Personal Watercraft (PWC)

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Sponsor: College of Engineering and Technology

UVU MECHANICAL ENGINEERING
UTAH VALLEY UNIVERSITY

Scope

This project aims to design, build, and test a self-powered, car-transportable personal watercraft for adults of varying body types. It will enable safe, near-shore recreational use across a range of speeds in Utah reservoirs under diverse conditions while meeting all regulatory requirements.

Solutions and Requirements

Customer Needs:

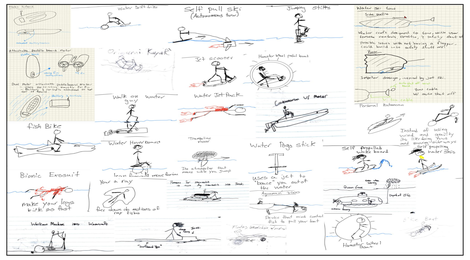
Performance	Safety & Reliability	Comfort	Utility & Storage	Portability & Setup	Design & Aesthetics	Novel Features
Stable in calm or choppy water	Safety lanyard and auto-shutoff	Comfortable seating	Top gear storage	Lightweight enough to lift solo	Stylish look and colors	Hovering capability
Resists tipping at all speeds	E-stop mechanism	Heated surfaces for cold water	Waterproof storage	Breaks down into smaller parts	Unique/standout appearance	Underwater viewing ability
Smooth impeller propulsion	Beginner-friendly operation	Stays warm/dry	Secure tie-down points	Compact for easy transport	Quiet/low disturbance	Hybrid body-powered + motor assist
Variable speed control	Durable, reliable construction	Sun protection	Space for cooler	Simple assembly	Fun/relaxing experience	Ability to do tricks/stunts
Good battery life	Doesn't sink when tipped	Comfort in cold water	Tackle/fishing storage	Quick setup/teardown	Minimal wildlife impact	
Swappable batteries	Clear gauges and low-battery alerts	Ergonomic design	Easy re-boarding from water	Fits in a 4Runner or small trailer		
Handles multiple riders	Low noise levels			Doesn't need a trailer		
Works in shallow water	Low maintenance			Stores easily		
Moves upwind	Legally lake-compliant					
Capable of basic tricks/stunts	Accommodates PFD					
Fast enough to be fun						

Design Requirements:

CUSTOMER NEEDS	DESIGN REQUIREMENT	SPECIFICATION	Hit Spec?
Low Operation Cost	Cost Per Day of Operation	< $20	$0.22 to charge.
Affordable	Cost To Produce	< $2,500	$2,484.51 cost to produce.
Fast	Maximum Speed	10 mph	~13 mph
	Minimum Speed	3 mph	Yes
Durable	Operational Lifespan	500 hours operational rating	Battery, ESC, and motor rated for 500+ operational hours.
Easily Transportable	Weight	< 85 lbs total (less than 45 lbs per component)	60 lbs total weight, highest 34 lbs highest single component weight.
Variable Speed Control	Speed Settings	> 5 settings	Continuous Variable Speed Control
No Exposed Moving Parts	Guarding Clearance of Moving parts	Yes	Propeller guard
Legally Able To Go In Lakes	Follow US federal/coast guard/CFR regulations, and Utah State codes.	Yes	Yes.
Accomodate Tall & Heavy People	User Weight	< 200 lb	Tested with 205 lb.
Accomodate Tall & Heavy People	User Height	59" - 76"	Yes, tested with multiple users of varied height.
Decent Range/Run Time	Time of Operation	> 1 hour	Operational Runtime 1.5 Hours.
	Waterproof	Yes	Electronics compartment IPX6 tested, and field tested.
	Floats	Yes	Yes
Easily Transportable	Stored Volume	(6 x 3 x 1) = 18 ft³	Meets per part stored volume
Stable In The Water	Able To Operate On Rough Water	Yes	Yes
Stable In The Water	Maximum Operational Wind Speed	5 mph	Yes, tested on days with gusts up to 8 mph.
Stable In The Water	Maximum Operational Wave Height	1.5 ft	Mast length of 650 mm > 1.5 ft.

Hit Specification: Green = Yes, Yellow = Possible/pending, not fully integrated, and Red = No

Brainstorming:



Selection Matrix:

Selection Matrix

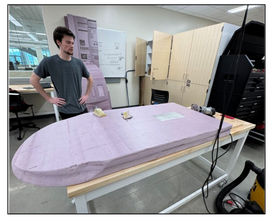
Selection Criteria

Proposed Solution	Score 1 - 5 (Anchored)																																	Total Score
Weight	0.1	1	0.6	0.1	0.3	0.3	0.3	0.2	0.6	0.3	0.2	0.5	0.7	1	1	0.6	0.5	0.7	0.5	0.5														
Electric Surfboard	5	5	3	5	5	5	5	5	5	3	5	5	4	5	5	5	3	2	2	5														41.9
E-kayak	5	4	4	5	5	2	5	5	5	5	2	5	5	5	5	1	2	5	4	1														38.5
E-foil	5	3	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	3	5	3														42.5
Jet Scooter	3	3	5	5	3	1	5	5	5	3	4	5	5	5	5	2	3	5	3	4														39.4

Materials and Methods

Board

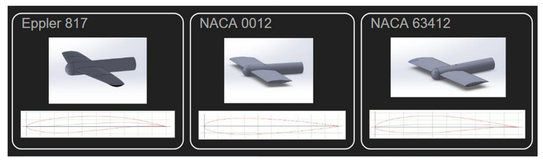
The board used two bonded 2-inch Foamular NGX layers shaped for buoyancy, with an aluminum mast plate and five fiberglass/epoxy layers for strength, rigidity, and low cost.





