AERO-SENTINEL
System Requirements Specification

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Issued Date	Changed by	Revision
12th November, 2023	Muhtasim Rahman, Safwan Hossain, Noor Alam, Micheal Lu, Farhan Rouf	0
21st March, 2024	Muhtasim Rahman, Safwan Hossain, Noor Alam, Micheal Lu, Farhan Rouf	1

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1. INTRODUCTION

1.1 Background

Drones have the potential to revolutionize industries such as transportation, healthcare, agriculture, public safety and beyond, however, their impact is currently undermined by their limited battery life. Our client VanWyn Inc. has proposed a radical new method to extend the operation time of drones by wirelessly transmitting power to drones from the ground, which would extend the battery life indefinitely.

1.2 Project Description

Our capstone team, The Aero-Sentinels, was entrusted with the ambitious goal of developing a UAV platform that comprises a ground station system that can communicate with the UAV as well as track the UAV in real-time, and along with the ground station a UAV system that can transmit mission-critical data.

1.3 Scope of Project

The scope of this project involves developing a fully stabilized UAV, a tracking system that can find and track the UAV, and an interface that establishes communication with the UAV and monitors essential UAV data to the user on the ground.

1.4 Purpose of Document

The System Requirements document serves as a comprehensive overview of the functional and operational specifications of our system. This document aims to define system interactions, behaviors, and performance criteria, to ensure clarity in project requirements as well as alignment between course requirements, project requirements and stakeholder requirements. Functional Decomposition Diagrams, System Diagrams, Context Diagrams and more will be provided in this document to better explain system interactions, nominal and error states and system boundaries and dependencies.

1.5 Defining Notation and Nomenclature

- UAV - Unmanned Aerial Vehicle (the term UAV and Drone are used interchangeably in this document)
- Cartesian Coordinate variables will be used to describe the motion of the drone's position and orientation.

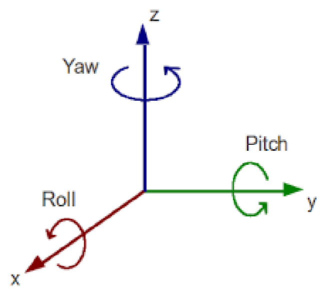

Figure 1: Cartesian coordinate variables

2. VARIABLES

2.1 Monitored and Controlled Variables

Monitored variables are parameters or quantities that are observed, measured, or monitored during an experiment. The purpose of monitored variables is to be able to gather data and information about how they behave under certain conditions. In our project, the following monitored variables and their descriptions are listed below.

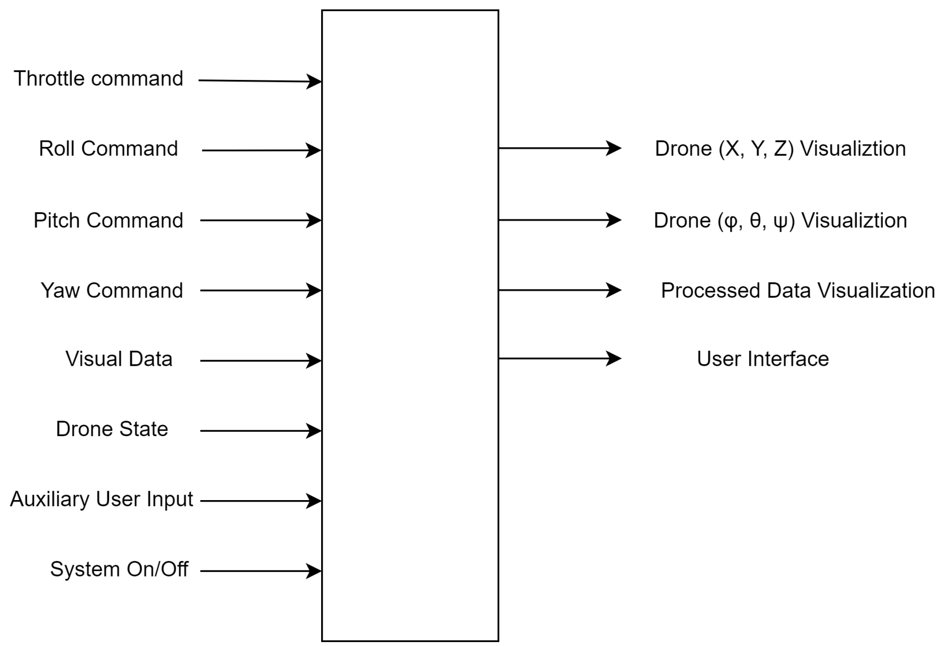

Figure 2: Black Box Diagram

Monitored Variables Table

Monitored Variables	***Description***
Throttle Command	Throttle command data will be a monitored variable that the UAV will use and observe to make appropriate changes in its movement.
Current Acceleration (X, Y, Z) [meters per second squared]	The UAV's acceleration (composed of X, Y and Z components) will be monitored to adjust UAV movement and provide acceleration data to the ground system.
Current Orientation (*Roll, Pitch, Yaw*) [degrees]	The UAV's orientation (composed of roll, pitch, and yaw components) will be monitored to adjust UAV movement and provide movement data to the ground system.
Angular Rates (*Roll, Pitch, Yaw*) [degrees per second]	The UAV's angular rate (composed of roll, pitch, and yaw components) will be monitored to adjust UAV movement and provide movement data to the ground system.
Remaining Battery Life [Percentage]	The remaining battery life of the UAV will be calculated through the current battery voltage and capacity. This variable will be sent to the ground station to provide real-time battery data.
Roll Command [degrees]	Roll command data will be a monitored variable that the UAV will use and observe to make appropriate changes in its movement.
Pitch Command [degrees]	Pitch command data will be a monitored variable that the UAV will use and observe to make appropriate changes in its movement.
Yaw Command [degrees]	Yaw command data will be a monitored variable that the UAV will use and observe to make appropriate changes in its movement.
Visual Data	Visual data collected by the camera sensor will be a monitored variable that the GUI system will use for processing. Visual data will change in response to

	various inputs and conditions affected by the environment and subsystem responses.
UAV State	UAV State will consist of all the sensor measurements that define the drone's position and orientation. The reason why this input is vague is that depending on the method we use the monitored variables will change. For example, for an IMU (Inertial Measurement Unit) the drone's acceleration and gyroscope data will be inputs to the system, however, if a visual motion capture system is used to measure position and orientation then visual data will be input to the system.
System On/Off	System On/Off is a monitored and controlled variable that triggers the initialization process that coordinates the powering-up and initialization of each subsystem. It ensures all the connected components start working in the appropriate sequence and manner. Additionally, it enables the implementation of an emergency stop feature for use in safety critical situations.

Controlled variables are the parameters or factors that are regulated during an experiment or engineering design process. The main goal of controlled variables is to be able to study the factors being manipulated and have a desired response or outcome. For an example. In a UAV flight controller, the amount of thrust/throttle into each motor needs to be a specific ratio for a desired outcome (eg; stabilize or move). This ratio is controlled in specific ways for the desired outcome.

Controlled Variables Table

Controlled Variables	***Description***
UAV (*X, Y, Z*) Visualization [meter]	This is the UAV's calculated (X, Y, and Z) position coordinates after processing the raw output from the user/controller. This is a controlled variable since the final X, Y, and Z positions of the drone are determined by the drone's processor itself taking into consideration other factors such as stabilization into account, not just the raw output from the user's controller.

