# THE EFFECT OF SHAPE CHANGE ON THE ADDED MASS GENERATED BY AN AXISYMMETRIC BODY

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## OBJECTIVES

◊ To analyze how shape change affects the added mass generated by an axisymmetric, deformable body

◊ To validate the physical results using the bounded solution of the theoretical world

## ABSTRACT

Added mass is a hydrodynamic effect produced when an accelerating body displaces the surrounding fluid particles as it moves through the water. A similar effect is produced in steady incident flow or impulsively when the body changes its shape. Cephalopods mimic this unsteady added mass effect by expelling water through a cavity and thus changing shape while in motion. This deformation allows cephalopods to recover substantial energy otherwise lost to the flow and quickly escape predators. To mimic the motion of a cephalopod, a deformable body that changes shape from a cylinder to a sphere was constructed. Testing of the dynamic model involves measuring the total hydrodynamic force on the body in various testing conditions. This research aims to provide insight into the performance capabilities of cephalopods and the possible marine applications of shape change.

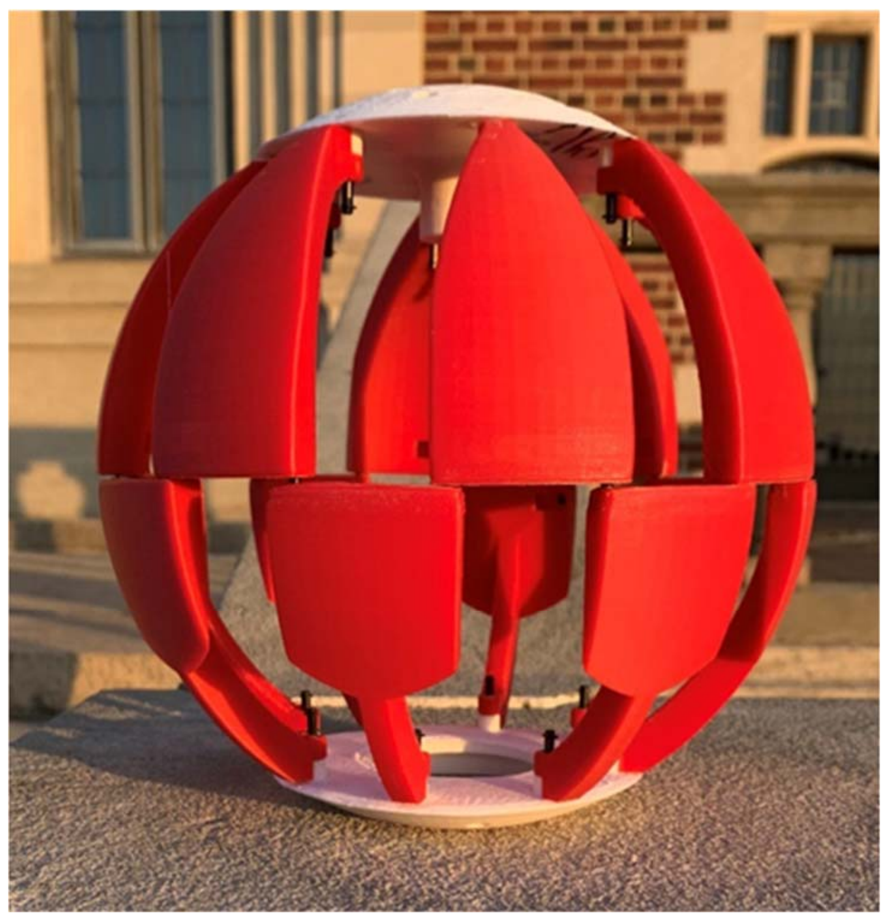
## BACKGROUND

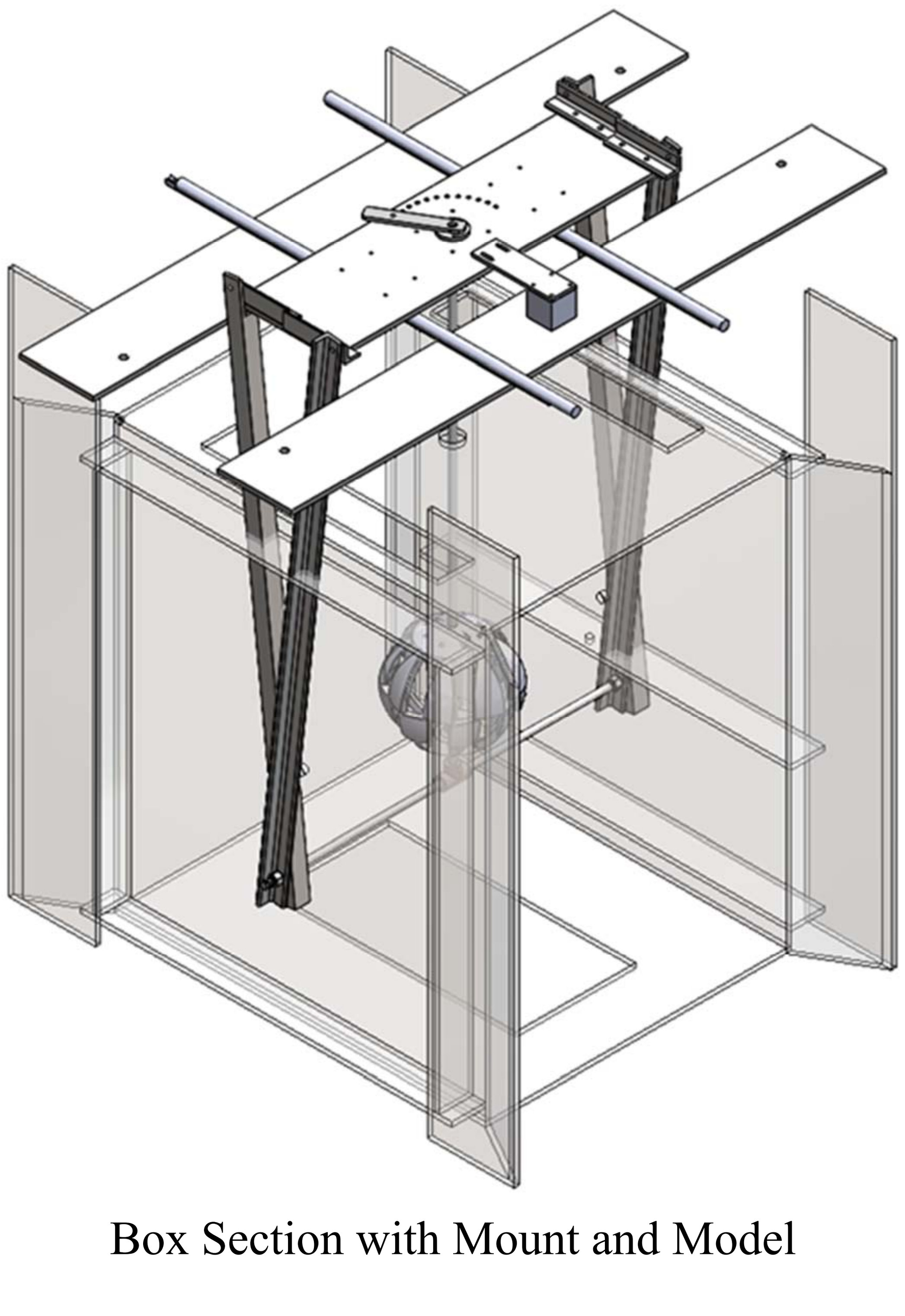
Cephalopods are marine animals that fall under the phylum *Mollusca* and class *Cephalopoda*. These animals generally have symmetrical bodies with prominent heads and a set of arms or tentacles. Over their 500 million years of existence, cephalopods have continually developed and adapted for survival. Over