# Project Icarus – Top Aéro
# ($\mu$-fusée)

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## Abstract

This report presents Project Icarus, a micro-class rocket designed, manufactured, and launched as part of the Top Aéro association's initiative at Sorbonne Université. The primary objective was to develop a reusable rocket capable of achieving a target apogee of approximately 500 meters. The project followed an iterative development methodology, incorporating aerodynamic simulation with OpenRocket, detailed computer-aided design (CAD), and fabrication of components using 3D printing with PLA+ material. The rocket featured a custom electronics bay with a servo-actuated parachute deployment system. The project culminated in a launch campaign, where an on-site modification to an eight-motor configuration enabled the rocket to achieve an apogee greater than 500 meters, followed by a successful parachute deployment. Project Icarus served as a comprehensive validation of applied engineering principles and demonstrated the team's ability to solve complex interdisciplinary challenges.

# Contents

# 1 Introduction

This technical report details the design, manufacturing, and launch of the Icarus rocket, a micro-class rocket developed as part of the Top Aéro association's micro-fusée initiative at Sorbonne Université. The project was undertaken during an 8-month academic exchange program. The primary objective of Project Icarus was to successfully design, build, and launch a reusable micro-rocket, achieving a target apogee of approximately 500 meters. The project covered all phases, from simulation and CAD design to 3D printing, electronics integration, launch and recovery.

# 2 Methodology and Project Phases

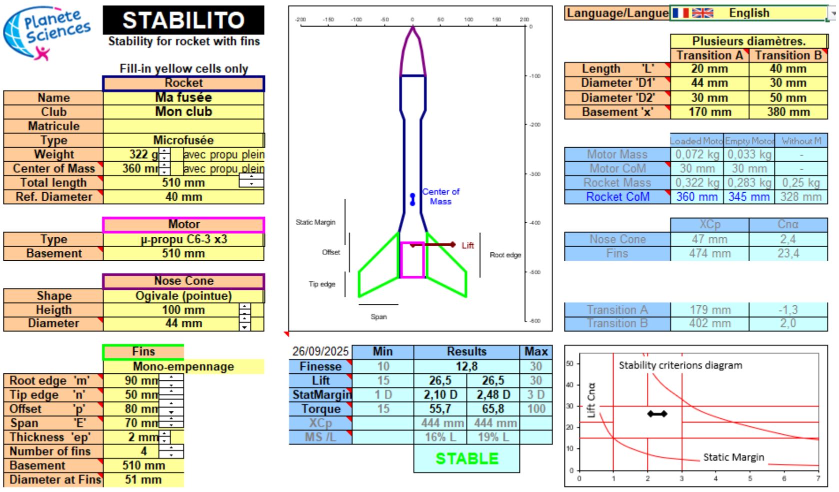
The project followed an iterative development methodology, cycling through design, analysis, and prototyping stages to refine the rocket's performance and reliability.

## 2.1 Preliminary Design with OpenRocket

The initial design phase was conducted using OpenRocket, an open-source model rocket simulator. This software allowed for the preliminary definition of the rocket's architecture, including the selection of materials, the number and shape of components, and the initial placement of the center of mass (CM) and center of pressure (CP). Several design iterations were simulated to optimize for stability and performance, focusing on achieving a stable flight profile with the selected motor.

## 2.2 Feasibility Calculations

To validate the OpenRocket simulations and gain a deeper understanding of the flight dynamics, a custom spreadsheet (**StabTraj**) was used. This tool was used to calculate key flight parameters, including the expected trajectory, apogee, maximum velocity, and stability margin. The data from the spreadsheet was used to iteratively revise the design in OpenRocket, ensuring that the theoretical performance met the project's objectives.



