ADCSS 2014

ARCHITECTURAL TRADE-OFFS: AVIONICS ARCHITECTURE NON-FUNCTIONAL ANALYSIS

Avionics Modelling Language AAML

2014, October 28th

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INTRODUCTION AND OBJECTIVES

INNOVATING SOLUTIONS

INTRODUCTION

- The ESA **AAML (Avionics Architecture Modelling Language)** study aims at advancing the avionics engineering practices towards a model-based approach.
- Consortium led by GMV:
- Project Kick-Off Meeting on February 2013.
- Project Acceptance Review on April 2014.

SCOPE AND BACKGROUND

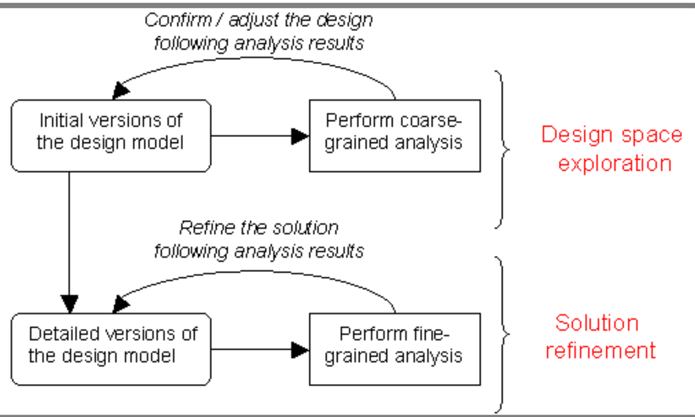
- Defining an avionic architecture for a given project means making several key architecture choices and sizing several performance parameters.
- The selection is usually based on:
  - The architect's expertise and background.
  - Avionics-specific analyses (to perform trade-offs).

Traditional process:

- Each type of analysis is based on a dedicated model.
- Some training is required to be used effectively.

AAML model-based approach:

- Usage of a single architectural model.
- The same input is used to perform different avionics analyses.
- The analyses cover most of the phases of the life-cycle.



PROCESS

INNOVATING SOLUTIONS

MODELLING PROCESS

Avionics Functional Definition

- Used to design the avionics system as a set of high-level functions.
- It answers directly to what the avionics is supposed to do.

Logical Architecture Definition

- Representation of how the system will work so as to fulfil the requirements and expectations of the users.

Physical Architecture Definition

- It represents how the system will be concretely developed and built using real components.

