Special Notice 13-SN-0009
Special Program Announcement for 2013 Office of Naval Research Research Opportunity:
Computational Methods for Decision Making

I. INTRODUCTION

This announcement describes a research thrust, entitled Computational Methods for Decision Making, to be launched under the ONRBAA13-001, Long Range Broad Agency Announcement for Navy and Marine Corps Science and Technology which can be found at http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx. The research opportunity described in this announcement specifically falls under numbered paragraph 1 of the Command, Control, Communications, Computers; Mathematics, Computers and Information Research (Code 31) sub-section. The submission of proposals, their evaluation and the placement of research grants and contracts will be carried out as described in that Broad Agency Announcement.

The purpose of this announcement is to focus attention of the scientific community on (1) the area to be studied, and (2) the planned timetable for the submission of white papers and proposals.

II. TOPIC DESCRIPTION

The purpose of this topic is to identify, understand, and resolve key issues, develop and mature algorithms and methods; determine and demonstrate performance of algorithms, methods, techniques, and strategies for automated computational methods and information systems that support decision making. The algorithms, methods, techniques, and strategies must support autonomous information processing systems that can successfully and securely execute a variety of missions in complex environments while exploiting multiple sources of sensor and open domain data. The program will pursue a wide variety of approaches that enable automated systems to, within the context of a mission, automatically analyze multiple sources of data supporting interpretation of the data; combine data and generate interpretations from multiple data sources to provide understanding of the battle space, provide management of sensor and other resources to maintain and improve the battle space picture, and to enable and build high performance software systems that are defect free and trustworthy to implement these algorithms, methods, techniques, and strategies.

Background:

The development of automated decision systems provides a number of significant technical challenges including processing, interpreting and developing decisions using diverse data sources, multiple modalities, unstructured data, and large volumes of data with varying

latencies while compressing the time-line for arriving at a decision. Additional challenges occur when we consider that the computing hardware and software environment must protect the data, function correctly, while simultaneously providing security and trustworthiness. These issues will likely be exacerbated in practical implementations that are distributed and employ networks. The quality of the decisions developed by the system is dependent upon the quality of the underlying data and it's relation to the mission. The quality of the decisions is also impacted by the security of the data and the computing hardware that also impact the trustworthiness of the decision.

The processing and interpretation of data requires understanding of the context of the mission. The context of a mission enables a set of hypotheses, expressed as models, to provide a viewpoint that enables a system to determine data that is relevant and important to producing a picture of the battle space (situational awareness). Missions also provide a context in which the inherent uncertainty and imprecision of the data can be identified and understood with respect to subsequent processing steps involving data and inferences over the data. The presence of multiple data sources introduces additional technical issues associated with aligning the data prior to fusion, schemes for fusion, and assessing, understanding, and controlling the effects arising from incompleteness, imprecision, and contradiction in the data upon inferences and decisions.

A key issue for Naval Forces in developing situational awareness is to understand what is known, how well it is known, what is unknown and to provide strategies to determine new data that should be collected to maintain or improve situational awareness. In turn this requires capabilities to perform optimization of scarce resources in order to support a mission. If the process is to be automated and timely relative to a mission then algorithms must be implemented that can sense, interpret, reason and successfully act in an open world with uncertain, incomplete, imprecise, and contradictory data. These information processing systems should also be capable of autonomously validating their hypotheses and derived models, as well as autonomously developing new hypotheses and models as warranted. Achieving operational capabilities such as Persistent Pervasive Tactical Surveillance or Adaptive Tasking, Collection, Processing, Exploitation, and Dissemination could be straightforward if information processing systems were capable of understanding the information and quality of information that they need to produce and maintain a model of the world given its hypotheses and mission goals.

This applied research topic aims to develop knowledge and understanding of key technologies that will enable rapid, accurate decision making by autonomous processes in complex, time varying highly dynamic environments that are probed with heterogeneous sensors and supported by open source data. The applied research results should lead to understanding, computational theory, algorithms, techniques, strategies, and practical implementations providing security and trustworthiness that enable information processing systems and decision aids to adapt in an open, complex, and uncertain environment over an arbitrary set of missions.

