Final Subsystem Design

UAVPayload^{TAQ} Payload Enclosure

Revision Record

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Definitions

ED	Enclosure Design
ST	Sampling Tube
AQS	Air Quality Sensor
GPIO	General Purpose Input Output

1 Introduction

This document is a final design of UAVPAYG19 for the subsystem of Enclosure Design (ED). A final design report is an essential part of the System Engineering Design Approach as it provides an overview of the subsystem and provides a seamless transition to developing the final solution.

This document outlines the ED subsystem requirements provided in RD/1 and how these requirements are to be achieved. A Subsystem Architecture is shown which describes the interfaces this subsystem has with the others. These interface are further expanded upon in document RD/4. The final design of the enclosure with modelling images and shown with justifications to the design choices.

1.1 Scope

This final design document of the ED subsystem contains details on the subsystem design and its interfacing connections to the other systems and will discuss how requirements are to be achieved.

1.2 Background

The Queensland University of Technology's Airborne System Lab (ASL) has commissioned the group UAVPAYG19 to design and develop a payload capable in detecting specific objects, recording air quality data to be displayed on a web interface and to pierce a ground sample. This payload is to be attached to a S500 UAV which will complete an automated flight path. The payload is mounted on the bottom of the UAV using a provided bracket. This payload must contain all components to complete its required tasks. These components are:

- Raspberry Pi 3b+
- Raspberry Pi Camera
- Pimoroni Enviro+ sensor
- DF15RSMG 360 Degree Motor

The payload is required to identify three targets, a valve (In open or closed position), a fire extinguisher and an ArUCO marker. The Pimoroni sensor is to be used to record air temperature, pressure humidity, light and potentially hazardous gas level data. This data along with a live feed of the Raspberry Pi Camera is to be visualized on a Web Interface. Lastly a soil sample must be obtained using a sampling mechanism.

2 Reference Documents

2.1 QUT Avionics Documents

RD/1	UAV - Customer Needs	Advanced Sensor Payload for UAV Target Detection and Air Quality Monitoring in GPS Denied Environments
RD/2	UAV - System Requirements	UAVPayloadTAQ System Requirements
RD/3	UAVPAYG19-PM-PMP-02	PMP
RD/4	UAVPAYG19-ICD-01	ICD
RD/11	UAVPAYG19-ED-D1-02	Main Enclosure Drawing
RD/12	UAVPAYG19-ED-D2-02	Enclosure Lid Drawing
RD/13	UAVPAYG19-ED-D3-02	Enclosure Plate Drawing
RD/14	UAVPAYG19-ED-D4-02	Enclosure Motor Mount Drawing
RD/20	UAVPAYG-19-ED-TR-01	Enclosure Test Report
RD/29	UAVPAYG19-AQS-FD-02	AQS Final Design Report
RD/30	UAVPAYG19-TAIP-FD-02	TAIP Final Design Report
RD/31	UAVPAYG19-ST-FD-02	ST Final Design Report

2.2 Non-QUT Documents

DOC/1	IP-Rating-PDF	Alpeco, “IP Rating Reference Chart”, n.d. [Online]. Available: https://www.alpeco.co.nz/downloads/IP%20Rating%20Form.pdf. [Accessed 26/08/2022]I

3 Subsystem Introduction

The Enclosure subsystem primary purpose is to protect and contain all other payload components. This enclosure was modelled and fabricated using a 3D printer with the design meeting the Ingress Protection level of IP41. This standard requires the structure to provide protection from tools and small wires greater than 1 millimetre and protection from condensation (DOC/1). To ensure these standards are met, the design contains no openings >1mm and the design shape prevents any condensation from forming within the payload. The payload also allows for the Enviro Sensor's LCD screen to be visible, and it also has a suitable attachment for interfacing with the Sampling Tube subsystem.

3.1 Subsystem Requirements

Requirement	Description	Verification
REQ-M-01	The UAVPayloadTAQ shall remain under the maximum weight of 320 g and comply with an IP41 rating. The air quality sensors must be exposed to the environment to allow for accurate reading.	**REQ-M-01**
REQ-M-13	The LCD screen shall be placed on the side of the payload in order for the user to easily see its operation during flight.	**REQ-M-13**
REQ-M-14	Developed solution shall conform to the systems engineering approach.	**REQ-M-14**

4 Subsystem Architecture

The Enclosure Design subsystem interfaces with all physical components in the project. This includes the Raspberry Pi, Raspberry Pi Camera, The Pimoroni Sensor & LED screen and Motor.