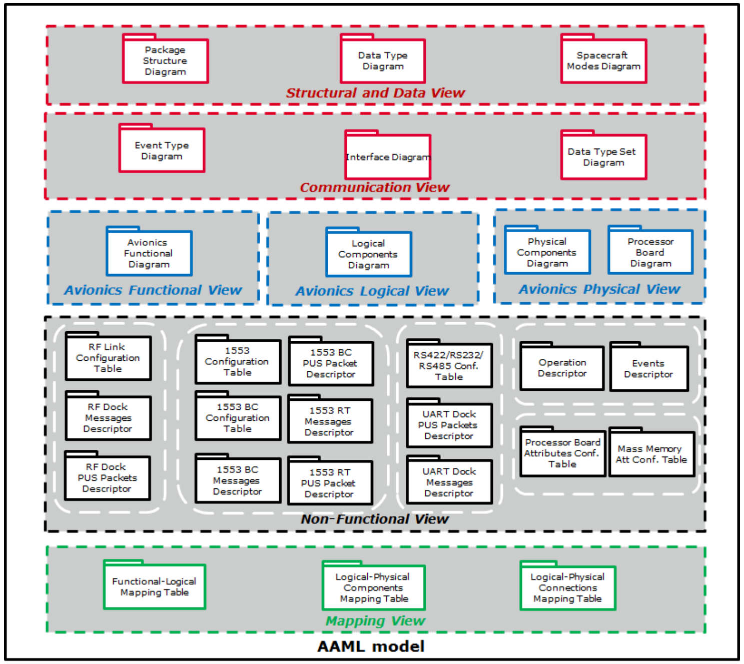
Non-Functional Properties Definition

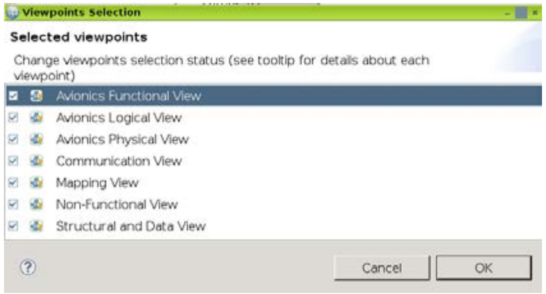
AVIONICS ANALYSIS

- **Satellite mode definition, RAMS, FDIR and autonomy concept**
- **Design consistency and correctness checks**
- **Commandability and Observability**
- **Bus/Network load & latency analysis**
- **Space/ground communication**
- **Avionic resources analysis**
- **On-board functions and performance**
- **Power and mass analysis**

MODELLING LANGUAGE AND PROTOTYPE

- **AAML Modelling Language**.
  - Domain Specific Language.
  - Inspired by the Space Component Model.
- **Prototype**:
  - Demonstrator for a graphical editor (design views) and analyses tools.
  - Technology:
    - Eclipse.
    - Obeo Designer.
  - Capabilities:
    - Management of an AAML model through the graphical editor.
    - Configuration of the avionics analyses from a GUI based on Eclipse wizards.
    - Execution of the avionics analyses.
    - Identification of model inconsistences.





