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**Abstract**

This document outlines the high level and derived system requirements for the Predictive Flight Management System (PFMS) 2009 project. The requirements described in this document are derived from the projects High Level Objectives (HLOs). The system requirements and their respective functional requirements are explicitly defined with testing procedures detailed to ensure successful operation and reference to associated work packages.

The document details five high level system requirements which represent successive stages of the project. The stages are associated with the development of a literature review, a 2D simulation model, a 3D simulation model, integration of the PFMS onboard a UAV and lastly incorporation of advanced concepts within the system.

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**Definitions**

|  |  |
| --- | --- |
| PFMS | Predictive Flight Management System |
| HLO | High Level Objectives |
| PMP | Project Management Plan |
| QUT | Queensland University of Technology |
| QUAV | QUT Uninhabited Aerial Vehicle |
| UAV | Uninhabited Aerial Vehicle |
| ARCAA | Australian Research Centre for Aerospace Automation |
| BEE | Built Environment and Engineering |
| HLSR | High Level System Requirement |
| ATC | Air Traffic Controller |

# Introduction

This document details the high level and the respective functional requirements for the PFMS project. Each system requirement is explicitly defined and a testing procedure is detailed. The definitions in this document with appropriate test measures will ensure the project requirements are met.

## Scope

This document outlines the system requirements for the PFMS 2009 project. The requirements described in this document are derived from the projects HLOs as per RD/1.

## Background

QUT has been developing UAV technology in various forms since 1991. In the past, subsequent to receiving commands from an autonomous traffic controller, flight trajectory prediction has been performed by linear methods which ignore the states of the aircraft, weather effects and successive waypoints. A PFMS allows for an Uninhabited Aerial Vehicle (UAV) to have some level of intelligence to determine whether it will be capable of intercepting a demanded waypoint at a given time, whether to ignore waypoints that may/may not be invalid if there is a higher then expected latency in the system, and how to handle the difference between mandatory (mission) waypoints and the demanded waypoints from the traffic controller. In advanced stages of the project the PFMS may include concepts such as autonomous collision avoidance that is independent of the autonomous traffic controller.

This year the Australian Research Centre for Aerospace Automation (ARCAA) requires a PFMS for the Smart Skies QUT Uninhabited Aerial System (QUAS) resulting in the PFMS project. This document outlines the system requirements for the project.

# Reference Documents

## QUT Avionics Documents

|  |  |  |
| --- | --- | --- |
| RD/1 | QUAV-PFMS-SYS-HO-0001 | QUAV Project, PFMS, High Level Objectives for |

## Non-QUT Documents

|  |  |  |
| --- | --- | --- |
| None. |  |  |

In the event of any conflict between this document and any RD referenced herein, such conflict shall be notified to .

In the following text, RD/x identifies referenced documents, where "x" denotes the actual document.

# System Requirements Details

The system requirements have been derived by breaking down the HLOs as per RD/1. Each HLO has a corresponding High Level System Requirement (HLSR), and each of these has further functional requirements. The overall requirements tree is outlined in , and described in the following sections where system requirements are detailed and respective functional requirements are defined.



Figure 1 - System Requirement Tree

## SR-1 - Literature Review

SR-1 is to conduct a comprehensive literature review on existing Flight Management Systems, associated methods of control and flight dynamics. The literature review should conclude the methods that best suit the application of designing a PFMS for a robotic aircraft like that available at QUT through in depth research. The review will be utilised as a baseline for development of the PFMS in later stages of the project.

The associated functional requirements, testing procedures and associated work packages for this system requirement are detailed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement** | **Definition** | **Testing Procedure** | **Associated Work Package** |
| **FR-1-01** | Write a trade study detailing existing Flight Management Systems, associated methods of control and flight dynamics | Supervisor Review | WP - 3 |

Table - SR-1 Functional Requirements

## SR-2 – 2D PFMS Simulation

SR-2 is to apply understanding from conducted literature review to develop a simple 2D model capable of determining a level of prediction with multiple waypoints. The model should undertake considerations of flight dynamics and control methods to enable it to have some level of intelligence in order to predict if the UAV is capable of intercepting waypoints and to distinguish invalid commands due to communication system latency. The system should also mimic the ability to receive standard and process autonomous Air Traffic Controller (ATC) commands.

In addition a selection of a suitable modelling environment must be made at this stage.

The associated functional requirements, testing procedures and associated work packages for this system requirement are detailed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement** | **Definition** | **Testing Procedure** | **Associated Work Package** |
| **FR-2-01** | System is capable of a prediction time of 0-10 seconds. | Validate prediction utilising independent waypoint orientated flight simulation software. | WP-08 |
| **FR-2-02** | System can determine if it is capable of intercepting a waypoint. | Validate utilising a Matlab simulation and comparing with a independent waypoint orientated flight simulation software. | WP-08 |
| **FR-2-03** | System is capable of distinguishing invalid commands due to system latency. | Simulate invalid commands and determine is the system adequately deals with the waypoints. | WP-08 |
| **FR-2-04** | System is capable of receiving and processing ATC commands. | Provide ATC commands and determine if the system process the data and responds as required. | WP-08 |

Table - SR-2 Functional Requirements

## SR-3 –3D Simulation

SR-3 is to apply understanding from conducted literature review to develop a simple 3D model to build on the 2D model simulation. This model should also be capable of determining a level of prediction with multiple waypoints. The model should undertake considerations of flight dynamics and control methods to enable it to have some level of intelligence in order to predict if the UAV is capable of intercepting waypoints and to distinguish invalid commands due to communication system latency. The system should also mimic the ability to receive standard and process autonomous ATC commands.

