QUEENSLAND UNIVERSITY OF TECHNOLOGY

Project Management Plan

EGH450: Advanced Unmanned Aircraft Systems

Prepared By ______ Owen Claxton, PROG6 Date 25/10/2021

Checked By ______ Sarah Lewis, INTG6 Date 25/10/2021

Approved By ______ Owen Claxton, PROG6 Date 25/10/2021

Authorised for use by ______ Assoc. Prof. Felipe Gonzalez, CS1 Date ______

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Group 6			
Team Member	**Primary Role**	**Code**	**Identifier**
Owen Claxton	Project Manager	PRO	n09957421
Tom Benedetti	System Specialist	SYS	n10217185
Matt Crimson	Navigation Specialist	NAV	n10528881
Sarah Lewis	Interface Specialist	INT	n10467122
Anthony Caracella	Communications Specialist	COM	n09667911
Natasha Goucher	Computer Vision Specialist	CVS	n10223622
Dan Brandenburg	Structure Specialist	STR	n10461345

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Julian Andres Galvez Serna	Client and Supervisor	CS2	s00000002
Alexander Farrall	Client and Supervisor	CS3	s00000003

Front Matter

Table of Revisions

Date	Issue	Description	Approval
24-MAR-2021	00.00	Document Creation	PRO
26-MAR-2021	01.00	Document Published	PRO
16-APR-2021	01.20	Addition of System Architecture, Work Packets, Timeline & Gantt Chart, Meeting Minutes, Budgets, Document Management, Resource Management	PRO
22-APR-2021	01.30	Minor corrections to header and title page	PRO
10-SEP-2021	01.40	Minor corrections to header and title page, updates to Gantt Chart and Test Plan.	PRO
27-OCT-2021	01.50	Minor corrections to header and title page. Adjusted document numbering scheme.	PRO

Definition of Terms

ASL	Airborne Systems Lab
BEC	Battery Eliminator Circuit
CAD	Computer Aided Design
Csen	Current Sensor Pin
ESC	Electronic Speed Controller
EKF	Extended Kalman Filter
GUI	Graphical User Interface
GCS	Ground Control Station
HUD	Heads Up Display
HLO	High Level Objective
MAVROS	Micro Air Vehicle ROS
mAh	Milliamp-hours
N&C	Navigation & Control
OBC	On-board Computer
OIS	Operator Interface Software
PRM	Payload Release Mechanism
PX4	PixHawk 4
PID	Proportional Integral Derivative
QGC	QGroundControl
QUT	Queensland University of Technology
QFS	QUT Flight Stack
RP4	Raspberry Pi 4
RC	Remote Control
ROS	Robot Operating System
SAR	Search and Rescue
SMS	System Management Software
UAV^{A}SR	UAV (Antarctica) SAR
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
VRPN	Virtual Reality Peripheral Network
Vsen	Voltage Sensor Pin
WBS	Work Breakdown Structure

Contents

List of Project Documents

Reference	Document Code	Document
RDP.001	SR21G6-PMT-CND	Customer Needs Document
RDP.002	SR21G6-PMT-PMP	Project Management Plan
RDP.003	SR21G6-PMT-SRQ	System Requirements
RDP.004	SR21G6-PMT-ICD	Interface Control Document
RDP.005	SR21G6-PMT-WPD	Work Packet Document
RDP.006	SR21G6-PMT-VAV	Verification and Validation Document
RDP.007	SR21G6-PMT-MMC	Meeting Minutes Compiled
RDP.008	SR21G6-PMT-WBS	Work Breakdown Structure
RDP.010	SR21G6-PDD-STT	Preliminary Design Document ARM/PLD
RDP.011	SR21G6-PDD-SSM	Preliminary Design Document PWR/PPL
RDP.012	SR21G6-PDD-ATP	Preliminary Design Document ATP
RDP.013	SR21G6-PDD-CTL	Preliminary Design Document GCS/CMM
RDP.014	SR21G6-PDD-IPS	Preliminary Design Document IPS
RDP.015	SR21G6-FDD-STT	Final Design Document ARM/PLD
RDP.016	SR21G6-FDD-SSM	Final Design Document PWR/PPL
RDP.017	SR21G6-FDD-ATP	Final Design Document ATP
RDP.018	SR21G6-FDD-CTL	Final Design Document GCS/CMM
RDP.019	SR21G6-FDD-IPS	Final Design Document IPS
RDP.020	SR21G6-TRD-ARM-SA	Test Report Document ARM Suite A
RDP.021	SR21G6-TRD-PWR-SA	Test Report Document PWR Suite A
RDP.022	SR21G6-TRD-PPL-SA	Test Report Document PPL Suite A
RDP.023	SR21G6-TRD-PAY-SA	Test Report Document PAY Suite A
RDP.024	SR21G6-TRD-ATP-SA	Test Report Document ATP Suite A
RDP.025	SR21G6-TRD-IPS-SA	Test Report Document IPS Suite A
RDP.026	SR21G6-TRD-GCS-SA	Test Report Document GCS Suite A
RDP.027	SR21G6-TRD-CMM-SB	Test Report Document CMM Suite A
RDP.030	SR21G6-TRD-ARM-SB	Test Report Document ARM Suite B
RDP.034	SR21G6-TRD-ATP-SB	Test Report Document ATP Suite B
RDP.035	SR21G6-TRD-IPS-SB	Test Report Document IPS Suite B
RDP.036	SR21G6-TRD-GCS-SB	Test Report Document GCS Suite B
RDP.037	SR21G6-TRD-CMM-SB	Test Report Document CMM Suite B
RDP.044	SR21G6-TRD-ATP-SC	Test Report Document ATP Suite C
RDP.045	SR21G6-TRD-IPS-SC	Test Report Document IPS Suite C
RDP.046	SR21G6-TRD-GCS-SC	Test Report Document GCS Suite C
RDP.047	SR21G6-TRD-CMM-SC	Test Report Document CMM Suite C
RDP.050	SR21G6-TRD-ITT-SA	Test Report Document Integration Suite A
RDP.051	SR21G6-TRD-ITT-SB	Test Report Document Integration Suite B
RDP.052	SR21G6-TRD-ITT-SC	Test Report Document Integration Suite C
RDP.053	SR21G6-TRD-ITT-SD	Test Report Document Integration Suite D
RDP.060	SR21G6-SDS-CHK	Operational Checklists
RDP.061	SR21G6-SDS-TDC	Technical Documents Compiled

1.0.0 Organisational Chart

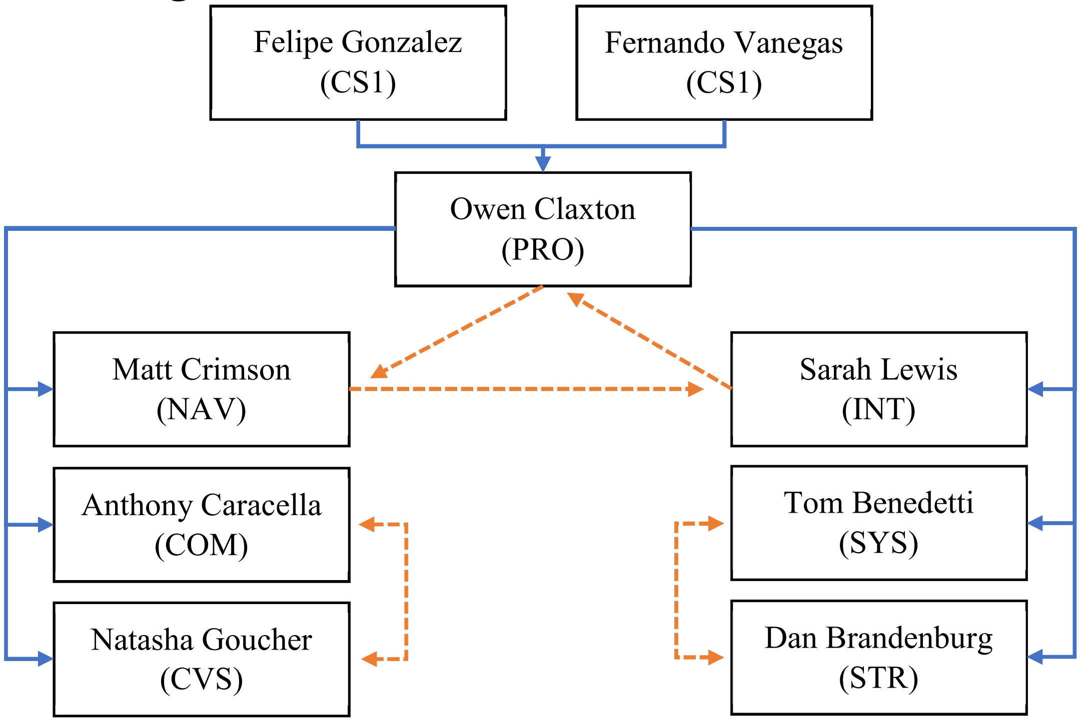


Figure 1: Organisational Chart. Blue lines indicate direction of supervision. Each team member has their primary role included on their panel. Orange lines represent supporting relationships (secondary roles).