UAV (*ϕ Roll, θ Pitch, ψ Yaw*) Visualization [radians]	This is the UAV’s calculated (Roll, Pitch, and Yaw) angles after processing the raw output from the user/controller. This is a controlled variable since the UAV’s final angular degrees are determined by the drone’s processing of the raw gyroscope data and the combination of the user's X, Y, and Z movement commands., taking into consideration other factors such as stabilization.
Angular Rates (*ϕ Roll, θ Pitch, ψ Yaw*) [degrees per second]	The UAV’s angular rate (composed of roll, pitch, and yaw components) will be monitored to adjust UAV movement and provide movement data to the ground system.
Processed Data Visualization	Processed Data Visualization is data that is processed by the GUI for the camera to identify and continue to track a UAV. This is a controlled variable as the raw data itself will need to be manipulated/computed for the camera system to identify if the object in question is a UAV and whether or not to track it.
User Interface	The User Interface provides a visual interface of the GUI to access all the necessary information of the system in a comprehensive and seamless manner. The users are allowed to provide a responsive and effective command to interact with the system.

2.2 Constants

In engineering design and analysis, variables are used to represent parameters that can be adjusted or measured. A constant is a quantity that does not change its value and will remain fixed throughout the experiment and analysis. For our project, there will be a few variables that will remain constant throughout.

Constants Variables Table

Constant Variables	*Description*
Gravity	According to the required behaviour of the project, the UAV will only be operational on Earth with the gravitational

	constant of 9.8 m/s^2. This variable does not change.
Translational (X, Y, Z) [meters]	The UAV will be constrained to rotating in a sphere of radius 0.5 meters with a translational constant of 0 meters for X, Y and Z (3 degrees of freedom constrained).
Payload Capacity	The project will only have a payload capacity of itself. It will not be required to lift or operate on anything external.
Max Room Temperature [Celsius]	This drone will operate at a maximum room temperature of 25°C
Min Room Temperature [Celsius]	This drone will operate at a minimum room temperature of 15°C
Air Density [kg per meter squared]	The typical air density at sea level and room temperature (15°C to 25°C) is approximately 1.204 kg/m^3. We will assume this value as the operational air density for our drone activities.
Weather Conditions	The drone will be operated exclusively indoors, and thus we do not anticipate any weather conditions

3. CONTEXTUAL DIAGRAMS

3.1 System Diagram

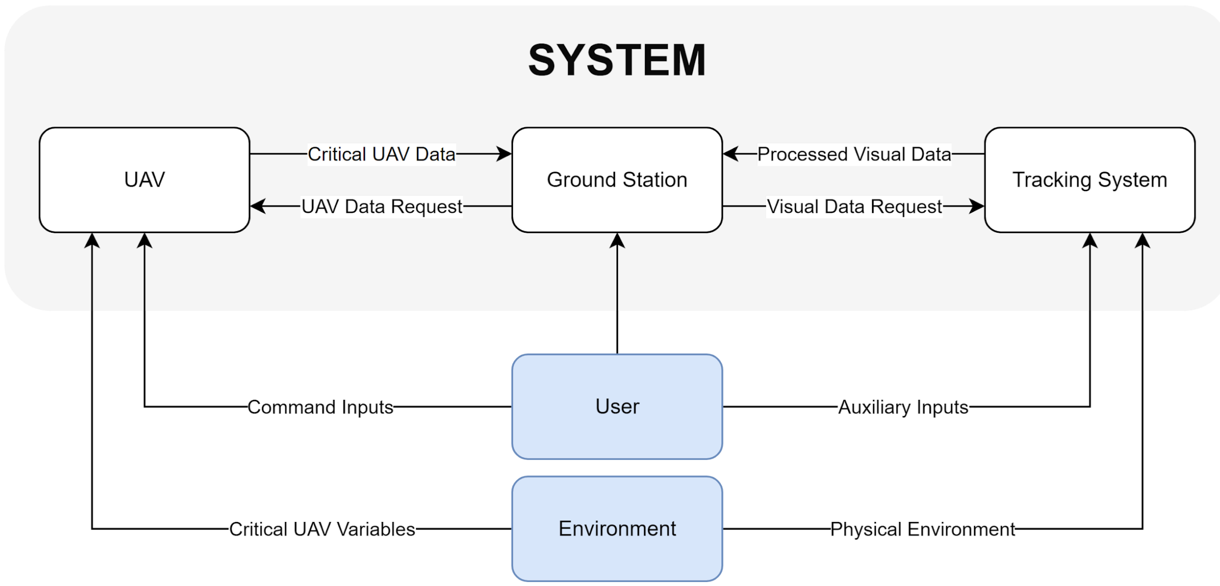

Figure 3: System Context Diagram

System Diagram Overview

Signals/Commands	***Description***
Critical Drone Measurements	The UAV system will transmit comprehensive insights into the drone's status, environmental conditions, and overall performance
UAV Data Request	Ground Control Station will request critical drone data to visualize the drone status and states in real-time
User Inputs	Any user interaction in the ground station's GUI are intended to get more details or control of the system
Processed Visual Data	Processed visual information that identifies the UAV
Visual Data Request	Ground Station requests for processed data to display visualized information
Auxiliary Inputs	Any user-initiated inputs that are deliberately triggered to initiate specific functionalities or responses

Command Inputs	Inputs could include directives for *takeoff, landing, navigation,* or other maneuvers, allowing users to actively control and guide the system's actions.
Physical Observed Data	Physical Observed Data is the drone characteristics identified by the senor
Critical UAV Variables	Inputs for the drone's control system to make real-time decisions and adapt to changing conditions.