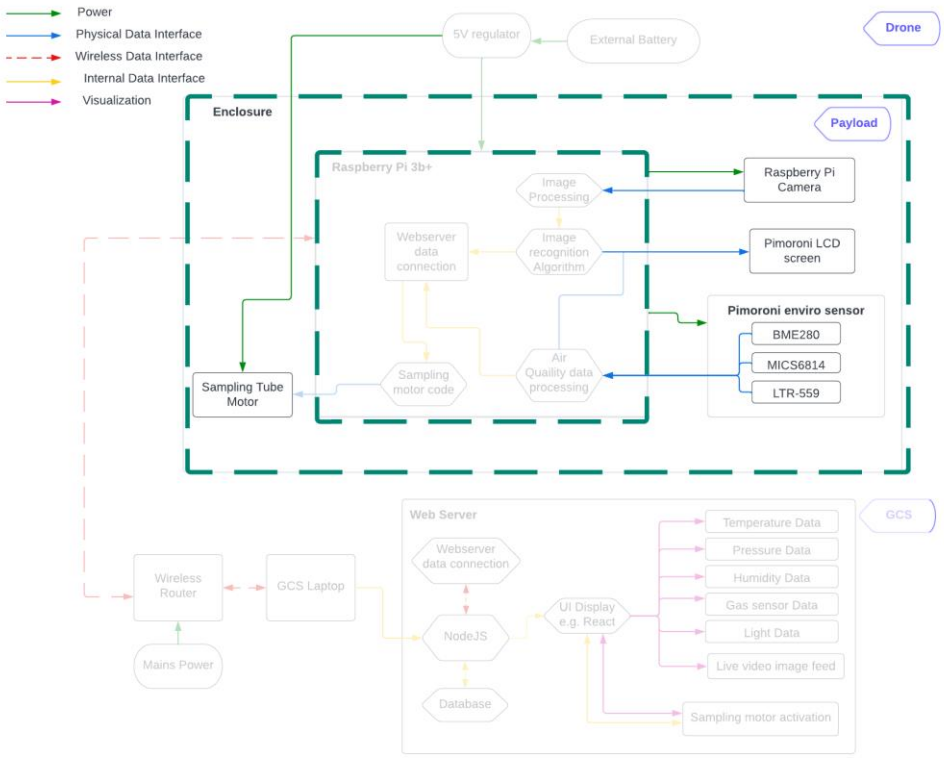

Figure 1- Enclosure Subsystem Architecture

4.1 Interfaces

Interface	Component	Interface Description
Interface 1	Drone Brackets	The Payload with be physically attached to the Drone through the supplied bracket. The Raspberry Pi 3 B+ and sample mechanism motor will draw power from the Drone's power supply.
Interface 2	Raspberry Pi 3B+	The Raspberry Pi 3B+ is mounted within the payload to reduce movement.
Interface 3	Sample Tube Mechanism	The Sample Tube Mechanism's motor is mounted to the inside of the enclosure
Interface 4	Enviro+ Sensor	The Enviro+ is physically mounted within the enclosure and powered through the Pi.
Interface 5	Raspberry Pi 3 B+ Camera	The Raspberry Pi 3 B+ Camera is attached to the enclosure and powered through the Pi.

Table 1 - Table of all interfaces with ED

4.2 Interface Diagram

The subsystems that are interfacing with the Enclosure subsystem is ST, AQS and TAIP and is physically attached to the drone. A diagram of these connections can be seen in Figure 2.