Objective:

The Office of Naval Research Computational Methods for Decision Making Applied Research Program is partitioned into four thrusts: Resource Optimization, Automated Image Understanding, Information Integration, and Cyber Security thrusts. Together these thrusts seek to develop new technological capabilities that support Naval Operations across a wide variety of missions. Each of these thrust areas is described below.

1) Resource Optimization

The objectives of the Resource Optimization thrust are the development and application of mathematically rigorous techniques (e.g., mathematical optimization) that provide optimal or provably near-optimal solutions to resource-allocation problems. These techniques will serve as the basis of automated decision aids in support of naval planning and execution. Within the Resource Optimization there are currently two themes: Maritime Mission Planning; and Sensor Management and Allocation. Maritime Mission Planning seeks capabilities that improve power projection and achieve far better utilization of expensive Navy maritime assets. The Sensor Management and Allocation seeks to achieve an ability to optimally task and re-task large sensors networks based on current picture and sensor availability to understand the battle space and maintain dynamic persistent surveillance. For each theme, the goals are mathematical-optimization model and algorithm development that serve as the basis for decision aids.

2) Automated Image Understanding

The objective of the Automated Image Understanding thrust is to develop efficient computational methods based on principled approaches that advance the understanding of issues governing performance that are needed to support system engineering. Image understanding is a broad field that requires advances along many directions. Under this thrust, we plan to address the following issues: (a) developing principled methods for fusion of multiple imaging modalities based on the physics of image formation, leading to image enhancement and improved recognition capabilities; (b) methods for integrating images from multiple platforms for improved object recognition, scene modeling, and meaningful change detection; (c) developing methods for indexing images based on semantic content for storage and retrieval; (d) detection and tracking of objects on water or in urban areas and inferring the threat level they may pose; including real-time detection of partially occluded objects in urban clutter; and (e) developing robust recognition methods that integrate low-level image processing with high-level knowledge, or generative and discriminative models. This will also require investigating best representations, or hybrids of representations, for description and recognition of objects and activities. Furthermore, we want to extend recent advances in reasoning with image/video that make recognition of objects and activities more robust. Domain knowledge plays a critically important role in reasoning; hence an additional area of applied research would be methods for building visual knowledge bases. This also involves investigation of suitable representations for high-level semantic knowledge, which may

come in various forms including contextual information, background models, shape and appearance and behavior information, relationships among entities.

3) Information Integration

The objectives of the Information Integration thrust is to develop efficient, theoretically sound, and consistent algorithms for organization, fusion of high-dimensional data sources, interpretation of the fused product, determination of the value of data and information, and to investigate their application and potential to support naval applications. The Information Integration thrust is currently developing, maturing and assessing algorithms that organize high-dimensional datasets of interest to Naval Operations. Current efforts include applied research focused on image, video, structured database, social or complex networks, hyper-spectral, multispectral, acoustic, sensor array, and other structured datasets as well as assessing the potential value of missing information. Issues that are to be addressed under this thrust include (a)methods that lead to structuring unstructured datasets in an organized and meaningful way are desirable and should facilitate more efficient and accurate processing tasks including data matching or alignment, data merging, data search, outlier detection, learning and classification, query response, reasoning and decision making; (b) automated algorithms that fuse high-dimensional datasets that are comprised of uncertain, incomplete, imprecise, and contradictory data for the purpose of recognizing and classifying features, objects, entities, activities, patterns of interest, and relationships; and (c) assess and understand the quality of the resulting fused battle space picture and its impact on decision making.

