Adam Jirovec

Mechanical Design Engineer

EV Systems - Composite Structures - Product Development

Ply Labs P1

Lightweight Electric Motorcycle

Founder - Project Lead - Mechanical Design - Composite Structures - Systems Integration
Senior capstone project at Rose-Hulman Institute of Technology and a Start-up

P1 brings full commuter performance to e-bike and scooter riders.

Such vehicle must be: lightweight, safe, and simple while reaching highway speeds.

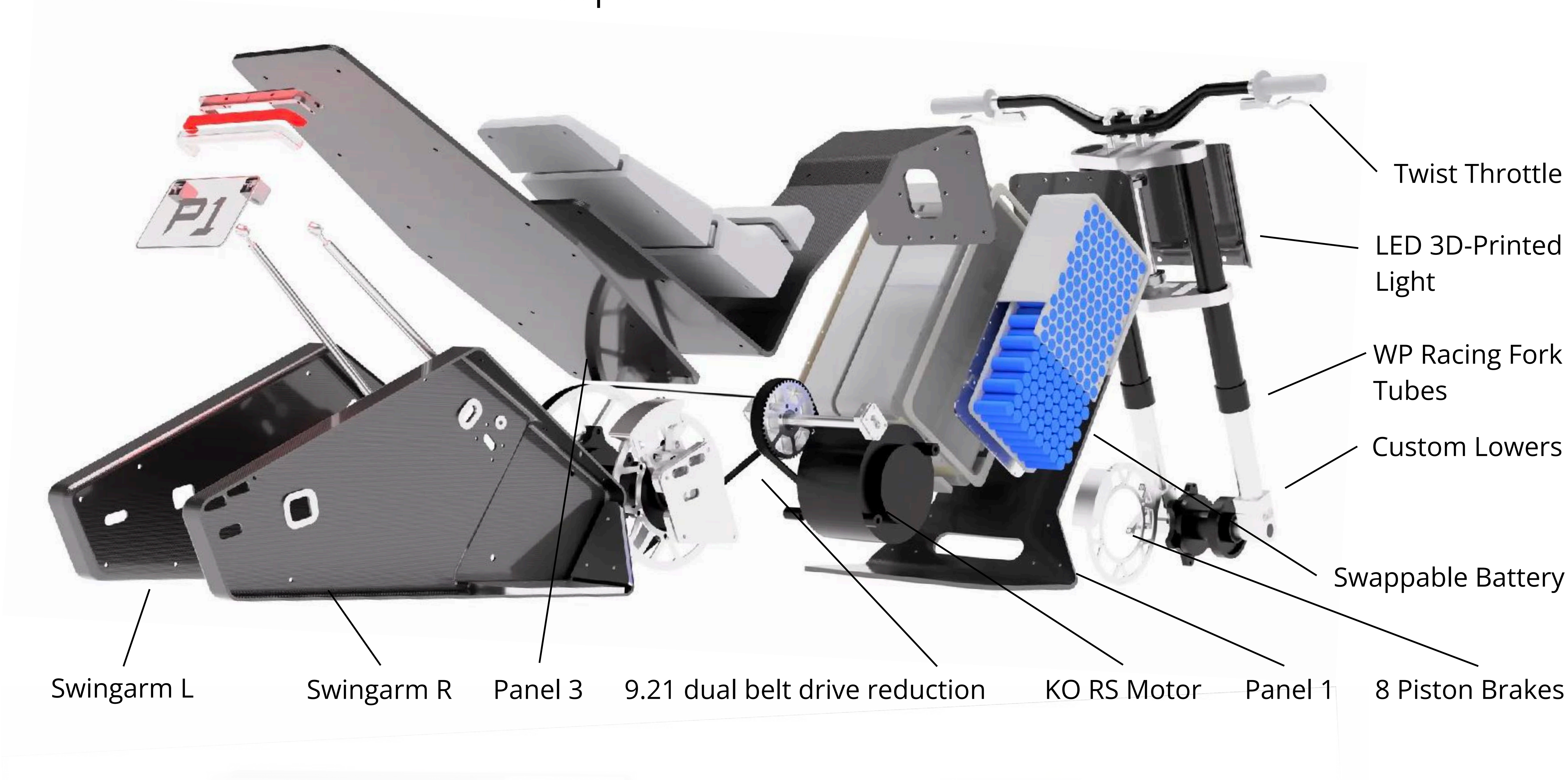
To achieve that, the motorcycle chassis was reinvented through structural carbon fiber panels alongside the development of a swappable battery ecosystem.

Validated Performance Specifications:

Weight: **54 kg** - Top Speed: **121 km/h** - City Range Per Battery: **100 km** - Target Price **$5000**

A Coupled Engineering Problem

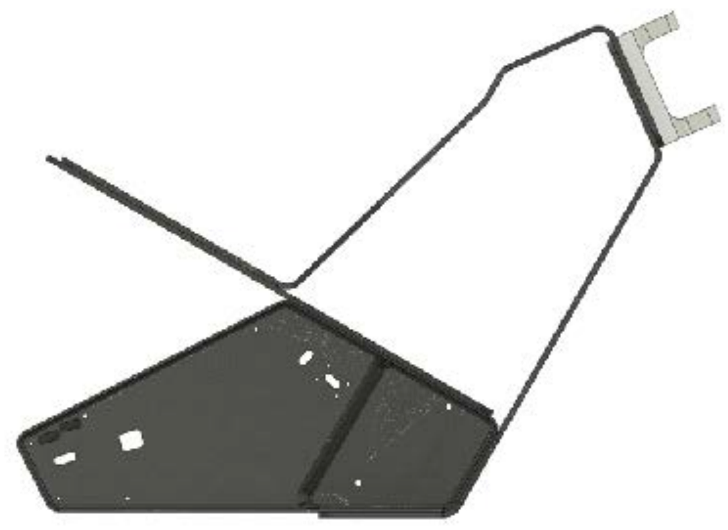
The novel architecture separates the motorcycle into structural subsystems with direct interaction and load sharing, unlike traditional designs where the bodywork, battery, and motor are mounted onto an independent frame.



Composite Paneled Chassis - The Core Innovation

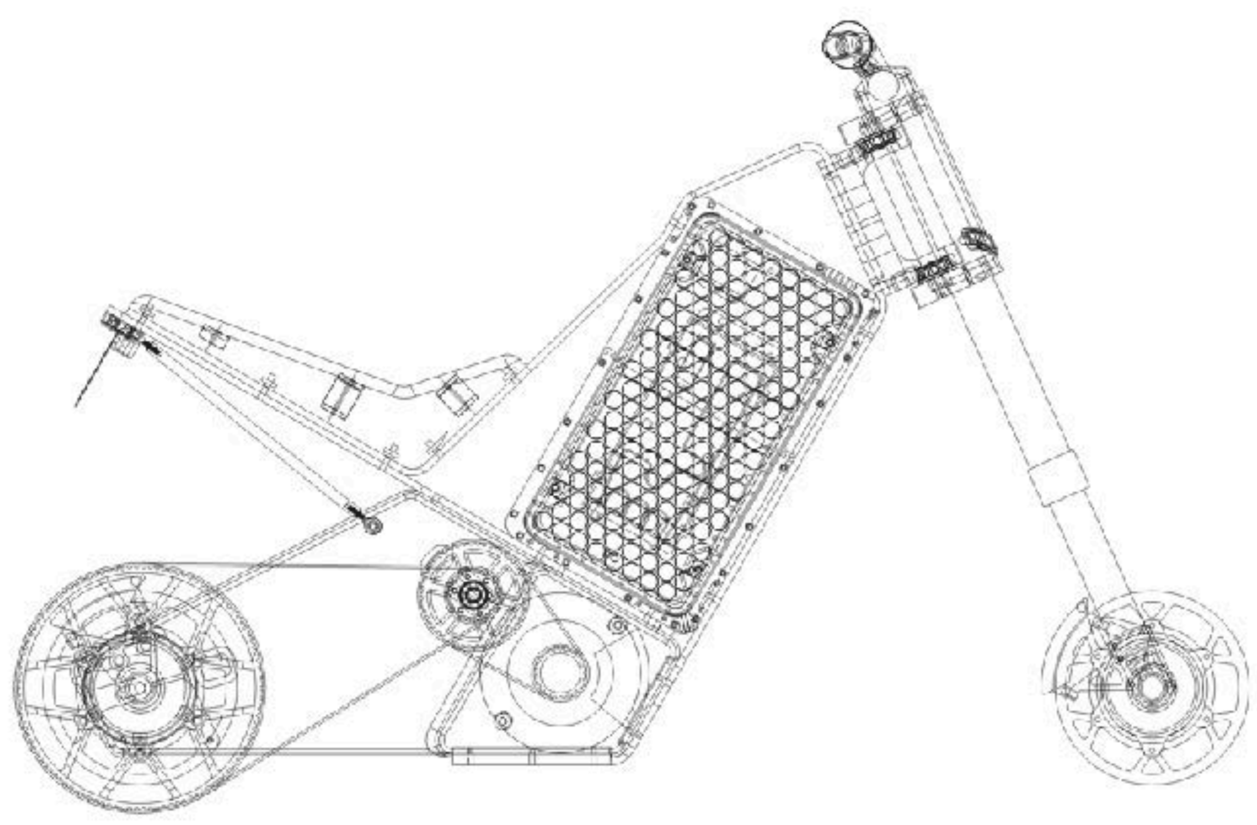
Traditional motorcycle frames are typically based around welded tubular structures originally developed for combustion powertrains. The P1 replaces this architecture with a structural composite paneled chassis, where carbon fiber panels act as the primary load-bearing elements.