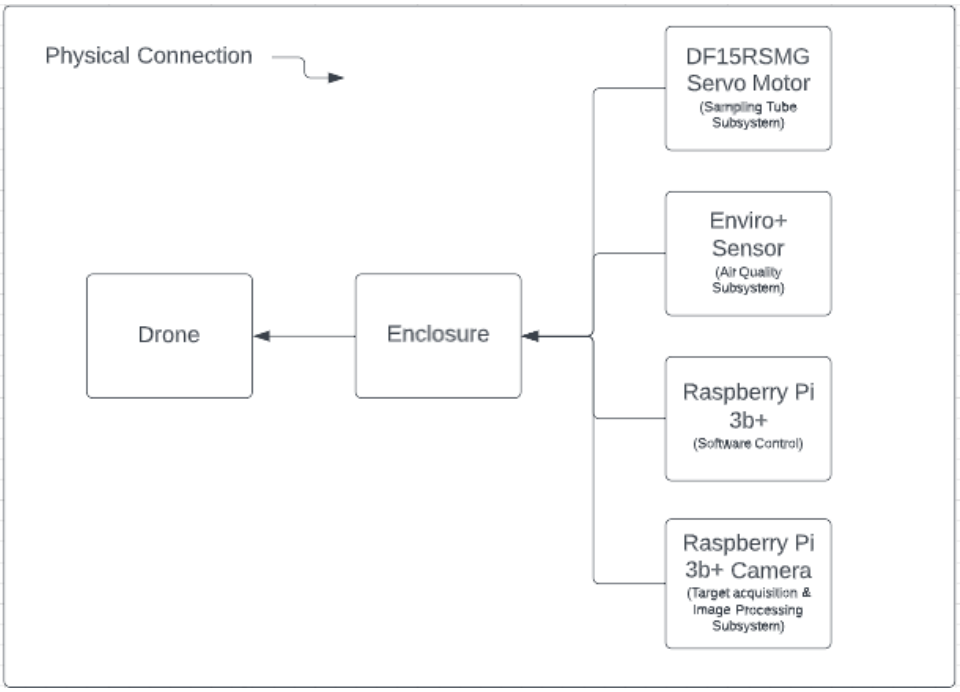

Figure 2 - Subsystem Interfaces

5 Design

As supplied by the project supervisor, the hardware to be used in the construction of the payload is: a Raspberry Pi 3b+, Raspberry Pi Camera, Pimoroni Enviro+ Sensor and a 360-degree motor. The designed enclosure was able to house these components successfully. This was done through background research of component sizing and testing completed located in document RD/20.

5.1 Hardware Specifications

5.1.1 Raspberry Pi 3B+

The Raspberry Pi 3B+, as stated by the official Raspberry Pi website, is a low cost, credit-card sized computer. This device is currently the 4th most recent model of Raspberry Pi. The Pi contains GPIO pins which allow for both input and output signals.

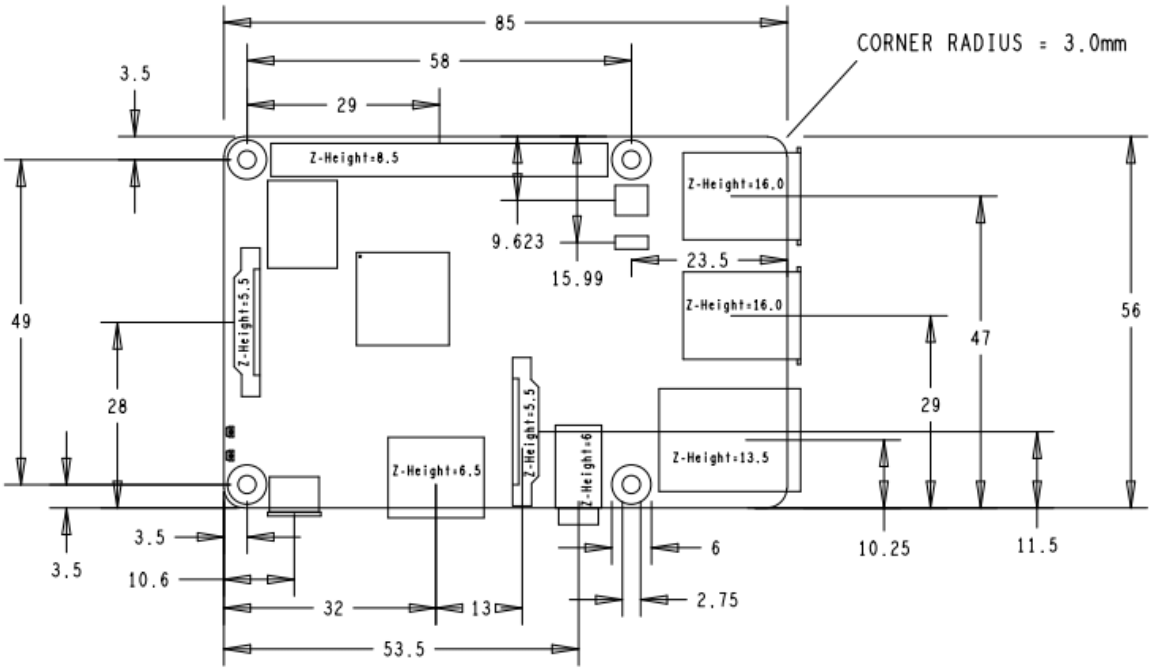

Figure 3 -Raspberry Pi 3B+ Scientific Diagram

Figure 3 shows a scientific diagram displaying all possible dimensions required when designing a housing enclosure. Table 2 displays key dimensions used for the enclosure design.

