Project Management Plan

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Definitions

PMP	Project Management Plan
USB	Universal Serial Bus
AQS	Air Quality Sensor
TAIP	Target Acquisition and Image Processing
ED	Enclosure Design
ST	Sampling Tube
WVI	Web Visualization and Interface
QUT	Queensland University of Technology
GPS	Global Positioning System
ASP	Advance Sensor Payload
UAV	Unmanned Aerial Vehicle
HLO	High Level Objective
RPi	Raspberry Pi

1. Introduction

The team members of Group 19 have been appointed to research, design, plan and implement an Advance Sensor Payload (ASP) for Unmanned Aerial Vehicle (UAV) target detection and air quality monitoring in GPS denied environments. The group has committed to the specified budget whilst implementing the project requirements stated by the client. The team has also committed to meeting the deadline date specified by the client with a full functioning ASP that has been tested to ensure the client requirements have been met.

The project management approach Group 19 has implemented for this project is a 'systems engineering' approach. All team members will utilise the system engineering approach in order to ensure the project meets the cost and deadline requirements whilst maintaining engineering standards. The system engineering approach breaks down the High-Level objectives (HLO) set by the client into small manageable subsystems that can be allocated to each team member. The team then develops the small subsystems and then integrates them back to their HLO's.

The Project Management Plan (PMP) has detailed showcases of these smaller subsystems. These smaller subsystems allow for group 19 to allocate the workload for the project evenly and will also allow for better organisation to ensure that the project meets the time deadlines and budget costs. The PMP was reflected on throughout the project and was continually updated to ensure that any revised schedules or due dates were to occur. The PMP also reflects the project progress which can be used for reference by the team or the client.

1.1 Scope

The scope of the project is to research, plan, design, implement and test the ASP for UAV target detection in GPS denied environments. The PMP does not provide the technical details for the project or disclose how Group 19 has completed the HLO's set by the client. Other document has been developed with discloses these technical details and guides for the project. The PMP will disclose the details needed to complete the HLO's using a system engineering approach to breakdown HLO's into the smaller subsystems. The PMP also oversee each individual small subsystem requirement and their allocation to each team member. Lasty it will contain the management on the project.

1.2 Background

The Queensland university of Technology (QUT) Airborne Systems Lab (ASL) has commissioned group 19 to research, design, implement and test an ASP for UAV target detection in GPS denied environments. The ASP will use a camera for target detection, detecting targets such as a fire extinguisher, multiple ArUCO markers and detect whether a valve is open or closed. The ASP will also sample and measure the air quality. The ASP will have an LCD screen for displaying information and a sampling tube to collect ground samples from a landing site. Finally, in addition to these requirements, all the data the ASP collects will be transmitted to a server, then saved to a database and made accessible online via a website interface that is hosted on a local network. Further information regarding these requirements is stated in the PMP. Technical details regarding these requirements are stated in the Project Brief, RD/1.

2. Reference Documents

2.1 QUT Avionics Documents

RD/1	UA–System Requirements	UAVPayloadTAQ System Requirements
RD/2	UA –Customer Needs	Advanced Sensor Payload for UAV Target Detection and Air Quality Monitoring in GPS Denied Environments
RD/20	UAVPAYG-19-ED-TR-01	Enclosure Test Report
RD/21	UAVPAYG-19-AQS-TR-01	Air Quality Sensor Test Report
RD/22	UAVPAYG-19-ST-TR-01	Sampling Tube Test Report
RD/23	UAVPAYG-19-TAIP-TR-01	Target Acquisition and Image Processing Test Report
RD/24	UAVPAYG-19-WVI-TR-02	Web Vision Interface Test Report
RD/25	UAVPAYG-19-AQS-TAIP-WVI-TR-01	Air Quality Sensor, Target Acquisition and Image Processing, Web Vision Interface Integration Report
RD/26	UAVPAYG-19-ED-AQS-TAIP-ST-TR-01	Enclosure, Air Quality Sensor, Target Acquisition and Image Processing, Sampling Tube Test Report
RD/27	UAVPAYG-19-ED-AQS-TAIP-WVI-ST-TR-01	Enclosure, Air Quality Sensor, Target Acquisition and Image Processing, Sampling Tube Integration Report
RD/28	UAVPAYG-19-TR-AT-01	Acceptance Test Report
RD/29	UAVPAYG-19-VV-01	Verification and Validation Report
RD/30	UAVPAYG19-ED-FD-01	Enclosure Final report
RD/31	UAVPAYG19-AQS-FD-01	Air Quality final report

RD/32	UAVPAYG19-TAIP-FD-01	Target and image final report
RD/33	UAVPAYG19-ST-FD-01	Sampling tube final report
RD/34	UAVPAYG19-WVI-FD-02	Web final report
RD/35	UAVPAYG-19-ED-AQS-TAIP-TR-01	Enclosure, Air Quality, Target and Image processing Test Report

2.2 Non-QUT Documents

3. Project Aims and Approach

The aim for the UAV Payload Systems Engineering project is to design, develop, implement, and test an integrated payload system on a UAV. The constructed payload will be comprised of multiple sub-systems, based off the requirements of the client who has provided the project. During flight, the payload will use sensors recording temperature, pressure, humidity, light, and gas information. The onboard computer module will make use of a camera to detect defined objects; notably a fire extinguisher, a valve with its status indication, and ArUCO markers. The information will then be stored and transmitted to a remove device to visualise the data throughout the flight. From this device, the sampling tube can be controlled to take a sample from a specified landing surface.

Numerous system requirements are needed to be accomplished to consider the project complete. The set of system requirements are derived from the high-level objectives outlined in the customer needs documentation. These objectives can be used to define the sub-systems required for the project, allowing the team manager to appropriately assign the tasks based on the skills of each team member.

