ARTICLES, NEWSNOTES, TOPICAL MATERIAL

Readers, Members, and All who are interested in the technologies and practices of mine warfare and related activities are urged to submit short articles such as the one by Chris O Donnel. The length should be about 150 words - or a column in 10 point type. Submittal by disk in Word Perfect would be greatly appreciated.

CALL FOR VOLUNTEERS TO GIVE MENNEKEN LECTURES AT THE NAVAL POSTGRADUATE SCHOOL

The MENNEKEN LECTURES in Mine Warfare are designed to acquaint the Faculty and Students of the Naval Postgraduate School with the technologies, art, and practice of Mine Warfare and related activities. Individuals who would like to communicate information on technology or the operational arts (but not product marketing) are urged to volunteer their services.

Please contact Al Bottoms through MINWARA or at his home (804)296-3080; e-mail amb2m@virginia.edu for further information.

MEMBERSHIP INFORMATION

The Mine Warfare Association (MINWARA) is a not-for-profit educational organization that is incorporated in the State of Virginia. MINWARA meets the requirements of a 501 (c) (3) corporation under the Internal Revenue Act of 1954 as amended.

Financial resources that are needed to conduct the business of the organization and to prepare, publish, and disseminate the Newsletter, MINE LINES, come from the contributions of individuals or corporations. Officers and Directors serve without compensation. Such revenues as may be derived from symposia, workshops, or other training and research activities will be used to offset expenses and the costs of event preparation.

The classes of membership and the associated annual dues are as follows:

Individual Memberships

Life	\$1000
Charter	\$100
Active	\$ 25

Corporate Memberships

Corporate Benefactor	\$5000	(Unlimited persons)
Corporate Sustaining	\$1000	(Up to 5 Persons)
Corporate Annual (per person)	\$500	

The Mine Warfare Association Year is 1 October to 30 September.

 MINWARA

P.O. Box 7135, CHARLOTTESVILLE, VA 22906-7135
 Please remit by check or money order in U.S. dollars.

Albert M. Bottoms
 Tel. (804)296-3080; e-mail amb2m@virginia.edu; FAX (804)295-0857

APPLICATION FOR MEMBERSHIP

NAME	MEMBERSHIP CLASS
	REMITTANCE
ADDRESS	TEL (HOME)
	TEL (OFFICE)
	FAX
	E-MAIL
PROFESSIONAL AFFILIATION	CITIZEN OF ____

AREAS OF INTEREST/EXPERTISE (Check as many as apply)

OPERATIONAL ____ TECHNOLOGICAL ____ ARMS CONTROL ____
 HUMANITARIAN DEMINING ____ WEAPONRY ____ HISTORICAL ____
 REMEDIATION OF CONTAMINATED AREAS ____
 OTHER (Please Specify)

WILLINGNESS TO TAKE ACTIVE PART IN MINWARA

OFFICER --- BOARD MEMBER --- EVENT SPONSOR ____
 RESOURCE PERSON ____ EVENT ORGANIZER ____ MEMBERSHIP ____
 OTHER (Please Specify)

COMMENTS:

MINE LINES
QUICK-LOOK SUMMARY
OF THE
SYMPOSIUM ON AUTONOMOUS VEHICLES
IN MINE COUNTERMEASURES

Return address:

SUPERINTENDENT
CODE UW
589 DYER ROAD, ROOM 200A
NAVAL POSTGRADUATE SCHOOL,
MONTEREY, CA 93943

MINWARA WWW Administrator

Last modified: Fri Nov 3 00:38:07 EST 1995