IRIDIUM NEXT
Simulators & EGSE

16/10/2012

Ref.: BANT-TAS-PA-39409

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ThalesAlenia Space
A Thales / Finmeccanica Company

83230919-DOC-TAS-EN-001

Introduction

- The purpose of Simulators and EGSE for IRIDIUM-Next program is to support the following activities:
  - Platform software (PFSW) validation and debugging through Software Test Bench (STB),
  - Avionics validation preparation through e-ATB,
  - Avionics validation and debugging through Avionics Test Bench (ATB),
  - AIT preparation through AIT simulator (SIM-AIT),
  - Payload AIT through EMO AIT bench (SIM-EFM),
  - Power AIT through Power Test bench (SIM-EFM),
  - Satellite operations preparation through Dynamics Satellite Simulator (DSS).

- Before IRIDIUM, these facilities were based on THALES building blocks: simulation core K2 and check-out system OCOE-6.

- For all IRIDIUM simulators and EGSE the main objectives are to have:
  - same hardware target : HP DL server,
  - same operating system target : Linux Real-time Redhat 6 MRG 2,
  - same software core : K2,
  - same check-out system : OCOE-6,
  - same satellite models.

Simulators and EGSE for IRIDIUM-Next program are based on THALES building blocks

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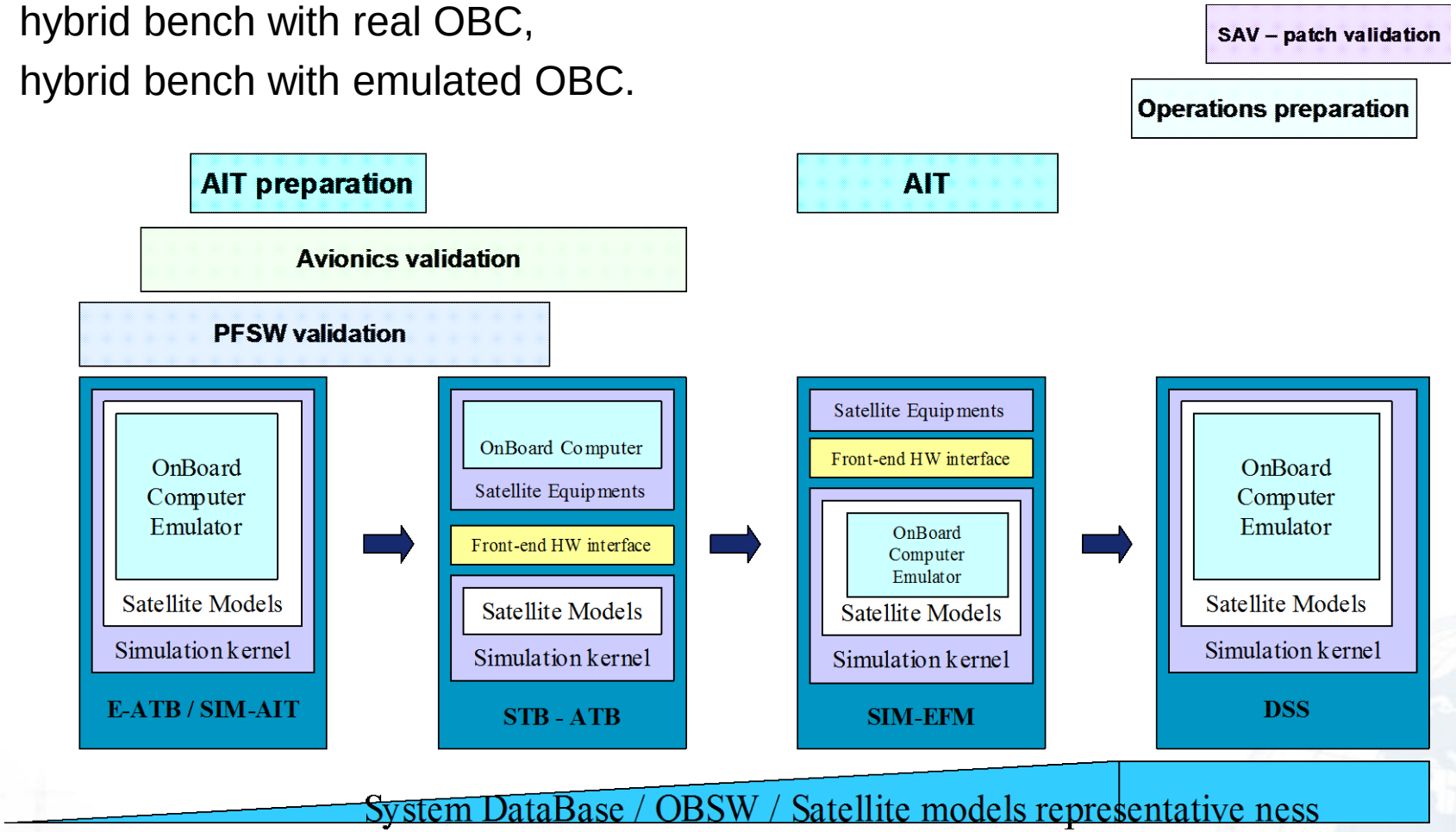
Introduction

- These facilities can be divided in 3 families :
  - numerical bench,
  - hybrid bench with real OBC,
  - hybrid bench with emulated OBC.



