OHB-SYSTEM VIEWS ON AVIONICS FUNCTIONAL VERIFICATION

ADCSS 2022 16TH ESA WORKSHOP ON AVIONICS, DATA, CONTROL & SW SYSTEMS

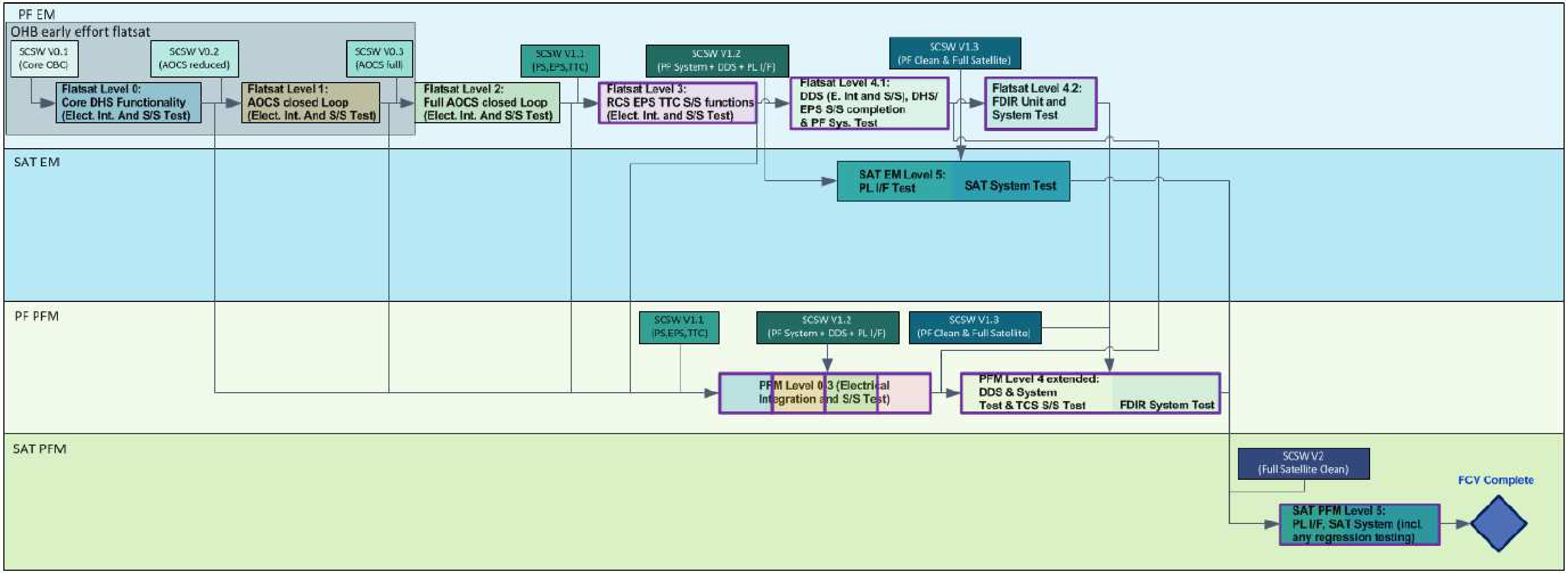
OHB-SYSTEM VIEWS ON AVIONICS FUNCTIONAL VERIFICATION

CONTENTS

OHB-SYSTEM VIEWS ON AVIONICS FUNCTIONAL VERIFICATION

CURRENT PROCESS - AVIONICS VERIFICATION FLOW

- OHB Typical Avionics Verification Flow



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CURRENT PROCESS - AVIONICS VERIFICATION FLOW

- Typical Avionics Verification Flow vs. ECSS-E-HB-10-03A
  - Same principle but outlined in an sequential form to cover all subsystem verifications
  - CSW verification realized in an staggered approach
  - Exploitation of the different models (EM; PF; SAT level) illustrated