STABILITO

Stability for rocket with fins

Fill-in yellow cells only

| | Rocket | |
|---|---|---|
| Name | Ma fusée | |
| Club | Mon club | |
| Matricule | | |
| Type | Microfusée | |
| Weight | 322 g | avec propu plein |
| Center of Mass | 360 mm | avec propu plein |
| Total length | 510 mm | |
| Ref. Diameter | 40 mm | |

| | Motor |
|---|---|
| Type | µ-propu C6-3 x3 |
| Basement | 510 mm |

| | Nose Cone |
|---|---|
| Shape | Ogivale (pointue) |
| Heigth | 100 mm |
| Diameter | 44 mm |

| | Fins |
|---|---|
| | Mono-empennage |
| Root edge 'm' | 90 mm |
| Tip edge 'n' | 50 mm |
| Offset 'p' | 80 mm |
| Span 'E' | 70 mm |
| Thickness 'ep' | 2 mm |
| Number of fins | 4 |
| Basement | 510 mm |
| Diameter at Fins | 51 mm |

| Language/Langue | English |
|---|---|

| | Plusieurs diamètres. | |
|---|---|---|
| | Transition A | Transition B |
| Length 'L' | 20 mm | 40 mm |
| Diameter 'D1' | 44 mm | 30 mm |
| Diameter 'D2' | 30 mm | 50 mm |
| Basement 'x' | 170 mm | 380 mm |

| | Loaded Moto | Empty Motor | Without M |
|---|---|---|---|
| Motor Mass | 0,072 kg | 0,033 kg | - |
| Motor CoM | 30 mm | 30 mm | - |
| Rocket Mass | 0,322 kg | 0,283 kg | 0,25 kg |
| Rocket CoM | 360 mm | 345 mm | 328 mm |

| | XCp | Cnα |
|---|---|---|
| Nose Cone | 47 mm | 2,4 |
| Fins | 474 mm | 23,4 |
| Transition A | 179 mm | -1,3 |
| Transition B | 402 mm | 2,0 |

| 26/09/2025 | Min | Results | | Max |
|---|---|---|---|---|
| Finesse | 10 | 12,8 | | 30 |
| Lift | 15 | 26,5 | 26,5 | 30 |
| StatMargin | 1 D | 2,10 D | 2,48 D | 3 D |
| Torque | 15 | 55,7 | 65,8 | 100 |
| XCp | | 444 mm | 444 mm | |
| MS /L | | 16% L | 19% L | |
| | | STABLE | | |

Figure 1: Stability analysis with the spreadsheet StabTraj

## 2.3 CAD Design

Following the preliminary design and feasibility analysis, each component of the rocket was modeled in detail using computer-aided design (CAD) software. Special attention was given to critical subsystems:

- **Parachute Bay:** Designed for reliable deployment of the parachute.

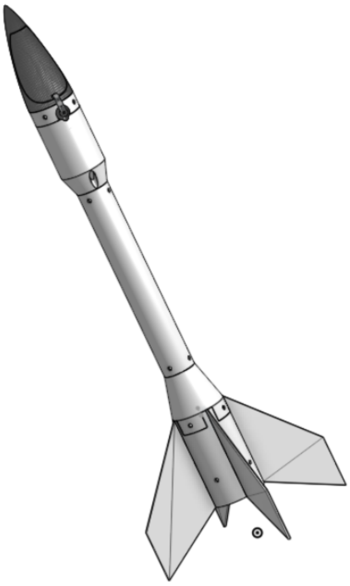


Figure 2: Rocket CAD design

- **Electronics Bay:** Sized to house the flight controller, servo, and battery, ensuring secure mounting and protection.
- **Threaded Inserts:** Pockets for threaded inserts were incorporated into the design to allow for robust assembly and disassembly of the rocket's sections.
- **Tolerances:** All components were designed with appropriate tolerances to ensure a proper fit after 3D printing.

## 2.4 Manufacturing and Assembly

The rocket's airframe and structural components were manufactured using a 3D printer with PLA+ filament, chosen for its strength and ease of printing. The manufacturing and assembly process included:

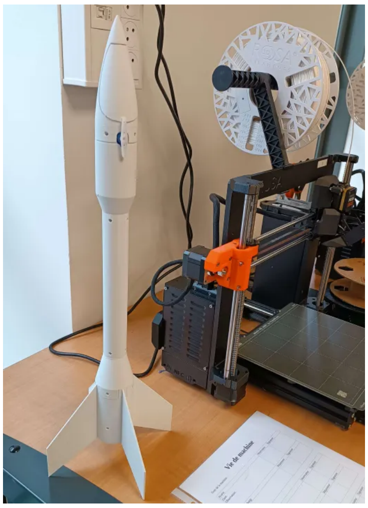


Figure 3: Icarus' first prototype

- **3D Printing:** All parts were printed, with careful attention to print settings to maximize layer adhesion and strength.