Simulators and EGSE for IRIDIUM-Next program follow an incremental process

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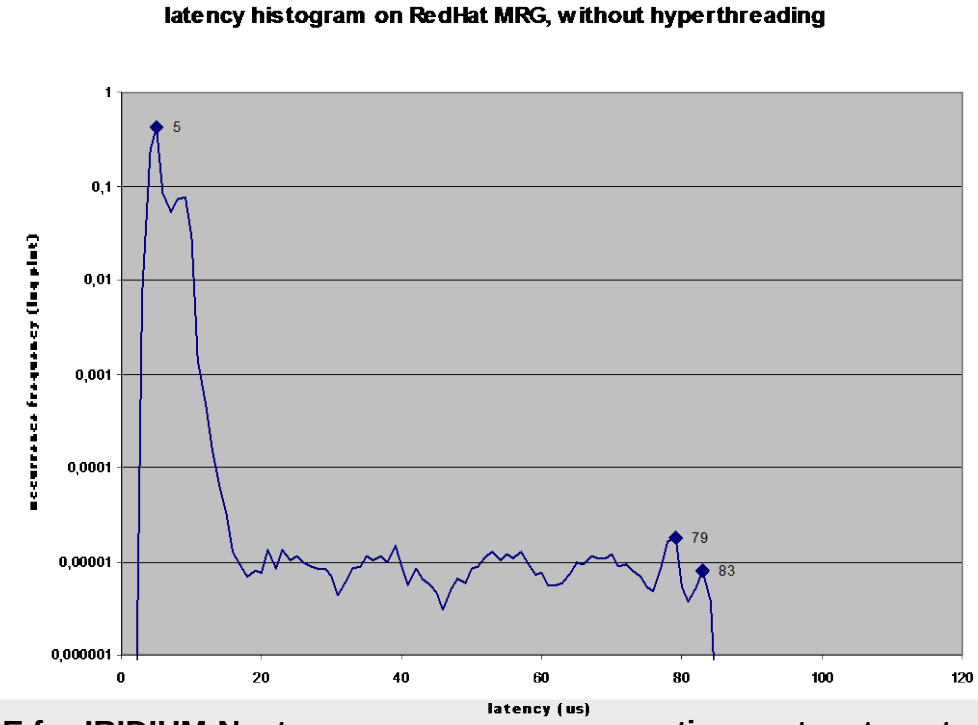
A generic approach for simulator and EGSE

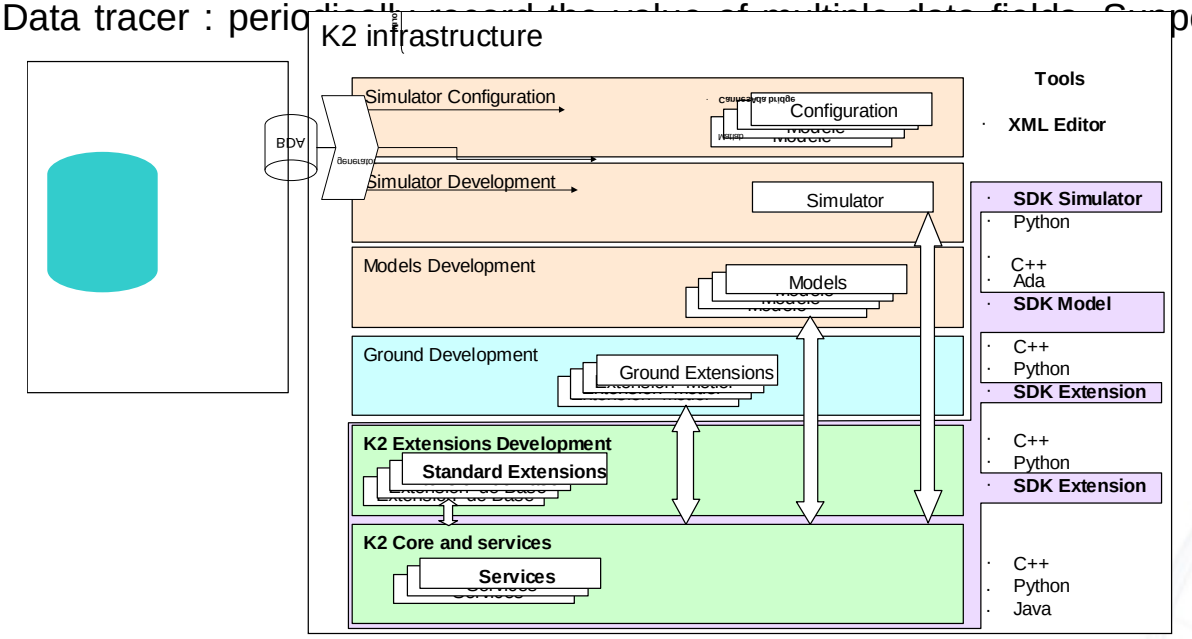
- All simulators and EGSE are based on an unified software infrastructure SCSIM which embeds following layers :
  - a operating system target : Linux Real-time Redhat 6 MRG 2,
  - a software core : K2 simulation kernel,
  - a check-out system : OCOE-6.
- First Layer, the operating system, the choice has been driven by hybrid bench constraints. We have decided to use Linux to answer to all needs (for all simulators and EGSE).



