Blue Duck II: A low-cost AUV design based on a moving mass for shallow-water operations

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I. Introduction

Our main goal is the development of a shallow water AUV (up to 10m depth) with the goal of being semi-modular, easy to build, with as many parts as possible 3D printable, easy to modify based on needs, and low cost. We tried to focus on using standard structural materials, and try to keep the design as simple as possible, while respecting the requirements set above. It can be used for marine research at low depths, but also for teaching and educational activities in marine robotics.

II. Concept

As the design focuses on low-cost and easy-to-get materials, the main structural components are a 1m acrylic tube (with inside radius of 150 cm and outside radius of 160 cm), Bosch-profiles (as you can use them as general structure that can be easily modified) and 3D printed parts. We base our design on the TomKyle Rucksuck AUV [**?**]. One of the main differences is the internal configuration of the vehicle with respect to motion. Instead of having several thrusters, we want to implement a movable weight-center system inside the hull. Controlling the change of the centre of mass of the vehicle, it is possible to control the pitch. Additionally, many components are 3D-printable, and with the proposed design, the AUV can be opened without disassembling the whole robot, making it more user-friendly. Using this exterior system, we can easily add new sensors, lights or grippers, and change motor configuration based on need.

III. Design solution

The 3D-printable end-caps are shown in Fig. 1. The front one is designed with an acrylic disk to allow the camera to be positioned inside the hull, and accommodate three Bosh-profile holders. Those profiles are held by an outside ring at the back end, which allows us to take the back end-cap out without dismantling the robot structure. The back end-cap has two holes: one for the enclosure vent and plug, to let air in when we want to open our robot, and one for the connector to the outside, used for battery charging and fast data transfer.

The research leading to these results has received funding from the project IMPACT - Intelligent Marine systems a Pathway towards sustAinable eduCation, knowledge and empowermenT, EU Erasmus+ program, Key Action 2, 2018-1-DE01-KA203-004259.

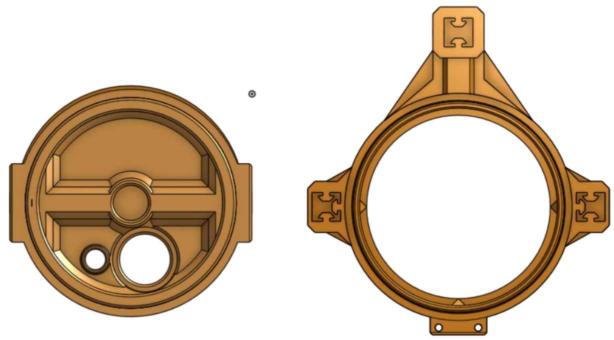


Fig. 1. The back and front end-caps.

On the back part we have placed a simple system to easily remove the end-cap, show in in Fig. 2. a simple system using clips to keep in place the holder. Also, our enclosure vent and plug has an easy-to-use design, while using a triple O-ring waterproofing system (like the rest of our robot).

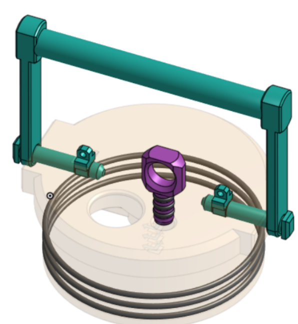
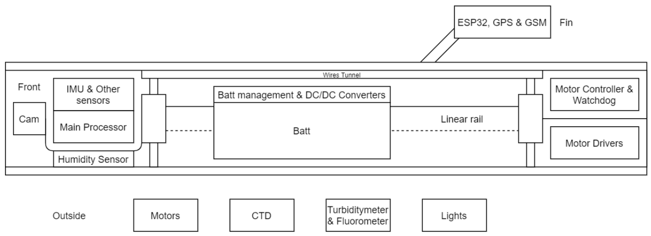
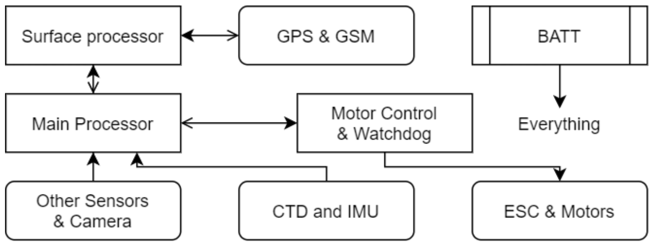


Fig. 2. The system to remove the back end-cap.

IV. System breakdown

- Surface Mode: At the surface, we can use GPS and GSM to let the AUV locate itself and communicate with us on long distances, and Wifi for short-distance communication and data transfer. In this mode, we can use some energy-saving measures, such as getting our main processor into low-power mode and stop the motors
- Normal Mode: The AUV runs the mission.





- Emergency Mode: If the main processor doesn't answer the watchdog, there is too much humidity in the main hall, or the battery is too low, the AUV simply goes up until it reaches the surface where it sends couple of fast SOS messages with the position and enters low-power mode. After that, it sends periodic SOS messages.

V. Cost

Our goal is to have a functional AUV under 1000 EUR. This is achievable using in-house component design and 3D-printed parts. More details are in the following section, together with the description of the design solution.

Required sensors [?]		
Function	Component	Price (euro)
Conductivity	2 wire contacts	2
Temperature	DS18B20	3.5
Pressure	Oil Sensor	20
Turbidity	Keyestudio sensor	20
Fluorometer	TBD	
IMU	BNO055	30
Hall humidity	GY-BME280	15

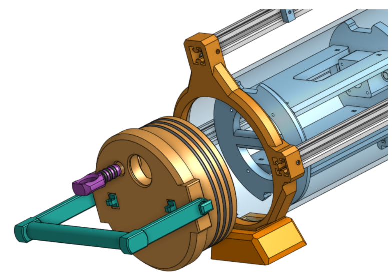
Main electronics parts		
Function	Component	Price
Main processor	TBD	TBD
Motor control and watchdog	Arduino Due	20
Motor driver	ESC	8/piece
Thruster	A2212	Our design - 40/piece
Battery	18650 Li-Ion	Min 46 - 4.5/piece

Surface mode electronics		
Function	Component	Price (euro)
GPS	NEO-6M	8.5
GSM	SIM900	7.5
Processor	ESP32 Dual-Core	10

Main Structure		
Parts	Notes	Price(euro)
Acrylic Tube	D:150mm/160mm H:1m	60
Acyilic Disk	D: 150mm, H: 5mm	7.5
2020 profiles	1m / 3 Bars	15
Printed parts		TBD
Buoyant Foam	Configuration dependent	
Connector	Waterproof	15

VI. Design Challenges

Our main design challenge was to make our assembly waterproof, yet easy to construct/assemble. As we are using mainly 3D printed parts, we have to think about material expansion and water getting into our infill. As just making the components dense is not necessarily a complete idea, we had to give extra-care to the way the components interact in the mechanical system.



VII. Schedule

June
Finish mechanical design
PLA print
Make the inside sliding system (control weight center)
Give the possibility to make it into a missile form
Finish and test thruster and connector designs
Design battery charger
DC/DC converter systems
Setup ROS system

July
Test Robot with ABS/Nylon prints
Implement modifications

Current developments: 3D printed thruster and front end-cap