- **Post-Processing:** Minor post-processing, such as sanding and filing, was performed to ensure smooth surfaces and correct component fit.
- **Insert Installation:** Brass threaded inserts were thermally set into the designated pockets in the 3D-printed parts.
- **Ejection System Assembly:** The parachute ejection system, actuated by a servo motor, was assembled and tested.

### 2.5 Electronic Systems

The rocket's electronic system was responsible for controlling the parachute ejection sequence. The key components included:

- **Microcontroller:** A XIAO ESP32 was used as the flight computer due to its small form factor and built-in Bluetooth capabilities.
- **Actuator:** A FS90R servo motor was used to trigger the parachute deployment mechanism.
- **Power Source:** A 3.7V LiPo battery powered the electronic system.
- **Remote Control:** A custom mobile application was developed to interact with the rocket via Bluetooth, allowing for remote initiation of the countdown and launch sequence.

The system was programmed in the Arduino environment to execute a timed countdown and activate the servo at a predetermined point in the flight, estimated to be near apogee.

## 3 Rocket Technical Data

The final specifications of the Icarus rocket are presented in the table below.

| **Parameter** | **Specification** |
|---|---|
| Total Length | 510 mm (550 with fins) |
| Diameter | 50 mm |
| Thickness | 3 mm |
| Mass (with motor) | 322 g |
| Main Material | PLA+ |
| Motor | 4 x Klima C6-5 |
| Parachute | Klima 35 cm |
| Apogee (estimated) | 500 m |

Table 1: Icarus Rocket Technical Specifications

## 4 Testing and Launch

### 4.1 Preparation

Launch preparations were conducted with a strong emphasis on safety. A suitable launch site was selected in a rural area outside of Paris, ensuring a large, open area clear of obstacles. A safety perimeter was established, and a launch platform was used.

### 4.2 Initial Launches

The initial launch campaign focused on validating the rocket's structural integrity and the functionality of the parachute deployment system. The first flights with a cluster of four Klima C6-5 motors were successful, with the rocket exhibiting a stable ascent and the parachute deploying as planned, allowing for safe recovery.

### 4.3 Improved Variant

For the final launch, the Icarus rocket was modified on-site to substantially increase its total impulse. This version featured an eight-motor configuration, an increase from the previous four. To maintain stability with the added mass of the additional motors at the rear, a counterweight was added to the nose cone. This iteration successfully achieved an apogee greater than 500 meters, with the parachute system performing flawlessly.

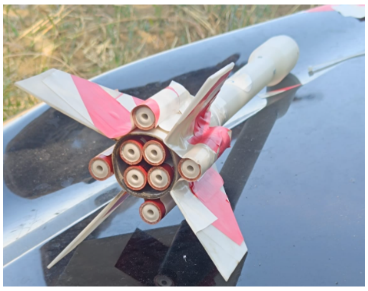


Figure 4: Icarus' final launch

## 5 Estimated Budget

The following table provides an estimated breakdown of the project costs.

| **Category** | **Estimated Cost (€)** |
|---|---|
| Printing Material (PLA+ ) | 30 |
| Inserts and Fasteners | 15 |
| Electronic Components | 25 |
| Motors | 50 |
| Parachute | 15 |
| Other (wires, battery, etc.) | 20 |
| **Total** | **155** |

Table 2: Estimated Project Budget

## 6 Conclusion

The Icarus project met its primary objective of designing, building, and launching a reusable micro-rocket to its target apogee. The project's lifecycle served as a practical application and validation of key engineering theories, proving the effectiveness of the iterative development methodology adopted.

Throughout the project, the team faced and overcame several technical difficulties inherent in rocketry development. A key challenge was maintaining flight stability after the on-site modification to an eight-motor configuration, which was managed through the analysis and implementation of a counterweight system. The integration of mechanical, electronic, and software systems also presented a complex task that was successfully resolved.

Ultimately, Project Icarus was a significant learning experience, allowing the team to develop a robust, interdisciplinary skillset spanning from simulation in OpenRocket and detailed CAD modeling to 3D printing, electronics design, and software development for the launch and ejection.

