BAA Call N00014-23-S-C002
Amendment 0003
Special Program Announcement for Office of Naval Research
Research Opportunity:
"Hierarchical Command and Control of Unmanned Systems (H- C^2 UxS)"

The purpose of this amendment is to Revise BAA N00014-23-S-C002 as follows:

1. Update the submission dates.
2. Clarify that white papers shall not exceed 5 single-sided pages, exclusive of cover page, references, and resume of principal investigator, and should be in 12-point Times New Roman font with margins not less than one inch per side.
3. All changes are in red.

I. INTRODUCTION

This announcement describes the following technology areas listed at https://www.nre.navy.mil/our-research/onr-technology-and-research

1. Command Decision Making
2. Command and Control
3. Expeditionary Robotics, Autonomic, and Autonomy
4. Human Interaction with Autonomous Systems
5. Science of Autonomy
6. Tactical AI for Marine Corps

All Technology Areas fall under the Long Range Broad Agency Announcement for Navy and Marine Corps Science and Technology (S&T) (N00014-23-S-B001), which can be found at https://www.nre.navy.mil/work-with-us/funding-opportunities/announcements.

The submission of proposals, their evaluation, and the placement of contracts and grants will be carried out as described in the above Long Range 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 full proposals.

II. TOPIC DESCRIPTION

ONR is interested in receiving white papers and proposals in support of advancing hierarchical command and control of unmanned systems for future naval applications. Work under this program will consist of basic and applied research, with projects funded under Budget Activity 1, Basic Research, and Budget Activity 2, Applied Research, as defined in the DoD Financial Management Regulation, Vol. 2B, Ch. 5 (https://comptroller.defense.gov/portals/45/documents/fmr/current/02b/02b_05.pdf). The

overall S&T efforts will be conducted at the Technology Readiness Level (TRL) 1 – 5 stages (https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level).

Topic 1

Title: Hierarchical C^2 of Unmanned Systems (H- C^2 UxS)

Background: Military command and control (C^2) entails operating with a hierarchy of individual decision makers working across echelons, each of which provides unique contributions to the command and control of the military organization. Future Navy and Marine Corps operations are envisioned to feature use of multiple UxSs (operating in the air, surface, ground, and subsurface domains), with varying degrees of autonomy, and performing a variety of combat and support functions, sometimes in a communications denied and degraded environment (D2E). The command and control requirements of these individual decision makers for using these UxSs are not currently well defined. This topic is seeking basic and applied research to explore alternative models for managing the command and control of UxSs, defining the information requirements for decision makers in a H- C^2 organization, and performing initial research and development of C^2 autonomy that would support those models. The research is expected to lead to follow on advanced development efforts that will be pursued in one or more follow-on solicitations.

Many operations will feature UxSs working in cooperation with each other, and with manned platforms and/or dismounted troops. This introduces additional complexity for managing mission objectives and tasks. Various aspects of H-C2 will be exercised at different levels of the command hierarchy. Mission success requires effective H-C2 of these UxSs from each level of command.

Key issues being addressed under this topic include:

- What autonomy is required to support command and control of UxSs?
- How should the management of autonomous systems be integrated into the existing military command and control structure?
- What relationships and information will be needed, expected and/or required between individuals in the human command and control hierarchy and UxSs?
- What autonomy capabilities will be required to manage dynamic tasking of UxSs in support of military missions engaged in across the Naval enterprise?

Research Issues of Interest:

1. Orders and plans: How will orders, other formal command documents, mission plans, and associated processes need to be modified to incorporate tasks and requirements for UxSs in support of military operations? Formal documents such as operational orders (OPORDs), fragmentary orders (FRAGOs), and other documents flow from upper echelons of command to lower levels. These documents are further interpreted and expanded upon at lower echelons as they prepared detailed plans for specific operations. Research issues include:

a) How can these orders, plans and supporting documents be made both machine readable and human interpretable, with easy comprehension by troops and enable manageable computational requirements by software systems, at each level in the control hierarchy? Can we standardize the language and other elements used in these documents so that effective C2 of UxSs can be achieved through their contents, as they flow down through each level of command?
b) How do autonomous UxSs fit into existing command structures? How can these systems be direct recipients of orders and commands? How can they formulate and disseminate plans in response to those orders and commands, similar to the way humans use context and implicatures? How is the initial mission plan involving multiple platforms properly coordinated, summarized, and conveyed to all participants, and to all levels of the command structure and to support the different needs for planning?
c) When an on-going operation must be dynamically re-planned in response to unforeseen events, how is updated information transmitted to and from the platforms involved, potentially using a priori knowledge? How should the higher levels of command be involved in dynamic re-planning?
d) How much re-planning can / should occur within the unmanned system itself and for what kinds of changes or eventualities and what planning should be managed by more central control nodes? How is an updated plan disseminated to other participants, and across all levels of the command structure?
e) How should voice commands and other modes of human communication be used to command and control UxSs?
f) In the presence of denied or degraded communications, what implicit or explicit behaviors might be embedded in autonomous systems in order to convey critical mission status? What analytic capabilities would need to be embedded in operator workstations to detect these behaviors (or lack thereof)? How might operators monitor the status of missions as they execute in denied environments with limited communication capabilities?

