TECHNICAL DETAILS FOR 'ADITI' CHALLENGE

Fabrication, Integration and Testing of AUV as per 'Jalkapi' Design

1. The *Jalkapi* Autonomous Underwater Vehicle (AUV) is intended for underwater survey missions. It is envisaged to have a mission endurance of 45 days at sea, with on-board recharging (by Diesel Generator) to replenish its battery. Preliminary design has been undertaken by the Indian Navy's Directorate of Naval Design (SDG) (DND(SDG)). The design envisages use of COTS payloads / sensors, batteries and other associated systems.

2. The Industry partner (MSME) is to undertake detailed design of the AUV as per this preliminary design, procure components/ equipment, fabricate, integrate and test one prototype of *Jalkapi* AUV. The main characteristics of the preliminary design are summarised below.

Table 1. Main Particulars of *Jalkapi* AUV

Sl.	Parameter	Specifications
(a)	Length Overall	10 m (approx.)
(b)	Beam/ Diameter	2 m (approx.)
(c)	Displacement	20 tons (approx.)
(d)	Speed (knots)	3 (nominal) / 8 (max)
(e)	Mission endurance (at nominal speed)	30 to 45 days
(f)	Range	> 3000 nm
(g)	Max Operating Depth	> 300 m
(h)	Structural Material	Pressure hull: High-strength steel DMR 249A Exo-structure: GRP/ Aluminium/ carbon fibre
(j)	Sensor Payload	EO/ IR cameras, Multi-beam Echo Sounder, CTD, ESM, Passive Bow and/or Flank Sonar
(k)	Navigation & Obstacle Avoidance Payload	INS, DVL and Pressure sensor, GPS, Altimeter, USBL, Collision-Avoidance Front-Looking Sonar, COTS Radar
(l)	Communication	Acoustic (USBL), V/UHF (Line-of-Sight), Satellite
(m)	Propulsion Thruster	10.5 kW / 300 V PM BLDC Motor
(n)	Control Surfaces	Four fins at stern, each with 24 V PM BLDC motor
(p)	Power Source (Battery)	225 kWh, 300 V Lithium-ion (preferably LFP)

Sl.	Parameter	Specifications
(q)	Diesel Generator (for recharging battery)	100 kW,1500 rpm; 415V 50Hz 3 phase
(r)	Control and autonomy	Ethernet-based IPV6 wired star topology with two L3 switches

3. **Role and Mission**. The envisaged role for prototype *Jalkapi* AUV is to navigate autonomously to a specified region in the sea and to gather useful surface and underwater data through visual, acoustic and electronic means, occasionally communicating with its Shore Control Station.

4. **Sequence of Operations**. The general sequence of operations to be undertaken (demonstrated) by *Jalkapi* AUV are as follows:-

(a) **Launch**. Prior to cast off, various systems/ sensors of the AUV such as navigation, communication, radar, echo sounder would be switched on. The AUV is to cast off from a jetty, or be launched from a ship. The AUV would follow a pre-fed path, while ensuring safe (collision-free) exit from harbour on surface using its Radar and Collision-avoidance Sonar.

(b) **Dive to preset depth**. The platform should be able to dive to preset depth as per the (pre-fed) requirements of the mission. The AUV should be able to change depth autonomously using its control surfaces while propelling ahead.

(c) **Outbound Transit**. The platform should be able to transit in dived condition at nominal speed (3 knots) to the pre-set Designated Area. In compliance with a pre-fed overall mission plan, the AUV is to undertake mission planning, diving/ surfacing, adjust buoyancy, and navigate underwater (without GPS). The AUV would autonomously monitor its battery condition and recharge its batteries by periodically coming near the sea surface and running its Diesel Generator. Air intake mast is to be raised for this purpose. Communication antenna fitted on the mast would be used to send/ receive data to/ from Shore Control Station.

(d) **Operations in Designated Area**

(i) **Vehicle Path Pattern**. The AUV should switch on its sensors and proceed at specified speed in a pre-defined pattern (say, lawn-mower pattern) staying within a specified area/ volume of sea, for pre-defined duration.

(ii) **Data Recording**. As per pre-defined mission requirements, the AUV would record parameters in the designated area using its sensors.

This may include Acoustic data from Sonars, Visual data from EO/IR sensor, and bathymetric data from CTD probe. The data would be stored for subsequent (post-mission) analysis ashore.

(iii) **Communication**. The vehicle should surface at pre-defined intervals to communicate with its control station, and dive thereafter to continue its data recording.

(f) **Return Transit**. On completion of mission, the AUV should transit back to harbour/ pre-defined position. All aspects pertaining to outbound transit would be applicable during the return transit as well.

5. **Payload**. The sensors / payload required to be procured, installed and integrated in the *Jalkapi* AUV are listed in the table below. Items exposed to sea water are to be suitably depth-rated.

