# Test plan

Editor: Klas Gudmundsson

Version 0.2

Status

| | | |
|---|---|---|
| Reviewed | CM | 2016-10-14 |
| Approved | | |

# PROJECT IDENTITY

2016 HT

Linköping University, Dept. of Electrical Engineering (ISY)

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Document History

| **Version** | **Date** | **Changes** | **Sign** | **Reviewed** |
|---|---|---|---|---|
| 0.1 | 2016-10-05 | First draft. | KG | KG,EB |
| 0.2 | 2016-10-14 | Fixed comments from supervisor. | EB | EB,LF |

# 1 Reading this Document

In this document there are at least one test specified for each requirement in the requirement specification. The tests are on a standardised table form. An empty test table can be seen in table 1.

Table 1: Empty test table. The different cells are numbered with blue numbers.

| | | |
|---|---|---|
| **Test number** 1. | Pass Fail 2. | **Requirement:** 3. |
| **Requirement** | | |
| 4. | | |
| **How to test** | | |
| 5. | | |
| **How to pass** | | |
| 6. | | |
| **Cause of failure** | | |
| 7. | | |
| **Test responsible:** 8. | | **Signature** 10. |
| **Date:** 9. | | |

The contents of the different fields in the test table are explained below.

1. Test number, a number used solely to distinguish between tests.
2. A space for the tester to mark if the test has passed or failed. It is done manually on the printed copy of the test. If a test fails, a new page can be printed to redo the test.
3. A reference to the requirement in the requirement specification associated to the specific test.
4. The requirement as it is written in the requirement specification.
5. Description of how to perform the test.
6. When applicable this field is used to state the minimum requirement for a test to pass or fail.
7. If the test fails the tester will write the cause of failure in this field.
8. The person that is responsible for the test writes their initials in this field.
9. The date that the test is performed, written manually on the printed copy.
10. A signature of the person that has performed the test.

## 2 Tests

| | | |
|---|---|---|
| **Test number 1** | Pass Fail | **Requirement:**<br>RS_2_1 |
| **Requirement** | | |
| The system should have a clear subdivision according to figure 1. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

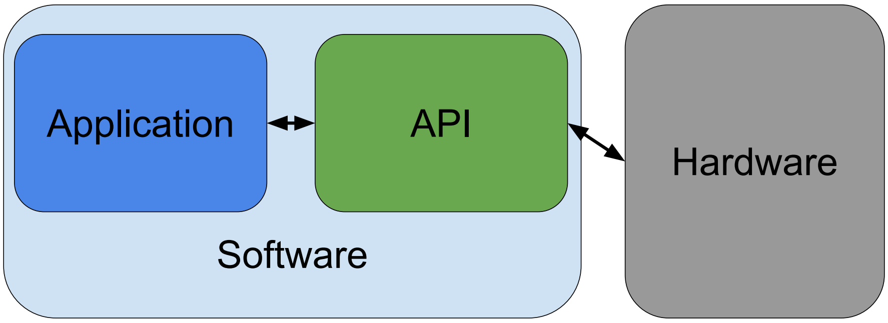

Figure 1: An overview of the system

<table>
<tr><td><b>Test number 2</b></td><td>Pass Fail</td><td><b>Requirement:</b><br>RS_2_2</td></tr>
<tr><td colspan="3"><b>Requirement</b></td></tr>
<tr><td colspan="3">The Application will communicate with the hardware through the API.</td></tr>
<tr><td colspan="3"><b>How to test</b></td></tr>
<tr><td colspan="3">Confirmed by the tester. Make sure the Application only communicates with the hardware using the functions provided by the API.</td></tr>
<tr><td colspan="3"><b>How to pass</b></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3"><b>Cause of failure</b></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2"><b>Test responsible:</b></td><td rowspan="2"><b>Signature:</b></td></tr>
<tr><td colspan="2"><b>Date:</b></td></tr>
</table>

| | | |
|---|---|---|
| **Test number 3** | Pass Fail | **Requirement:**<br>RS_2.2_3 |
| **Requirement** | | |
| The system should be able to transmit specified sound at specified L/M units. | | |
| **How to test** | | |
| For all 64 assembled L/M units, play some sound and listen for it. | | |
| **How to pass** | | |
| The test is passed if the tester hears any sound. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

