UAVPayload^{TAQ}

Final Design – Enclosure

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Definitions

UAV	Unmanned Aerial Vehicle
ENC	Enclosure

1 Introduction

This preliminary design outlines the ENC subsystem for the UAVPayload project. By following the systems engineering design system this subsystem forms the enclosure design subsystem. This preliminary design document outlines the integration and high-level operation of the ENC subsystem.

As this is a preliminary design integration with other subsystems has not been tested and will highly likely influence future design iterations.

1.1 Scope

This preliminary design outlines the ENC subsystem and how it interfaces with the other subsystems within the UAVPayload project. High level analysis of the ENC subsystem will be provided along with diagrams of the projected system.

The ENC system is required to determine a payload with a weight that does not superceed the required amount of 250g in total (REQ-M-01) and that the UAV and payload must remain under a maximum take-off weight of 2.2kg (HLO-M-4). The enclosure should be designed to harbor the payload in such a way that it makes it easy to retrieve and place the payload, secure enough so that the payload is not at risk of falling out mid-flight and is designed to account for the heat that will be produced from the payload during activstion.

1.2 Background

The Queensland University of Technology (QUT) Airborne Sensing Lab have appointed Group 2 of the EGH455 (Advanced Systems Design) class to design a UAV Payload for indoor air quality to be installed on a S500 UAV designed for navigating in GPS denied environments. The UAVPayloadTAQ is required to conduct constant air quality sampling in a simulated underground mine. During monitoring, it must find and identify multiple markers placed by miners around the mine. Additionally, QUT Airborne Sensing Systems requires that the UAVPayloadTAQ is designed and developed using Systems Engineering to ensure QUT Airborne Sensing Systems requirements are met. Taken from RD/3.

2 Reference Documents

2.1 QUT Avionics Documents

RD/1	CN-UAVPayloadTAQ-01	UAV Payload Customer Needs
RD/2	SR-UAVPayloadTAQ-01	UAV Payload System Requirements
RD/3	PMP-UAVPayloadTAQ-01	UAV Payload Project Management Plan

2.2 Non-QUT Documents

3 Subsystem Introduction

In this subsystem, the enclosure design details are taken from RD/1, RD/2 and RD/3 of the Customer Needs documentation in which it states in the High Level Objective (HLO) that the complete payload system shall be installed inside the customised 3D printed enclosure and its weight should not exceed the 250g weight requirement (HLO-M-4).

To design the 3D printed enclosure, I have made use of the program called OnShape which is what was suggested in previous weeks of design ideas and implementations. OnShape is an open source, web-based software which utilises the cloud to save and resume work on the fly. As opposed to its other competitors, it is quite robust and provides a lot of customizable options to apply to your project for a web-based interface. Many of its competitors are download and install based software applications which have quite a lot of overhead in terms of installation and space required, not to mention potential conflicts during the installation/setup process. As an engineer using the Systems Engineering approach, it is paramount that we operate with efficient software/hardware and optimise resource management without compromising time, budget, and performance (HLO-M-5).

4 Subsystem Architecture

Ideally, the enclosure should be big enough to host the payload along with the peripherals such as the camera and power supply cable. So that means, that the enclosure must be designed with optimisation of the placement of materials so that it does not inhibit the setup process of the payload when it is time to demonstrate. The enclosure must not use unnecessary materials to optimise aesthetics over practicality, using less is more in this case would be extremely beneficial as being under the threshold weight of 250g would perhaps allow for additional future modifications if needed to optimise certain parts of the enclosure.

4.1 Design Implementations

The enclosure was designed to account for the optimisation of weight, ventilation, and space. In this concept, the enclosure will be a rectangular fashioned payload with 3 sides of the payload hollowed to account for optimal ventilation of the system. This can be seen in the below in Figure 1 taken straight from the On Shape software:

