SUMMARY DESCRIPTION OF THE EURODOCKER

INTRODUCTION

The EURODOCKER concept provides a universal autonomous Docking - Downloading - Recharging System for Autonomous Underwater Vehicles (AUVs).

This system overcomes the current restrictions of AUV's, namely operative range due to limited energy storage capacity, and the repeated launch and recovery operations necessary to get the vehicle onboard the support ship. A submerged docking station for AUVs, either as part of an unmanned underwater platform on the seabed or lowered from a support ship from the surface, is a suitable means to solve these two problems.

OPERATIVE SCENARIOS

The following operative scenarios have been identified in which the EURODOCKER is envisaged to be used.

Operative Scenario 1 - Ship support at any water depth

The first Operative Scenario is based on the manner in which AUV's are currently operated, and therefore foresees the use of the EURODOCKER as a support to AUV's that are deployed and recovered from dedicated or chartered ships. It shall have the advantage of not requiring a launch and recovery operation for each mission, and thus the AUV may perform repeat missions without the requirement to be recovered on board the ship.

Operative Scenario 2 - Open water missions from Coastal waters

In the second scenario identified the EURODOCKER shall be placed on the ocean floor and not be deployed from a ship. The AUV shall treat the EURODOCKER as a subsea home base from whence it shall emerge to perform its mission, and to which it shall redock at the end of the mission for data downloading and recharging. This scenario shall permit the AUV's to perform repeat missions over a significant period of time without the necessity to recuperate to the surface or to have a costly vessel in support.

Operative Scenario 3 - Ice infested waters

The development of AUV's and their docking systems are considered essential 'technological packages' for the exploration and exploitation of Arctic and Antarctic waters. Within this scenario therefore the EURODOCKER would be placed on the seabed much as in scenario 2, however in this case in an area with periodic or permanent ice pack above it. The main advantages shall clearly be obtained from the cost saving tied to the use of expensive icebreaker vessels, and the vastly lengthened time that the AUV's can operate.

EURODOCKER SYSTEM DESCRIPTION AND OPERATIVE SEQUENCE

The system description is given following the operative sequence requirements as illustrated below:

Homing System

The **long distance tracking of the AUV's**, as assistance to or in back up to the on board navigation and positioning system, is performed utilising four **GPS-LBL (Global Positioning System - Long Base Line)** buoys for first circle re-entry. For scenarios in which the homing shall be performed under the ice, the buoys shall not be available and therefore a LBL (Long Base Line) system with a set of repeater stations shall be placed on the sea floor in the area of the EURODOCKER system.

Once the **AUV is within 50 metres** from the EURODOCKER an acoustics system for close range tracking is utilised to assist in guiding the AUV into the EURODOCKER. The acoustics solution consists of an **USBL (Ultra Short Base Line)** system, which is suitable for the close range approach. This narrows the position accuracy typically to ± 20 cm, at a rate of 2-4 fixes per second. The USBL may be that of the AUV if it is already part of its equipment or may be on board the EURODOCKER. In this latter case the AUV shall carry only the transponder part of the system.

The navigation of the AUV into the EURODOCKER is based on a passive role for the EURODOCKER system. This means that the AUV shall maintain navigation control but shall receive information on its position relative to the docking component from the EURODOCKER system.

AUV Mating and Release system

The mating and release system is characterised by the following operative functions:
- fine guidance during docking;
- the manner in which the AUV is protected during docking and launch and recovery;
- the system for connecting the electrical connector to the AUV;
- and the manner in which the AUV is released for its next mission.

These aspects have led to the selection for a garage system as described below.

Garaging system

The four sector modular garage selected consists of a frame made of steel beams, segmented transversely and longitudinally, hosting suitable bumpers, positioned to cope with the AUV cross section. Connecting the bumpers to the structure with resilient elements provides shock absorption, while giving the bumpers a low angle conical configuration that performs braking of the AUV within the garage. The use of special alignment and support elements is also foreseen. These bumper sections are lined with a low friction material placed on the surfaces that shall come into contact with the AUV, to ease the docking manoeuvre and minimise surface scratching.

The release and expulsion of the vehicle from the garage is performed by permitting the garage structure to open up or down (respectively when sea bottom or ship supported) so that the AUV can swim away under its own power.

The Launch and Recovery system

The Launch and recovery system is characterised by the use of guide wires and a dead weight, in order to reduce the horizontal motions of the EURODOCKER while crossing the splash zone. In this way the L & R system is compatible with sea state 4 without active systems.

The launch and recovery system satisfies the following operative requirements:

- Deployment of the garage to sea level on the lift wire, following which the garage is stopped via a variable buoyancy system and the lift wire made slack.
- The garage then continues its decent autonomously (in a negative configuration controlled by the variable buoyancy) down to the established depth.
- The lift wire shall be shackled to one of the guidelines every 10 meters to ensure it does not tangle.
- In order to return to the surface lift tanks are inflated from dedicated air bottles located on the garage.
- Once the garage is at its operative depth it can rest on suitable landing bumpers placed on the dead weight.
- When the AUV commences its homing procedure the garage can be brought up to a suitable distance above the dead weight, say 10 m, utilising the variable buoyancy system.