3.2 Drone System Diagram

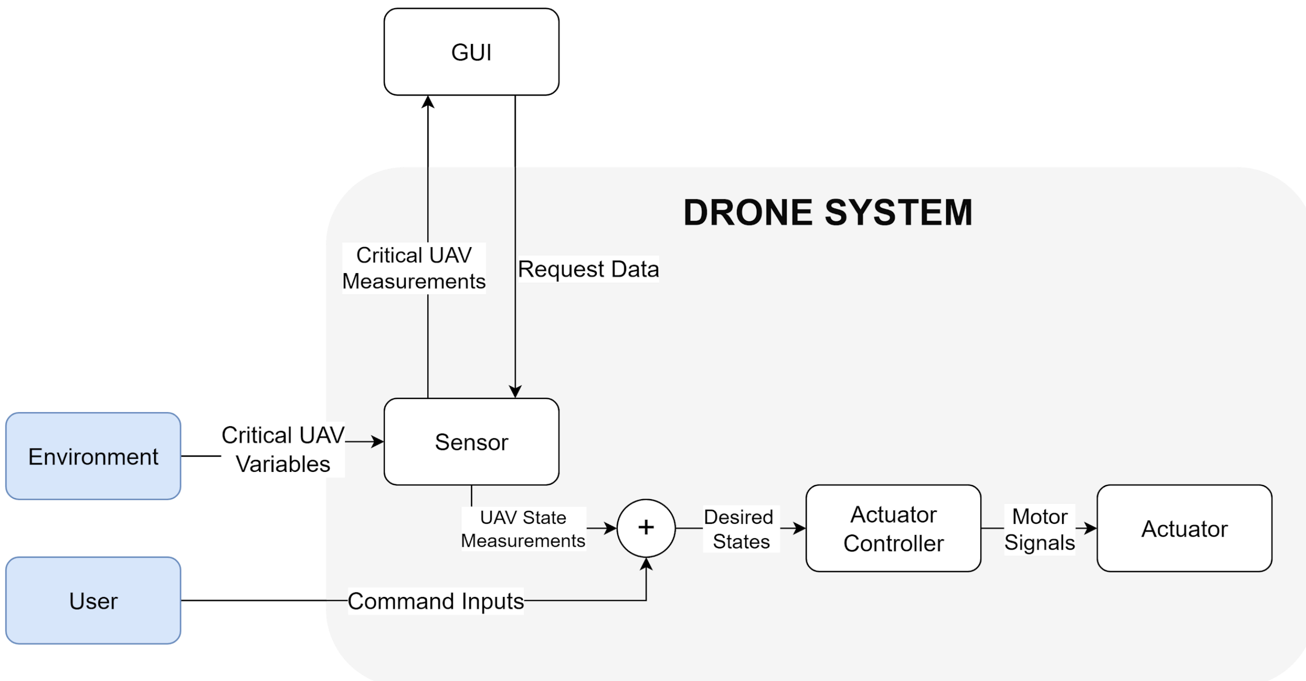

Figure 4: Drone Context Diagram

Drone Context Diagram Variables

Signals/Commands	***Description***
Critical UAV Variables	Inputs for the drone's control system to make real-time decisions and adapt to changing conditions.
Command Inputs	Inputs could include directives for ***takeoff, landing, navigation,*** or other maneuvers, allowing users to actively control and guide the system's actions.
Critical UAV Measurements	The sensor will transmit comprehensive insights into the drone's status, environmental conditions, and overall performance

Request Data	GUI will request critical drone data to visualize the drone status and states in real-time
Drone State Measurements	Measurements regarding drone orientation
Desired States	Combines the drone’s orientation measurements and desired user inputs to calculate desired orientation
Motor Signals	Electrical signals directing the motors to manipulate the throttle, ϕ, θ, ψ based on the received signals

3.3 Tracking System Diagram

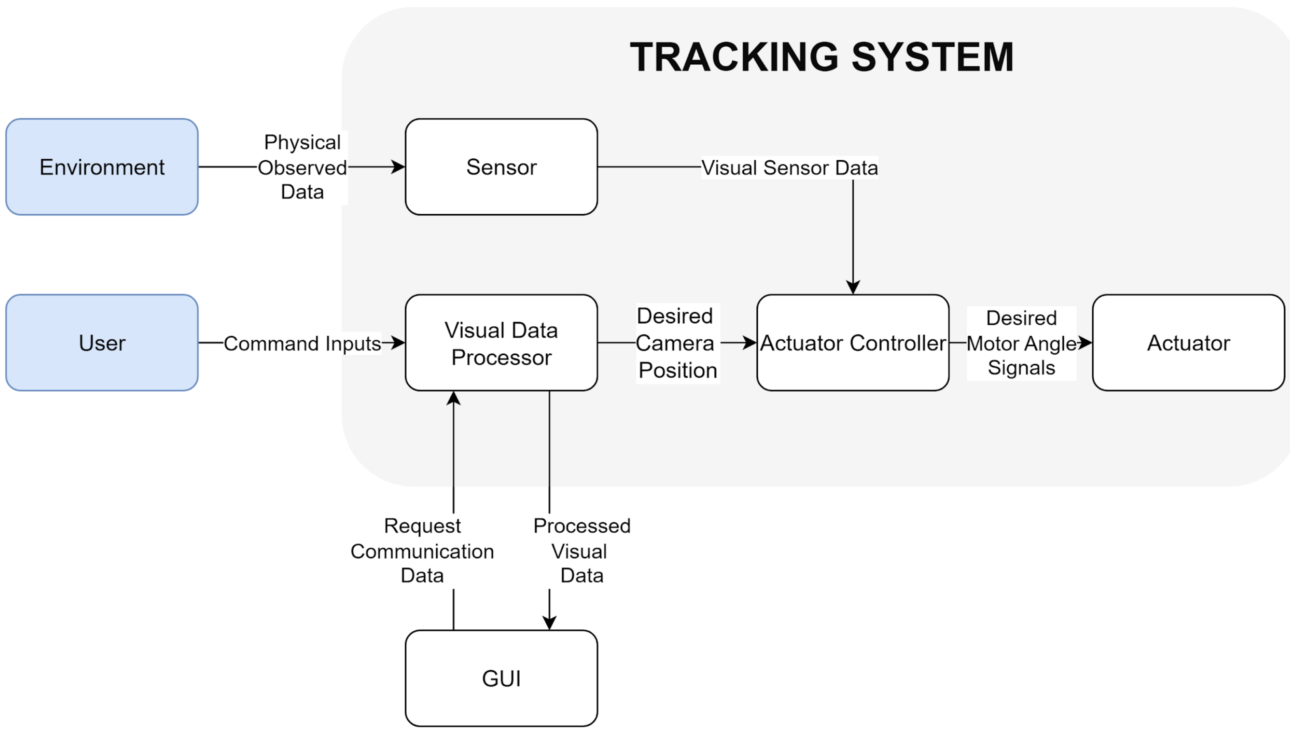

Figure 5: Tracking System Context Diagram

Tracking System Diagram

Signals/Commands	***Description***
Physical Observed Data	Physical Observed Data is the drone characteristics identified by the senor
Command Inputs	Command inputs enable users to actively control how

	they desire the processed data to be displayed and visualized in the UAV
Visual Sensor Data	Raw information pertaining to the visuals of the environment
Processed Visual Data	Processed visual information that identifies the UAV
Request Data	GUI informs the Visual Data Processor whether it wants visual information or not
Desired Camera Position	Desired camera position to keep UAV within the Field of View
Desired Motor Angle Signals	Desired motor angle signals to change camera position to desired camera position

3.4 Ground Station System Diagram

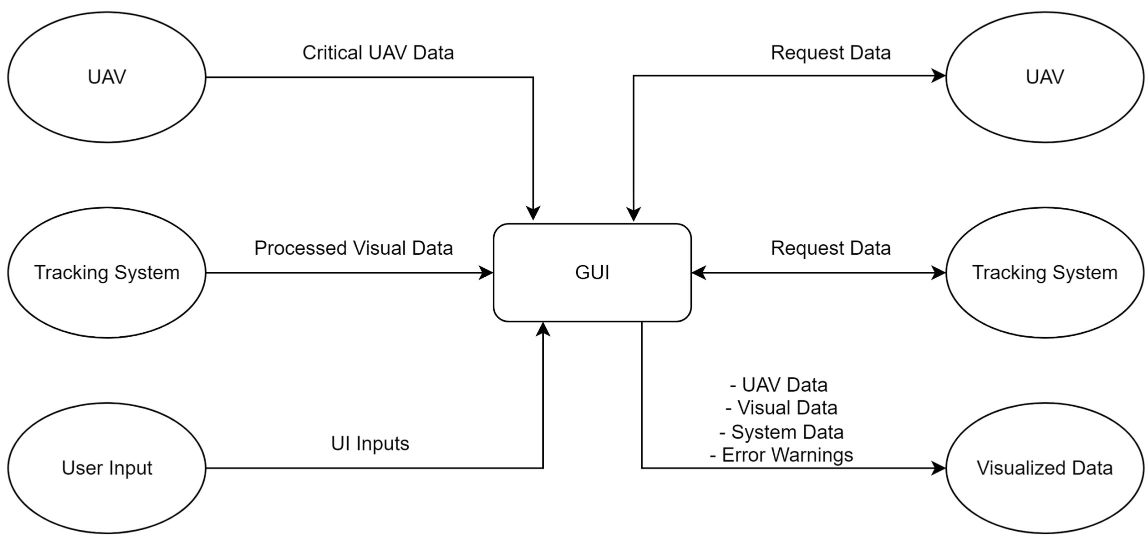

Figure 6: Ground Station System Diagram

Ground Station Context Diagram

Signals/Commands	***Description***
Critical Drone Data	Inputs for the drone's control system to make real-time decisions and adapt to changing conditions
Processed Visual Data	Processed visual information that identifies the UAV

UI Inputs	Any user interaction intended to get more details or control of the system
Request Data	**UAV**: GUI will request critical drone data to visualize the drone status and states in real-time **Tracking System**: GUI informs the Visual Data Processor whether it wants visual information or not
- **UAV Data** - **Visual Data** - **System Data** - **Error Warnings**	Based on the data received from the GUI from different subsystems and states, it will display all the details in graphs, 3D models or any other means of appropriate data visualization

4. REQUIRED BEHAVIOUR OVERVIEW

The following section is the behavioural overview for our system. Our system is split into three main sub-systems. As such, there will be behavioural diagrams for each of the 3 subsystems (Drone, Camera System, GUI) and how they interact together.