Simulators and EGSE for IRIDIUM-Next program use same operating system target : Linux Real-time Redhat 6 MRG 2

A generic approach for simulator and EGSE

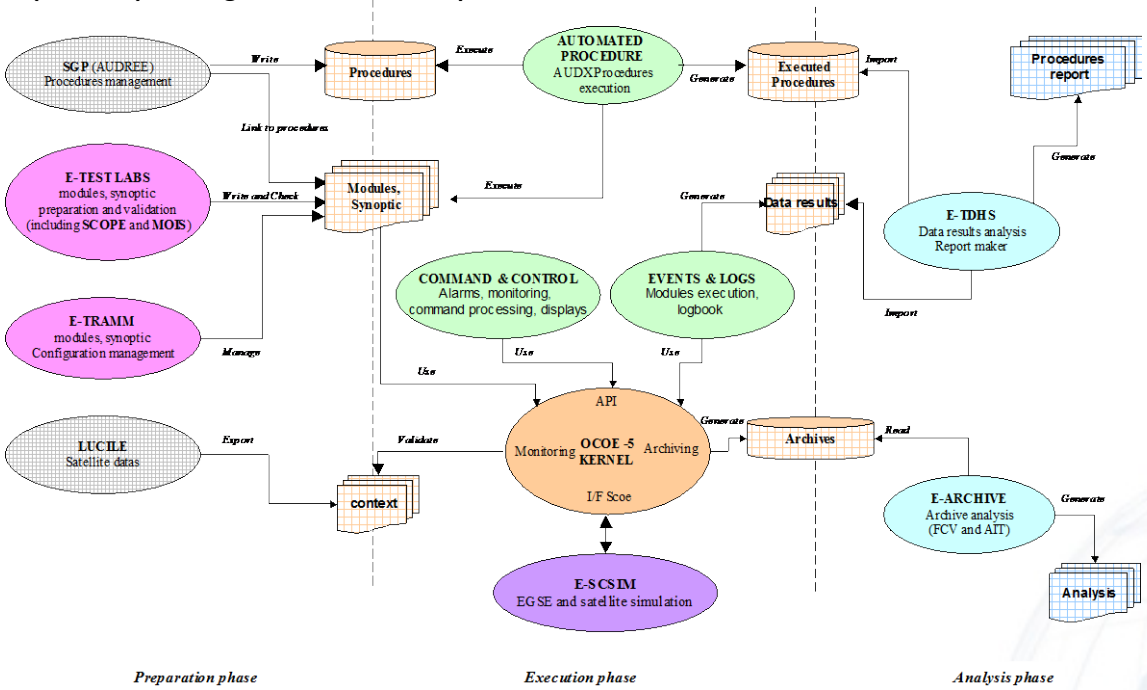
- Second layer, the software core, is based on an internal product K2 which embeds different kind of services :
  - Data exchange : input / output, activation / routine, bus routines,
  - Scheduler : is responsible for the co-ordination and processing of all events within the Simulation Kernel. An event on the schedule identifies an action that needs to be performed at a specified time in simulated time,
  - Time Keeper : is responsible for maintaining and providing models and the MMI with the correct simulation-Time. It provides time in four formats, Simulation-Time, Epoch-Time, Zulu-Time and Correlated Zulu-Time,
  - Data explorer : is responsible for making the values of both model and Kernel data items available for display in an MMI,
  - Logger and Data tracer : periodically record the value of multiple data fields. Supports state, feature, input.



