HelicopterSystemRequirements Requirements Report

Author(s): bpotter

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Chapter 1: Requirement Set: HelicopterSystemRequirements

Description

Attributes

Filepath	C:\Users\bpotter\MATLAB\Projects\ARP_DO_Project\DO_02_Requirements\specification\HelicopterSystemRequirements.slreqx
Revision	9
Created by	bpotter
Created on	29-Sep-2017 13:12:52
Modified by	bpotter
Modified on	08-Apr-2019 14:11:30

Implementation Status

Total	Implemented	Justified	None
11	11	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
11	0	0	0	0	11

Change Information No change issue detected.

1 Imported from HelicopterSystemRequirements.docx

Requirement Type Container

ID HelicopterSystemRequirements

Description

Revision Information

SID	1	**Revision**	8
Created by	bpotter	**Created on**	29-Sep-2017 13:12:56
Modified by	bpotter	**Modified on**	10-Dec-2018 07:44:35

Change Information No change issue detected.

Implementation Status

Total	Implemented	Justified	None
11	11	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
11	0	0	0	0	11

1.1 Introduction

Requirement Type Informational

ID Introduction

Description

This document provides the system level requirements for a helicopter flight control system that provides attitude and attitude rate control based on pilot input commands.

Revision Information

SID	2	**Revision**	8
Created by	bpotter	**Created on**	29-Sep-2017 13:12:57
Modified by	bpotter	**Modified on**	10-Dec-2018 07:44:40

Change Information No change issue detected.

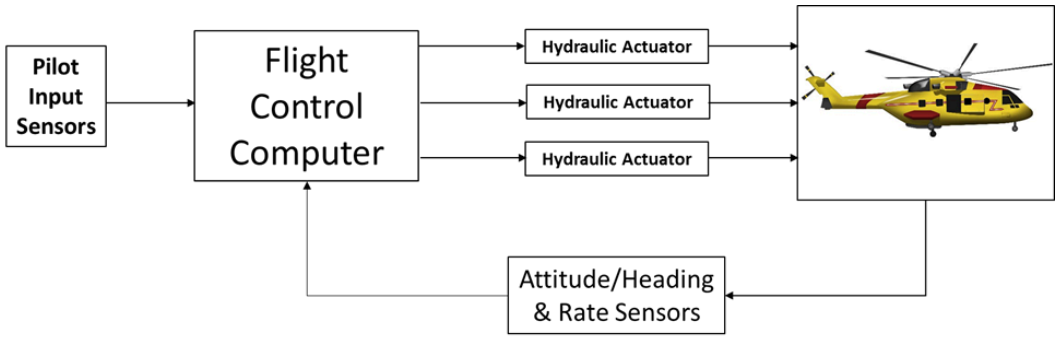
1.2 System Description

Requirement Type Informational

ID System Description

Description

The flight control system consists of pilot input controls, cyclic and pedals, a flight control computer and hydraulic actuators to control the main and tail rotors. A diagram of the system is shown in the figure below.



Helicopter Control System

The cyclic controls the pitch of the rotor blades to allow the helicopter pitch up or down and roll right or left. The pedal input controls the tail rotor to allow the helicopter to yaw right or left. This control system does not include throttle control or collective control, which combined control the total lift of the helicopter.

Revision Information

SID	3	**Revision**	9
Created by	bpotter	**Created on**	29-Sep-2017 13:12:57
Modified by	bpotter	**Modified on**	08-Apr-2019 08:52:32

Change Information No change issue detected.

1.3 System Requirements

Requirement Type Container

ID System Requirements

Description

This section provides the system level requirements for the flight control system. Each requirement is tagged with SR_ and a unique number for the purposes of providing trace anchors for the high-level software requirements and system verification cases to trace to. Each requirement is also put into a subsection of this section.

Revision Information

SID	4	**Revision**	8
Created by	bpotter	**Created on**	29-Sep-2017 13:12:57
Modified by	bpotter	**Modified on**	10-Dec-2018 07:44:51

Change Information No change issue detected.