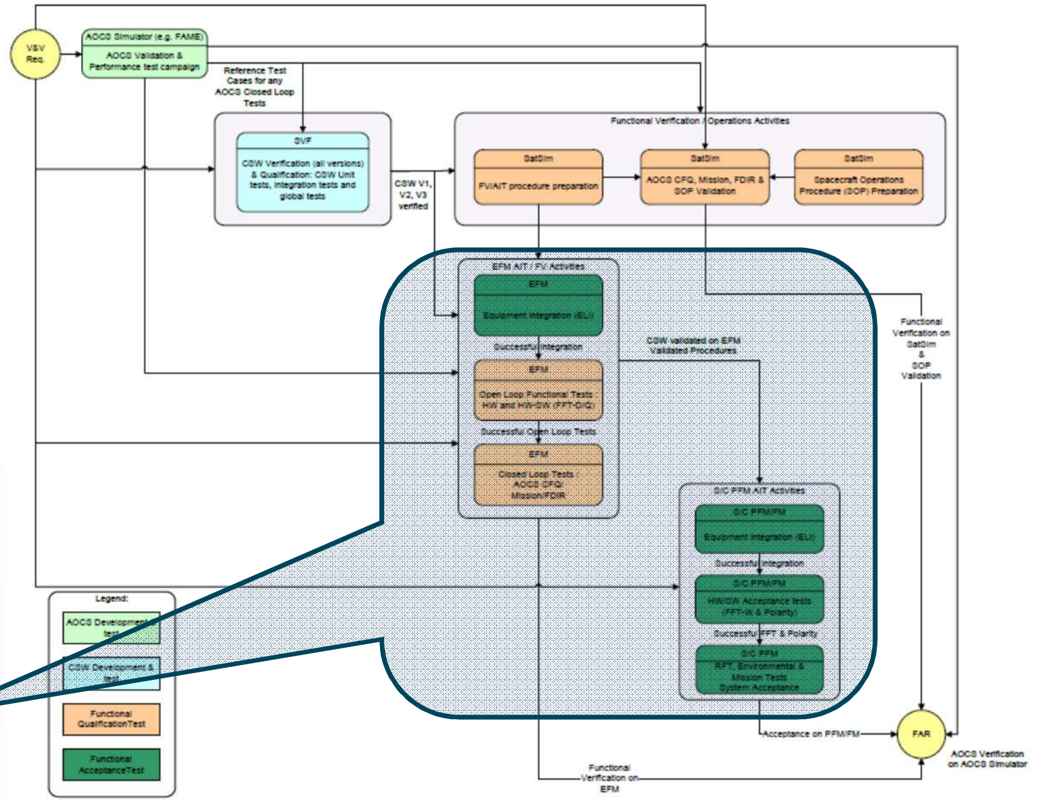
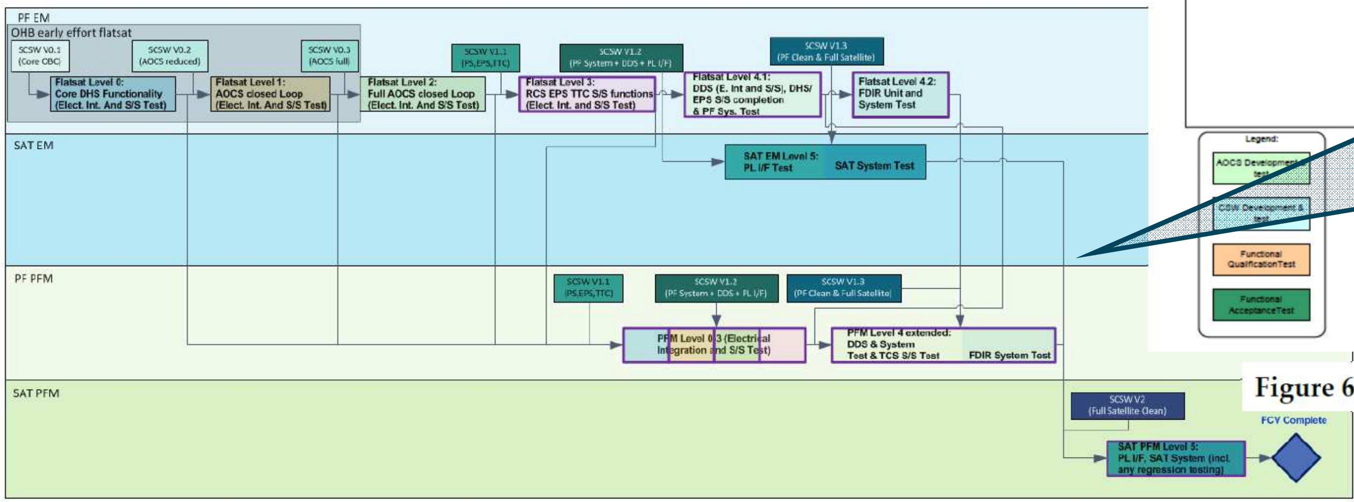


Figure 6-2: Typical sequence of tests for element level functional verification



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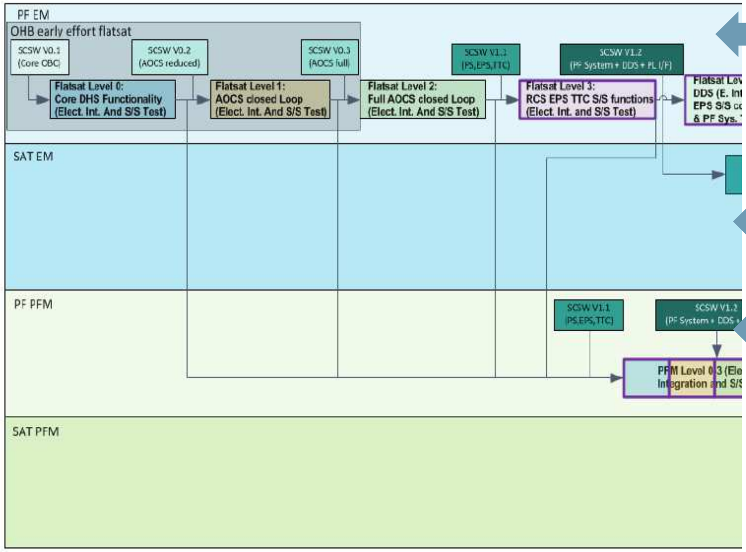
CURRENT PROCESS - AVIONICS VERIFICATION FLOW