Simulators and EGSE for IRIDIUM-Next program use same software core : K2

A generic approach for simulator and EGSE

- Third layer, the Check-out System, is based on an internal product OCOE-6 which embeds different kind of services :
  - Test configuration management (e-tramm) : consists in test procedure configuration and test matrix definition,
  - Test preparation (e-test labs) : consists in test procedure writing, checking and testing using the Satellite Database. It will also generate all necessaries data files needed for execution / report purposes,
  - Real-Time TM checks (monitoring kernel) : it will check TM parameter values during real-time test execution,
  - Test monitoring (C&C MMI): consists in displaying the test execution to the end-user and bench errors/warning,
  - Test execution analyze (e-tdhs) : it generates a report about execution and will make some off-line check about recorded data.



Simulators and EGSE for IRIDIUM-Next program use same Check-out System : OCOE-6

A generic approach for simulator and EGSE

- Thanks to previous choices, the way is opened to share same satellite models between all numerical simulators and hybrid benches.

Satellites models	Numerical bench	Hybrid bench with real OBC	Hybrid bench with simulated OBC
OBC		NA	
PAYLOAD Functional			NA
PAYLOAD coupler			
AOCS Functional			NA
AOCS Coupler			NA
Power Functional			NA
Power Coupler			
Thermal Functional			NA
Thermal Coupler			NA
ATB			NA
EGSE		NA	
SCC		NA	NA

Shared models

Specifc models

Simulators and EGSE for IRIDIUM-Next program share same models

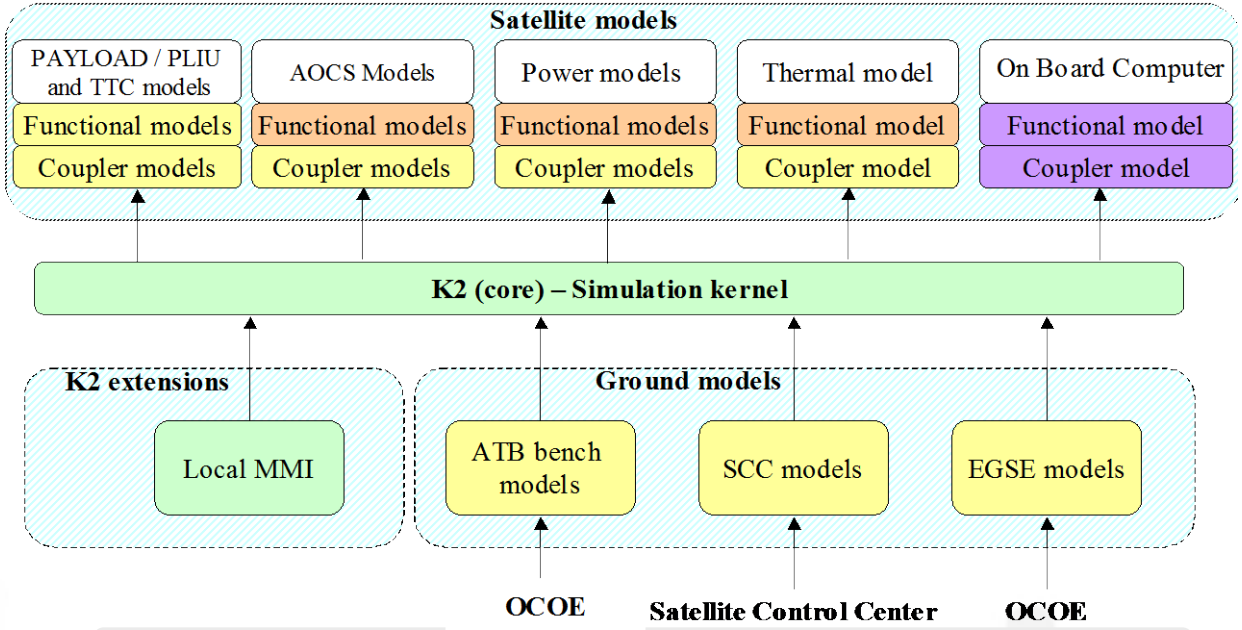
Numerical bench : from avionic validation to operational preparation

- Numerical benches support the following activities :
  - Avionics validation preparation through e-ATB
  - AIT preparation through AIT simulator (SIM-AIT),
  - Satellite operations preparation through Dynamics Satellite Simulator (DSS)
- First, they are used to support avionics development. It is called e-ATB. It is delivered by increment to allow PFSW validation in open loop configuration up to closed loop configuration (AOCS, EPS and Thermal).
- Then, the numerical bench SIM-AIT support the preparation of test procedures before to be run on the AIT bench. Thanks to SIM-AIT, the test sequences are developed on a numerical bench one can run outside the AIT area and easily reproduced.
- Finally, numerical bench is used to support the preparation of satellite operational procedures. It is a complete satellite simulator. All the satellite equipments are simulated including the SCC interface and link budget model

Numerical benches support Avionics, AIT and Operation preparation

Numerical bench : from avionic validation to operational preparation

- Numerical benches are composed of :
  - Satellite models :
    - OBC (or PFC in IRIDIUM case) model with new LEON 3 emulator board,
    - Platform models : PLIU, Power, Star tracker, Wheels, MAG, MTB, CSS, environment & dynamics,
    - Thermal model based on e-therm kernel,
    - Payload models : OBP, TTC, receivers, transmitters, docon, MFGU, MMA, link budget…
  - Ground models :
    - Architecture & scheduling models : RTS, time manager,
    - EGSE models : UMBILICAL, SAS, BATSIM, AOCS, PYRO, SCC.
    - ATB models : ML/DS - 1553 - SPW simulation, monitoring and, archives.