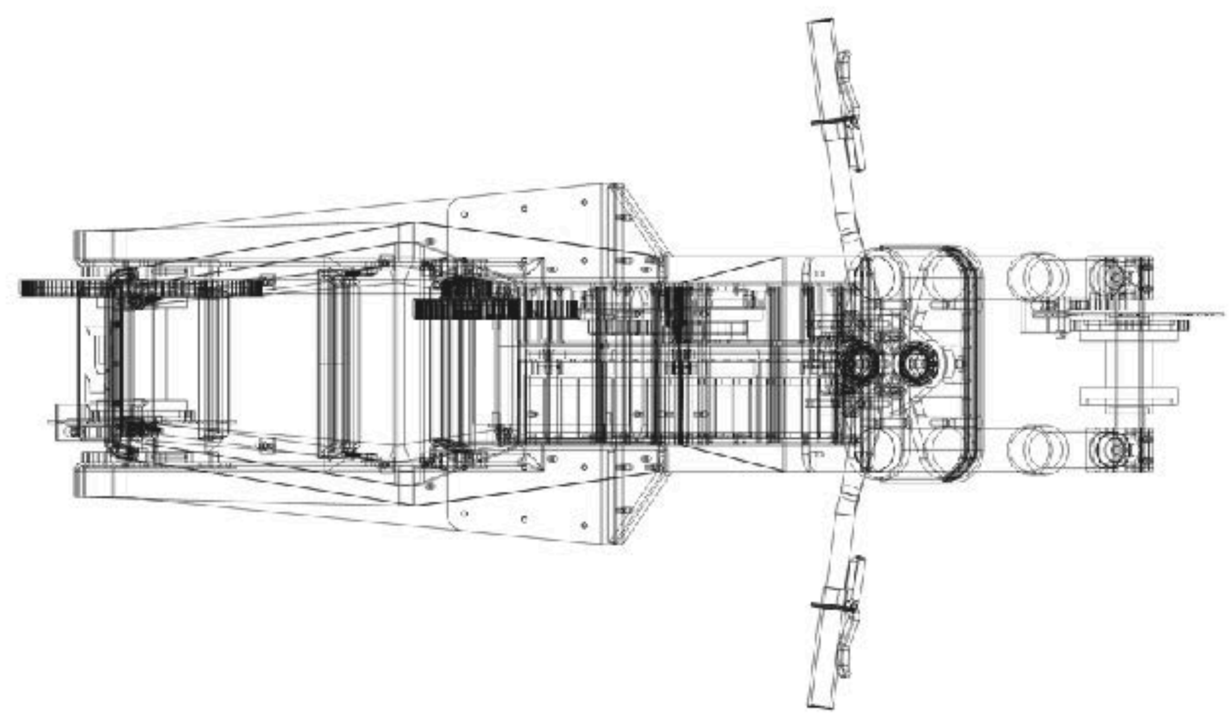
Tubular Metal
- Complex
- Heavy

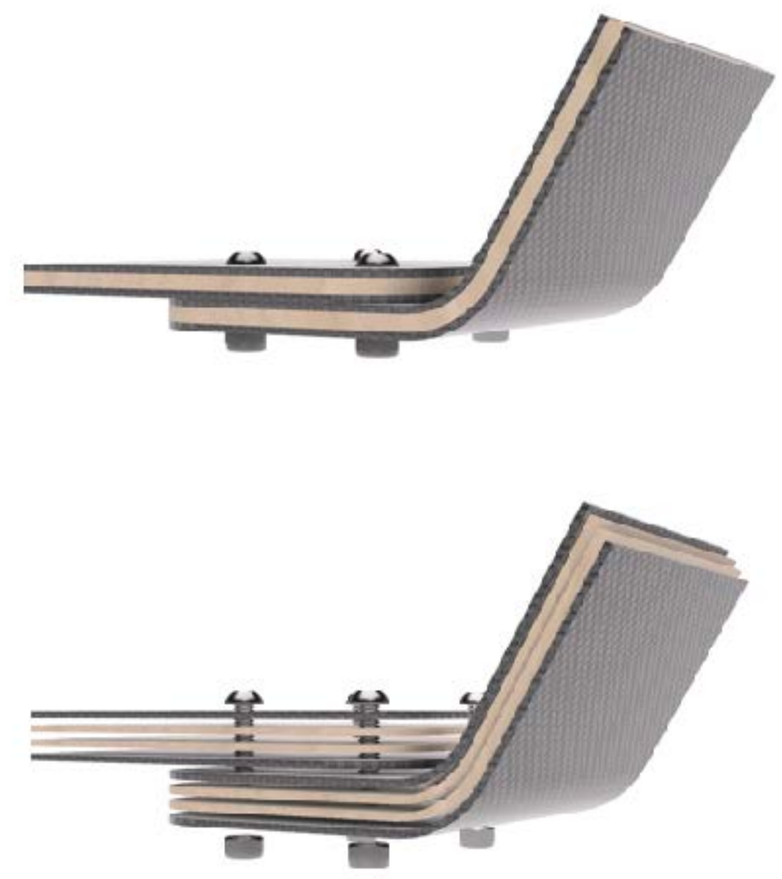


Paneled Composite
- Optimized
- Lightweight

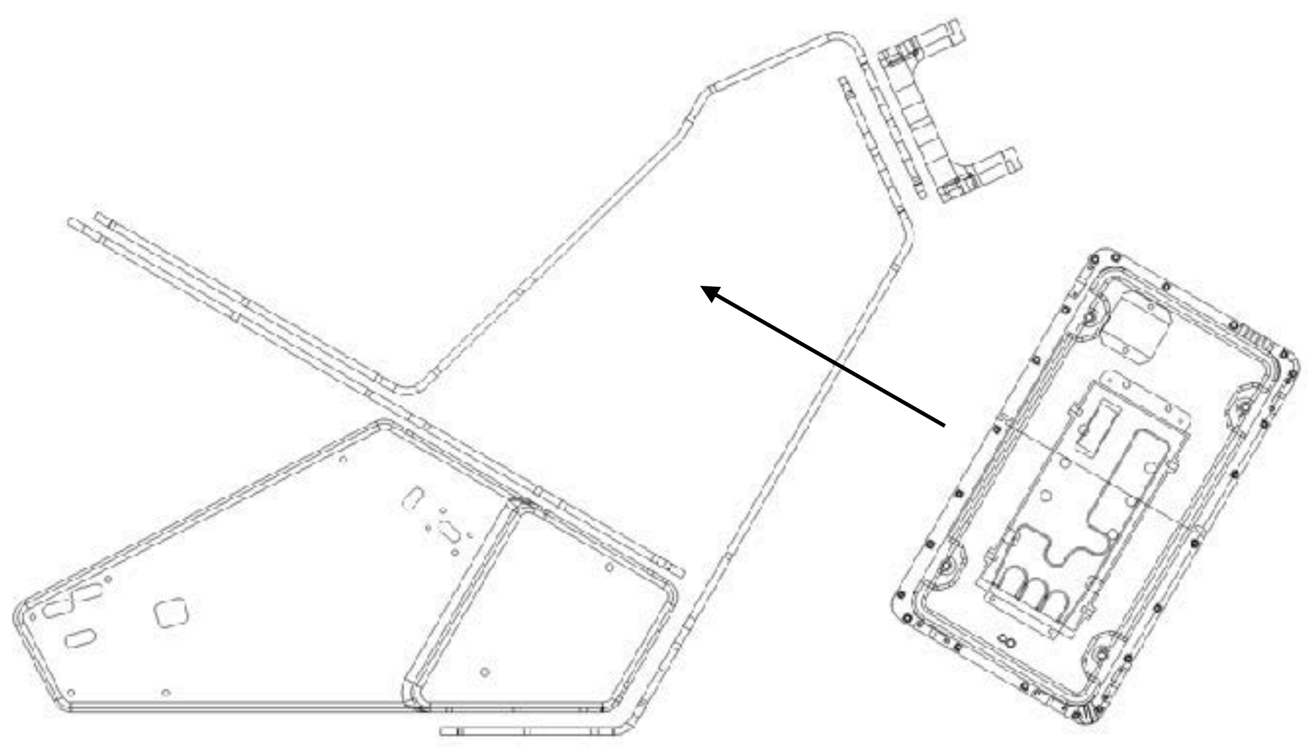
The panel-frame concept was developed as original intellectual property and patented by the author in the United States in 2025.

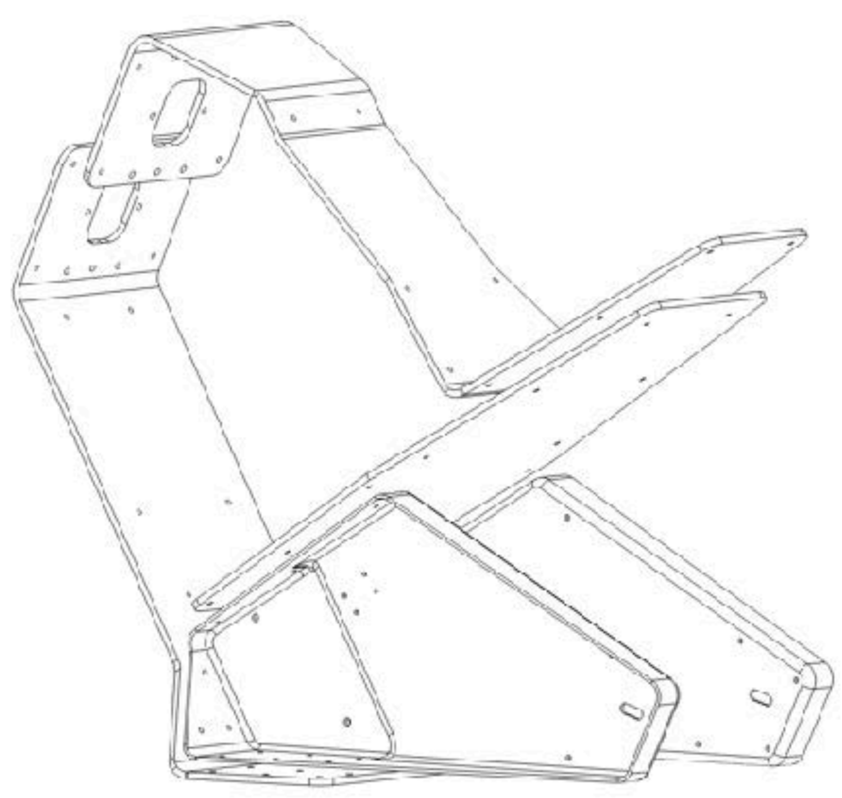


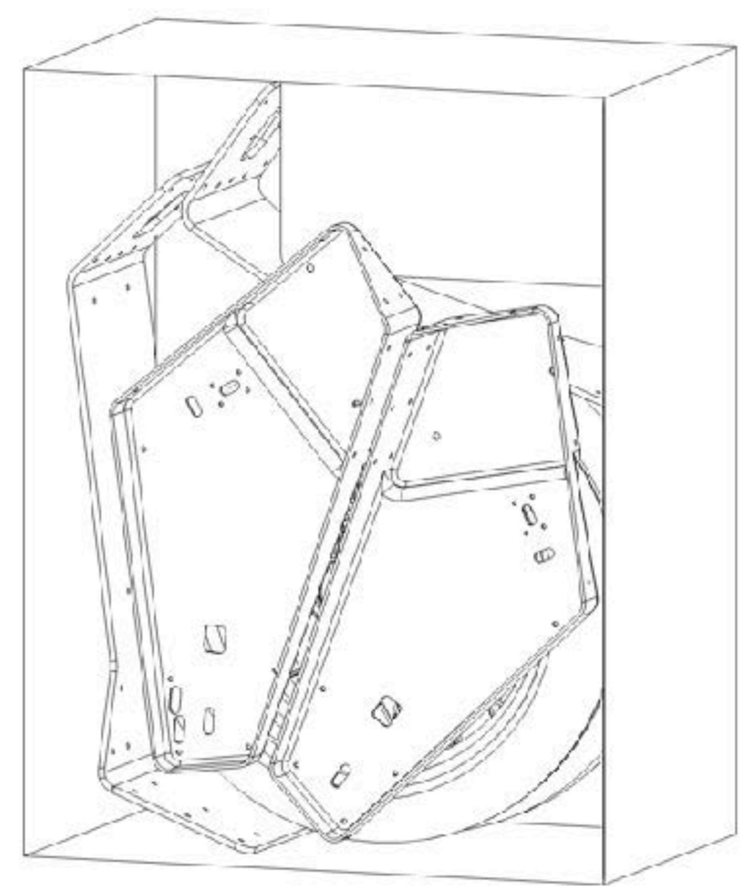




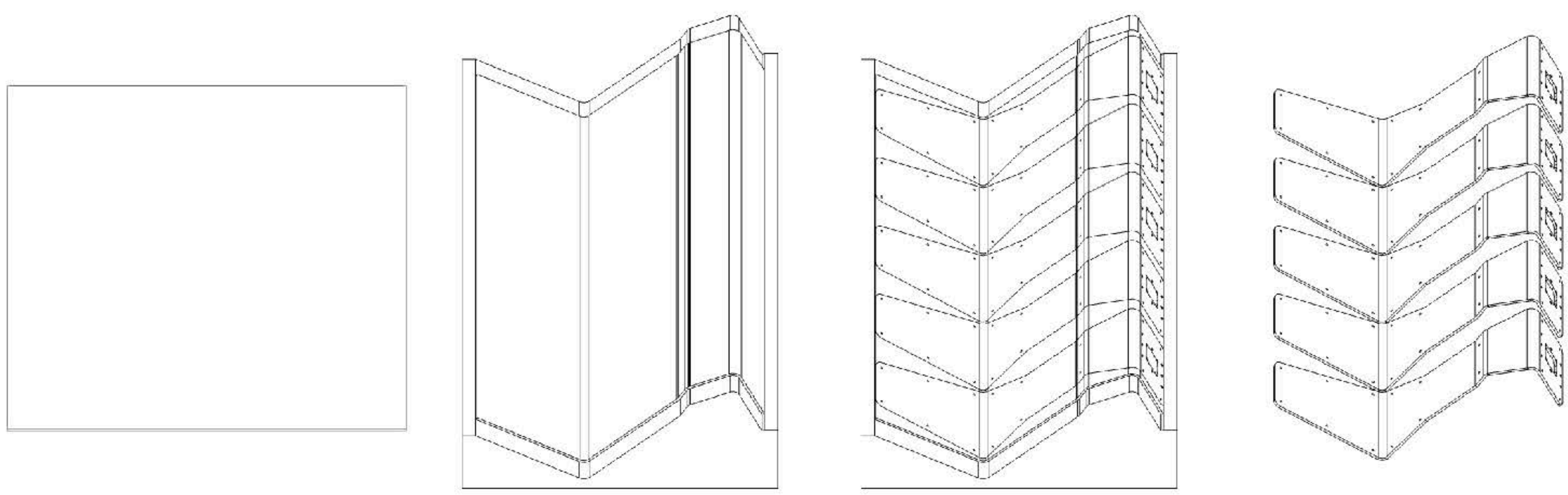
Five structural panels form the primary load-bearing structure. The panels are mechanically fastened together, enabling rapid assembly, disassembly, and transport.







Manufacturing sequence of the paneled chassis, where a flat composite laminate is formed and CNC-cut into structural components.



Swappable Lithium-Ion Battery Pack - Solution to Long Range

Range remains one of the core challenges of electric motorcycles.

Increasing battery capacity adds weight, which has a significantly greater impact on motorcycle performance than on larger 4-wheeled electric vehicles.

To address this, the P1 was developed around a swappable battery ecosystem, where modular battery packs can be shared across multiple devices and platforms.

