Special Notice N00014-15-R-SN11
Special Program Announcement for Office of Naval Research
Research Opportunity:
Automation for UxV-based Mine Countermeasures

I. INTRODUCTION

This announcement describes the research thrust "Automation for UxV-based Mine Countermeasures," to be launched under the BAA entitled, "Long Range Broad Agency Announcement (BAA) for Navy and Marine Corps Science and Technology" which can be found at http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-AgencyAnnouncements.aspx.

The research opportunity described in this announcement currently falls under the following sections of FY15 Long Range BAA, ONR BAA15-001: Section I, entitled "General Information", sub-section F, entitled "Research Opportunity Description". The "Ocean Battlespace Sensing (Code 32)" item, paragraph 1, subparagraph b, entitled "Ocean Engineering and Maritime Sensing."

The purpose of this announcement is to (1) focus attention of the scientific & technology community on the areas of interest, (2) encourage dialogue amongst those interested in these areas with ONR, and (3) provide a planned timetable for the submission of white papers and proposals.

II. TOPIC DESCRIPTION

The Office of Naval Research (ONR) is soliciting white papers and full proposals for the Automation for UxV Based Mine Countermeasures program. Work under this program will consist of applied research and advanced technology development, and it will be funded under Budget Activity 2 and 3 respectively (as defined in DoD Financial Management Regulation Vol. 2B, Ch. 5). The overall S&T effort is envisioned to be conducted at the TRL 4-6 stage.

Background and Objectives

The overall objective of this program is to conduct applied research and advanced technology development that will improve the Navy's ability to conduct mine countermeasures (MCM). Its focus is on automating the employment and operation of both manned platforms and UxVs (i.e., unmanned underwater, surface, and air vehicles) as well as improving the quality, speed of production, and level of automated production for the various MCM data products.

There are two distinct but related technology Product Areas as part of this research opportunity. Interested parties are welcome to propose against one or both products; however, separate proposals are required for each Product Area.

Product Area 1 – MCM Task Force Planning will provide the capability for planning at the MCM Commander (MCMC) level. This will be achieved via software tools that incorporate an intuitive

presentation capability allowing the commander to track status of MCM effort; schedule and de-conflict assets; and re-plan based on key events such as mines found, faults detected, and environmental changes.

Product Area 2 – Automated MCM Data Analysis will provide advanced automatic target recognition (ATR), environmental characterization, and target detection/classification performance estimation algorithms for mine hunting sensors. These technologies will enable both a priori and in-situ real-time planning and adaptation at the platform level, improve ATR robustness to various seabed environments, and estimate ATR and human operator performance.

The following two subsections describe the technology products in detail. Some specific topics of interest are given below. Six distinct topics are discussed for Product Area 1 and three for Product Area 2. Submissions within the general interest area but not specifically listed below are encouraged and will be considered.

The expected deliverables include software prototypes, algorithmic descriptions, and study findings as appropriate. Data rights for technologies developed or leveraged for this effort should be clearly stated in the white paper and proposal. However, proposals should assume either government purpose rights (GPR) or unlimited rights. Justification must be provided for data rights that are more restrictive than GPR, and these will be considered on a case by case basis.

1. MCM Task Force Planning

This product will develop new tools to streamline planning and evaluation of squadron-level MCM operations. Current MCM planning is an arduous and time consuming process performed largely without the benefit of software to enable schedule development and efficient re-planning after military operations commence. For example, the MCMC has no software tools to facilitate re-planning a mission when mines are found. Furthermore, tools are lacking to assist the commander in creating a schedule to coordinate and re-task MCM systems using knowledge acquired during the mission which provides an updated view of the threat, environment, and own forces. The planning challenges are exacerbated by the lack of situational awareness tools to allow the commander to track the status of the MCM effort. Current tools either lack the ability to make adjustments or provide too much automation by overly constraining planning decisions that require military judgment. The software should present users with options, as appropriate, to support fluid interactions with the commander when military judgment is involved.

