OVERLORD PROGRAM

Phase I Demonstration Plan

Unmanned Surface Vehicle (USV)

DRAFT

Contents

OVERLORD PROGRAM DESCRIPTION

I. General

On behalf of the Office of the Secretary of Defense (OSD), Strategic Capabilities Office (SCO), Washington Headquarters Services (WHS) Acquisition Directorate (AD), is soliciting Proposals for a prototype program. The Government intends to award a Firm-Fixed-Price Other Transaction Authority (OTA) in accordance with 10 U.S.C. 2371b. To the maximum extent practicable, competitive procedures will be used when entering agreements to carry out the Overlord Program, however, the Competition in Contracting Act (CICA) (10 U.S.C. Section 2304) is not applicable.

SCO is partnering with the U.S. Navy, specifically the Unmanned Maritime Systems Program Office (PMS 406), to develop and demonstrate capability for independently-deploying autonomous Unmanned Surface Vehicles (USVs) as part of an OSD/SCO program known as the Overlord Program. The Overlord Program USVs will be used to demonstrate an enhanced warfare capability to negatively impact adversaries in a given maritime region. USV autonomy capability is intended to augment the existing complement of manned naval warships and enhance the warfighting effectiveness of the fleet. Critical to the Overload program is partnership and coordination with industry to rapidly deliver the required prototype capability to support demonstration and evaluation. The Government envisions a relationship with industry to provide a vehicle in which to demonstrate autonomy in Phase I of the program, and then down-select Partner Teams in Phase II for further test and demonstration, in order to deliver an optionally-manned vehicle to the Government. Given the rapid nature of this effort and the foundation it will likely lay for the Navy's future medium and large USV efforts, partnering with industry is critical.

During the 12-month Phase I, the Government is seeking to evaluate developmental prototype solutions that address the autonomous operation of USVs for applicability to future advanced technology demonstrations. A competitive capability evaluation is planned in order to determine the maturity of potential industry solutions and to assess the state of the practical with respect to USV autonomy. The evaluation approach assumes multiple contractors developing or integrating advanced technology platforms for assessment by the Government. Assessment will include data gathered from structured tests executed by each Partner Teams in conjunction with the Government. Testing will be focused on exercising USV autonomy capabilities under increasingly more complex operational scenarios. The Government intends to integrate the assessment data into a planned future agreements action; the Government reserves the right to change or abandon planned future agreements actions based upon the results of the assessment.

The Government requires that all hardware and software systems developed, integrated, or otherwise supplied under this solicitation adhere to best practices for open architecture systems engineering. This means that the Partner Teams shall provide solutions that are modular, decomposable, replaceable, substitutable, and interchangeable so that functional components such as plant control, localization, navigation, sensing, perception, planning, world modeling, behavioral, and other functional components may be used from a variety of vendors through well-defined open interfaces. The Government will be evaluating the Partner Teams solution to determine the degree to which an open architecture has been implemented. Proprietary solutions are not desired.

For use within this solicitation, the following definitions apply:[1]

- Autonomous: Operations of an unmanned system wherein the unmanned system receives its mission from the human and accomplishes that mission with or without further human-robot interaction. The level of human-robot interaction, along with other factors such as mission complexity, and environmental difficulty, determine the level of autonomy for the unmanned system. Finer-grained autonomy level designations may also be applied to the tasks, lower in scope than mission.

- Autonomy: The condition or quality of being self-governing. An unmanned systems own ability of sensing, perceiving, analyzing, communicating, planning, decision-making, and acting, to achieve its goals as assigned by its human operator(s) through designed human-robot interface. Autonomy is characterized into levels by factors including mission complexity, environmental difficulty, and level of human-robot interaction to accomplish the missions.

II. Executive Summary

The Overlord Program intends to convert extant vehicle designs into USVs in order to provide the Navy with novel and cost-effective capabilities to service existing mission sets. The Overlord Program will develop and mature reliable USV autonomy within an approximate three-year timeframe with the end goal of vehicle(s) capable of sustaining autonomous operations at sea for a 90-day period without any embarked crew, and will involve integration and test of payloads for Electronic Warfare (EW), Anti-Surface Warfare (ASuW), and/or Strike Warfare (STW). The prototyping effort will include provisions for a small crew (8-12 people) necessary to test and evaluate reliability and autonomy. The vehicle(s) will be converted for unmanned operation, and be capable of operating in an unmanned mode, but retain an (optional) crew for safety and evaluation. The program will use experimentation with large-scale prototypes as the primary method for technology maturation and risk reduction.

Broadly, the USV must be capable of safe navigation, avoiding grounding and allisions, as well as avoiding collisions with other vessels in a manner consistent with International Regulations for Preventing Collisions at Sea (COLREGs). The USV must be capable of fixing its position using the Global Positioning System (GPS) and other fix sources, and must be capable of accurately sensing nearby vessels and hazards to navigation. The USV must also be capable of managing subsystems and mechanical components (e.g. engines, generators, and support equipment) to provide maximum mission readiness.

The USV will deploy mission-specific payloads. Effective payload deployment will require USV autonomy to process Command and Control (C2) data for basic mission structure, as well as link payload-specific data to support payload deployment. Communications links to support both general vehicle operation as well as payload/mission execution, to be specified by the

[1] "Autonomy Levels for Unmanned Systems (ALFUS) Framework, Volume I: Terminology, Version 1.1," NIST Special Publication 1011, September 2004.

Government, must be integrated with USV autonomy. The USV's C2 and payload control systems, to the maximum extent possible, must integrate with existing fleet assets. C2 must be transferrable between control stations afloat and ashore.

The program will provide the Navy with one or more operationally-capable leave-behind assets to use for testing and fleet experimentation. Additionally, the program will deliver a technical data package for USV autonomy that will permit construction (or conversion) of a USV with variable physical characteristics, to support future Navy acquisitions without prescribing a specific hull type.

III. Program Plan

Under the Overlord Program, the Government will use a phased approach to mitigate risk in the most expeditious manner through the award of an OTA between SCO and a U.S. commercial Partner Team. **The expected proposals in response to this solicitation will address the terms and requirements of Phase I only**. The Partner Team must include an autonomy provider along with ship provider and or a ship design team. The Overlord Program will take advantage of commercial technologies, integrate existing vehicle designs, and mature existing autonomy capabilities to accomplish its goals. The approximate three-year Overlord Program is separated into two distinct phases and is designed to have a seamless flow from one phase to the next. The Government intends to award multiple prime agreements for Phase I (12-months) and subsequently down-select for Phase II (24-months). The Phase I agreements will be modified for those Partner Teams entering Phase II as required. The two phases of the Overlord Program are discussed below.

A. Phase I Demonstration Plan

The agreements will be awarded to develop independently-deploying USVs for evaluation by the Government. In Phase I, the Government intends to award up to four agreements for no greater than $90M (total for up to four efforts) for maturing larger USV autonomous capabilities. Under Phase I, the Government is seeking to evaluate the Partner Teams' developmental prototype solutions that address the autonomous operation of larger USVs to include both autonomy for vehicle navigation and hull, mechanical and electrical (HM&E) autonomy. The Government does not intend to provide vehicles as part of the Overlord Program. Partner Teams shall propose their method to secure, through cost-effective means, a minimum of one large-scale USV. The USV shall be used to integrate autonomy technologies into a prototype system for test and evaluation. Partner Teams must secure the vehicle(s) via a method that permits continued development using the same vehicle(s) in Phase II, if selected, and ultimately transfer of the vehicle (s) to the Government, at the Government's discretion, at the conclusion of Phase II. A milestone plan will be required as a deliverable one-month after the Phase I award. The milestone plan shall include a timeline for achieving the measures of performance (MOP) in Phase I and a plan for Phase II follow on work. The Phase II plan should include strategy for procuring a minimum of one boat that will be a deliverable at the end of Phase II, along with cost and schedule of transitioning from Phase I to Phase II if awarded.