2. Tools, methods, and models: What models, languages, and representations of individual platforms, environments, and mission types are needed to support design, development, testing, and operation of UxSs, and of detailed plans for specific operations? What tools and methods are needed to ensure C2 can be exercised over these systems? Research issues include:

a) How can the models of UxS missions be standardized and represented so they serve multiple purposes, including mission planning, performance prediction, and estimating the status and health of an unmanned system before, during, and after an operation? How are their outputs to be used at each level of command?
b) How can the models used in initial planning for an operation be used to maintain estimates of the status of that operation as it executes, especially in a D2E? How can these estimates be used at each level of command to decide whether to intervene?
c) How can these models be used to analyze and assess performance of UxSs in a completed operation, providing appropriate feedback to each level of command regarding mission success and to support future mission planning?

d) What underlying models are needed to represent platforms, data flows, and contextual variables during system design and development in order to enable HC2? How will these models exchange information as the systems engineering process executes?
e) What analytical techniques are needed to identify and manage vulnerabilities and sources of brittleness in proposed H-C2 systems and technologies?
f) What tools and environments are needed to enable proper definition and use of measures of performance (MOP) and effectiveness (MOE) for systems and technology in a representative H-C2 environment?

3. Resilient C2 structures: Hierarchical C2 structures may need to adapt to changing operational conditions, such as loss of C2 links or a C2 node, as an operation is in progress. They also need to be resilient in the face of enemy attacks and environmental conditions that interfere with communications. Autonomous C2 agents may be needed. Research issues include:

a. How can an autonomous C2 agent effectively coordinate activities of participating systems, manned and unmanned, particularly in D2E?
b. How can the C2 of UxSs normally exercised at the lowest level of command be effectively monitored or executed at higher levels of the command hierarchy?
c. What alternate communications methods could UxSs use in a D2E to communicate with each other and with the command hierarchy?

4. Commander understanding of unmanned autonomous systems: How will humans, including those at higher levels of command, acquire accurate understanding of the capabilities, limitations, and behavioral tendencies of UxSs that have relatively high degrees of autonomy? These issues apply to autonomous systems that function independently, but are especially salient to those that behave as part of a team. Live training events and large-scale exercises provide limited capabilities for people to acquire this knowledge, but such knowledge is essential for planning and executing operations involving these systems. Research issues include:

a. How should an unmanned system's tasks and intent be effectively conveyed to humans in a dynamic operational environment?
b. How can large scale simulations of unmanned systems performing in a variety of operational conditions generate sufficient information about the tendencies, strengths, and weaknesses of unmanned autonomous systems and the adequacy of their command and control mechanisms and autonomy? How can the results of simulation be presented to operators and commanders to promote accurate mental models of unmanned system capabilities, limitations, and the UxS's behavioral tendencies?
c. How do we incorporate hierarchical C2 that includes autonomous systems in to the established training cycle for the Navy/MC?
d. What types of mission preview/rehearsal capabilities are needed to help commanders and operators prepare for an upcoming planned operation during the development of UxS mission plans, especially as it relates to various contingencies and anomalies that may occur? What types of testing and evaluation is needed to ensure commander understanding of system capabilities?

e. How can an autonomous system in the HC2 hierarchy explain its actions and plans adequately to the commander? How can viewpoints from multiple autonomous systems or humans be combined into a single narrative?
f. How will novel capabilities and other emergent properties of multiple UxSs behaving as a team, perhaps as part of a manned-unmanned team, be identified and conveyed to commanders?

Program Structure: We request a maximum 4-page white paper prior to full proposal submission.

The white paper will describe the following:

- Description of research and/or capabilities being proposed, and their expected utility for the Naval enterprise;
- Proposed technical approach for the research;
- A summary of the most critical technical problems / research questions to be addressed by the proposed research;
- A description of the domain and data-driven task (use case(s)) to be used; and
- A description of any simulation environments, data, and metrics you plan to use in developing and testing your agents.

Full proposals will expand on the white paper and include the following:

- Present a clear story of the proposed research, an understanding of the current state of the art, where the science and technology are headed, and specific contributions to be made;
- Describe the science and capabilities required to achieve a successful end state for a the application of your research to H-C2;
- Frame the research and progress along well-defined research & development milestones; provide milestone descriptions in text and provided details to the quarter year;
- Clearly identify any datasets, benchmarks, and simulation environments planned to be leveraged;
- Clearly identify any proprietary or limited use data rights for tools you will be using in conducting the proposed research;
- Provide sufficient detail on research strategies and how the proposed research should be technically evaluated;
- Identify principle performers on research team;
- Define a program schedule and critical program performance metrics supported by a Program Objective And Milestone Chart (POAM);
- Define proposed programmatic metrics to evaluate technical progress; and
- Cost & labor scope for two 24-month phases of effort.

Proposals need to define 2 phases each with a notional duration of 24 months.

