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# Operating real equipments with fully simulated On Board Computer SimEFM, a new validation infrastructure

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**ACE83 Satellite FVI**

All the space you need

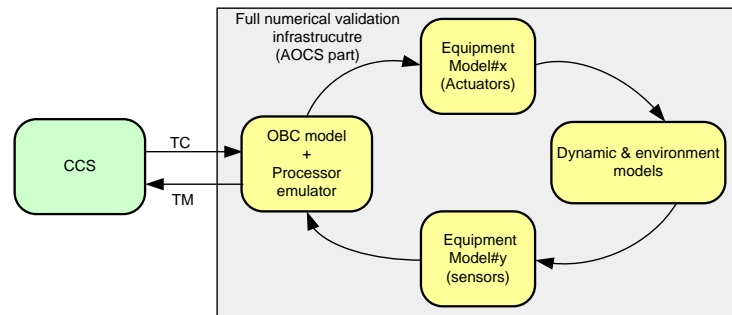


# Introduction

- In Functional Validation approach, tests involving real equipments use large hardware test benches
  - With a hardware model of the OBC and its associated EGSE
  - Direct impact on cost, schedule, and processes
- Alongside, numerical simulators are now widely used
  - Fully representative numerical model of the OBC
  - Emulation of the OBC processor
  - Low cost and versatile systems
- Numerical simulators performances make possible a new configuration : SimEFM
  - A mix of numerical simulator and some H/W interfaces
  - Operating real equipments with fully simulated OBC

# Numerical Simulators

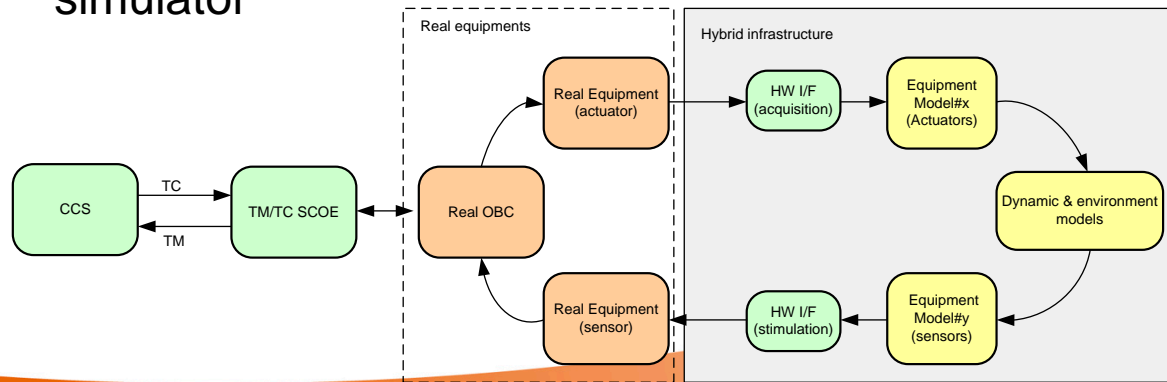
- Based on a fully representative model of the OBC
  - Run exactly the same Flight Software (FSW) as the one used on the real computer, taken as a binary image file



- High performance and excellent fidelity
  - Faster than real-time
  - From FSW validation up to space operations validation
  - Low cost and versatile systems, easily deployed
  - Available for a large number of people involved in validation

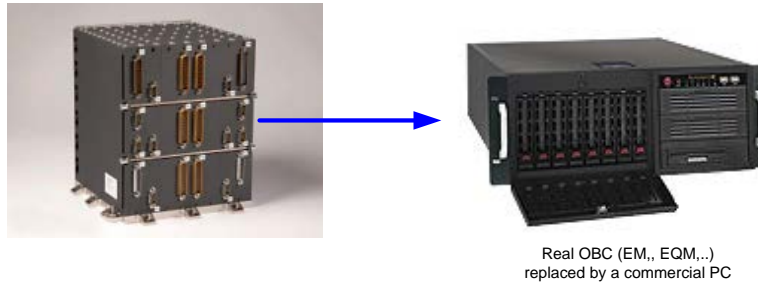
# Hybrid infrastructures

- Dedicated to tests with real equipments
  - Characterization test benches, with HW I/F to equipment
  - Large hardware test benches
    - Avionic Test Bench, “flatsat”, EFM/PFM benches ...
    - Include, at least, one real OBC and its associated EGSE (TM/TC...)
    - Additional SCOE to interface equipments (stimulators...)
- Coupled with simulations, for closed-loop (HIL) tests
  - Use the same models and simulation infrastructure as for numerical simulator