1.1.0 Team Members

Owen Claxton

Primary Role: Project Manager [PRO]
Secondary Role: Navigation Specialist [NAV]

Involved in all aspects of project management. Primary point of reference for all other team members. Supervisors all progress in the project and reports directly to the client. Chairs all team meetings. Role includes work in: Document formatting, project management, supervision, and providing support to all team members.

Dan Brandenburg

Primary Role: Systems Specialist [STR]
Secondary Role: Payload Specialist [SYS]

Performs the research, design, implementation, verification, and validation of the airframe and payload subsystems. Responsible for providing the required documentation for the, power, and propulsion subsystems to the PRO. Role includes work in: CAD, electrical to mechanical transfer systems, and stress analysis.

Tom Benedetti

Primary Role: System Specialist [SYS]
Secondary Role: Structure Specialist [STR]

Performs the research, design, implementation, verification, and validation of the power and propulsion subsystems. Responsible for providing the required documentation for the airframe and payload subsystem to the PRO. Role includes work in: CAD, electronics, power systems, and microelectronics.

Natasha Goucher

Primary Role: Computer Vision Specialist [CVS]
Secondary Role: Communications Specialist [COM]

Performs the research, design, implementation, verification, and validation of the mission sensors subsystem alongside the COM, with work focussing on the image processing and computer vision aspects. Shares responsibility for providing the required documentation for the mission sensors subsystem to the PRO with the COM. Role includes work in: Image processing, computer vision, sensor drivers.

Anthony Caracella

Primary Role: Communications Specialist [COM]
Secondary Role: Computer Vision Specialist [CVS]

Performs the research, design, implementation, verification, and validation of the mission sensors subsystem alongside the CVS, with work focussing on the image processing and computer vision aspects. Shares responsibility for providing the required documentation for the mission sensors subsystem to the PRO with the CVS. Role includes work in: ROS, package installation, and software systems.

Matt Crimson

Primary Role: Navigation Specialist [NAV]
Secondary Role: Interface Specialist [INT]

Performs the research, design, implementation, verification, and validation of the autopilot subsystem. Responsible for providing the required documentation for the autopilot subsystem to the PRO. Role includes work in: telemetry analysis, Extended Kalman Filters (EKFs), and control sensor configuration.

Sarah Lewis

Primary Role: Interface Specialist [INT]
Secondary Role: Project Manager [PRO]

Performs the research, design, implementation, verification, and validation of the ground control station subsystem and related interface design. Responsible for providing the required documentation for the ground control station subsystem to the PRO. Role includes work in: Python interface development, ROS, QGroundControl (QGC), and Graphical User Interfaces (GUIs).

1.2.0 Relevant Management

1.2.1 Document Management

Team members are encouraged to use the designated formatting, contents, naming conventions, and storage due to the scale and longevity of the project. These standard procedures will ensure effortless communication between group members and provide clarity for the client when reviewing the project. Each final document is to be passed onto the PRO for reviewing before the document can be signed off and presented to the client.

1.2.2 Document Templates

The project supervisors have provided templates and guides for documentation, which are then modified and/or applied by the PRO to suit the team's needs. These modifications include the team name, dates, and other project related information, as well as minor stylistic choices. Team members are expected to use the templates provided by the project manager to ensure documentation cohesion.

1.2.3 Document File Numbering

Each document will have a unique alphanumeric code to assist in identification and location purposes. Each naming convention will contain the project name, document name, document version, and other relevant identifiers where appropriate such as subsystem codes.

For example, this document uses the code: SR21G6-PMT-PMP to represent Search and Rescue (SR) 2021 (21) Group 6 (G6) – Project Management (PMT) – Project Management Plan (PMP).

For documents related to a specific subsystem, the notation would be similar to SR21G6-TRD-APT-SA. This code represents Search and Rescue (SR) 2021 (21) Group 6 (G6) – Test Report Document (TRD) – Autopilot (APT) – Suite A (SA).

1.2.4 Revision of Documents

Document revision will need to be recorded and updated as the project progresses. As a document is being edited and compiled, team members are to record progress through the application known as Trello. Each section is to be checked off on Trello once completed with notes attached to the tasks regarding any information other team members need to know.

1.2.5 Document and Media Storage

Google Drive is to be used as the storage platform. Members are encouraged to edit the documents through Word instead of Google Docs or Excel instead of Google Spreadsheets to allow for an easier formatting process. Each document has its own folder with each section further broken down into subfolders for ease of access and editing. Once the development process is completed, each section will be compiled into the finalised document for formatting and final editing. A shared Google account will be made and used, alongside the Google Drive Backup & Sync application.

1.3.0 Resource Management

There are numerous resources available to the group conducting the UAV^{A}SR project. This section will detail the resources available, sectioned under human, locational, facility, and software resources.

1.3.1 Human Resources

The group conducting the project comprises seven members, each with allocated roles and sub-roles to subsystems, with one project manager. Each member of the group is a human support resource. The project manager is responsible for assigning adequate workload to each member of the group and is a resource each member can access to modify workload.

If assistance is needed on a subsystem, the member with the relevant sub-role can be accessed as a supporting resource. Support is additionally available by technical support staff, located at QUT, level nine S-Block. The project supervisor, Dr. Felipe Gonzalez, is additionally a support resource that each member of the group can contact to acquire assistance on the project.

1.3.2 Facility Resources

Facilities exist as a resource to help facilitate the project completion. Located at QUT, level nine S-Block, S901 is a dedicated avionics lab. This lab has the necessary equipment in order to test and develop the UAV. This lab additionally has a netted test space in order to flight test the UAV. The S-Block level nine store additionally is a resource to provide any physical components needed in the development of the project. The S-9 store provides the parts listed in the mass budget.

Additional facilities include the electronics lab, S905-C, located at QUT, S-Block level nine, which can facilitate the development and testing of the electronic components of the UAV. The LaunchPad workshop additionally exists at QUT O-Block, level two, O230, catering as a resource to the physical development of the UAV.

1.3.3 Locational Resources

Locational resources exist for the group to utilise in order to facilitate the development of the project. These include QUT locations, such as V block, which act as both a collaborative meeting space and workspace in order to develop the project. The Da Vinci Precinct will also be utilised for the VICON system. Collaborative workspace rooms additionally exist around QUT and serve as a resource for the project team to utilise.

1.3.4 Software Resources

Various software programs exist as a resource in order to aid the development of the project. The Zoom meeting application is utilised in team meetings. This app allows meetings to occur, regardless of the location of each team member. For work collaboration and document organisation, Google Drive is utilised. This software allows each subsystem and milestone requirements to be organised in folders and allows multiple group members to work on a single document simultaneously. Trello, an organisation web service, is used to facilitate the management and assignment of tasks to team members. “To-do” list tasks are used in order to meet required components of each task, with each member being assigned to each task on the “To-do” list.

2.0.0 Concept of Operations

2.1.0 Introduction

The concept of operations (CONOPS) gives a detailed insight as to how the mission will be conducted. For this mission, the team will be simulating a search and rescue scenario in an Antarctic environment. By nature of a simulation, markers will be used to represent people suffering from medical emergencies, and the medical equipment will be suitably replaced with a simulant as well. This section will provide descriptions of each section in the CONOPS. The CONOPS sectioned and numbered to depict stages of the mission and high-level requirements needed for operation. Each numbered point will be provided with an overview later referenced and as to how they relate to the high-level requirements.

2.2.0 CONOPS Diagram

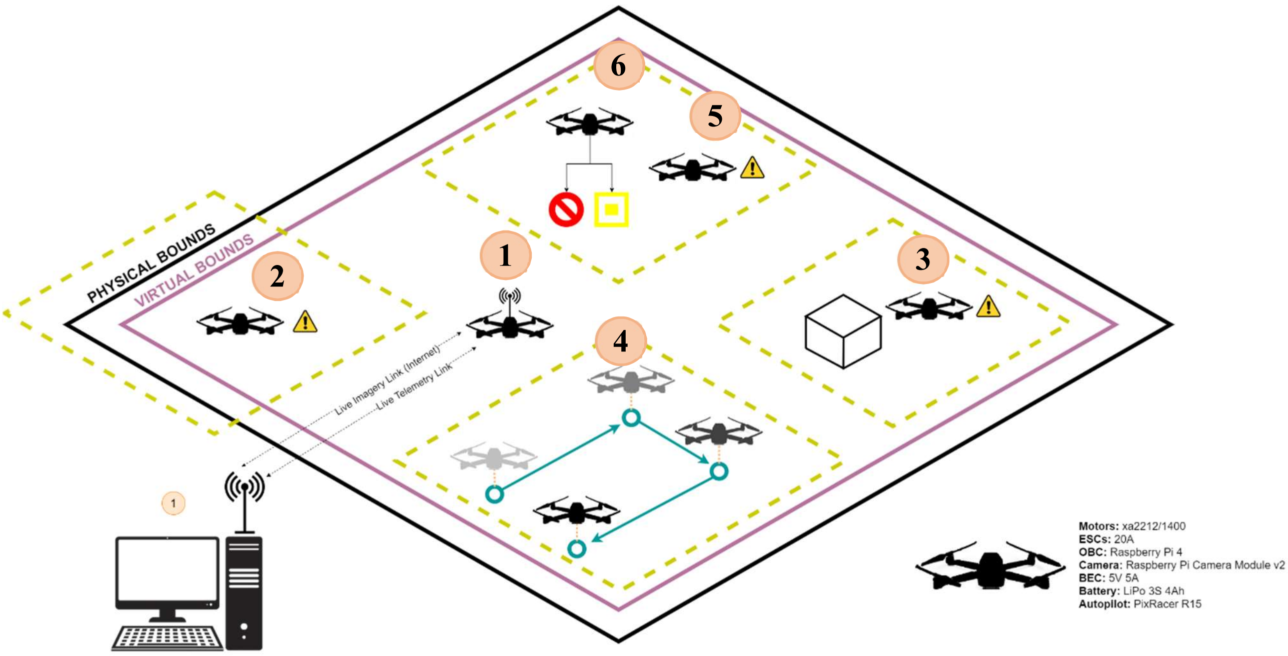


Figure 2: Concept of Operations Diagram

2.2.1 Ground Control and User Interface

1. The UAV will have both a live telemetry link and a live imagery link in order to provide the team with mission progress and real time data. The ground control station shall graphically display and log the real time data through transmission through a telemetry and imagery link. The real time data will be made available at the GCS through ROS, utilising standardised ROS messages. The GCS will additionally display a 3D visualisation of the search area for the operator.