The approach taken to complete the project aims will follow the Systems Engineering 'V' Model shown in Figure 1. This approach begins with client consultation and exploration of the project at hand. Once the project has been scoped, it is then broken down into system requirements, (high-level design) sub-system requirements, and component level design. At this stage, the overall project has been broken up into many smaller sub-systems that can be more easily developed, unit tested, and verified before combining the sub-systems together and verifying. Once the individual sub-systems have been combined, the entire system can be tested and validated before progressing to the deployment life cycle of the product.

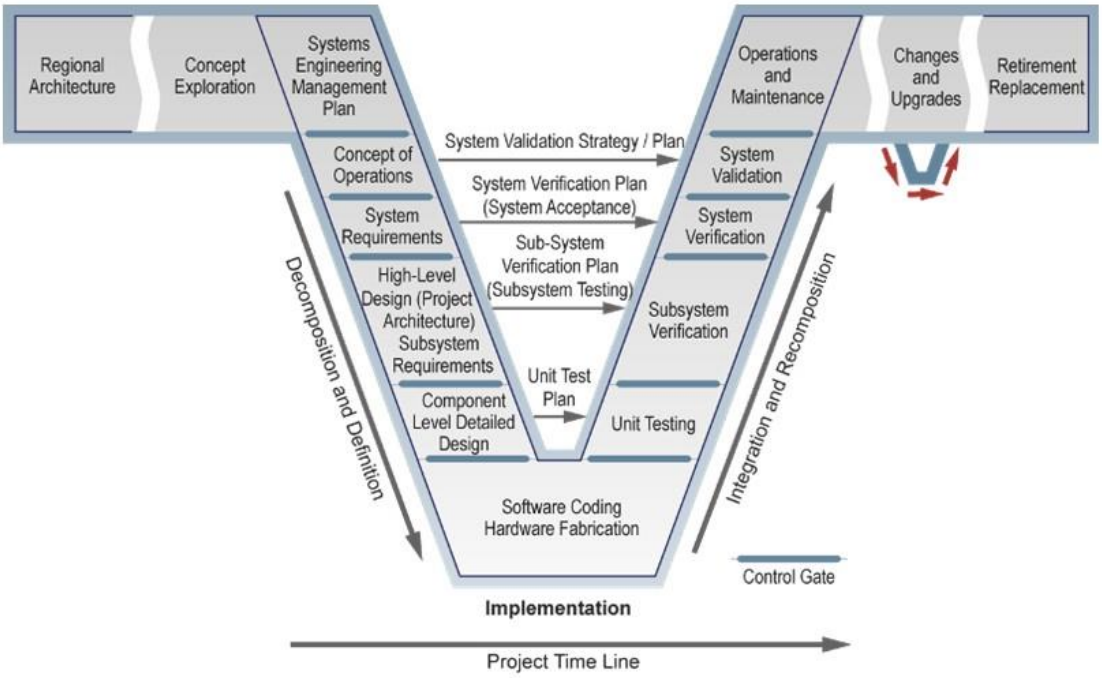


Figure 1: The Systems Engineering V Model (RD/2)

4. Project Organisation

4.1 Subsystem Roles and Responsibilities

The UAVPAYG19 team consists of six group members currently undertaking a degree of Bachelor of Engineering Honours at QUT. The team consists of three Mechatronics, two Computer and Software Systems, and one Electrical and Aerospace major students. Table 1 outlines each group member's selected subsystems and responsibilities regarding these systems.

Team Member	Subsystem	Code	Responsibilities
Marissa Bowen (MB)	Project Manager	PM	• Developing Work Breakdown structure • Developing project schedule • Managing budget (money, power, weight) • Developing risk assessment
	Enclosure Design	ED	• Research background information in relation to subsystem • 3D modelling enclosure for project • 3D printing designed enclosures
Alex Switala (AS)	Target Acquisition	TAIP	• Research background information in vision software • Developing image processing system • Testing and integration with other subsystems
Connor Harvey (CH)	Target Acquisition	TAIP	• Research background information in vision software • Developing image processing system • Testing and integration with other subsystems
Alex Gray (AG)	Air Quality Sensor	AQS	• Research background information in relation to subsystem • Developing code for data gathering of Air Quality Sensor • Testing and integration with other subsystems
Jeremy Naylor (JN)	Sampling tube	ST	• Research background information in relation to subsystem • 3D Modelling design for sampling tube system • 3D Printing and testing of system • Developing code for system

Ryan Brooker (RB)	Web Visualization & Interfaces	WVI	• Research background information in relation to subsystem • Designing of web interface • Developing and testing web interface and connections to other systems
Felipe Gonzalez (FG)	Client and Supervisor	CSU	