As part of this effort, algorithms and techniques will be developed to assist the MCMC in monitoring and assessing the progress of MCM operations. The two measures of effectiveness (MOE) are time to conduct the operation and residual risk to the ships transiting the cleared area. The MCMC reports risk as an MOE but needs better ways to plan to that risk using current tools. Emerging planning approaches, allowing the commander to plan to a specified level of risk, require an iterative re-planning process. Many of these concepts place new burdens on the commander's staff, requiring the timely assessment of in stride data products to inform subsequent plan modifications. Future planning tools must provide the flexibility to incorporate emerging tactical considerations such as probabilistic representations of the enemy course of action , appropriate evaluation of MCM effort considering its multiple phases, the employment of adaptive MCM force packages, and force protection measures.

Software delivered under Product 1 must support interactions with the Mine and Environmental Decision Aids Library, Enterprise Architecture (MEDAL EA), Net-Centric Sensor Analysis for MIW (NSAM), and other related MCM planning products intended for the year 2020+ time frame. As appropriate, the development will utilize Modular Open Systems Approach (MOSA). Ongoing assessment during development cycles will determine level(s) of system openness that best facilitate transition. This will allow upgrades and integration of software components with minimal effort as the roles and capabilities of MCM systems improve. Anyone selected to perform under this research opportunity will receive appropriate functional and interface documentation during the kick-off meeting. No further information on MEDAL EA or other relevant tools/systems will be provided prior to source selection, and an abundance or lack of familiarity with MEDAL EA, NSAM, or related tools will have no effect on award selection.

The six topics to be addressed under this Product Area are mission planning, waterspace management, planning algorithms, situational awareness, scheduling, and data management. Offerors addressing two or more topics should submit a single whitepaper covering the multiple areas. It should be noted that Product 1 is not intended to develop another planning tool but rather to enhance the effectiveness of existing tools such as MEDAL EA to support mission planning and execution at the MCMC level.

Topic 1.1 Mission Planning
This task will enable rapid re-planning during MCM operations based on key events, also called triggers, determined by the commander. Decision aids will assist with mission planning while considering multiple planning constraints (logistics, command and control limitations for offboard systems, force protection, etc.) at the MCMC level. Specific areas of interest include:

a. Capability to re-plan a mission based on trigger events. Utilize available knowledge from situational awareness technology to recommend multiple appropriate corrective actions in response to changes in Force, Threat, and Environment.

b. Metrics and method(s) to assess the utility/cost of generated options when compared against one another and against the current plan.

Topic 1.2 Waterspace Management
This task will provide the capability to segment the operation area based on the environment (hydrography, oceanography), mine threat, transit ship risk, transportation and logistics. Segmentation is a complex three-dimensional problem that may include dividing the region by depth based on the mine threat to account for mines on the surface, volume, or sea floor. This is an integral part of the planning process with significant impacts on the MOE's of time and risk.

A specific topic of interest includes Automation to provide the MCMC with recommendations for segmentation and asset assignments which can be used during preliminary schedule development and re-planning in response to changing conditions. Asset assignments will match the appropriate MCM gear to the mines. When combined with automated segmentation, this capability will speed the planning process and by providing the MCMC with a nominal starting point from which adjustments can be made by planning staff. Recommendations should be accompanied with supporting justification for the selected option as well as providing tradeoff analysis between varying assignments.