- Mapping of Models



Model Category	Test Bench Name	Test Bench Main Purpose	Bench Technology
Virtual Model	**AOCS Simulator (e.g. FAME)** Functional AOCS Modelling & Simulation Environment	• To support the development, verify and validate AOCS algorithms and performance, allowing closed loop simulations with either an image of the AOCS flight S/W application or single modules of the AOCS flight S/W in the loop.	Numerical Bench (Virtual Model)
	SVF Software Validation Facility	• To support the SW development, verify and validate on-board SW.	Numerical Bench (Virtual Model)
	SatSim Satellite Simulator	The SatSim allows to verify essential parts of the SW requirements (SW-SW integration tests & global tests) in an open and/or closed loop set-up, based on a simulated on-board time reference.	Numerical Bench (Virtual Model)
Electrical Functional Model	**EFM** Electrical/Functional Model bench	EFM use case: • To validate the HW/HW and verify the HW/SW compatibility through open and/or closed loop tests • To verify main mission requirements : proof of design • To prepare the (P)FM verification and AIT campaign, including the (operational) validation of EGSE.	Hybrid Bench
(Proto) Flight Models	**PFM/FM** (Proto-) Flight Model bench	• The flight configuration, in the end a 100% hardware configuration • Proof of workmanship (acceptance) • System validation activities • In Orbit Testing	HW bench

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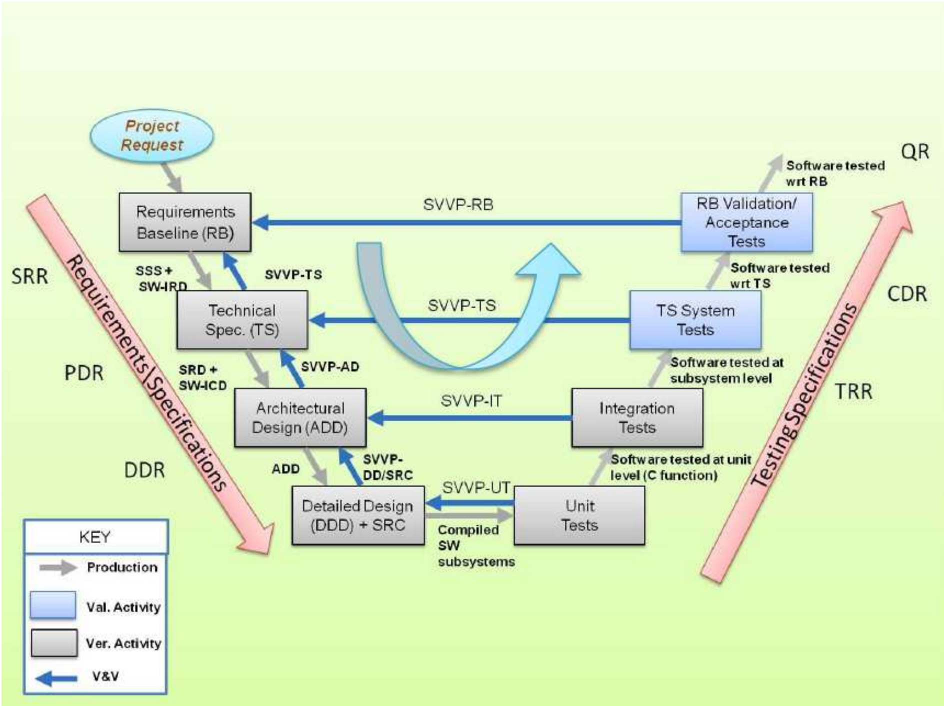
CURRENT PROCESS - SW

- Typical SW Verification Flow
  - SSS/SRS breakdown >> **Good compromise to be defined in the level of details of the SSS.**
  - Synergies between System test & RB validation need to be exploited >> **Requires optimization of requirements**.



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CURRENT PROCESS – SOFTWARE VALIDATION FACILITY (SVF)

