Referencing existing glider specifications, the average weight of underwater gliders was determined to be 100 lbs (Goni, 2022). The simulations and the model should reflect this weight.

The dimensions of the glider are very important. They will be further flushed out during concept generation and selection when the team chooses a design, but as a baseline the glider should not exceed 1 m^3 of volume.

1.5 Concept Generation

Ideas were generated through a variety of different methods to ensure a wide range of possible solutions to the posed issue. The ideation process requires the group to have an unrestricted and focused brainstorming session to generate 100 ideas. These ideas will be generated through different strategies like morphological charts, biomimicry and crapshoot to mention a few. The complete list of generated concepts can be found in Appendix D.

1.5.1 Morphological Chart

To create a morphological chart, the base functions were separated into columns and concepts were generated by identifying relationships across rows. The columns were split into shape, fin count, buoyancy control method, propulsion, material, and navigation. Multiple ideas were generated based on existing designs and by the group members. Table 3 shows the morphological chart used to come up with these ideas

Table 3: Morphological Chart

	Shape	**# of Fins**	**Buoyancy Control**	**Propulsion**	**Material**

1.	Manta	1	Oil Bladder	Propellor	Carbon Fiber
2.	Submarine	2	Ballast Tank	Booster	Fiberglass
3.	Hydrofoil	3	Piston Excavated Cylinder	Flapper	Aluminum
4.	Rocket	4	Water Bladder	Paddle	Syntactic foam
5.	Plane	5		Ionic Thruster	Auxetic Foam
6.				Compressed Air	

1.5.2 Brainstorming and Research

The concept of a glider has been researched and tested in both air and water. Since the fundamental dynamics of gliding are related for both mediums (air and water), models and designs from both fields can be used during concept generation. The goal is to increase lift and decrease drag. This can be achieved by differences in body size, body shape, wing shape, wing count, tail design, and various joints that add degrees of freedom. Using research papers and general knowledge of fluid mechanics acquired from taking classes at FAMU-FSU College of Engineering a list of concepts was generated.

1.5.3 Biomimicry

Team 502 also looked to the animal kingdom for inspiration in concept generation. There are many examples of ocean life that can be used to generate concepts for submerging such as dolphins and whales. It is a goal of the project to increase efficiency through minimizing drag and decreasing weight. The characteristics of birds and other fast animals were examined when pursuing these goals.

1.5.4 Anti-Problem

Anti-problem is the process of ideation on the negative and potential obstacles that the glider could face that would inhibit it from operating correctly. In terms of an underwater glider this could be represented as water-tight components, large oceanic current interference, hazards, and pressure differences. By noting these anti-problems different concepts that would supersede these were created.

1.5.5 Medium Fidelity Concepts

Medium fidelity concepts were selected on feasibility, manufacturability, efficiency, and cost. When looking at the list of 100 concepts generated listed in Appendix D the task is to determine which ones will work. This is rooted in both background research as well as prior experiences gained from time at FAMU-FSU College of Engineering. An engineering perspective uses intuition on the fundamentals of hydrodynamics, materials, controls, and systems integration to conceptualize the concept and its success probability. Of the 100 concepts generated five were chosen as medium fidelity.

The kinetic energy harvesting glider was chosen as a medium fidelity concept. Energy harvesting is an idea that the group has considered, and some method of harvesting kinetic energy would allow the glider to operate for longer without maintenance and collect more data points. However, Boeing has mentioned that energy harvesting is not necessary to incorporate into the glider. Energy could be collected through piezoelectric beams or wave motion should the team decide to implement it.