Table 1: Team Members and Subsystem allocation

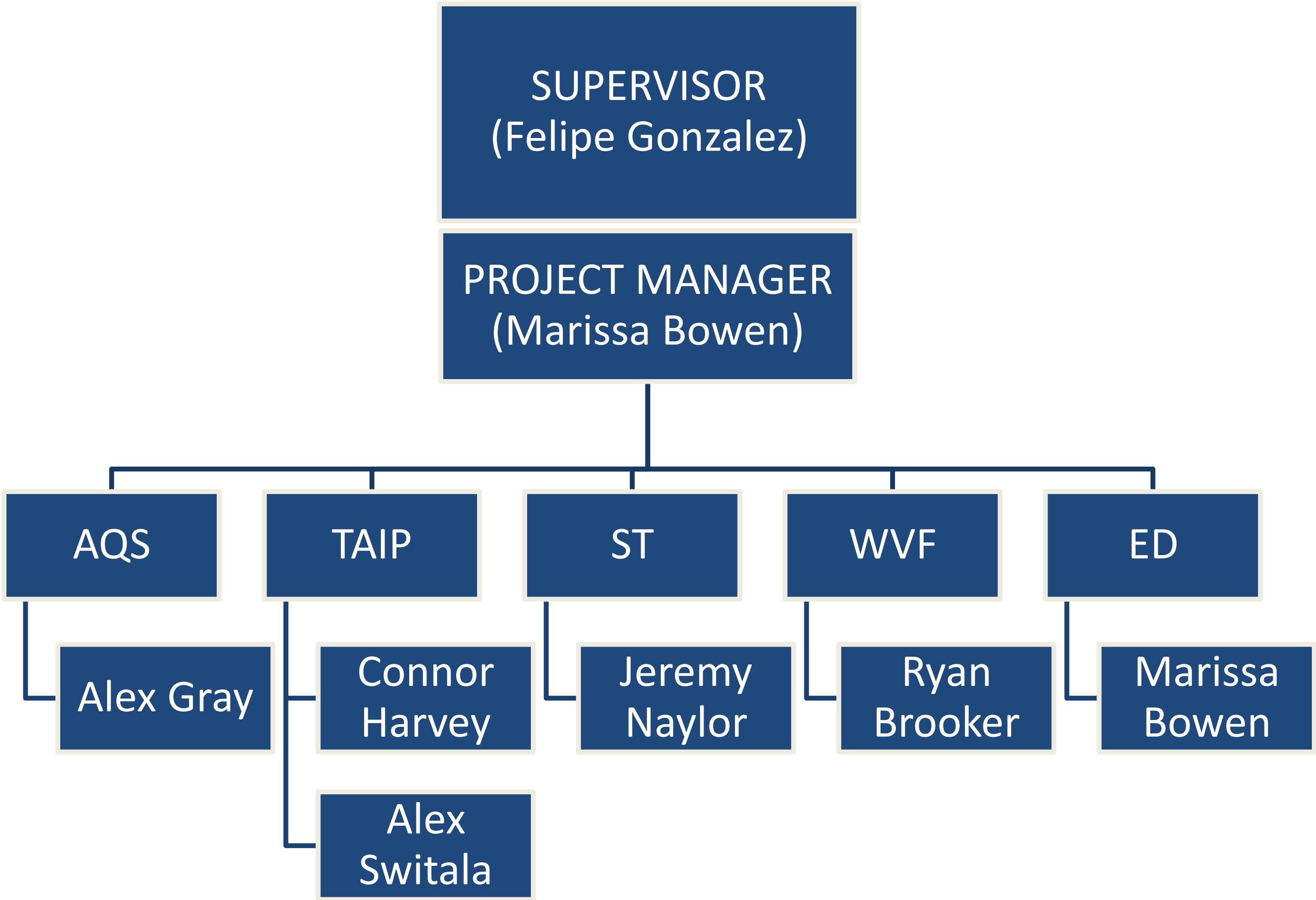


Figure 2: Diagram of Communication Hierarchy

4.2 Document Management

Documentation management of this project is to be completed in an orderly manner to ensure no documents are lost or over written. Sections 4.2.1 to 4.2.4 explains the organisational system that is used.

4.2.1 Document Templates

Template documents used when developing documentation for this project were previous year's samples provided by the Project Supervisor. These sample documents were used primarily for the structural layout.

4.2.2 Document File Naming

Documents have been named using the following system, group code, document type, subsystem code, version then version number separated via hyphens like so: UAVPAYG19-PD-ED-01

TYPE	CODE	MEANING
Group Code	UAVPAYG19	Drone payload project group 19
Document Type	PMP	Project Management Plan
Document Type	WEB	Website Interface Control Document
Document Type	VV	Verification and Validation
Document Type	RD	Research Document
Subsystem Code	PM	Project Management
Subsystem Code	ST	Sampling Tube
Subsystem Code	TAIP	Target Analysis and Image Processing
Subsystem Code	WVI	Web Visualisation and Interfaces
Subsystem Code	AQS	Air Quality Sensor
Subsystem Code	ED	Enclosure Design
Document Type	D	Technical Drawing
Document Type	PD	Preliminary Design
Document Type	TR	Test Report
Document Type	FD	Preliminary Design
Version number	00,01,02,03... (numbered)	The numbers correlate to the latest document version with higher numbers being newer versions

4.2.3 Revisions of Documents

During the time period of this project all documents will be over going revision in order to developed correct and high-quality documentation. These revision changes are to be tracked using a table located within each document. This table states the current version of the document, the type of changes made as signed by the person who approved the review.

4.2.4 Document and Media Storage

Document and media storage was performed on a shared one drive, with this cloud-based storage preventing the loss of these documents and allowing for them to be easily shared.

5. Resource Management

This section will discuss the resources available to complete the project. These include the Physical and human resources along with financial, mass, data, and power budgeting. These factors need to be considered throughout the development of the payload to ensure the client requirements and brief is reached.

5.1 Human Resource

The primary human resources allocated to this project are provided by the six team members. Each of the members of group 19 will contribute equally to the project to complete their assigned subsystem. Any issues faced during the project's timeline will be brought to the team's project manager. The project manager will then communicate with the project supervisor/client (Felipe Gonzalez) these issues to find a solution.

It is expected that all group members will apply a high level of effort into their sections to produce a high quality fully functional prototype at the end of the 12-week development cycle. If a group member feels as if their section is too much of a workload for themselves to complete to the expected level. This will be first communicated to the project manager before then asking if there is anyone available in the group to assist.

Additional human resources for this project include the client (Felipe Gonzalez) and tutors (Fernando Vanegas and Sebastien Boiteau). Contact for these resources will be during tutorials and practicals. If there is a need for any questions to be asked outside of these times this will be conducted via email by the project manager.

Meeting are to be conducted every week to ensure that the project is progressing as planned with. Meeting minutes have been recorded as located in document RD/5.