In addition a selection of a suitable modelling environment must be made at this stage.

The associated functional requirements, testing procedures and associated work packages for this system requirement are detailed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement** | **Definition** | **Testing Procedure** | **Associated Work Package** |
| **FR-3-01** | System is capable of a prediction time of 0-10 seconds. | Validate prediction utilising independent waypoint orientated flight simulation software. | WP-09 |
| **FR-3-02** | System can determine if it is capable of intercepting a waypoint. | Validate utilising a Matlab simulation and comparing with a independent waypoint orientated flight simulation software. | WP-09 |
| **FR-3-03** | System is capable of distinguishing invalid commands due to system latency. | Simulate invalid commands and determine is the system adequately deals with the waypoints. | WP-09 |
| **FR-3-04** | System is capable of receiving and processing ATC commands. | Provide ATC commands and determine if the system process the data and responds as required. | WP-09 |

Table -SR-3 Functional Requirements

## SR-4 – UAV PFMS Capability

SR-3 is to integrate the developed PFMS 3D simulation to a UAV with subsequent testing and validation. The UAV is to be equipped with an autopilot and suitable hardware to operate the PFMS. The PFMS is to be validated during cruising stages of flight. The UAV must also have the appropriate data detailing its dynamics.

The PFMS at this stage will have to be developed in a suitable programming language for operation onboard the UAV.

The associated functional requirements, testing procedures and associated work packages for this system requirement are detailed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement** | **Definition** | **Testing Procedure** | **Associated Work Package** |
| **FR-4-01** | System is capable of operation for flight duration of UAV. | Test if the system operates for the flight duration of the UAV. | WP-12 |
| **FR-4-02** | System is capable of operation on the processing hardware available on the UAV. | Check if mode runs on the provided hardware with the resources available. | WP-12 |
| **FR-4-03** | System is capable of a prediction time of 0-10 seconds. | Compare the location of the aircraft within 0-10 seconds with the predicted location. | WP-12 |
| **FR-4-04** | System can determine if it is capable of intercepting a waypoint. | Ensure that the system is able to determine if a waypoint is not achievable during flight. | WP-12 |
| **FR-4-05** | System is capable of distinguishing invalid commands due to system latency. | Simulate invalid commands and determine is the system adequately deals with the waypoints. | WP-12 |
| **FR4-06** | System is capable of receiving and processing ATC commands. | Provide ATC commands and determine if the system process the data and responds as required. | WP-12 |

Table - SR-4 Functional Requirements

## SR-5 – Advanced UAV PFMS Capability

SR-3 is to include advanced concepts of operation within the developed PFMS with subsequent testing and validation. Concepts such as consideration of weather effects and autonomous collision avoidance will be included into the system at this stage. Further specification of advanced concepts may evolve during later phases of the project.

The associated functional requirements, testing procedures and associated work packages for this system requirement are detailed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement** | **Definition** | **Testing Procedure** | **Associated Work Package** |
| **FR-4-01** | System is capable of operation for flight duration of UAV. | Test if the system operates for the flight duration of the UAV. | WP-14 |
| **FR-4-02** | System is capable of operation on the processing hardware available on the UAV. | Check if mode runs on the provided hardware with the resources available. | WP-14 |
| **FR-4-03** | System is capable of a prediction time of 0-10 seconds. | Compare the location of the aircraft within 0-10 seconds with the predicted location. | WP-14 |
| **FR-4-04** | System can determine if it is capable of intercepting a waypoint. | Ensure that the system is able to determine if a waypoint is not achievable during flight. | WP-14 |
| **FR-4-05** | System is capable of distinguishing invalid commands due to system latency. | Simulate invalid commands and determine is the system adequately deals with the waypoints. | WP-14 |
| **FR4-06** | System is capable of receiving and processing ATC commands. | Provide ATC commands and determine if the system process the data and responds as required. | WP-14 |
| **FR-4-07** | System is capable of considering weather effects. | Determine if the system makes accurate predictions with the consideration of wind conditions. | WP-14 |
| **FR-4-08** | System is capable autonomous collision avoidance. | The system successfully provides collision avoidance data independent of the ATC. This may be tested at ground level or during flight. The test methods for FR-4-08 may develop further later in the project. | WP-14 |

Table - SR-5 Functional Requirements

# Conclusions

By meeting the system requirements and appropriate testing procedures detailed above, the HLOs in RD/1 will be achieved.

# Appendices

None.