Integrated Agile Verification and Validation of On-board Space Embedded Systems Using Hardware-in-the-loop Design and Simulation Platforms

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Outline

- Motivation
- Methodology
- Architecture of the Simulation
- On-board Computer
- Hardware-in-the-loop Simulation Platform
- Simulation
- Further work
- Publications

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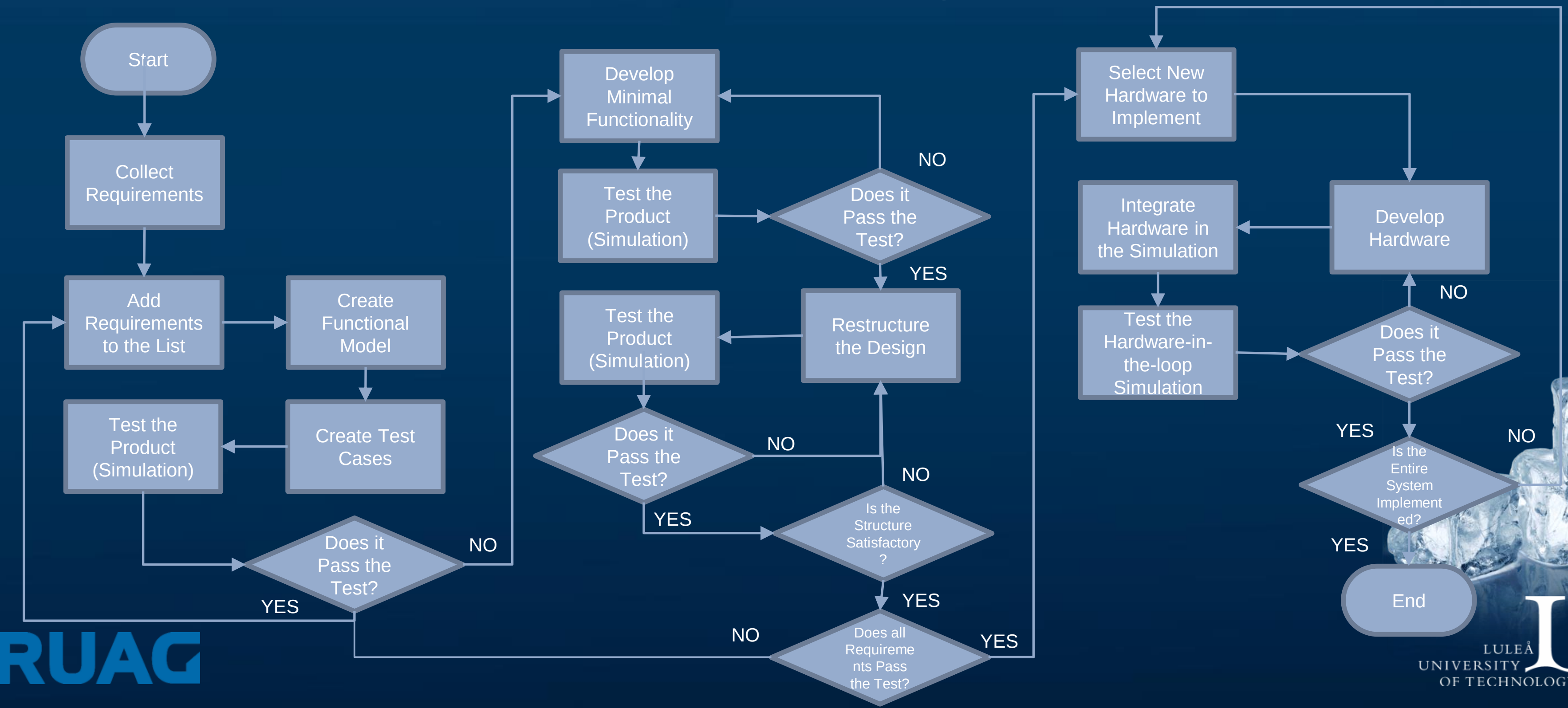
Motivation

- Can the design be combined with the verification and validation to make an efficient development process?
- How can we check the behavior of an on-board computer?
- How can we define automatic tests for hardware development?
- How can we emulate environmental conditions to develop an on-board computer?