# SimEFM, a mix of numerical and hybrid

- Replacing the real OBC by its numerical model
  - Real equipments are connected to the OBC model



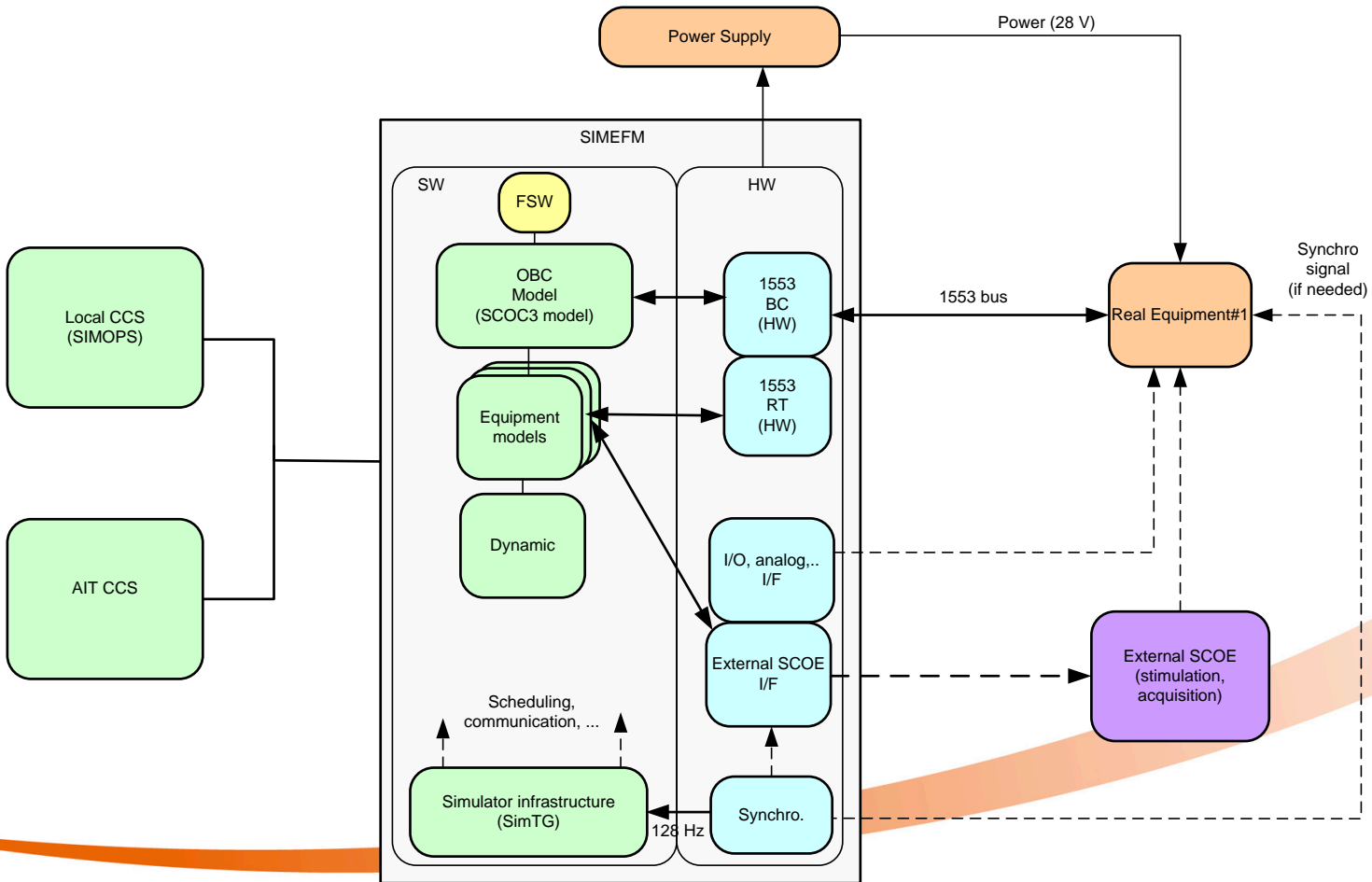
- The real Flight Software controls real equipments
  - FSW runs in the simulated OBC
  - Equipments are operated as identical to EFM/PFM configuration (using the same TM/TC sequences)

# SimEFM part of simulator product line

- Based on Astrium simulation infrastructure (SimTG)
  - Shared across all simulations use cases
- No specific model development required
  - Models, including OBC model and processor emulator, are fully reused
- Built with components shared with other systems
  - HW interfaces identical as for hybrid configurations (EFM/PFM benches)
  - User interface can be the simulator native one (SIMOPS) or the AIT CCS

