BAA Call Attachment 1

Additional Information

BAA Call N0001425SBC04
Ocean Explorer (OEX)

Office Of Naval Research
Code 33

I. OEX TECHNICAL OVERVIEW

The key enabling attributes for achieving a viable operational OEX system are reliability, endurance, communications, and autonomous operation. Significant advances in battery technology due to commercial electric vehicle investment, provide the basis for an all-electric propulsion system capable of theater scale multi-month on station operations from a single charge. This meets operational needs, while dramatically improving vehicle reliability through the elimination of complex diesel/snorkeling systems and elimination of hydraulic actuation. Additionally, the all-electric system minimizes the need for surface operations, enabling the vast majority operating hours to be conducted in relatively benign (near isothermal) and secure steady state submerged conditions. This significantly reduces operational risks and further reduces mechanical and thermal stresses cycles.

In terms of autonomy, a key challenge is reliability. The program seeks to leverage extensive developments in uncrewed operations for both air, surface and sub-surface vehicles. Key enabling capabilities include tactical navigation systems able to navigate through all phases of the mission profile and an integrated communications manager able to maintain the communications posture and channels to respond and execute the mission. The mission profile is designed to minimize environmental and operational complexity to focus vehicle autonomy development on creating sufficient automation to execute required tasks and reasoning ability to effectively address abnormal or casualty conditions. The current state of the art in autopilots and navigation systems is sufficient to address piloting throughout the mission. Maintaining mission communication postures while minimizing periscope depth operations will require innovation to develop new or modification of current communication capabilities. Mission and vehicle autonomy will also require innovative development but should not exceed the complexity of other uncrewed system autonomy systems. The focus is addressing integration and testing of payload, vehicle, and mission autonomy ‘engines’ to form a robust architecture able to support long duration high reliable operations.

Payload modularity is a key attribute to the OEX vehicle. While one particular payload has been identified to provide focus for the vehicle design for this BAA Call, the ability to adapt to others in the future must be included.

II. PROGRAM APPROACH

A. Key Program Objective and S&T Challenges

The ultimate OEX objective is to demonstrate the ability of an all-electric powered ultra large Uncrewed Underwater Vehicle (UUV) to reliably perform an extended autonomous mission without underway refueling. Four categories constitute the key S&T challenges. First is reliability, specifically the reliability of systems and software in a highly complex vehicle to operate over an extended deployment. Second is the ability to maintain two-way communications necessary for command and control, including payload, vehicle operation, and mission replanning throughout all phases of an extended transit and patrol while minimizing above and near surface time. Third is endurance, specifically the ability to achieve and maintain the extremely low hull hydrodynamic drag and propulsive efficiencies required to enable the extended mission on battery power without recharging. The final key S&T category is the ability to develop and demonstrate a reliable, fault tolerant autonomy software suite able to address payload, vehicle, and mission control decisions throughout all phases of an extended deployment.

The core of this demonstration is a large-scale prototype vehicle to be designed, built, and tested at sea on an accelerated schedule along with a separately designed, built, and land-tested payload module. Accompanying the prototype vehicle is an integrated design of the full capability production vehicle and associated support infrastructure to support Navy leadership assessment of the feasibility and executability of the OEX concept.

An overall guiding tenet of the OEX program, and the Prototype Vehicle in particular, is that it should add no additional stress to the Navy's submarine construction and delivery schedules.

This design effort is guided by the following documents, to be disseminated as part of the classified addendum for this BAA Call:

- Top Level Requirements (TLRs) establishing the high level performance goals of the production OEX vehicle.
- Design Reference Mission (DRM) describing in detail the functions, durations, and communication inherent in the OEX mission.
- Detailed performance goals and constraints of the OEX vehicle and systems/subsystems organized by the Government Work Breakdown Structure (WBS).
- External communications architecture/strategy defining the communications system circuits and networks available for use by the vehicle and/or required to support payload mission.
- Payload Initial Capabilities Document (ICD). Detailed description of the payload hull, mechanical, and electrical (HM&E) requirements.