Methodology



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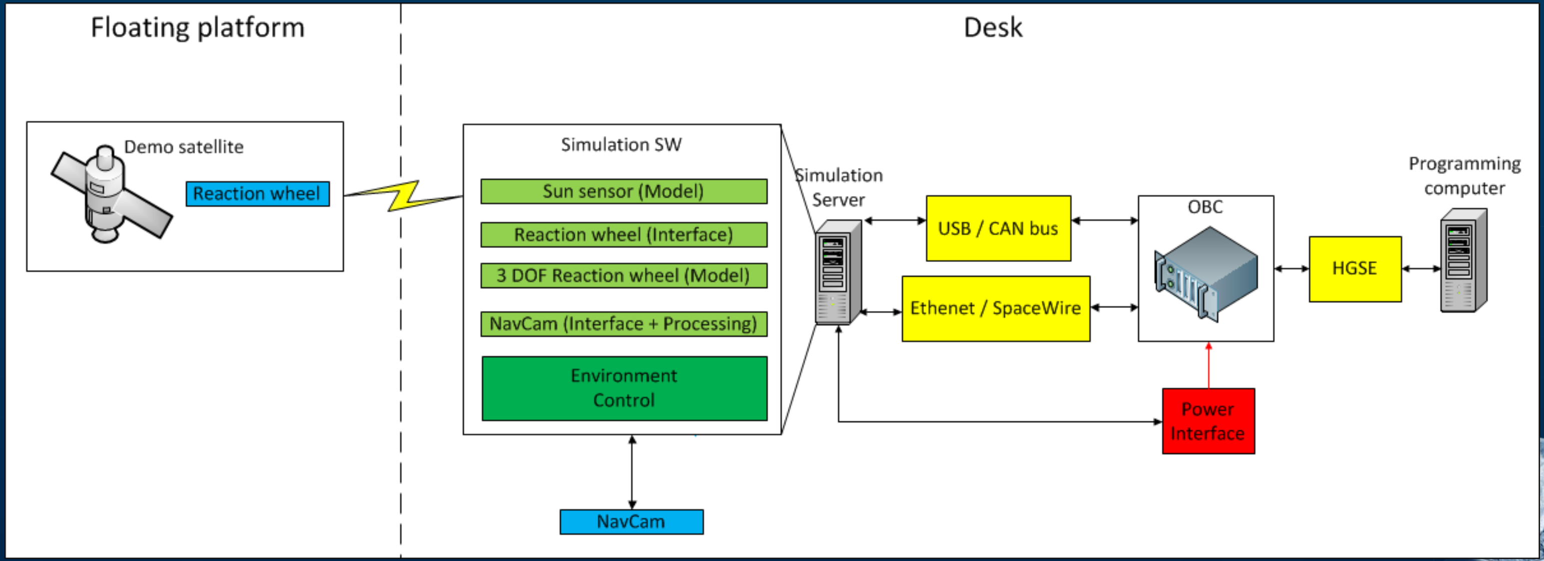
Architecture of the Integrated Design and Simulation Environment



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On-board Computer

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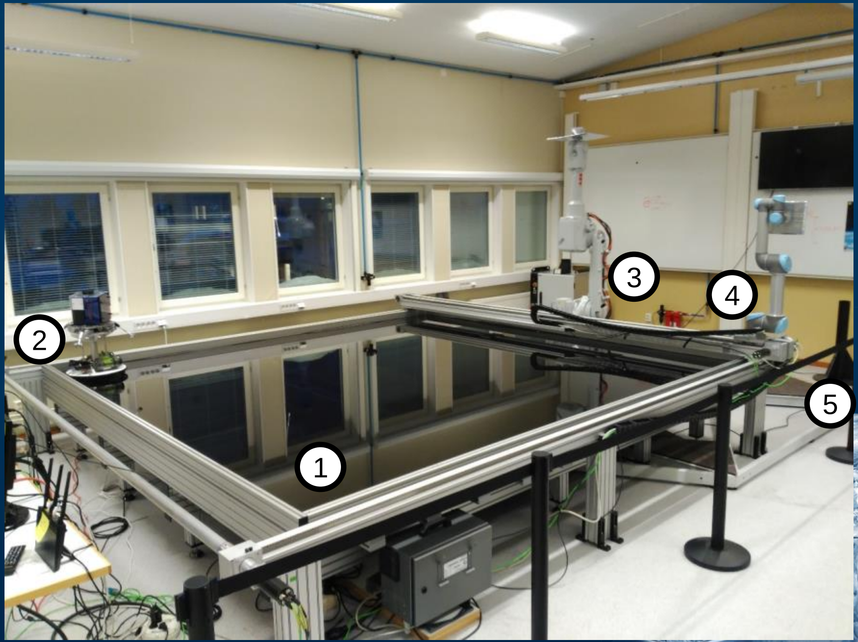
Hardware-in-the-loop Simulation Platform