After evaluation of the proposals and a recommendation for funding is made, notification will be provided to the Partner Teams if the proposal is selected for Phase I. After selection is made, the Contracting Officer will initiate agreement negotiations with the Partner Teams for Phase I under this program solicitation.

Approximately 12-months after the award date, Phase I will conclude with a competitive capability evaluation to determine the maturity of potential industry solutions and to assess the state of the practical with respect to USV autonomy.

B. Phase II

The Government intends to issue a separate solicitation for Phase II that will only be open to Phase I Partner Teams. Under Phase II, the Government intends to down-select from the Phase I Partner Teams up to two agreements for extended USV development, Government Furnished Equipment (GFE) integration (radios, HM&E autonomy technologies, C2 station, payloads), and integration with other fleet assets to deploy mission payloads.

Approximately 24-months after the start of Phase II, the Overlord Program will conclude with a capstone demonstration of the overall USV capability and subsequent delivery of the USV(s) to the Government. For the capstone demonstration event, the USV(s) will conduct an extended unmanned deployment and operate payloads in coordination with manned Navy assets. Following a successful capstone demonstration, the USV(s) shall be delivered to the Government. Delivered USV(s) shall be ready in all respects to be accepted by the Government and capable of continuing autonomy experimentation with only minor exceptions such as outfitting items or other unique Navy requirements outside the scope of the Overlord Program. Partner Teams shall deliver all test memoranda, reports, and certificates reflecting compliance and correction of significant deficiencies. Waiver requests are to be minimized. Delivered USV(s) shall include all equipment (propulsion, maneuvering, command and control, habitable berthing/messing spaces, etc.) in operating condition and ready for use.

C. Management Approach

For each award, the Partner Teams will lead systems engineering and autonomy integration. The Partner Teams will own and operate the integrated system, will have primary responsibility for achieving the Overlord Program demonstration objectives, and will continue to operate the USV(s) for the remaining lifetime of the Overlord Program should they be chosen for Phase II. In Phase II, the Partner Teams will be the integrator of the Government furnished payload and is expected to work with the Government team, including both management and technical Subject Matter Experts (SMEs), to ensure mission objectives are being addressed.

SCO and the Navy, specifically PMS 406, are responsible for the overall management of the Overlord Program, including technical matters, acquisition, and security. SCO requires sufficient and timely insight to ensure that the Partner Teams are executing its commitments under the agreements—effectively executing the program and leveraging the Government investment. Use of an OTA agreement, authorized under 10 U.S.C. § 2371b, provides significant flexibility to enable streamlined program management and collaboration between Government and industry.

The Government is committed to a vision of working with the Partner Teams as a true partnership, facilitating the best technical development and program outcome within program constraints. SCO and PMS 406 will employ a technical support team leveraging the Navy's expertise as well as other Government and contracted SMEs. As appropriate, the SCO Program Manager and PMS 406 will occasionally include other Government stakeholders in Partner Teams-led program reviews and other major events for program liaison, visibility, and advocacy, including policy matters. An OTA allows the Partner Teams to propose a range of collaboration alternatives, to leverage Government personnel and facilities as desired and appropriate, and to define the most effective Government/industry working relationship. The Government encourages potential Partner Teams to offer a management approach that will enable the most efficient and cost-effective program that meets mission objectives.

IV. Overall Program Requirements

Certain elements of USV autonomy are required for the Overlord Program to be successful. Specifically:

- Perception of all surrounding vessels and other collision hazards via radar, Electro-Optical/Infrared (EO/IR), Automatic Identification System (AIS), and/or other sensors.
- Path planning consistent with safe vehicle operation and mission objectives, dynamically avoiding collisions, allisions, and grounding. Interactions with other vessels should be consistent with COLREGs, principally Rules 11 through 19.
- Autonomy must be capable of managing the USV's engineering plant to maximize vehicle readiness, i.e. the engineering plant must maintain the USV in a maximum state of maneuverability as well as maintaining the ability to provide payloads with requisite electrical power and cooling, on demand.
- Mechanical equipment must be capable of running to meet the 90-day period without direct human operator intervention or maintenance.
- Ability for a human supervisor to remotely monitor vehicle status, reassign mission waypoints and objectives, and take direct control of the vehicle, and authorize payload release. Vehicle command and control must be via both line-of-sight and beyond-line-of-sight communication links. It is expected that the command and control systems will be capable of integration with existing Navy Fleet systems.

Specific elements of these requirements will be demonstrated during Phases I and II. These requirements are critical to the success of the Overlord Program, and as such shall not be compromised. Proposals for USV autonomy solutions that do not allow a path to satisfy these requirements at the end of program will not be considered. To allow Partner Teams to best assess their vehicle and autonomy approach to Phase I, the Government is including the Overlord End of Program Attributes that will be required, at the end of Phase II, in Attachment 01, *Overlord Program Technical Attributes (Total Program)*. **However, this solicitation only is limited to achieving the MOPs detailed in Section IV of Phase I.**

SOLICITATION INSTRUCTIONS

I. Administrative Information

Since SCO and the Navy have funded related technology development under numerous programs, submittals that build on current or previous Department of Defense (DoD) work are encouraged. However, if Partner Teams are enhancing work performed under other DoD programs, they must clearly identify the point of departure, what existing work will be brought forward, and what new work will be performed under this solicitation. Industry, Academia, Small Businesses, Small Disadvantaged Businesses, Educational Institutions, Historically Black Colleges and Universities, and Minority Institutions are all encouraged to participate.

II. Security

Partner Teams must be able to certify that they have an appropriate facility clearance to meet the security requirements of work proposed if chosen for Phase II, although no security clearance is necessary for Phase I, there needs to be a path presented in the Phase I milestone plan deliverable that shows a path to achieve the appropriate SECRET clearance.

Phase I support will be UNCLASSIFIED and Phase II support will be SECRET.

Phase I will be UNCLASSIFIED and Partner Teams shall include thoughtful requirements to properly protect the Government utility throughout Phase I, allowing for a smooth transition of technology into the classified Phase II portion. Such as, but not limited to:

- All program personnel shall be U.S citizens;
- Control software, underlying 'AI' algorithms, and documentation shall be developed, compiled and tested in an access control area on an "air gapped network";
- Partner Teams shall maintain an access roster for critical components and software; and
- All Information under these agreements have been deemed as Distribution Statement F.

III. Data Rights and Proprietary Data

The Government seeks data rights that will permit future development of USV autonomy by Government and industry performers without requiring technical support from or payment of licensing fees to specific developers. This generally requires an open software architecture, allowing extension of the autonomy software for future use cases, as well as Government access to source code for components that would need to be modified for purposes of interoperability or extension. Proprietary software should be limited to that which would not need to be modified for extension of the autonomy for future use cases.

The Partner Teams shall justify the use of proprietary, vendor-unique, or closed components including but not limited to hardware, software and interfaces in current or future designs. All non-proprietary licenses, source code, drawings, repair, and engineering documentation shall be

provided to the Government and third-party contractors at specified key events or at defined intervals. Since the Government supports Open Architecture principles, asserted rights other than Government Purpose Rights will be considered during proposal evaluation. The data will be used to support demonstrating the Overlord Program capability, inform new research and development in the context of transitioning an operationally viable architecture, promote program execution, and sustain competition.

SCO's policy is to treat all submissions as source selection information as defined by 41 U.S.C. § 2101(7), and to disclose the contents only for the purpose of evaluation. Restrictive notices notwithstanding, during the evaluation process, submissions may be handled by support contractors for administrative purposes and/or to assist with technical evaluation. All SCO and PMS 406 support contractors performing this role are expressly prohibited from performing SCO-sponsored technical research and are bound by appropriate nondisclosure agreements. Proposals and other submissions during the selection process will only be utilized for evaluation and negotiation purposes.