5.2 Financial Resource, Mass, Data, Power

For any project, an understanding of the financial, mass, data and power budget must be considered. In this case it is of importance as there are budgetary requirements set by the client and limitations on how much power or data that can be used set by the provided devices. A full list of these requirements can be seen in document RD/1.

The maximum mass that the payload is allowed to be is 320 g. This has been listed as part of the physical requirements of the payload (**REQ-M-01**). This has been listed as a mandatory requirement. As the components for this project have already been supplied by the client the weight consideration will limit the size and complexity of the cover and drill design. When these are designed weight should be considered, as a lower weight will lead to better flight characteristics leading to a longer possible mission time (this is not listed as a requirement).

The other primary budget to be considered for this project is the financial budget. This project has a maximum budget of $50 per student leading to a maximum budget of $300. As the components have already been purchased any additional monies left over will be used as contingency in case of component failure. During calculations, a contingency amount of 20% has been used inflating the overall cost of the project. This will allow for some leeway in budgeting replacement components.

At this stage only an estimate of the power usage (voltage and current) has been provided on the power table. These values have been pulled from the component's datasheets where possible. The data table is incomplete at this stage as no estimates have been run.

Subsystem	Components	Cost ($)	
		Estimated	**Actual**
All	Raspberry Pi3B +	58.10	70.00
All	Raspberry Pi3B + Case	12.50	15.00
All	Raspberry Pi3B + Power Supply	18.95	20.00
All	SanDisk Ultra Plus 32GB micro-SD card	13.00	15.00
All	SD card reader	19.00	17.00
TAIP	Raspberry Pi Camera V2	38.95	29.00
ST	DF15RSMG 360 servo motor	34.20	34.00
AQS/TAIP	Pimoroni Enviro +	92.25	100.00
Total		**$ 286.95**	**$ 300.00**
Contingency		**20%**	
Total (Contingency Included)		**$ 344.34**	**$ 360.00**

Table 2: Financial Budget

Table 2 above shows the financial budget for the project. The prices listed in the estimated column represent the cost to replace the components at time of writing (10/08/2022). It should be noted that the total cost to replace the system currently is at the maximum budget of $300. However, if the contingency of 20% is considered the project will be over budget by $60.00. The actual cost of all the components was $300, which is below the limit. It is not expected that any of the components will require replacement as they have been sourced from reputable suppliers.

Subsystem	Components	Mass (g)	
		Estimated	Actual
All	Raspberry Pi3B +	50	50
All	Raspberry Pi3B + Case	13.6	13.3
All	Raspberry Pi3B + Power Supply	118	118
	SanDisk Ultra Plus 32GB micro-SD card	~	~
All	SD card reader	~	~
TAIP	Raspberry Pi Camera V2	3	3
ST	DF15RSMG 360 servo motor	60	60
AQS/TAIP	Pimoroni Enviro +	10	10
ED	Enclosure	72	69
ST	Drill	20	19
All	Missing Mass (cabling, connectors, etc.)	50	29
Total Mass		**406.6**	**371.3**
Payload Mass		**288.6**	**240**
Contingency		**10%**	
Total Mass, including contingency		**447.26**	**408.43**
Payload Mass, including contingency		**317.46**	**264**

Table 3: Mass Budget

The second budget discussed relates to the mass of the payload and what the individual mass of each component is. Table 3 describes this with a total mass of 371.3g and a payload mass of 240g. These values have been gathered from the datasheets of the components and where no mass was provided the value was estimated. At first glance it appears that the total mass of the project exceeds the maximum allowed value. However, this value is calculating the mass of all componentry. This includes the Raspberry pi power supply which will not be used during the mission as the Pi will be powered from the UAV. With this removed the overall mass of the system is below the requirement allowing for additional mass to be allocated to the enclosure or drill if needed. A contingency was also calculated in this budget table however the final weight of the payload was much under the maximum limit of 320g.

Subsystem	**Components**	**Data (kB)**	
		Estimated	**Actual**
TAIP	Image Data, Time Stamps, Target Information	50	36.1
ST	Deploy Flag	0.008	0.008
AQS	Air Quality Data, Time Stamps	0.5	0.293
Total		**58.5**	**36.401**
Contingency		**20%**	
Total (Contingency Included)		**70.2**	43.68

Table 4: Data Budget

Table 4 shows the data budget for each component. The measurements of the data sizes in the table are taken directly from the database from an average of 100 samples. However, the data that is sent to the Server may have a dramatic increase in data size if the resolution of the images is increased or the images taken need to hold more data. Moreover, the data budget does not include the total data the Web Interface receives when it makes a request as the request also has information that may vary such as request or response and other information needed to complete the HTTP request protocol. As shown in the table above, the average actual data size comes under the estimated data budget by approximately 62% with respect to contingency. Furthermore, in the case of the server receiving a large request, the server is able to process data request up to 1MB, however, this data would fail to be saved in the database due to data size restriction put in place to minimize database bloating.

Subsystem	**Components**	**Cost (V)**	**Cost (A)**
		Estimated	**Estimated**
All	Raspberry Pi3B +	5	0.4
TAIP	Raspberry Pi Camera V2	3.3	0.225
ST	DF15RSMG 360 servo motor	5	3 (Stall Current)
AQS/TAIP	Pimoroni Enviro +	3.3	0.0426
Maximum Draw		**5**	**3.667**
Contingency		**30%**	
Maximum Draw (Contingency Included)		**5**	**4.767**

Table 5: Power Budget

Table 5 shows the power budget of each component. Only estimates drawn from the respective datasheets are displayed due to the dangerous of damaging the Raspberry Pi when performing measurements. The exception to this is the estimated current draw of the “Pimoroni Enviro+” sensor. There is no single datasheet provided for this sensor instead a datasheet for each of the sensors included on the PCB was investigated to find the estimated current draw. Another item of note is the estimated current draw of the servo at stall. This servo operates over a range of voltages and this reading has been taken at 8V. This has led to a larger estimate then what will be physically possible by the system, however, no other accurate data has been provided so this number will be used here. Overall, it is expected that the system will draw a maximum of 5V at 4.767A (with a 30% contingency). This leads to a power usage of 23.835W.

