Performance Work Statement (PWS) for Underwater Training and Testing

1.0 Objective and Scope

The Contractor shall provide the infrastructure, personnel, training, materials, foods, supplies, and operational support necessary to execute a multi-day Underwater Training / Testing Capability Demonstration. The primary objective is to systematically demonstrate and evaluate the contractor's ability to perform spaceflight-analog training. Secondary objective is to perform human research, and technology maturation within a subsea environment.

2.0 General Requirements

The Contractor shall demonstrate the following technical and operational capabilities across the contract lifecycle:

a. **Subsea Saturation Habitat**: Support four (3-4) NASA-provided participants simultaneously for a minimum of five (5) continuous days at a minimum depth of 12 meters.

b. **Helmet Diving Operations**: Provide umbilical-based helmet diving from the habitat for (3-4) NASA-provided participants.

c. **Bi-Directional Telemetry**: Deliver real-time, bi-directional audio, data (including file transfer) and video streaming between the control center, habitat, and habitat divers when on umbilical connection.

d. **Facility Control Center**: Operate a shore- or vessel-based facility control center. In response, the vendor should include recommendations on recommended NASA-provided personnel to monitor, log, and interact with the habitat, diver crewmembers, and vehicle systems. Also, include maximum number recommended.

e. **Data Integration & Compliance**: Collect, monitor, and integrate human research, performance, health, medical, vehicle, and environmental data while ensuring compliance with federal data protection regulations.

f. **Payload Integration**: Provide mechanical, physical, and software interfaces to accommodate NASA-provided payloads, mockups, and operational software tools.

g. **JSC Remote Mission Control**: Establish real-time bi-directional connectivity with NASA Johnson Space Center (JSC), including simultaneous audio, video and data representative of expected Artemis EVA conditions. Provide an adjustable

communications latency emulator to simulate Earth-to-Moon or Earth-to-Mars delays.

h. **Regulatory & Readiness Compliance**: Maintain compliance with all state and federal safety and environmental regulations for subsea build, deployment, and operations.

i. **Schedule:** All mission timelines, durations, and crew allocations must remain flexible to accommodate unpredictable NASA crew scheduling constraints and research asset availability.

3.0 Tasks and Deliverables

Task 1: Planning & Facility Readiness (Base Period)

The Contractor shall establish the operational baseline and complete facility validation. This includes a notional schedule with contingency plans if there is poor weather/delays.

- **Task 1.1: Coordination Plan**: Identify Contractor Responsible Persons (RPs) and establish a joint NASA-Contractor coordination framework.
- **Task 1.2: Joint Test Plan**: Co-develop a Joint Test Plan outlining the criteria for evaluating all technical and training capabilities.
- **Task 1.3: Facility Site Visit & NASA Readiness Review:** Provide photos, certifications, permits, data, personnel support, and facility documentation; including a Facility Readiness Review (FRR) and Test Readiness Review (TRR). The FRR/TRR would include NASA participation and concurrence.
- **Task 1.4**: Facility must be certified in accordance with JPR 1700.1L. Facility must complete an internal Facility and Test readiness review.
- **Task 1.5: Participant Processing**: Support NASA-provided participant selection and medical clearance screening workflows.

Task 2: Training & Facility Demonstration Mission (Base Period)

The Contractor shall execute the initial training blocks and the baseline saturation mission.

- **Task 2.1: Test Readiness Review**: Conduct a Training Readiness Review prior to entering the water or beginning hazardous testing.
- **Task 2.2: Diver & Habitat Training**: Complete working diver and pre-saturation helmet dive training for 6 NASA personnel. Complete habitat operations training for

6 NASA personnel. Training shall prepare participants to assume operational responsibilities inside the habitat and in shore/vessel support roles, including (1-2) NASA participant is certified as a habitat/rescue diver.

