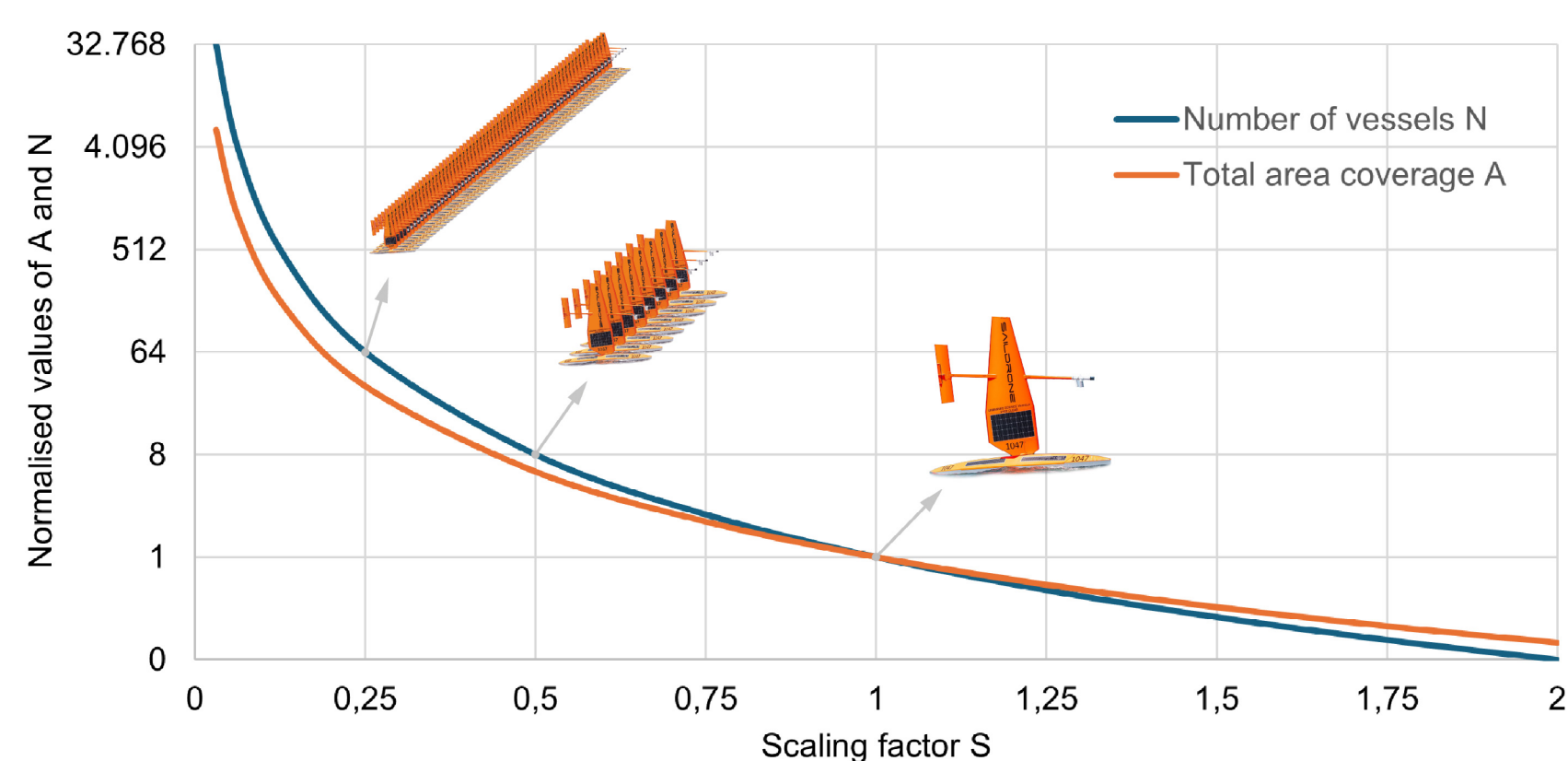


# Sustainable autonomous swarm sailing

Autonomous sailboats (ASBs) have been researched since the early 2000s. Despite their theoretical advantages in autonomous data gathering, especially in the form of swarms, successful real-world deployment remains rare. Many ASBs still fail during deployments in the harsh marine environment, often as a result of structural failures due to their small size and prototype-nature. This thesis explores how to design ASBs with minimal environmental impact, without compromising basic functionality, when embracing the inevitable failure of small ASBs.