<table>
<tr><td><b>Test number 4</b></td><td>Pass Fail</td><td colspan="2"><b>Requirement:</b><br>RS_2.2_3</td></tr>
<tr><td colspan="4"><b>Requirement</b></td></tr>
<tr><td colspan="4">The system should be able to transmit specified sound at specified L/M units.</td></tr>
<tr><td colspan="4"><b>How to test</b></td></tr>
<tr><td colspan="4">For all 64 different L/M units in the assembled system, play some sound and using an external microphone record it.</td></tr>
<tr><td colspan="4"><b>How to pass</b></td></tr>
<tr><td colspan="4">Compare the received signal with the transmitted one. Let N be the number of sent samples, $\mathbf{x}$ be the transmitted signal with variance $\sigma_x^2$ and $\mathbf{y}$ be the received signal. Then the signal-to-noise ratio:<br>$$SNR = \max_{c} \frac{\sigma_x^2}{\frac{1}{N}\sum_{n=1}^{N}(x_n - c \cdot y_n)^2} \qquad (1)$$<br>should be greater than 3 dB.</td></tr>
<tr><td colspan="4"><b>Cause of failure</b></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="2"><b>Test responsible:</b></td><td colspan="2"><b>Signature:</b></td></tr>
<tr><td colspan="2"><b>Date:</b></td><td colspan="2"></td></tr>
</table>

| | | |
|---|---|---|
| **Test number 5** | Pass Fail | **Requirement:**<br>RS_2.2_4 |
| **Requirement** | | |
| The sound's frequency is in the interval 300 - 3000 Hz. | | |
| **How to test** | | |
| Connect an external microphone to an oscilloscope and play sound from each L/M with the frequencies 300 Hz, 600 Hz, 1000 Hz and 3000 Hz. Measure the fundamental frequency in the oscilloscope. | | |
| **How to pass** | | |
| The measured fundamental frequency should be the same as the transmitted one. Less than 0.1% difference is allowed. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 6** | Pass Fail | **Requirement:**<br>RS_2.2_5 |
| **Requirement** | | |
| The system should be able to record signals at specified L/M units. | | |
| **How to test** | | |
| Using an external speaker, play a signal and choose, for each L/M unit to record the signal. | | |
| **How to pass** | | |
| Compare the recieved signal with the transmitted one. Let N be the number of sent samples, $\mathbf{x}$ be the transmitted signal with variance $\sigma_x^2$ and $\mathbf{y}$ be the received signal. Then the signal-to-noise ratio in equation 1 should be greater than 3 dB. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 7** | Pass Fail | **Requirement:**<br>RS_2.2_6 |
| **Requirement** | | |
| The system should be operable in a Windows environment. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 8** | Pass Fail | **Requirement:**<br>RS_2.2_7 |
| **Requirement** | | |
| The system should be able to direct sound so that it is heard loudly at a specified point in space while being much lower around it. | | |
| **How to test** | | |
| Measure the amplitude of the signal with an external microphone and an oscilloscope at different positions in space. | | |
| **How to pass** | | |
| The signal should at least have 10 dB higher amplitude at the chosen terminal than around it. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 9** | Pass Fail | **Requirement:**<br>RS_3.1_8 |
| **Requirement** | | |
| The API should be able to send digital signals to the D/A-converters. | | |
| **How to test** | | |
| Confirm that the functions `transmit_array` and `transmit_terminal` are implemented. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