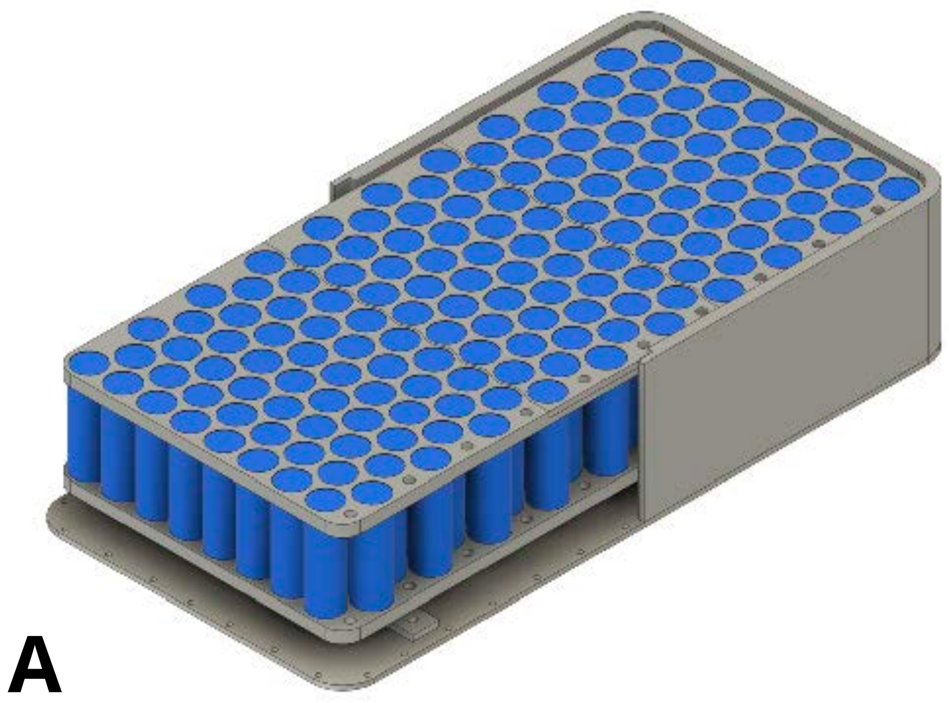
Cell Type: **Samsung 50S 21700**

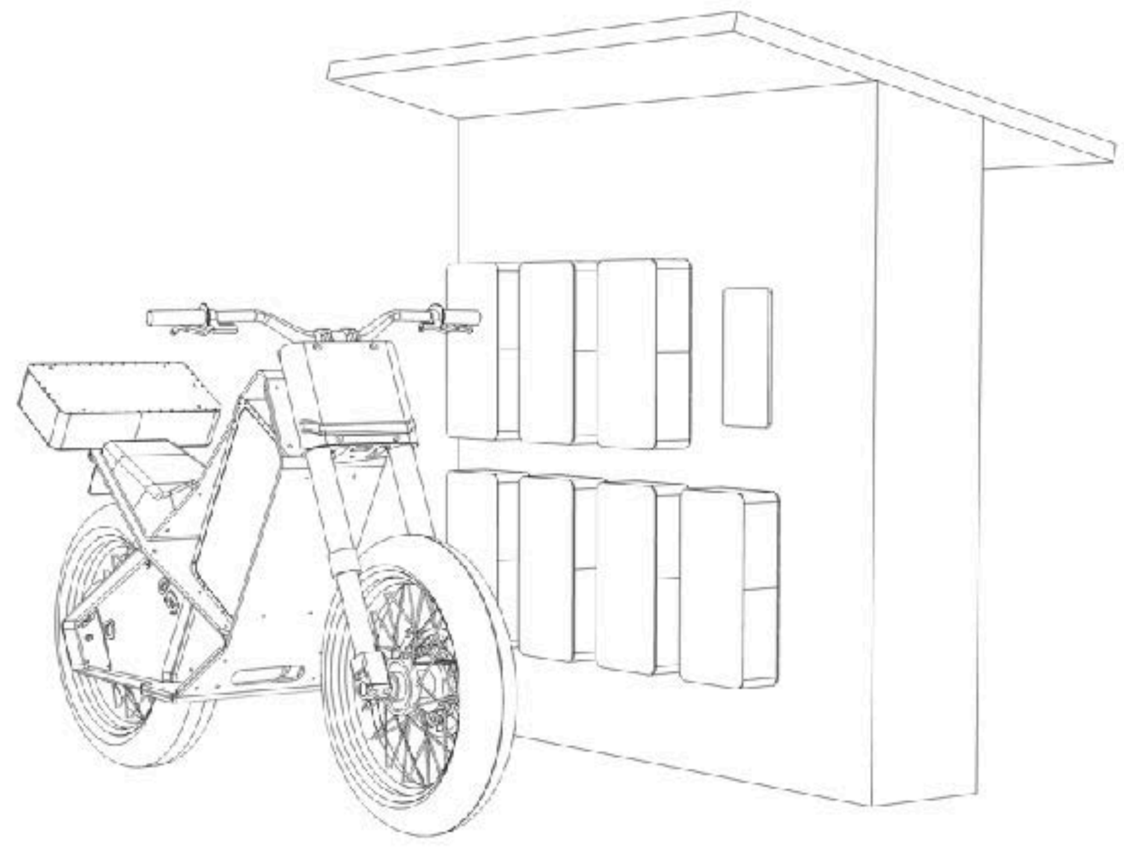
Configuration: **20s8p**

Nominal Voltage: **72 V**

Pack Capacity: **2.88 kWh**

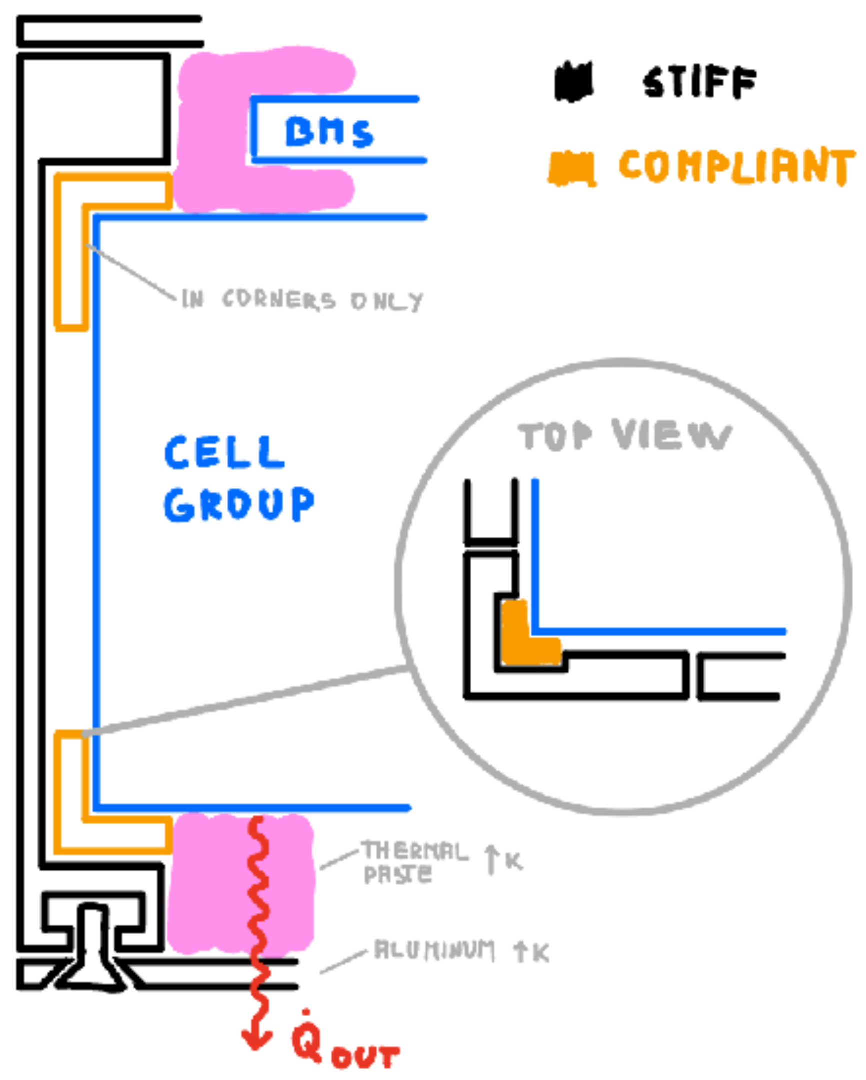
Continuous Output Current: **200 A**

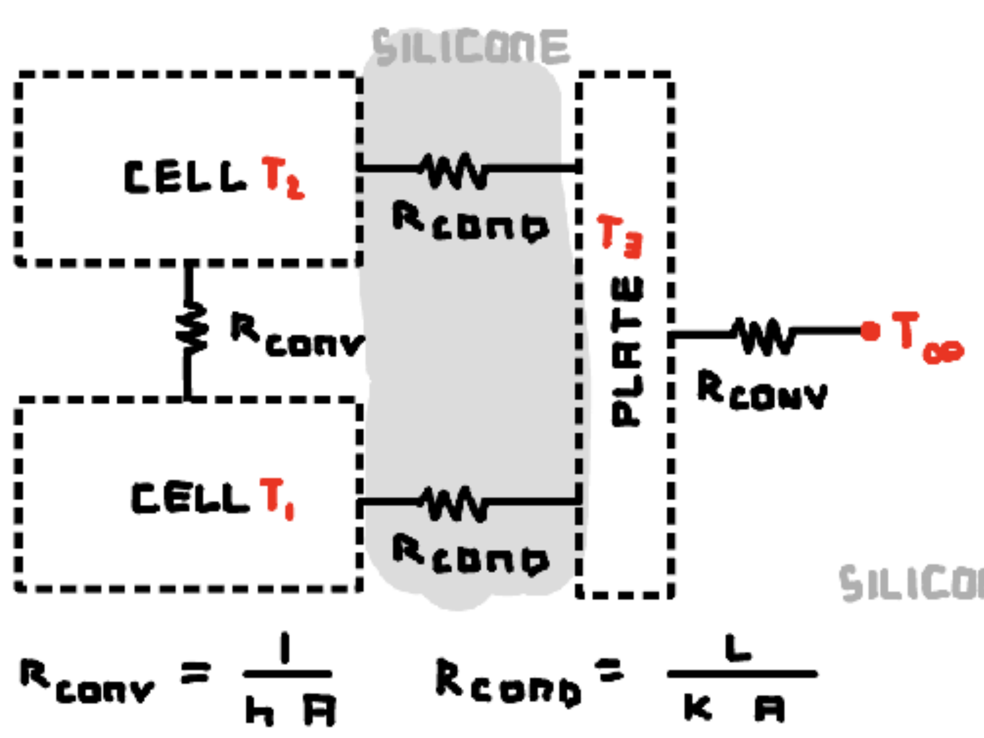


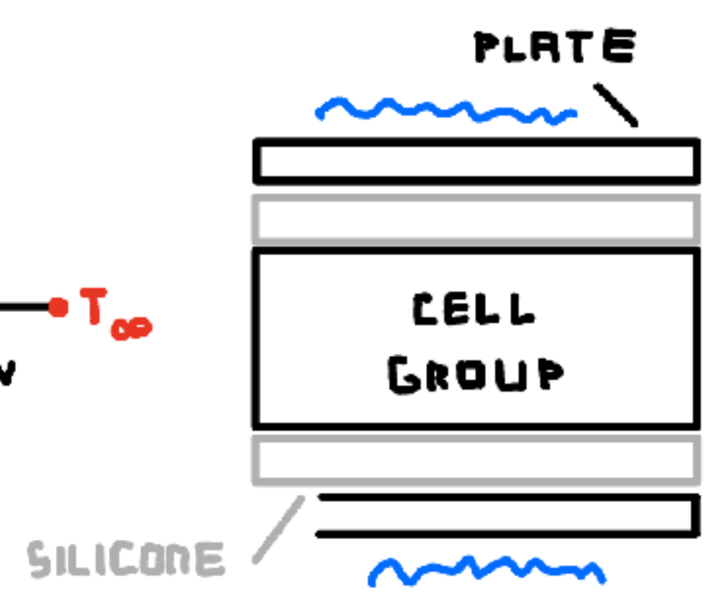


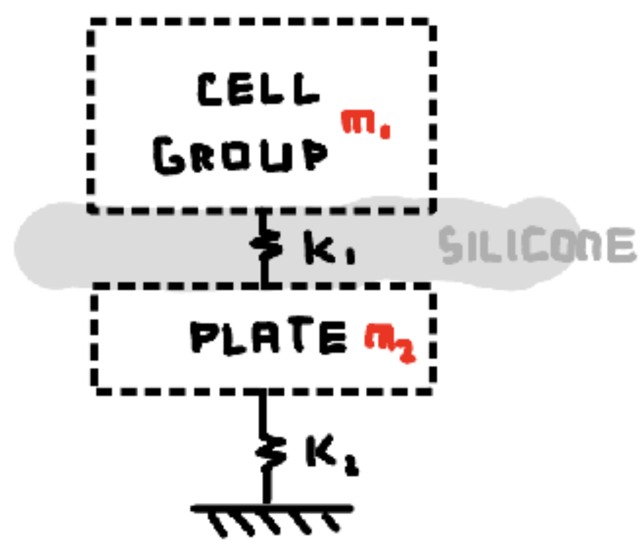
Battery Pack Analysis - Mechanical and Thermal

The swappable battery system on the P1 must withstand both mechanical vibrations and thermal loading. Modeling the system through spring and thermal resistance analogies guided the material selection and structural design, allowing both challenges to be addressed simultaneously.