4) Cyber Security

The objective of the Cyber Security thrust is to develop a software development environment that enhances the robustness and security properties of the resulting codes, while minimizing penalties to code performance and overhead. Currently flaws in software are a major contributor to the vulnerability of cyber systems. Most if not all of these vulnerabilities originate from improper software implementations. Identified flaws that lead to improper implementations include, and are not limited to, buffer overflow, stack and heap overflow, dangling pointers, input data format violation, race conditions, etc.. Methods for software implementation still lead to these deficiencies. Significant investment has been made to address this issue through techniques that seek to provide formal or other forms of software verification. However, complementary efforts to verification, that lead to understanding of techniques that enhance the development and generation of robust secure code is under-explored. Alternatively automated methods that capture and utilize work flow, thought/design-decision, and documentation during software coding that also are aware of software implementation issues could address this need. Only rarely are all of the details for the implementation of software specified in advance. Currently programmers make instantaneous detailed design decisions during software coding. These instantaneous decisions (and assumptions) have far reaching effects, and they are often forgotten and lost. A tool that captures and documents these design decisions (and hence assumptions) automatically as coding is in progress and can significantly enhance maintainability, robustness, and security of codes. The availability of

these tools also provide an opportunity to provide feedback to programmers to improve the correctness of their product and enhance productivity and efficiency.

Research Areas:

The Office of Naval Research (ONR) is interested in receiving proposals that address specific interests in each theme. These interests are described below.

1) Resource Optimization:

To a large extent, current mathematical-optimization techniques used for Navy planning-and-execution problems operate in a centralized manner, meaning that the necessary information is imported to a centralized computing node at which a solution (or a sequence of solutions, in a dynamic environment) is determined. This approach is appropriate many scenarios, and it has the advantage of producing high-quality solutions. In others scenarios, however, a de-centralized approach may be more appropriate. Consider, for example, the task of mission planning and execution for Unmanned Aerial Vehicles (UAVs) or Unmanned Underwater Vehicles (UUVs), where communication bandwidth may be severely constrained and communication latencies may be detrimental. In such a case, it may be desirable to have a decision aide that is capable of operating in a distributed or de-centralized manner. Specific research areas of interest include:

a) Model and algorithmic development for de-centralized optimization for Navy planning and execution problems;
b) Hybrid techniques – methods that can operate either in centralized or de-centralized mode depending on the available communications connectivity and mission requirements;
c) Rigorous empirical and/or theoretical analysis of the "price of anarchy"; that is, a measure of how solution quality degrades in a de-centralized system versus a centralized system.

2) Automated Image Understanding

The development of principled methods and algorithms for image/video understanding as well as investigating their performance limits are the focus of this thrust. The algorithms and methods should perform in complex, realistic scenes that contain varieties of objects, activities, and events. Examples of complex, cluttered environments are urban, port/harbor, and riverine areas. Technical approaches should be general in nature, robust with respect to appearance variations, and computationally efficient. Current research areas of interest are:

a) Representations for objects and actions that are optimized for recognition, inference, and scene understanding. These representations must be insensitive to nuisance factors such as scale, pose, and appearance, and in the case of actions insensitive to durations. Features and attributes that comprise these representations should be readily detectable, persistent, and efficient, and support techniques for fast matching.

b) Integration of low-level image data and high-level knowledge for simultaneous segmentation, grouping, and recognition; developing efficient techniques for building visual knowledge bases that are portable and extensible, and identification of attributes and relations that should be included in knowledge bases; and methods for visual reasoning.
c) Development of an adaptive and collaborative network of controllable imaging sensors (including EO/IR video and other modalities) for tracking and recognizing objects and activities, with potentially non-overlapping coverage that is able to resolve ambiguities due to gaps in the visual information, occlusions, and loss of tracks. Methods for the network to autonomously determine if additional information is needed for accurate recognition. In conjunction with the Resource Optimization thrust the network should also determine strategies for acquiring the needed information, and optimal allocation of imaging assets to track and recognize the most interesting objects/activities.