IV. Proposal Format Instructions

The format shall be a narrative in Partner Teams' format. The response shall be single-spaced pages and no less than 1-inch margins and 12-point font. Submissions shall be in Microsoft Word 2010 or searchable Adobe Acrobat Portable Document Format (PDF). Proposals shall include a Technical Volume, Price Volume, and an Attachment Volume to include resumes and appendices. Partner Teams shall submit their proposals by the time and date requested in the solicitation.

The Technical Volume has page limitations identified in the Technical Volume section below. The page limitation does not include the Price Volume, resumes, and any appendixes such as the completed OTA template.

A. Technical Volume

The length of the Technical Volume is limited to fifty (50) pages. The Technical Volume shall include sections for a cover page, executive overview, management approach, technical details, and shall not include any prices.

The Technical Volume shall include the following sections as a one-file submittal with each of the following sections clearly labeled:

1. Cover Page

The Cover Page must include:

(1) Program Solicitation number;
(2) Organization(s) submitting
(3) Submitter's reference number (if any)
(4) Business size and any applicable socio-economic categories for each organization in the proposal

(5) Technical points of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, electronic mail
(6) Administrative points of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, electronic mail
(7) Date of submission
(8) Organization(s) DUNS Number(s)
(9) Organization(s) CAGE Code(s)

2. Executive Overview

The Executive Overview section shall include a high-level schedule and event based plan for the Phase I program; deliverables, and key milestones needed to accomplish the effort requested by the Government. This section shall include a strong system integration program plan necessary to lead a diverse team. A summary of any innovative claims and any relevant experience of the key personnel and company(ies) should also be included.

3. Technical Details

The Technical Details section shall be sufficiently accurate and complete to assist the Government in assessing the proposal. All Proposals shall provide an open system architecture, using widely-supported and consensus-based standards for key interfaces, to be evaluated using the US Navy's Open Architecture Assessment Tool (OAAT), Version 3.0. The Partner Teams shall use OAAT to assess, on a continuing basis, the Open Architecture maturity of the program and its systems. The Partner Teams shall report the results of the assessment. The OAAT is an analytic tool that evaluates responses to a set of interrelated questions to provide program offices with an objective and evidence-based assessment of the degree that a program exhibits openness. OAAT and its supporting documents are available under the Naval Open Architecture website located at https://acc.dau.mil/oa. Modular Open Systems Architecture (MOSA) compliance shall be a minimum of 85% as calculated by OAAT at Critical Design Review (CDR).

The first page of the Technical Section shall include a brief overview with a simple table of contents. Partner Teams shall indicate the proposed method to secure, through cost-effective means, a minimum of one large-scale USV.

The submission will concisely itemize how the proposed vehicle complies with objectives of Phase I. Submissions that do not meet all required elements will not be considered.

Each sub-section shall include a summary of the deliverables including associated data. If any portion of the proposed effort is predicated upon the use of Government-owned resources of any type, the Partner Teams shall clearly identify the resources required, the date the resource is required, the duration of the requirement, the source from which the resource may be acquired, if known, and the impact on the effort if the resource is not provided. This section shall include supporting information to validate claims associated with the concept, method, or approach proposed for the following sub-sections.

4. Management Approach

The Management Approach section will discuss in detail how the Partner Teams intend to manage the overall scope of the program. The section must detail the Partner Teams' capability to contractually manage the team of performers necessary to execute the program. All sub-contracted performers must be detailed, along with the Partner Teams' strategy for managing and integrating the efforts of the various performers. This will include a schedule of the efforts and major events that feasibly deliver a USV with the Technical Attributes specified by SCO. Quality assurance processes will be identified, including relevant Objective Quality Evidence (OQE). Key technical and management personnel should be identified.

B. Price Volume

Pricing information shall only be included in the Price Volume. The Price Volume shall include the following sections:

1. Price Narrative

The Price Narrative shall be single-spaced pages and no less than 1-inch margins and 12-point font. The Price Narrative shall be in Microsoft Word 2010 or searchable Adobe Acrobat PDF. There is no page limit for the Price Volume.

The Price Narrative shall justify costs to support the Volume I: Technical Proposal and shall separate costs for Travel, Material, and any Other Direct Costs (ODCs). Include proposed costs to secure, through cost-effective means, a minimum of one large-scale USV.

The Price Volume shall provide efforts in $K for each technical sub-section; the Price proposal shall demonstrate a complete understanding of the effort necessary to organize and perform. Sufficient supporting data shall be provided to permit the Government to perform a review and analysis of the pricing.

2. Price Breakout

The Price Breakout shall be a minimum of 10-point font, be in a format readable Microsoft Excel format, and additional worksheets may be added.

The Price Breakout shall identify the following for the 12-month period:

- Direct Labor - Individual labor category or person, with associated labor hours and burdened direct labor rates; along with justification of the Basis of Estimate (BOE)
- Travel - Number of trips, number of days per trip, departure and arrival destinations, and number of people. (Note: Travel costs will not be entitled to Fee);
- Sub-contract - Separately identify sub-contractor and/or consultant costs;
- Material - Itemized or estimated costs. An explanation of any estimating factors, including their derivation and application, shall be provided. Include a brief description of the Partner Teams procurement method to be used (Note: Material costs will not be entitled to Fee);
- Other Directs Costs - Itemized or estimated costs (Note: ODCs will not be entitled to Fee);

- License Option Price for providing data rights that are at least Government Purpose Rights (if applicable).

C. Attachment Volume

The Attachment Volume shall include resumes and any appendices such as the completed OTA template.

EVALUATION CRITERIA FOR PHASE I AWARD

I. Basis for Award of Phase I Demonstration Plan

This is a request from the Government for full proposal, including Technical and Price Volumes, for Phase I. Partner Teams may be considered for Phase I agreements only upon preparation and submittal of a fully compliant Proposal. The selections for Phase I awards will be based on subjective evaluation of proposals as described in this section. Each Partner Teams' proposal will receive an integrated evaluation by a single multi-functional team. The selection of Proposals for Phase I award will be based on the potential benefits to the Government weighed against the price proposal, in view of the availability of funds.

II. Proposal Evaluation

The evaluation of proposals submitted in response to this solicitation will be based on solutions that are most advantageous to the Government. The Government reserves the right to select all, some, or none of the proposals received in response to this solicitation. The major purpose of the evaluation will be to determine the merit of the overall approach of each proposal.

A. Proposal Factors

The evaluation will be based on the following factors in descending order of importance. Each Partner Teams' proposal will be evaluated using all factors and sub-factors below. Risk will not be a separate factor but will be considered in the evaluation of each factor and sub-factor.

1. Technical Feasibility

When considering technical feasibility, the following sub-factors will be evaluated:

Sub-factor A: Technical Approach

The Partner Teams shall discuss their approach for converting an existing vehicle into an autonomous USV that satisfies the technical attributes of this solicitation. The Partner Teams' proposal should include review of the price, reliability, and minimization of parts while maintaining USV capability to meet the Overlord Program Phase I objectives. Data rights assertions will also be considered.

Sub-factor B: Capabilities

In the evaluation of this sub-factor, the understanding of the work, as evidenced by the proposed plan for overall implementation and execution of the program, will be assessed. Proposals will be evaluated to ensure:

a. The Partner Teams shall demonstrate an understanding of the work as evidenced by proposed plan for the overall implementation and execution of the program

b. The Partner Teams shall describe internal capabilities relevant to USV autonomy development, including autonomy software engineering, machinery controls and automation, and maritime systems integration.
c. The Partner Teams shall describe internal quality assurance methods and processes relevant to the tasks identified in the Phase I Technical Objectives.
d. The Partner Teams shall describe planned capabilities for necessary testing of autonomy systems. Government laboratory assistance and facilities may be requested if these represent the best option for testing in the framework of the overall program.