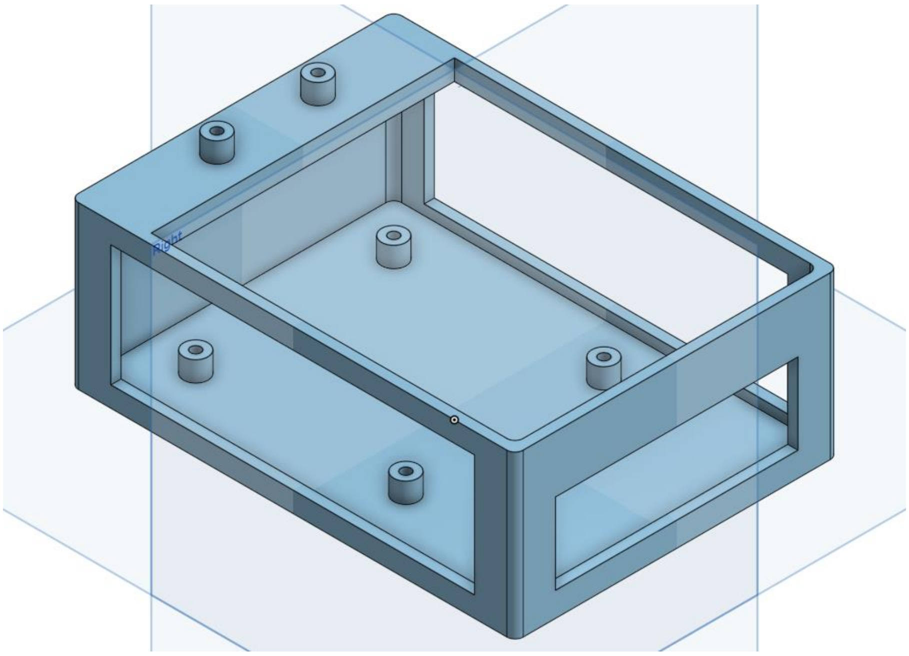

Figure 1: Payload depiction from On Shape software.

As shown in the figure, there are 4 hollowed parts of the rectangular payload as described previously, with emphasis on the 3 sides. The points on the bottom of the payload will provide the ability for the Raspberry Pi to be screwed in place using either 3D printed screws or conventional ones. As per RD/1, the sensory system that will be attached on top of the payload and will require a spacing of 25mm with holes not exceeding the required 2.5mm diameter to fit the screws. This applies for the mount of the Raspberry Pi inside the case where the payload has been optimally adjusted to account for a snug fit for the system and correct dimensions to line up with the mounting points.

It was decided by the group to cater for the camera that will be used for image detection in such a way that it will be securely attached to the payload. To achieve this, there will be a small slide-in-slide-out slot, acting like a CD bracket, where the camera shall sit inside this slot located underneath the Pi facing directly downwards. This will provide excellent stability for image processing and work in favour of the design.

4.2 Redesigning Implementations

After the testing of the delivered product, it was noted that the enclosure design that was implemented did not fasten securely to the UAV drone. The slot compartment for the Pi Camera also was located on the opposite side of the enclosure which made it difficult to securely place the Pi Camera. To temporarily amend these design faults during the demonstration, zip ties and double sided tape was used to ensure that the payload was fastened to the UAV and the Pi Camera was attached to the bottom of the payload so it can process the images in flight.

During the redesign phase post demonstration, it was decided that the functionality of the enclosure must be reconsidered if it is to satisfy the customer needs document. The amendments included redesigning the top part of the enclosure so that there is in fact a two-part system in place involving a stand alone cover that will have the holes drilled into the top so that the peripheral can be screwed in safely and securely for the UAV. Additionally, the stand-alone cover will also ‘slide in’ to the enclosure, secured in place and is easily removable.

The slot compartment for the Pi Camera was mirrored to the opposite side as it was understood that the Pi Camera was bi-directional when in actual fact it wasn’t; it would only be connected to the Pi in one way. In addition to this design flaw, the thickness of the material used for printing was not taken into account for when the dimensions of the slot was designed which resulted in the inability to fit the Pi Camera into the designed slot compartment. To combat this, the necessary design implementation of moving the slot to the other side and widening the dimensions to accommodate for the thickness of the 3D printed plastic which will allow for the Pi Camera to securely pass through to reach the slot compartment.

Thankfully, the payload could be securely fastened to the inside of the enclosure which meant that it still satisfied the high-level objective set out by the customer needs document.

The design of the enclosure will now satisfy RD/1 and the high-level objectives related to this requirement. See Figures 2 and 3 below for the rendered designs of the new and improved payload.