Length	85mm
Width	56mm
Height	17mm
Bolt size	M2.5
Length between mounting holes	58mm 49mm

Table 2 - Key Dimensions of Raspberry Pi 3B+

5.1.2 Raspberry Pi camera

The Raspberry Pi camera is an attachment manufactured by the same company as the Raspberry Pi. This camera is an 8MP device and connects directly into the Pi board through its flex cable into the "Camera" port. Figure 4 shows the diagram of the Camera and Table 3 displays the primary measurements.

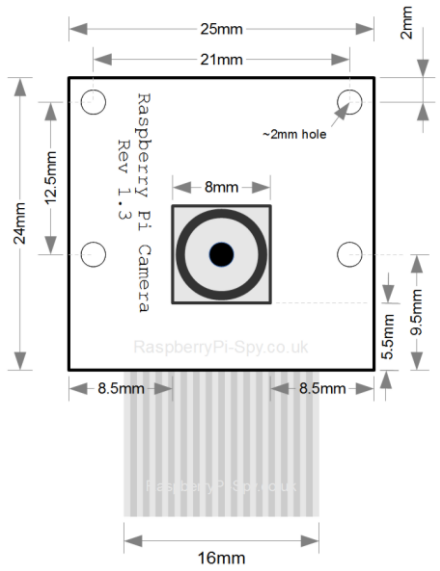

Figure 4 - Raspberry Pi camera Scientific Diagram

Length	24mm
Width	25mm
Height	6mm
Bolt size	M2
Cable length	100mm

Table 3 - Key Dimensions of Raspberry Pi Camera

5.1.3 Pimoroni Enviro+ Sensor

The Pimoroni Enviro+ Sensor device contains numerous sensors. These are:

- BME280: Temperature, pressure, humidity Sensor
- LTR-559: Light and proximity Sensor
- MICS6814: Analog Gas sensor

The Enviro+ is connected to the Raspberry Pi through a ribbon cable attached to the back pins. Figure 5 should an image of the sensor and Table 4 displays the key dimensions of the device.

Figure 5 - Pimoroni Enviro+ Sensor

Length	65mm
Width	30mm
Height	8.5mm
Bolt size	M2.5

Table 4 - Key Dimensions of Enviro + Sensor

5.1.4 DF15RSMG 360 Degree Motor

The supplied motor is the DF15RSMG 360 Degree Motor. This motor is a part of the Sampling Tube subsystem and has a stall torque of 19.3kg/cm @ 7.4V. Figure 6 shows the dimensions of the motor and Table 5 displays the key dimensions.

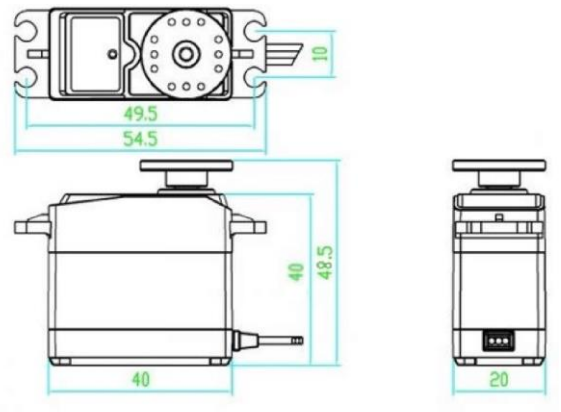

Figure 6 - 360 Degree Motor Scientific Diagram

Length	40mm
Width	20mm
Height	40mm
Bolt Size	M4

Table 5 - Key Dimensions of 360 Degree Motor

5.2 Software Specifications

5.2.1 Autodesk Inventor

Autodesk Inventor is a 3D modelling software can be used for design modelling and simulations. For this subsystem the Inventor software was used to model all components of the Enclosure design. These individual components were then assembled using Autodesk's Assembly function.

5.3 Enclosure Design

The final Enclosure design was modelling using Autodesk Inventor. This design included a method of mounting/containing all required components within the payload. These are the Raspberry Pi, Raspberry Pi camera, Enviro+ and Motor. Once modelled, the design was then 3D printing using ABS filament. The enclosure design is comprised of 3 components, the main body, the door panel and the middle plate. The design was also modelled to satisfy the IP41 rating requirement **[REQ-M-01]**.