1. Flat surface
2. Floating-base 5 d.o.f. Air Bearing Stand (Floating platform)
3. Fixed-base 6 d.o.f. Robot Manipulator
4. Free-base 6 d.o.f. Robot Manipulator
5. Static 3 d.o.f. Air Bearing Stand



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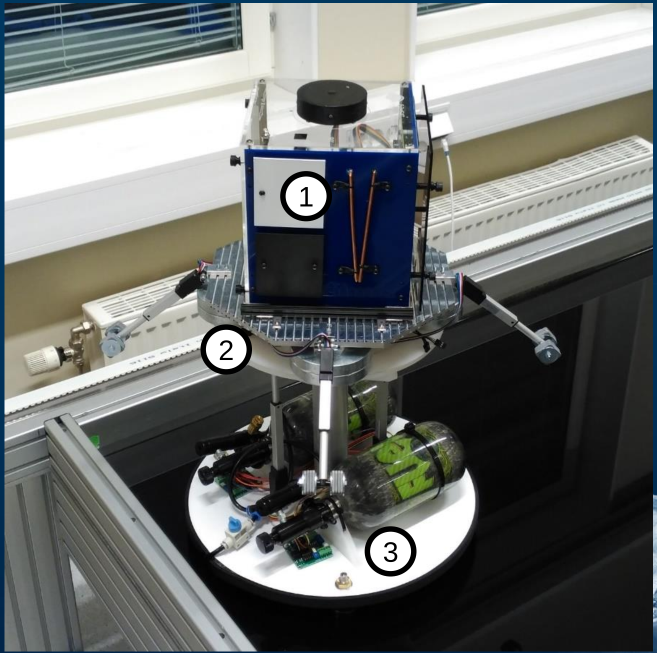
Floating platform

1. Demonstration satellite.
2. Attitude segment.
3. Translation segment.



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Hardware-in-the-loop Simulation Platform

