Project Title: AUV Docking

Project # 900593

Prepared by: Brett Hobson (version 4.1 and after)
Jim Bellingham (version 3.1 and after)
Tarun Podder, Mark Sibenac (versions 1-2.1)

Rev. #	**Date**	**Changes**	**Approved by**
Draft	04-Feb-2003	First draft	
1	11-Feb-2003	Changes after meeting on 06-Feb-2003	
1.1	10-March-2003	Changes after meeting on 26-Feb-2003	
1.2	11-April-2003		
2.1	07-June-2004	Changes to address 2005 needs	
3.1	24-Nov-2004	New version to address reformulated docking project	
3.2	8 June 2005	Objectives rewritten to reflect needs and opportunities.	
3.2.1	22 June 2005	Revised to reflect conversations from concept brainstorming.	
4.1	2 Aug 2005	Reduced max depth from 4.5k to 4k	
4.2	30 Aug 2005	Changed formatting, removed trawl resistance, added *would be nice* phrase	

FUNCTIONAL REQUIREMENTS: AUV DOCKING SYSTEM 2005

1. Scope of Project

The AUV Docking system is intended to provide AUV survey functionality able to:

1) respond to episodic events in a timely and flexible manner[1] (O1)
2) obtain repeat surveys without requiring onsite human presence[2] (O2)
3) operate even in adverse environments (e.g. high sea state or under ice covered oceans) (O3)

In addition, the AUV Docking system should enable other capabilities such as retrieving data from benthic instrumentation. (O4)

To enhance the capability of exploration of the vast oceanic environment, there is a need for prompt deployments and prolonged operations of AUV that avoids frequent deployment and recovery. Therefore, we are looking for an AUV docking system that allows an AUV to home and transfer data and power, as required for long-term underwater operations. The AUV docking system will be a part of the MOOS/MARS systems and, in the future, the technology and experiences will be made available to the NEPTUNE community.

2. Requirements

2.1. User/High Level Requirements

2.1.1. The system shall provide a method allowing an AUV to conduct multiple missions over extended period without human presence. (O1, O2, O3)

2.1.2. The system shall provide a method to communicate with the vehicle to trigger missions, recover data, and download new mission scripts and commands.

2.1.3. The system shall provide a method of recharging AUV batteries so that AUV operational capability is not limited by onboard battery capacity.

2.2. Design Derived Requirements

2.2.1. The system shall be capable of being operated as an element of the MARS observatory

2.2.2. *It would be nice if* the system could also be operated as an element of MOOS

2.2.3. The AUV shall be capable of autonomously[3] finding the dock so that docking can be conducted.

2.2.4. The AUV shall be capable of docking autonomously.

---

[1] Examples of event response include survey of the mega plume created by an underwater eruption on a mid-ocean ridge. Such eruptions might be detected acoustically, perhaps with SOSUS or and equivalent, or even seismically. Detection of an event would trigger an AUV survey. The AUV thus would allow an observatory like NEPTUNE to deploy sensors directly to a region of interest, thus using a comparatively small number of underwater nodes to obtain coverage otherwise unobtainable.

[2] Time series measurements in the ocean are typically 'point measurements.' An AUV docking system would allow one to leverage observatory infrastructure to obtain a time series of surveys. These might provide the spatial context for more intensive local measurements, or might

[3] Autonomously shall mean without human intervention, other than the configuration of AUV mission scripts.

2.2.5. *It would be nice if* AUV Docking system could enable the retrieval of data from and possibly even recharge the batteries of benthic instrumentation. (O4)
2.2.6. There shall be a method of attaching the AUV to the docking station (hereafter called docking).
    2.2.6.1. The docking attachment method shall provide a communication and power connection between the AUV and docking station.
    2.2.6.2. There shall be a method for minimizing or eliminating AUV power consumption (putting the AUV to sleep) when the AUV is attached to the docking station.
2.2.7. There shall be a way to wake the vehicle from a sleep state.
2.2.8. The system shall extend OBSERVATORY communications to the AUV when the AUV is docked so as to allow the downloading of new mission scripts, the initiation of new AUV missions, the recovery of AUV data, and to support direct interaction with the AUV main computer and subsystems.
2.2.9. The system shall provide a means of recharging AUV batteries from the OBSERVATORY power system.
2.2.10. There shall be a method by which the AUV can detach from the dock (undock) and conduct autonomous operations (i.e. run a new mission).
2.2.11. There shall be a method for of releasing a dead AUV for recovery to the surface, or providing a way for an ROV to recover a dead AUV, or both.
2.2.12. Reliable operations is of paramount importance
    2.2.12.1. The docking attachment shall be sufficiently robust that damage or disengagement is not a risk when the vehicle is in a sleep state.
    2.2.12.2. The attachment method should support hundreds of dock/undock cycles
    2.2.12.3. Failure modes should be minimized.
    2.2.12.4. The number of actuators shall be minimized
    2.2.12.5. *It would be nice if* docking system failures could be detectable by the vehicle/dock system and be recoverable.
2.2.13. *It would be nice if t*he docking solution should be scalable to support multi-AUV operations with minimal added costs or maintenance requirements.
2.2.14. The dock should impose minimum constraints on vehicle features such as volume for science payload, drag, and external appendages (e.g. antenna).
2.2.15. *It would be nice if* the docking system could be used for Arctic deployments.
2.2.16. The Docking AUV shall:
    2.2.16.1. Be based on the Dorado vehicle design.
    2.2.16.2. Have rechargeable batteries that provide 12 mission capability
    2.2.16.3. Have navigation sensors
        2.2.16.3.1. Onboard AHRS
        2.2.16.3.2. Onboard ADCP/DVL
        2.2.16.3.3. Onboard LBL
        2.2.16.3.4. Onboard GPS
    2.2.16.4. Have relocation devices
        2.2.16.4.1. USBL transponder
        2.2.16.4.2. RF beacon
        2.2.16.4.3. strobe
        2.2.16.4.4. RF data modem

2.3. Environmental Requirements

2.3.1.	Operating depth	250 m to 4000 m
2.3.2.	Operating temperature (ambient surface temp.)	-4 to 60 degrees C
2.3.3.	Operating temperature (in water)	0 to 30 degrees C
2.3.4.	Operating current	0 to 1.0 knot

2.3.5. The dock shall be resistant to bio-fouling and debris fouling and high sedimentation rates.

2.4. Operational/ Maintenance Requirements

2.4.1. Minimize System maintenance

2.4.1.1.Target AUV maintenance interval is > 3months

2.4.1.2.Target Docking station maintenance interval > 2 years

2.5. Design Constraints

2.5.2 The docking station shall be capable of being deployed from R/V Pt. Sur and R/V Western Flyer.

2.5.3 *It would be nice if* the docking system could be deployed from Zephyr, or smaller vessel, preferably R/V Zephyr.

2.5.4 *It would be nice if* the docking station could freefall through the water column, safely land on the seafloor, and be relocated on the seafloor by an ROV.

2.6 Other Constraints

2.7 Interfaces

2.7.2 Data Transfer:

2.7.2.1 AUV – Dock Compatible with existing deck cable (TCP-IP 10/100 Base-T)

2.7.2.2 Dock - OBSERVATORY Compatible with MARS (TCP-IP 10/100 Base-T)

2.7.3 Power Transfer

2.7.3.1 AUV – Dock Compatible with existing battery charger (36 VDC nominal charger input)

2.7.3.2 Dock – OBSERVATORY Compatible with MARS (400 VDC or 48 VDC, 4 kW max)

2.7.4 Cable Connector Compatible with MARS (ODI 12-pin MARS connector-plug)