5.3 Physical Resource

There are two main locations where this project will be developed and tested. The lab room in S block lv 9 (S901) and the UAV testing area in O block room 134 (O134). The testing area will only be used on two occasions: during the final demonstration and a test flight the week before. This test area can be seen in Figure 3 below with a netted space of 12x8x4m and a flight area of 10x6x4m.

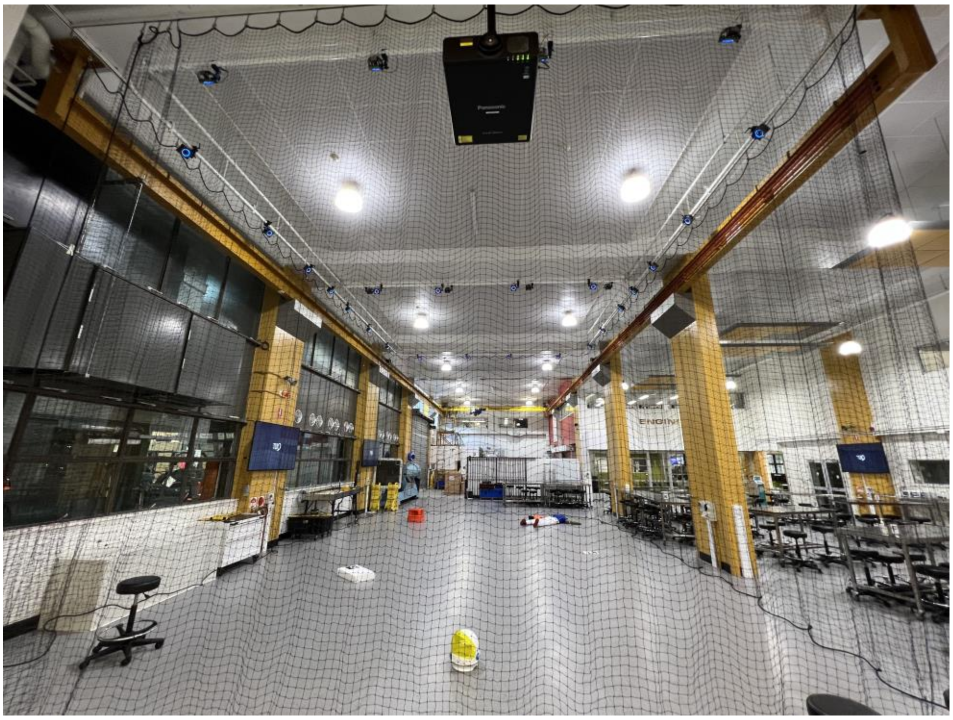


Figure 3: Indoor Flight Test Zone (O134)

The S901 room will be used throughout the semester to aid the group in the design and development of the project outside of personal time. Whilst this room does contain a netted area no test flight will be run in this space. The room can be seen in Figure 4 below:

Figure 4: Practical Design Room (S901)

