HelicopterSystemRequirements Report

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Chapter 1: Requirement Set: HelicopterSystemRequirements

Description

Attributes

Filepath***:*** C:\Users\bpotter\MATLAB\Projects\ARP\_Example\_Project\ARP\_02\_SystemRequirements\specification\HelicopterSystemRequirements.slreqx

Revision: 11

Created by: bpotter

Created on*:* 29-Sep-2017 13:12:52

Modified by***:*** bpotter

Modified on*:* 21-May-2019 09:35:48

Implementation Status

Total: 11, Implemented: 11, Justified: 0, None: 0

Verification Status

Total: 11, Passed: 2, Justified: 0, Failed: 0, Unexecuted: 0, None: 9

Change Information No change issue detected.

1 Helicopter Flight Control System Requirements

Requirement Type Container

ID HelicopterSystemRequirements

Description

Revision Information

SID: 1

Revision: 11

Created by: bpotter

Created on: 29-Sep-2017 13:12:56

Modified by: bpotter

Modified on: 21-May-2019 09:35:32

Change Information No change issue detected.

Implementation Status

Total: 11, Implemented: 11, Justified: 0, None: 0

Verification Status

Total: 11, Passed: 2, Justified: 0, Failed: 0, Unexecuted: 0, None: 9

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.

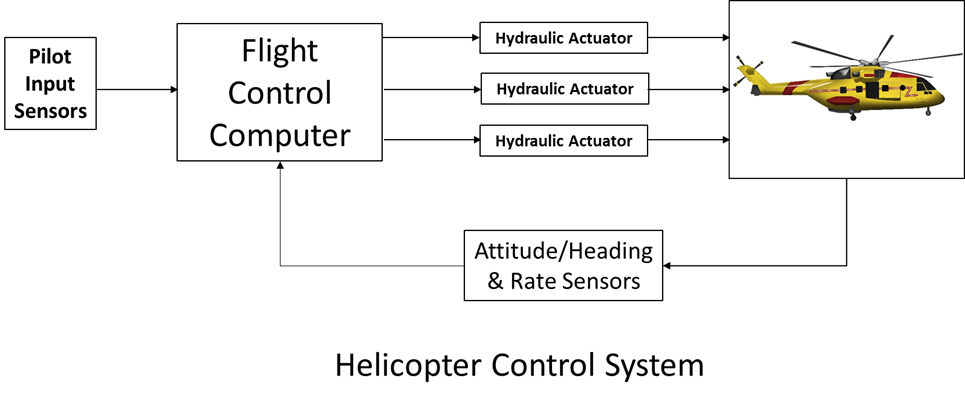
1.2 System Description

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.



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: 11, Implemented: 11, Justified: 0, None: 0

Verification Status

Total: 11, Passed: 2, Justified: 0, Failed: 0, Unexecuted: 0, None: 9

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

Modified by: bpotter

Modified on: 30-Oct-2017 13:12:19

Change Information No change issue detected.

Links

Artifact: [HelicopterSystem.slx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| HelicopterSystem:24 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| [HLR\_1 Pilot Input Signal Processing](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%225%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

Total: 1, Passed: 0, Justified: 0, Failed: 0, Unexecuted: 0, None: 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: [HelicopterSystem.slx](#ArtifactListTable)

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| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |
| HelicopterSystem:10 | Implemented by |
| HelicopterSystem:12 | Implemented by |
| HelicopterSystem:14 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| [HLR\_2 Hydraulic Actuator Feedback](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%226%22,%22%22%5d) | Refined by |
| [HLR\_3 Hydraulic Actuator Drive](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%227%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

Created by: bpotter

Created on: 29-Sep-2017 13:12:57

Modified by: bpotter

Modified on: 30-Oct-2017 13:11:36

Change Information No change issue detected.

Links

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| HelicopterSystem:21 | Implemented by |
| HelicopterSystem:14 | Implemented by |
| HelicopterSystem:12 | Implemented by |
| HelicopterSystem:10 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| Linked Item | Link Type |
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| [HLR\_3 Hydraulic Actuator Drive](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%227%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

Created by: bpotter

Created on: 29-Sep-2017 13:12:57

Modified by: bpotter

Modified on: 30-Oct-2017 13:11:56

Change Information No change issue detected.

Links

Artifact: [HelicopterSystem.slx](#ArtifactListTable)

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| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

|  |  |
| --- | --- |
| Linked Item | Link Type |
| [HLR\_4 Hydraulic Actuator Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%228%22,%22%22%5d) | Refined by |

Artifact: [ActLoopTest.mldatx](#ArtifactListTable)

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| ActLoopTest:?? | Verified by |
| ActLoopTest:?? | Verified by |
| ActLoopTest:?? | Verified by |
| ActLoopTest:?? | Verified by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

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

Modified by: bpotter

Modified on: 30-Oct-2017 13:12:13

Change Information No change issue detected.