Sub-factor C: Personnel Qualifications.

Proposals will be evaluated to ensure the Partner Teams propose Systems Engineering personnel with requisite experience to integrate the various tasks in the Phase I Technical Objectives. For each engineering area (e.g. software development, machinery automation, maritime systems integration, systems engineering etc.) the Partner Teams shall propose Subject Matter Experts capable of rapid development and prototyping of desired capability.

- Resume: For each proposed key personnel, Partner Teams shall submit resumes, not to exceed two (2) pages each. There shall be two (2) pages per person proposed. Describe in sufficient and succinct detail the technical experience of the proposed individual that meets or exceeds the minimum education and experience stated in the corresponding Program Solicitation.

  The resume shall identify the individual's:

  - Name
  - Proposed position
  - Relevant Employment History: to include title, employer, and starting and ending dates
  - Education: degree, school, major(s), minor(s)
  - Relevant Qualifications and Specialties: A brief summary of training, qualifications, achievements, honors, awards, publications, and professional organizations
  - Security Clearance status (e.g. Top Secret, Secret, etc.)
  - Nationality

2. Management Approach:

In the evaluation of this factor, the Partner Teams' capability to manage program execution will be assessed. Proposals will be evaluated to ensure:

a. The Partner Teams possess current corporate capability to perform the agreements, including relevant corporate experience.
b. The Partner Teams provide a description of any teaming to meet the required Technical Objectives. Teaming may include, but is not limited to, team members,

sub-contractors, Government laboratories and warfare centers, consultants, and business partners.

c. The Partner Teams show a plan for integrating and managing the diverse teams of Factor 2.b necessary to meet the required Phase I Technical Objectives.
d. The Partner Teams provide an internal program schedule, including efforts by team members, which feasibly accomplishes the required elements and objectives of the Overlord Program in the specified timeframe.

The Government intends each award to be on a fixed-price basis.

PHASE I DEMONSTRATION PLAN

I. Phase I Demonstration Plan Technical Objectives

USVs must be capable of both autonomous navigation and autonomous mission execution. The missions envisioned for these systems dictate a high degree of autonomy at both the platform navigation and vehicle sustainment level, as well as the mission execution level. Platform-level autonomy includes the software and hardware components necessary for the USV to safely navigate an assigned route to execute a mission while avoiding obstacles and hazards.

Mission-level autonomy includes the software necessary for an autonomous USV to complete complex, multi-objective missions with minimal human interaction and consideration of dynamic plan adjustments due to unforeseen events (component failures, tactical situation updates, changes in the environment, etc.).

Autonomy solutions must use a non-proprietary, modular open-architecture and provide software documentation at a minimum to include a user's manual, integration specification, and autonomy architecture documentation. It is encouraged that the Partner Teams leverage existing open source tools. Component capabilities should be separated into individual software modules at the lowest standalone level.

Each Partner Teams funded under this solicitation shall develop a fully integrated USV that is capable of autonomously operating in a maritime (open ocean) environment. The Partner Teams shall develop a system controller (i.e., computer system with engineering user interface) that is capable of exercising the autonomy capabilities of the USV under test conditions as defined by the Government. The Partner Teams, in conjunction with Government personnel, shall test the USV using a series of vignettes (i.e., at-sea courses) in order to evaluate the performance of the USV under varying conditions. The Partner Teams shall be responsible for coordinating all test activities, supplying all logistics and systems required for tests, and for providing all data collected during test activities to the Government for evaluation.

A. Vehicle

The Partner Teams shall secure, through cost-effective means, a minimum of one vehicle representative of a large-scale USV that will be used to integrate existing autonomy technologies into a prototype system for test and evaluation. Phase I is intended to mature the autonomy of the Overlord Program USV(s). For efficiency, the Government wishes to utilize the same vehicle(s) in Phase I and Phase II, where the Government will have the option to purchase the vehicle(s) at the end of Phase II. Therefore, it is important to clarify vehicle attributes in addition to autonomy that will aid in selecting the appropriate vehicle(s) for the Overlord Program Phase I. The Phase I proposed vehicle(s) should be able to achieve the following program attributes if it is down-selected for Phase II to program completion. The vehicle(s) must ultimately be capable of performing as a manned surface vehicle as well as an USV. The USV(s) must have built in redundancy in all critical hardware and software systems. Vehicle(s) attributes are summarized below.

In choosing a vehicle(s) for Phase I, it is necessary to understand that the following elements are required and must be present, without compromise at the end of the Overlord 3-year Program:

- Vehicle with range of at least 4,500 nautical miles, capable of operating in at least Sea State 5, with at least 80,000 lbs. of payload capacity and 75 kW of 450V, 60 Hz, three-phase AC power reserved for payloads.
- Capable of continuous operation for 90 days without any manned maintenance, e.g., shifting lubricating oil or fuel oil strainers, preventative maintenance, inspection, etc.
- Perception capability to detect all vehicles greater than 7m in length within six nautical miles using radar and/or other sensors, and to fuse data from sensors into a world model. Perception must use, at a minimum, one sensor other than AIS, must maintain 360-degree coverage, and must detect all vessels and hazards at a distance which allows safe navigation in accordance with standard maritime practices.
- Path-planning autonomy capable of autonomous safe pilotage to include path planning, obstacle avoidance, and mission behaviors outside of restricted waters. Pilotage shall include the ability to navigate around charted obstacles to include buoys and waters shallower than the vehicle's depth. The autonomy must be capable of complying with COLREGs, principally Rules 11 through 19, although follow-on work to adhere to the sound, light, and shape requirements of Rules 20 through 37 will also be considered.

The Partner Teams shall choose a vehicle that supports or that may be adapted to support a standard plant interface that may be implemented in a modular fashion to facilitate the eventual replacement of the test vehicle with a more capable vehicle. This allows the Government to decouple the autonomy solution from the target vehicle with minimal effort. The Partner Teams will define and the Government will comment on and approve an open interface to the test vehicle HM&E and low-level control systems. At a minimum, this interface will support course and speed commands from the autonomy system in order to move the vehicle in a given direction at a given speed with appropriate feedback to the autonomy system. Control equipment shall operate continuously without mechanical or electrical damage and in accordance with performance and functional requirements in any compartment ambient temperature between the limits of 0C and 60C. The device level control hardware shall be compliant with IEC 61131. The control devices shall support a hot backup capability, peer to peer communication with higher level control workstations, and Ethernet IP protocol to remote Input/Output (I/O) devices.

B. System Controller

The Partner Teams shall provide a system controller interface that may be used to exercise all of the functions of the USV in order to fully demonstrate operation against the autonomy evaluation vignettes. The system controller will include a high-level graphical user interface that will allow for the designation of navigational way-points (or start/end points) on a digital nautical chart, and for the high-level direction of the USV to execute the path autonomously. The system controller must be capable of displaying the internal settings, states, sensor data, classified objects/contacts, world model, and other engineering data that the Government may need to determine the performance of the system.

The system controller must be capable of placing the autonomy system in a "passive" mode such that the planned actions of the system may be observed on the system controller display while the autonomy system is active but "disconnected" from actual vehicle control such that the autonomy system shall not affect vehicle motion; this will allow the Government the ability to examine execution of the autonomy system in a safe manner while the USV is being controlled manually.