Implementation Status

Total	Implemented	Justified	None
11	11	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
11	0	0	0	0	11

1.3.1 Pilot Input Signals

Requirement Type Functional

ID SR_1

Description

The flight control system shall process three LVDT inputs from the pilot cockpit controls, including fore/aft cyclic position, left/right cyclic position and pedal left/right position.

Revision Information

SID	5	Revision	4
Created by	bpotter	Created on	29-Sep-2017 13:12:57
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_1 Pilot Input Signal Processing (⇦Refined by)

Artifact HelicopterSystem.slx

Pilot Inputs (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.2 Hydraulic Actuator Interfaces

Requirement Type Functional

ID SR_2

Description

The flight control system shall interface to three hydraulic actuators, two for cyclic control and one for tail rotor control.

Revision Information

SID	6	Revision	4
Created by	bpotter	Created on	29-Sep-2017 13:12:57
Modified by	bpotter	Modified on	30-Oct-2017 13:11:11

Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_2 Hydraulic Actuator Feedback (⇦Refined by)

HLR_3 Hydraulic Actuator Drive (⇦Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (⇦Implemented by)

Actuator1 (⇦Implemented by)

Actuator2 (⇦Implemented by)

Actuator3 (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.3 Hydraulic Actuator Signals

Requirement Type Functional

ID SR_3

Description

Each hydraulic actuator interface shall consist of an electro-hydraulic valve to control the actuator and an LVDT feedback signal providing the piston position.

Revision Information

SID	7	Revision	4
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_2 Hydraulic Actuator Feedback (⇦Refined by)

HLR_3 Hydraulic Actuator Drive (⇦Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (⇦Implemented by)

Actuator3 (⇦Implemented by)

Actuator2 (⇦Implemented by)

Actuator1 (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.4 Hydraulic Actuator Control Loop Performance

Requirement Type Functional

ID SR_4

Description

The flight control system shall control the hydraulic actuator position with a minimum bandwidth of 10Hz and a minimum damping of 0.4. The steady state error tracking shall be within 5% of the position command.

Revision Information

SID	8	**Revision**	4
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_4 Hydraulic Actuator Loop Control (Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.5 Attitude Heading Reference System Interfaces

Requirement Type Functional

ID SR_5

Description

The flight control system shall process three MIL1553 digital bus inputs from Attitude/Heading Reference Systems (AHRS), including pitch attitude, roll attitude, pitch rate, roll rate and yaw rate.

Revision Information

SID	9	**Revision**	4
Created by	bpotter	**Created on**	29-Sep-2017 13:12:57
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_10 AHRS Input Signal Processing (Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (Implemented by)

AHRS Sensor3 (Implemented by)

AHRS Sensor2 (Implemented by)

AHRS Sensor1 (Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.6 Attitude Rate Tracking Performance

Requirement Type Functional

ID SR_6

Description

The control system shall track set point changes in theta and phi within 1 degree steady-state error, rise time of about 2 seconds, maximum of 10% overshoot. The control system shall track set point changes in r within 0.5 degree/sec steady-state error, rise time of about 2 seconds, maximum of 10% overshoot.

Revision Information

SID	10	Revision	4
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

- HLR_5 Multi-Variable Inner Loop Control (⇦Refined by)
- HLR_6 Pitch Outer Loop Control (⇦Refined by)
- HLR_7 Roll Outer Loop Control (⇦Refined by)
- HLR_8 Yaw Outer Loop Control (⇦Refined by)

Artifact HelicopterSystem.slx

- Flight Control Computer (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.7 Control Bandwidth

Requirement Type Functional

ID SR_7

Description

The control bandwidth shall be limited to 40 rad/sec in order to guard against high-frequency rotor dynamics and measurement noise.