   Relevant Criteria: [**REQ-H3.1**], [**REQ-H3.1.5**], [**REQ-H3.1.7**], [**REQ_H6.5**], [**REQ_H6.6**]

2.2.2 Operational Area

2. The simulation of the mission will be conducted within a 4 square meter netted flight zone. This will ensure the safety of the team and the functionality and precision of the on-board navigation system. The UAV will have programmed boundaries, which prevent the UAV exceeding the virtual bounds, in addition to colliding with the net. This is additionally aided by obstacle detection capabilities to ensure the UAV stays within its operational area.

   Relevant Criteria: [**REQ-H3.1**], [**REQ-H3.2**]

2.2.3 Control and Automation

3. The UAV will have on-board obstacle detection and avoidance software to manoeuvre around any potential obstructions. This will prevent mission failure by any unpremeditated descent or controlled flight into terrain.

   Relevant Criteria: [**REQ-H2.1**]

4. The UAV will be able to follow a waypoint navigation system to ensure that all aspects of the mission area are covered. The waypoints will cover a square pattern in the operational area, and the UAV shall traverse all four waypoints autonomously without user input.

   Relevant Criteria: [**REQ-H4.3**]

5. The UAV will be able to identify various types of markers located on the ground in the operational area. The markers will be representative of the particular medical emergency. The yellow marker will represent a person with a haemorrhage. The red marker will represent a person with anaphylaxis. The UAV, when identifying the type of marker, will deliver the correct package to the relevant marker with precision. The position of each marker will be localised to an accuracy of 50 cm.

   Relevant Criteria: [**REQ-H4.2**], [**REQ-H4.3**], [**REQ-H5.2**], [**REQ-H5.3**]

2.2.4 Payload Deployment

1. The UAV will detect the drop zone autonomously and hover above the target for five seconds without user input to ensure drop accuracy. The UAV will then autonomously place the appropriate package within 20 cm of the target.

   Relevant Criteria: [**REQ-H5.1**], [**REQ-H5.2**], [**REQ-H5.3**], [**REQ-H6.2.5**

3.0.0 Project Formulation

3.1.0 Project Stages

As the project progresses, the broken-down structure of the work will pass through ten stages. These ten stages may occur either consecutively for the whole system, or concurrently per subsystem.

Table 2: Project Stages and Descriptions

ID	Stage	Occurrence	Description	WBS Colour Code
S0	Project Establishment	Consecutive	Processes, largely administrative, for commencement.	
S1	Research	Concurrent	Performing general research and trade studies relevant to the project and subsystem	
S2	Design	Concurrent	Applying the knowledge of S1 in context of the HLOs to design an appropriate subsystem	
S3	Subsystem Assembly	Concurrent	Constructing the subsystem designed in S2	
S4	Subsystem Testing	Concurrent	Testing the subsystem constructed in S3	
S5	Full System Assembly	Consecutive	Merging all subsystems once each has reached the end of S4 to construct the full system	
S6	Full System Testing	Concurrent	Performing full system testing, which includes subsystem testing	
S7	Revision and Updates	Concurrent	Applying the results reached in S4 and S6 to revise designs or products.	
S8	Mission Operation	Consecutive	Demonstrating the UAV to validate project work.	
S9	Project Conclusion	Consecutive	Reporting on the successes and shortcomings of S8 and closing project work.	

3.2.0 Subsystems

The project product will be split into the following subsystems.

Table 3: Subsystem List

Code	Subsystem	Specialist	Typical Components
ARM	Airframe	SYS	Airframe, Payload mounting, Housing, Canopy
PWR	Power	SYS	Battery, BEC
PPL	Propulsion	SYS	Motors, ESC, Propellers
PLD	Payload	PAY	Mechanical System, Electrical System, Payload
APT	Autopilot	NAV	Flight Controller, GPS, IMU, Altimeter, OBC
MSS	Mission Sensors	CVS	Camera, Detection System, Image Processing
CMM	Communications	COM	Telemetry Link, RC Link
GCS	Ground Control Station	INT	SMS, VICON Server, N&C, OIS
PMT	Project Management	PRO	Paperwork

For latter stages such as integration, several subsystems will be redefined and grouped as follows:

Table 4: Grouped Subsystem List

Code	Subsystem	Specialist	Grouped subsystems
SSM	System	SYS	ARM and PAY
STT	Structure	STR	PWR and PPL
CTL	Control	INT	GCS and CMM

5.0.0 Project Timeline

Time management is critical to the timely deliverance of an effective solution. To ensure project milestones are met and new projects are started on time, a Gantt chart has been developed to depict the status of the project. The chart displays the start and end start and end dates of the project, in addition to the duration and the percentage of completion. The chart is used to trace the project as a whole.

Semester 1

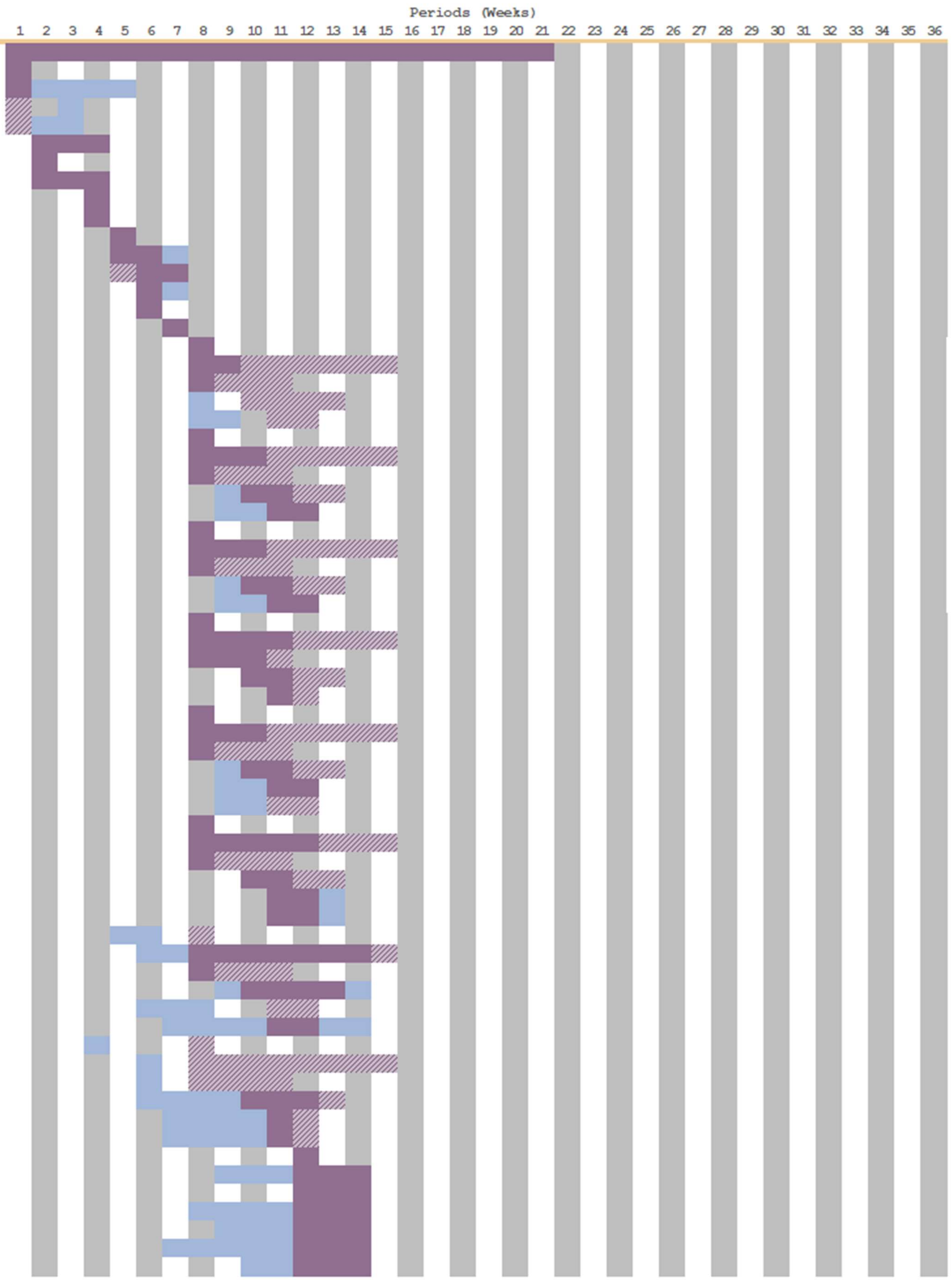
Period	Monday	Sunday	Significance
1	1/03/2021	7/03/2021	Week 1
2	8/03/2021	14/03/2021	Week 2
3	15/03/2021	21/03/2021	Week 3
4	22/03/2021	28/03/2021	Week 4
5	29/03/2021	4/04/2021	Week 5
6	5/04/2021	11/04/2021	Midsemester Break
7	12/04/2021	18/04/2021	Week 6
8	19/04/2021	25/04/2021	Week 7
9	26/04/2021	2/05/2021	Week 8
10	3/05/2021	9/05/2021	Week 9
11	10/05/2021	16/05/2021	Week 10
12	17/05/2021	23/05/2021	Week 11
13	24/05/2021	30/05/2021	Week 12
14	31/05/2021	6/06/2021	Week 13
15	7/06/2021	13/06/2021	Week 14; Exam Block
16	14/06/2021	20/06/2021	Week 15; Exam Block
17	21/06/2021	27/06/2021	Mid-Year Break
18	28/06/2021	4/07/2021	Mid-Year Break