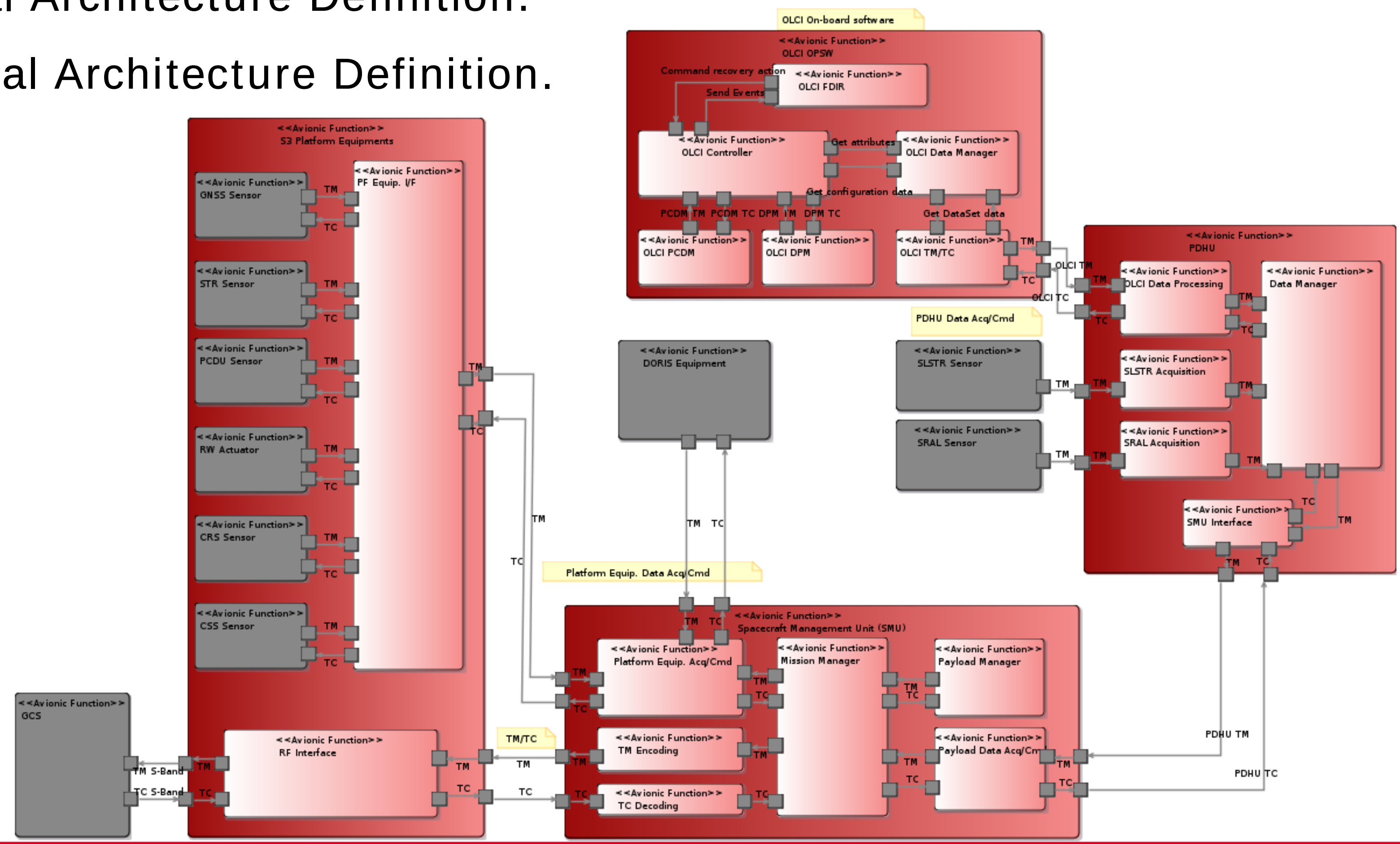
TOOLING: AVIONICS ANALYSES

- **Commandability and observability.**
  - Goal: Size the RF communication system.
  - Metrics: Data throughput, link occupation, link occupation margin.
- **Bus load and data latency.**
  - Goal: Size the MIL-STD-1553B bus and RS-422/RS-232/RS-485 serial links.
  - Metrics: Data latency, message transmission time, bus load, bus margin, bus utilization.
    - MIL-STD-1553B schedulability analysis.
- **On-board functions and performance.**
  - Goal: Analyse the CPU load and memory sizing.
  - CPU Metrics: CPU usage, CPU throughput, CPU usage margin.
  - Memory Metrics: Non-volatile/volatile memory size, non-volatile/volatile memory margins.

USE CASE RESULTS

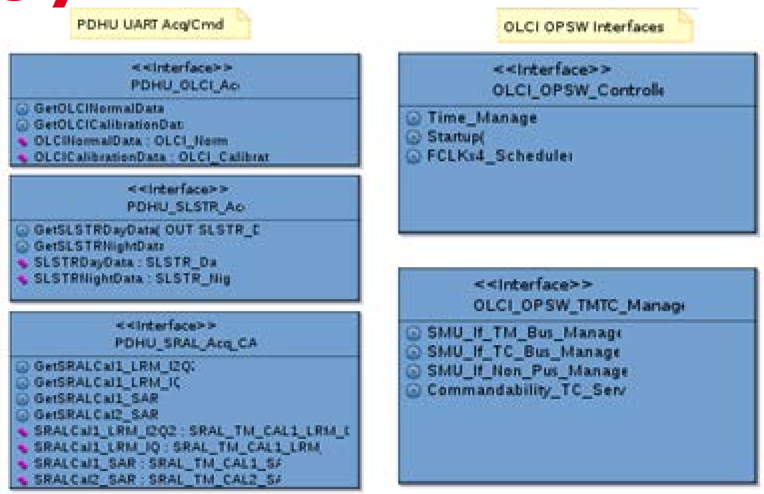
USE CASE – DESIGN (1/3)