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Topic 1.3 Planning Algorithms
This task will formulate the core algorithms that provide the mathematical foundation to enable planning on risk, re-planning, and incorporation of both legacy and emerging MCM systems. Specific areas of interest include:

a. Algorithms to formulate and update a probabilistic representation of the enemy course of action (ECOA) for utilization during mission execution and mission evaluation. These algorithms will be used to generate operator alerts and serve as triggers to determine if the existing plan and assumptions are still valid or if a re-planning event is warranted.

b. Algorithms supporting clearance-based planning and re-planning, as well as emerging planning approaches to satisfy operator-defined MOE's of time and risk. Algorithms will determine MCM objectives for each area, may recommend sub-segmenting areas, will determine the assignment of areas to task groups, and allocation of assets to task groups. Results/recommendations must be presented in a manner that provides insight into decision space and flexibility for operator to alter aspects of the recommended plan to generate and explore additional COAs and understand the impact in a timely manner. Algorithms will also support re-planning based on changes reported in the running estimates which consider current plan and progress when developing repair strategies (new threat, additional assumed risk in area, decreased performance, mines found) or workload leveling among the Task Groups. May use ATR or other processing products as indications and warnings to inform and develop an alternate course of action. Approaches which include the ability to incorporate learning of commander preferences and parameterization of factors for use in re-planning and presentation of results are encouraged.

c. Automated technique to evaluate impact of delivered versus planned effect on overall mission objective and prompt issuance of alert/recommendation for follow-on activities. Incorporate Phase-based evaluation to assess viability of current plans and issue re-plan.

Topic 1.4 Situational Awareness
This task will improve situational awareness for the MCMC by providing an intuitive presentation capability to track the status of the MCM effort throughout the water column. This capability is especially critical to enable emerging tactical planning concepts. The MCMC must have a clear view of the operational picture to make decisions on when and how to adjust the current plan.

A specific topic of interest includes a tool that provides a clear view of the operational picture including up-to-date status (availability, utilization, for example) of Task Force assets and visualization of asset effectiveness per region. Users should also be able to visualize critical performance parameters for specified equipment given an area or sub-segment. The tool should also provide alert generation/presentation capability for key events which are triggered by monitoring incoming Naval Message Traffic as well as information from other sources and systems (MEDAL EA or NSAM).

Some example situational awareness elements might include a dashboard display of MCM running estimate information which includes a reference map that plots areas, assets, plans and projected plan completion, and completed effort. Additional information might include representations of areas,

locations of units and/or assets, actual start/stop times for completed effort, and estimated start/stop times for planned effort. Spatio-temporal awareness products providing the users with a snapshot of MCM effort being performed at a specified time should also be considered. This snapshot might include effort completed in the past or planned effort in the future. Visual representations of clearance achieved and effort planned throughout the water column are also candidates for inclusion.

Topic 1.5 Scheduling
This task addresses the important and difficult bookkeeping effort of schedule development to assist the MCMC. The initial schedule will utilize results of segmentation, performance estimates, logistics, and time considerations. A key feature is the ability to modify the schedule during re-planning with consideration for multiple potentially conflicting factors. Specific areas of interest include:

a. Scheduling framework which supports de-confliction of assets, schedule repair based on re-planning events, and asset provisioning with re-tasking. De-confliction capability should incorporate mutual interference, fratricide, assets/teams with in situ adaption and limited communication. Schedule repair should respond to re-planning events based on commander preferences, historical interactions, or other criteria such as minimizing disruptions to the existing schedule, as appropriate. Asset provisioning should consider the entire kill chain including contingency and sustainment during mine search operations in addition to follow-on identification and neutralization. The schedule should incorporate the following real world constraints: logistics planning such as support craft availability, launch and recovery constraints (sea state, time considerations), refueling, asset availability (next available time, current tasking), reliability, state of readiness, embarkation points, force protection/ scheme of maneuver, command and control constraints including communication range and reporting frequency for actionable data and re-tasking. The schedule should include workload leveling approaches at appropriate level in command structure.

b. Dynamic Task Force Asset Database which includes readiness information, logistical considerations for an assets employment, readiness information, and additional information to support automated scheduling and schedule repair such as area coverage rate, endurance, MCM capability provided, operating constraints, mines against which the system is effective, and contact localization accuracy. This database is intended as a supplement to information contained within MEDAL's Tactical Performance database.