3) Information Integration:

The information integration effort is focusing effort in two directions. The first is the development, maturation, evaluation and understanding of methods and algorithms that provide a capability for automatic mapping of data from one modality to another modality. An example of the type of technologies that we seek to develop are ensonification where data from another domain is converted to acoustic data. Of particular interest for this Special Notice are methods for

a) Automatic conversion of images/video to text, where the text provides a complete summary of the objects, relationships, activities, and events given a context.

b) Automatic storyboarding in which a text document is converted to an appropriate sequence of images that convey the information content of the text.

c) The development of metrics which address the precision and accuracy of the translation process, as well as metrics that describe the computational costs and complexity of the proposed algorithm.

The second emphasis area for the Information Integration thrust focuses upon the development, maturation, evaluation, and understanding of algorithms that address the value of missing and conflicting information with respect to informing models of the world that support decision making in autonomous, manned, and hybrid decision making processes. For the purposes of this Special Notice, proposers may assume that all data sources have been aligned, however methods that can relax the assumption of aligned data or automatically align data sets are preferred. Of particular interest to ONR are methods that enable the use of unstructured data in conjunction with sensor data and methods that can determine which information should be collected. Specifically ONR seeks to improve the automated performance of systems that:

a) Ingest unstructured data, including text and relationships that are often expressed as text or graphs, and provide structured data that enable further analysis and integration of this data with sensor data. ONR is not interested in methods that are based upon key word search or on the development of ontologies or relationships within an ontology.

b) Develop, assess, and understand algorithms that enable an automated system to infer the values of missing data. ONR is interested in automated methods that for a single modality, or multiple modalities, enable missing data to be inferred with minimal assumptions.

c) Develop, assess, and understand algorithms and methods that define the value of acquiring new data. These methods should also determine appropriate data that should be collected to support the formation of an operational battle space picture that can be used to support decision-making or mission focused autonomy. In creating a strategy for data collection it is desirable that the algorithms and methods provide implementable strategies that can resolve contradiction arising from integrating information derived from uncertain, incomplete, and imprecise data.

d) Similar to c) above ONR is interested in sensor systems in which the use of an outer metric associated with a system function (detection, track, object recognition,…) is used to adapt the parameters of the data processing and information integration algorithms. This capability will require the system to adapt itself based upon an estimate of the achievable performance of the system. In turn this will require additional capabilities that determine when the underlying data support the existing model or when the underlying data is incompatible with the model and a new model is hypothesized, instantiated, validated, and verified.

4) Cyber Security

Develop and demonstrate tools and an environment that lead to the generation of robust and secure codes. The development environment and tools should support codes at both the system (or operating system) level, as well as at the software application level.

a) Security and vulnerability aware compilers with automatic insertion of constructs that guarantee robustness and security of codes written in unsecured languages.

b) Automated generation of secure and robust codes from high-level description (design-entry) of function that leads to software that is both readable and efficient.

c) Methods that automatically capture and utilize work flow, thought/design-decision, and documentation during software coding that lead to functioning code that meets performance and security requirements.

III. WHITE PAPER SUBMISSION

Although not required, white papers are strongly encouraged for all offerors seeking funding. Each white paper 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 initial white paper appraisal is intended to give entities a sense of whether their concepts are likely to be funded.

Detailed Full Proposals (Technical and Cost volumes) will be subsequently encouraged from those Offerors whose proposed technologies have been identified through the above referenced e-mail as being of "particular value" to the Government. However, any such encouragement does not assure a subsequent award. Full Proposals may also be submitted by any offeror whose white paper was not identified as being of particular value to the Government or any offeror who did not submit a white paper.

For white papers that propose 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.

White papers should not exceed 4 single-sided pages, exclusive of cover page and resume of principal investigator, and should be in 12-point Times New Roman font with margins not less than one inch.

The cover page should be labeled "White Paper for ONR 2013 Research Opportunity: Computational Methods for Decision Making" and include the following information: title of the proposed effort, technical point of contact, telephone number, fax numbers, and e-mail address.

The 4-page body of the white paper should include the following information:

(1) Principal Investigator;
(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.

A resume of the principal investigator, not to exceed 1 page, should also be included after the 4-page body of the white paper.