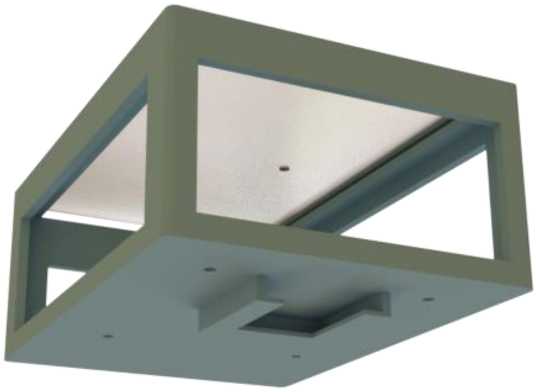

Figure 2: Redesigned enclosure perspective render of bottom view.

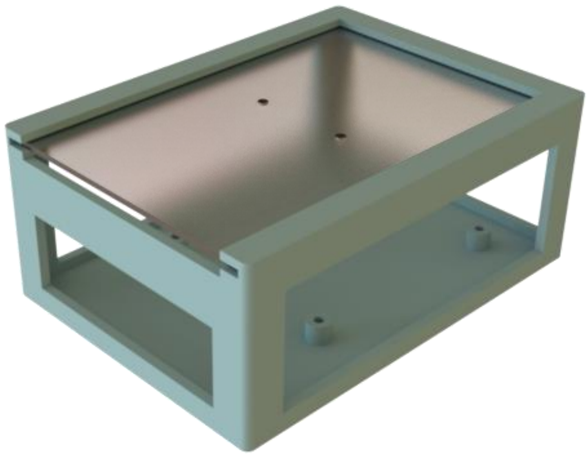

Figure 3: Redesigned enclosure perspective render of top view.

5 Final Design Description

The payload is approximately 110mm x 80mm to account for extra room to fit the peripherals onto the device and to mount it without worrying about inconveniences. The payload has been extruded to 45mm, which is around 10mm more than the depth of the device. This allows for additional room between the payload and the system for ventilation purposes and ease of mounting.

The stand-alone cover for the enclosure is measured to be approximately 102mm x 73mm with enough room on each side for the cover to slide in to the top of the enclosure with ease and also not be too loose so that there is no structural integrity for the payload when fastened to the UAV. It is also approximately 2mm thick which also allows enough room on the sides so that the cover may slide in and out easily without much resistance.

The purpose of incorporating a two-part system is so that the mounting of the enclosure to the UAV will be incredibly easy and very convenient. This will avoid any complications with screwing in the peripheral from the UAV. The extra space on the top of the enclosure will allow the ability to mount the payload into the enclosure with ease and without much hassle and fiddling.

The “CD bracket” placeholder located on the bottom will be placed towards the opposite of the USB peripherals end of the payload, meaning, where the raspberry pi USB ports are located and directly under. As there is a bit of give in the cable from the camera, we can use this to our advantage when designing the placeholder for this camera and make it curve around through the hollowed end of the payload and underneath where it will be attached. This is a design implementation derived by me when exploring the ergonomics of the parts that were given.

6 Subsystem Implementation Reasoning

Implementation and design are key components from a Systems Engineering standpoint, and they respectively resonate with each other throughout the process until the final product. Therefore, whenever an implementation is designed, there needs to be a justification as to why this is necessary and how it benefits the system overall. In this section, we will explore the many design features of the enclosure that have made it into the product that it is.

The payload was designed to create enough room for the system to be placed while not compromising the weight of the payload. The holes in the side of the payload not only provide the ventilation necessary for the system but also cut down on the amount of material necessary for production. This means that the amount of the budget spent on 3D printing the model would be less as opposed to printing a much larger and material dense project.

The overall weight of the enclosure was 170g stand alone and with the payload it was 1.5kgs which is well under the required maximum amount according to RD/1 and HLO-M-4, satisfying this requirement.

The placeholder for the camera located on the bottom of the payload is a feature that is engineered for convenience primarily. This design implementation will prove to be a functioning asset for keeping the camera in a stable and secure position for image processing.

7 Conclusion

In conclusion to this preliminary design of the enclosure, the requirements of the Customer Needs documents with reference to RD/1, RD/2 and RD/3 have been satisfied conceptually. The shortcomings during the demonstration process has opened up the avenue to improve the overall design of the enclosure. From a Systems Engineer standpoint, the overall payload will be able to host the required system without compromising other High-Level Objectives in the process, for example HLO-M-1 and HLO-M-2.