These documents define performance goals and constraints the Government expects the OEX vehicle to be able to address.

In addition, the following documents are provided as Government Furnished Information (GFI) to assist the offerors in completing the design:

- The Government Concept Design. This design, with supporting narrative and calculations, represents a concept for hull structure, mechanical systems, and propulsion of the production OEX vehicle that the Government believes can meet the OEX performance goals and is indicative of the Government's preferred solution. It is expected that the offerors will use this concept as a starting point for their design process.
- Studies performed by the Government team in the process of assessing concept feasibility.
- OEX Compendium. A high-level description of the notional OEX vehicle design and characteristics utilized by ONR in explaining the OEX project to ONR and Navy Leadership.
- OEX Vehicle WBS. Used by the Government OEX team to manage the development of initial feasibility studies.

B. Program Execution

This BAA Call is requesting two separate but closely related designs, referred to as "Production Vehicle" and "Prototype Vehicle". The primary purpose of the production vehicle design is to develop an integrated vehicle design to demonstrate the feasibility of the fundamental OEX concept and to facilitate substantive transition planning. The Prototype Vehicle design is a variant of the Production Vehicle that will be built and tested to validate performance of feature assumptions of the production vehicle design that are key to vehicle mission capability (e.g. propulsion efficiency and drag). In addition to these designs, the BAA Call is requesting infrastructure support plans for the Production Vehicle as it would be operated and maintained by the Navy and for the fabrication and testing of the prototypes. The Production Vehicle design would naturally precede that of the prototype, however, some innovative compromise of this sequence is needed in order to streamline the project and shrink the timeline to get to a validated OEX design and accelerate prototype vehicle fabrication and delivery. Proposers should consider how to sequence the tasks in this design effort to achieve this accelerated prototype timeline for getting the prototype into the water. This approach should be discussed in the proposal and reflected in the proposed Integrated Master Schedule, along with the rationale for how this can be accomplished with minimal risk.'

Project execution should include regular collaborative meetings and teleconferences to inform the Government of program, design, and development status. Quarterly Project Reviews (QPRs) will be held to track technical and management progress. At substantial decision points, in-person technical reviews will be held. Proposers should aggressively identify technical and programmatic risks and resource parallel risk reduction paths over the life of the project. The minimum anticipated meeting rhythm is outlined below and may include multiple meetings on the same day.

- Monthly status teleconferences to provide insight into recent activities and near-term plans, briefing relevant technical development and program management topics, and summarize spend plan status.
- Quarterly Program Reviews to convey technical progress and overall program
- performance (in-person).
- Weekly status reports to summarize progress, issues, and next steps.

Note: All in-person reviews will be held at ONR.

C. Sample Contract Data Requirements Deliverables (CDRLs)

C.1 Phase 1A Preliminary Design

Deliverable	Initial Delivery	Update	Description and Example Content
System Engineering Management Plan (SEMP)	Kick-off mtg	QPR	
Integrated Master Schedule	Kick-off mtg	QPR	
Risk Management Plan	Kick-off mtg	QPR	
System Requirements Review Report (SRR)	1 month after award (MAA)		Review of OEX vehicle TLRs, Detailed Performance Goals, associated requirements material, DRM, and GFI to demonstrate understanding and assess completeness, consistency.
Concept Design Review Report (CoDR)	3 MAA	PDR	Review of the Government concept design and associated GFI; document proposer's Concept Design
Design Technical Data Package (production vehicle)	Initial PDR	Final PDR	Drawings, system/subsystem descriptions and single line diagrams, SDD, ICDs, etc
Design Technical Data Package (prototype vehicle)	Initial PDR*	Final PDR*	Drawings, system/subsystem descriptions and single line diagrams, SDD, ICDs, etc
Vehicle Weight Report	Initial QPR	Qtrly	To WBS level 4/5
Vehicle Energy Budget	Initial QPR	Qtrly	To WBS level 4/5
Vehicle Reliability Assessment	Initial PDR (draft)	Final PDR	Reliability of the total vehicle incl HM&E, electronics, software, autonomy, comms in the context of an autonomous system and the extended duration DRM
Detailed Vehicle Budgetary Cost Estimate (production vehicle)	Initial PDR (draft)	Final PDR	Breakdown to WBS level 4
Detailed Vehicle Budgetary Cost Estimate (prototype vehicle)	Initial PDR (draft)	Final PDR	Breakdown to WBS level 4
OEX Operation and Infrastructure Support Description and Budgetary Cost Est (production vehicle)	Initial PDR (draft)	Final PDR	In-service "squadron" of operational OEXs. Incl infrastructure, manning, support, etc.