Revision Information

SID	11	Revision	4

Created by	bpotter	Created on	29-Sep-2017 13:12:58
Modified by	bpotter	Modified on	30-Oct-2017 13:12:54

Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

- HLR_5 Multi-Variable Inner Loop Control (⇦Refined by)
- HLR_6 Pitch Outer Loop Control (⇦Refined by)
- HLR_7 Roll Outer Loop Control (⇦Refined by)
- HLR_8 Yaw Outer Loop Control (⇦Refined by)

Artifact HelicopterSystem.slx

- Flight Control Computer (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.8 Control Gain and Phase Margins

Requirement Type Functional

ID SR_8

Description

The gain margin shall be a minimum of 10db and the phase margin shall be a minimum of 45 degrees in all axes.

Revision Information

SID	12	Revision	4
Created by	bpotter	Created on	29-Sep-2017 13:12:58
Modified by	bpotter	Modified on	30-Oct-2017 13:13:09

Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

- HLR_5 Multi-Variable Inner Loop Control (⇦Refined by)
- HLR_6 Pitch Outer Loop Control (⇦Refined by)
- HLR_7 Roll Outer Loop Control (⇦Refined by)
- HLR_8 Yaw Outer Loop Control (⇦Refined by)

Artifact HelicopterSystem.slx

- Flight Control Computer (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.9 Attitude Rate Authority Limiting

Requirement Type Functional

ID SR_9

Description

The flight control system shall limit the pitch and roll attitudes to 30 degrees, +/-10%. The yaw rate shall be limited to 15 degrees/sec +/- 10%.

Revision Information

SID	13	Revision	4
Created by	bpotter	Created on	29-Sep-2017 13:12:58
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Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

- HLR_6 Pitch Outer Loop Control (⇦Refined by)
- HLR_7 Roll Outer Loop Control (⇦Refined by)
- HLR_8 Yaw Outer Loop Control (⇦Refined by)

Artifact HelicopterSystem.slx

- Flight Control Computer (⇦Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.10 Sensor Validation

Requirement Type Functional

ID SR_10

Description

The flight control system shall determine the validity of each of the three AHRS prior to using the data from them.

Revision Information

SID	14	Revision	4
Created by	bpotter	Created on	29-Sep-2017 13:12:58
Modified by	bpotter	Modified on	30-Oct-2017 13:13:40

Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_9 AHRS Validity Check (Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

1.3.11 Sensor Voting

Requirement Type Functional

ID SR_11

Description

When all three AHRS sensors are indicating valid, the flight control system shall use the middle value for each of the individual parameters.
When only two AHRS sensors are indicating valid, the flight control system shall use the average of the individual parameter values from the two valid AHRS.
When only one AHRS is indicating valid, the flight control system shall use the individual parameter values from that valid AHRS.

Revision Information

SID	15	**Revision**	4
Created by	bpotter	**Created on**	29-Sep-2017 13:12:58
Modified by	bpotter	**Modified on**	30-Oct-2017 13:14:02

Change Information No change issue detected.

Links

Artifact HelicopterSoftwareRequirements.slreqx

HLR_11 AHRS Voting for Triple Sensors (Refined by)

HLR_12 AHRS Voting for Dual Sensors (Refined by)

HLR_13 AHRS Usage of Single Sensor (Refined by)

Artifact HelicopterSystem.slx

Flight Control Computer (Implemented by)

Implementation Status

Total	Implemented	Justified	None
1	1	0	0

Verification Status

Total	Passed	Justified	Failed	Unexecuted	None
1	0	0	0	0	1

Appendix

Artifact List

Simulink Requirement Set files:

#	Name	Folder	Revision
1	HelicopterSoftwareRequirements.slreqx	C:\Users\bpotter\MATLAB\Projects\ARP_DO_Project\DO_02_Requirements\specification	11

Simulink models:

#	Name	Folder	Version
1	HelicopterSystem.slx	C:\Users\bpotter\MATLAB\Projects\ARP_DO_Project\work	1.24