Assumptions:

- Operation in a controlled environment
- A passing system check before the operation

4.1 Drone

The following section is the behavioural overview section for the drone. The notations below will show how the drone system will behave with regards to various inputs given by the user and external conditions introduced.

The main behaviours of the Drone can be grouped into the following:

1. Off State.
2. Grounded State
3. In Air Flight (Take Off, Hovering, Movement)
4. Error State
5. Landing State

State Descriptions

State	State Description
State 1: Off	This is the off state of the drone, synonymous

State	with power off.
State 2: Grounded	In this state the drone will be on the ground.
State 3: In Air	In this state the drone will be in the air. This state also has 3 substates: Take Off, Hover, and Move.
State 3.1: Take Off	A state where the drone will be taking off from a grounded state.
State 3.2: Hover	A state where the drone will remain stabilized in midair.
State 3.3: Move	A state where the drone receives inputs to move.
State 4: Error	This is the state where the drone will try to handle any errors either caused by system malfunction or external environmental factors.
State 5: Landing	A state where the drone is descending to the ground.
State: Transmit Data	At any point, the drone is continuously transmitting its state data.

The 5 main behaviours above are represented as various states in a behavioural diagram below. How the drone system responds in different scenarios will be based on the input variables it takes from the user. Various input scenarios are classified in the table below along with their expected output when encountering such a situation.

State Transition Diagram

State Number	Input Source	Input	Expected Behaviour
State 1: Off State	User	Starts Drone	Move to **State 2**
State 2: Grounded	User	Up Input	Move to **State 3.1**
State 3: In Air	System	Error Detected	Moves to **State 4**
	Environment	Touches Ground	Move to **State 2**
State 3.1: Take Off	User	No Input	Moves to **State 3.2**

	User	Movement Input	Moves to **State 3.3**
State 3.2: Hover	User	Movement Input	Moves to **State 3.3**
State 3.3: Move	User	No Input	Moves to **State 3.2**
State 4: Error	System	Error Resolved	Moves to **State 3**
	System	Error Can Not Be Resolved	Move to **State 5**
State 5: Landing	Environment	Touches Ground	Move to **State 1**
Any State	N/A	N/A	Transmits Data

NOTE (Refer to the diagram below)

In State 3.1 (Take off), the drone is lifting up from the ground.

If the drone is taking off, and user input stops giving input, then the drone will hover in the air (no lateral or vertical movement)

If the drone is taking off and movement input is given (forward input) then the drone will start moving in the input direction

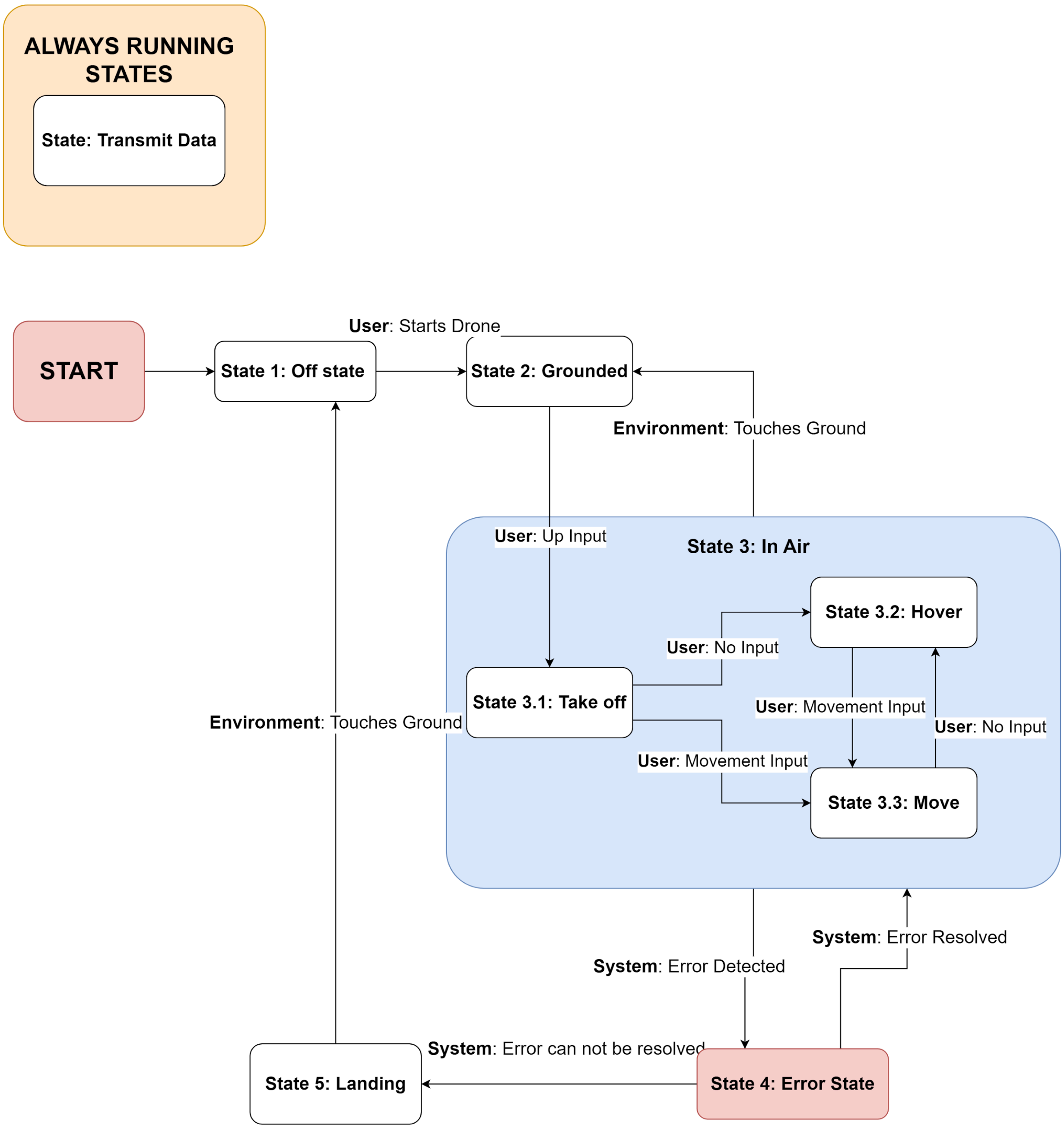

Figure 7: Drone Behaviour Diagram

The combination of our inputs and expected outputs will do their best when attempting to account for any possible behavioural scenario. This is however not an exhaustive list. To address this, the drone will always have a fault-checking state concurrently running in case an unknown scenario occurs. If an unknown scenario occurs, the user will be alerted

4.2 Tracking System

The following section is the behavioural overview section for the tracking system. The notations below will show how the tracking system will behave due to various inputs of the user and external conditions introduced.