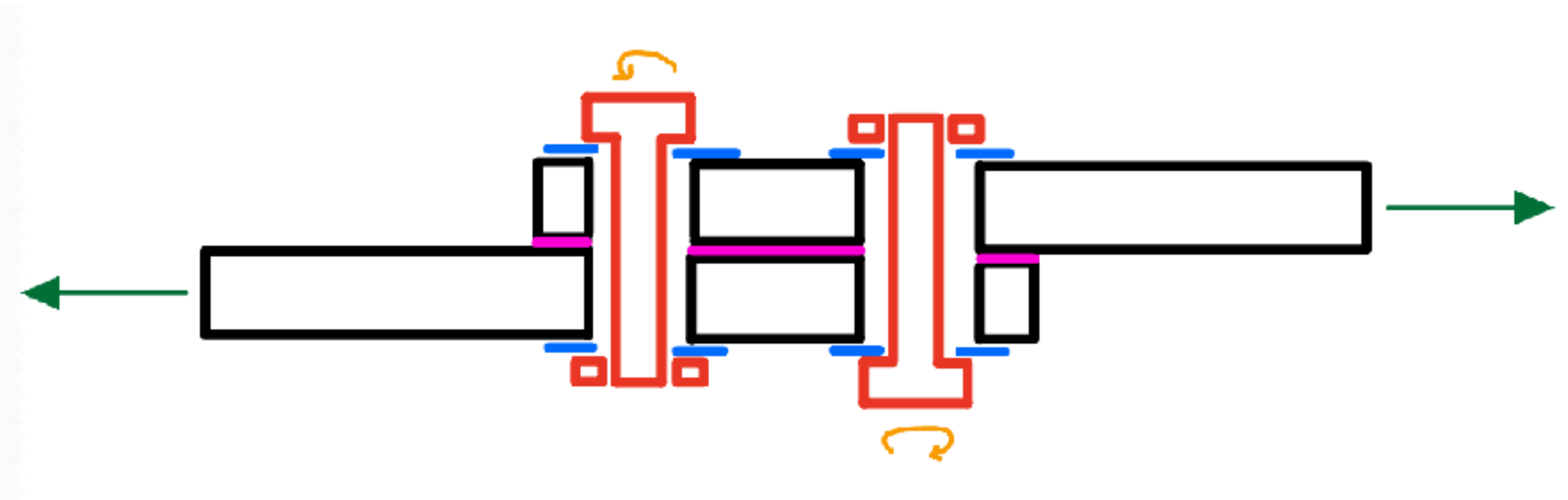


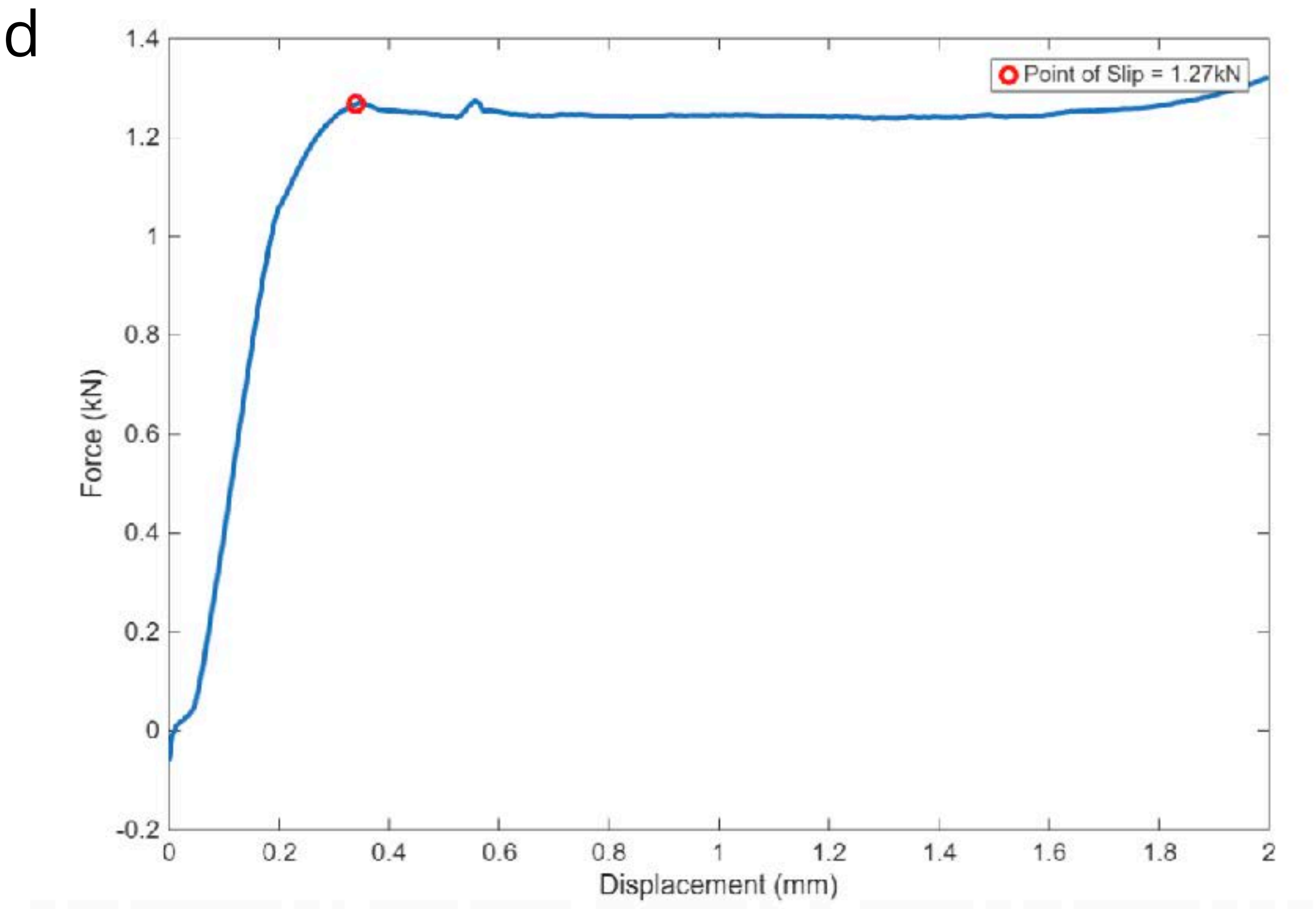




Panel Interface Study - Transmission of Load Through Friction

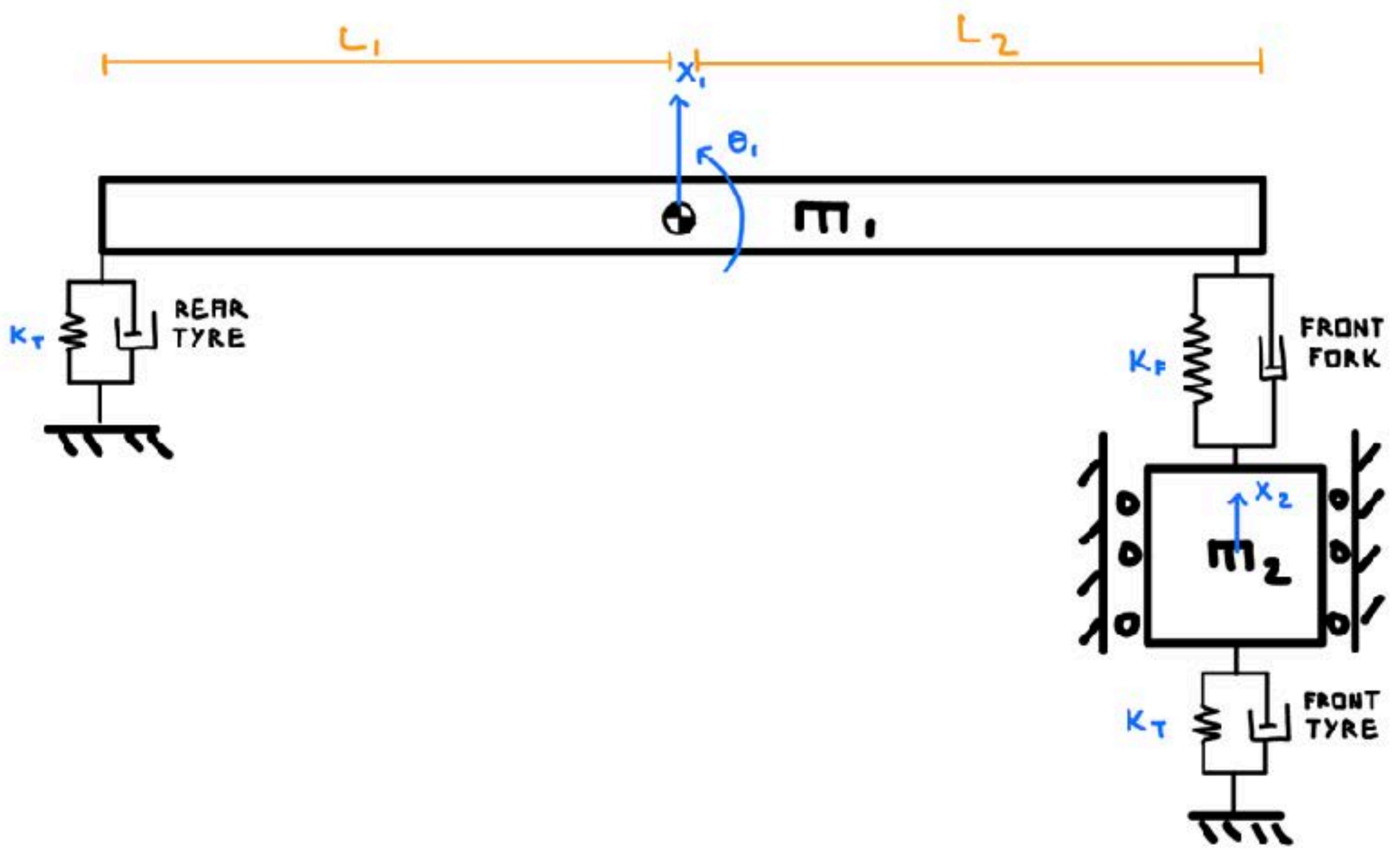
The paneled chassis must behave as a single rigid structure under load. Rather than transmitting forces directly through the fasteners, the joints rely on compression and friction between the panels. This plot shows displacement under shear loading across the panel interfaces.

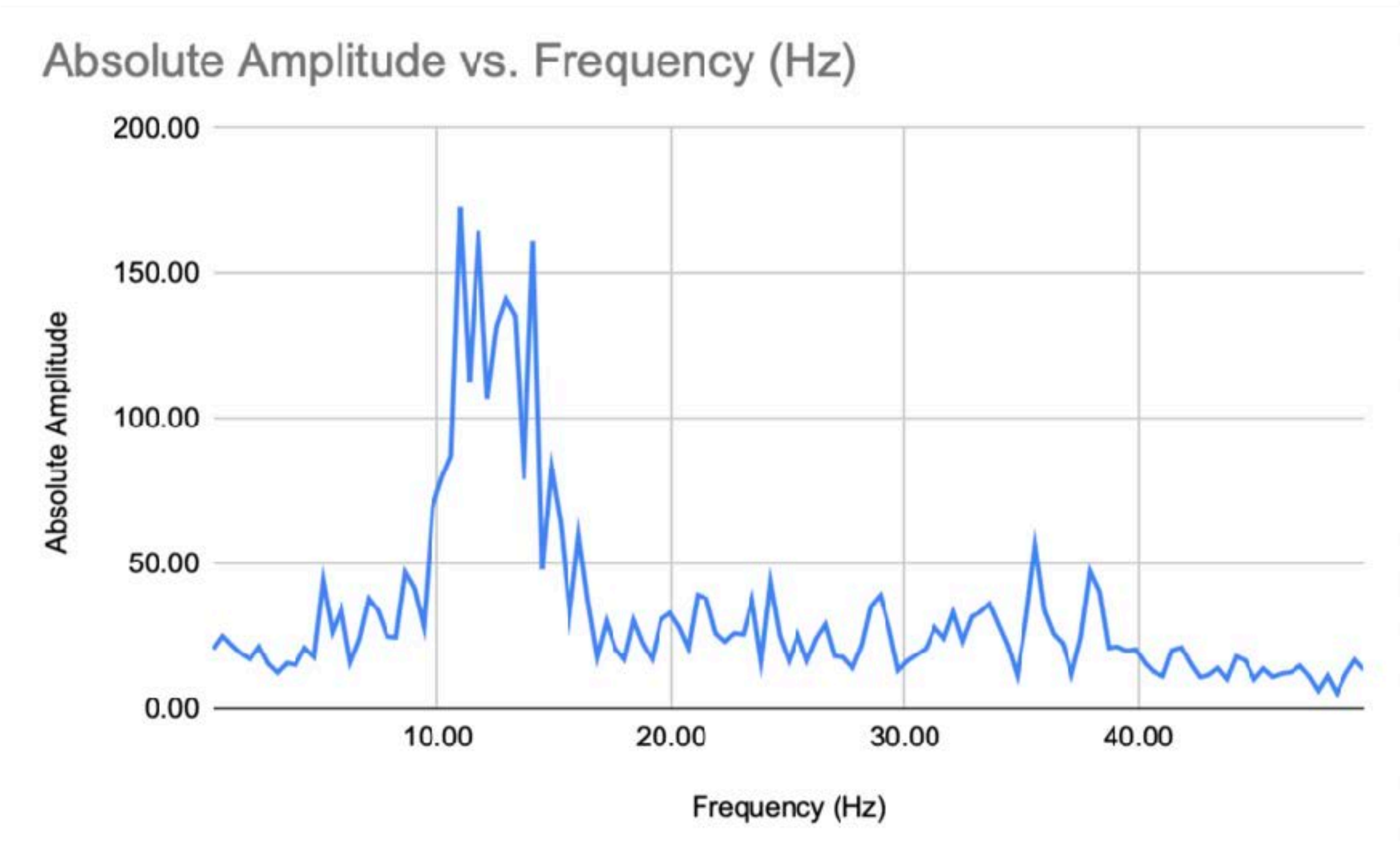




Chassis Vibrational Analysis

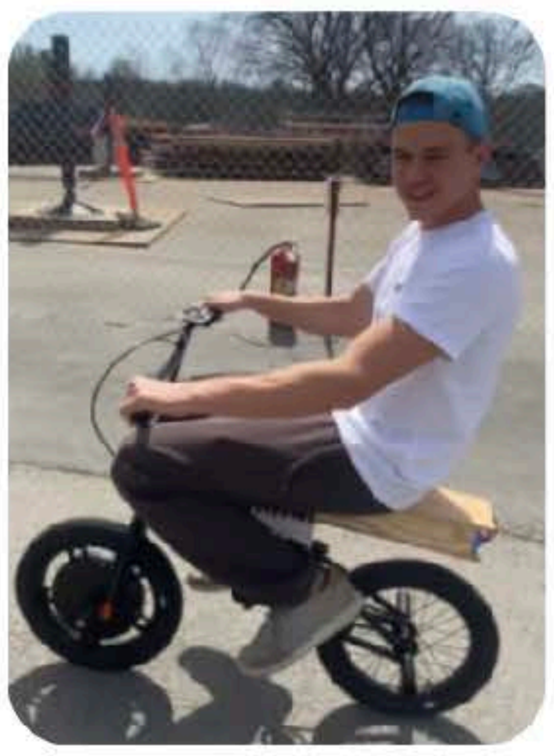
A lumped parameter model was developed to simulate the natural frequencies of the system. This provided insight into the parameters driving chassis behavior and helped tune the structure for optimal riding characteristics.