The main body of the enclosure can be seen in Figure 7. The design contained 5 openings, all of which are covered once the components are placed within. The motor is to be mounted at the bottom of the enclosure with brackets and bolts. The Raspberry Pi camera is also to be mounted at the base of the enclosure for maximum visibility. On the side of the enclosure there is a large opening that fitted to the dimensions of the Enviro+ sensor . The sensor is to be mounted on the outside of the payload by slotting in place against the side panel and mounts.**[REQ-M-02 & REQ-M-13]**. Lastly the Raspberry Pi is to be powered through a small opening on the same as the sensor. Within the

enclosure are side railings for the middle plate placement. This plate is for the mounting of the Raspberry Pi. These railing have been placed with ample room bottom for the camera cable. The top of the enclosure body is left open allowing for access inside. This is to be covered using the Enclosure lid. Appendix 7.1 shows the full Technical Drawing.

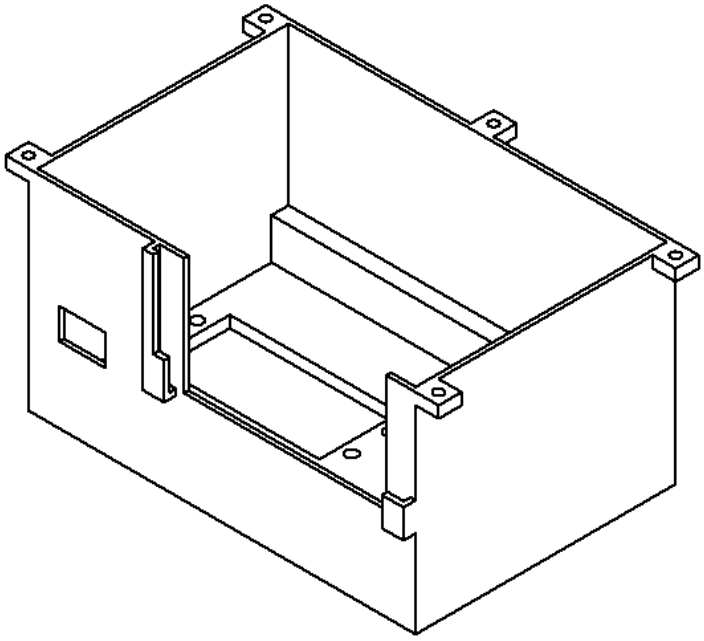

Figure 7 - Orthographic View: Enclosure Body

The second component of the model is top lid used to seal shut the payload. This can be seen in Figure 8. This lid is attached to the body using bolts in each corner. A total of five bolts are used to ensure that are no gaps between the body and lid that would breach the IP41 requirement. The payload is to be attached to the drone through a single mounting point of 2 bolts located on this lid. Appendix 7.2 shows the full Technical drawing for this component.

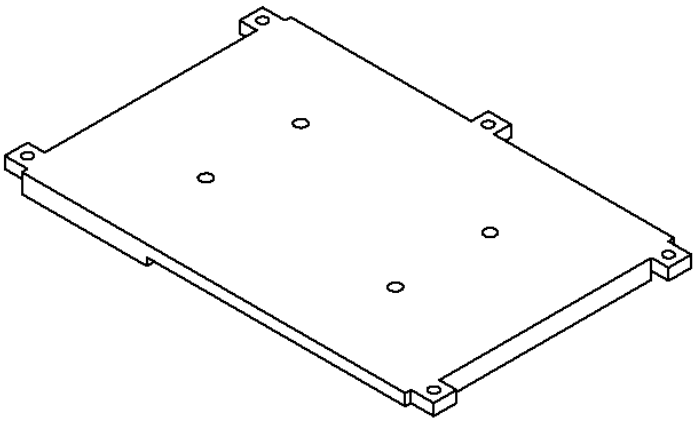

Figure 8 – Orthographic View: Enclosure Lid

Within the Enclosure is a middle plate used to mount the Raspberry Pi on top. This design can be seen in Figure 9. This plate is held in place by railing located on the sides of the main body. Bolt holes are located on the plate to allow for the Pi to be mounted. Part of the plate's centre is hollowed out to preserve weight for other components. The full Technical drawing can be seen in Appendix 7.3.