ECSS

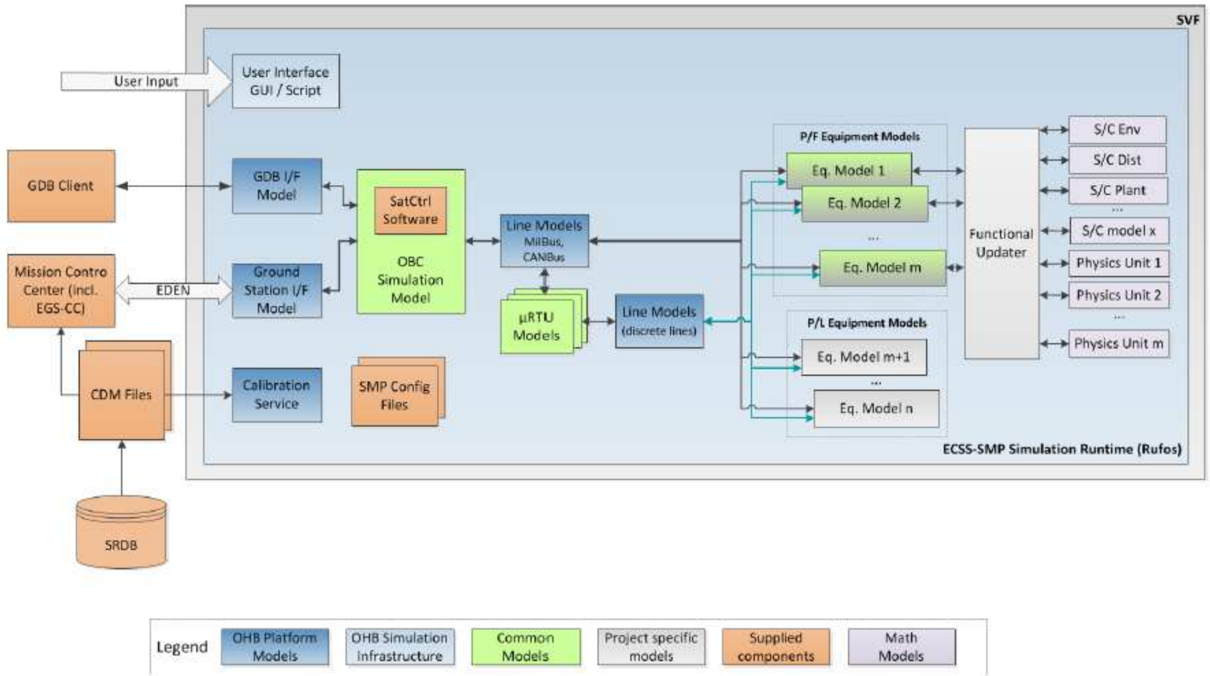
ECSS-E-HB-10-03A
31 May 2022

The S/W verification (against its specification) tests, performed on the SVF (Software Validation Facility). The SVF allows verifying essential parts of the SW requirements (SW-SW integration tests & global tests) in an open or closed loop set-up, based on a simulated on-board time reference.

- Early availability as development platform and (regression-) test bench is crucial
- Model re-use between programs enabled by ECSS-SMP Standard
- OHB's ECSS-SMP Simulation Environment: Rufos
- Projects profit from a library of shared Common Models and

  simulator infrastructure
- Further improvements for model interoperability ongoing

  - on ESA/European level: RATIO-SIM Initiative and ECSS-SMP Evolution



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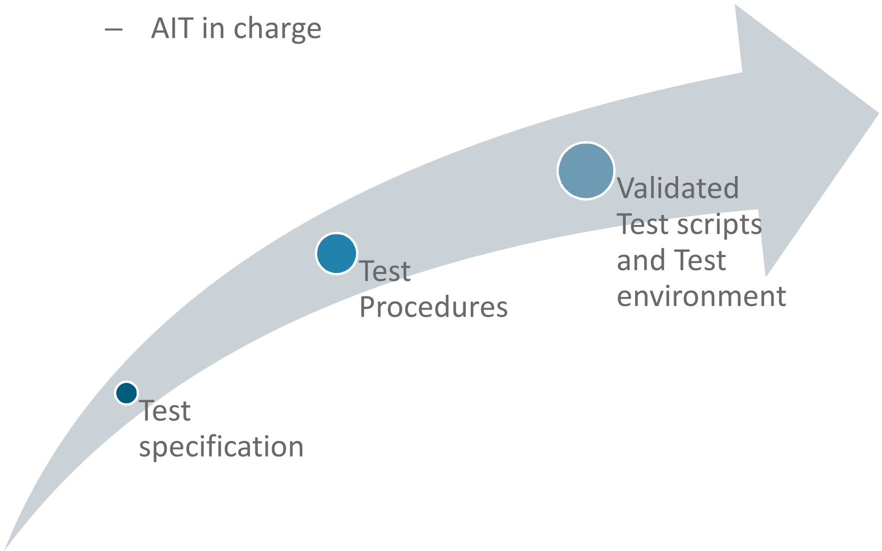
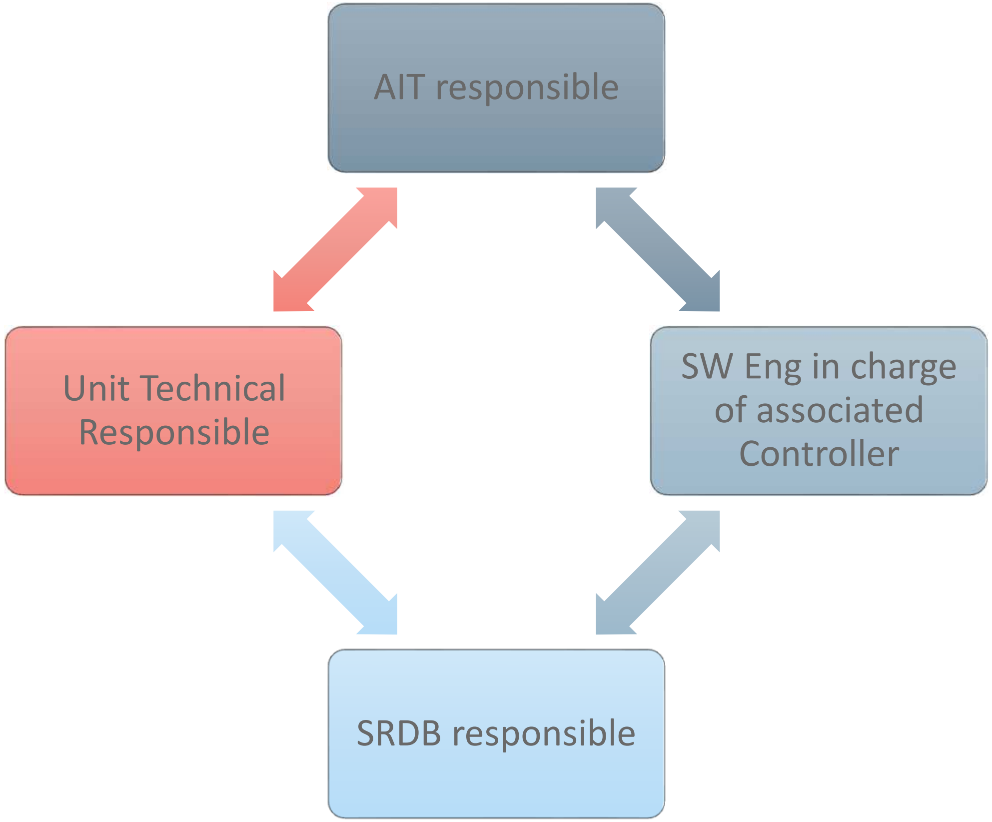
CURRENT PROCESS - INTEGRATED TEST TEAM CONCEPT