The main behaviours of the tracking system can be grouped into the following:

1. Observe its environment
2. Categorize objects
3. Give the user the option to track the categorized object
4. Continue to track such categorized objects by itself

State Descriptions

State	State Description
State 1: Observing	The tracking system will take in the video feed.
State 2: Categorizing	The tracking system will attempt to categorize and identify an object seen in the video feed.
State 3: Tracking	The tracking system will track the object.
State 4: Rotate to Search	The tracking system will move itself to continue to track the object.
State: Manual	At any point, the user can take manual control of the tracking system.

The 4 behaviours above are represented as various states in a behavioural diagram below. How the tracking system responds in different scenarios will be based on the input variables it takes from either the tracking sensor or user input from the GUI. Various input scenarios are classified in the table below along with their expected output when encountering such a situation.

State Transition Table

Current State	Input Source	Input	Expected Output
State 1: Observing	Tracking Feed	No Object On Video	Stays in **State 1**
State 1: Observing	Tracking Feed	Recognisable Object on video	Moves to **State 2**
State 1: Observing	GUI	Desired x, y angle for tracking system	Moves to **State 4**

State 2: Categorizing	Tracking Feed	Drone is detected	Moves to **State 3**
State 2: Categorizing	Tracking Feed	Drone is not detected	Moves to **State 1**
State 2: Categorizing	GUI	Drone given	Moves to **State 3**
State 3: Tracking	GUI	Cancel Tracking	Moves to **State 1**
State 3: Tracking	Tracking Feed	Drone is not detected	Moves to **State 1**
State 3: Tracking	Tracking Feed	Drone moves out of Field of View (FOV)	Moves to **State 4**
State 4: Rotate to Search	N/A	Finished Rotating	Moves to **State 2**

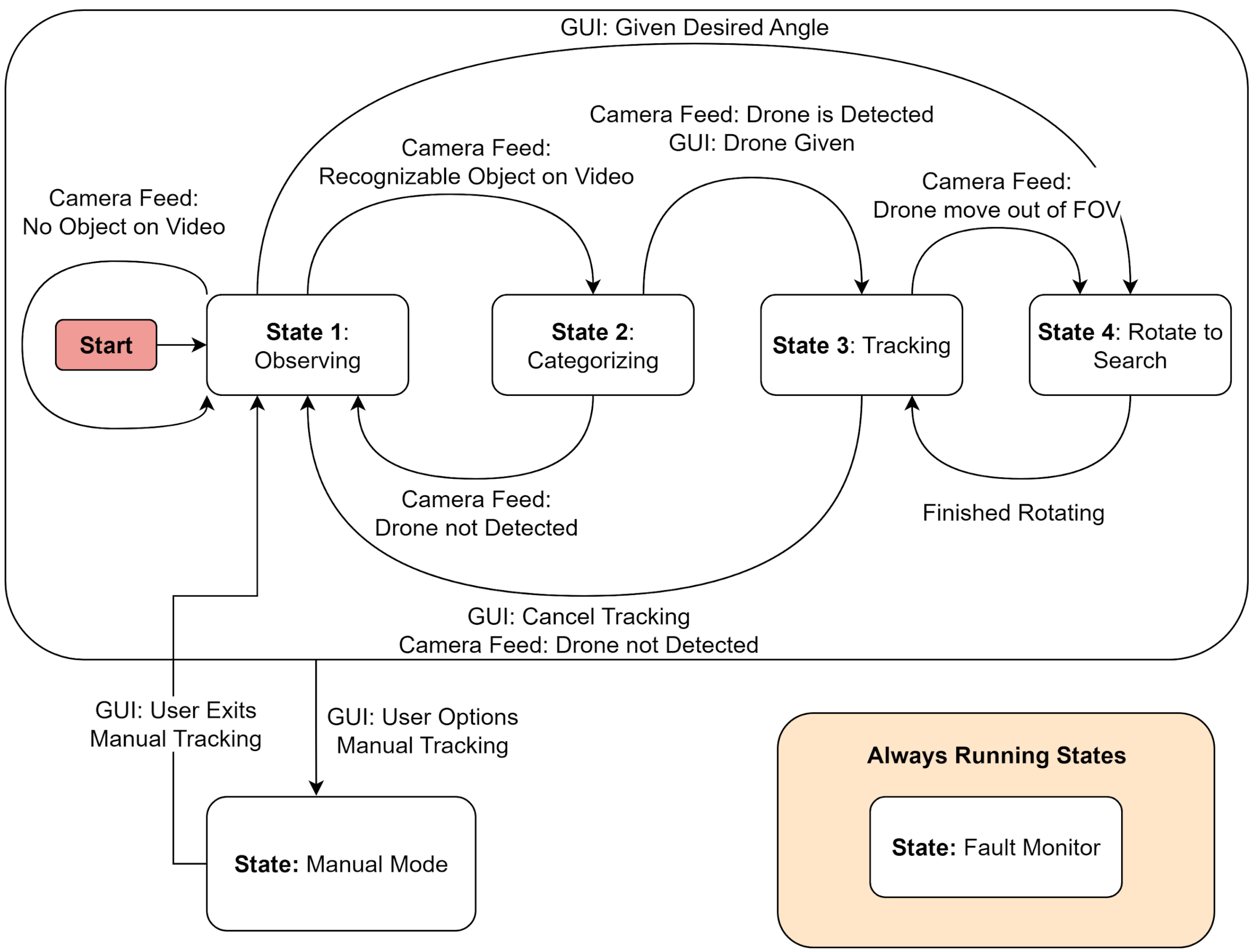

Figure 8: Tracking System Behaviour Diagram

The combination of our inputs and expected outputs will do their best when attempting to account for any possible behavioural scenario. This is however not an exhaustive list. To address this, the tracking system will always have a fault-checking state concurrently running in the background in case an unknown scenario occurs. An unaccounted for scenario might be something such as an external environment influence (eg; tracking system malfunctions) that will cause the tracking system to deviate from its main behaviours. When this happens, the tracking system will output a message and give the user the option to attempt to restart the system.

4.3 GUI

The following section is the behavioural overview section for the GUI system. The notations below will show how the GUI will behave due to various inputs from the user and external conditions introduced.

The main behaviours of the GUI system can be grouped into the following:

1. Remaining in an idle state waiting for user input
2. Attempting to connect to the drone.
3. Being connected to the drone.
4. Continuously update the view to display data to the user

State Descriptions

State	State Description
State 1: Idle	In this state, the GUI is waiting for user input.
State 2: Trying to Connect	In this state, the GUI will attempt to establish connection to the UAV.
State 3: Connected	In this state, the GUI will be connected to the drone.
State 4: Error State	In this state, an unexpected behaviour was introduced. The GUI will alert the user.

The 3 behaviours above are represented as various states in a behavioural diagram below. How the GUI system responds in different scenarios will be based on the input variables it takes from either the drone or user input. Various input scenarios are classified in the table below along with their expected output when encountering such a situation.