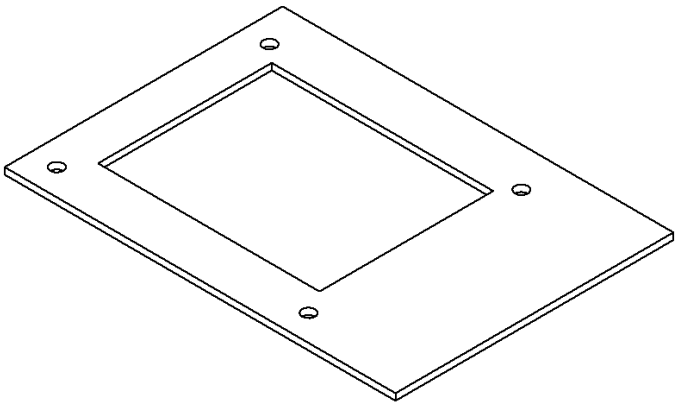

Figure 9 – Orthographic View: Enclosure Plate

The final component of the enclosure design is the servo motor mounts for the ST subsystem. This component is to be attached at the bottom of the main enclosure using two bolts and connecting to the servo on the opposite side in the same matter. This component is to be 3D printed twice to allow for attached on both sides of the servo motor. Figure 10 displays an isometric view of the component. Appendix 7.4 contain the technical drawing for this component.

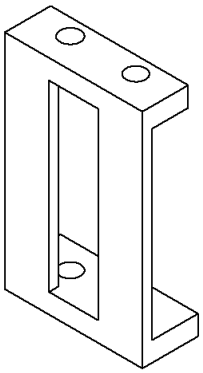

Figure 10: Orthographic View: Motor mount bracket

The full assembly of all Enclosure Components are shown in Figure 11. The total weight of the Enclosure design is 69g.

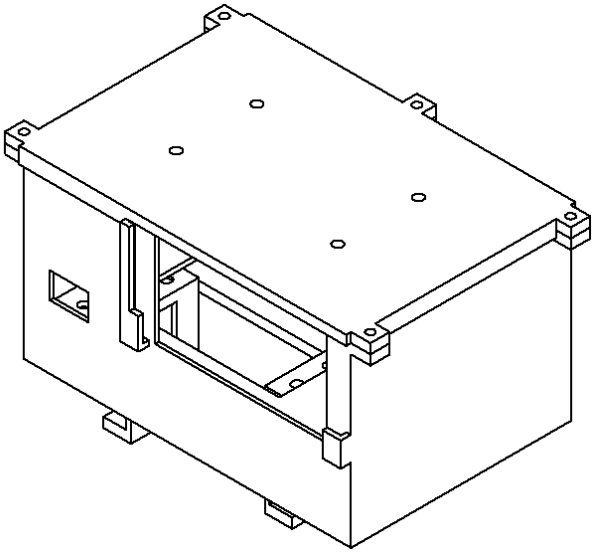

Figure 11 - Enclosure Design Assembly

6 Conclusion

The Enclosure Design subsystem been designed to satisfy all requirements supplied by the project supervisor. As this subsystem does not contain any software components only the hardware components have been designed. To ensure that all components fit exactly in place numerous tests prints have be developed. Table 6 shows the requirements required by this subsystem and the design considerations that have been planned.