Semester 2

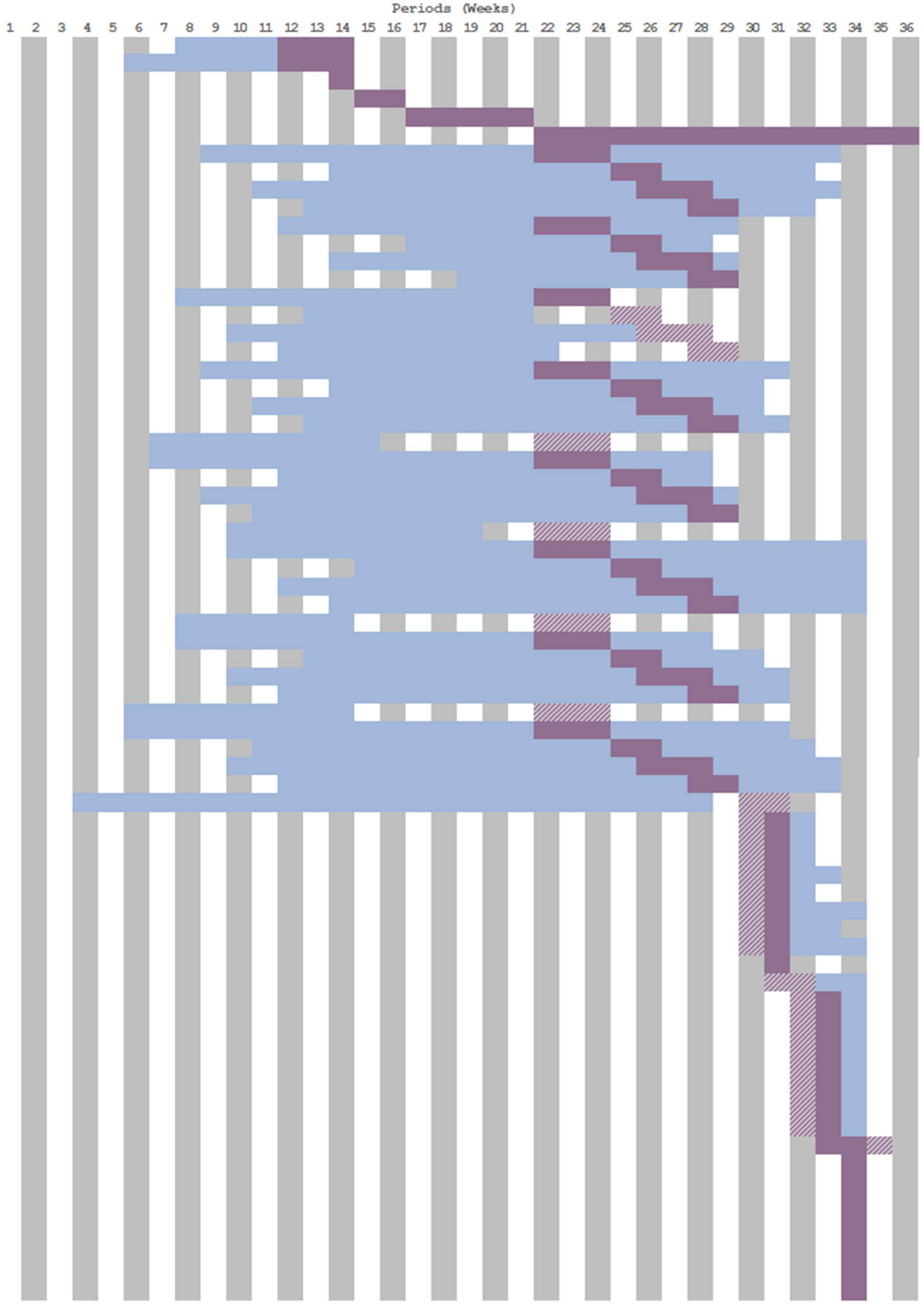
Period	Monday	Sunday	Significance
19	5/07/2021	11/07/2021	Mid-Year Break
20	12/07/2021	18/07/2021	Mid-Year Break
21	19/07/2021	25/07/2021	Mid-Year Break
22	26/07/2021	1/08/2021	Week 1
23	2/08/2021	8/08/2021	Week 2
24	9/08/2021	15/08/2021	Week 3
25	16/08/2021	22/08/2021	Week 4
26	23/08/2021	29/08/2021	Week 5
27	30/08/2021	5/09/2021	Week 6
28	6/09/2021	12/09/2021	Week 7
29	13/09/2021	19/09/2021	Week 8
30	20/09/2021	26/09/2021	Week 9
31	27/09/2021	3/10/2021	Midsemester Break
32	4/10/2021	10/10/2021	Week 10
33	11/10/2021	17/10/2021	Week 11
34	18/10/2021	24/10/2021	Week 12
35	25/10/2021	31/10/2021	Week 13
36	1/11/2021	7/11/2021	Week 14; Exam Block