- **Task 2.3: Baseline Saturation Execution**: Execute a minimum 5-day mission utilizing 2 NASA-provided habitat crewmembers and 2 NASA-provided shore/vessel mission support personnel. This includes a mission scheduling tool to track mission timeline/tasks.
- **Task 2.4: Integration Documentation**: Document the formal NASA-Contractor Integration Process for future payload, research, and training activities. This includes delivery of a 'payloads interface requirements document' detailing what constraints/limitations future equipment will be subject to (mass, power, volume, data interfaces, etc)
- **Task 2.5: Technical Capabilities:** Conduct the following technical capabilities demonstrations:

  Communication Demo:

  - Two-way audio/video communications and file data transfers between in-habitat and remote individuals
  - Adjustable communications delay (from 1 second to 22 minutes each way)

  Research and Technology Demo capability

  - Minimum of two (2) computer-based tests/ questionnaires
  - Minimum of two (2) biological/cold-chain sample transfers for (samples can be representative fluids):
    - Ten (10) blood test tube simulators, each 10ml
    - Four (4) 500ml urine containers simulators
    - Dried blood spot DBS card*
    - Saliva collection using dry saliva technology*

*DBS and dry saliva technology consistent with early Artemis missions. Vendors will reply how they intend to demonstrate cold-chain sample transfer and if this will be simulation or will result in acutal cold stowage.

  - Exercise equipment demo – small very light weight device

  EVA Demo Capability

  - Minimum of two (2) EVA scenario demonstrations, each with 2 divers performing a simulated EVA
  - Emergency simulation

- **Task 2.6: Reporting**: Deliver a Joint NASA-Contractor Report and outbrief detailing demonstrated capabilities, ConOps recommendations, and architectural designs for future scalable training (up to higher crew capacities).

Performance Assumptions and Constraints

- **Participant Profiles**: NASA participants may include astronauts, flight controllers, or test subjects who may have diving experience limited to basic open-water scuba certification. Contractor training programs shall accommodate this baseline.
- **Limited Training, Research and Technology Demonstrations**: All training materials, mission designs, and evaluation scenarios shall be created collaboratively to align directly with NASA's Training Needs Assessment and astronaut training focus. Secondary objectives focus on: Human Research Program (HRP), Science Mission Directorate, and Space Technology Mission Directorate research and priorities.

Option 1: One 5-day integrated space analog missions

Task 3

- **Task 3.1: Analog Mission Planning**: Develop a Joint Test Plan and a flight-like Mission Timeline derived from base period findings. Conduct a formal Mission Readiness Review (MRR).
- **Task 3.2: Saturation Mission Execution**: Execute 5-day integrated space analog missions utilizing 4 NASA/International Partners habitat personnel and 4 NASA/International Partners shore/vessel support personnel. Include nominal and off-nominal simulations/tasks consistent with Artemis-like scenarios.
- **Task 3.3: Rescue Diver Provision**: Ensure at least one (1) NASA participant is certified as a habitat/rescue diver.
- **Task 3**.4: Spaceflight Analog Tasks: Assess the following crew habitability parameters: sleep duration, food system performance, and exercise capability with both subjective and objective measures. For all tasks, include a report of the fidelity achieved for each measure, any "lessons learned" and future plans to remedy those "lessons learned".

Option 2: Two 5-day integrated space analog missions

Requirements Identical to Option 1 but with two additional 5 day analog missions.

Option 3: Four 10-day integrated space analog missions

- **Task 4.1: Artemis ConOps Planning**: Develop a Joint Test Plan, an Institutional Review Board (IRB) approved protocol matching Artemis human research objectives, and an active timeline integrated into NASA mission systems software.
- **Task 4.2: Extended Saturation Execution**: Execute a minimum of four 10-day integrated Artemis surface simulation mission with 4 NASA/International Partner habitat personnel and 6 NASA/International Partner shore/vessel support personnel. Include nominal and off-nominal simulations/tasks consistent with Artemis-like scenarios.
- **Task 4.3: Advanced Operations**: Support advanced individual competency, commander readiness, and team dynamic training protocols during active saturation.
- **Task 4**.4: Spaceflight Analog Tasks: Assess the following crew habitability parameters: sleep duration, food system performance, and exercise capability with both subjective and objective measures. For all tasks, include a measure of the 'simulation validity' along with the task assessment to evaluate how relevant/valid the implementation is in the analog environment.

Option 4: Three twelve-day Integrated Mission Rehearsal

Same requirements as Option 2 but three twelve-day missions.