Numerical benches contain satellite and ground models

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Numerical bench : from avionic validation to operational preparation

- The building blocks and interfaces are based on standard decomposition of a real equipment functions in two model categories : functional (and service) and coupler Models.
- Functional (and service) models are responsible for the mathematical simulation of a spacecraft equipment (e.g. actuators and sensors) and for simulating the command and control functions of the spacecraft payload (scientific instruments) and platform (sensors/actuators) equipments.
- Coupler Models provide the interface between the Service models and the On Board Computer model. These models act as adapters between the functional models which handle command and control and the On Board Computer.
- Most of the models are re-used between each full numerical bench:

Numerical bench models	e-ATB	SIM-AIT	DSS
OBC			
PAYLOAD Functional			
PAYLOAD coupler			
AOCS Functional			
AOCS Coupler			
Power Functional			
Power Coupler			
Thermal Functional			
Thermal Coupler			
ATB			
EGSE	NA		NA
SCC	NA	NA	

Fully shared models

Partially shared models

Numerical benches share same models

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Hybrid bench with real OBC : software and avionic test benches

- The hybrid bench with real OBC are used to perform PFSW integration tests (in STB configuration) and avionics equipment integration tests (in ATB configuration).

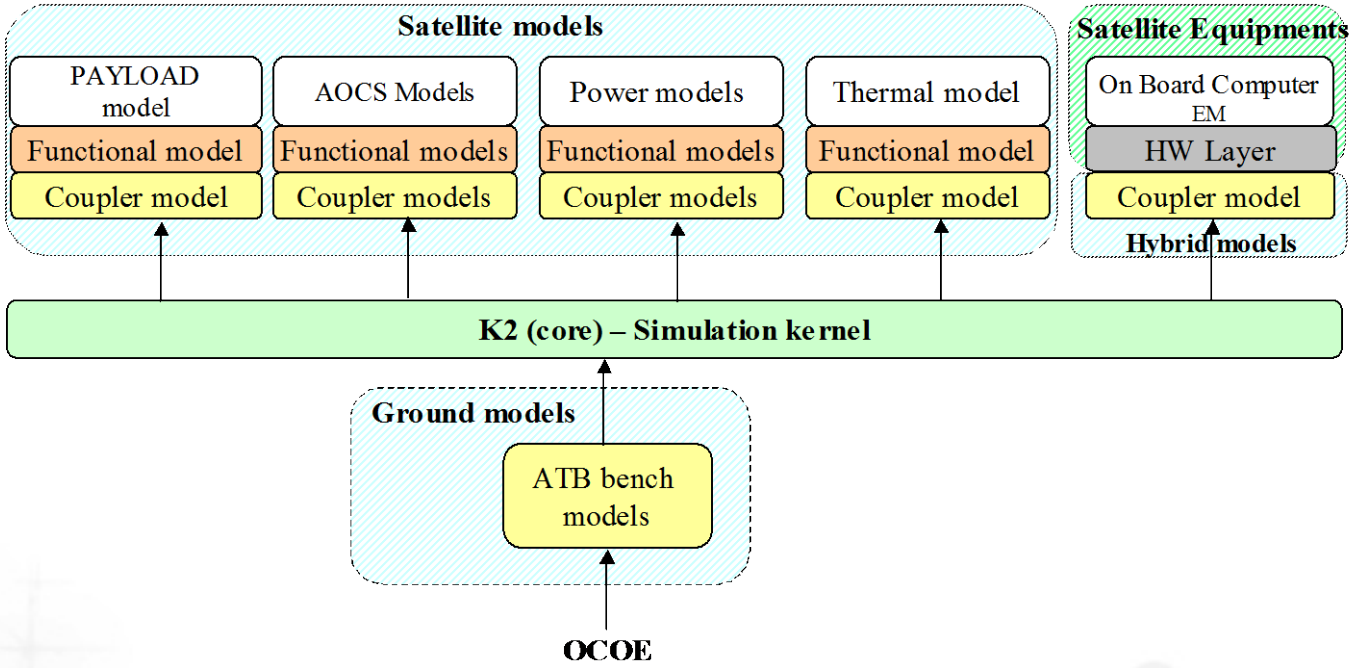
- The major purposes of this bench are :
  - to support the verification of the PFSW running on the real OBC,
  - to support closed loop testing of the whole avionics,
  - to support the integration of the satellite equipment tests,
  - to cross validate simulation models,
  - to support the PFSW and avionics maintenance.