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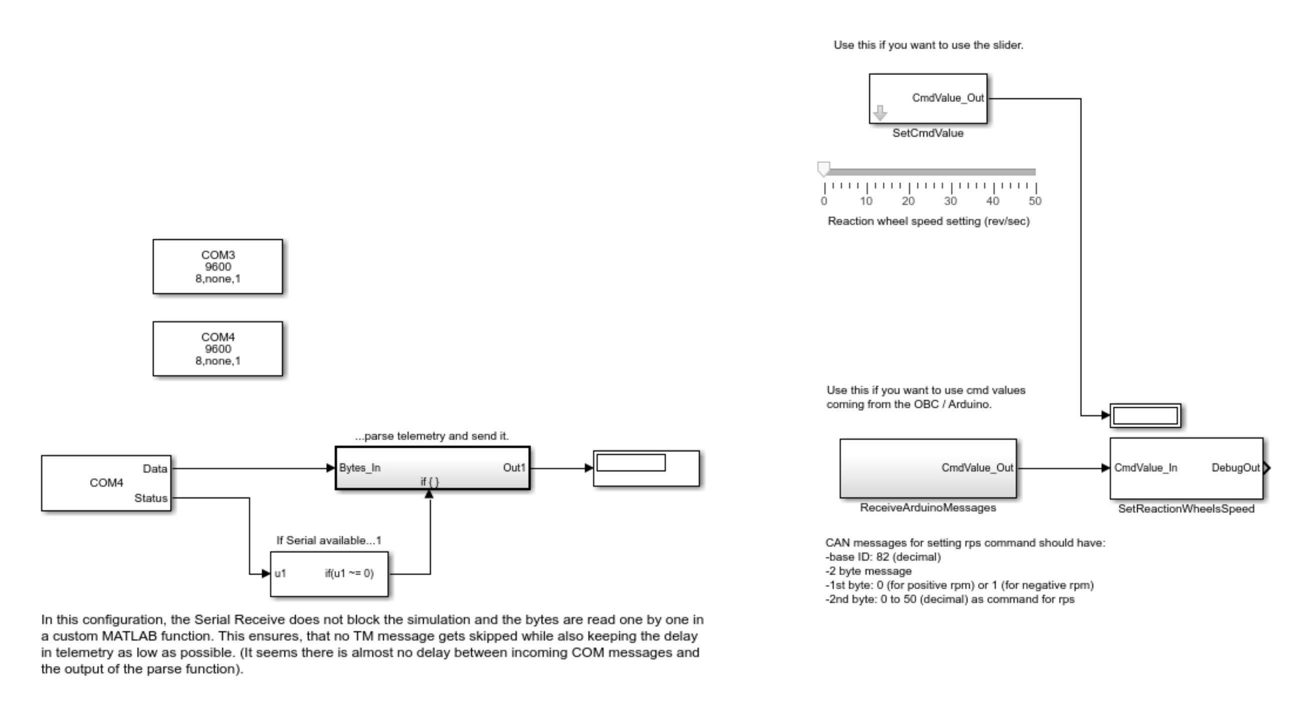
Current simulation



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Current simulation

- The simulation runs in a Matlab/Simulink environment.
- Left side of the model:
  - Telemetry is received from the demo sat through a wireless interface connected via USB and sent to the OBC.
- Right side:
  - Commands are received from the OBC via the CAN bus interface and sent to the demo sat.
  - The demo sat can also be controlled through a slider without the need for OBC to send commands.

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Application Software

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Task 1



Task 3

RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec


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Do you want to send a CAN message (0=no, 1=yes)? (Range 0 - 1) : 1

Use base 11-bit (set to 0) or extended 29-bit CAN identifier (set to 1)? (Range 0 - 1) : 0

Enter base CAN identifier (decimal): (Range 0 - 2047) : 82

How many bytes do you want to send? (Range 0 - 8) : 2

Please enter message byte 1 as decimal value: (Range 0 - 255) : 0

Please enter message byte 2 as decimal value: (Range 0 - 255) : 10
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Application Software

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Please enter message byte 2 as decimal value: (Range 0 - 255) : 10

RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
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RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
    TEST_CHECK OK : "CanTxMsgSize == sizeof (CanTxMsg)" : file "../src/MyCanExampleTasks.c", line 49
Waiting for TxSendList to deactivate...
RX MSG ENTRY [ID=0082]: 0x000a
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
CAN transmission finished.
RX MSG ENTRY [ID=0083]: 0x2b30302e30
The current reaction wheel speed is: 0.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30332e30
The current reaction wheel speed is: 3.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30372e30
The current reaction wheel speed is: 7.0 rev/sec
RX MSG ENTRY [ID=0083]: 0x2b30392e35
The current reaction wheel speed is: 9.5 rev/sec


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Do you want to send a CAN message (0=no, 1=yes)? (Range 0 - 1) :
```

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Further work

- More subsystem models.
- Improve the set-up so that the OBC can be tested in a proper environment.
- Automate the creation of test cases.
- Validate the methodology.

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Publications

- Integrated Design and Simulation Environment for Space-qualified Onboard Computers, SECESA 2018 (27 October 2018)
- Implementation of Hardware-in-the-loop Design and Simulation to Satellite Onboard Computer Systems (In progress)
- Application of Behavior-driven Development to Verification and Validation of Satellite Onboard Computer Systems (In progress)
- Detailed design of nanosatellites using concurrent design methodologies and hardware-in-the-loop platforms (Planned)

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