Fact Sheet No: 10/9

AQUA*shuttle* Mk III

Undulating Towed Oceanographic Vehicle

The AQUA*shuttle* Mk III is a stable, highly robust, versatile undulating towed vehicle for deploying a wide range of oceanographic monitoring equipment.

Designed and developed by Chelsea Technologies Group and the Plymouth Marine Laboratory, UK, it has a proven record of reliability over many thousands of miles of operation.

INTRODUCTION

General

AQUA*shuttle* is a stable, undulating vehicle which can be towed beneath the sea at controllable depths. With 20 litres of instrumentation space, it is capable of carrying a suite of instrumentation for the measurement of parameters such as depth, temperature, salinity, chlorophyll fluorescence, bioluminescence, nutrient, redox, and dissolved oxygen. The basic vehicle is shown in Figure 1.

Developed by Chelsea Technologies Group, together with Plymouth Marine Laboratory, AQUA*shuttle* was originally developed for low cost deployment on 'ships of opportunity'. The introduction of real-time control has given it much more scope, in the field of ocean research.

AQUA*shuttle* can be towed from research vessels and merchant ships at speeds up to 25 knots, to operational depths of 0 to 135m. It can be launched and recovered while the vessel is under way, by non-scientist crew-members with minimal training (see specification for restrictions).

AQUA*shuttle* is self contained, with an independent power source and an integral servo control system driving the elevator. The required undulation path is adjustable and the depth and pitch parameters are stored in solid state onboard memory. These parameters are set over the RS422 communications interface and can be set either prior to deployment or during deployment in real-time.

AQUA*shuttle* has been designed as a flexible package and can be purchased alone as a basic towing unit or with an extensive range of compatible underwater monitoring instruments, which include sensors for measuring Conductivity, Temperature and Depth (CTD), Sound velocity in water, Turbidity and Transmission. Mountings for these instruments are custom built into the vehicle.

Principle of Operation

AQUA*shuttle* utilises a microprocessor based digital servo system in which the vehicle elevator angle is controlled by the difference between the observed pressure and a synthesised command signal generated within the servo control unit. This difference signal determines the speed and direction of a highly geared stepper motor within the servo control unit, the output shaft of which is linked to the elevator crank arm. The elevator crank arm is in turn coupled to the elevator rotating it through varying pitch angles enabling AQUA*shuttle* to climb or dive through the water column. AQUA*shuttle* can operate in real time manual mode with in-flight operator adjustment of the servo flight parameters or self contained autonomous mode when a simple non-conducting tow cable is used. A system block schematic is shown in Figure 2.

Depending upon the system configuration the undulation profile can be pre-programmed into the servo controller for autonomous flight, or if real-time communications is available over a multi-conductor tow cable then the profile parameters can be changed in-flight. The user defined operational variables are:

- Minimum depth of undulation
- Maximum depth of undulation
- Climb / dive rate (dbar/minute)
- Programme for undulating or level flight mode
- Flight commands modified without coming out of servo control mode, ensuring control of AQUA*shuttle* at all times
- Manual emergency over-ride, causing AQUA*shuttle* to surface to a safe depth at keyboard command (when operated in real-time over a multi-conductor tow cable).

SPECIFICATION

AQUA^shuttle Body

Length	1.06 metres
Height	0.50 metres
Width (including wings)	0.72 metres
Weight (including Servo Control, excluding sensors)	In Air: 66Kg In Water: 45Kg

Recommended Tow Cable (real time control)

Type	Standard Typical	Option Rochester 7-H-314A (High strength armour)
Diameter	8.2mm	8.2mm
Conductors	7	7
Breaking strain	42.7 kN	51.6 kN
Working load	17.1 kN	20.6 kN
Bend diameter	43 cm	43 cm
Weight:Air	268 kg/km	268 kg/km
Water	210 kg/km	210 kg/km

Recommended Fairing

Type	Indal Technologies Flexnose FA-478-350-1
Section length	10.2 cm
Sheave diameter	91 cm (minimum)

Performance

Undulation Range	0 to 70 metres (unfaired cable) 0 to 135 metres with faired cable
Towing speed range	8 to 25* knots
Maximum rate of change of depth	1 m/s
Level towing accuracy	+/- 1 metre nominal

* Maximum Tow speed depends upon payload, ship capability and use of cable fairing.

The undulation aperture depends upon payload, ships speed and tow cable characteristics.