The system controller shall not be part of the USV autonomy system – they must be separate, severable, and distinct such that the Government may replace the system controller with a capability of its choosing without any loss in autonomy capability on the USV. The system controller shall communicate with the USV in any manner that the Partner Teams chooses as long as the system controller is separated physically from the USV, that is, the system controller must be implemented using a separate computer system that shall be completely detached from the USV without loss of function on the USV. For example, the system controller may be connected to the USV via a high-speed wireless radio or a wired Ethernet network connection.

C. USV Autonomy Solution

The Partner Teams shall adapt, port, and integrate the software systems required to implement a fully autonomous USV capable of long duration operations at sea. The Partner Teams shall adapt, port, and integrate the hardware systems required to host the software systems on board the USV. This includes the sensors, mounts, wiring, radios, computers, electrical, and mechanical components to implement the full autonomy system. This also includes the integration of the autonomy system with the USV HM&E and low-level control systems. The autonomy solution must be a fully integrated system that may be controlled from the bridge of the USV using the system controller.

The Partner Teams solution shall allow for simultaneous manned and autonomous operation such that a human operator may take remote or local control of the USV and apply safety measures (e.g., stop the USV), and then return the USV to autonomous operation upon command.

D. USV Autonomy Architecture Review

The Partner Teams' proposal should include the initial plan of the high-level and low-level architecture of the USV autonomy solution to include definition and description of all major system and sub-system level hardware/software components, the definition of the interfaces between components, and the physical and logical connections between components. Before test and evaluation activities take place, the Partner Teams shall provide documentation to the Government describing the detailed high-level and low-level architecture of the USV autonomy solution. This shall include definition and description of all major system and sub-system level hardware/software components, the definition of the interfaces between components, the physical and logical connections between components, and the protocols used to communicate between components, and the messaging standards used to communicate between components. It shall also identify any/all third-party components or dependencies (drivers, libraries, application software, and utility software), any/all proprietary components, and any restrictions on the use of any/all components. Finally, it shall include an assessment of the maturity of all components (i.e., whether or not the software implementing the components has been successfully used in operation

directly supporting maritime applications). The intention is to better understand the autonomy architecture for the purposes of assessing the potential applicability of the autonomy solution to future programs. The Government will review the documentation and include that review in its assessment of the overall system.

As part of the autonomy architecture review, the Partner Teams shall use the OAAT, version 3.0 or later, to assess the open architecture maturity of its solution, which will be independently assessed by the Government team. The Partner Teams shall report the results of the assessment to the Government during a review of its technical approach at the beginning of the effort and again at the end of the effort (to ensure that open standards are being maintained throughout the program). The OAAT is an analytic tool that evaluates responses to a set of interrelated questions to provide program offices with an objective and evidence-based assessment of the degree that a solution exhibits openness. OAAT and its supporting documents are available under the Naval Open Architecture website located at: https://acc.dau.mil/oa.

II. USV Autonomy Evaluation and Measures of Performance (MOPs)

The Government's objective for this solicitation is to determine the maturity, reliability, availability, and extensibility of existing USV autonomy solutions for potential (immediate) use on other programs. The autonomy solution provided by the Partner Teams as integrated onto the USV will be tested during a series of vignettes of increasing complexity in order to assess the overall performance of the system. The Partner Teams shall be responsible for detailing its approach for completing the vignettes by providing end-goal commands to the USV such that the USV may autonomously (without human intervention) execute the steps required to complete the vignettes.

The Partner Teams shall be responsible for the safe operation of the USV at all times; this may require that the Partner Teams intervene during test and evaluation activities to ensure safe operation while at sea. In general, the USV, while being piloted by human sailors and/or while operating autonomously, must adhere to COLREGs that apply to the safe operation of sea faring vessels. The USV while operating autonomously is expected to adhere to principally Rules 11 through 19, although follow-on work to adhere to the sound, light, and shape requirements of Rules 20 through 37 will also be considered.

The series of vignettes defined below will allow the Partner Teams to demonstrate the USV autonomy under progressively more complex and demanding conditions. For each vignette, MOPs are given that will help the Government assess the performance of the system. The vignettes are intended to examine performance details within the USV's sensing, perceiving, planning, navigating, maneuvering (obstacle detection/avoidance), and low-level control autonomy architecture. The vignettes below are representative samples of what the Government intends to test. The Government reserves the right to change the details, number, scope, and complexity of the vignettes as needed to fully evaluate the performance of the USV autonomy solution. The Government will coordinate with the Partner Teams to define the final set of tests before the agreements award. Unless otherwise specified, all vignettes are assumed to be carried out autonomously in clear weather conditions with unlimited visibility, during the daytime, at a sea state of two (2) or less.

The high-level operational scenario framing the evaluation of the autonomy solution involves the designation of a destination or a series of waypoints on a digital nautical map that the USV must autonomously transit to within certain performance parameters (e.g., accuracy, speed). The USV must sense, perceive, model, plan, and navigate safely to the destination on its own with little to no human intervention; human intervention may be required for a variety of reasons (e.g., safety, systems failure), but the degree of intervention will impact the Government's assessment of the maturity of the autonomy solution. The degree or frequency of required human intervention is an overall MOP.

1. Vignette 1: Obstacle Detection while Stationary:

Demonstrate the ability to reliably detect small, medium, and large obstacles (both moving and stationary) on the surface of the ocean while the USV is stationary.

MOP: Object detection certainty (false positive/negative), object detection accuracy (perceived object location versus ground truth), object detection range.

Objective is to test sensing, perception, and fusion/classification within the world model.

2. Vignette 2: Obstacle Detection while Moving:

Demonstrate the ability to reliably detect small, medium, and large obstacles (both moving and stationary) on the surface of the ocean while the USV is underway, making way. This includes times when the vehicle is changing course and/or speed.

MOP: Object detection certainty (false positive/negative), object detection accuracy (perceived object location versus ground truth), object detection range, speed at which objects detected.

Objective is to test sensing, perception, and fusion/classification within the world model.

3. Vignette 3: Navigation in Open Ocean:

Demonstrate the ability to navigate in the open ocean over a significant distance (> 10 nautical miles).

MOP: Success rate over multiple test runs, human intervention rate, system fault rate, obstacle detection false positive rate. Success is defined as reaching destination point within 40 minutes.

Objective is to test sensing, perception, fusion/classification within the world model, and path planning (deliberative).

4. Vignette 4: Navigation in Low Contact Density Environments:

Demonstrate the ability to navigate in the presence of minimal surface contacts over a significant distance (> 10 nautical miles).

MOP: Success rate over multiple test runs, human intervention rate, system fault rate, obstacle detection false positive/negative rate. Success is defined as reaching destination point without contacting any of the obstacles.

Objective is to test sensing, perception, fusion/classification within the world model, path planning (deliberative/reactive), and obstacle detection/avoidance.

5. Vignette 5: Navigation in High Contact Density Environments:

Demonstrate the ability to navigate in the presence of increased surface contacts over a significant distance (> 10 nautical miles).

MOP: Success rate over multiple test runs, human intervention rate, system fault rate, obstacle detection false positive/negative rate. Success is defined as reaching destination point without contacting any of the obstacles.

Objective is to stress test sensing, perception, fusion/classification within the world model, path planning (deliberative/reactive), and obstacle detection/avoidance.

6. Vignette 6: Navigation in compliance with COLREGs:

Demonstrate the ability to navigate, in accordance with the COLREGs as outlined in this solicitation, over a significant distance (> 10 nautical miles).

MOP: Success rate over multiple test runs, human intervention rate, system fault rate, obstacle detection false positive/negative rate, number of COLREGs violations (or non-compliances). Success is defined as reaching destination point without contacting any of the obstacles.

Objective is to stress test sensing, perception, fusion/classification within the world model, path planning (deliberative/reactive), obstacle detection/avoidance, and specific adherence to COLREGs in planning/maneuvering.