DESCRIPTION OF THE GARAGE

A more complete description of the EURODOCKER garage system is given below.

The **Support Structure** is characterised by the following:
- It is an open lattice structure.
- It is constructed in tubular members that are sealed to limit weight in water.
- Material for the structure is robust to ensure damage does not occur.
- A suitable corrosion protection system must be foreseen.

The **Bumper system** is characterised by the following:
- It is shaped so as to provide a conical entry point into the garage.
- It is lined with low friction material at the contact points.
- It is connected to the structure with elastomeric elements.
- It performs braking of the AUV within the garage.

The **Permanent buoyancy system**:

The actual weight/net buoyancy of the garage in water is the minimum necessary to guarantee that the garage shall descend down the guidelines under the force of gravity at a moderate velocity of $\leq$ 0,2 m/s.

The EURODOCKER garage is composed of steel beam members that are sealed and therefore have a limited weight in water. The desired weight is achieved by use of suitably distributed permanent buoyancy elements and lead weights if necessary.

The **variable buoyancy system** (required only for the ship-supported version) shall:
- ensure that the garage shall float during the first phase of the launch operations down to the level of the water.
- permit the garage to descend under its own weight to the dead weight.
- raise the garage to a height of about 10 m above the dead weight.
- maintain a neutral position during the docking phase.
- return the garage to the surface for the recovery operations.

Release System

The release and expulsion of the vehicle from the garage is performed by permitting the garage structure to hinge open so that the AUV can swim away under its own power.

Orientation for ship supported scenario

In the case of the deployment of the garage from a surface vessel the garage may be provided with suitable fins to ensure that its orientation is constantly maintained along the axis of the current. The closed end of the EURODOCKER faces the current so that the AUV may swim straight into the current to enter the garage at low relative speed.

The **Mechanical block**, that:
- ensures that the AUV cannot accidentally be dislodged from the garage once it is docked.
- provides the positive reference position that shall permit the Power and Signal connector to be actuated.
- is an automatic system that is activated when the AUV enters the garage.
- permits the AUV to be released easily by the release system utilised.

The solution selected is a pin and groove system, due to its simplicity and ease of construction. The pin is provided by a dedicated fin that is placed on the AUV.

The **Power & Signal Connector**

The signal and power connector is suitable for relocation along dedicated rails within the EURODOCKER structure.

The connector is of the electrical conductive kind.

The connector mating system is able to bring the plug of the connector into contact with the receptacle placed on the AUV within the tolerances that the connector system itself can cope with.

The **Umbilical system**

The umbilical has been specified as a typical, integrated, dynamic umbilical. It shall contain all the power and signal lines that are required between the garage and the surface. These is contained within two polyurethane sheaths, interspersed by a two contra-helically wound armour wires.

DESCRIPTION OF THE BOTTOM SUPPORTED SYSTEM

For the bottom supported system the solution that has been identified is for the use of the same garage described for the ship supported version, turned upside down and anchored to the sea bed via an anchor line. The anchor line is attached to a structure placed on the seabed.

The garage is maintained oriented into the current to aid in the alignment of the AUV during docking. A passive orientation system has been selected therefore no thrusters are foreseen on the garage. In order to prevent the umbilical twisting, a swivel system has been foreseen that shall permit the garage complete freedom of movement due to the current.

The principal systems are described below.
- The release system has to be oriented upwards, and therefore the garage is turned over for use on the seabed.
- Suitable permanent buoyancy must be added to the garage.
- The connection point of the umbilical is positioned near the closed end of the garage.

Anchoring system

The anchoring system guarantees that the EURODOCKER is kept in its correct position throughout the operations. A simple gravity based system has been selected.

The anchoring system is the termination of the umbilical from shore and is connected to it via a bell mouth bend restrictor that ensures the umbilical is not damaged during installation.

The anchoring system has a central post up which the termination of the umbilical to shore is situated and into which a ROV operated pin attached to the garage tether system is inserted. The ROV operated pin is attached to the umbilical/anchor line system that shall ensure that the garage is kept at a suitable distance from the seabed as specified below:

- Minimum distance from seabed: 5 metres
- Maximum current at 5 m from seabed: 1 m/s
- From preliminary calculations a length of 10 meters of umbilical/anchor line is suitable.
- These calculations have indicated a required weight in water for the anchor structure of 10 kN.

Swivel system

The swivel system is located as part of the ROV operated pin and shall permit rotational freedom of movement between the tether system and the anchoring system. It shall also be provided with slip rings to ensure the passage of all the necessary electric lines. A hinged fork has been foreseen as the interface between the anchor line and the ROV pin. This hinged fork should be limited in the angle it can tilt in the range of 30° to 120° to the horizontal plane.

Umbilical/anchor line

The umbilical basic design data is the same as that for the surface deployed system, with in addition consideration given to: integration of the anchor line into the umbilical; fatigue life of the umbilical in long term dynamic conditions; signal attenuation over long distances

Orientation system

In order to ensure that the garage's orientation is constantly maintained along the axis of the current the following is designed: the garage is tethered as near as possible to the closed end; correct distribution of the buoyancy elements; use of correctly placed fins; and use of a swivel mounted on the umbilical, which also acts as the tether.