EGB349 & EGH450 Timeline

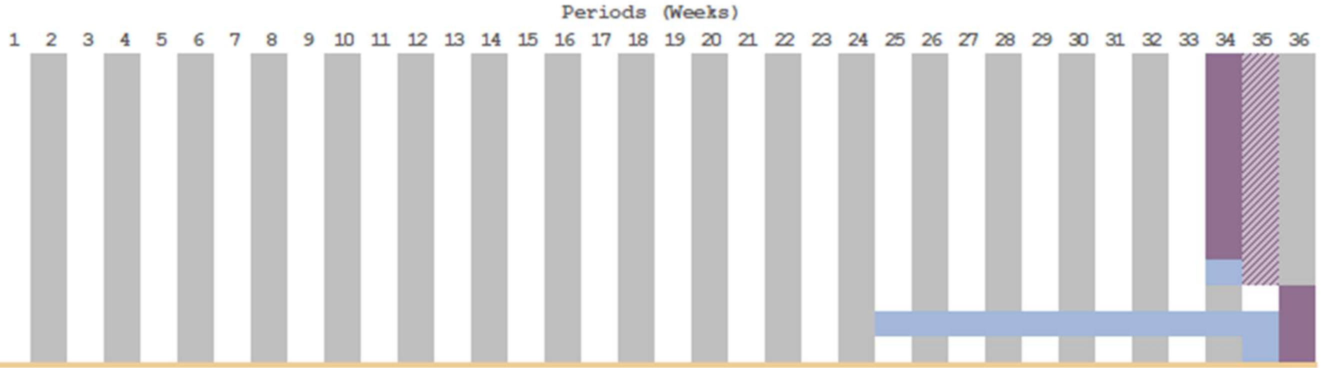
Work Packet	Title	Planned Start	Planned Duration	Actual Start	Actual Duration	Percent Complete
WP-PMT-01-N	Management	1	21	1	21	100%
WP-PMT-02-N	HLOs Definitions	1	1	1	1	100%
WP-PMT-03-N	Team Strategy	1	1	1	5	100%
WP-PMT-04-N	Organisational Chart	1	1	3	1	100%
WP-PMT-05-N	Concept of Operations	1	1	2	2	100%
WP-PMT-06-N	System Requirements	2	3	2	3	100%
WP-PMT-07-N	Project Formulation	2	1	2	1	100%
WP-PMT-08-N	Work Breakdown Structure	2	3	2	3	100%
WP-PMT-09-N	Project Management Plan	4	1	4	1	100%
WP-PMT-10-N	Milestone 1	4	1	4	1	100%
WP-PMT-11-N	Project Timeline	5	1	5	1	100%
WP-PMT-12-N	Work Packages	5	2	5	3	100%
WP-PMT-13-N	System Architecture Plan	5	3	6	2	100%
WP-PMT-14-N	Budgets	6	1	6	2	100%
	Mid Semester Break 1	6	1	6	1	100%
WP-PMT-15-N	Milestone 2	7	1	7	1	100%
WP-ARM-01-N	Initialisation	8	1	8	1	100%
WP-ARM-02-N	Background Research	8	8	8	2	100%
WP-ARM-03-N	Trade Studies	8	4	8	1	100%
WP-ARM-04-N	Preliminary Design	10	4	8	1	100%
WP-ARM-05-N	Prototype	11	2	8	2	100%
WP-PWR-01-N	Initialisation	8	1	8	1	100%
WP-PWR-02-N	Background Research	8	8	8	3	100%
WP-PWR-03-N	Trade Studies	8	4	8	1	100%
WP-PWR-04-N	Preliminary Design	10	4	9	3	100%
WP-PWR-05-N	Prototype	11	2	9	4	100%
WP-PPL-01-N	Initialisation	8	1	8	1	100%
WP-PPL-02-N	Background Research	8	8	8	3	100%
WP-PPL-03-N	Trade Studies	8	4	8	1	100%
WP-PPL-04-N	Preliminary Design	10	4	9	3	100%
WP-PPL-05-N	Prototype	11	2	9	4	100%
WP-PLD-01-N	Initialisation	8	1	8	1	100%
WP-PLD-02-N	Background Research	8	8	8	4	100%
WP-PLD-03-N	Trade Studies	8	4	8	3	100%
WP-PLD-04-N	Preliminary Design	10	4	10	2	100%
WP-PLD-05-N	Prototype	11	2	11	1	100%
WP-ATP-01-N	Initialisation	8	1	8	1	100%
WP-ATP-02-N	Background Research	8	8	8	3	100%
WP-ATP-03-N	Trade Studies	8	4	8	1	100%
WP-ATP-04-N	Preliminary Design	10	4	9	3	100%
WP-ATP-05-A	Hardware Prototype	11	2	9	4	100%
WP-ATP-05-B	Software Prototype	11	2	9	2	100%
WP-IPS-01-N	Initialisation	8	1	8	1	100%
WP-IPS-02-N	Background Research	8	8	8	5	100%
WP-IPS-03-N	Trade Studies	8	4	8	1	100%
WP-IPS-04-N	Preliminary Design	10	4	10	2	100%
WP-IPS-05-A	Hardware Prototype	11	2	11	3	100%
WP-IPS-05-B	Software Prototype	11	2	11	3	100%
WP-CMM-01-N	Initialisation	8	1	5	2	100%
WP-CMM-02-N	Background Research	8	8	6	9	100%
WP-CMM-03-N	Trade Studies	8	4	8	1	100%
WP-CMM-04-N	Preliminary Design	10	4	9	6	100%
WP-CMM-05-A	Hardware Prototype	11	2	6	3	100%
WP-CMM-05-B	Software Prototype	11	2	7	8	100%
WP-GCS-01-N	Initialisation	8	1	4	1	100%
WP-GCS-02-N	Background Research	8	8	6	1	100%
WP-GCS-03-N	Trade Studies	8	4	6	1	100%
WP-GCS-04-N	Preliminary Design	10	4	6	7	100%
WP-GCS-05-A	Hardware Prototype	11	2	7	5	100%
WP-GCS-05-B	Software Prototype	11	2	7	5	100%
WP-PMT-16-N	Demonstration 1	12	1	12	1	100%
WP-ARM-06-N	Design Revision	12	3	9	6	100%
WP-PWR-06-N	Design Revision	12	3	12	3	100%
WP-PPL-06-N	Design Revision	12	3	8	7	100%
WP-PLD-06-N	Design Revision	12	3	9	6	100%
WP-ATP-06-N	Design Revision	12	3	7	8	100%
WP-IPS-06-N	Design Revision	12	3	10	5	100%



Work Packet	Title	Planned Start	Planned Duration	Actual Start	Actual Duration	Percent Complete
WP-CMM-06-N	Design Revision	12	3	8	7	100%
WP-GCS-06-N	Design Revision	12	3	6	9	100%
WP-PMT-17-N	Milestone 3	14	1	14	1	100%
	Exam Block 1	15	2	15	2	100%
	Mid Year Break	17	5	17	5	100%
WP-PMT-01-N	Management	22	15	22	15	100%
WP-ARM-07-N	Final Design	22	3	9	25	100%
WP-ARM-08-N	Production	25	2	14	19	100%
WP-ARM-09-N	Testing & Correction	26	3	11	23	100%
WP-ARM-10-N	Integration	28	2	13	20	100%
WP-PWR-07-N	Final Design	22	3	12	18	100%
WP-PWR-08-N	Production	25	2	17	12	100%
WP-PWR-09-N	Testing & Correction	26	3	14	16	100%
WP-PWR-10-N	Integration	28	2	19	11	100%
WP-PPL-07-N	Final Design	22	3	8	17	100%
WP-PPL-08-N	Production	25	2	13	9	100%
WP-PPL-09-N	Testing & Correction	26	3	10	16	100%
WP-PPL-10-N	Integration	28	2	12	11	100%
WP-PLD-07-N	Final Design	22	3	9	23	100%
WP-PLD-08-N	Production	25	2	14	17	100%
WP-PLD-09-N	Testing & Correction	26	3	11	20	100%
WP-PLD-10-N	Integration	28	2	13	19	100%
WP-ATP-07-A	Final Hardware Design	22	3	7	9	100%
WP-ATP-07-B	Final Software Design	22	3	7	22	100%
WP-ATP-08-N	Production	25	2	12	17	100%
WP-ATP-09-N	Testing & Correction	26	3	9	21	100%
WP-ATP-10-N	Integration	28	2	11	19	100%
WP-IPS-07-A	Final Hardware Design	22	3	10	10	100%
WP-IPS-07-B	Final Software Design	22	3	10	25	100%
WP-IPS-08-N	Production	25	2	15	20	100%
WP-IPS-09-N	Testing & Correction	26	3	12	23	100%
WP-IPS-10-N	Integration	28	2	14	21	100%
WP-CMM-07-A	Final Hardware Design	22	3	8	7	100%
WP-CMM-07-B	Final Software Design	22	3	8	21	100%
WP-CMM-08-N	Production	25	2	13	18	100%
WP-CMM-09-N	Testing & Correction	26	3	10	22	100%
WP-CMM-10-N	Integration	28	2	12	20	100%
WP-GCS-07-A	Final Hardware Design	22	3	6	9	100%
WP-GCS-07-B	Final Software Design	22	3	6	26	100%
WP-GCS-08-N	Production	25	2	11	22	100%
WP-GCS-09-N	Testing & Correction	26	3	10	24	100%
WP-GCS-10-N	Integration	28	2	12	22	100%
WP-PMT-18-N	Full System Assembly	30	2	4	25	100%
WP-ARM-11-N	Verification	30	2	31	2	100%
WP-PWR-11-N	Verification	30	2	31	2	100%
WP-PPL-11-N	Verification	30	2	31	2	100%
WP-PLD-11-N	Verification	30	2	31	3	100%
WP-ATP-11-N	Verification	30	2	31	2	100%
WP-IPS-11-N	Verification	30	2	31	4	100%
WP-CMM-11-N	Verification	30	2	31	3	100%
WP-GCS-11-N	Verification	30	2	31	4	100%
	Mid Semester Break 2	31	1	31	1	100%
WP-PMT-19-N	Full System Testing	31	2	33	2	100%
WP-ARM-12-N	Revision & Updates	32	2	33	2	100%
WP-PWR-12-N	Revision & Updates	32	2	33	2	100%
WP-PPL-12-N	Revision & Updates	32	2	33	2	100%
WP-PLD-12-N	Revision & Updates	32	2	33	2	100%
WP-ATP-12-N	Revision & Updates	32	2	33	2	100%
WP-IPS-12-N	Revision & Updates	32	2	33	2	100%
WP-CMM-12-N	Revision & Updates	32	2	33	2	100%
WP-GCS-12-N	Revision & Updates	32	2	33	2	100%
WP-PMT-20-N	Revision & Updates	33	3	33	2	100%
WP-ARM-13-N	Validation	34	1	34	1	100%
WP-PWR-13-N	Validation	34	1	34	1	100%
WP-PPL-13-N	Validation	34	1	34	1	100%
WP-PLD-13-N	Validation	34	1	34	1	100%
WP-ATP-13-N	Validation	34	1	34	1	100%
WP-IPS-13-N	Validation	34	1	34	1	100%
WP-CMM-13-N	Validation	34	1	34	1	100%
WP-GCS-13-N	Validation	34	1	34	1	100%



Work Packet	Title	Planned Start	Planned Duration	Actual Start	Actual Duration	Percent Complete
WP-ARM-14-N	Operation & Maintenance	34	2	34	1	100%
WP-PWR-14-N	Operation & Maintenance	34	2	34	1	100%
WP-PPL-14-N	Operation & Maintenance	34	2	34	1	100%
WP-PLD-14-N	Operation & Maintenance	34	2	34	1	100%
WP-ATP-14-N	Operation & Maintenance	34	2	34	1	100%
WP-IPS-14-N	Operation & Maintenance	34	2	34	1	100%
WP-CMM-14-N	Operation & Maintenance	34	2	34	1	100%
WP-GCS-14-N	Operation & Maintenance	34	2	34	1	100%
WP-PMT-21-N	Mission Operation	35	1	34	1	100%
	Exam Block 2	36	1	36	2	100%
WP-PMT-22-N	Final UAV Documentation	36	1	25	12	100%
WP-PMT-23-N	Acceptance	36	1	35	2	100%



6.0.0 Budgets

6.1.0 Data Budget

The data budget outlines the data rate (BAUD rate) capable by the communications links, of which is derived from the time available for communications. The rates are separated into downlink and uplink, with minimum, typical, and maximum data rates provided. The quality of the data, resolution, package size and bandwidth are tracked parameters in the data budget.