6. Concept of Operations

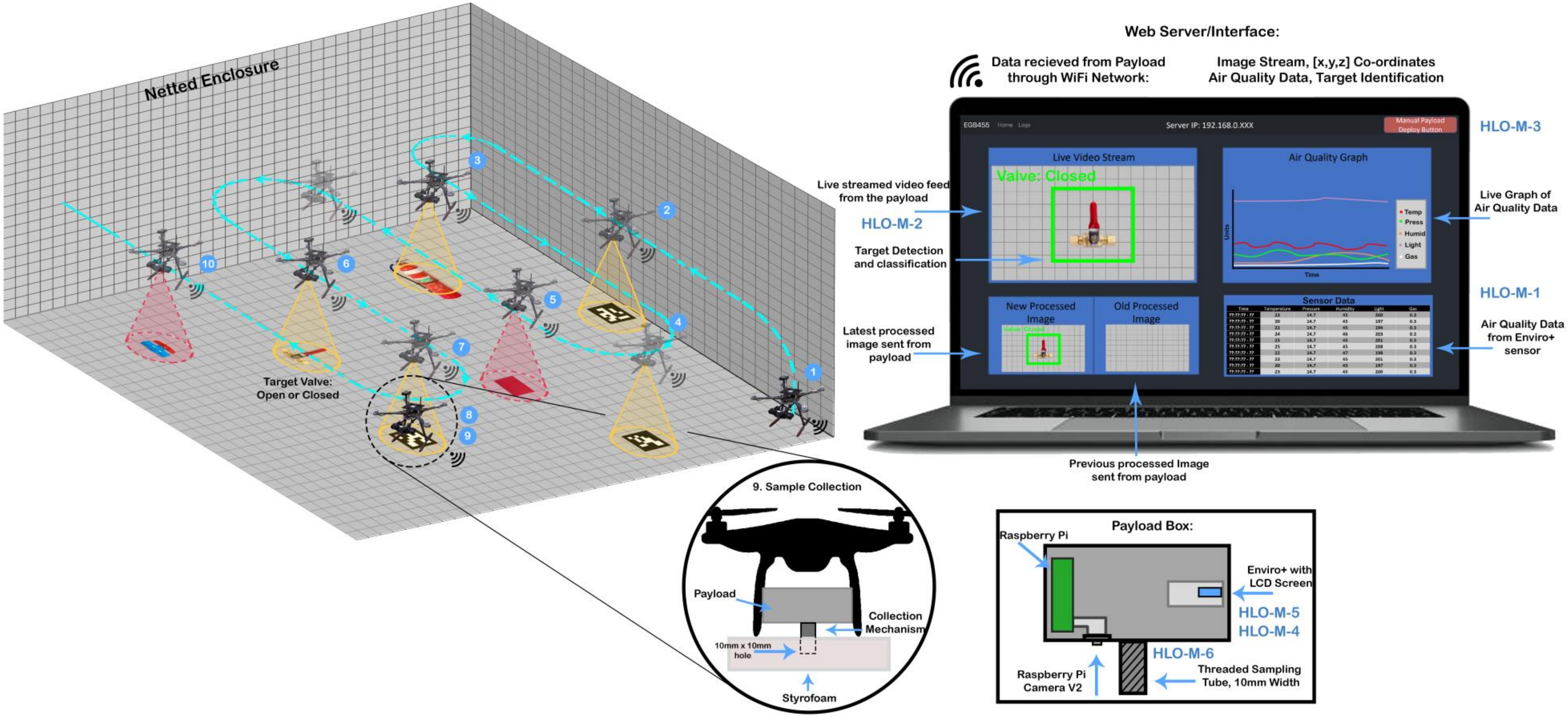


Figure 5 - Diagram of Concept of Operations

6.1 Concept of Operations description

The UAV will take off following a lawnmower like path flying at 2m/s, with a range of 1 to 3m off of the ground. As it moves through the path, the payload will use image processing to detect relevant targets being multiple ArUco markers, a fire extinguisher and an open or closed valve and inform the web interface through a live video stream. During the flight, an enviro sensor is collecting air quality data and sending it to the web server to be displayed on the web interface along with the processed images. The payload will avoid detecting objects that are not the specified targets, i.e. a red piece of paper of a different type of valve. The payload will locate a specific ArUco marker through its corresponding ID and initiate the landing for sample collection. After landing, a sampling tube will be deployed to dig a 10mm x 10mm section of Styrofoam landing area.