7. Vignette 7: Operation in Higher Sea State:

Repeat Vignette 5: Navigation in High Contact Density Environments and Vignette 6: Navigation in compliance with COLREGs vignettes at sea state three (3) and four (4).

Objective is to stress test sensing, perception, fusion/classification within the world model, path planning (deliberative/reactive), obstacle detection/avoidance, and specific adherence to COLREGs in planning/maneuvering.

8. Vignette 8: Operation in Other than Clear Conditions:

Repeat Vignette 5: Navigation in High Contact Density Environments and Vignette 6: Navigation in compliance with COLREGs vignettes at higher sea state (3-4) under decreased visibility conditions (measurable fog and/or rain).

Objective is to stress test sensing, perception, fusion/classification within the world model, path planning (deliberative/reactive), obstacle detection/avoidance, and specific adherence to COLREGs in planning/maneuvering.

Low contact density operations are defined as a maximum of three (3) surface vessels (small, medium, or large) operating within one (1) nautical mile of the USV's three-minute projected track, with all contacts obeying COLREGs.

High contact density operations are defined as a maximum of six (6) surface vessels (small, medium, or large) operating within one (1) nautical mile of the USV's three-minute projected track, with all contacts obeying COLREGs.

Small obstacles include ocean buoys down to 3 meters in diameter, floating or semi-submerged obstacles up to 6 meters in length/width, and other floating or semi-submerged obstacles such as logs or clumps of nets ("ghost nets"), and individual fishing nets.

Medium obstacles include ocean going craft with sails rigged up to 30 meters long, rigid hull Inflatable boats up to 7 meters long, and large sea buoys up to 10 meters in diameter.

Large obstacles include large ships at least 200 meters long, tugboats and tow at least 65 meters long and tow up to 914 meters behind tug, and fishing boats more than 30 meters long.

III. Test Planning and Execution

In advance of testing, the Partner Teams shall prepare a formal test plan that documents the specific actions to be taken to prepare for, execute, observe, analyze, and assess the performance of USV autonomy. The Government will review and comment on the test plan, and will approve the final test plan. The Partner Teams shall revise the test plan according to Government comments.

The Partner Teams shall be responsible for coordinating all test activities, for ensuring that all data are collected during test activities, for integrating Government personnel into test activities, and for providing all (unprocessed and processed) data collected during test activities. The Partner Teams shall be responsible for reserving test ranges, and for obtaining formal (written) approval for the use of those test ranges in support of this solicitation. If Government ranges are required, the Partner Teams shall provide test range requirements, test dates and duration, and impact if Government ranges are not available.

Sufficient test data shall be collected by the Partner Teams during test events to enable the Government to analyze detailed performance of the USV. Test data shall include, but will not be limited to, unprocessed (raw) and processed information that captures:

- navigational information (e.g., GPS, AIS, Inertial Measurement Unit (IMU)),

- perception information (e.g., contacts, tracks, obstacles, word model),
- path planning information (heading and speed commands, planned paths (at the planning cycle rate), and actual path travelled),
- vehicle information (e.g., hull, mechanical & electrical), and
- internal software/hardware state information (e.g., mode of operation – including human interventions, system status, exceptional events, system faults, etc.) and obstacle vehicle state information (position, course, speed) which is time synchronized with the data being collected the USV.

There shall be recorded video from hi-definition (e.g., Go Pro-quality) cameras covering the majority of the USV looking outward as well as from the obstacle vessels showing the USV in order to correlate test data with observational (situational awareness) data.

The Government intends to evaluate all data collected during testing to assess the level of performance of the autonomy solution provided by the Partner Teams. The Partner Teams are encouraged to propose additional measures of performance, and offer various automated data analysis tools to facilitate this evaluation in an objective and quantitative manner. The Government will use the results of the Phase I as part of the determination which Partner Teams are selected as part of the Phase II solicitation. To this end, Partner Teams will be evaluated based on their level of performance against the Phase I objectives outlined above.

Attachment 01: OVERLORD PROGRAM TECHNICAL ATTRIBUTES (TOTAL PROGRAM)

I. Overlord Program Summary

The Overlord Program will develop and demonstrate independently-deploying unmanned surface vehicles capable of networking and integrating with existing systems to support payloads in a contested environment. Within an approximate 3-year timeframe, the program ultimately seeks to demonstrate:

1. An autonomy architecture and behaviors capable of sustained at-sea operations consistent with a self-deploying, long-range USV.

2. A communications architecture to permit human operators to supervise USV operations using anti-jam, low-probability-of-detection, line-of-sight and over-the-horizon links. The USV will also be able to share data with manned fleet assets using existing fleet data links.

3. A C2 capability to permit human operators to supervise the range of USV operations from nearby manned assets, and from a shore-based operations center.

4. HM&E systems automation to provide and maintain resources to the platform, including mitigation of failure modes for full mission duration through a graceful degradation of capability, with the ability to dynamically provide appropriate resources (including power, cooling, data, and monitoring) to varied mission loads.

While the Navy has fielded, or is in the process of fielding, several USV types with various levels of autonomy, substantial risk still exists with regard to the integration of autonomous USVs with manned fleet assets as a part of normal peacetime and wartime operations. The Overlord Program will develop core autonomy, communications, and C2 components and field prototype USVs capable of being seamlessly operable with the fleet. The Overlord Program will have built in redundancy in all critical hardware and software systems. The program will involve integration and test of payloads for EW, ASuW, and STW.

The Overlord Program includes design studies and engineering analysis, as well as operational analysis for detailed designs for USV systems and subsystems. The Overlord Program includes risk reduction, component testing, and modeling and simulation to demonstrate the efficacy of these systems. The design and development efforts will result in autonomy, navigation, perception, communication, C2, and payload employment subsystems capable of supporting full-scale autonomous USV operations. The USV will use a command and control interface to test elements of command and control necessary for fleet integration.

The Program will demonstrate shared data links between the USV, Cruiser/Destroyer type ships, and/or a shore-based control facility. When ready, USV control will transition from Partner Teams and Government engineers to Navy personnel with engineering oversight. Navy personnel will develop Tactics, Techniques, and Procedures (TTPs) to prepare for regular use of USVs with

the fleet. The Program will include integrated tests of the USV executing missions using EW, ASuW, and STW payloads in coordination with traditional fleet assets.

As an integrated fleet asset, the USV must meet Government information assurance and cybersecurity standards. Accordingly, the USV must be developed and delivered such that on-board IT systems are able to obtain authorization to operate through the DoD Risk Management Framework (RMF) process.

The Program requires Partner Teams support for Government testing of the USVs. Testing will evaluate both the technical and operational performance of the USVs, using progressively stressing scenarios, to inform future USV programs and operations.

II. Overlord Program Technical Specifications

A. Overlord Program Requirements

The vehicle shall be capable of performing as a manned surface vehicle as well as an USV. Ideally, the Overlord Program USV will be an open architecture design with modularity across the platform and with well-defined interfaces and data rights for ease of both software and hardware upgrades. The Overlord Program must have built in redundancy in all critical hardware and software systems. Vehicle attributes are summarized below.

The following elements shall be present, without compromise:

- Capable of continuous operation for 90 days without any manned maintenance, e.g., shifting lubricating oil or fuel oil strainers, preventative maintenance, inspection, etc.
- Perception capability to detect all vessels greater than 7m in length within six nautical miles using radar and/or other sensors, and to fuse data from sensors into a world model. Perception must use, at a minimum, one sensor other than AIS, must maintain 360-degree coverage, and must detect all vessels and hazards at a distance which allows safe navigation in accordance with standard maritime practices.
- Path-planning autonomy capable of autonomous safe pilotage to include path planning, obstacle avoidance, and mission behaviors outside of restricted waters. Pilotage shall include the ability to navigate around charted obstacles to include buoys and waters shallower than the vehicle's depth. The autonomy must be capable of complying with COLREGs Rules 11-19. Emergent collision threat responsiveness will be evaluated on ability to logically reduce risk and make timely action.