# 7 Appendix: CAD Drawings

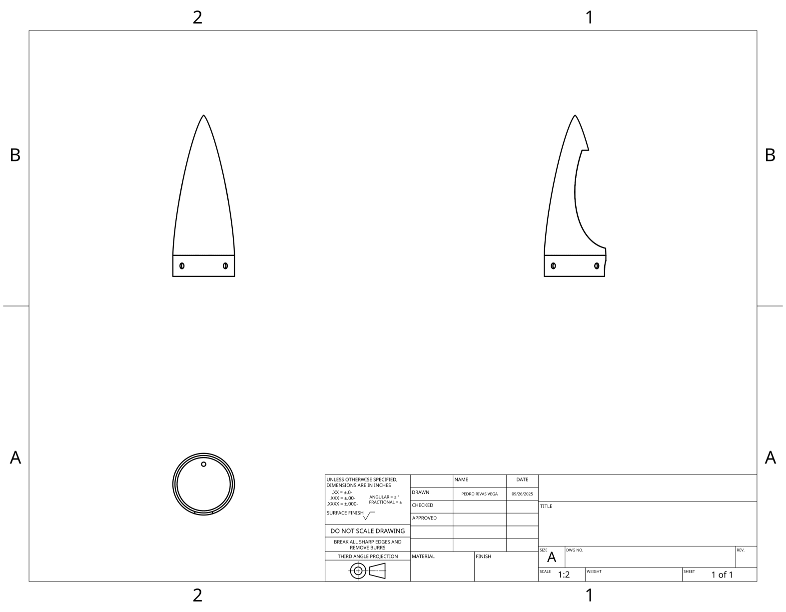


Figure 5: Nose Cone and Parachute Bay Assembly

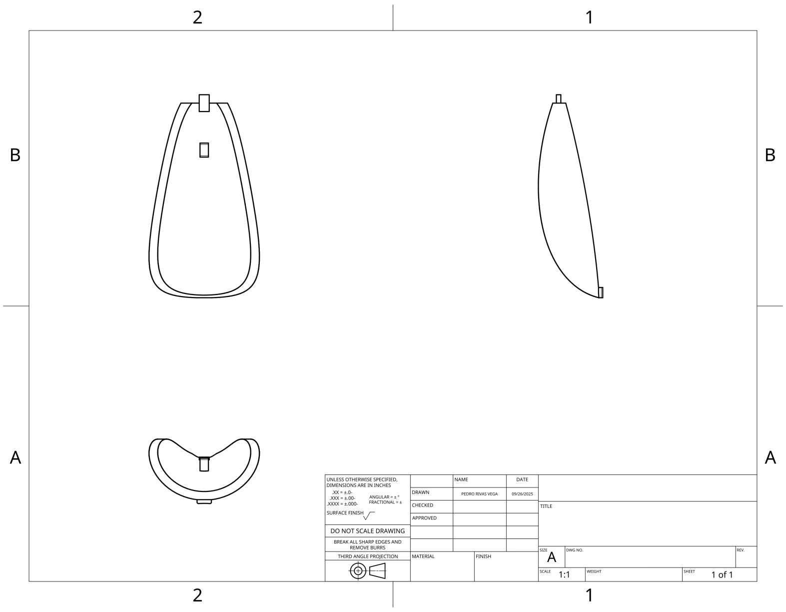


Figure 6: Parachute Bay Cover

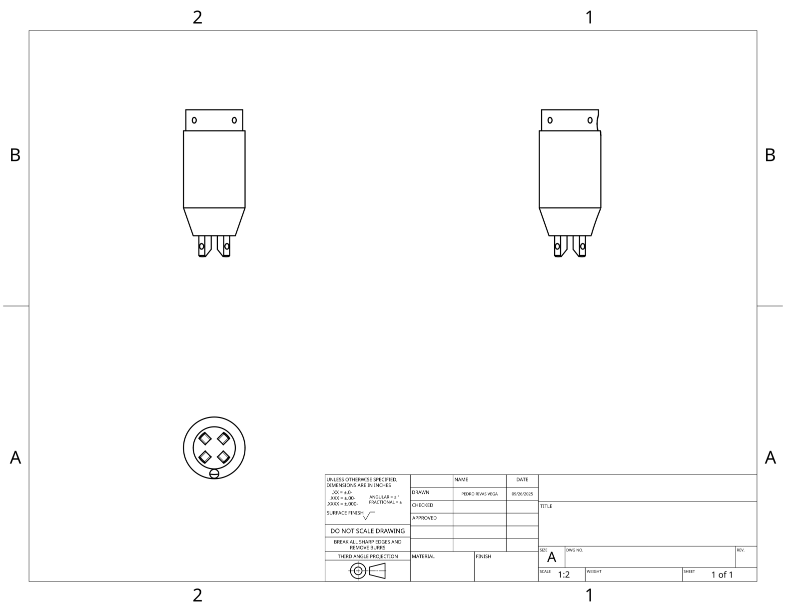


Figure 7: Electronics Bay and Upper Transition