Table 5: Data Budget

Value of Interest		Value	Unit	Significance
Link Time		3600.00	seconds	Number of seconds available for connection each hour
Downlink Rate	Min	*40.00*	*Mb/s*	Downlink speed for receiving at GCS
	Typical	*58.00*		
	Max	*97.60*		
Uplink Rate	Min	*19.00*	*Mb/s*	Uplink speed for sending from GCS
	Typical	*25.00*		
	Max	*30.00*		
MDT/h		31.00	GB	Maximum amount of data transferable each hour
Downlink Reservation	Min	30.00	percent	Amount of the MDT/h reserved for downlink communication
	Typical	45.00		
	Max	75.00		
Uplink Reservation	Min	5.00	percent	Amount of the MDT/h reserved for uplink communication
	Typical	10.00		
	Max	15.00		
Total Reservation	Min	35.00	percent	Amount of the MDT/h reserved for all communication
	Typical	55.00		
	Max	90.00		

6.2.0 Power Budget

Power is critical to the operation of the UAV; every electrical system on board the aircraft requires power. Power supply is limited to the output of an on-board battery, which must power the motors to generate lift, sensors for data acquisition, and auxiliary systems for data processing, data transmission and the autopilot. The power budget ensures that there is enough power such that all these components receive enough power to function correctly.

Table 6: Power Budget

ID	Part Name	QTY	Voltage Range			Current Range			Power Range		
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
15	PixRacer Power Module	1	0.00	12.00	42.00	0.00	3.00	90.00	0.00	36.00	3780.00
04	Electronic Speed Controller	4	0.00	5.00	5.00	0.00	20.00	25.00	0.00	100.00	125.00
02	Motor	4	8.00	10.00	12.00	16.00	20.60	24.00	128.00	206.00	288.00
18	LiPo 3S 4.0Ah + Bag	1	9.80	11.10	12.40	0.00	240.00	480.00	0.00	2664.00	5952.00
06	Battery Eliminator Circuit	1	8.00	12.00	40.00	1.50	2.00	3.00	12.00	24.00	120.00
07	Turnigy Receiver	1	3.10	3.30	3.60	0.01	0.01	0.02	0.03	0.04	0.06
10	Raspberry Pi 4B	1	4.63	5.10	6.00	0.54	1.00	1.30	2.50	5.10	7.80
09	Raspberry Pi Camera Module	1	4.63	5.10	6.00	0.20	0.21	0.25	0.93	1.09	1.50
03	Servomotor	2	4.80	5.00	6.50	0.10	0.20	0.30	0.48	1.00	1.95

6.3.0 Finance Budget

The financial budget outlines the total expected project expenses to ensure that all needed components can be purchased. The project was allocated a total of $350 for project needs ($50 per team member) however, most components were provided by the client. Otherwise, parts were either produced, purchased, or in stock within the team resources.

Table 7: Finance Budget

ID	Part Name	QTY	Purchased	Value	Total
01	F330 Frame Arm	4	Provided	$ 5.00	$ 20.00
02	Motor	4	Provided	$ 17.00	$ 68.00
03	Servomotor	2	Provided	$ 1.00	$ 2.00
04	Electronic Speed Controller	4	Provided	$ 15.00	$ 60.00
05	Power Distribution Board	1	Provided	$ 20.00	$ 20.00
06	Battery Eliminator Circuit	1	Provided	$ 11.00	$ 11.00
07	Turnigy Receiver	1	Provided	$ 12.00	$ 12.00
08	Turnigy Transmitter	1	Provided	$ 50.00	$ 50.00
09	Raspberry Pi Camera Module	1	Provided	$ 31.00	$ 31.00
10	Raspberry Pi 4B	2	Provided	$ 120.00	$ 240.00
11	Raspberry Pi 4B Kit	1	Provided	$ 40.00	$ 40.00
12	Landing Leg, Tall	4	Produced	$ 1.00	$ 4.00
13	Landing Leg	4	Provided	$ 1.00	$ 4.00
14	PixRacer R15	1	Provided	$ 110.00	$ 110.00
15	PixRacer Power Module	1	Provided	$ 5.00	$ 5.00
16	Acrylic Sheet	1	In Stock	$ 5.00	$ 5.00
17	Propeller 8'' 4.5	4	Provided	$ 2.50	$ 10.00
18	LiPo 3S 4.0Ah + Bag	1	In Stock	$ 90.00	$ 90.00
19	SD Card, 16 GB	2	Provided	$ 6.00	$ 12.00
20	Ribbon Cable	1	Purchased	$ 20.00	$ 20.00
21	Pin 4-1 Header Cable	1	Provided	$ 2.00	$ 2.00
22	Telemetry Cable	1	Provided	$ 2.00	$ 2.00
23	HDMI Cable	1	In Stock	$ 20.00	$ 20.00
24	Serial Connection Cable	1	Provided	$ 5.00	$ 5.00
25	USB Extension Cable	1	In Stock	$ 5.00	$ 5.00
26	Buzzer, Safety Switch Cable	1	Provided	$ 2.00	$ 2.00
27	RC Cable	1	Provided	$ 2.00	$ 2.00
28	HDMI to Mini HDMI Adaptor	1	In Stock	$ 5.00	$ 5.00
29	USB to micro USB	1	In Stock	$ 5.00	$ 5.00
30	Kit Box	1	Provided	$ 5.00	$ 5.00
31	Weatherproof Case	1	In Stock	$ 20.00	$ 20.00
32	Middeck plate	1	Provided	$ 0.10	$ 0.10
33	Pin Header Strip	1	In Stock	$ 0.20	$ 0.20
34	Strip Board	1	In Stock	$ 0.20	$ 0.20
35	M2.5 30mm Steel Screw	20	In Stock	$ 0.20	$ 4.00
36	M2.5 Steel Nut	20	In Stock	$ 0.20	$ 4.00
37	M2 15mm Steel Screw	20	In Stock	$ 0.20	$ 4.00
38	M2 Steel Nut	20	In Stock	$ 0.20	$ 4.00
39	M3 20mm Steel Screw	20	In Stock	$ 0.20	$ 4.00
40	M3 Steel Nut	20	In Stock	$ 0.20	$ 4.00
41	M3 42mm Nylon Screw	20	In Stock	$ 0.20	$ 4.00
42	M3 Nylon Nut	20	In Stock	$ 0.20	$ 4.00
43	Nylon Lock Nut	4	Provided	$ 0.10	$ 0.40
44	Plastic Washer	4	Provided	$ 0.10	$ 0.40
45	Cable Tie	20	In Stock	$ 0.10	$ 2.00
46	Battery Strap	2	Provided	$ 2.00	$ 4.00
47	Velcro Dots	10	In Stock	$ 0.20	$ 2.00
48	Blu Tack Adhesive	1	Purchased	$ 3.00	$ 3.00
49	Payload Assembly	1	Produced	$ 1.00	$ 1.00
50	Cowl	1	Produced	$ 1.00	$ 1.00
				Total Sum	$ 933.30
				Margin	30.00%
				Final Sum	$1,213.29

6.4.0 Mass Budget

The mass budget is crucial for determining the final mass of the airborne UAV. The overall mass directly affects the power consumption and overall lift that the UAV can produce. It is important to keep the mass budget under a total of 1.5 kg in order to satisfy the customer requirements (HLOs).

Table 8: Mass Budget

ID	Part Name	Mass (g)	QTY	Mass Total (g)
01	F330 Frame Arm	312.0	4	312.0
04	Electronic Speed Controller		4	
05	Power Distribution Board		1	
06	Battery Eliminator Circuit		1	
02	Motor	53.0	4	212.0
03	Servomotor	14.0	2	28.0
07	Turnigy Receiver	8.0	1	8.0
09	Raspberry Pi Camera Module	3.0	1	3.0
10	Raspberry Pi 4B	48.0	1	48.0
12	Landing Leg, Tall	18.0	4	72.0
14	PixRacer R15	41.0	1	41.0
15	PixRacer Power Module	22.0	1	22.0
17	Propeller 8'' 4.5	5.0	4	20.0
18	LiPo 3S 4.0Ah + Bag	140.0	1	140.0
19	SD Card, 16 GB	0.1	1	0.1
20	Ribbon Cable	1.0	1	1.0
21	Female Pin 4-1 Header Cable	2.0	1	2.0
22	Telemetry Cable	2.0	1	2.0
25	USB Extension Cable	5.0	1	5.0
26	Buzzer, Safety Switch Cable	2.0	1	2.0
27	RC Cable	2.0	1	2.0
33	Pin Header Strip	0.1	1	0.1
34	Strip Board	1.0	1	1.0
35	M2.5 30mm Steel Screw	100.0	X	100.0
36	M2.5 Steel Nut		X	
37	M2 15mm Steel Screw		X	
38	M2 Steel Nut		X	
39	M3 20mm Steel Screw		X	
40	M3 Steel Nut		X	
41	M3 42mm Nylon Screw		X	
42	M3 Nylon Nut		X	
43	Nylon Lock Nut	0.1	4	0.4
44	Plastic Washer		4	
45	Cable Tie	0.3	20	6.0
46	Battery Strap	6.0	2	12.0
47	Velcro Dots	0.2	10	2.0
48	Blu Tack Adhesive	10.0	1	10.0
49	Payload Assembly	150.0	1	150.0
50	Cowl	100.0	1	100.0
			Total	1301.600
			Margin	10.00%
			Total with Margin	1431.760

6.5.0 Parts List

The parts list outlines the parts supplied by the Client(s) for development of the UAV^{A}SR prototype. Once these have been tested in the preliminary design, the team will validate their suitability for the final design and consider components that are more appropriate.