- The ATB can gradually be extended by real hardware instead of simulation models.

Hybrid bench with real OBC support software and avionics validation.

Hybrid bench with real OBC : software and avionic test benches

- Hybrid bench is composed of :
  - Satellite and Ground models: same numerical bench
  - HW IF FEE :
    - TM/TC FEE : Linux PC equipped with PCI cards responsible to provides satellite TC /TM IF for real OBC,
    - Simulation FEE :Linux PC equipped with PCI cards responsible to transfer simulated IO data into electrical signals and vice versa (……)
    - Power FEE : Linux PC equipped with PCI cards responsible to provide power supply for HW IF FEE and additional equipments like hardware in the loop,
    - Star Tracker EGSE : To control and stimulate real STR equipments.



Hybrid bench with real OBC contain real equipments, HW FEE and software models

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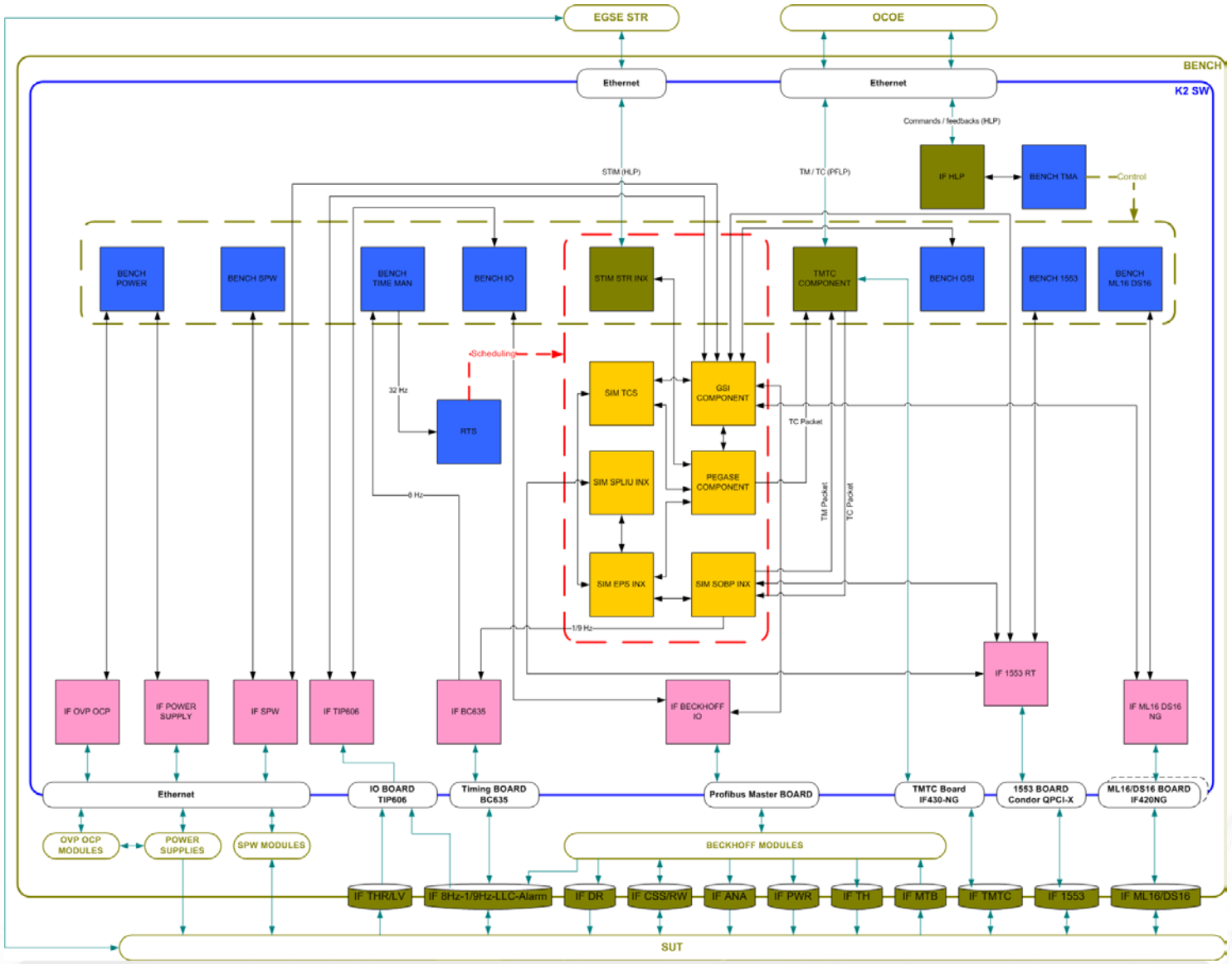
Hybrid bench with real OBC : software and avionic test benches



Hybrid bench with real OBC contain real equipments, HW FEE and software models

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Hybrid bench with emulated OBC : payload and PCDU SIM-EFM

- The hybrid bench with emulated OBC allows to perform validation of functional chains without using a real OBC. The hybrid bench is connected to the dedicated equipment (power or payload).
- The major purpose is to reduce the cost by using a numerical model of the OBC instead of a real one.
- The major constraint is to respect real time timing due to hardware connection with real equipment (PL or Power).