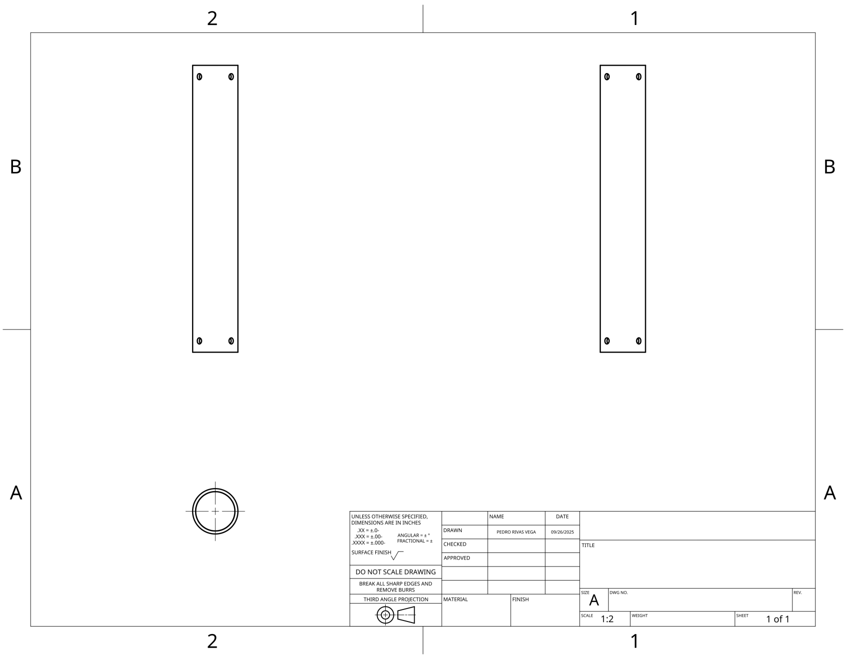


Figure 8: Main Body Tube

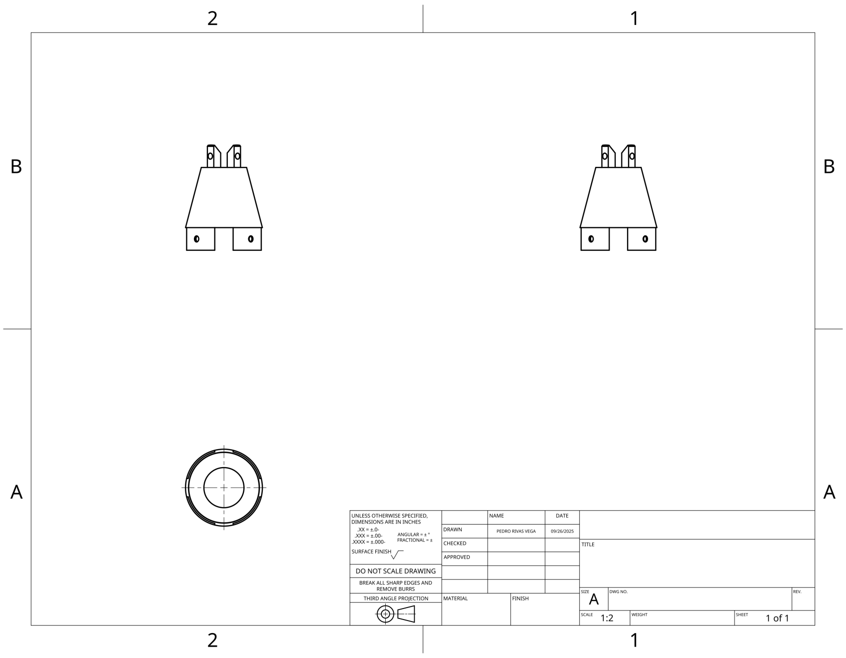


Figure 9: Lower Transition

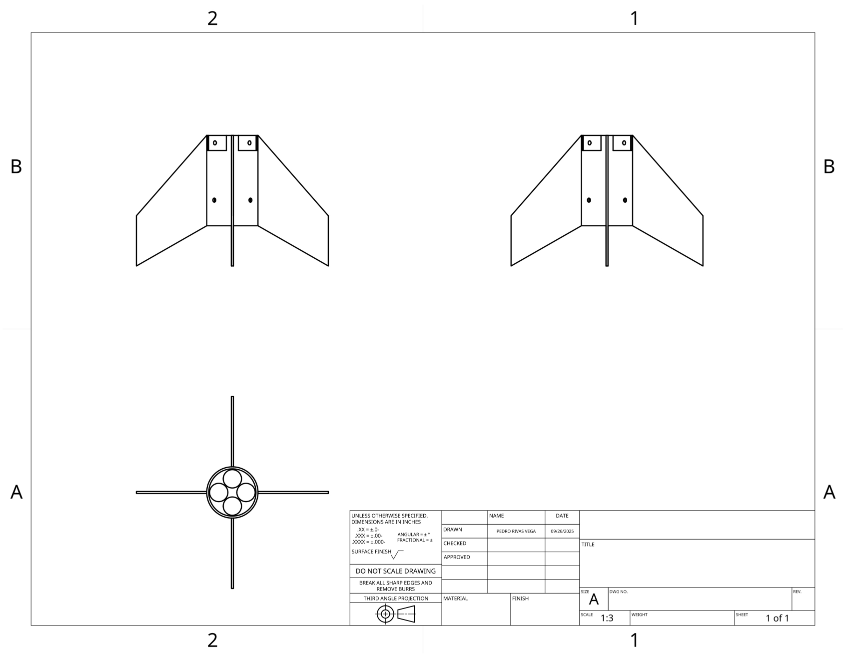
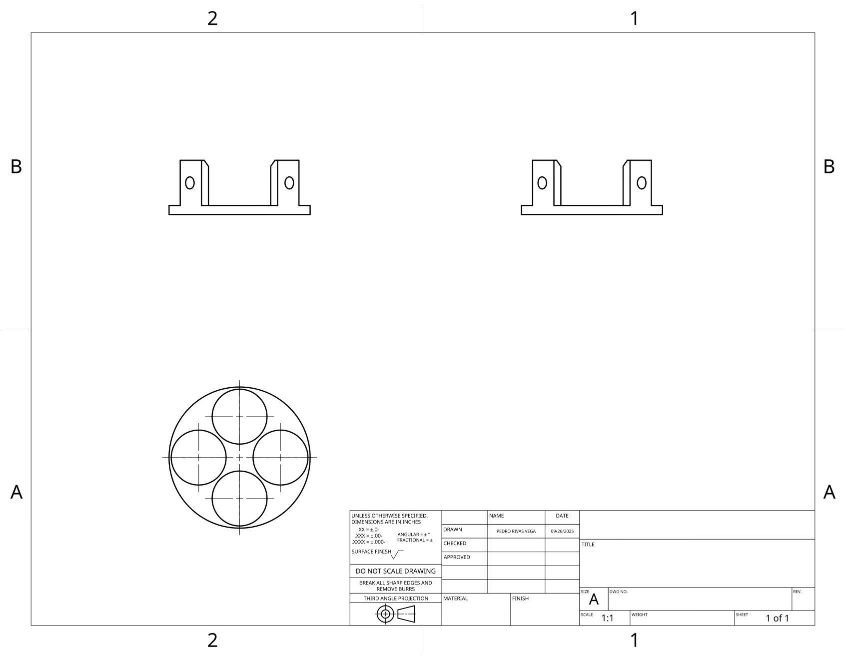


Figure 10: Fin and Motor Mount Assembly



UNLESS OTHERWISE SPECIFIED,
DIMENSIONS ARE IN INCHES
.XX = ±.0-
.XXX = ±.00-
.XXXX = ±.000-
ANGULAR = ± °
FRACTIONAL = ±
SURFACE FINISH

DO NOT SCALE DRAWING

BREAK ALL SHARP EDGES AND REMOVE BURRS

DRAWN PEDRO RIVAS VEGA 09/26/2025

SIZE A

SCALE 1:1

SHEET 1 of 1

Figure 11: Motor Retainer