Links

Artifact: [HelicopterSystem.slx](#ArtifactListTable)

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| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |
| HelicopterSystem:7 | Implemented by |
| HelicopterSystem:4 | Implemented by |
| HelicopterSystem:1 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| [HLR\_10 AHRS Input Signal Processing](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2214%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

Total: 1, Passed: 0, Justified: 0, Failed: 0, Unexecuted: 0, None: 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 2 seconds(+/-0.5), 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 2 seconds (+/-0.5), maximum of 10% overshoot.

Revision Information

SID: 10

Revision: 10

Created by: bpotter

Created on: 29-Sep-2017 13:12:57

Modified by: bpotter

Modified on: 03-May-2019 13:21:26

Change Information No change issue detected.

Links

Artifact: [HelicopterSystem.slx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

|  |  |
| --- | --- |
| Linked Item | Link Type |
| [HLR\_5 Multi-Variable Inner Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%229%22,%22%22%5d) | Refined by |
| [HLR\_6 Pitch Outer Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2210%22,%22%22%5d) | Refined by |
| [HLR\_7 Roll Outer Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2211%22,%22%22%5d) | Refined by |
| [HLR\_8 Yaw Outer Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2212%22,%22%22%5d) | Refined by |

Artifact: [HeliLoopTest.mldatx](#ArtifactListTable)

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| HeliLoopTest:?? | Verified by |
| HeliLoopTest:?? | Verified by |
| HeliLoopTest:?? | Verified by |
| HeliLoopTest:?? | Verified by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

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: [HelicopterSystem.slx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| Linked Item | Link Type |
| [HLR\_5 Multi-Variable Inner Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%229%22,%22%22%5d) | Refined by |
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| [HLR\_7 Roll Outer Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2211%22,%22%22%5d) | Refined by |
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Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

Total: 1, Passed: 0, Justified: 0, Failed: 0, Unexecuted: 0, None: 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: [HelicopterSystem.slx](#ArtifactListTable)

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| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| Linked Item | Link Type |
| [HLR\_5 Multi-Variable Inner Loop Control](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%229%22,%22%22%5d) | Refined by |
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Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

Modified by: bpotter

Modified on: 30-Oct-2017 13:13:27

Change Information No change issue detected.

Links

Artifact: [HelicopterSystem.slx](#ArtifactListTable)

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| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

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Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

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| --- | --- |
| Linked Item | Link Type |
| [HLR\_9 AHRS Validity Check](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2213%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

Total: 1, Passed: 0, Justified: 0, Failed: 0, Unexecuted: 0, None: 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: [HelicopterSystem.slx](#ArtifactListTable)

|  |  |
| --- | --- |
| Linked Item | Link Type |
| HelicopterSystem:21 | Implemented by |

Artifact: [HelicopterSoftwareRequirements.slreqx](#ArtifactListTable)

|  |  |
| --- | --- |
| Linked Item | Link Type |
| [HLR\_11 AHRS Voting for Triple Sensors](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2215%22,%22%22%5d) | Refined by |
| [HLR\_12 AHRS Voting for Dual Sensors](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2216%22,%22%22%5d) | Refined by |
| [HLR\_13 AHRS Usage of Single Sensor](http://localhost:31415/matlab/feval/rmi.navigate?arguments=%5b%22linktype_rmi_slreq%22,%22C:%5C%5CUsers%5C%5Cbpotter%5C%5CMATLAB%5C%5CProjects%5C%5CARP_Example_Project%5C%5CARP_04_ItemRequirements%5C%5Cspecification%5C%5CHelicopterSoftwareRequirements.slreqx%22,%2217%22,%22%22%5d) | Refined by |

Implementation Status

Total: 1, Implemented: 1, Justified: 0, None: 0

Verification Status

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

Appendix

Artifact List

Simulink Requirement Set files:

|  |  |  |  |
| --- | --- | --- | --- |
| # | Name | Folder | Revision |
| 1 | HelicopterSoftwareRequirements.slreqx | C:\Users\bpotter\MATLAB\Projects\ARP\_Example\_Project\ARP\_04\_ItemRequirements\specification | 14 |

Simulink models:

|  |  |  |  |
| --- | --- | --- | --- |
| # | Name | Folder | Version |
| 1 | HelicopterSystem.slx | C:\Users\bpotter\MATLAB\Projects\ARP\_Example\_Project\ARP\_03\_SystemArchitecture\specification | Unloaded. |

Simulink Test files:

|  |  |  |  |
| --- | --- | --- | --- |
| # | Name | Folder | File timestamp |
| 1 | ActLoopTest.mldatx | C:\Users\bpotter\MATLAB\Projects\ARP\_Example\_Project\ARP\_06\_SystemVerification\verification\simulation\_tests | 20-May-2019 14:15:02 |
| 2 | HeliLoopTest.mldatx | C:\Users\bpotter\MATLAB\Projects\ARP\_Example\_Project\ARP\_06\_SystemVerification\verification\simulation\_tests | 20-May-2019 14:15:02 |