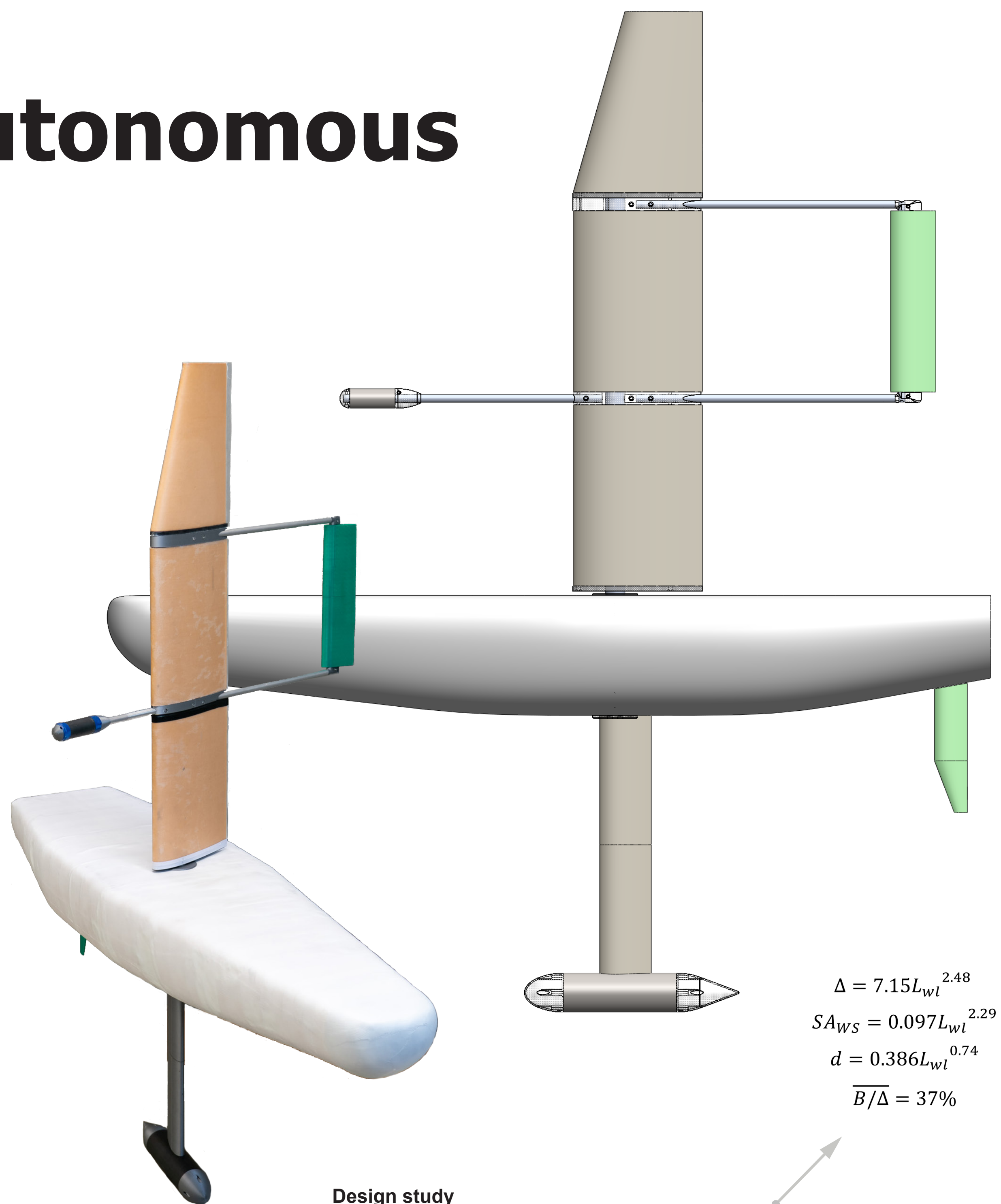


## Smaller is advantageous

Small ASBs travel more slowly, but collectively in a swarm, achieve higher data collection for the same total material cost as a single large vessel. For a similar material cost, a swarm of smaller ASBs could thus outperform larger vessels in data gathering, so one would need to expend less material!

## Material use & LCA issues

For durable, scalable production, glass fibre composites and steel were identified as relatively low-impact options when balanced against performance needs. A more radical approach explored biodegradable structural materials, particularly flax fibre-reinforced bioplastics. Two resin options, polyglycerol citrate and polyvinyl alcohol, were identified for their environmental degradability and non-toxicity. The total life cycle cost of both approaches cannot yet be known, as the environmental cost of marine litter is not yet quantifiable.