Table 6 – Requirements met by Final Design

Requirement	Description	Verification
REQ-M-01	The UAVPayloadTAQ shall remain under the maximum weight of 320 g and comply with an IP41 rating. The air quality sensors must be exposed to the environment to allow for accurate reading.	**REQ-M-01**
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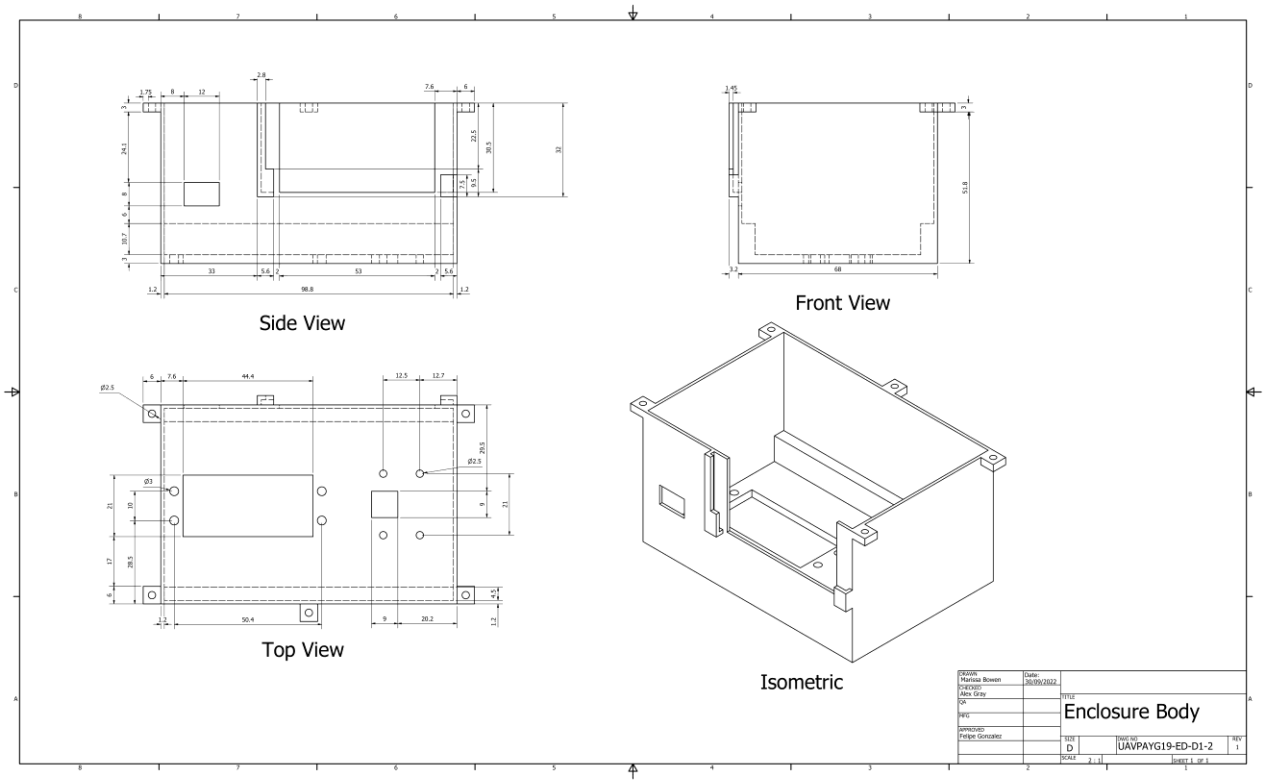
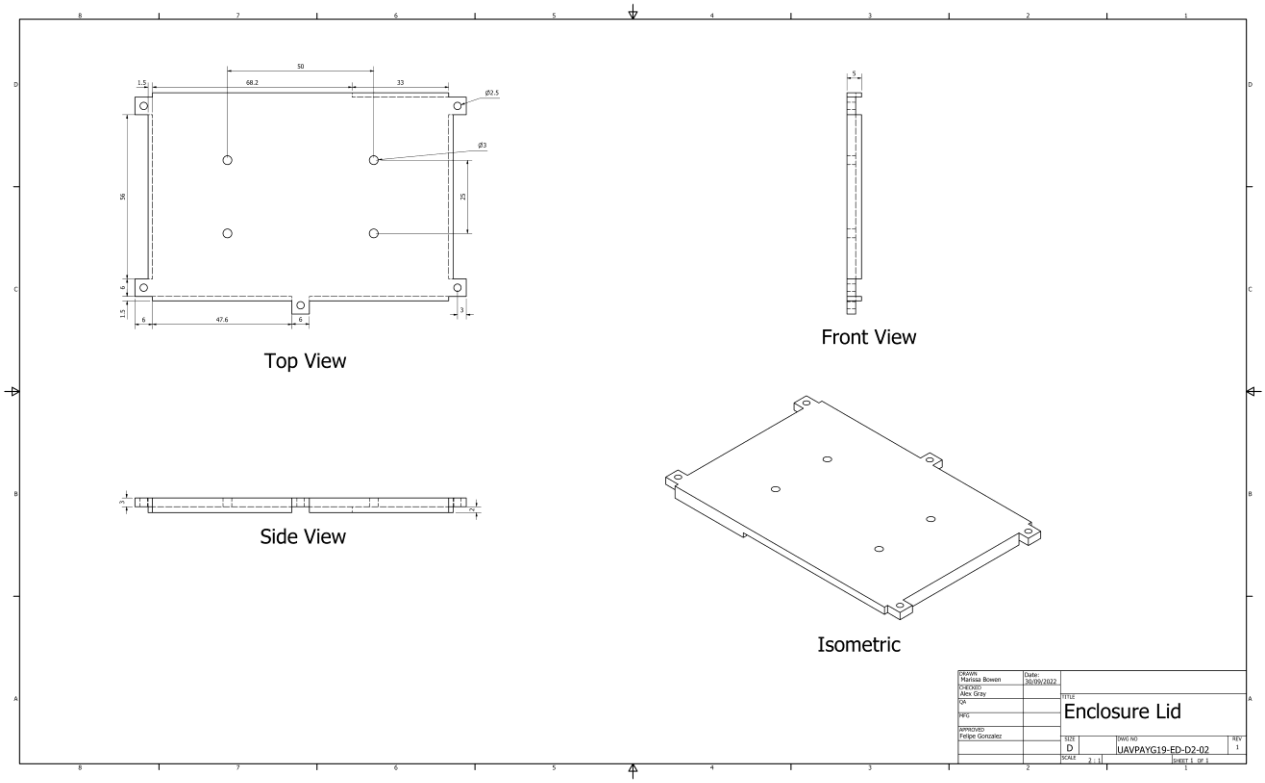
7 Appendix