B. Overlord Program Capability Objectives

The capability objectives listed below will satisfy the Overlord Program Goals. However, it is recognized that in a rapid prototyping effort, trade-offs in performance exist in order to achieve an operational prototype within price and schedule. Therefore, SCO may entertain proposals that meet these objectives in approximation while maintaining the overall platform requirements.

- Endurance of 4,500 nm or more at 19 knots transit speed or higher

- Top speed of 28 knots with full load capacity in calm water
- Capable of remaining sufficiently stable to operate payloads in up to Sea State 4 (per North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 4194)
- Capable of surviving in Sea State 5 (per NATO STANAG 4194) or higher and maintain mission-critical systems
- Topside space and sufficiently reinforced deck to support 80,000 lbs. of deck cargo with ability to integrate ship systems
- Ability to embark/debark crew via helicopter and small boat
- A minimum of 75 kW of 450V, three phase, 60 Hz A/C power reserved for payloads accessible from payload locations to be defined later
- Configured or equipped with redundant systems such that a failure of a single main engine, marine propulsion gear, or electrical generator will not reduce vehicle maximum speed below 20 knots.
- Vehicle systems autonomy able to optimally and autonomously control all craft systems to include propulsion, fuel systems, heading, HVAC, electrical power generation and distribution, anti-tamper, bilge, ballast, firefighting, flooding, ventilation, etc.
- Vehicle systems autonomy capable of handling all emergency responses to component failures, fire/flooding, and other damage situations that are not overmatching to the platform. The vehicle system autonomy shall develop contingencies and optimally allocate system resources in a manner that maximizes the likelihood of mission success.
- Vehicle systems autonomy capable of handling all health monitoring and prognostics. It shall, as feasible, provide contingencies for any required maintenance and repairs that would be expected within an objective 90-day window. Those maintenance actions shall be conducted within a window of the mission in which it is not critical enough to impact the craft's ability to execute the success of the mission.
- Seven day berthing for no less than twelve personnel to Surge Personnel Standards (e.g. Part II, Figure 4-4) in NAVSEA Technical Publication T9640-AC-DSP-010/HAB Revision 1 dated 21 December 2016, or better.
- Notional tasks for crew on the vehicle include piloting in/out of harbor, fueling at sea, maintenance, and conducting emergency repairs topside and/or in engineering spaces; crew will be unarmed and the vehicle will not require a dedicated rescue vessel. A life raft, rings, and Personnel in Water recovery ladders shall be included.
- Capable of piloting into and out of port with a tug and a crew of 4 or fewer.
- Path-planning autonomy capable of autonomously sensing its environment and maneuvering consistent with applicable provisions of COLREGs. The autonomy should also be able to plan the vehicle's voyage to avoid anticipated areas with Sea State 5 or higher.
- An autonomy architecture that is highly modular in nature including modular components for sensors, software components (i.e. navigation, obstacle avoidance, machinery control, health monitoring, mission behaviors) and payloads. This architecture will be capable of being monitored and controlled remotely by an Off-board Control system.
- Situational awareness capability that includes audio and visual sensors that provide 360-degree coverage around the USV. Visual sensors must be capable of operation in a marine environment, must be fully capable of day/night operation, must be able to be remotely

cleaned (e.g., remote wipers), and must be able to provide a remote operate with the ability to recognize small craft (7 m in length/width) at a minimum distance of 0.5 km in unlimited visibility. Audio/visual data must be able to be digitized and sent through the communications system to a remote operator.
- Resistant to boarding from unauthorized personnel while easy to access by appropriately trained and equipped U.S. forces
- Resistant to physical tampering from unauthorized personnel
- Able to be delivered and/or made available within 12-months of the agreement award

Capable of recognizing unauthorized tampering and deploying incremental anti-tamper measures.

1. USV Modes of Operation

The vehicle should be capable of operating and transitioning between three distinct modes. These modes of operation are required elements and must be present without compromise:

- Manned – Onboard operator maintains control the craft and its systems,
- Remotely Piloted – the craft is in an autonomous mode but its course and speed are being manually controlled remotely from the craft,
- Supervised Autonomous Control – the craft is in autonomous mode and is governing its own operation except certain actions would require human approval (human in the loop) at the remote-control station (i.e. payload deployment). The USV will continue operations if communications are lost, but may not be able to execute tasks requiring human approval.

2. USV High-level Autonomy Objectives

High-level autonomy and Command, Control and Communications (C3) requirements, except when otherwise specified, are program objectives, and SCO may entertain proposals that meet these objectives in approximation while maintaining overall platform performance.

Paths for mission control, integration with a command center (communications, mission planning and data storage), military-compatible communications, information assurance/cyber standards, and safety certifications of the vehicle must be included in the system design. The vehicle must be able to autonomously plan its paths, avoiding grounding, fixed obstacles, and clearly visible power-driven vessels. Additional autonomous compliance with other requirements of the COLREGs is desired.

High level autonomy should include a resilient framework to enable execution of both deliberative and reactive behaviors. This autonomy will need the capability to dynamically compose complex mission plans through composition of multiple individual behaviors including ability to monitor mission execution and adapt the plan based on platform health conditions, environmental conditions, and off board C2 updates.

The proposed solution should clearly separate and delineate between the HM&E automation systems, platform-level autonomy architecture, and the mission-level autonomy architecture. The software developed under each should be standalone and capable of interfacing to and working

with other vendors' solutions (i.e., vendor A's platform autonomy with vendor B's mission-level autonomy). No standard interface definition currently exists for these but the selected vendors shall work with and support the Government in the definition of those interfaces.

C. Command and Control

The Overlord Program USVs must be capable of integrating into existing fleet operations and Navy Command and Control systems. The autonomy on-board the USVs will be augmented by the necessary supervisory control to support monitoring of mission execution, system security, and navigation safety. Dedicated operators on command staffs will provide the human supervision for the USV control. The USV shall be capable of being monitored and controlled by one person, and ideally multiple USVs could be supervised by one person.

Supervisory control is defined as human-aided operation required or desired to assist autonomy algorithms that become unable to proceed on their own due to technical, environmental, operational or safety issues. Supervisory control is required when the system is unable to operate autonomously, and needs a human to intercede in order to bring the system back into a state where it is able to operate on its own again. Supervisory control is bounded by available communications paths to unmanned systems. High-level autonomy must be robust to unanticipated communication outages between team members and jamming. In the event of a communications outage, the USV should still be able to perform the assigned mission. The mission autonomy should be able to recover and make adjustments as needed once communications are reestablished.

Operators at an ashore or afloat operation center will maintain Tactical Control (TACON) of the USVs at all times. USVs shall continue with loss of communication and certain actions will only be executed with human authorization. Each operations center should be capable of monitoring mission execution of USVs and a warfare commander must be able to transfer TACON to other commands as required. The Overlord Program operators will manage and direct USV operations based on higher-level command to include the monitoring of mission execution and warnings, cautions, and advisories (WCAs) of individual USVs as necessary.

The proposed supervisory control solution will develop and demonstrate software services and displays that complement the mission-level and platform-level autonomy capabilities onboard USVs. The solution must integrate into existing C2 infrastructure onboard Naval warships and at a Maritime Operation Center (MOC). The solution must allow the Overlord Program staff to collaborate with the surface warfare commander staff to support targeting and fire control.

The Government reserves the right to independently develop a Navy supervisory control solution; however, Partner Teams are encouraged to propose solutions based on modular software architectures and support open standards where possible. Interfaces between systems should use US Navy standard messaging or commercial open standards. Partner Teams are also encouraged to propose algorithmic approaches to autonomy for control and state awareness that may be instantiated in a Navy supervisory control system, or integrated therein.