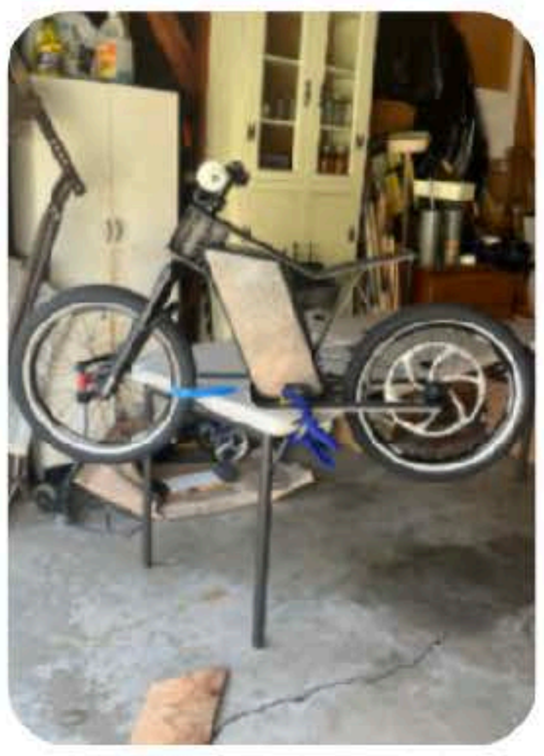


Manufacturing and Prototyping - Iterative Journey

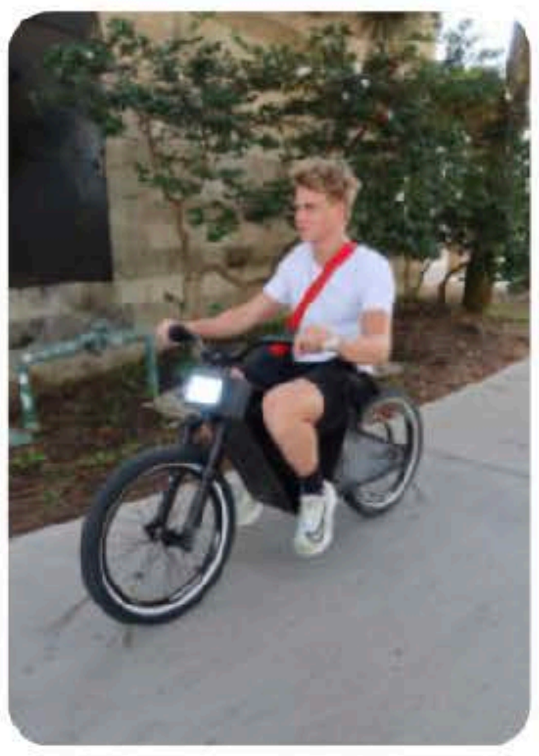
The project originated in April 2024 and steadily evolved in scale and complexity over the following two years, ultimately resulting in the final P1 platform. Prior to the P1, six distinct prototype generations were designed, manufactured, and tested.



Yamaglide



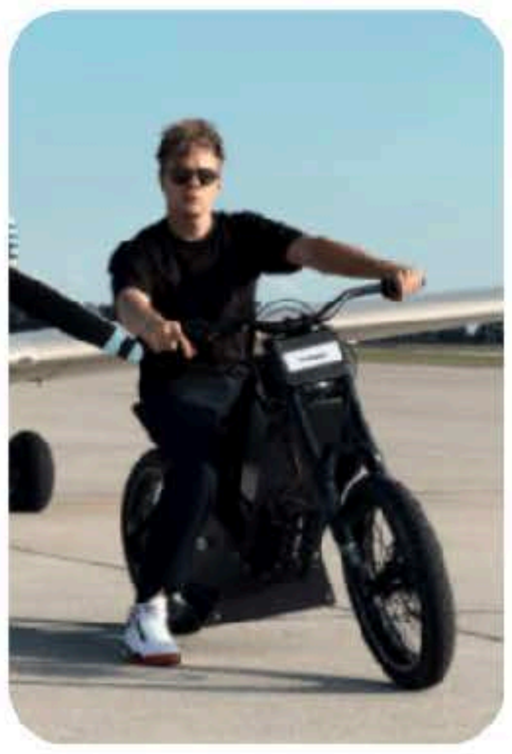
Cyberglide 1.0



Cyberglide 2.0

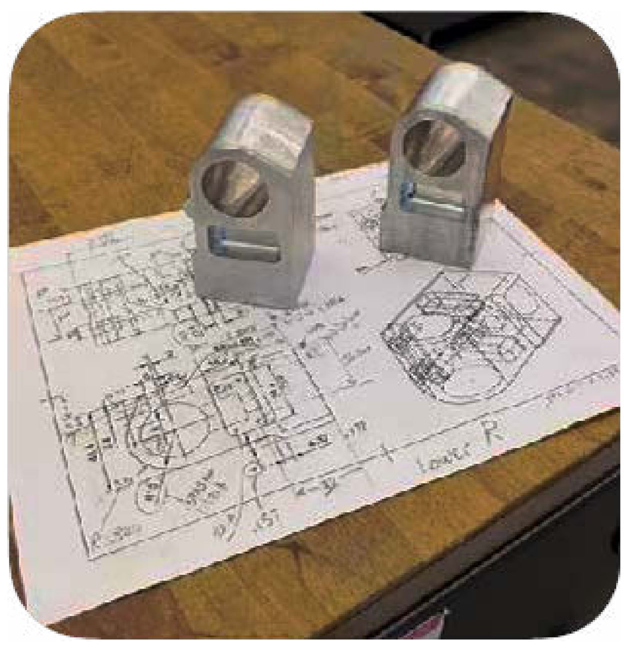
27

Darkster 1.0



Darkster 2.0

The manufacturing process involved extensive composite fabrication, battery assembly, electrical integration, and precision machining.



Road Testing and Validation

To validate the usability of the P1 in day-to-day operation, as well as its initial resistance to fatigue and wear, over 500 km of road testing was accumulated on the prototype. Early user feedback was also collected, helping define the direction of the next iteration and next steps.

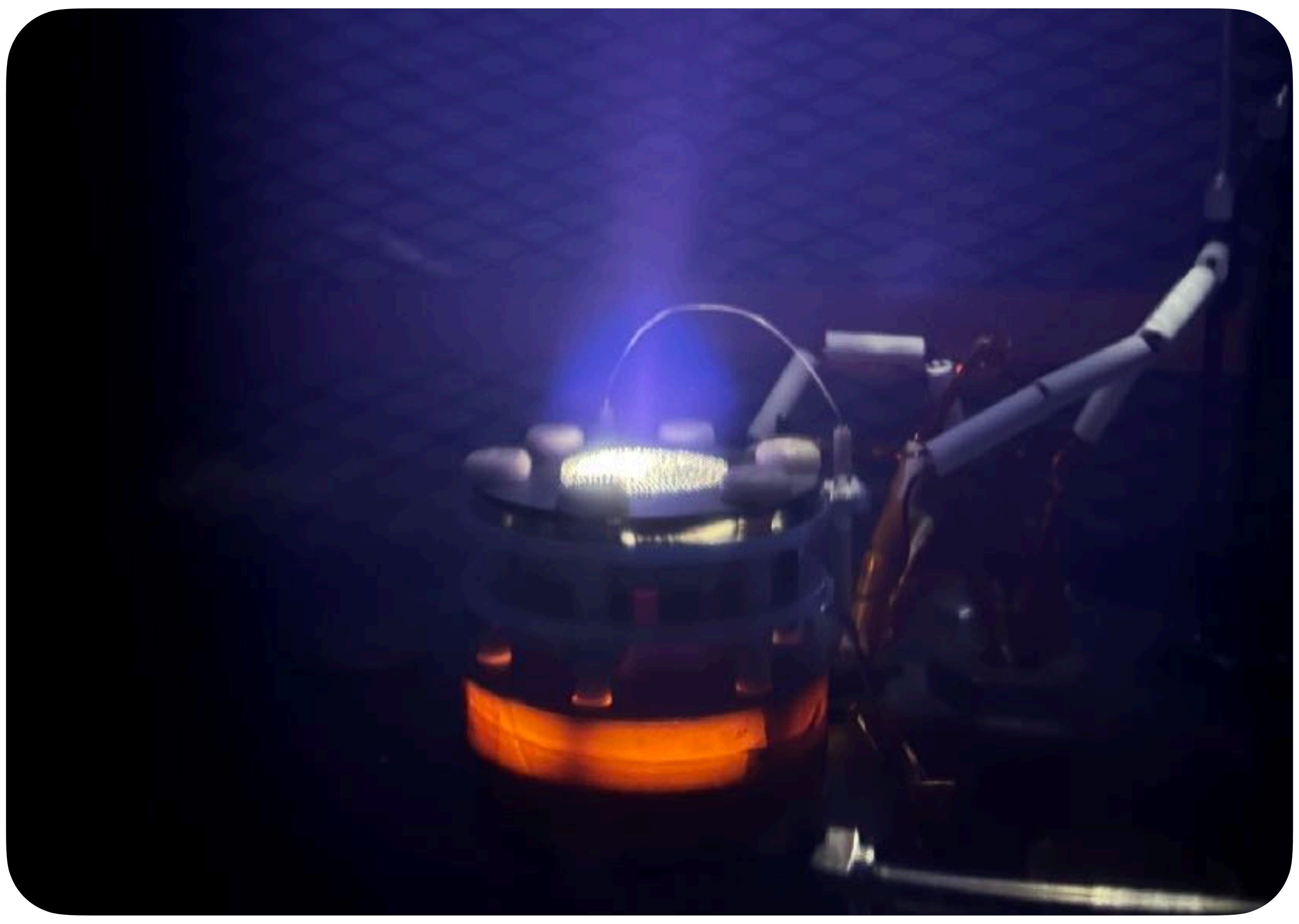
More can be found at: **https://ply-labs.com**

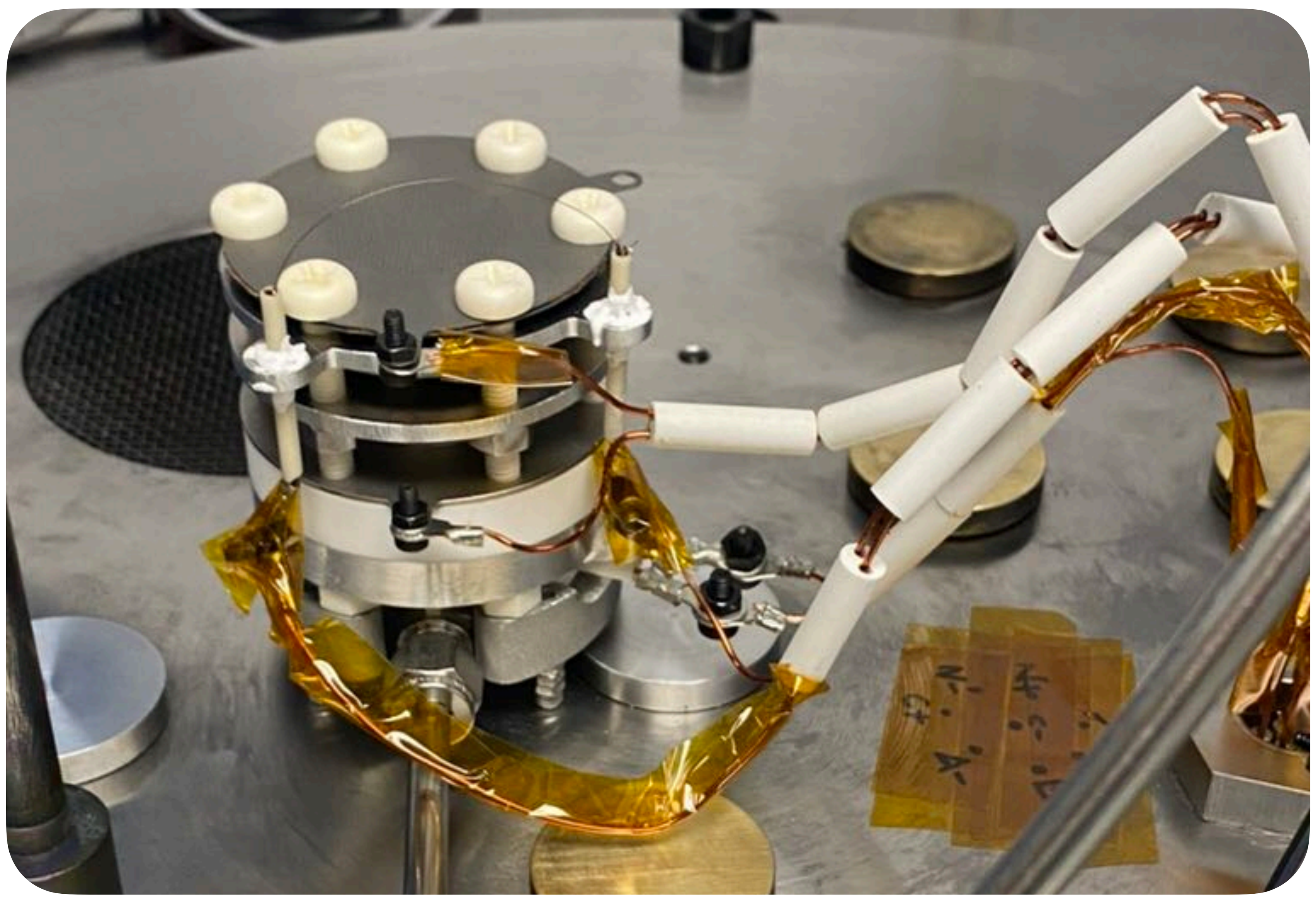
Electric Propulsion Group

Miniature 3cm 135W Gridded Ion Thruster

Mechanical Design Lead - Mechanical Design - Plasma - Systems Integration
Independent Research Group at Rose-Hulman Institute of Technology