State Transition Table

Current State	Input Source	Input	Expected Behaviour
State 1: Idle	User	Initiate Tracking	Moves to **State 2**
State 2: Trying to connect	User	Disconnects From Drone	Moves to **State 1**
State 2: Trying to connect	Drone	Drone Data Is Received	Moves to **State 3**
State 2: Trying to connect	Drone	Drone Data Is Not Received For More Than 10 Seconds	Moves to **State 4**
State 3: Connected	User	Disconnects From Drone	Moves to **State 1**
State 3: Connected	Drone	Drone Stops Transmitting Data	Moves to **State 2**
Any State	N/A	N/A	Update View

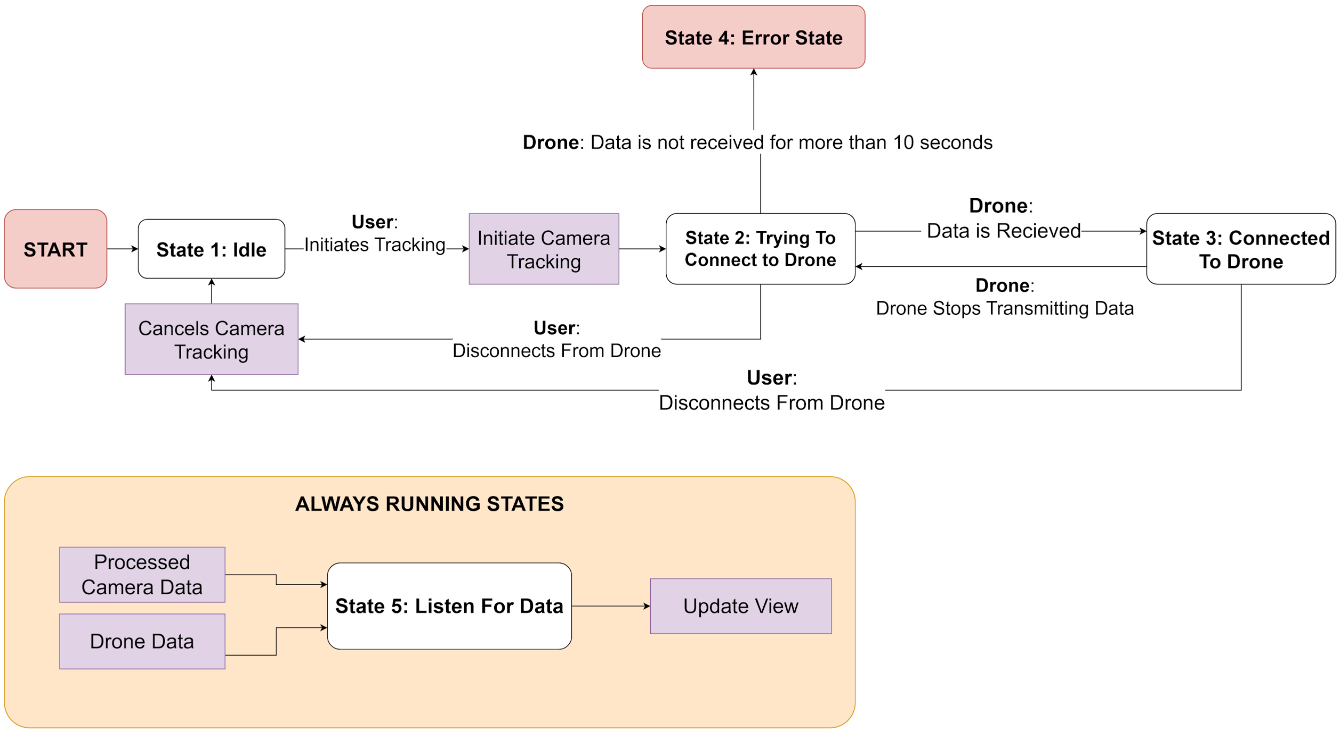

Figure 9: GUI Behaviour Diagram

The combination of our inputs and expected outputs will do their best when attempting to account for any possible behavioural scenario. This is however not an exhaustive list. To address this, our system has an error state that will notify the user if there is an unencountered scenario.

5. SYSTEM REQUIREMENTS

- **Performance Requirements** are specifications of the operational characteristics of the system.
- **Non-Functional Requirements** are intended to specify 'system qualities', various system attributes that are not directly related to their functionality. These attributes do not tell what the system does but how well it does it.
- **Functional Requirements** are requirements that detail the functionality the system must have. These requirements usually outline what the system should output based on its inputs.

Req ID	Requirement Description	Type	Rational	Status
1. Unmanned Aerial System Requirements				
REQ-001	UAV shall be able to establish a connection to the ground station from a minimum distance of	Performance	It was decided internally that a minimum	Subject to Change

	2m from the test stand		distance of **2m** is a sufficiently safe distance from which the drone can be controlled	
REQ-002	User must be able to remotely control UAV orientation (**ϕ, θ, ψ**)	Performance	To mitigate the complexities of autonomous drone control we opted to allow a user to	Not Subject to Change
REQ-003	UAV must be able to self stabilize its orientation with a damping ratio between **ζ = 0.5 ~ 0.6** and a settling time ($T_s < 4\ sec$)	Performance	Research conducted on the ideal damping ratio (ζ) and settling time [1]	Subject to Change
REQ-004	UAV shall transmit real-time telemetry data to the ground station	Performance	This is an explicit requirement from the stakeholder	Not Subject to Change
REQ-005	UAV shall be able to withstand mild gusts of wind **(~10 mph)** and operate within temperature range of **15**℃ to **25**℃	Non - Functional	To mitigate issues that can come up while operating outdoors in the wind our system will only operate indoors and in ambient temperature conditions	Subject to Change
REQ-006	UAV must be designed for easy maintenance and all critical components must be accessible	Non - Functional	Once again an explicit requirement from stakeholder	Not Subject to Change
REQ-007	UAV must allow remote software/firmware updates	Non - Functional	To ensure we are able to mitigate software bugs and update software to	Not Subject to Change

			replace faulty software	
2. Tracking System Requirements				
REQ-008	Tracking system must be able to identify the UAV in the field of view that is between **2-5 m** away	Performance	Limited by the size of the testing room which is around 7-8 m long.	Subject to Change
REQ-009	Tracking system must be able to keep the UAV within Field of View while moving up to **1.4 m/s**	Performance	Tracking will track the constrained drone while being moved by humans travelling at an average of **1.4 m/s** *(tracking tracking system will be moving relative drone at 1.4 m/s*) [2]	Subject to Change
3. Communication System				
REQ-010	Connection between the drone and communication system should be maintained for at least 30 minutes	Performance	Average UAV flight time will be around 10 to 15 minutes. So communication needs to be maintained throughout.	Subject to Change
REQ-011	Communication system must be able to receive **1 signal per second** from the UAV with information about its telemetry	Performance	In order to monitor the UAV we need information on its critical data at least every one second. Anything more than that would mean lost monitored variables.	Not Subject to Change

4. Graphical User Interface				
REQ-012	GUI must be able to display data received from the communication system within **100 ms** of receiving the data	Performance	The average brain requires **200 ms** to process visual data, updating within 100 ms allows user to monitor drone effectively [3]	Not Subject to Change
REQ-013	GUI must be able to send data to the tracking system	Performance	The GUI must be able to communicate with the tracking system to initiating tracking	Not Subject to Change
REQ-014	GUI must be able to display data received from the tracking system	Performance	The GUI must be able to display video data coming from the tracking system	Not Subject to Change
REQ-015	GUI must be able to notify the user when it is unable to display data accurately.	Performance	If the GUI cannot display data, any information regarding the cause can be useful	Not Subject to Change
5. Safety Requirements				
REQ-016	Power Electronics System should be equipped with appropriate fuses, circuit breakers and other electrical failsafe devices	Non - Functional	In order to ensure system electronics	Not Subject to Change
REQ-017	Drone shall stay within the line of sight of operator	Performance	***Safety***	Not Subject to Change
REQ-018	Drone shall not exceed an altitude of 2m	Performance	***Safety***	Subject to Change

REQ-019	Drone shall be constrained laterally	Performance	***Safety***	Subject to Change

5.1 Rational for requirement likely change status

REQ-001
REQ-001 might be subject to change depending on whether the minimum distance of **2m** is a sufficiently safe distance from which the drone can be controlled. Regulatory changes or compliance standards in different locations might require adjustments to be made.