Topic 1.6 Data Management
This task will automate the generation and interpretation of information products shared between assets and Fleet staff. For example, automation can improve management of mine contacts identified by MCM sensors through classification using pre-defined rules. Currently some of this data is manually entered into planning tools like MEDAL and can be lost if not done properly. Environmental data contained in Naval Message Traffic offers another automation path to speed mission execution and reduce errors. Specific areas of interest include:

a. Principled approach to contact management which automates the entry and tracking of contacts while supplementing contact localization data with additional products from sensor processing (acoustic color, environmental features, size, shape, orientation, acoustic resonance, etc.), environmental factors, and time varying features to improve the quality of fused contacts and

minimize the likelihood of operator error while increasing the speed and efficiency in which contacts are managed.

b. Extraction of critical data in Naval Message Traffic needed to understand and assess the current situation. Critical content will be archived in a database or other structure for consumption by any components requiring access to the information. This capability will reduce mission timeline, improve situational awareness, minimize likelihood of operator error in message processing, and reduce occurrences of lost or delayed message traffic.

c. Propagation of contact information throughout the MCM Task Force by distilling critical contact information needed to support command decision-making. This effort requires analysis of existing (and emerging) available communication channels and bandwidth for supporting MIW Community of Interest contact with fusion score. Solutions should also consider supporting a commander's requests for amplifying contact information.

d. Sharing of processed MCM data products not covered under task 1.6c, such as information regarding state of environment, water currents, sound velocity profile, and other relevant data for performance evaluation and environmental characterization functions from post-mission analysis (NSAM) and planning tools (MEDAL EA).

2. **Automated MCM Data Analysis**
This Product Area will develop ATR technologies to accelerate MCM time lines and/or improve operator performance using MCM sonar system data. Topics of interest include: 1) advanced ATR approaches that are robust or adaptive to the seabed environment, 2) target detection/classification performance estimation algorithms, 3) and online active learning (operator-in-the-loop) or in situ ATR re-training algorithms. Proposed technologies should be relevant to hunting targets using side-looking or forward-looking acoustic sensing systems, e.g. side scan sonar, multi-band synthetic aperture sonar (SAS), etc.

Specific topics of interest are given below. Submissions within the general interest area but not specifically listed below are encouraged and will be considered.

Topic 2.1 Performance estimation models and techniques for acoustic (imaging and non-imaging) sensors. Approaches that predict mine hunting performance (i.e. Probability of Detection and Classification (PdPc), false alarm rate, etc.) through prior or historical environmental conditions, received sensor information, and via platform diagnostics.

Topic 2.2 Advanced, adaptive ATR algorithms that leverage multi-frequency, multi-aspect, and/or multi-platform information to improve detection/classification performance over single-pass, narrow-band, single-platform approaches. These algorithms should adjust operating parameters or automatically switch operation modes based on a sensed environment or sensor/platform diagnostics. Adaptive ATR approaches may include elements of performance estimation and active learning.

Topic 2.3 Active and online learning ATR approaches that improve detection/classification performance in difficult mine-hunting environments.

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Performers are expected to deliver algorithms that function within a modular software test bed environment. Performers will be required to write code that can interface with the MATLAB® programming language. Algorithms will not be required to be programmed in MATLAB®; rather, they must be able to interface with the MATLAB® environment. Additionally, those performers who successfully compete for funding will receive appropriate sensor data, software test bed interface documentation, possible transition platform information, and notional performance metrics during the kickoff meeting. All performers should be able to receive and handle unclassified, for official use only (FOUO) data to develop and test algorithms. While initial development may be carried out on publicly available or simulated data, technology demonstrations will likely use sensitive, but unclassified data.

During algorithm demonstrations blind-test algorithm performance will be evaluated by the government within the above software test bed environment using well-defined performance metrics. Expected ATR performance metrics may include receiver-operating characteristic (ROC) curves (i.e. probability of detection/probability of classification (PdPc) vs. false alarm density), area under the ROC curve (AUC) vs. number of queries, query rate, and performance variance across environments. Performance estimation metrics may include accuracy of performance prediction values versus benchmark data sets labeled by appropriately trained ATR algorithms. All performers will have access to these performance metrics before beginning development.