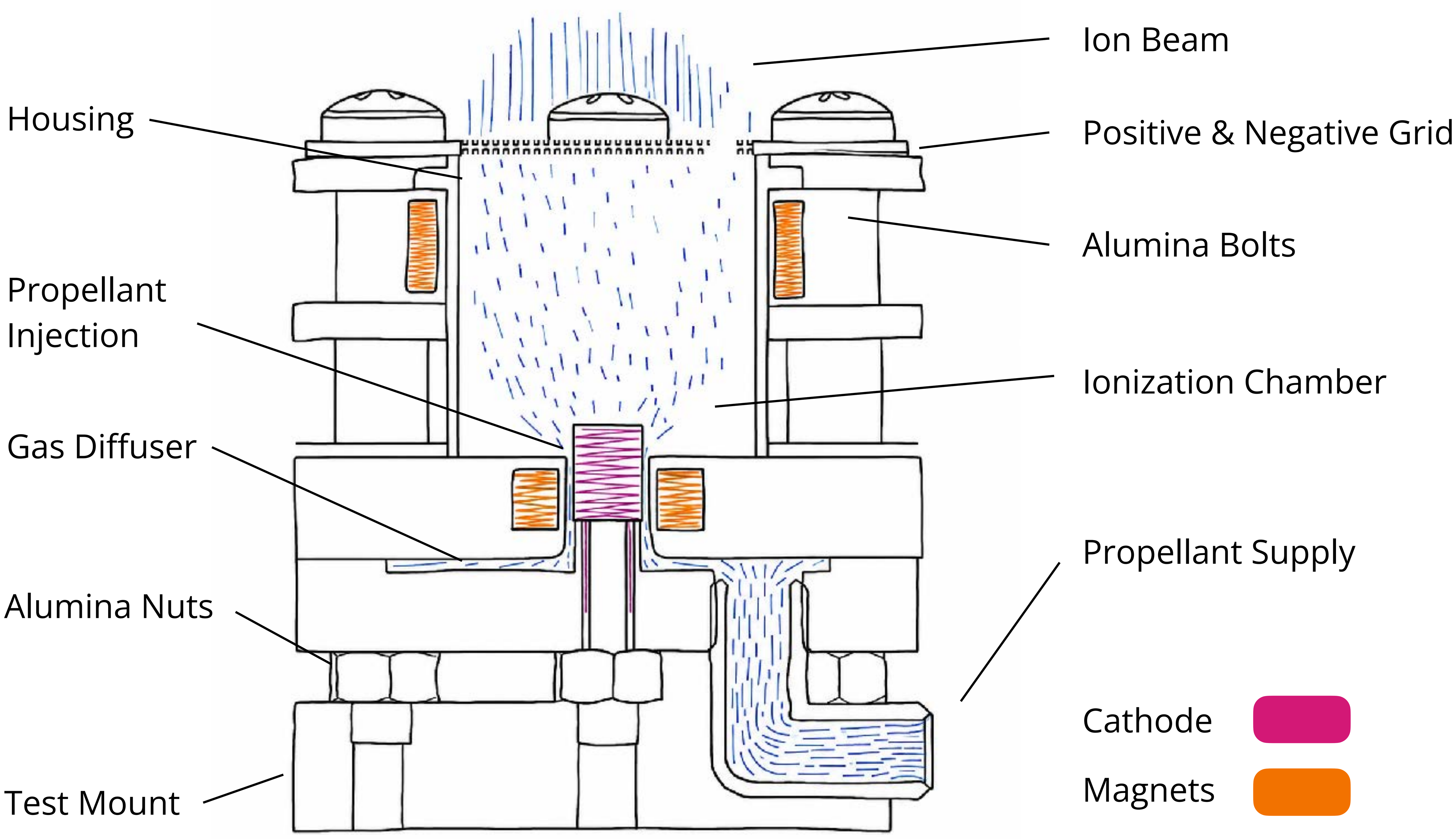
Ion propulsion has traditionally been associated with deep space exploration and advanced research laboratories. The goal of this project was to develop a functional and affordable miniature gridded ion thruster within an undergraduate engineering environment.

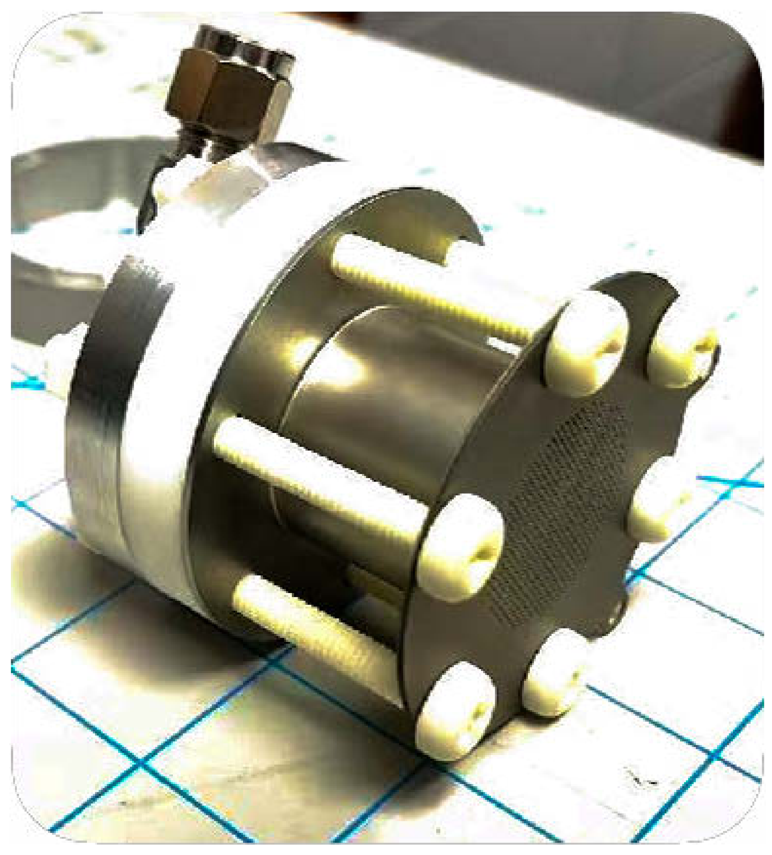




My Contribution to the Project - Mechanical Design

I was responsible for the complete mechanical structure of the thruster. The primary challenge was material selection to ensure structural stability under high temperatures and vacuum conditions.





IEEE Publication - 2024 IEEE Aerospace Conference

The project resulted in the publication of Development of an Undergraduate DC-Discharge Ring-Cusp Miniature Gridded Ion Thruster at the 2024 IEEE Aerospace Conference.

DOI: 10.1109/AERO58975.2024.10521066

Skyleader Aero

Components for Skyleader 400 and 600

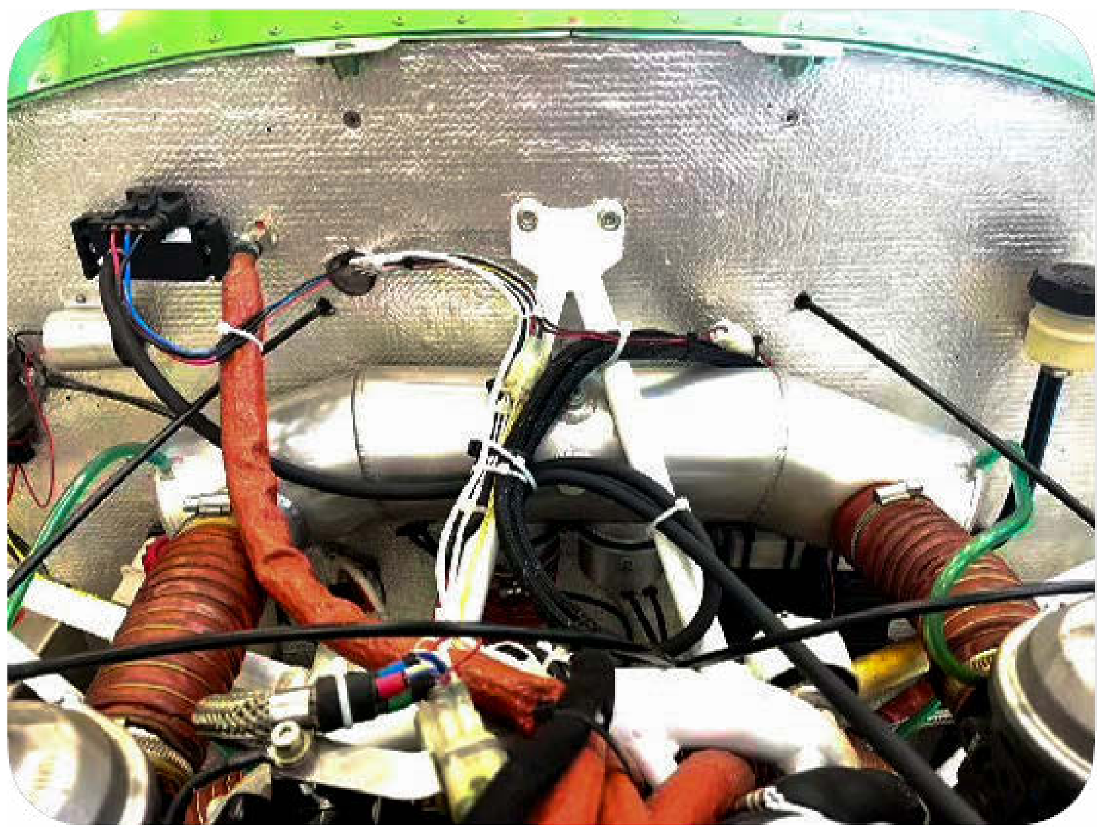
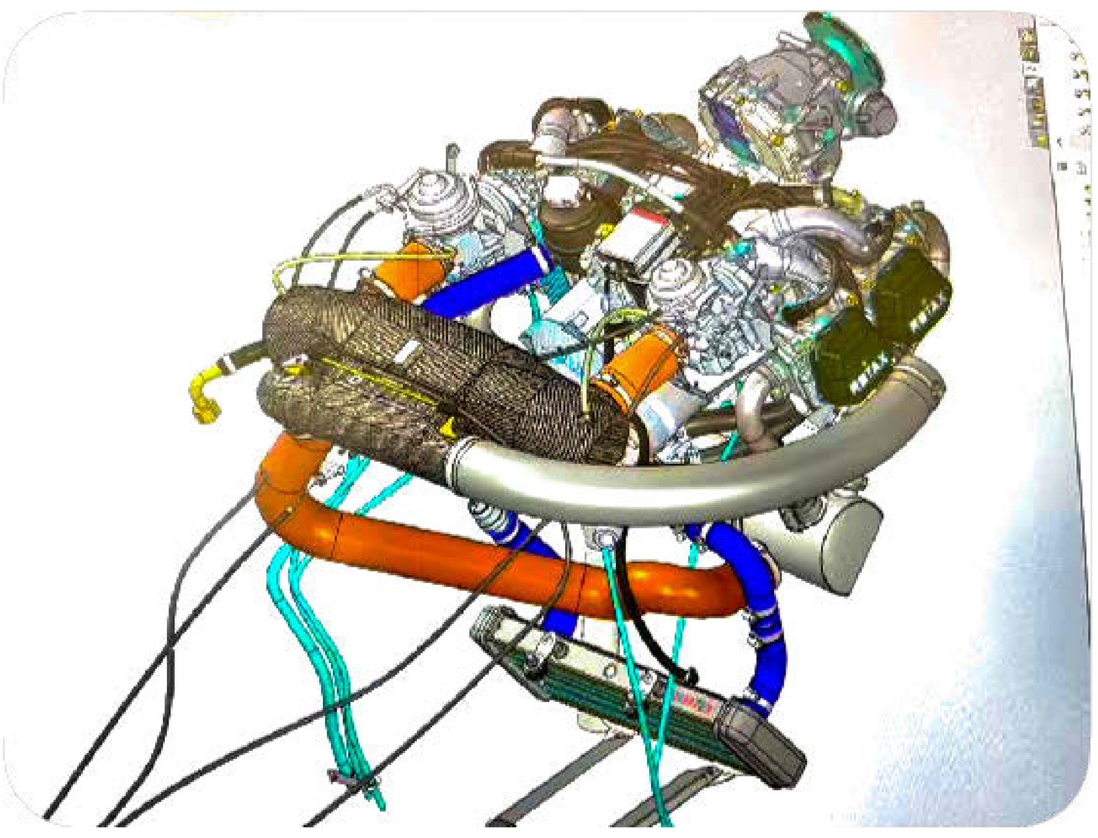
Mechanical Design Intern - Mechanical Design - Composites Engineering - UI Design
3 Month Full Time Summer Internship

Skyleader is a Czech manufacturer of ultralight aircraft. During my summer internship, I focused on the design of composite aircraft components with emphasis on structural integrity, weight optimization, and production feasibility.