<table>
<tr><td><b>Test number 10</b></td><td>Pass Fail</td><td><b>Requirement:</b><br>RS_3.1_9</td></tr>
<tr><td colspan="3"><b>Requirement</b></td></tr>
<tr><td colspan="3">The API should be able to receive digital signals from the A/D-converters.</td></tr>
<tr><td colspan="3"><b>How to test</b></td></tr>
<tr><td colspan="3">Confirm that the functions <code>record_array</code> and <code>record_terminal</code> are implemented.</td></tr>
<tr><td colspan="3"><b>How to pass</b></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3"><b>Cause of failure</b></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2"><b>Test responsible:</b></td><td rowspan="2"><b>Signature:</b></td></tr>
<tr><td colspan="2"><b>Date:</b></td></tr>
</table>

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|---|---|---|
| **Test number 11** | Pass Fail | **Requirement:**<br>RS_3.1_10 |
| **Requirement** | | |
| The operation mode of the L/M units (transmit or receive) should change when requested through the API. | | |
| **How to test** | | |
| Confirm that the functions `set_array` and `set_terminal` are implemented. For every L/M unit, switch between the different operation modes of the unit. | | |
| **How to pass** | | |
| The small LED-diode indicating send or receive should change. The diode should light up when in Loudspeaker mode. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 12** | Pass Fail | **Requirement:**<br>RS_3.2_11 |
| **Requirement** | | |
| The system should be built according to the design provided by the customer | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 13** | Pass Fail | **Requirement:**<br>RS_3.3_12 |
| **Requirement** | | |
| The speakers should be able to both send and receive sound and should be individually controllable | | |
| **How to test** | | |
| Confirmed by test 4 and 6. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 14** | Pass Fail | **Requirement:**<br>RS_4_13 |
| **Requirement** | | |
| The software is written in MATLAB | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 15** | Pass Fail | **Requirement:**<br>RS_4.1.1_14 |
| **Requirement** | | |
| Given what L/M units to be used as receivers, the API should return the received signals from these receivers to the Application | | |
| **How to test** | | |
| Preform the same test as in test 6 but control it from the Application. | | |
| **How to pass** | | |
| The same passing requirement as test 6. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 16** | Pass Fail | **Requirement:**<br>RS_4.1.1_15 |
| **Requirement** | | |
| The API should be able to send the requested data from the Application to the desired L/M units | | |
| **How to test** | | |
| Perform the same test as in test 4 but control it from the Application. | | |
| **How to pass** | | |
| The same passing requirement as test 4. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 17** | Pass Fail | **Requirement:**<br>RS_4.2.1_16 |
| **Requirement** | | |
| L/M units in array and at terminal can be chosen in the user interface. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 18** | Pass Fail | **Requirement:**<br>RS_4.2.1_17 |
| **Requirement** | | |
| The user should be able to choose what sound to transmit and which terminals these sounds will be directed to. | | |
| **How to test** | | |
| Confirmed by the user. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 19** | Pass Fail | **Requirement:**<br>RS_4.2.1_18 |
| **Requirement** | | |
| The system shall support two users | | |
| **How to test** | | |
| Run the Application and select two L/M units to be terminals. Play two different songs to the two terminals. Record the received signals. | | |
| **How to pass** | | |
| The signal-to-noise ratio (1) at each terminal should be greater than 1 dB. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 20** | Pass Fail | **Requirement:**<br>RS_4.2.1_19 |
| **Requirement** | | |
| The system shall support more than two users | | |
| **How to test** | | |
| Perform test 19 but select more L/M units as terminals and play as many songs to each terminal. | | |
| **How to pass** | | |
| The signal-to-noise ratio (1) at each terminal should be greater than 0 dB. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 21** | Pass Fail | **Requirement:**<br>RS_4.2.2_20 |
| **Requirement** | | |
| The software shall be able to precode the signals that will be sent to the L/M units such that the sound is heard at the specified L/M unit but not at the other L/M units. | | |
| **How to test** | | |
| Use the application beamform one sound to one of the terminals. Use one other terminal to record sound. | | |
| **How to pass** | | |
| The recorded sound at the target terminal should be at least 14 dB louder than at the other terminal. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 22** | Pass Fail | **Requirement:**<br>RS_4.2.2_21 |
| **Requirement** | | |
| The software shall be able to produce pilot signals for channel estimation | | |
| **How to test** | | |
| Use the application to generate pilots. | | |
| **How to pass** | | |
| The generated software pilots should be orthonormal. The requirement can be proven in software which means that no hardware, except for the computer, is needed to perform this test. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 23** | Pass Fail | **Requirement:**<br>RS_4.2.2_22 |
| **Requirement** | | |
| The software shall perform channel estimation for each path between array L/M unit and terminal L/M unit | | |
| **How to test** | | |
| Confirm that the method `estimate_channel` implements a channel estimation method. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 24** | Pass Fail | **Requirement:**<br>RS_5_23 |
| **Requirement** | | |
| The two sounds should be distinguishable from each other at each user. It should be clear that the two users receive different sounds. | | |
| **How to test** | | |
| Use the Application to play two different sounds. The tester should stand with their ear close to one of the terminals and then move to the other terminal and repeat the process. | | |
| **How to pass** | | |
| If the tester can not distinguish the sounds from each other, the test has failed. | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

