RUTGERS School of Engineering

MAE Senior Design

Mobula: Autonomous Underwater Vehicle Capable of High Velocity Breaches

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Project Overview

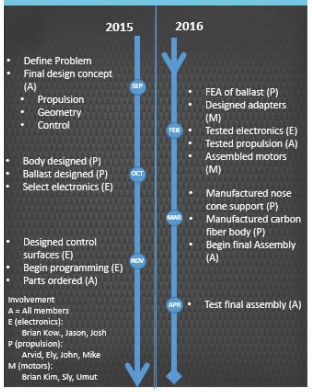
What:

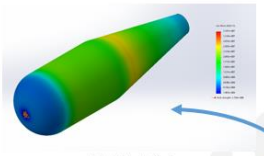
Mobula is a bio-inspired Autonomous Underwater Vehicle that is capable of breaching the surface of water. A novel propulsion system, based on discharge of a compressed gas, provides the capability to rapidly leave the water surface.

Why:

This vehicle adds a new and unique capability to underwater vehicles and can be used for reconnaissance and data gathering, water-to-air communication, environmental missions, and for launching small aerial unmanned vehicles.

Project Timeline

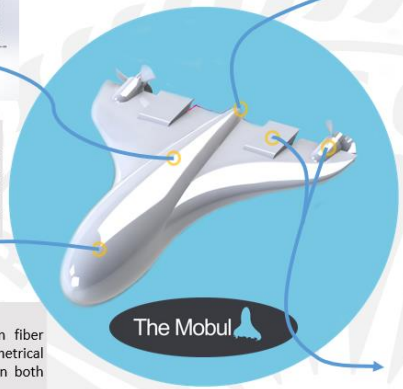




FEA of the ballast

The Ballast

Designed to hold 500psi with a safety factor of 9. The ballast was manufactured as two halves joined by a weld. The ballast serves as both a stabilizer and nozzle.



Shape of this Hybrid

This vehicle employs a full carbon fiber teardrop shaped body with symmetrical airfoils for hydro and aerodynamics in both mediums (water and air).

Side view of Mobula

Mold for CF body

Detachable nose cone for access

Carbon fiber body

Modified ballast

Motor with custom adapter

During assembly (oblique view)

During assembly (top view)

Getting Out of the Water

The main propulsion unit consists of a pressure tank connected to a ballast. The tank releases compressed air into the ballast full of water. The ballast expels water with a high mass flow rate, enough to launch the vehicle with considerable force. This mechanism is not unlike a water bottle rocket.

Thrust is defined as the change in momentum $\dot{p} = \dot{m}V_e$

Where exit velocity $V_e = \sqrt{\frac{2(P - P_{atm})}{\rho}}$

Mass flow rate $\dot{m} = \dot{\forall}\rho$

Volumetric flow rate $\dot{\forall} = V_e A$

Automatic Control

The Arduino Mega microcontroller implements multiple PID controllers to independently control the propellers and flaps (to adjust yaw and pitch). A 9-DOF inertial measurement unit and pressure transducer give information about the vehicle's orientation and depth/altitude. It is also responsible for controlling the solenoid – the gate between the pressure tank and ballast.