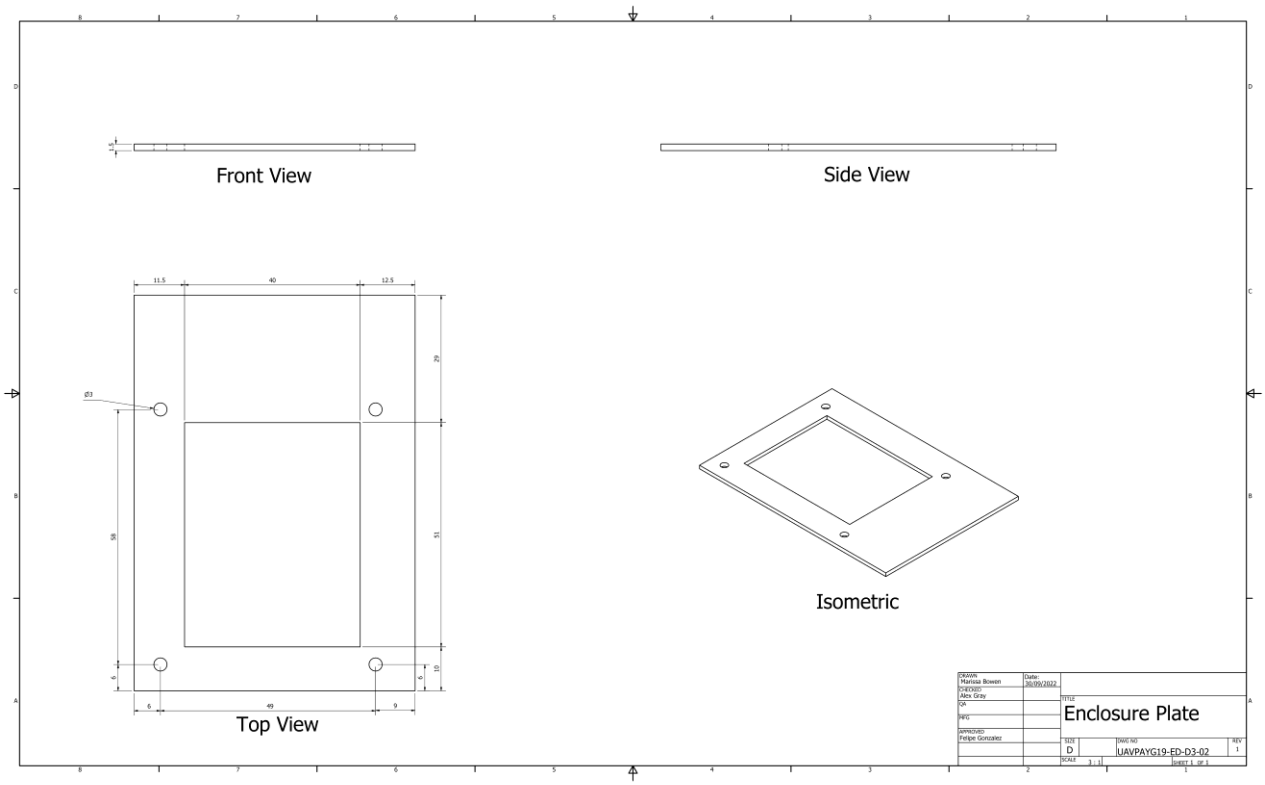
7.1 Main Enclosure



7.2 Enclosure Lid



7.3 Enclosure Plate



7.4 Enclosure Motor brackets