time, some cephalopods, such as squid and octopi, have traded their hard, protective shells for flexible and muscular mantles that expand and contract to provide jet propulsion. As the mantle changes shape during propulsion, the exterior shape of the creature changes and creates an added mass effect that has inspired many recent scientific studies, including this thesis.

**DESIGN:** Our model was adapted from a design originally created at the University of Rhode Island (URI) under Professor Jason Dahl. The body expands from a cylinder to a sphere through 120° of rotation and then returns to a sphere after another 120° of rotation. The mount, which locates the model in the flow channel, was fully designed within this thesis.

**BUILD:** The model was constructed from 3D-printed parts, using ABS filament and Webb's Prusa i3 MK3S printer. The three components of the model - the nose, fins, and base - were assembled using oil-free bushings and pivot pins. The components of the mount were machined in Webb's machine shop by Mr. James Swan and later assembled in Haeberle Lab.

**TEST:** The model is being tested in Webb's CWC to achieve the objectives of this thesis. An acrylic box section, adapted from Heitman's 2019 thesis, smooths the incoming flow and houses the mount and model. Initially, the model will be tested at various fixed radii in steady flow to obtain control points. Subsequently, the model will be tested in accelerated flow at the same positions to determine the additional drag, or added mass.





Box Section with Mount and Model

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