7. System Architecture

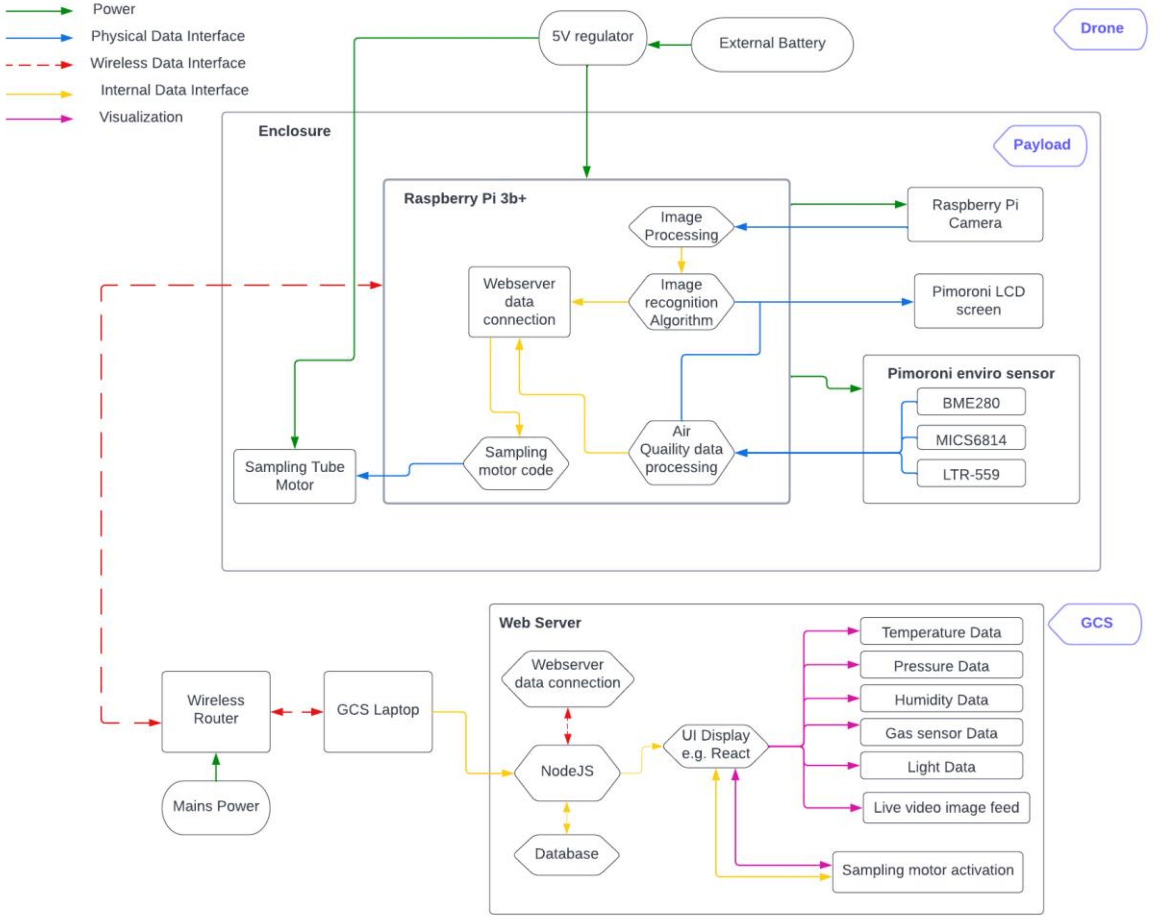


Figure 6 - System Architecture

7.1 Description of Subsystem Interfaces

7.1.1 Enclosure

The Enclosure subsystem is responsible for keeping all required components safe within the payload. The design interfaces directly with the Air Quality, Target Acquisition/Image processing and the Sampling Tube subsystems. These interfaces are the physical mounts for the components of these subsystems are to be held in place. This includes the Enviro+ air quality sensor, the camera and pi mount and motor. The purpose of this subsystem is to complete the HLO-M-4 3D Printed Enclosure and Temperature. This HLO includes the payload to weight under 320g and be designed to be IP41 rating. This HLO is also stated in a System Requirement **[REQ-M-01]**. The payload is to also contain the electronics system of the Air Quality sensor and RPi within the enclosure and the payload should be attached to the drone using the provided bracket. This subsystem is to also complete a number of requirements from the System Requirements Document RD/2. The Payload must be able to take measurements **[REQ-M-02]** therefore the device needs to be mounted with no obstructions to the sensors and the LCD screen must be visual **[REQ-M-13]**. The Payload must be able to detect objects **[REQ-M-04]** therefore the camera must have clear visibility. The sampling mechanism must be able to reach the soil sample and retract **[REQ-M-08 & REQ-M-09]** so it must be mounted in a clear space on the enclosure.

7.1.2 Air Quality

This subsystem is responsible for measuring hazardous gases, humidity, pressure, temperature, and light using the Pimoroni Enviro+ sensor as described in HLO-M-1 and required by [**REQ-M-02**]. Power will be provided by the Raspberry Pi using the provided header board extension cable. This cable will also allow for control of the sensor to occur with data passing between the sensor and the raspberry pi though it. The sensor will be attached to the side of the enclosure to ensure clear readings can be made and the LCD screen can be seen [**REQ-M-12**]. Code for this sensor will be completed using python. The code will collect and display all relevant data before sending it to the web server to display the data to the client along with all other data sources [**REQ-M-19**]. This is in accordance with HLO-M-3. This subsystem shall meet the requirements as laid out in the AQS preliminary design document.

7.1.3 Web Visualization and Interfaces

The Web Visualization and Interfaces subsystem is responsible for receiving the collected data from the payload and displaying the information in a readable format on a website interface as described in HLO-M-3. The subsystem is also responsible for displaying the information in real-time to the web interface without the needing to refresh the data **[REQ-M-05]**. The web server will be run locally on a laptop that is connected to the same network as the Raspberry pi, allowing the Raspberry Pi to send data over the local network **[REQ-M-03]**. The Web Interface is also hosted locally on a laptop, the Web Interface will display a live video stream and processed images sent from the Raspberry Pi in real-time **[REQ-M-06]**. The web interface will also display air quality data in a graph and table displayed within the interface, alongside the UAV coordinates. The data the WVI subsystem will receive is images and live video stream as described in HLO-M-2 and, air quality data sent from the AQS subsystem as outlined in HLO-M-1. The data sent from the Raspberry Pi will be stored in a database for later data retrieval which can be accessed with the database credentials. Finally, the web interface will also have a button allowing us to manually deploy the Sampling Tube subsystem if necessary.

7.1.4 Target Acquisition and Image Processing

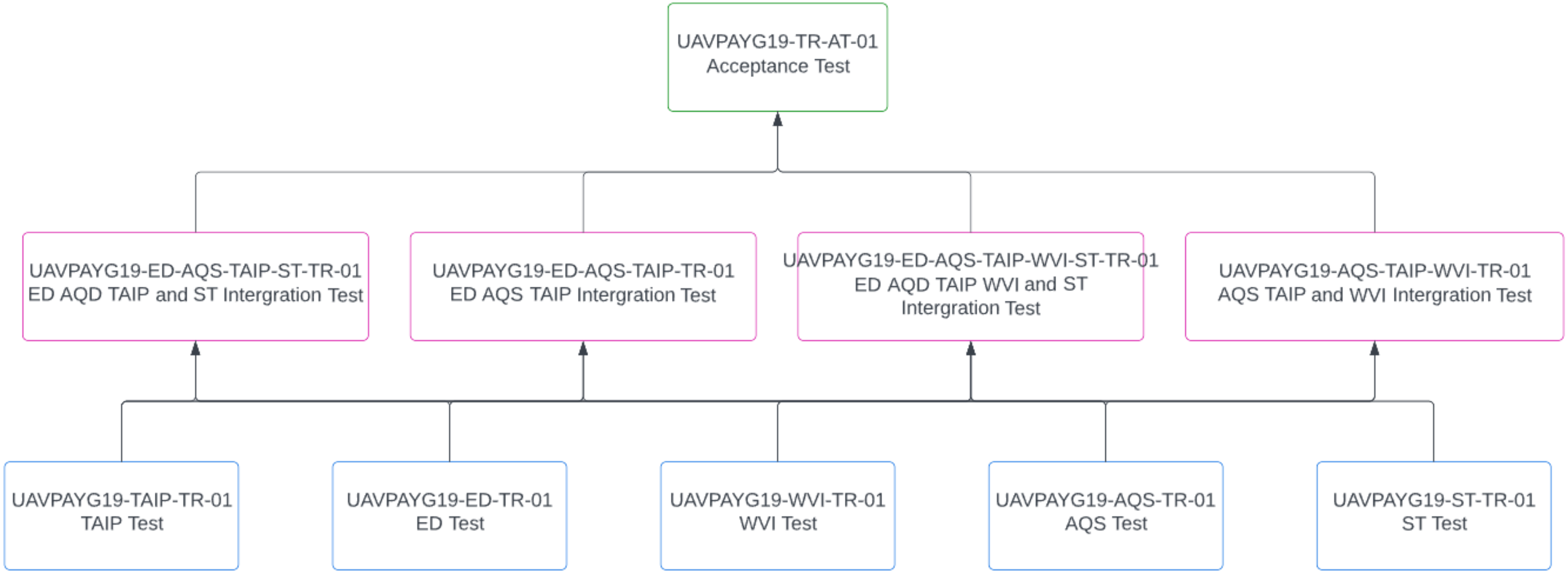
The Target Acquisition and Image Processing subsystem of the payload is responsible for the autonomous detection and identification of a set of three designated targets, namely an open or closed valve, a fire extinguisher and multiple ArUco markers as described in HLO-M-2. The subsystem is also responsible for providing a pose estimation of localisation coordinates (x, y, z) in a local frame to the UAV through the ArUco markers. The image processing will run on-board using the Raspberry Pi utilising a Raspberry Pi Cam V2 as required by **[REQ-M-16]** and will communicate with the web server by transmitting a live video feed and images of target detection along with the localisation coordinates (x, y, z) as per the requirements of HLO-M-3. This subsystem shall meet the requirements as described in the TAIP preliminary design document.