- Test design, preparation, validation and execution is an Iterative process, involving:
  - Subsystem Responsible
  - Unit responsible
  - SW controller responsible
  - SRDB responsible
  - AIT in charge





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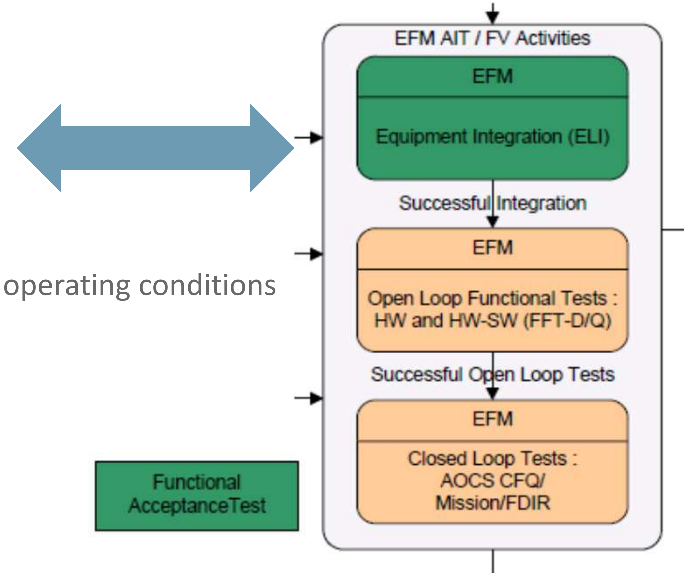
LESSONS LEARNED (1/3) – VERIFICATION MODELS

- EM fidelity is Key, allowing:
  - Early SW development Activities
  - Validation of Test sequences
  - Close out (to a certain extent) of Requirements and function verifications.
- Early Integration, Unit test and FAI activities allow for Early verification of certain functions/requirements.
- Automatic sequences: tests must be carefully designed to cover possible anomalies in the chain.
- SW Controllers (with intensive command and control) must be tested in 'flight-like' (against the REAL HW) operating conditions



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LESSONS LEARNED (2/3) – SW & FDIR

- **Requirements completeness & stability is essential to allow validation in parallel to the development**
- Identify need for **support SW services** to allow testability:
  - Patch TM Service
  - Override protections
- **Memory content verification** is Key for certain Avionics tests along the entire AIT until Launch.
- **FDIR Verification**
  - SYS FMECA / Requirement analysis is required to start with
  - Apply common FDIR approach / Reuse concept
  - SVF potential for FDIR verification (when SW-HW interactions less critical)
  - EM Fidelity! Missing HW redundancy on the EM requires a lot of FDIR verification on the (at that stage very used) FMs >> Trade off!