White papers should be submitted electronically to the program technical point of contact, Dr. Carey Schwartz, (carey.schwartz@navy.mil). Files exceeding 10MB in size should not be emailed, but instead transmitted via a file transfer service, for example AMRDEC Safesite,

https://safe.amrde.army.mil, or mailed on CDROM or DVD. White papers shall be in Adobe PDF format (preferred) or in Microsoft Word format compatible with MS Office 2007.

To ensure full, timely consideration for funding, white papers should be submitted **no later than 11 April 2013**. White papers received after that date will be considered as time and availability of funding permit.

The planned date for completing the review of white papers is **01 May 2013.**

V. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals should be submitted under **ONRBAA13-001** by **15 July 2013.** Full Proposals received after that date will be considered as time and availability of funding permit.

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

Full proposals for contracts should be submitted in accordance with the instructions at Section IV, Application and Submission Information, item 2.b, Full Proposals and item 6, Submission of Full Proposals for Contracts, Cooperative Agreements, and Other Transactions. The Technical Proposal/Content shall be single spaced and not exceed 15 pages. The cover page, resumes, bibliographies, and table of contents are excluded in the page count. For contract proposal submission, 5 hardcopies and one (1) electronic submission on CD-ROM are requested.

Full proposals for grants should be submitted in accordance with the instructions at Section IV, Application and Submission Information, item 5, Submission of Grant Proposals through Grants.gov. All full proposals for grants must be submitted through www.grants.gov. The following information must be completed as follows in the SF 424 to ensure that the application is directed to the correct individual for review: Block 4a, Federal Identifier: Enter N00014; Block 4b, Agency Routing Number, Enter the three (3) digit Program Office Code 311 and the Program Officer's name, last name first, in brackets ([Schwartz Carey]). All attachments to the application should also include this identifier to ensure the proposal and its attachments are received by the appropriate Program Office.

ONR plans to fund five (5) to ten (10) individual awards with a value of $250,000 per year, using Applied Research funds. However, lower and higher cost proposals will be considered.

The period of performance for projects may vary from one (1) to three (3) years.

Although ONR expects the above described program plan to be executed, ONR reserves the right to make changes.

Funding decisions should be made on or about 01 August 2013. Selected projects will have an estimated grant award date of 15 November 2013 and an estimated contract award date of 15 JAN 2014.

VI. SIGNIFICANT DATES AND TIMES

Event	Date	Time
Recommended White Paper Submission Date*	11 April 2013	1400 EST
Notification of White Paper Valuation*	01 May 2013	1400 EST
Recommended Full Proposal Submission	15 July 2013	1400 EST
Notification of Selection: Full Proposals *	01 August 2013	1400 EST
Grant Awards *	15 November 2013	
Contract Awards *	15 January 2014	

Note: * These are approximate dates**.**

VII. POINTS OF CONTACT

In addition to the points of contact listed in ONRBAA13-001, the specific points of contact for this announcement are listed below:

Technical Point of Contact:
Dr. Carey Schwartz, Program Officer, Carey.Schwartz@navy.mil

Business Point of Contact:
Jennifer Brown, Contract Specialist, Jennifer.Brown4@navy.mil

Rebecca Foster, Contract Specialist, Rebecca.d.Foster@navy.mil

VIII. ADDRESS FOR THE SUBMISSION OF WHITE PAPERS AND FULL PROPOSALS FOR CONTRACTS

White Papers must be emailed to Dr. Carey Schwartz at the following email address: carey.schwartz@navy.mil. Full Proposal submissions including the DVD or CD-ROM and all supporting documentation should be sent to the Office of Naval Research at the following address:

Primary Point of Contact	Secondary Point of Contact
Office of Naval Research Attn: Dr. Carey Schwartz ONR Department Code 311 875 North Randolph Street – Suite 1179 Arlington, VA 22203-1995	Office of Naval Research Attn: Kimberly McCormick ONR Department Code 311 875 North Randolph Street – Suite 1105C Arlington, VA 22203-1995 (703) 696-8528

IX. 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 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/Funding-Opportunities/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 this date may not be answered.