Hydrofoil

Designed a hydrofoil to support a 200 lb rider and board by selecting three candidate profiles from performance and cavitation literature. Scaled prototypes were fabricated via additive manufacturing and tested in a wind tunnel under Reynolds number–matched conditions to ensure dynamic similarity to full-scale water operation.



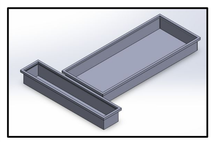
$$Re = \frac{\rho v l}{\mu} = \frac{v l}{\nu}$$

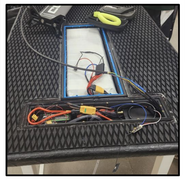
MPH Water	MPH Air
3	41
4	54
5	68
6	81
7	95
8	109
9	122
10	136

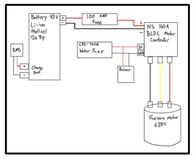


Electronics

Boxes were designed to house electronics in waterproof enclosures. Electronics were sourced from multiple manufacturers to be plug and play, making it easy to swap components if issues arise.







Engineering Analysis

FEA on Enclosure lids

A static structural ANSYS analysis compared 6061 aluminum and epoxy-coated plywood under a central load, using isotropic and anisotropic elasticity, respectively. The plywood deflected 3.87 mm, exceeding allowable limits, while aluminum deflected 0.17 mm. Therefore, 6061 aluminum was selected.

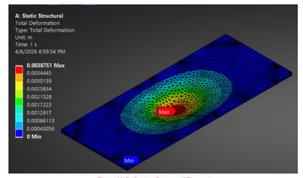


Figure X: Deflection Contour of Plywood

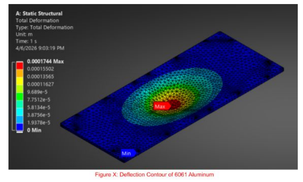
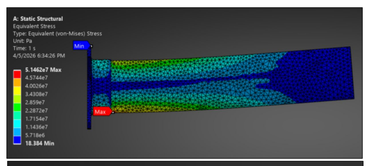
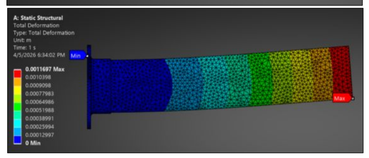


Figure X: Deflection Contour of 6061 Aluminum

Mast FEA Analysis

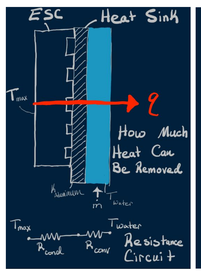
Evaluating whether purchased components can be reliably repurposed beyond their original design intent. Finite element results show 1.17 mm maximum deflection and 51.4 MPa peak von Mises stress, giving a factor of safety >5 relative to 6061 aluminum, with deflection <0.2% of the 650 mm mast length.

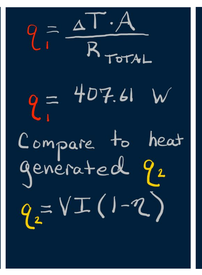


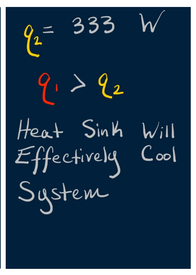


Heat Transfer Analysis for ESC

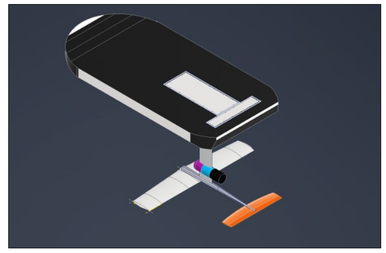
A steady-state heat transfer analysis showed the ESC generates 333 W, while the heatsink dissipates 407.61 W, confirming adequate thermal management under heavy-use conditions.

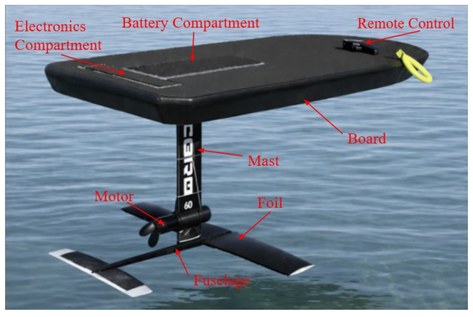






Final Prototype/Results









Acknowledgements

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