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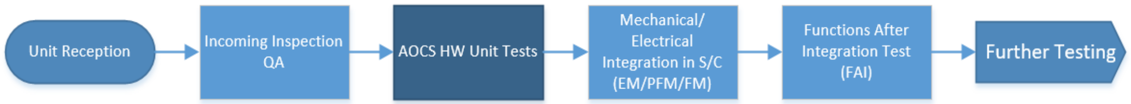
LESSONS LEARNED (3/3) – AOCS/GNC



- **AOCS/GNC Verification LL**
  - **Standalone unit test** before integration:
    - These test have been proven successful at identifying unit issues at early stages, minimising schedule impact.
    - The effectiveness of these tests depends on the type of unit.
    - The process is being optimised to execute the test only for the units for which the benefits are higher.
  - EM Fidelity very important -> The use of **HW emulators** is preferred when the real unit not available
  - The assessment of performance representativity of HW closed loop test is to be treated carefully due to:
    - Influence of additional stimulation/emulation delays
    - GSE limitations
  - The early check of AOCS/GNC SCOE interface compatibility is highly beneficial. SCOE Integration Test was introduced to check these chains:
    - To check AOCS SCOE stimulation → AOCS sensor → Data Acquisition → SCSW sensor readout
    - SCSW actuator command → AOCS actuator → Command Transmission → AOCS SCOE actuator readout
  - E2E polarity test crucial for avoiding catastrophic in-orbit scenarios.
    - The test of safe modes should be the main target. Exercising experimental or advanced modes may not be needed.
  - Testing the S/C with longer test > 24h can highlight issues which could go unnoticed with shorter tests.

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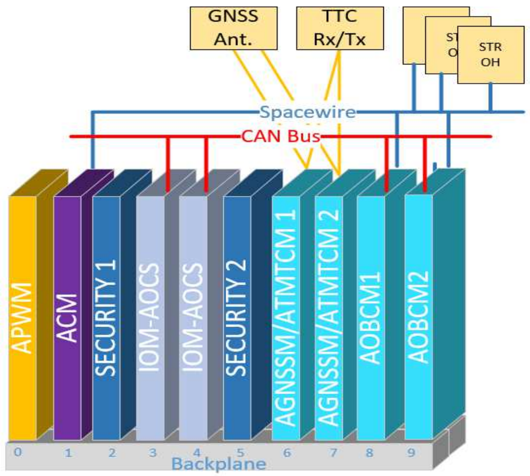
PERSPECTIVES – ADHA

- ADHA targets a standardized architecture, as well as an ecosystem of compatible modules that are mutually interchangeable and interoperable between different missions and Large Scale Integrators (LSI).
- ADHA opens the doors for diverse procurement and integration approaches that can lead to 'non-classical' Unit acceptance & Functional chain Verifications, e.g:
  - STR SW and GNSS receiver potentially within the OBC rack
  - Late Module Integrations at SC level
  - Early Functional Chain verification before integration of a complete ADHA Rack



ADHA Unit for OBC application

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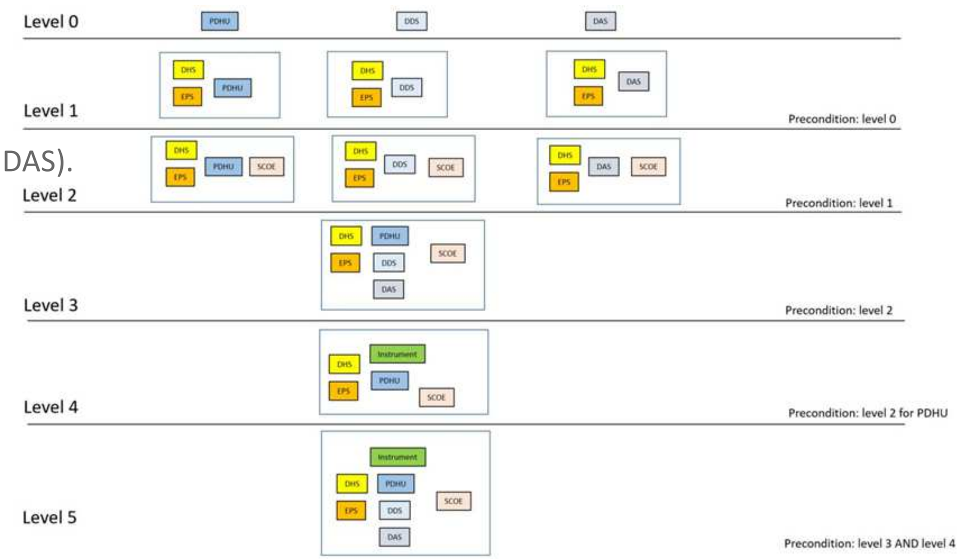
PERSPECTIVES – PAYLOAD DATA HANDLING & TRANSMISSION (PDHT) CHAIN (1/2)