7.1.5 Sampling Tube

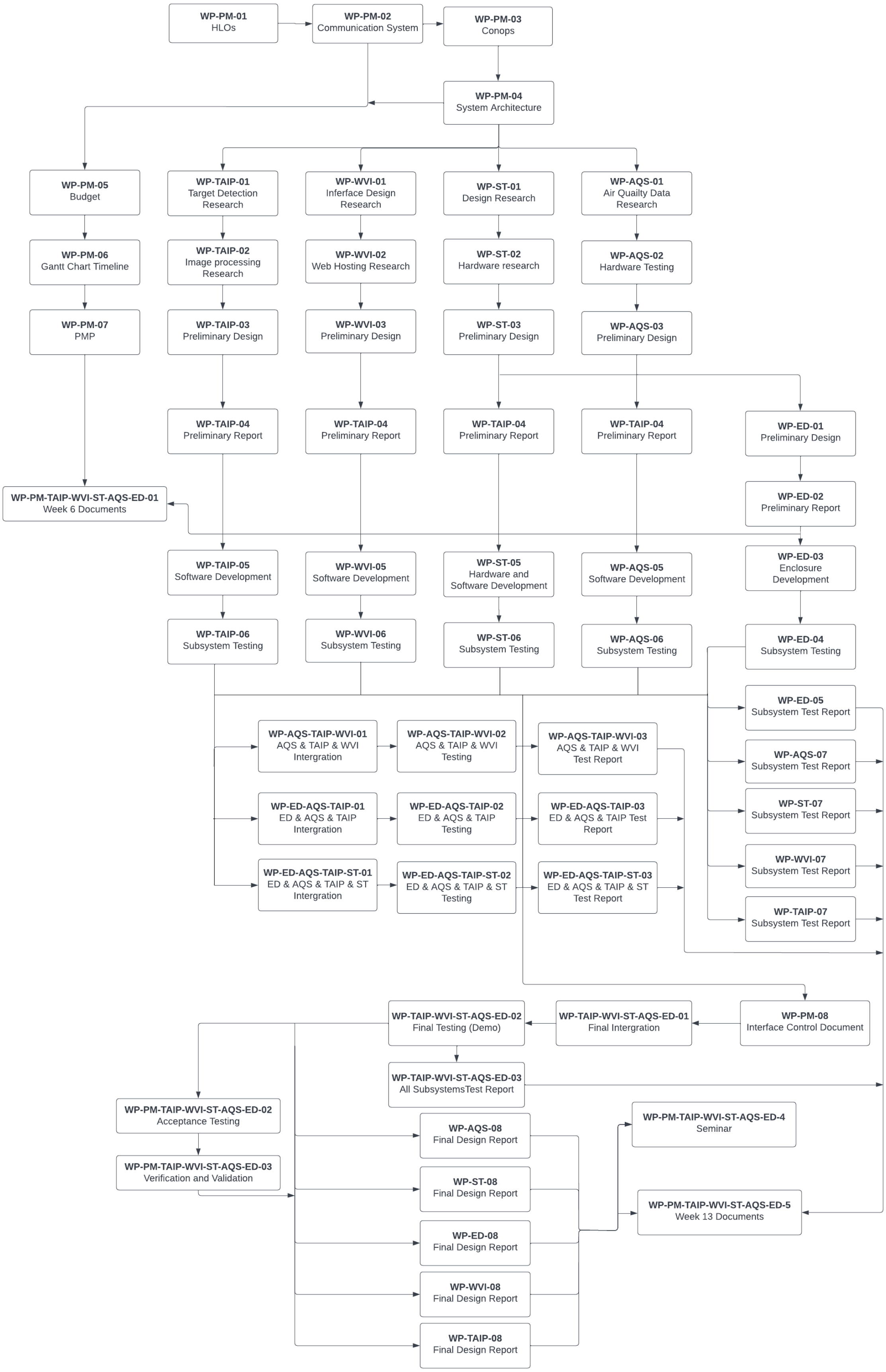
The Sampling Tube Subsystem is responsible for making a 10mm wide and 10mm deep indentation on a simulated soil with the use of a DF15RSMG servo motor as listed in HLO-M-6 and required by [**REQ-M-0s8**]. This system will be connected to the drone via the Enclosure Subsystem. Power cables consisting of a voltage common connector and a ground connector will be connected to a female adapter coming from the power adapter. A final cable will then connect with the Raspberry Pi via a general-purpose input/output pin that is passed through the Pimoroni Enviro+ module from the power adapter. This will allow the servo motor to be controlled by the Web Visualisation Interface Subsystem, before being converted in the Raspberry Pi and sent to the servo motor to allow the ST to extend and retract to meet [**REQ-M-09**]. Weight will also need to be taken into account to ensure that [**REQ-M-01**] is met.

8. Test Plan

The test plan is used developed of the Payload system to ensure that all requirements are met. Individual tests of each system is completed first followed by an variations of integration tests then finally the Acceptance Test.



9. Work Breakdown Structure



10. Gantt Chart

The Gantt Chart shows the status and timeframe of each task for subsystems within the project. It displays when the task is started and its due date.