D. USV Off-Board Communications

The Government intends to supply Navy communications systems specifications for use on USVs. Partner Teams will be required to integrate the specified communications systems with the USV, and additional space on board the USV will be allocated for expansion of the communications systems suite. The communications equipment must be located in a controlled space that meets or exceeds Navy communications security (COMSEC) standards. The controlled space must be readily accessible by maintenance personnel for key management. For reference purposes, the USV communications systems as specified by the Government will possess the following characteristics:

- USVs will be capable of communicating with Navy command and control elements for the purposes of mission execution and payload operation, and for coordination and inclusion into the larger strategic and tactical plan. The proposed missions for these systems will dictate the need for highly-reliable, anti-jam, and low-probability-of-detection (LPD) encrypted communications with the USVs. The communications system will employ both a line-of-sight (LOS) and beyond line-of-sight (BLOS) communications path for tactical control and reach-back to the operations center. BLOS communications will generally be accomplished using satellite communications equipment.

- The location of the operations center will be a land-based MOC or a deployed maritime platform associated with Navy operational formations (e.g., Carrier Strike Group). Active prosecution of a target requires operations center approval in all cases.

- For redundancy, the USV communication solution will include a minimum of two encrypted communication paths with other vessels and two communication paths with the operations center. At a minimum, USV communications will include terminals capable of Ultra High Frequency (UHF) Integrated Broadcast Service (IBS), Extremely High Frequency (EHF) Low Data Rate/Medium Data Rate, UHF Demand Assigned Multiple Access (DAMA), and UHF Link-16. Footprint, power, and cooling accommodations for this equipment shall not be less than five (5) Electronics Industries Alliance (EIA) standard 19” equipment racks, not less than 25KW of single and 3-phase 60 Hz power, and not less than 60K British Thermal Units (BTU) of cooling capacity. Communication systems will support 256-bit Advanced Encryption Standard (AES) encryption for all local storage. Spaces housing communications equipment shall meet security requirements for storage and operation of COMSEC equipment.

- USV topside design shall accommodate mounting antennas and radomes for all communications equipment to include sufficient power to support radome heating elements, antenna pointing motors, etc., as required. Topside design shall account for radiation patterns for communications systems antennas, and locate mounts in a manner providing the greatest possible isolation from other communications systems antennas as well as other radiating elements (navigation radars, payload radiation, etc.).

- USV communication paths with the operations center will use existing protocols/circuits and message standards to minimize the impact on the operations center established

systems. The USV will report its platform status to keep the operations center well informed of the USV current movements and capabilities. A radio management system will be employed on board the USV to automatically establish and actively maintain appropriate communications links between the operations center and the USV in order to meet mission requirements. The USV communication solution should accept directives from only the designated primary operations center that has TACON of the USV.

In order to support initial system testing, Partner Teams should include in their solutions a temporary commercial or military communications set that is capable of LOS C2 of the USV and its associated payloads. The communications set should be able to employ 256-bit AES encryption at a minimum. This temporary solution will be replaced by the Government-specified solution after initial USV acceptance testing.

E. USV On Board Network(s)

Command and control data is anticipated to be classified in nature. USVs must include support for an onboard local area network. If an unclassified local area network is also required, then the Partner Teams must supply a Navy certified cross-domain solution. The Partner Teams will coordinate with the Government to establish the logical and physical topology of the on-board network; this will include the exact configuration of the network to identify the beginning and ending points of the classified and unclassified segments of the network should a cross-domain solution be required. The Partner Teams shall ensure that all classified network segments meet or exceed Navy physical and network security standards.

F. Reliability

- It is expected that the system shall successfully accomplish 70% of 30-day missions without mission degradation. The system shall be designed to ensure this capability.
- The system shall have at a minimum the following capabilities:
    - Health monitoring - helps to identify problems with the existing system and reports to the mission level computer any limitations the system may have.
    - Prognostic capability - ability to predict failures and provides solutions either before or at the time of failure. System shall be used to identify required maintenance/repairs between missions.
    - Maintainer's software that allows easy identification of issues and troubleshooting of the system.
    - Alert system to notify remote operator if failure continues to persist.
    - Remote Operator should be able to remotely shift plant conditions to supplement faulty automated prognostics.

G. Fueling at Sea

- Interfacing with existing Military Sealift Command (MSC) oilers.
- Capability to refuel in up to Sea State 3.
- Not more than four personnel temporarily aboard the USV during refueling.

H. Habitability for Emergency Manned Operations

- Able to sustain a crew of up to twelve 95th percentile sized males.
- Sustain crew of up to twelve for up to 7-days with basic sanitation, berthing, H&C, food, and water accommodations.

I. Anti-Tamper and Cybersecurity

- Craft access control – ensure easy entry to craft for authorized personnel trying to board at sea to perform preventive or corrective maintenance, while making the task very difficult for unauthorized personnel to board – mechanical, electronic, other, or combination.
- Craft towing control – ensure an authorized towing crew shall easily rig the craft for towing, while making the task difficult for unauthorized personnel.
- Memory wipe upon remote command.
- Cybersecurity / Information Assurance (IA) / network protection in accordance with DOD Instruction 8510.01 RMF for DoD Information Technology (IT).

J. Test Planning

- Novel approaches are sought that will ensure the USV meets its objectives while minimizing test duration and cost.
- Surrogate testing is allowed with Government approval.
- Modeling and Simulation is allowed with Government approval.
- Particular emphasis will be placed on testing to demonstrate both hardware and software reliability.

Attachment 02: GLOSSARY OF ACRONYMS

AES	Advanced Encryption Standard
AIS	Automatic Identification System
ALFUS	Autonomy Levels for Unmanned Systems
ASuW	Anti-Surface Warfare
BLOS	Beyond Line-of-Sight
BOE	Basis of Estimate
BTU	British Thermal Unit
C2	Command and Control
C3	Command, Control and Communications
CDR	Critical Design Review
CICA	Competition in Contracting Act
COLREGs	International Regulations for Prevention of Collisions at Sea
COMSEC	Communications Security
CS	Computer Software
CSD	Computer Software Documentation
DAMA	Demand Assigned Multiple Access
DoD	Department of Defense
DUNS	Data Universal Numbering System
EHF	Extremely High Frequency
EIA	Electronics Industries Alliance
EO/IR	Electro-Optical/Infrared
EW	Electronic Warfare
GFE	Government Furnished Equipment
GPS	Global Positioning System
HM&E	Hull, Mechanical and Electrical
I/O	Input/Output
IA	Information Assurance
IBS	Integrated Broadcast Service
IMU	Inertial Measurement Unit
IT	Information Technology
LOS	Line-of-Sight
LPD	Low-Probability-of-Detection
MOC	Maritime Operation Center
MOP	Measures of Performance
MOSA	Modular Open Systems Architecture
MSC	Military Sealift Command
NATO	North Atlantic Treaty Organization
NOFORN	Not Releasable to Foreign Nationals
OAAT	Open Architecture Assessment Tool
ODC	Other Direct Cost
OQE	Objective Quality Evidence
OSD	Office of the Secretary of Defense
OTA	Other Transaction Authority
PDF	Portable Document Format

RMF	Risk Management Framework
SCO	Strategic Capabilities Office
SIPRNet	Secret Internet Protocol Router Network
SME	Subject Matter Expert
STANAG	Standardization Agreement
STW	Strike Warfare
TACON	Tactical Control
TD	Technical Data
TTPs	Tactics, Techniques, and Procedures
UHF	Ultra High Frequency
USV	Unmanned Surface Vehicle
WCAs	Warnings, Cautions, and Advisories
WHS/AD	Washington Headquarters Services Acquisition Directorate