- The Payload Data Handling & Transmission Chain is composed by following Equipment (or Unit):
  - A Payload Data Handling Unit (PDHU), that may include a Mass Memory for Data Storage (for the Missions not having continuous connectivity to the Ground), in addition to the capability to multiplex input, prioritize data in output, generate CADUs.
  - A Data Downlink Subsystem (DDS), aggregation of Modulators, TWTs, RF Filters, Radio Frequency Distribution Network (RFDN)
  - A Downlink Antenna Subsystem (DAS), that may include the Electronics and the Mechanism for the Deployment and, in case, for the Pointing of the Antenna.
- the Functional chain verification of the PDHT includes the following incremental steps:
  - Level 0: Test at Unit level of PDHU, DDS, DAS
  - Level 1: Separate Integration of each Equipment (PDHU, DDS, DAS) in the PF
  - Level 2: Separate Functional and Performance Test on each Equipment (PDHU, DDS, DAS).
  - Level 3: Test of the full PDHT chain.
  - Level 4: Test of the Instrument – PDHU Integration.
  - Level 5: End to End Test of the Instrument – PDHT Chain.



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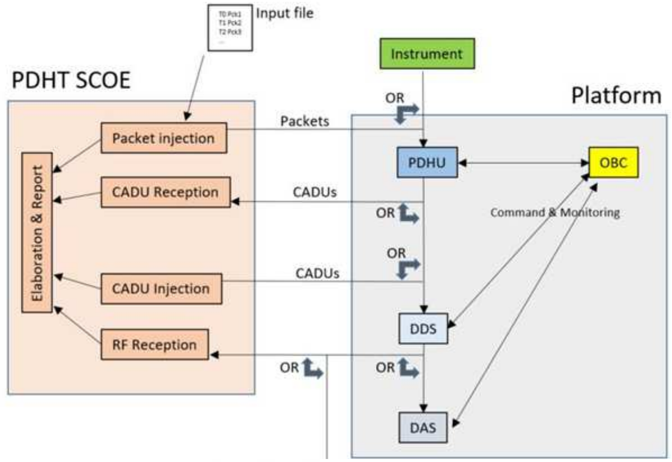
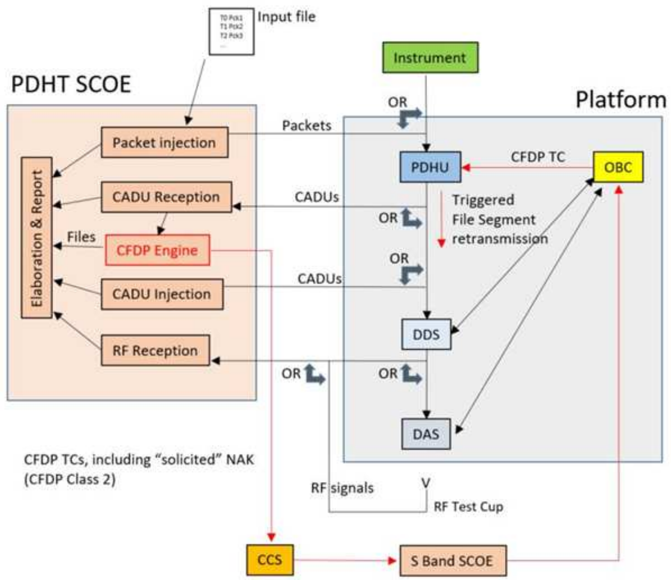
PERSPECTIVES – PAYLOAD DATA HANDLING & TRANSMISSION (PDHT) CHAIN (2/2)

- Level 5: Test of the Instrument – PDHT Chain.
  - The Instrument is injecting data as in level 4, but the SCOE is collecting data at the DAS output.



- CFDP Use Case
  - Requires presence of 'Return channel' (via the TC/TM Band link)
  - SCOE shall have the capability to
    - command the PDHU, in order to trigger the retransmission of the data by the PDHU
    - Simulate a link disruption
    - Include a CFDP Engine



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PERSPECTIVES – SW VERIFICATION

- Challenge to develop SVF for new processors:
  - change in architectures, e.g. ARM with a fragmented processor landscape (many architecture variations, many vendors with different proprietary solutions also for simulation)
  - increase in performance of processors poses a challenge for standard processor emulation technology, especially for (faster-than-) real-time simulation
  - possible solutions include for example the integration of virtualization technology in SVF/TOMS simulators, or the increased use of development boards/EMs, including hybrid setups
- More powerful processors enable the implementation of more functionality in software, and the execution of more (functionally independent or loosely coupled) modules on the same processor:
  - increases importance of low-level modularization and separation of concerns (e.g. hypervisor technology), especially for independent validation and testing
- Important to consider verification concerns in the entire lifecycle: use of (software development) tools that integrate verification tasks in the development workflow will become even more important (e.g. test designs linked to MBSE tools)
- Large constellations demand revision of ‘Classical’ FDIR implementations
  - AI enhanced concepts for Increased Autonomy & Collision avoidance
  - Equipment COTS based lower cost designs require OBSW FDIR to take over certain failure detection & reconfigurations

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PERSPECTIVES – AOCS/GNC

- Advanced testing at avionics level of demanding GNC systems, e.g.:entry, descent and landing and vision-based navigation/rendezvous:
  - Field testing with drones, helicopter platforms or robotic arms and artificial terrain used for (mainly) open loop verification of navigation functions
  - New challenges in terms of including EDL sensors (such as altimeter, LIDAR, cameras) in the closed loop testing:
    - Stimulation (e.g. optical for cameras, RF for altimeter) for closed loop testing preferred if feasible in terms of signal delays and development effort
    - Electrical stimulation or emulation for closed loop testing also possible e.g. for LIDAR
- Large constellations demand specific time-optimized V&V approach:
  - Closed loop testing on all models not practical -> fast and thorough open loop testing envisaged.