Hybrid bench with simulated OBC support sub-system validation.

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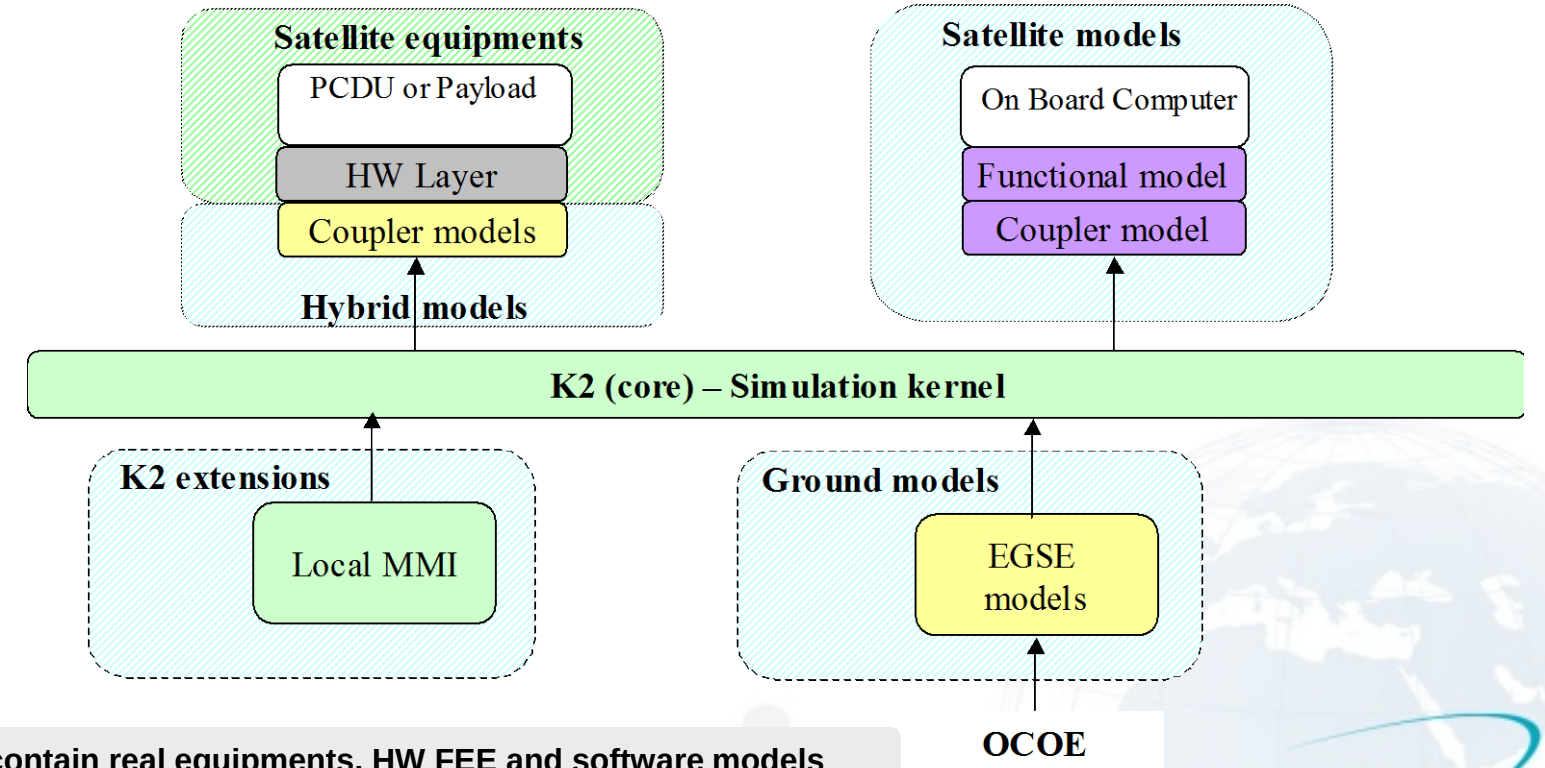
Hybrid bench with emulated OBC : payload and PCDU SIM-EFM