Table 2. Description of Sensors and Payloads for *Jalkapi* AUV

Sl.	Sensor	Description / Functions
(a)	Inertial Navigation System	Accelerometer and gyroscope, with motion processing unit computing the attitude information
(b)	Doppler Velocity Log	Estimate vehicle speed and hence, probable position
(c)	Pressure Sensor	Obtain depth information
(d)	GPS	Obtain speed and position of the vehicle (when on surface)
(e)	Altimeter (also integrated with AHRS)	Single beam sonar to obtain distance (height) from sea bed
(f)	Collision Avoidance (Active) Sonar	For obstacle avoidance in shallow water
(g)	Acoustic Communication (Ultra-Short Baseline)	Subsea wireless communication (short-distance) with Mother ship for telemetry and position correction
(j)	Satellite Communication	Transfer data (telemetry, vehicle health and mission data) when on surface
(k)	EO/ IR capable cameras	Visible and infrared sensors for situational awareness in day and night, when on surface
(l)	CTD Sensor	Measure sea water temperature, salinity and density
(m)	Pinger / Distress Signal	Transmit coordinates of AUV location in case of shutdown or emergency or for homing

Sl.	Sensor	Description / Functions
(p)	Flasher	Lights for indicating the extremities of AUV to aid during recovery
(q)	Radar	For detecting / avoiding traffic, obstacles, or approaching weather, when on surface
(r)	Passive sonar	Passive acoustic detection of vessels using Bow and/or Flank arrays
(s)	ESM	Detection/ recording of electronic transmissions (on surface)
(t)	V/UHF Communication	Line-of-sight data transfer to shore control or Mother ship, when on surface
(u)	Sub-Bottom Profiler	Scan sea bottom to detect embedded objects

6. **Systems**. Vehicle systems envisaged for *Jalkapi* AUV are tabulated below.

Table 3. Systems on *Jalkapi* AUV

Sl.	System	Purpose/ Features
(a)	Thruster and Fins	Forward movement will be achieved by thruster fitted at the aft end. Course keeping and manoeuvring is to be achieved by using control surfaces
(b)	Battery System	LiFePO4 (preferred) battery pack including BMS to provide power to all sensors and actuators
(c)	Diesel Generator	Diesel generator with associated systems and autonomous control for recharging battery pack
(d)	Power generation and distribution	Electrical system for power distribution, isolation and battery charging
(e)	Firefighting	Suitable firefighting arrangement with autonomous operation
(f)	Control system	Modular, robust, fault tolerant autonomous control system (hardware, software and network) managing sensors, payloads and systems of the AUV. The modules would include Mission computer, System Software, Sensors & Payload, and Data Processing.
(g)	Launch & Recovery	Fittings / fixtures and slings to enable lifting / lowering using typical cranes, with container for storage of the AUV.

(Dynamic); Mission plan repository and visualization; Initialisation; Navigation, sensor & systems status; Check Flags and fault monitoring; and Payload post processing.

8. **Scope of Work**. The activities expected to be undertaken by the industry partner under this project are as follows:-

(a) Prepare detailed design of AUV *Jalkapi*, to the level of detail required to undertake construction, integration, testing & trials, based on build specifications and preliminary design provided by *IN*.

(b) Procure suitable equipment and materials required for building the prototype, as per indicated specifications.

(c) Inspection and testing of procured equipment, components and material.

(d) Fabrication of hull structures.

(e) Installation, integration and assembly of components.

(f) Setting-to-work and testing of systems.

(g) Conduct Acceptance Trials of the AUV as per approved scope: Ashore, in sheltered waters, and at sea, including arrangements for transportation between sites (within India).

9. **Deliverables**. Salient deliverables of the project are as follows:-

(a) One operational prototype AUV, with storage container, and containerised Shore Control Station.

(b) Detailed design drawings, 3D CAD model, test reports and all associated software / firmware utilised in the prototype.

(c) Documentation of design, testing, component procurement & acceptance, inspections and trials

10. **Inputs from Customer**. The following information / support would be provided to the industry partner:-

(a) Preliminary design of *Jalkapi* AUV (documents, drawings and 3D CAD model) would be provided immediately on signing of contract.

(b) List of short-listed equipment and possible sources of supply.

(c) Results of supporting R&D studies undertaken for *Jalkapi* including control system architecture, collision avoidance algorithms, software for guidance, navigation & control and hydrodynamic characteristics of hull form.

(d) Facilitate procurement of structural steel for pressure hull

(e) Facilitate conduct of sea trials

(f) Facilitate necessary approvals from other government agencies.

11. **Standards**. The vehicle should comply with marine standards relevant for commercial AUVs. Collision avoidance features should enable compliance with IMO regulations for safety of navigation. The vehicle to be built is a prototype, with the objective to validate its design and autonomous operations. Therefore, requirement of Military-grade components is not envisaged. However, the company is to adhere to suitable industrial and marine standards (IEC/ EN/ Class Specifications/ equivalent) for hull construction, non-destructive testing, electrical & electronic equipment, mechanical & electrical systems, and associated software, to ensure safe and reliable operation

12. **Testing and Trials**. Evaluation and acceptance trials of the prototype AUV would be conducted by the Customer at factory (Hardware-Software in loop testing), in sheltered waters and in open sea. Trials protocol will be formulated and will be provided by the Customer.

13. **Delivery Timelines**. Construction, integration and hardware-in-loop testing of prototype at factory premises is to be completed within 12 months from contract. Harbour and sea trials are to be completed within 12 months thereafter. Total duration of the project is to be 18-24 months from contract.

14. **Technical Evaluation**. Short-listing / selection of industry partners for this project will be undertaken based on various technical and commercial considerations, including the following:-

(a) Experience in development and testing of marine vehicles and past performance in timely deliveries

(b) Systems Engineering / Vehicle development / Project management experience

(c) Capability in developing autonomous systems / marine robotics applications

(d) Facilities and infrastructure for fabrication, assembly, integration and testing a vehicle of the envisaged size

(e) Expertise in handling similar structural materials

(f) Expertise in development / integration of sensors relevant to the envisaged AUV

(g) Workload of ongoing projects / orders from IDEX / defence/ other agencies

(h) Workforce, expertise and support from established firms / shipyards

(j) Estimated time, cost and likelihood of successful completion of the project