REQ-002
REQ-002 is not subject to change. This is a requirement that must be needed in order to control the roll, pitch, and yaw of the drone. A drone will not be controllable without these variables.

REQ-003
REQ-003 might be subject to change depending on the ideal damping ratio needed to stabilize our specific UAV. The damping ratio listed is based on the ratio required based on a drone with similar weight as ours.

REQ-004
REQ-004 is not subject to change. This is an explicit requirement from our stakeholder.

REQ-005
REQ-005 is subject to change. This is a requirement that might vary depending on where our client wishes to have the system deployed. Depending on the setting of the new environmental condition, this value might increase or decrease.

REQ-006
REQ-006 is not subject to change. This is an explicit requirement from our stakeholder.

REQ-007
REQ-007 is not subject to change. It is important for the UAV to be able to update its software/firmware to mitigate software bugs and for feature updates when necessary.

REQ-008
REQ-008 is subject to change. This performance requirement is currently dictated by the size of the testing room (which is around 7-8m in length). Depending on future testing room size, this value might go up or down.

REQ-009
REQ-009 is subject to change. Regarding the testing scenarios available to the group, currently the tracking system needs to keep the UAV within field of view. The value of 1.4m/s might increase overtime depending on the actual speed of the drone since 1.4m/s is being determined as the average speed we want a human to move the UAV at.

REQ-010

REQ-10 is subject to change. Based on our tests with the UAV we may require the stable connection to operate for a longer or shorter period of time

REQ-011
REQ-11 is not subject to change. This is a performance requirement for our project. The communication system must receive real-time data from the UAV in order for the GUI to perform data visualization.

REQ-012
The ground system must be able to receive critical telemetry data from the drone. By displaying the data we will be able to evaluate whether the data being received is correct. Therefore displaying data is necessary and not subject to change.

REQ-013
A specific user requirement is the ability to track a selected drone. Enabling the GUI to transmit data to the tracking system allows users to initiate drone tracking via the GUI, eliminating the need for direct interaction with the tracking system. This functionality simplifies user engagement with the ground station and, as such, will not be altered.

REQ-014
The tracking system will have a camera system capable of outputting video data. By displaying this data, the user will be able to understand the current state of the tracking system and check if the system is working correctly. This feature allows ease of access and may also prevent errors. Therefore it is not subject to change.

REQ-015
Should the system fail to display data accurately, it is crucial to alert the user. Providing details about the error will assist the user in identifying and resolving the issue. This approach simplifies error management, and as such, this requirement will remain unchanged.

REQ-016
REQ-16 is not subject to change. It is fundamental for ensuring safety and reliability. Providing a stable frame framework for the overall system is crucial for maintaining a consistent and reliable level of protection throughout the project's lifecycle.

REQ-017
REQ-17 is not subject to change. This is to maintain a stable connection during the operation of our UAV and it also reduces the likelihood of accidents or incidents during its flight.

REQ-018
REQ-18 is a safety requirement that is likely to change. Depending on regulatory standards and the environment the UAV will be operating in, adhering to the compliance standards is essential for safety and legal requirements.

REQ-019

REQ-19 is a safety requirement that is likely to change. Currently, to adhere to McMaster University's safety standards and compliance, there can be no operation of UAVs flying indoors. [4]

5.2 Functional Decomposition Overview

Functional decomposition will outline the high-level functions of the ***Drone Monitoring, Piloting and Tracking System.*** This high-level system is then broken down into three sub-tasks: Drone Piloting, Drone Monitoring, and Drone Tracking.