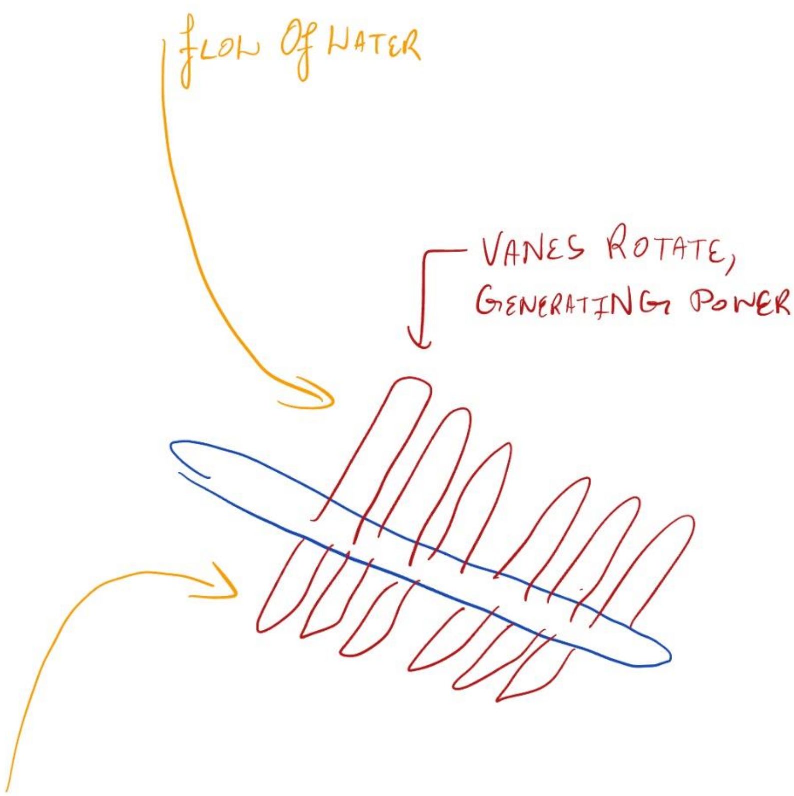
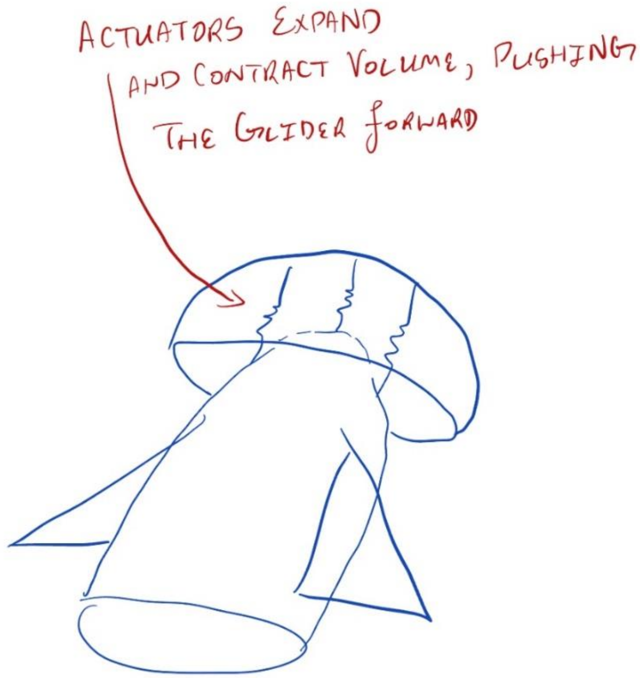


Figure 2: Kinetic Energy Harvesting Glider

When exploring underwater gliders biomimicry is a key area to explore, which produced the jellyfish glider. In terms of a jellyfish the only motion created is adjusting the orientation of the bulb to catch ocean currents. By relying on the motion of the ocean, jellyfish can travel large distances with low energy usage. This proved to be a medium fidelity concept because of the practicality of construction. The specific shape of jellyfish allows for this efficient motion and creating an accurate model would be difficult. The movements of a jellyfish are highly complex and would pose a challenge to bring to reality.



Electromagnetic Pump Glider

The electromagnetic pump glider is another example of a medium fidelity concept. The motion is created by a DC motor, but instead of an externally mounted propeller the entire assembly is in line with the rest of the glider hull. Water enters the space where the propeller is contained and is pushed out of space when the propeller rotates. This displaced fluid pushes the glider forward. Angled outlets are placed on the side of the assembly to allow water to be displaced in different directions. This concept allows the whole unit to be placed within a more compact package but could be complex to design due to water entering the space affecting the buoyancy of the glider. Figure 3 displays an example of the concept.