IV. 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 Proposal (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 5 single-sided pages, exclusive of cover page, references, and resume of principal investigator, 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 at least Microsoft Word 2016.

The Cover Page can be found at https://www.nre.navy.mil/work-with-us/how-to-apply/submit-contract-proposal for contract submissions and at https://www.nre.navy.mil/work-with-us/how-to-apply/submit-grant-application for grant submissions.
The 5-page body of the white paper should include the following information:

- Technical Concept: A description of the technology innovation and technical risk areas.
- Future Naval Relevance (where applicable) – A description of potential Naval relevance and contributions of the effort to the agency's specific mission.
- Operational Naval Concept (where applicable) – A description of the project objectives, the concept of operation for the new capabilities to be delivered, and the expected operational performance improvements.
- Operational Utility Assessment Plan (where applicable) – A plan for demonstrating and evaluating the operational effectiveness of the Offeror's proposed products or processes in field experiments and/or tests in a simulated environment.
- Rough Order of Magnitude (ROM) cost estimate.

A resume of the principal investigator, not to exceed 1 page, should also be included after the 5-page body of the white paper.

White papers must be submitted through Fedconnect at www.fedconnect.net in accordance with Section D in N00014-23-S-B001, Application and Submission Information, Section 2. Content and Form of Application Submission, paragraph d. White Paper Requirements, ii. White Paper Submission.

To ensure full, timely consideration for funding, white papers should be submitted **no later than Thursday, December 1, 2022 at 1200 EST**. White papers received after that date will be considered as time and availability of funding permit.

The estimated date for completing the review of white papers is **Wednesday, December 21, 2022**.

V. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals should be submitted under N00014-23-S-B001 by **Tuesday, February 7, 2023 at 1700 EST**. 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 Appendix 2 of N00014-23-S-B001. Full proposals for grants should be submitted via Grants.gov in accordance with Appendix 1 of N00014-23-S-B0001.

The total period of performance for projects may be from **3 – 5 years**.

Although ONR expects the above described program plan to be executed, the program is subject to availability of funding, and ONR reserves the right to make changes.

Funding decisions for FY23 funding should be made on or about **Friday, March 10, 2023 at 1700 EST**. Selected projects for initial funding will have an estimated award date of **4 – 6 months after selection**. Proposals not selected for initial funding will be held for potential future funding when additional funds become available.

VI. SIGNIFICANT DATES AND TIMES

Event	Date	Time
Recommended White Paper Submission Date*	**December 1, 2022**	**1200 EST**
Notification of White Paper Valuation*	**January 6, 2023**	**1200 EST**
Recommended Full Proposal Submission	**February 7, 2023**	**1200 EST**
Notification of Selection: Full Proposals *	**March 10, 2023**	**1700 EST**
Awards *	**4 – 6 months after selection**	**1200 EST**

Note: * These are approximate dates.

VII. Small Business Subcontracting

As indicated in ONR Broad Agency Announcements large businesses and non-profit organizations must submit a subcontracting plan along with their research proposal. While large businesses and non-profits are responsible for making these subcontracting arrangements, ONR will help facilitate prime contractor/small business contracting connections by posting to the ONR external website contact information of small businesses that have indicated their subcontracting interests and technological niche for prime contractor consideration for this program. This is not an endorsement, but an effort by ONR to help bring these parties together to provide superior solutions.

If you are a small business, and your company is interested in subcontracting activities with large businesses and/or non-profits considering your technology for this program, please provide the following information by email, to the ONR Small Business Director at ellen.simonoff@navy.mil with the subject line, "BAA Call N00014-23-S-C002." Provide this information:

1) Company Name and Website
2) Individual (POC) name and POC email address
3) Business Size and socio-economic category
4) Brief Technology Description (no more than 3 sentences)
5) Technology Key Words (no more than 10 words)

Note: Do not include ANY proprietary information. This information will be posted on the ONR website under this BAA call and will available to the public.

VIII. POINTS OF CONTACT

In addition to the points of contact listed in N0014-23-S-B001, the specific points of contact for this announcement are listed below:

Technical Points of Contact:

Topic 1:
Dr. Jeffrey Morrison, ONR Code 341, (703) 696-4875, jeffrey.g.morrison.civ@us.navy.mil
Dr. Michael Qin, ONR 34, 703-696-2833, michael.k.qin.civ@us.navy.mil

Business Point of Contact/Contracting Officer:
Charles S. Weiner, 813-465-3473, charles.s.weiner.civ@us.navy.mill

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 above. All questions shall be submitted in writing by electronic mail.

Answers to questions submitted in response to this BAA Call will be addressed in the form of an Amendment and will be posted to the following web pages:

- Beta.sam.gov Webpage –Contract Opportunities – https://beta.sam.gov/
- Grants.gov Webpage – http://www.grants.gov/
- ONR BAAs, FOAs and Special Program Announcements Webpage - https://www.nre.navy.mil/work-with-us/funding-opportunities/announcements

Questions regarding **White Papers or Full Proposals** should be submitted not later than two weeks before the dates recommended for receipt of White Papers and/or Full Proposals. Questions after this date may not be answered.