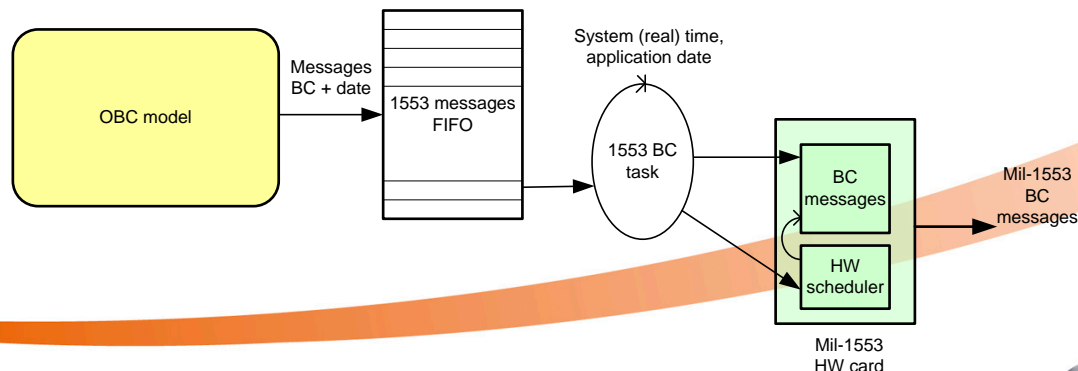
# SimEFM architecture overview

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# SimEFM is a real time simulator

- Using real equipments brings a hard real-time constraint
  - Generation of command signals to equipments
- SimEFM is configured differently compared to a classical numerical simulator
  - Use of *RedHawk* Linux OS
  - Simulation cycles real-time synchronised to a reference clock
  - Avionics bus I/F (e.g. Mil 1553) directly connected to the PC internal bus



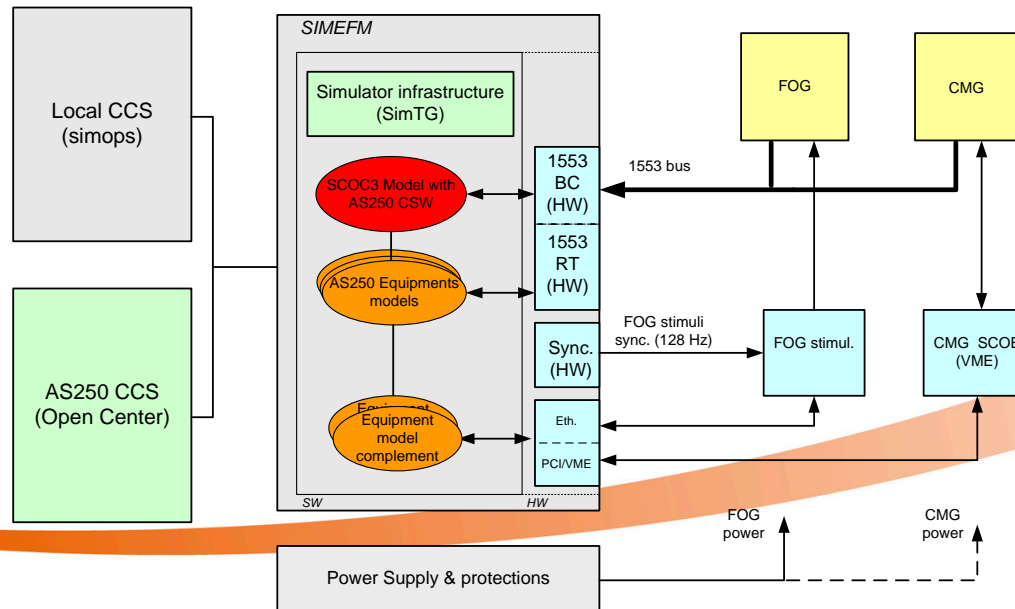


# SimEFM manages different HW interfaces

- In addition to avionics bus I/F
  - Equipment's external I/O (e.g. status acquisition, configuration strap...)
  - External SCOE such as complex stimulators
  - Synchronisation signals (e.g. PPS)
- With different technologies
  - Implemented with PCI cards plugged on the PC
  - Ethernet link or specific bus adapter to dedicated SCOEs
- Can be operated without models
  - Directly controlled by user test sequences
  - In early phases, check of electrical compatibility
  - Later on, upgraded to its complete configuration for functional validation