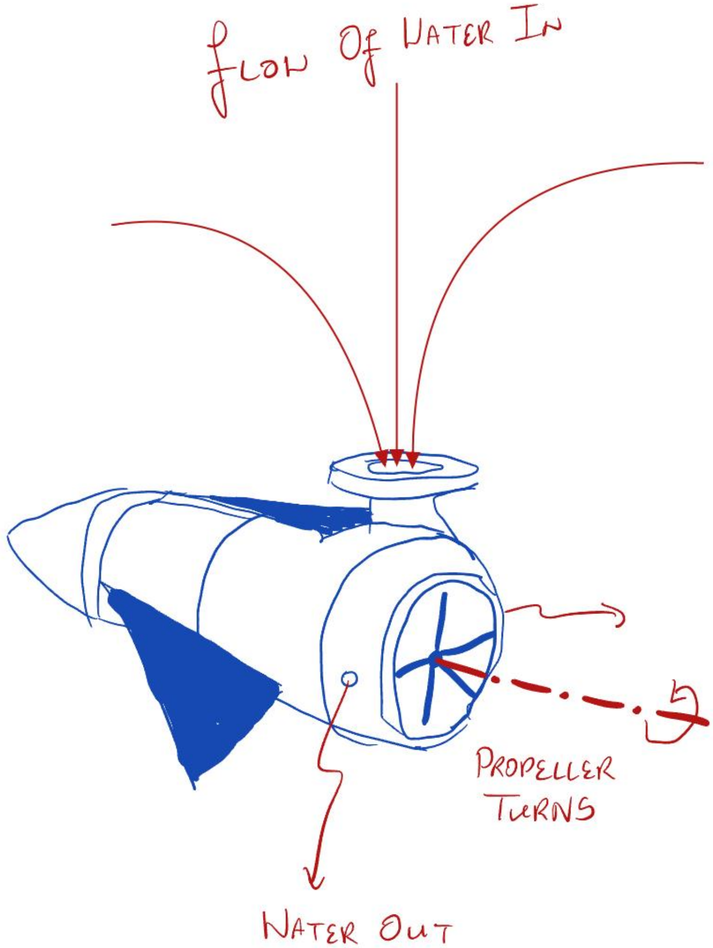


Figure 3: Electromagnetic Pump Glider

The helicopter glider was selected based on its pre-verified effectiveness. Based on prior research the shape of the wings allows for smooth descent through a water column that can propel the glider forward. Then at a certain depth the propellers would activate raising the glider and the pattern would repeat. This concept can dodge hazards and adjust its orientation easily and efficiently. However, the drag posed by the propellers would pose a challenge when trying to create an optimal efficiency glider.