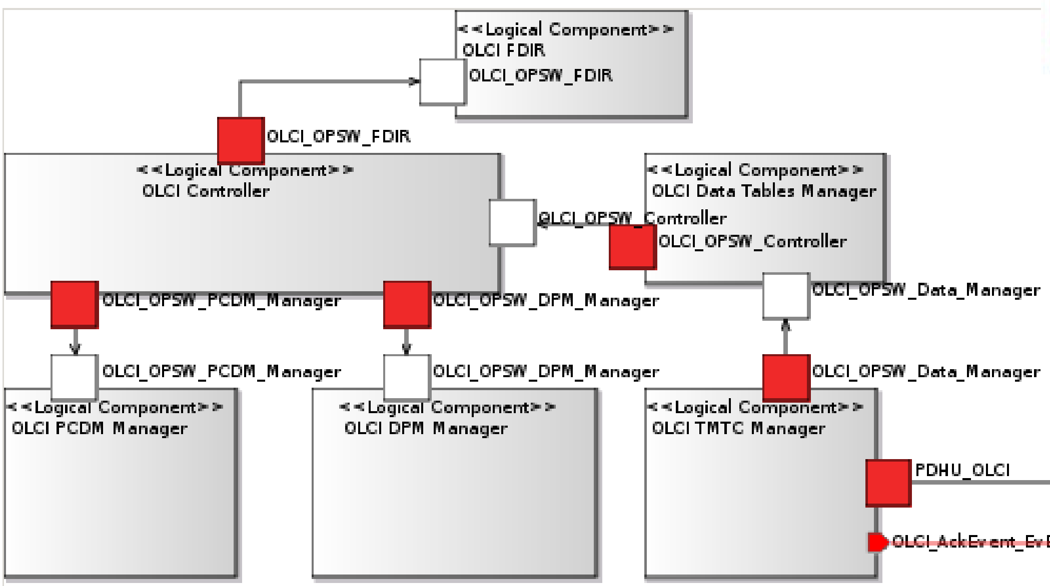
- ❑ Functional Architecture Definition.
- ❑ Logical Architecture Definition.
- ❑ Physical Architecture Definition.



USE CASE – DESIGN (2/3)

- ❑ Functional Architecture Definition.
- ❑ **Logical Architecture Definition.**
- ❑ Physical Architecture Definition.





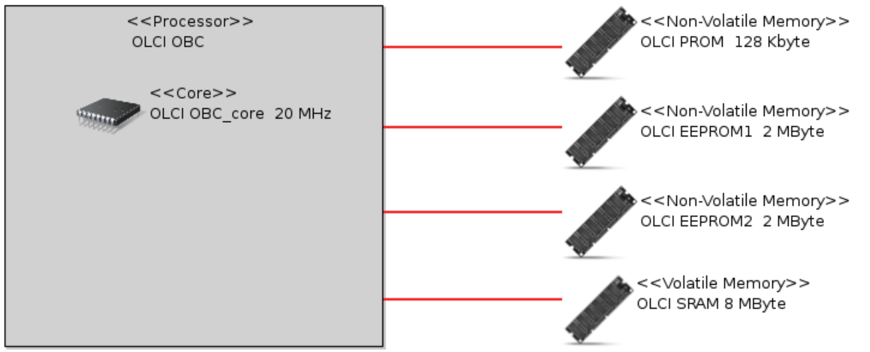
	S/C Mode	Type [S/A]	Freq./MIAT [Hz]
Operation: GetDoppler	Mode Normal	SYNCHRONOUS	1.0
Operation: GetITRFNavigation	Mode Normal	SYNCHRONOUS	1.0
Operation: GetGeodesicalNavigati	Mode Normal	SYNCHRONOUS	1.0
Operation: GetJ2000Navigation	Mode Normal	SYNCHRONOUS	1.0
Operation: GetDatation	Mode Normal	SYNCHRONOUS	1.0
Operation: GetRoutine	Mode Normal	SYNCHRONOUS	1.0
Operation: GetAnomaly	Mode Normal	SYNCHRONOUS	1.0
Operation: Polling	Mode Normal	SYNCHRONOUS	4.0