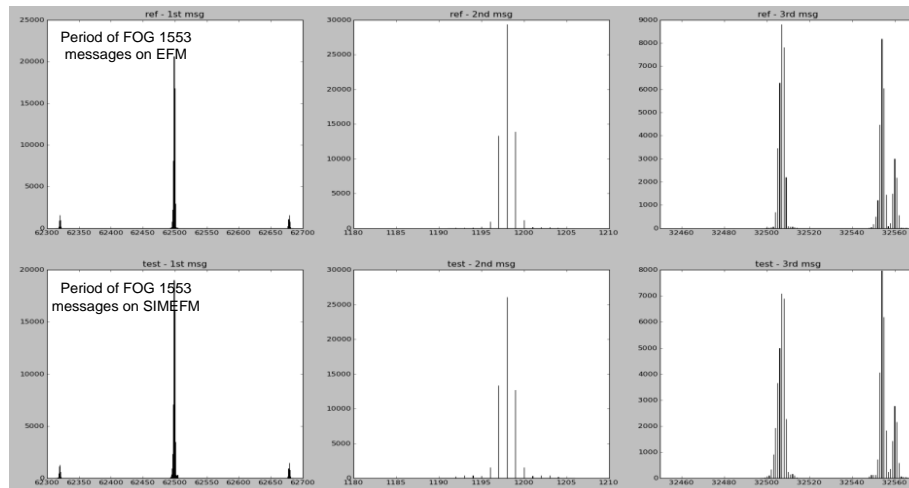
# SimEFM prototype implemented

- Based on Astrium latest OBC emulator for LEON3
- Use of elements from the Astrium AstroBus 250 program
  - Two real equipments : CMG, FOG
  - All the models directly reused from AstroBus 250 simulators
  - Reference case from AIT EFM test campaign
    - Already validated FSW, SRDB and test sequences



# SimEFM prototype results

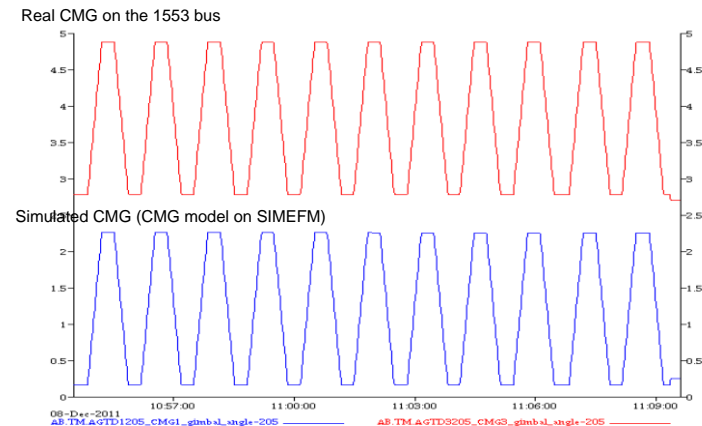
- The FSW controls equipments as if running in real OBC
  - The SimEFM generates all 1553 messages in real time
  - Fidelity, compared to real EFM measurements, is less than 3  $\mu$ s



- The prototype was able to run the same tests as EFM bench
  - Starting with simple equipment management (AOCS function disabled)
  - Ending with a complete AOCS closed-loop test

# SimEFM user experience

- Versatility in bench operation
  - Reuse of tests sequences from AIT EFM bench
  - Enriched with numerical simulators debug tools
- Prototype has demonstrated efficiency for test setup
  - User can switch from full simulated configuration to HW in the loop



# SimEFM use cases for platform AIV

- SimEFM used instead, or in parallel, of an EFM bench
  - Cost efficient reduction of EFM bottleneck
- Optimization and flexibility of the AIV Process
  - Activities can be parallelised on less complex configurations
  - Replacing EFM bench on programs based on recurrent platform
    - Instruments or new equipments can be tested on SimEFM and then, directly integrated on PFM
  - Effort and planning reduction per test (efficiency for test setup)
- Decrease the number of real OBCs necessary to the project for all validation activities

# SimEFM for equipments or P/L development

- **Electrical tests during development/qualification phases**
  - SimEFM is representative of OBC or platform electrical interfaces
  - SimEFM can be easily deployed at supplier premises
- **Pre-coupling tests, representative HW/SW and system validation tests**
  - SW validation with real FSW can be done directly at supplier level
  - Pre-test on FSW-SRDB and equipments compatibility
- **Early coupling activities between equipment and their external SCOE/EGSE**
  - Complex SCOE can be integrated/validated on SimEFM in parallel of EFM bench
    - GNSS receiver with GPS/GNSS constellation simulator
    - STR with optical/electrical Stimulator

# Conclusion

- SimEFM offers opportunities for the improvement of the Functional Validation process
- SimEFM combines state of the art technologies from Astrium numerical simulators and EGSE
- It offers opportunities to reduce costs and schedule on future space programs

# Thanks for your attention

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