Vehicle Infrastructure and Test Support Description and Cost Estimate (prototype vehicle)	Initial PDR (draft)	Final PDR	Nom 2 year prototype test/demo effort. Incl waterfront facilities, infrastructure, transportation, manufacturer support team
Vehicle Safety Plan (production)	Initial PDR (draft)	Final PDR	Deployment and retrieval, operations, maintenance (incl battery), payload
Vehicle Safety Plan (prototype)	Initial PDR* (draft)	Final PDR	Deployment and retrieval, operations, maintenance (incl battery)
Prototype Vehicle Build Plan	Initial PDR* (draft)	Final PDR	Approach to manufacture, integration, and delivery.

*Initial PDR and Final PDR for prototype vehicle may be separated from the production vehicle in order to optimize prototype schedule.

Table 1. Phase 1A Deliverables

C.2 Phase 1B (Option) Detailed Design

Deliverable	**Initial Delivery**	**Update**	**Description and Example Content**
Design Requirements Report	1 MAA		
Integrated Master Schedule	1 MAA	QPR	
Design Technical Data Package (prototype vehicle)	QPR (progress)	CDR* (final)	Drawings, system/subsystem descriptions and single line diagrams, etc
Autonomy and Software Design Package	QPR (progress)	CDR (final)	SDD updated, SDP, SDR, ICDs, etc
Prototype Vehicle Weight Report	QPR	CDR (final)	To WBS level 4/5
Prototype Vehicle Energy Budget	QPR	CDR (final)	To WBS level 4/5
Prototype Vehicle Build Plan Update	QPR (progress)	CDR	Manufacture, integration, delivery, schedule, acceptance test plan, etc
Vehicle Infrastructure and Test Support Description and Cost Estimate (prototype vehicle) Update		CDR	
Detailed Vehicle Cost Estimate (prototype vehicle)		CDR	Through delivery and acceptance. Breakdown to WBS level 4
Risk Management Plan	QPR	CDR	
Prototype Vehicle Safety Plan Update	QPR (progress)	CDR	To include manufacturing, integration, acceptance, transportation, prototype test/demo

Table 2. Phase 1B Deliverables

Electronic versions of all deliverables will be in Microsoft file formats (e.g., Word, Excel, PowerPoint). All design, scheduling, analysis, and simulation will be carried out using toolsets readily available in the open market or as open source.

D. Major Program Review Descriptions and Expectations

The Government expects that a rigorous systems engineering process will be used to execute the design process while identifying areas of high risk to be mitigated over the course of the project effort. Performers are expected to appropriately tailor their systems engineering processes such that they support tracking design maturation, managing risk, documenting OEX vessel design traceability against established performance goals and conducting verification and validation of requirements. System engineering should be the basis of estimating and improving reliability. Proposers should anticipate the following formal reviews: SRR, CoDR, Initial PDR, Final PDR and CDR (Phase 1b Option). Performers are also expected to execute QPRs, to keep the Government team informed on detailed technical status. In quarters where a formal review is planned, it may satisfy the requirement for a QPR.