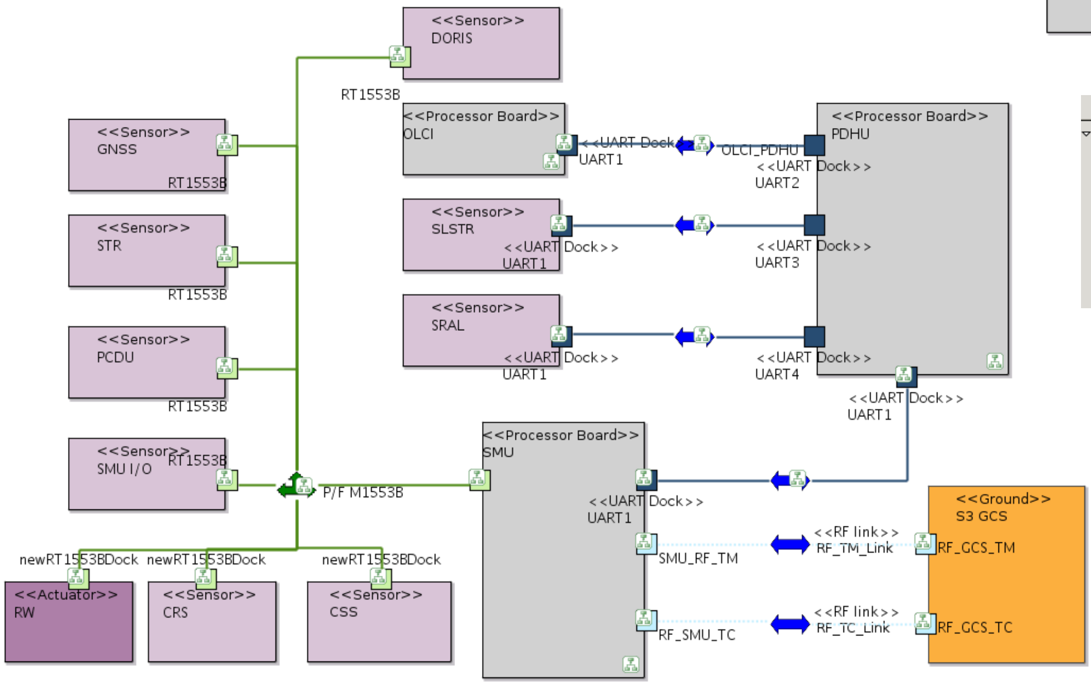
Avionic Function S3 Platform Equipments	Logical Component SMU Processor Module
Avionic Function PF TTC RF	
Avionic Function PF 1553 I/F	Logical Component SMU P/F 1553
Avionic Function GNSS Sensor	Logical Component GNSS Device
Avionic Function STR Sensor	Logical Component STR Device, Logical Component SLSTR Device
Avionic Function PCDU Sensor	Logical Component PCDU Device
Avionic Function RW Actuator	Logical Component RW Device
Avionic Function CRS Sensor	Logical Component CRS Device
Avionic Function CSS Sensor	Logical Component CSS Device
Avionic Function GCS	Logical Component GCS TM, Logical Component GCS TC
Avionic Function DORIS Equipment	Logical Component DORIS Device

USE CASE – DESIGN (3 / 3)

- ❑ Functional Architecture Definition.
- ❑ Logical Architecture Definition.
- ❑ Physical Architecture Definition.