Table 9: Parts List

ID	Part Name	QTY	Description
01	F330 Frame Arm	4	UAV airframe
02	Motor	4	EMAX XA2212 / 1400KV brushless motors
03	Servomotor	2	For payload release
04	Electronic Speed Controller	4	For brushless motors, 20A, 1 : 1
05	Power Distribution Board	1	Pre-soldered and connected to BEC, ESCs
06	Battery Eliminator Circuit	1	5V 5A voltage regulator
07	Turnigy Receiver	1	Turnigy TGY-iA6C
08	Turnigy Transmitter	1	Must have OpenTX software
09	Raspberry Pi Camera Module	1	v2.1, comes with 10cm ribbon cable
10	Raspberry Pi 4B	2	Comes with power adapter
11	Raspberry Pi 4B Kit	1	Plastic shell for raspberry pi
12	Landing Leg, Tall	4	Replacement legs
13	Landing Leg	4	Client provided 3D printed landing legs
14	PixRacer R15	1	Flight controller with WiFi board
15	PixRacer Power Module	1	Flight controller power module
16	Acrylic Sheet	1	400x600x3 mm
17	Propeller 8'' 4.5	4	Two CW, Two CCW
18	LiPo 3S 4.0Ah + Bag	1	For UAV power
19	SD Card, 16 GB	2	For computers
20	Ribbon Cable	1	30 cm extension/replacement
21	Pin 4-1 Header Cable	1	Connects breakout board to pi
22	Telemetry Cable	1	Connects to TELEM2 port
23	HDMI Cable	1	For raspberry pi
24	Serial Connection Cable	1	For connecting to raspberry pi via USB
25	USB Extension Cable	1	30cm Male to Female
26	Buzzer, Safety Switch Cable	1	Connects to SAFETY port
27	RC Cable	1	Connects to RCIN port
28	HDMI to Mini HDMI Adaptor	1	For raspberry pi
29	USB to micro USB	1	30 cm, for pixracer connection
30	Kit Box	1	Large plastic lunch box
31	Weatherproof Case	1	With pick'n'pluck foam
32	Middeck plate	1	Client provided, laser cut acrylic
33	Pin Header Strip	1	16 line, 4x4 header pins
34	Strip Board	1	4x4 hole area required.
35	M2.5 30mm Steel Screw	20	For airframe assembly
36	M2.5 Steel Nut	20	For airframe assembly
37	M2 15mm Steel Screw	20	For airframe assembly
38	M2 Steel Nut	20	For airframe assembly
39	M3 20mm Steel Screw	20	For airframe assembly
40	M3 Steel Nut	20	For airframe assembly
41	M3 42mm Nylon Screw	20	For airframe assembly
42	M3 Nylon Nut	20	For airframe assembly
43	Nylon Lock Nut	4	To secure propellers
44	Plastic Washer	4	To space propellers
45	Cable Tie	20	For securing parts to airframe
46	Battery Strap	2	For securing battery to airframe
47	Velcro Dots	10	For securing VICON markers to airframe
48	Blu Tack Adhesive	1	One pack.
49	Payload Assembly	1	Derived from the acrylic sheet
50	Cowl	1	3D printed + acrylic lid

7.0.0 System Architecture

The UAV^{A}SR contains independent subsystems consisting of; airframe, power and propulsion, payload deployment, autopilot and localisation, imagery and target acquisition and operator interfaces. Each subsystem will perform specific tasks in order to achieve the goals outlined in the system requirements, of which when integrated, forms a complete functioning system. The system architecture will detail how these subsystems will interact concerning power and data transfer, and how each subsystem will interface with each other. The system architecture is separated into airborne systems and ground elements.

7.1.0 Descriptions of Subsystem Interfaces

This section will give a brief description of each subsystem and its role in the operation of the UAV, and the subsequent interfaces required for integrating the subsystem architecture. The system architecture will be split into two parts: airborne elements and ground elements.

7.2.0 Airborne elements

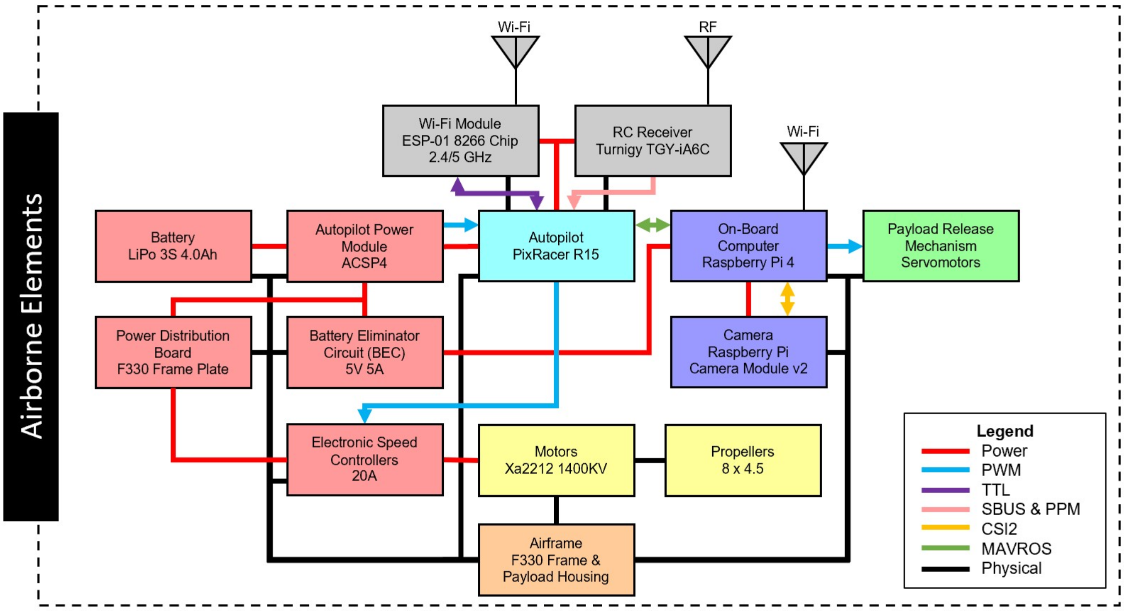


Figure 13: Airborne Elements System Architecture

The power supply for all airborne elements is a 3S 4.0Ah LiPo battery. The battery is connected to the ACSP4 autopilot power module via a wired connection. The ACSP4 supplies +12V to the power distribution board (the F330 airframe) and +5V to the autopilot. The F330 airframe, which is the metal plate of the airframe, supplies four ESCs (Electronic Speed Controllers) each with +12V and the BEC (Battery Eliminator Circuit) with +12V.

The autopilot is a PixRacer R15 and is in charge of piloting the system. The autopilot receives +5V and battery data from the ACSP4. The ACSP4 has a voltage sensor pin (Vsen) and a current sensor pin (Csen), and transmits voltage and current data over the Vsen and Csen pins respectively to the autopilot. This data provides battery life information and is relayed through to the 2.4/5GHz ESP-01 8266 WI-FI module, and is then transferred over the telemetry link. The autopilot is also able to determine information about its current state via its in-built sensors. The in-built sensors include an MPU-9250 3 axis accelerometer and gyroscope, a ST LIS3MDL magnetometer and a MEAS MS5611 barometer. The accelerometer determines acceleration of the UAV. The magnetometer measures the orientation, and the gyroscope measures angular acceleration of the UAV. The barometer measures altitude, using pressure readings. These in-built sensors allow the autopilot to navigate autonomously or semi-autonomously during operation by controlling the ESCs. This state information is also transferred over the telemetry link via the autopilot's WI-FI module.

There are six ESC ports on the autopilot module, capable of controlling ESC, four of which are used to connect the four ESCs. The four ESCs are then connected to the four *Emax* xa2212/1400KV motors and propellers, which are powered directly through the power distribution board (the F330 airframe) with a soldered connection. During autonomous control, the autopilot transmits a PWM data signal to the ESCs in order to control the UAV depending on state information measured from the in-built sensors. The PWM signal is transmitted through the ESC signal ports to the ESC servo ports. There is an additional PWM port on the autopilot module, which is connected to an additional servomotor for the payload deployment system. The autopilot uses this connection to send commands to the payload deployment system. The payload servomotor is powered via a +5V pin on the autopilot.