All design reviews should have content, entrance, and exit criteria tailored from a recognized industry or military standard for appropriate programs. Proposals should clearly address how these standards will be tailored in the proposed effort. Design review content and criteria must include an assessment of the design maturation and technical risk and incorporate demonstrable technology maturation progress and achievements. OEX system design review guidance for SRR, CoDR, Initial PDR, Final PDR, and CDR are outlined below. The entrance and exit criteria for each review, as well as the content checklists, will be evaluated to assess the adequacy of the proposed systems engineering processes. In addition, these checklists will need to be approved by the Government prior to the start of the reviews to allow the Government to understand and assess the adequacy of the proposed tailoring of these reviews.

D.1 General

- Performance Goal Development - A complete set of system performance goals and design requirements is established down to the lowest expected level of the system hierarchy (i.e., system, subsystem, and component) for the subject review. Each requirement must include verification provisions. System interfaces are identified and documented.
- Design Definition - The design of the system architecture is established down to the lowest expected level of the system hierarchy for the subject review, satisfies established performance goals, and is sufficiently detailed to enable the next level of design definition. Appropriate design margins are identified and maintained.
- Risk Management – Programmatic and technical risks are identified and assessed (e.g., consequence and likelihood). Mitigation plans are in place along with associated completion criteria. Programmatic and technical risks have been updated with results of any mitigation activities.
- Risk Reduction – Proposers should consider some resource allocation for engineering services and testing to support risk reduction during the program.

D.2 SRR

The objective of SRR is to ensure system design and development requirements are completed and documented. The performer will review the OEX vehicle TLRs, Performance goals, associated requirements material, DRM, and GFI to assess completeness and consistency.

Minimum information to be provided:
- Requirements Development – Requirements are complete and consistent and preliminary interfaces are defined. Gaps are identified and recommended resolutions are provided.
- A pathway to CoDR is identified and documented.

D.3 CoDR

The objective of this review is to determine the feasibility of the Government's concept design and the ability of this concept to meet project TLRs and Performance Specifications in the context of the DRM. The performer will present the results of their review of the Government concept design and associated GFI and propose changes in the concept design and/or performance goals necessary to achieve a formal OEX project conceptual design. Following Government approval of the vehicle concept design (and revised performance goals, if any) the performer will proceed to preliminary design.

Minimum information to be provided:
- Conceptual design is complete, and the approach is shown to be feasible
- through initial analysis.
- A pathway to PDR is identified.
- System baseline technologies for OEX HM&E and other key vehicle functions (e.g. autonomy and external communications) are identified.
- System baseline approach to health and mission autonomy is identified.
- Modeling and Simulation methods to verify the hull and propulsion design performance, HM&E reliability, and other critical factors are identified.
- Design support analysis and data from all design disciplines, to support the concept design.
- Performance specifications for all systems/subsystems are complete
- Projected performance capabilities against DRM profile.
- Final OEX conceptual design is adequately documented.
- Project IMS is updated.

D.4 Initial PDR

The objective of PDR is to determine the design maturity of the selected system concept to ensure consistency with OEX program goals. The performer will present the system preliminary design baseline with closure around documented vehicle performance goals, updated project risks, and updated schedule through completion of the project. The review will allow ONR to assess the feasibility of the design effort to complete a meaningful production vehicle within project cost and schedule constraints and to support the design of a prototype vehicle for build and test on an accelerated schedule.

Minimum information to be provided:
- Requirements Development – Interfaces and requirements are complete and external interfaces are documented.
- Design Definition – Assess the allocated design documented in subsystem performance goals.
- Preliminary design is complete to the subsystem/configuration level, TLRs and Detailed Performance Goals are traceable to system-level requirements, and the design closes around documented requirements and adequately demonstrates that performance achieves performance metrics.
- Draft vehicle design technical data package
- Drafts of all Deliverables
- Vehicle software architecture – Draft SDD and a detailed discussion of software design approach.
- Risk Management – Risks must include all design risks.
- Updated project schedule - Updated IMS available.

D.5 Final PDR

The objective of PDR is to review final OEX Technical Design Data Package and all Deliverables to ensure that all issues raised through PDR have been satisfactorily resolved. The performer will present the system design and deliverables along with a detailed accounting of how project issues have been retired.