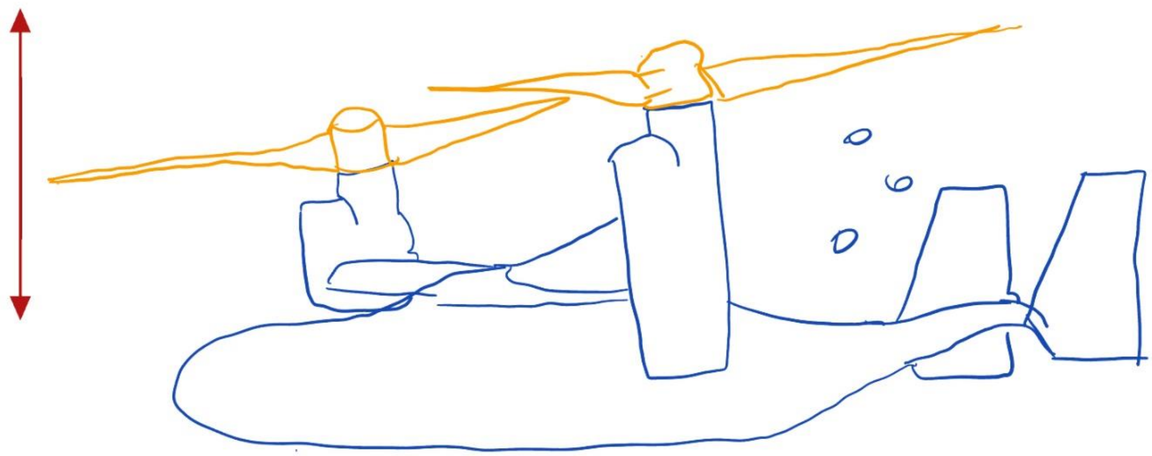


Figure 4: Helicopter Glider

1.5.6 High Fidelity Concepts

High fidelity concepts were selected by deciding on the 3 most feasible concepts from the medium fidelity category. Among those were the piston excavated buoyancy engine, the dual hull glider, and the adjustable wing manta.

Piston excavated buoyancy engines operate by linearly actuating a piston to fill or expel water from an air chamber. When the device takes on water it becomes heavier resulting in negative buoyancy. When the water is expelled, the extra weight is released, and the device returns to a positively buoyant state. This was determined to be a more reliable buoyancy solution than an oil bladder as it had less chance for fluid leakage into the important electrical components. Figure 5 shows a rough sketch of how the buoyancy engine operated glider would work.

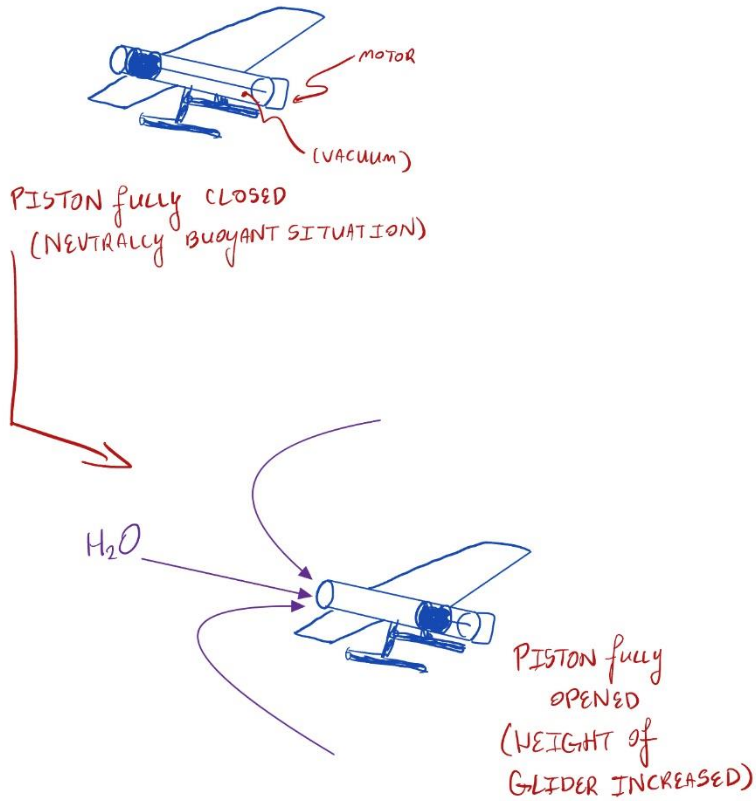


Figure 5: Piston Excavated Buoyancy Enginer

The dual-hull glider would consist of two parallel cylinders connected to each other. The pistons would each have a buoyancy engine in them that could control pitch and roll. Control laws would be implemented to ensure a balanced system. The group decided on this hull design due to its ability to control pitch easily and increased volume for various sensors. Figure 6 shows a rough sketch of the dual-hull glider.