The four *Emax* xa2212/1400KV motors are directly powered by the ESCs. The motor speed is directly controlled via PWM signal from the ESC, which originates from the autopilot producing PWM in autonomous flight mode, or from the RC link in manual control.

The on-board computer, the RP4, is powered through the +5V connection via the BEC. The on-board computer is responsible for computational image processing and target detection. The in-flight images will be captured via the camera. The camera, a RP4 camera module, is directly connected to the RP4 camera module port via a flex cable, utilising a CSI-2 connection for image data transmission. The cable connection additionally facilitates the powering of the camera. The image data is transferred from the camera to the RP4 on-board computer for image processing, specifically tasked for the identification of the markers. The image data will then be transferred from the on-board computer to the Wi-Fi router of the ground control station via the in-built RP4 2.4/5GHz Wi-Fi link. The router will then forward the data to the in-built Wi-Fi module of the GCS computer for visualisation.

The remote control (RC) link will be responsible for manual control of the UAV. The receiver, a *Turnigy* TGY-iA6C is connected to the PixRacer R15 autopilot module, and will be receiving RC signals at a frequency of 2.4GHz from a transmitter located at the GCS. The receiver is powered via the +5V pin on the RC port of the autopilot. The receiver connects to the data line (PPM/SBUS) to the RCIN port of the autopilot. The autopilot then passes the PWM signal directly to the ESCs, allowing direct manual control of the motors.

The telemetry link is a Wi-Fi connection via the detachable ESP-01 8266 Wi-Fi module on the PixRacer R15 autopilot. The Wi-Fi module transmits using a 2.4/5GHz frequency. Both the ground station and the airborne elements are connected to the same Wi-Fi network due to the small indoor distances of which the operation is being conducted. The Wi-Fi module allows both transmission and receiving capabilities for the telemetry link. When transmitting, the telemetry data is sent to the GCS Wi-Fi router from the autopilot's Wi-Fi module, which is then relayed to the intended receiver: the GCS Wi-Fi module. The detachable ESP-01 8266 Wi-Fi module is connected directly into the Wi-Fi module port located on the autopilot. This connection from the autopilot consists of TTL UART through GPIO pins, and a +3.3V power pin. Telemetry data is also required to be transmitted to and received by the RP4 on-board computer module. This connection is via the telemetry port on the autopilot, and the GPIO port connection on RP4. Data transmission will occur using TTL UART protocol.

7.3.0 GCS Elements

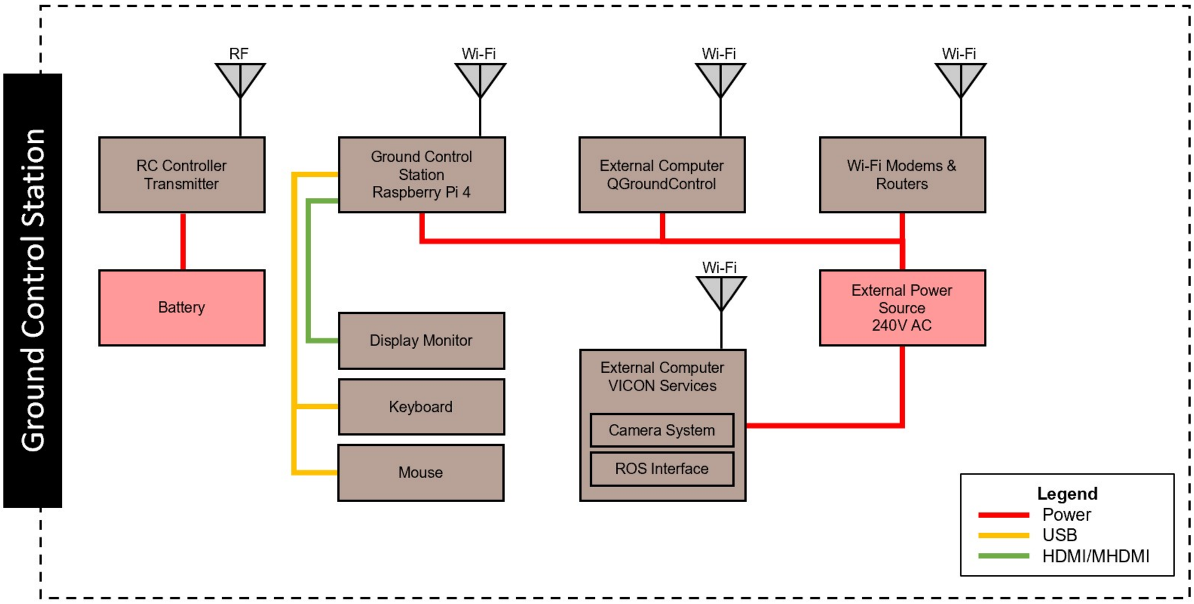


Figure 14: Ground Control Station System Architecture

The GCS elements consist of the following main components:

- Manual Controller
- GCS Laptop for main Graphical User Interface (GUI)
- VICON Motion Capture System
- Wi-Fi Router to connect ROS/Linux/VICON systems and the UAV

Manual control will be possible via the on-board *Turnigy* IA-6C receiver (2.4GHz) from a compatible hand-held remote control transmitter powered by an internal battery. There is also the possibility to send manual flight commands via the ROS Wi-Fi link from the GCS Laptop to the RP4.

The GCS Laptop will be running the Linux operating system (MATE 20.04) within the Oracle VM *VirtualBox* software, utilising Python programming language with ROS *Noetic Ninjemys*. Power for this will be mains supplied. It shall display key telemetry published to the UAV Flight Stack ROS topic by the UAV's on-board computer, as well as live video and mapping visualisation from the UAV sensors.

The GCS will additionally include a VICON system that tracks the UAV's position and pose visually with cameras around the simulation area and a set of motion capture spheres attached to the UAV. This position and pose data is published to a MAVROS topic via a VRPN bridge, which will be accessed through the Wi-Fi network by the UAV and GCS elements which have subscribed to that topic.

The telemetry and imagery link will be facilitated over Wi-Fi (2.4/5GHz). Both ground elements and airborne elements will be connected over the same network. Telemetry data will be transmitted and received via the inbuilt Wi-Fi module on the GCS computer. The RC controller will be located at the ground control station. The Wi-Fi module will be connected to the internet via TCP/IP protocol, which is connected to the web server hosts for GCS operation. The web server connects to the GCS via the computer's in-built Wi-Fi connection. The web server will subscribe to ROS nodes, allowing it to pass data and images to the GCS.

7.4.0 Physical Connections with Airframe

Six methods will be used to fix components to the airframe during UAV construction. These methods are detailed below in Figure 15.

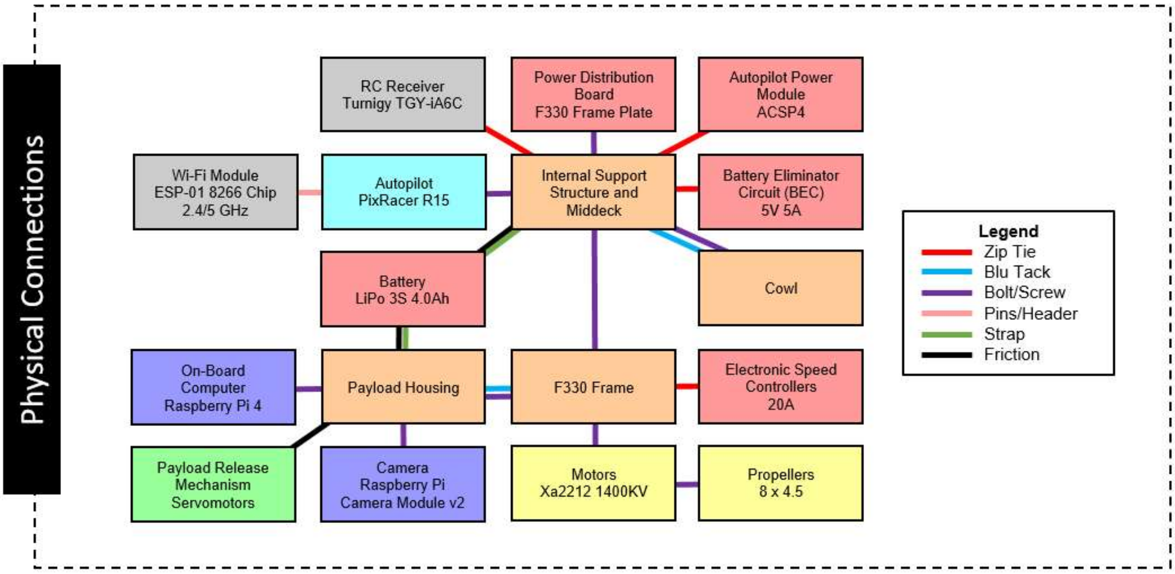


Figure 15: Physical connections and types

Further detail on connections is provided in the Interface Control Document, RDP.004.

8.0.0 Test Plan

The test plan for this project consists of three levels of testing, corresponding to Suite A, Suite B, and Suite C for each subsystem. The tests come together at integration testing Suites A, B, C, and D. The entire system is evaluated against the Customer Needs and relevant criteria in the Acceptance Test.