PDHU-SRAL RS232/RS422/RS485 Config



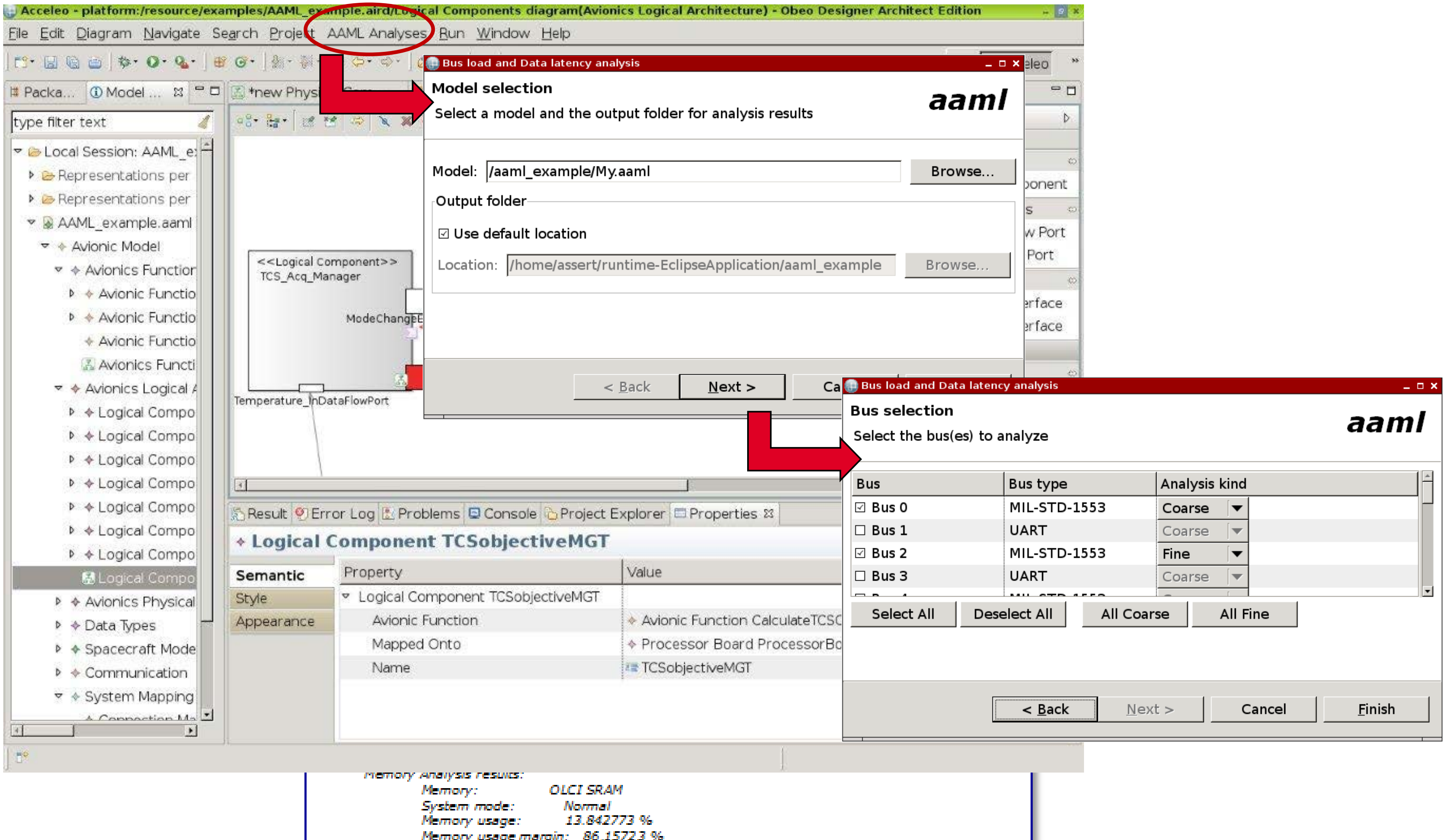


	S/C Mode	Type [S/A]	Freq./MIAT [Hz]	Packet Standard
UART Dock: UART1				
Operation: GetOLCINormalData	Mode Normal	SYNCHRONOUS	22.7272	
Packet Standard				PUS
Operation: GetOLCICalibrationData	Mode Normal	SYNCHRONOUS	22.7272	
Packet Standard				PUS
Event: AckEvent	Mode Normal	ASYNCHRONOUS	22.727274	
Packet Standard				PUS

- Instructions Per Line Of Code (only required for FINE analysis): 5
- Volatile Memory OLCI SRAM
  - Data Size: 8 MByte
- Non Volatile Memory OLCI PROM

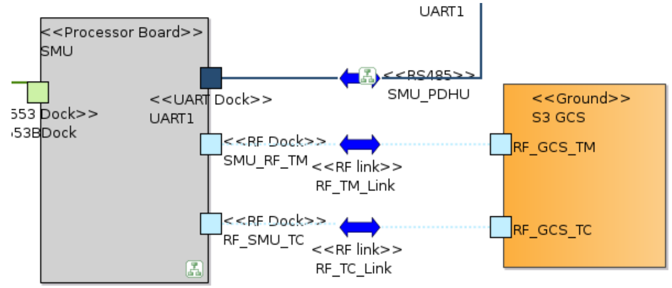
	Service Type	Sub-Service Type	Data Field [Byte]	Overhead [Byte]	Nº Packets
UART Dock: UART1					
Operation: GetOLCINormalData					
PUS Descriptor	1	1	33582.0	20.0	
Number Packets					5
Operation: GetOLCICalibrationData					
PUS Descriptor	1	1	35490.0	20.0	
Number Packets					10
Event: AckEvent					
PUS Descriptor	1	1	2.0	20.0	
Number Packets					1

USE CASE – ANALYSES



C&O AND BUS LOAD RESULTS

❑ Commandability and observability.