My work was divided into three primary projects:

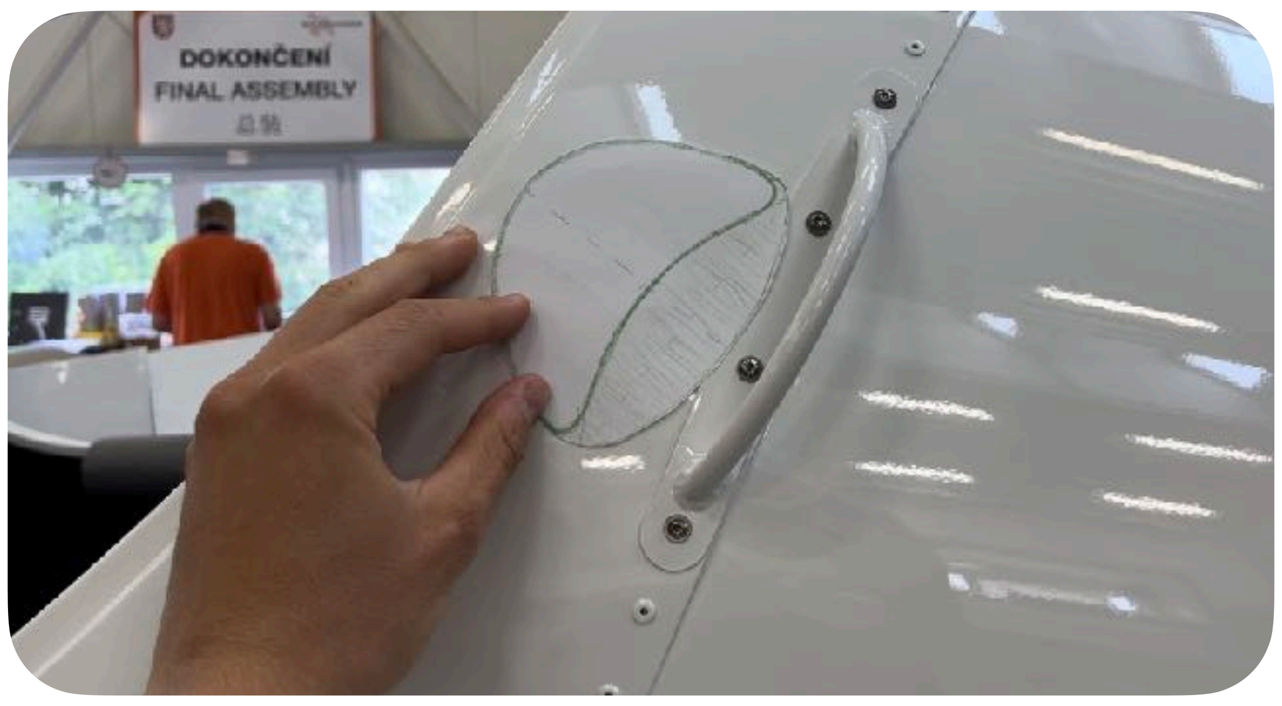
Composite Airbox - Skyelader 400 and 600

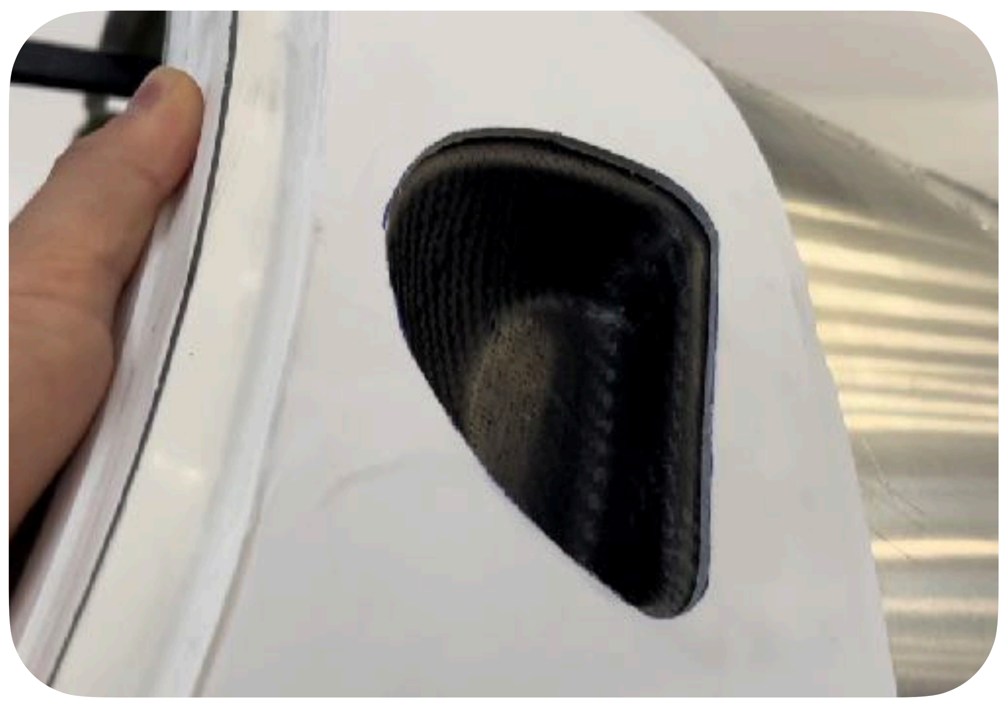
The original welded aluminum airbox was redesigned as a lightweight carbon fiber composite structure.


Composite Door Handle - Skyleader 600

An opening in the outer aircraft surface was redesigned to replace an external welded handle with an integrated recessed composite handle.



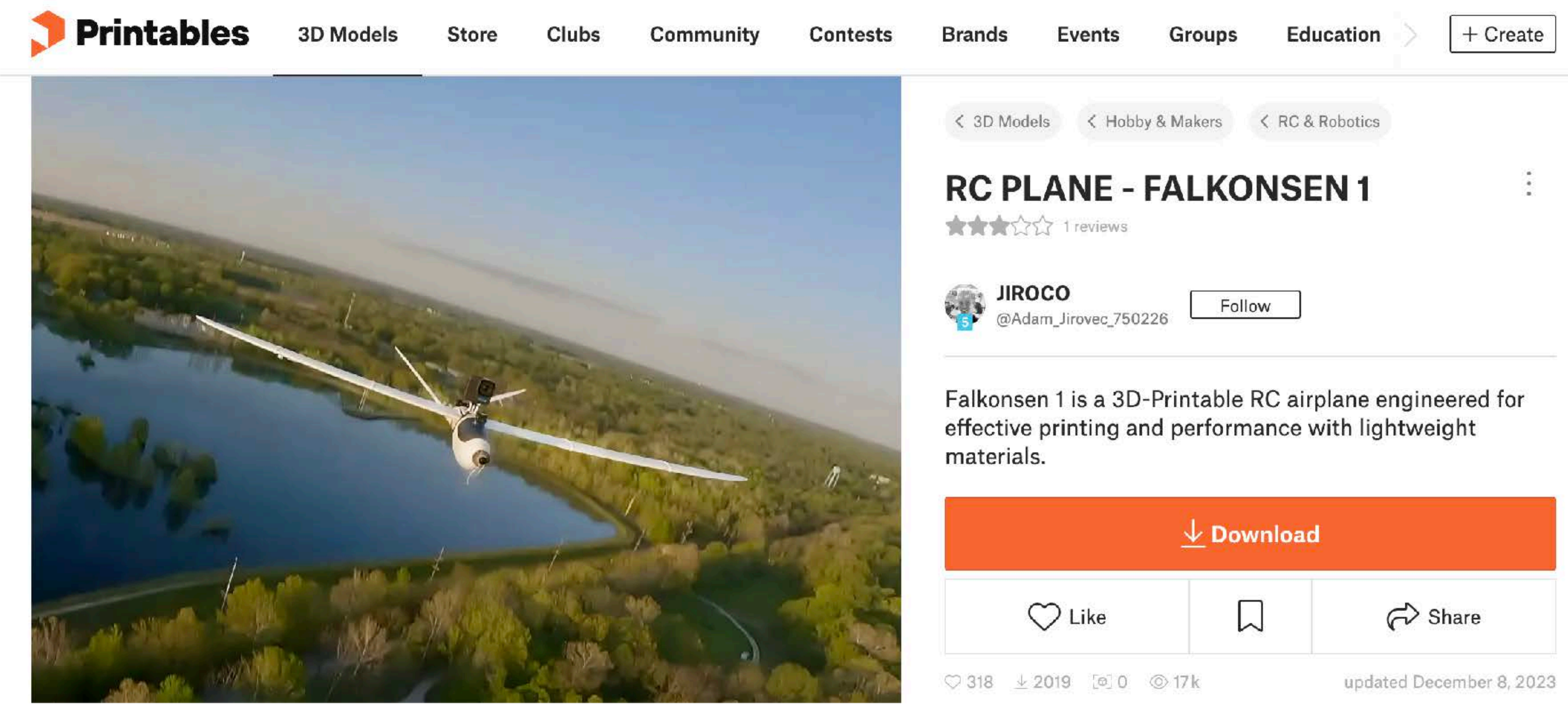
Engine Bay Door Prop Rod - Skyleader 400

A lightweight composite and 3D-printed support structure was developed to hold the engine bay door open during maintenance and preflight inspection procedures.


3D Printed Fixed-Winged Remote Control Aircraft

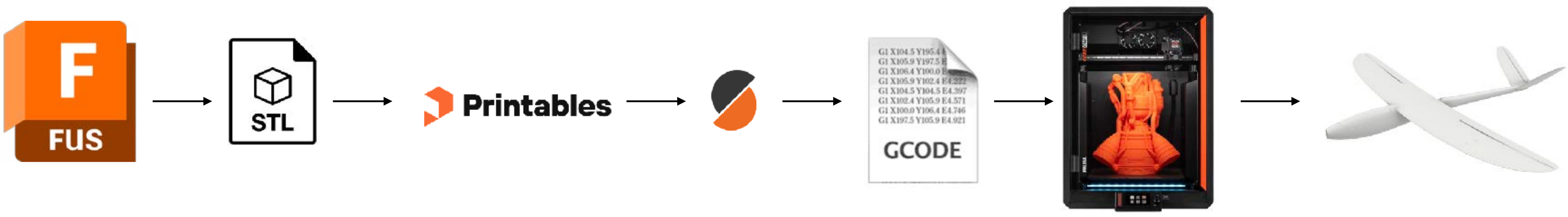
Falkonsen 1 - Globally downloadable - Printable within hours

Independent Project - Mechanical Design - Aerospace Additive Manufacturing -
Personal Endeavor and Small Scale Digital Product Start-up



The Concept of 3D-Printable Aircraft

A complete CAD model generates printable component files that can be distributed digitally worldwide. Using consumer-grade 3D printers and commercially available electronics, the aircraft can be manufactured, assembled, and flown within hours.



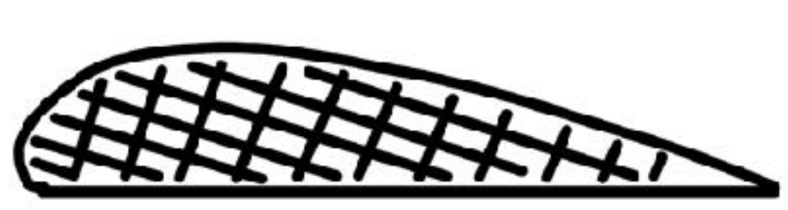
Structural Optimization Through Surface Mode Design

Normal Slicing

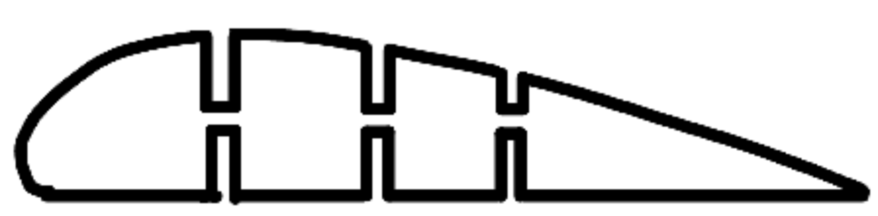
Most 3D Printed airplanes are sliced as solid bodies and the slicer generates unoptimized infill structures.