III. No events are planned

IV. WHITE PAPER SUBMISSION

There are two distinct but related Product Areas in this research opportunity. Interested parties are welcome to propose against one or both Product Areas; however, separate White Papers and Proposals are required for each Product Area.

White Papers will be evaluated by the Government to determine whether the technology advancement proposed appears to be of particular value to the Department of the Navy. Initial Government evaluations and feedback will be issued via e-mail notification from the Technical Point of Contact. The purpose of the White Paper is to give entities a sense of whether or not their concepts are of interest to this program and will result in either encouragement or discouragement of a Full Proposal submission. It should be noted that encouragement of a Full Proposal is simply an indication of interest and does not guarantee a subsequent award. White papers should not exceed 10 single-sided pages, exclusive of cover page, references, and resume(s) of principal investigator(s), and should be in 12-point Times New Roman font with margins not less than one inch. White papers shall be in Adobe PDF format (preferred) or in Microsoft Word format compatible with MS Office 2010. For White Papers addressing 3 or more Topics within a single Product Area, the page limit is extended to 15 pages to allow for sufficient detail to support the evaluation process.

For white papers proposing efforts that are considered of particular value to the Navy, but either exceed available budgets or contain certain tasks or applications that are not desired by the Navy, ONR may suggest a full proposal with reduced effort to fit within expected available budgets or an effort that refocuses the tasks or application of the technology to maximize the benefit to the Navy.

Specific details regarding each Product are provided below:

Product Area 1
A phased technology development strategy is envisioned for Product Area 1 to develop algorithms and decision aid tools. The base effort will consist of a short study to investigate approaches, develop designs, and an execution plan. This phase will be completed within 6 months of contract award. This will be followed by two option periods lasting 6 and 18 months respectively. The first option period will be used to develop early technology proofs of concept. The second phase will continue algorithm and technology development and produce prototype tools which can be evaluated for inclusion into MEDAL EA and NSAM. Proposals should price each portion separately. Near the conclusion of this initial 2.5 year period, a follow-on solicitation will be published to seek additional Science and Technology based upon what was learned during the initial 2.5 year period for Product Area 1.

Respondents proposing to tasks in support of Product Area 1 may require access to classified information and software up to the level of SECRET. Potential respondents who lack the ability to work with classified information may still submit white papers in support of the tasks outlined in this special notice. Whitepapers should indicate facilities and personnel to support classified work. At a minimum, all performers should be able to receive and handle controlled unclassified, for official use only (FOUO) data to develop and test algorithms.

Product Area 2
All performers under Product 2 should be able to receive and handle unclassified, for official use only (FOUO) data to develop and test algorithms. While initial development may be carried out on publicly available or simulated data, technology demonstrations will likely use sensitive, but unclassified data.

After initial technology development in the first 3 years, performers should seek to mature technology and prepare for realistic technology evaluations in years 4 and 5. Thus, proposals should address a base work plan of at least 3 years with options to mature and demonstrate the technology in years 4 and 5. Depending on the number of awarded proposals, the initial number of performers may be reduced via a down-select process prior to final technology demonstrations.

The cover page should be labeled "White Paper for Automation for UxV-based Mine Countermeasures" Followed by the Product Area that it targets. The cover page should also include the following information: title of the proposed effort, topic number as listed in this special notice, technical point of contact, telephone number, and email address.

The body of the white paper should include the following information:
(1) Principal Investigator(s);
(2) Relevance of the proposed effort to the research areas described in Section II;
(3) Technical objective of the proposed effort;
(4) Technical approach that will be pursued to meet the objective;
(5) A summary of recent relevant technical breakthroughs; and
(6) A funding plan showing requested funding per fiscal year.

Resume(s) of the principal investigator(s), not to exceed 1 page per principal investigator, should also be included after the body of the white paper.