$$\Delta = 7.15L_{wl}^{2.48}$$

$$SA_{WS} = 0.097L_{wl}^{2.29}$$

$$d = 0.386L_{wl}^{0.74}$$

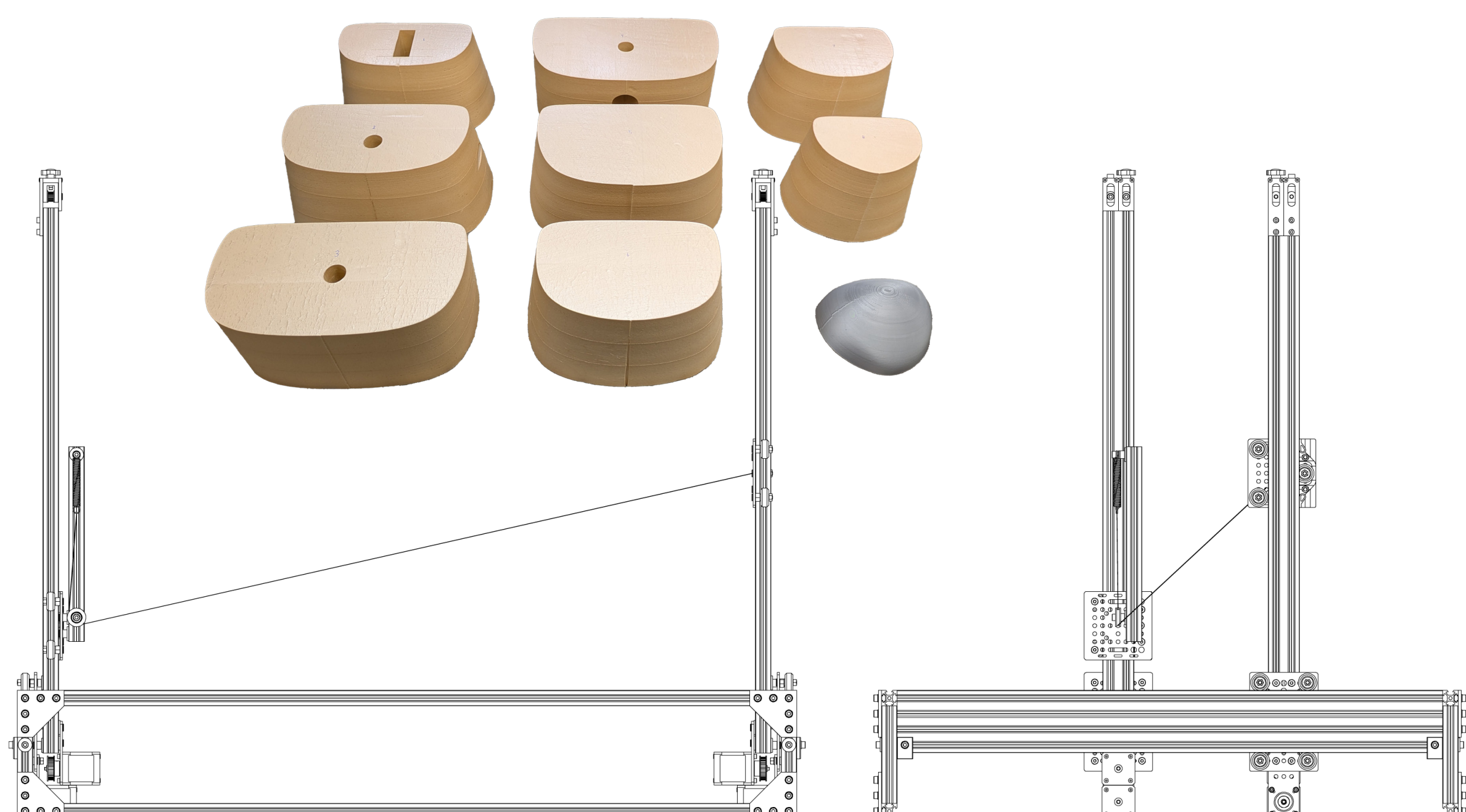
$$\overline{B/\Delta} = 37\%$$

## Design study

The SDC25 prototype: a small ASB which naval parameters were set using a statistical design approach, based on a comprehensive overview of existing ASB designs, compiled during this research. The swarm optimisation analysis provided a good argument to design a small ASB with an overall length of 1.36m. The resulting boat includes a self-trimming wingsail that uses no energy except during manoeuvres, to curb the use of electronic components and energy. Initial testing suggested the vessel was very stable, even though testing quality was limited by calm weather conditions.

## CNC foam cutter

A custom-built CNC foam cutter machine played a key role in fabricating the complex curvature of the wingsail and hull. The setup consists of two XY gantries holding a tensioned, heated nichrome wire, which cuts through foam by melting it along a programmed path. The machine, and the generation of the G-code, toolpaths directly from Rhino using Grasshopper, have been developed.



Lucas Daniël Korvemaker  
Towards environmentally friendly autonomous  
swarm sailing for environmental monitoring  
April 30th, 2025  
MSc Integrated Product Design

## Committee

Chair: Dr. J.H. Boyle  
Mentor: Z.P. Oikonomou