Surface Mode

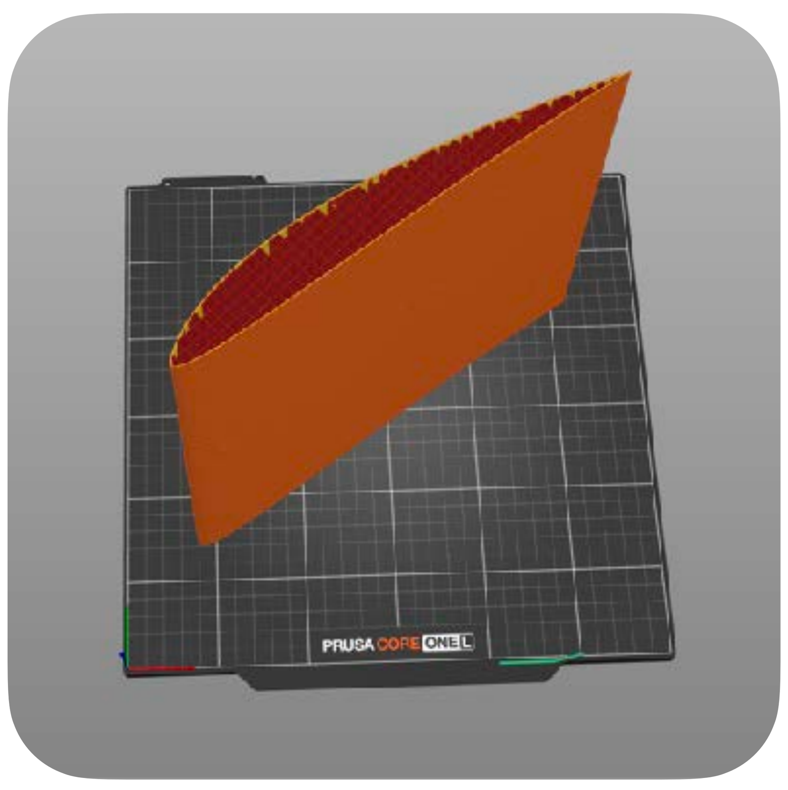
Falkonsen 1 utilizes surface shells that generate optimized paths, save weight and printing time

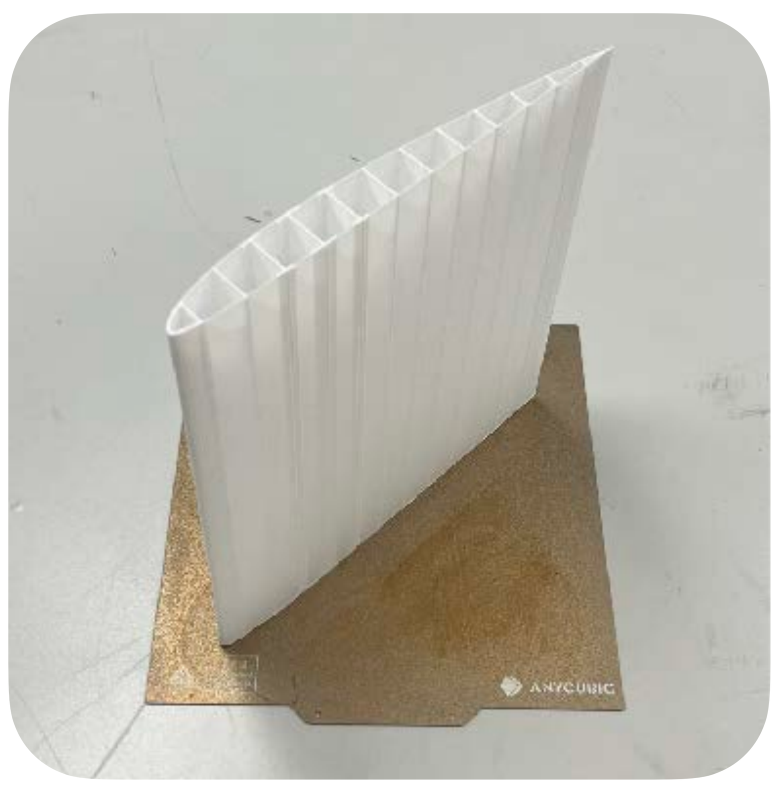


Normal Slicing



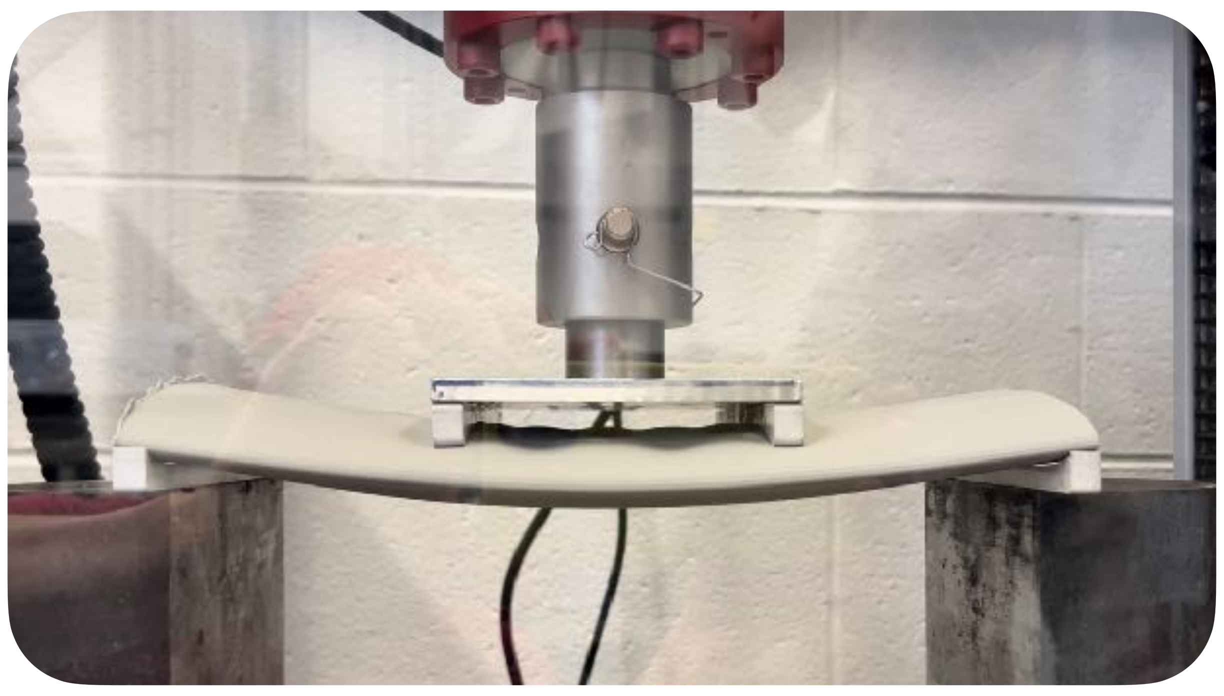
Surface Mode





Research under Dr. Matt Riley

Four-point bending tests were conducted on surface-mode 3D printed wing sections manufactured from multiple polymers, including PLA, LW-PLA, ABS, PETG, and CF-Nylon, to evaluate structural stiffness and material performance.

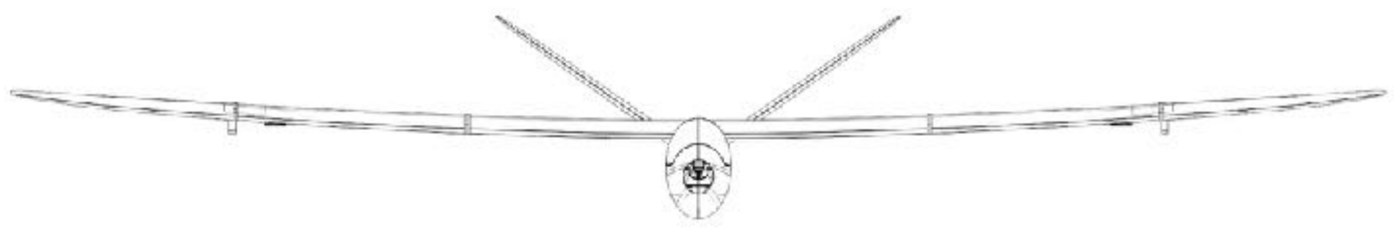
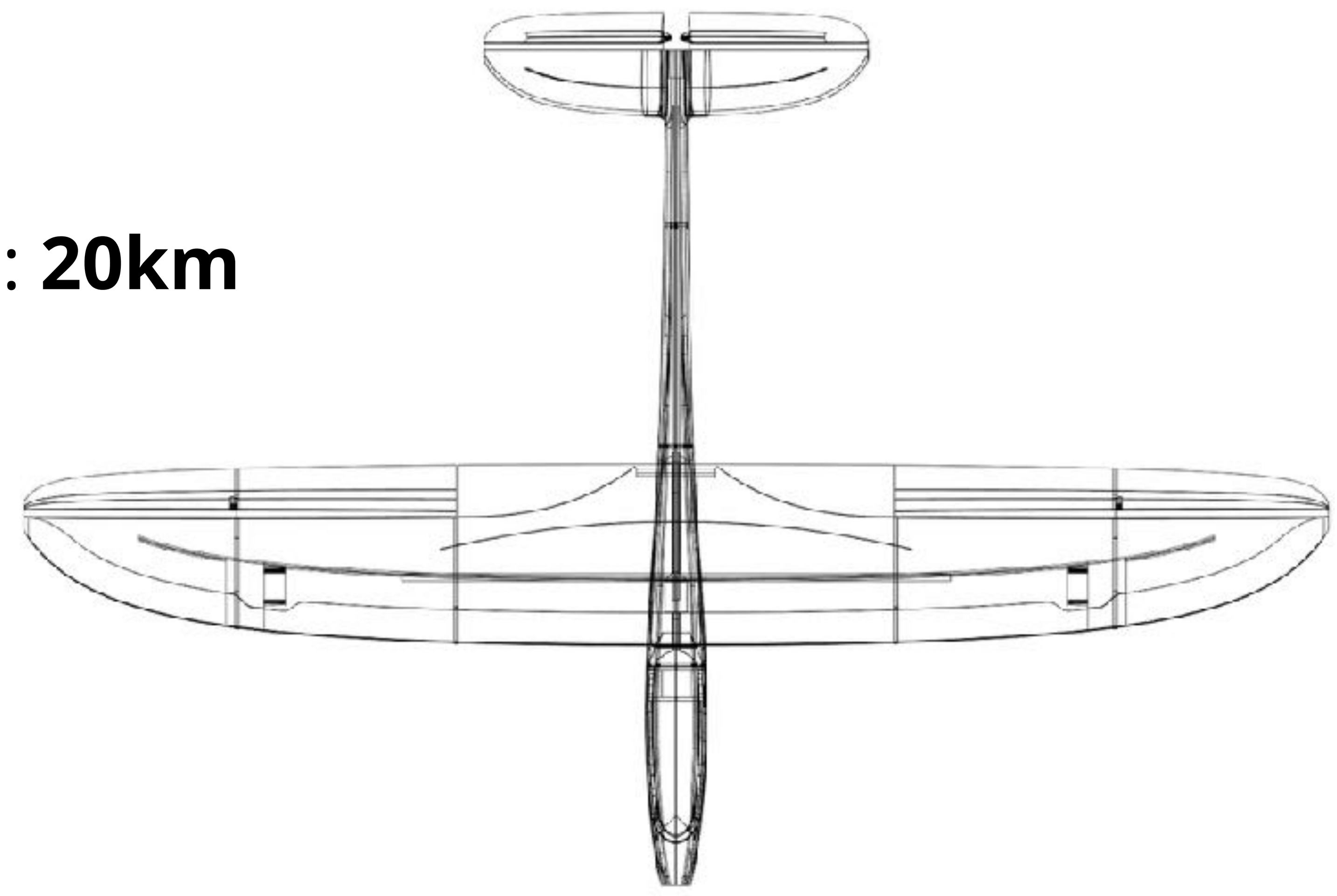




Performance Metrics - Lightweight, Efficient, Versatile

The aircraft can be equipped with onboard FPV systems and high-resolution cameras, extending its application beyond the hobby environment into aerial imaging, exploration, and utility-focused operations.

Validated Performance Specifications:

Takeoff Weight: **450g** - Max Speed: **150 km/h** - Range: **20km**

Project Impact - Built Worldwide

Following its release on online platforms such as Printables and Thingiverse, the Falkonsen 1 platform has been downloaded and built by makers across the world, spanning all continents and backgrounds, from students and teachers to engineering professionals.




The development of the Falkonsen 1 platform and its origins during my freshman year at Rose-Hulman Institute of Technology were also featured in an institute publication.

In First Year at Rose-Hulman, Student Designs and Develops 3D-Printed, Remote-Controlled Plane

SUNDAY, JUNE 18, 2023

As a first-year student at Rose-Hulman, Adam Jirovec was able to fully design and create a 3D-Printed, Remote-Controlled plane, called "Falkonsen 1," that flies up to 80 miles per hour.

←

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Great engineering is built through persistence and iteration.