White papers shall be submitted via email to ONR.NCR.321OE.list.OceanEngineering-and-MarineSy@navy.mil. If the submission exceeds 10Mb in size, please submit via upload to the secure site: https://onroutside.onr.navy.mil/ASPProcessor/annual321oe/. In either case, it is the responsibility of the submitting individual to ensure he/she receives an email confirming receipt from the Technical Point of Contact (listed below).

White Papers should be submitted in accordance with the schedule in Section VI. White papers received after the submittal date may not receive adequate consideration. Finally, interested parties are not required to submit a White Paper and may submit only a Full Proposal. However, White Paper submission is strongly encouraged as it affords ONR an opportunity to provide constructive feedback to the Full Proposal formulation process.

V. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals should be submitted to the ONR Long Range BAA 15-001 in accordance with the schedule in Section VI. Full proposals received after the submittal date will not be considered.

ONR anticipates that grants and/or contracts will be issued for this effort.

Full proposals should be submitted in accordance with the requirements of the FY15 Long Range BAA, ONR BAA15-001 and prepared using the templates and guidance posted on the ONR website. The Technical Content shall be single spaced and not exceed 20 pages (25 pages if proposal addresses 3 or more topics). The cover page, resumes, bibliographies, project schedule, and table of contents are excluded in the page count. All proposals will be evaluated in accordance with ONR BAA15-001.

Submissions for contracts should be submitted via email to ONR.NCR.321OE.list.OceanEngineering-and-MarineSy@navy.mil. If the submission exceeds 10Mb in size, please submit via upload to the secure site: https://onroutside.onr.navy.mil/ASPProcessor/annual321oe/. In either case, it is the responsibility of the submitting individual to ensure he/she receives an email confirming receipt from the Technical Point of Contact (listed below).

Submissions for grants should be submitted via grants.gov (as instructed in the aforementioned Long Range BAA). For SF424 preparation, the following shall be used:
Block 4a, Federal Identifier: N00014
Block 4b, Agency Routing Number: Jason Stack, Code 32

For Product Area 1, ONR plans to fund multiple awards. A typical award for a given Topic is $1M for the entire 2.5-year period (i.e., base and both options); however, awards for each Topic that are as small as $75k per year or as large as $700k per year are acceptable.

For Product Area 2, ONR plans to fund multiple awards. A typical award for this Product Area is $300k per year; however, awards for this Product Area as small as $75k per year or as large as $500k per year are acceptable.

VI. SIGNIFICANT DATES AND TIMES

Event	Date	Time
White Paper Submission Deadline	04 Sep 2015	1400 Eastern Time
White Paper Evaluation Feedback	09 Oct 2015	
Full Proposal Submission Deadline	13 Nov 2015	1400 Eastern Time
Full Proposal Selection Notification	18 Dec 2015	
Notional Award Start Date (for planning purposes)	01 May 2016	

VII. POINTS OF CONTACT

Technical Point of Contact:
Dr. Jason Stack
Program Officer & Team Lead
Mine Warfare & Ocean Engineering Programs
jason.stack@navy.mil

Business Point of Contact:
Chris Williamson, Contracting Officer, Code 252, Chris.R.Williamson@navy.mil

VIII. SUBMISSION OF QUESTIONS

Any questions regarding this announcement must be provided to the Technical Points of Contact and/or the Business Point of Contact listed in Section VII above. All questions shall be submitted in writing by electronic mail.

Answers to questions submitted in response to this Special Notice will be addressed in the form of an Amendment and will be posted to the following web pages:
• Federal Business Opportunities (FEDBIZOPPS) Webpage- https://www.fbo.gov/
• Grants.gov Webpage- http://www.grants.gov/
• ONR Special Notice Webpage- http://www.onr.navy.mil/Contracts-Grants/FundingOpportunities/Special-Notices.aspx

Questions regarding White Papers or Full Proposals should be submitted NLT two weeks before the dates recommended for receipt of White Papers and/or Full Proposals. Questions after these dates may not be answered.

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