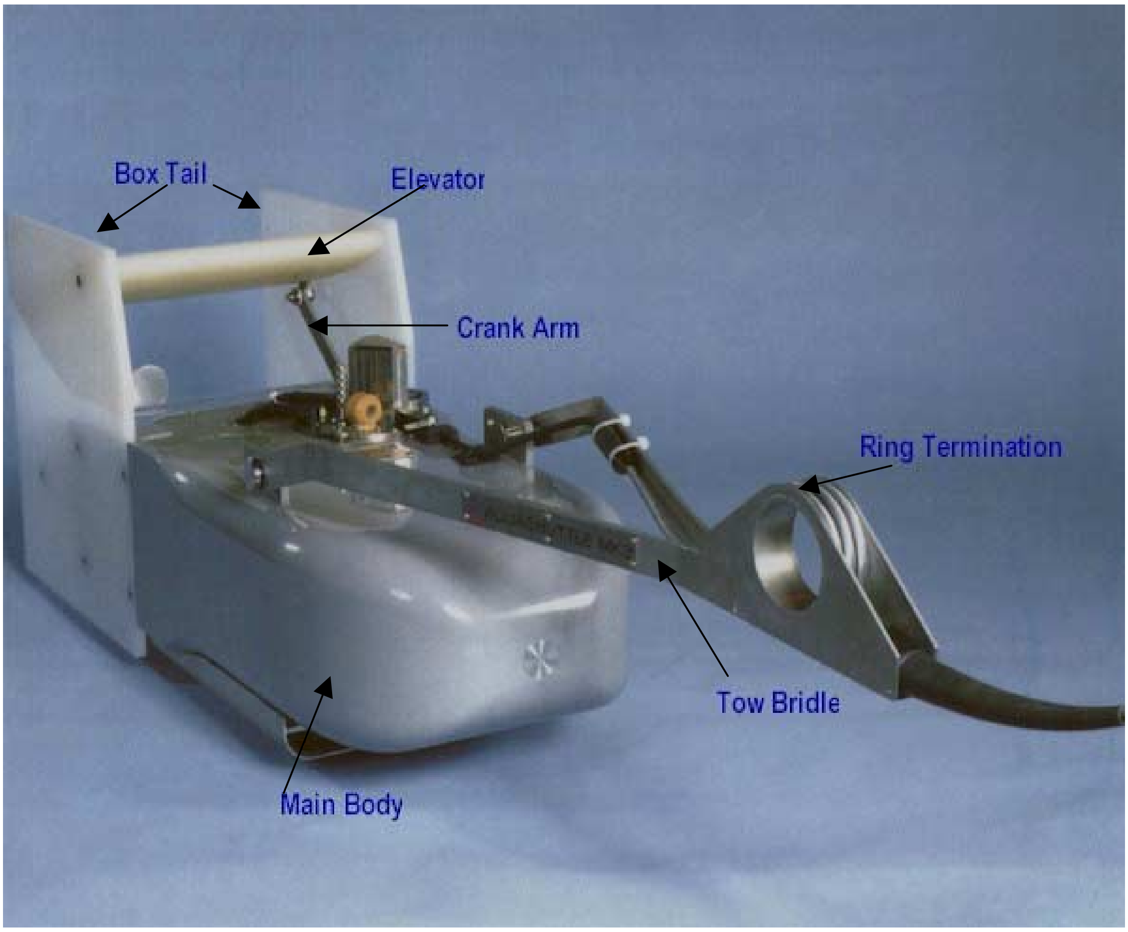

Figure 1 - AQUA*shuttle* Basic Vehicle

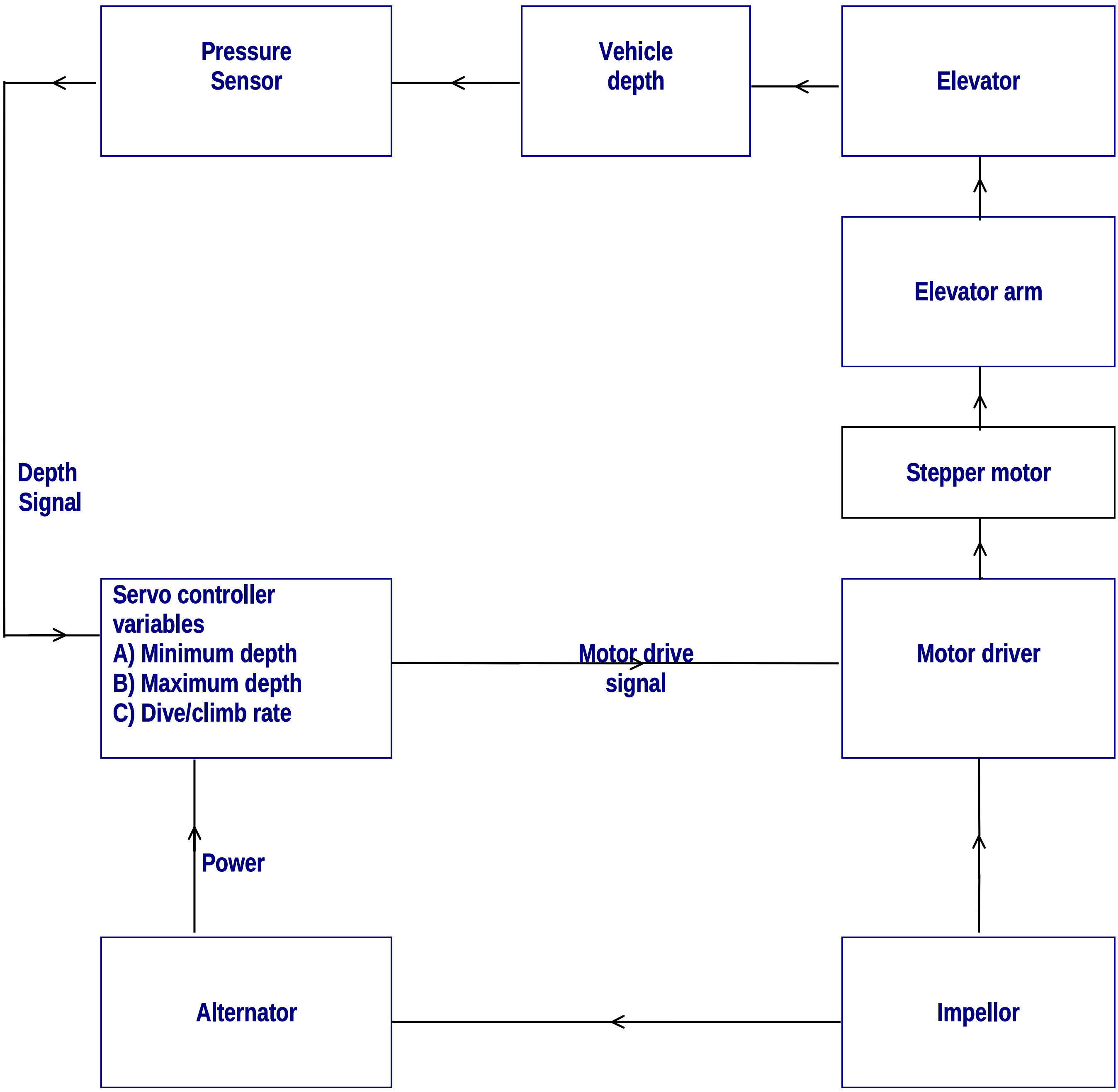

Figure 2 - System Block Schematic

VEHICLE DESCRIPTION

The AQUA*shuttle* vehicle consists of the following main sections:

Main Body

The body is rectangular in section, combining strength with optimum volume for instrument carrying. It is constructed from glass-reinforced plastic (GRP) built around a stainless steel sub-frame. The sub frame consists of two bulkheads connected together by a top plate and lower instrument mounting rails. The combination of stainless steel and GRP minimizes corrosion and enhances the durability.

The sub-frame projects through the central body to form mounting brackets; these are used for attaching the tow bridle and the side wings. The wings increase the diving force and it is possible to adjust the wing position forward and aft. The towing bridle is constructed from stainless steel and applies the tow cable force to the sub frame.

At the front end of the bridle is a small friction ring termination, this treats the cable very gently and minimises local bending stresses. The tow cable is spliced to an input connector tail, this splice depends upon the instrument configuration.

A side hatch and top cover are fitted to provide access to the inside of the vehicle. The side hatch, constructed from glass-reinforced plastic (GRP), is positioned towards the front of the vehicle and the stainless steel top hatch is fitted in the centre section.

Servo Unit

The servo unit is housed in a titanium cylinder, which mounts across the inside of the rear of the main body, the output from the servo unit is via a short crank and wing drive arm. Inside the servo housing is a pressure transducer, which gives a measure of depth feedback and a potentiometer to monitor the wing angle. The servo control board compares these two feedbacks with the stored undulation pattern to determine the drive required at the crank drive stepper motor. Also housed within the servo unit is an RS 422 communications board which allows the stored undulation path to be updated in real-time and a power supply PCB which smoothes and rectifies the input from the alternator.

Alternator

The input power to the servo is derived from an alternator, which is mounted at the rear of the main body. It is driven by an impellor, which is powered by the forward motion of the vehicle through the water.

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