<table>
<tr><td>Test number 25</td><td>Pass Fail</td><td>Requirement:<br>RS_5_24</td></tr>
<tr><td colspan="3">Requirement</td></tr>
<tr><td colspan="3">Two songs should be easily recognised and distinguished from each other at each user.</td></tr>
<tr><td colspan="3">How to test</td></tr>
<tr><td colspan="3">Use the Application to play two different songs. The song should be known to the tester. The tester should stand with their ear close to one of the terminals and then move to the other terminal and repeat the process.</td></tr>
<tr><td colspan="3">How to pass</td></tr>
<tr><td colspan="3">If the tester cannot recognise the two songs, the test has failed.</td></tr>
<tr><td colspan="3">Cause of failure</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Test responsible:</td><td rowspan="2">Signature:</td></tr>
<tr><td colspan="2">Date:</td></tr>
</table>

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|---|---|---|
| **Test number 26** | Pass Fail | **Requirement:**<br>RS_6_25 |
| **Requirement** | | |
| The system should be divided into subsystems to support easy upgrades of each. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 27** | Pass Fail | **Requirement:**<br>RS_7_26 |
| **Requirement** | | |
| There are 240 hours per group member for disposal. | | |
| **How to test** | | |
| At the end of the project, check the Time plan document and note each group member's logged hours. | | |
| **How to pass** | | |
| The group has passed if every group member has spent less than 240 hours each. | | |
| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 28** | Pass Fail | **Requirement:**<br>RS_7_27 |
| **Requirement** | | |
| No more than 15 hours of supervision from the supervisor shall be used. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
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| **Cause of failure** | | |
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| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 29** | Pass Fail | **Requirement:**<br>RS_7_28 |
| **Requirement** | | |
| No more than 25 hours of expert consultancy from the customer and the PhD students at the Division of Communication Systems shall be used. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 30** | Pass Fail | **Requirement:**<br>RS_8_29 |
| **Requirement** | | |
| All items in table should be delivered according to dates specified in Table 3 and described in Table 2 from the Requirement Specification [1]. | | |
| **How to test** | | |
| Confirmed by the tester. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 31** | Pass Fail | **Requirement:**<br>RS_10_30 |
| **Requirement** | | |
| The user manual shall be enough to teach a new user how to run the MAB for demonstration. | | |
| **How to test** | | |
| Confirmed by the customer. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 32** | Pass Fail | **Requirement:**<br>RS_10_31 |
| **Requirement** | | |
| The technical documentation shall contain all information needed for a non-project member to continue the development of the MAB. | | |
| **How to test** | | |
| Confirmed by the customer. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

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|---|---|---|
| **Test number 33** | Pass Fail | **Requirement:**<br>RS_10_32 |
| **Requirement** | | |
| The customer shall be given the opportunity of a guided instruction on the MAB. | | |
| **How to test** | | |
| Confirmed by the customer. | | |
| **How to pass** | | |
| | | |
| **Cause of failure** | | |
| | | |
| **Test responsible:** | | **Signature:** |
| **Date:** | | |

# References

[1] K.Gudmundsson et al. (2016). *Requirement Specification v.1.0*