D.6 CDR

The Critical Design Review (CDR) demonstrates that the system design is stable, expected to meet performance goals and on track to achieve cost goals as evidenced by the detailed design documentation. At this point, the system has reached the necessary level of maturity to start fabricating, integrating, and testing pre-production articles with acceptable risk. The CDR will allow ONR to assess the feasibility of the design to deliver a demonstrator that meets performance objectives within program cost and schedule constraints. The CDR entrance and exit criteria will be fully developed prior to the event and agreed to by ONR.

Minimum Information to be provided:

- Requirements Development – Prototype Vehicle design requirements are complete. Component verification methods and statements for each requirement are established. Traceability of requirements across all levels of the system hierarchy are documented. All interface requirements are documented.
- Design Definition – Prototype vehicle critical design is complete to the component level and achieves compliance with all associated performance goals. Hull, Mechanical and Electrical (HM&E) system design is sufficient to develop manufacturing-quality product drawings. All interfaces are under configuration control. The design closes around documented requirements and achieves OEX performance goals.
- Autonomy & Software Development – Software architectures are fully defined and show traceability to performance objectives. SDD is complete and validated. A Software Development Plan (SDP) is complete. Software Design Requirements are complete. A detailed software test and validation plan is established.
- Risk Management – All design, integration, and fabrication risks are captured and mitigation plans are defined. Risks are mitigated to an acceptable level that supports component fabrication and software development. Initial Environmental Hazard Mitigation Plan is prepared.
- System Cost – System production cost are established. A complete EBOM is defined and supports procurement.
- Program Schedule – Program schedule is updated and shows feasible path to support all Phase 2 fabrication, testing and demonstration activities
- Design Baseline – The design baseline is established and demonstrates that it effectively meets technical performance metrics and the ONR OEX program goals. Design baseline is placed under configuration control.

E. Additional Government Furnished Information

As part of the overall concept development prior to releasing the OEX BAA Call, the Government executed a series of design and analysis activities to establish feasibility for the OEX concept. In doing so the Government identified a preferred battery solution, initial design of the propulsor system, and identified the objective payload. In addition to making the information from these activities available to proposers, several procedures regarding Government assisted support to potential performers have been established to facilitate information exchange and efficient capability development.

E.1 Battery.

The Government will supply the Battery as Government provided Information (GFI) and Equipment (GFE). Performers should still account for technical interchanges and system integration in their program plans.

- The Government will contract directly with the preferred battery provider to account for design services and technical interchange support relevant to their batteries and associated battery management system.
- A Technical data package and explanation of information, services, and equipment provided by battery provider via the Government will be provided for all proposers with the BAA Call release. The Government will facilitate question and answer sessions for potential proposers regarding the battery system.
- The Government will facilitate technical data exchanges between the battery provider and selected Phase 1 design teams.

E.2 Propulsor

PSU ARL is the designated design agent for the propulsor assembly.

- PSU ARL will provide a single ‘proposal’ package outlining the design services that any proposer may include. Additionally, they will support answering questions regarding the reference propulsor design.
- Post selection PSU ARL will establish design teams to support selected vehicle design efforts.
- PSU ARL will contract directly with the Government and their services provided as GFI/GFE to the prime contractor.

E.3 Payload

The objective payload, and therefore, payload provider has been selected. All performer designs will be based on integration and operation of that payload. The payload supplier has provided general details of the payload in the Payload ICD attachment (to be provided later).

- The payload supplier will supply additional payload details on a non-exclusive basis to potential bidders.
- The payload supplier will contract directly with the Government and their services provided on a non-exclusive basis to the successful bidders as GFI during the period of this design in accordance with the terms of the proposed effort.

III. OTHER INFORMATION

A. List of Attachments (to be provided later)

- Design Reference Mission
- Top Level Requirements
- Detailed Performance Goals
- Communications Architecture
- Payload ICD
- Government Concept Design
- Other GFI
- Compendium
- Government WBS