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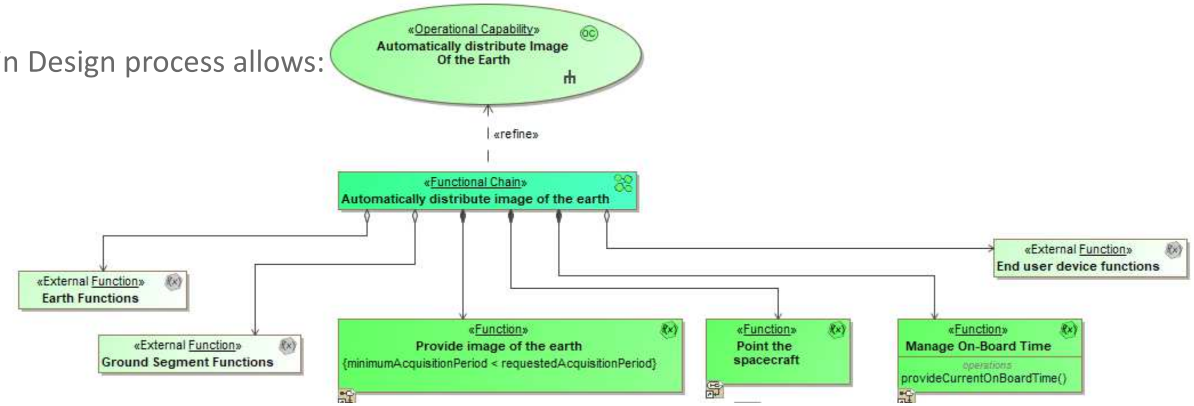
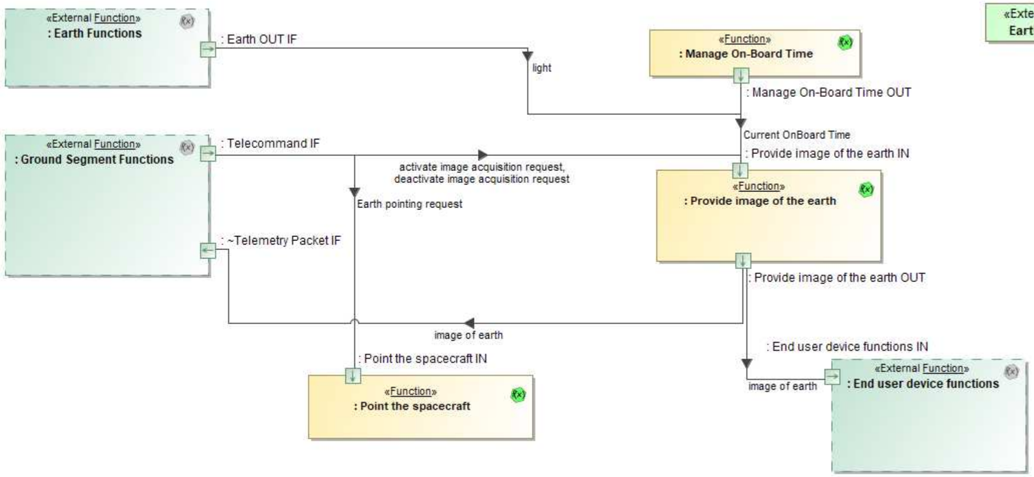
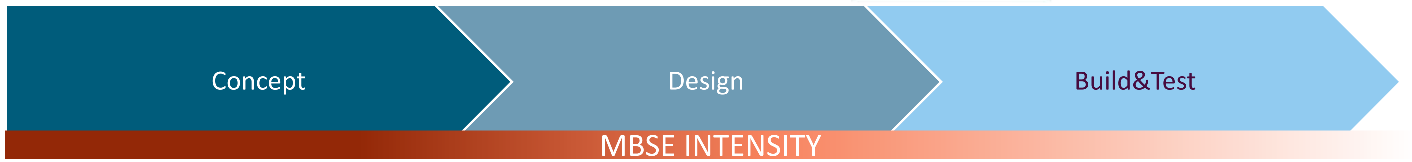
PERSPECTIVES – MBSE

- Definition of Functional Chains & Functional Interactions in the MBSE in Design process allows:
  - Optimal and Consistent Test design linked to MBSE
  - Preventing Verification gaps







Aim to Eliminate Losses

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QUESTIONS

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