- TM link at very low level of occupation (1.3-2.6%).
- TC links:
  - Assumption of visibility window of 10 min.
  - TC upload of SRAL binary: 7974 bps, 55.1% of occupation.
  - TC upload of CSW binary: 20796 bps, 143.7% of occupation.

❑ Bus load: 1553B.

- Scheduling: Major frame of 1000 ms and a minor frame of 125 ms.
- Fine-grained analysis computes a bus load of 14%.

❑ Bus load: UART.

- Fine-grained analysis detects that SRAL-PDHU data exchange exceeds bus capability (due to calibration messages).

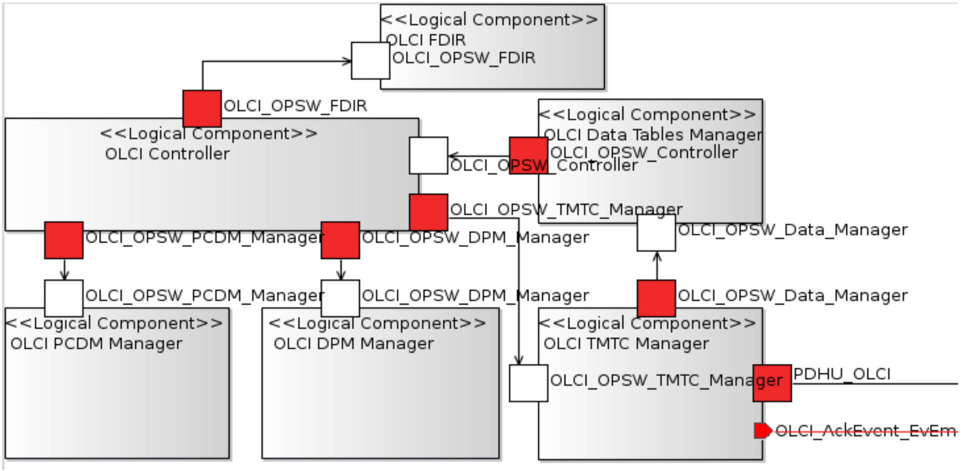
Bus 'SRAL_PDHU'
Mode 'Normal':
Bus load: 118.250046 %
Bus system load: 119.00389 %
Data throughput: 59125020 bps

- After introduction of calibration mode the bus load is reduced to 55.4% (normal) and 62.8% (calibration).

ON-BOARD FUNCTIONS AND PERFORMANCE RESULTS

❑ On-board functions and performance.

- Firstly, only one EEPROM is used.
- The fined-grained analysis detects:
  - o Computation of CPU load of OLCI OPSW: **51.6%**.
  - o SRAM occupation of **35.7%** (below 50%).
  - o High EEPROM1 occupation: **124.4%**.
- Reallocation of DPM, PCDM, FDIR, PDHU PL and SMU logical components over EEPROM2:
  - o EEPROM1 occupation: **67.3%**.
  - o EEPROM2 occupation: **56.9%**.



CONCLUSIONS AND FUTURE WORK

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CONCLUSIONS AND FUTURE WORK

- AAML study has provided:
  - **Identification and evaluation of the avionics analyses**.
  - **AAML modelling language**:
    - The AAML entities are **precise and practical** enough for capturing the avionics architecture and to be used as input for specialized avionics analysis.
    - It supports the possibility of both **coarse- and fine-grained specification** by means of the non-functional properties defined.
  - **AAML toolset**:
    - It allows the **design and analysis** of the avionics system through the different development phases.
- Future work activities in the modelling language and the toolset have been identified. Some examples:

Future Work	Priority
Extend the meta-model and toolset to support additional avionic analyses	MEDIUM
Improve the analysis reports output format	MEDIUM
Develop and independent model consistency validator	HIGH
Include hierarchy levels	MEDIUM

Thank you!

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