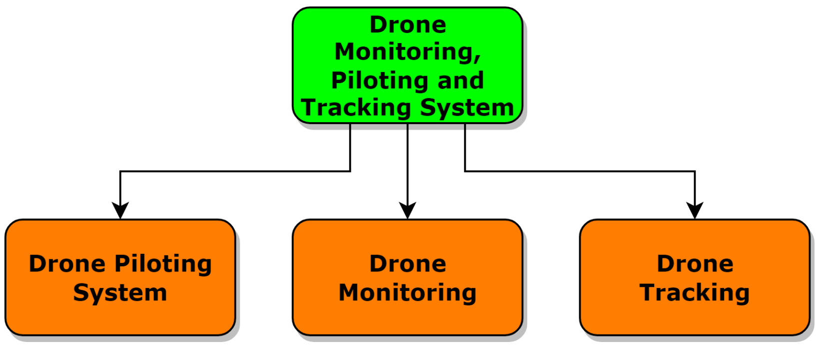

Figure 10: Level I Decomposition

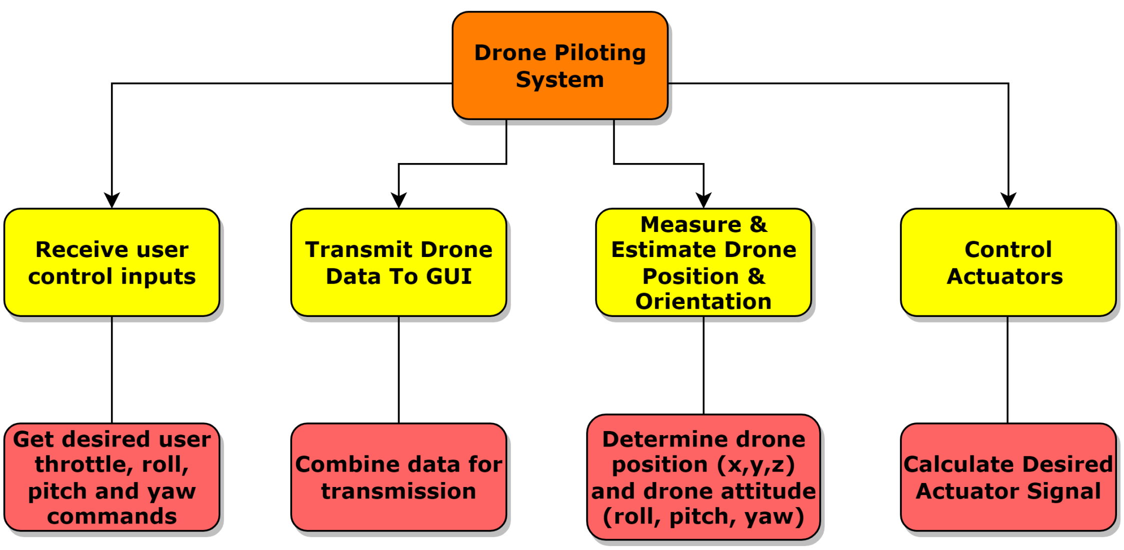

Figure 11: Level II Decomposition of Drone Piloting

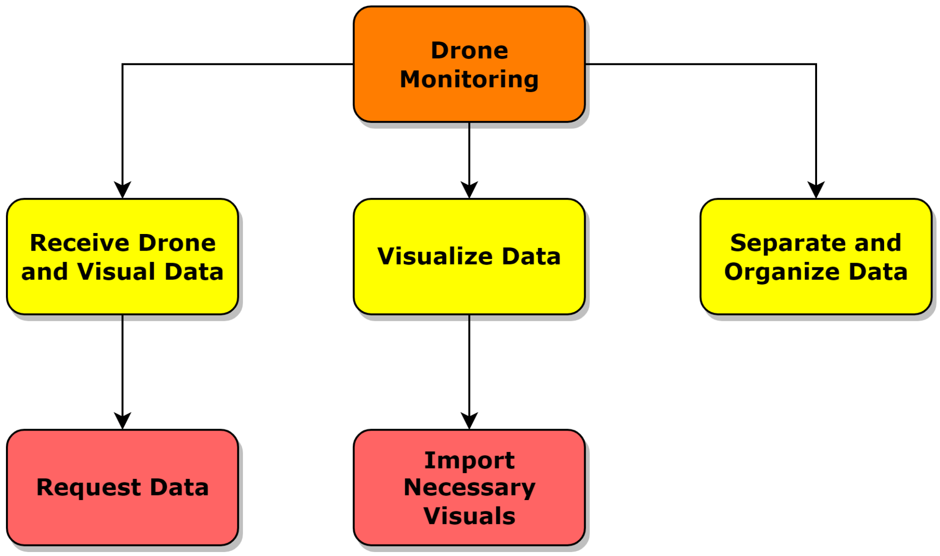

Figure 12: Level II Decomposition of Drone Monitoring

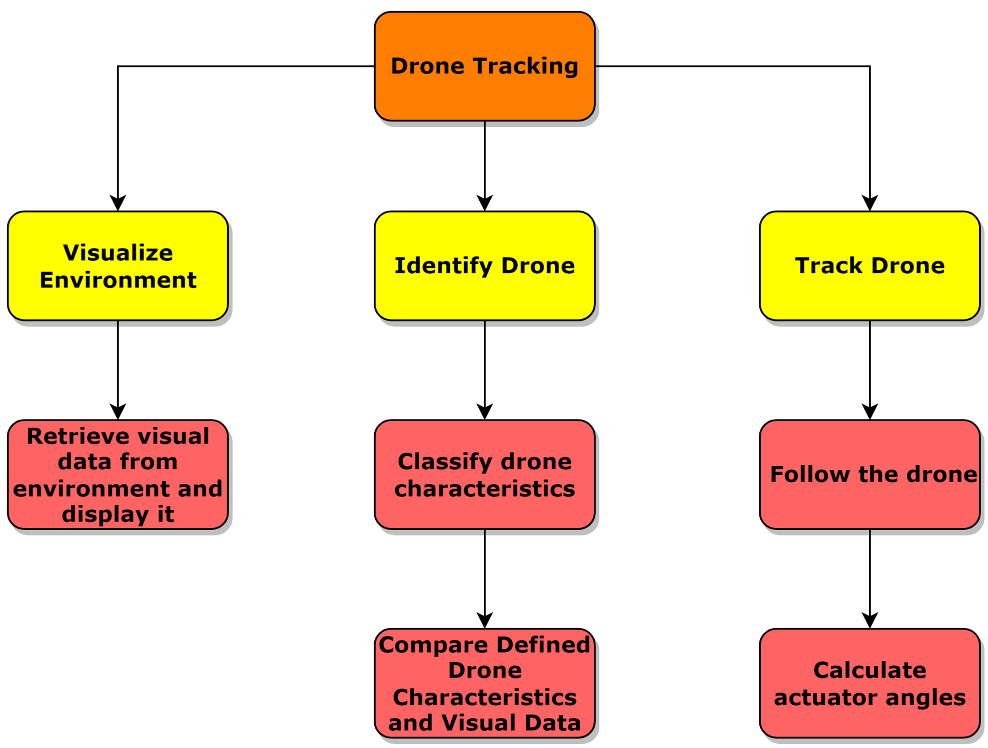

Figure 13: Level II Decomposition of Drone Tracking

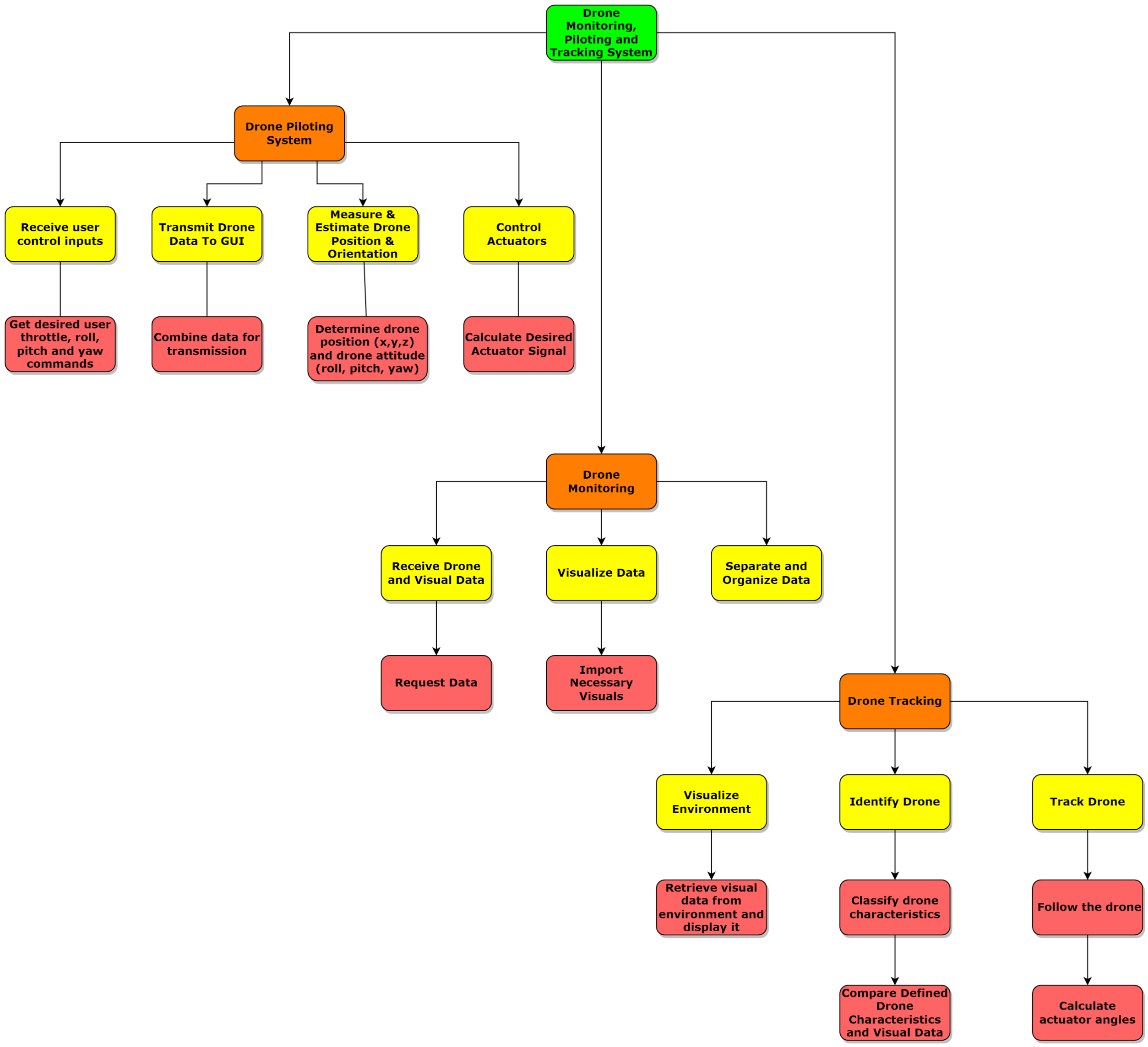

Figure 14: Functional Decomposition Diagram (Overall View)

6. REFERENCES

1. [1] (16) (PDF) Design and Fabrication of a Dual Rotor-Embedded Wing Vertical Take-Off and Landing Unmanned Aerial Vehicle (researchgate.net)
2. [2] Average walking speed: Comparisons by age, sex, and walking for health (medicalnewstoday.com)
   [3] A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students - PMC (nih.gov)
3. [4] Complete Policy Title: (mcmaster.ca)