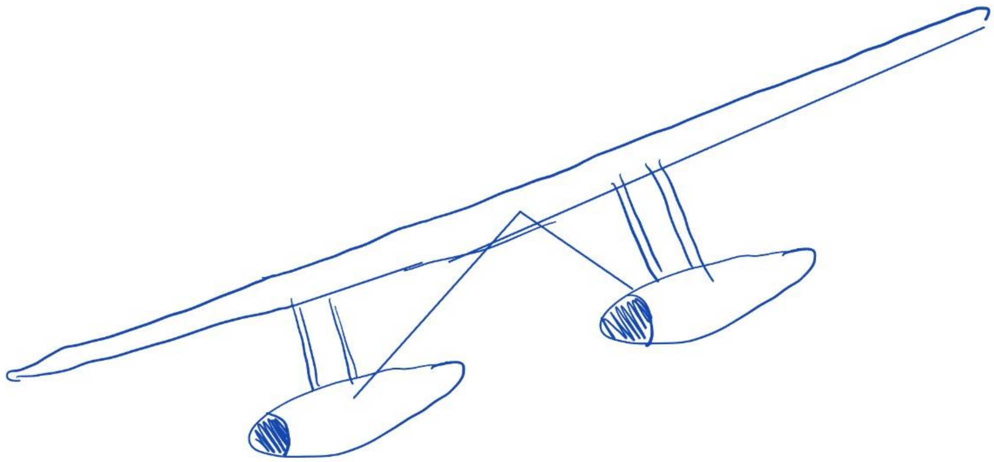


Figure 6: Dual-Hull Glider

The adjustable wing manta is a bio-inspired manta ray glider that would have flapping arms to generate forward thrust. This concept was deemed high fidelity because the shape is proven to be conducive to gliding, both in human imitation and nature. In addition, variation of the wings could steer the glider, providing increased maneuverability. Figure 7 shows a front view of the manta glider and possible wing profiles.

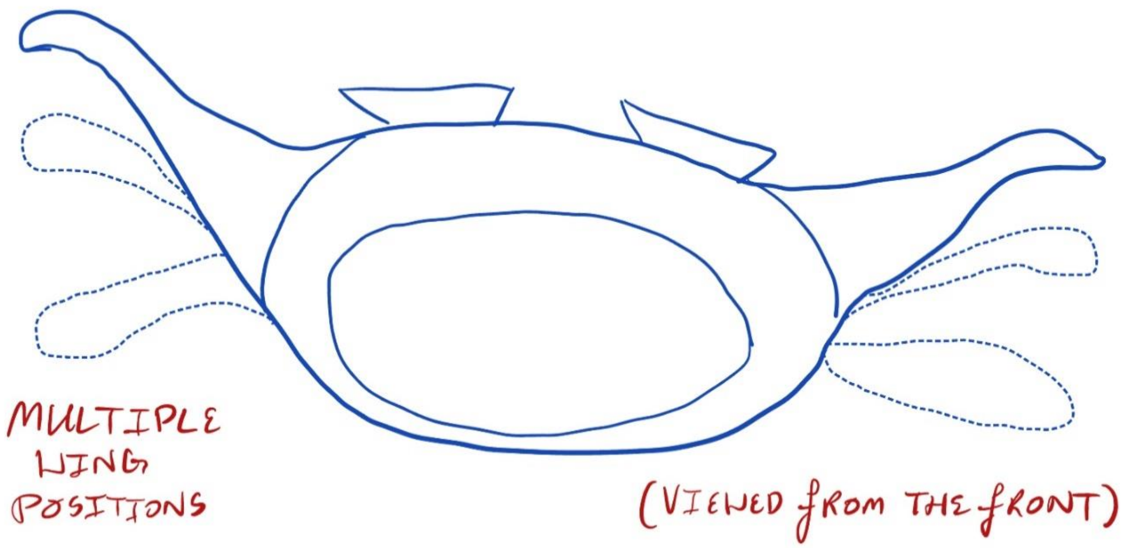


Figure 7: Manta Glider

1.6 Concept Selection

Now that medium-fidelity and high-fidelity concepts have been selected, the team will use different analytical techniques to weigh each concept and decide on a final selection. These techniques include the House of Quality (HOQ), Pugh Charts, and the Analytical Hierarchy Process (AHP).

1.6.1 Binary Pairwise Comparison

Individual weight factors (IWF) for each of the designs must be generated to gauge how important each design characteristic is to have a functional product. The values in the gray corner were decided by pitting each design characteristic against itself and all the other design characteristics. If the characteristic in the row was said to be more important than the characteristic in the column, a 1 was assigned. For the inverse a 0 was assigned. The values in the yellow corner are mirrored inverses of the values in the gray corner. Each row was summed