- Hybrid bench with emulated OBC is composed of :
  - Satellite and Ground models : same as numerical bench (including OBC emulator)
  - HW IF FEE :
    - Simulation FEE :Linux PC equipped with PCI cards responsible to transfer simulated IO data into electrical signals and vice versa (……)
      - 1553 Bus IF cards,
      - ANA, Digital, HPC, Pulse IF cards



Hybrid bench with simulated OBC contain real equipments, HW FEE and software models

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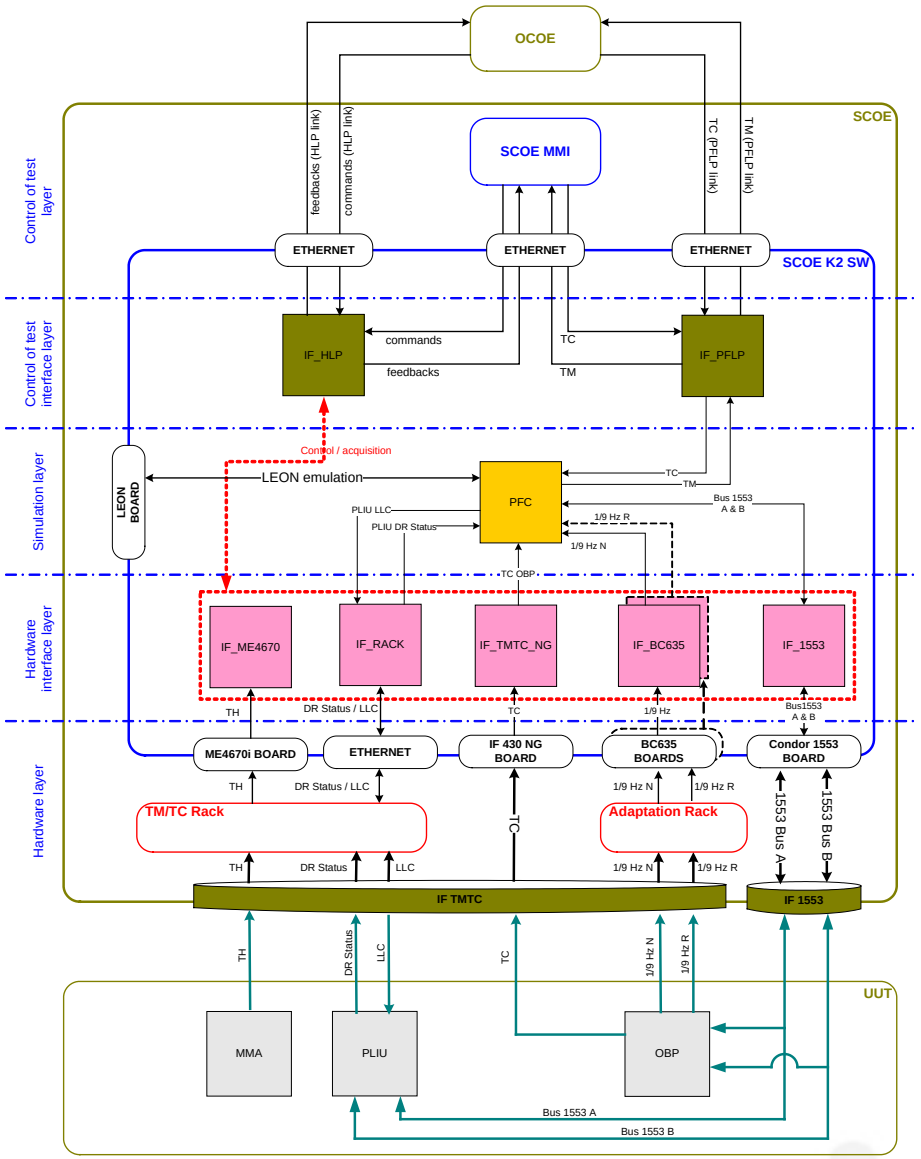
Hybrid bench with simulated OBC : payload and PCDU SIM-EFM



Hybrid bench with simulated OBC contains real equipments, HW FEE and software models

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Conclusion

- All simulators and EGSE for IRIDIUM NEXT
  - are based on an unified software infrastructure SCSIM which embeds following layers :
    - a operating system target : Linux Real-time Redhat 6 MRG 2,
    - a software core : K2 simulation kernel,
    - a check-out system : OCOE-6.
  - share same models (satellite and ground).

- This approach allows to re-use a lot of components, to consolidate schedule and reduce materials during each project phase:
  - Development phase : each model is develop one time for all needs
  - Validation phase : early model validation are benefit for next increment
  - Maintenance phase : simulator and EGSE team are the same

- The final goals is to:
  - Improve satellite validation and integration phases
  - Improve maintenance phase
  - Take into account all customers needs with the same end user package

This approach allows to re-use a lot of components, to consolidate schedule and to reduce materials during each project phase

THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS ?

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