Euclid AOCS Simulation Facilities

Workshop on Simulation for European Space Programmes (SESP)

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AIRBUS DEFENCE & SPACE

deimos elecnor group

SENER

The Euclid AOCS Program

The Euclid Mission

- Part of ESA Cosmic Vision
- Measuring shapes and redshifts of distant galaxies to understand accelerating expansion.
- Payload is a 1.2 m telescope with large FOV
- Prime is Thales Alenia Space
- To be launched in 2020

The Euclid AOCS program

- Lead by Sener with Airbus Defense and Space NL and Deimos as subcontractors
- Stringent pointing requirements (25 milli arcsec relative pointing error)
- High degree of agility to perform frequent maneuvers
- Single on board computer hosting AOCS (AASW) and Data Management (CASW)
- AOCS flight software partly auto coded from Matlab

Euclid AOCS Verification

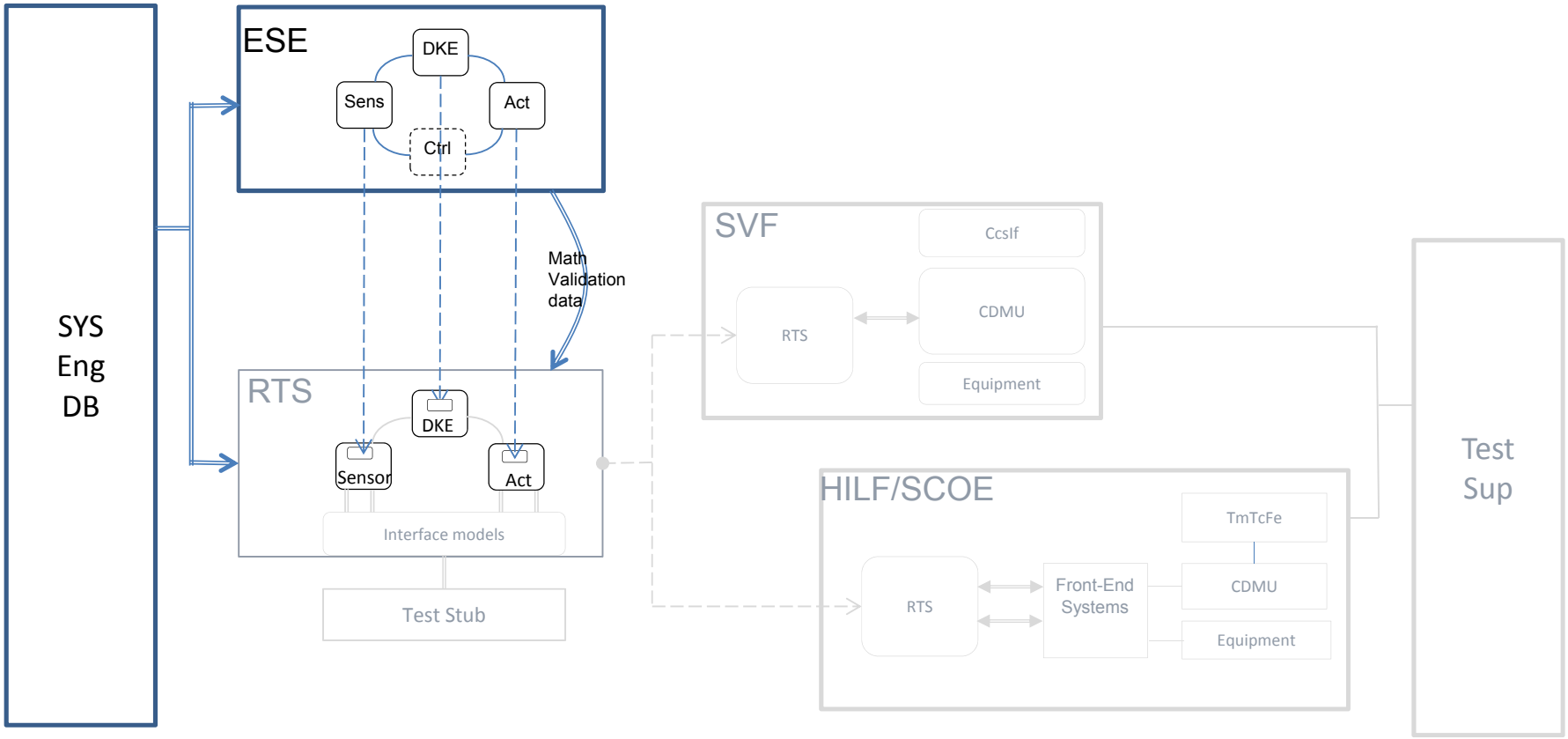
Verification challenges

- Modelling of stringent pointing requirements
- High frequency onboard cycle
- Use of reaction wheels at low speeds
- Impossibility of isolated testing of AOCS flight software

Verification approach

- ESE: For performance verification as well for validation of auto-coded software
- SVF: For functional verification of AASW & FDIR, AASW /CASW interface, and Operations. In basis all requirement close-out.
- HILF: Integrates the hardware related aspects into the simulation, typically long duration runs. Validation of SVF.
- AVM / PFM: Re-use AOCS SCOE with HIL Equipment at TAS premises

Euclid AOCS Verification Facility Overview



Engineering Simulator (ESE) - introduction

Introduction

- A FES developed by Deimos Space on specification by Sener and Airbus DS NL
- Supports functional and performance verification of AOCS algorithms at MIL and SIL

Features

- Based on MATLAB/Simulink
- Faster than real-time simulation
- Monte Carlo simulations
- Model-In-the-Loop and Software-In-the-Loop verification
- Performance metrics
- XML model parameter database
- MATLAB scripting
- Attitude dynamics, including wheel dynamics and propellant sloshing
- No orbital propagation: only non-gravitational acceleration is integrated to evaluate delta-V manoeuvres in OCM mode

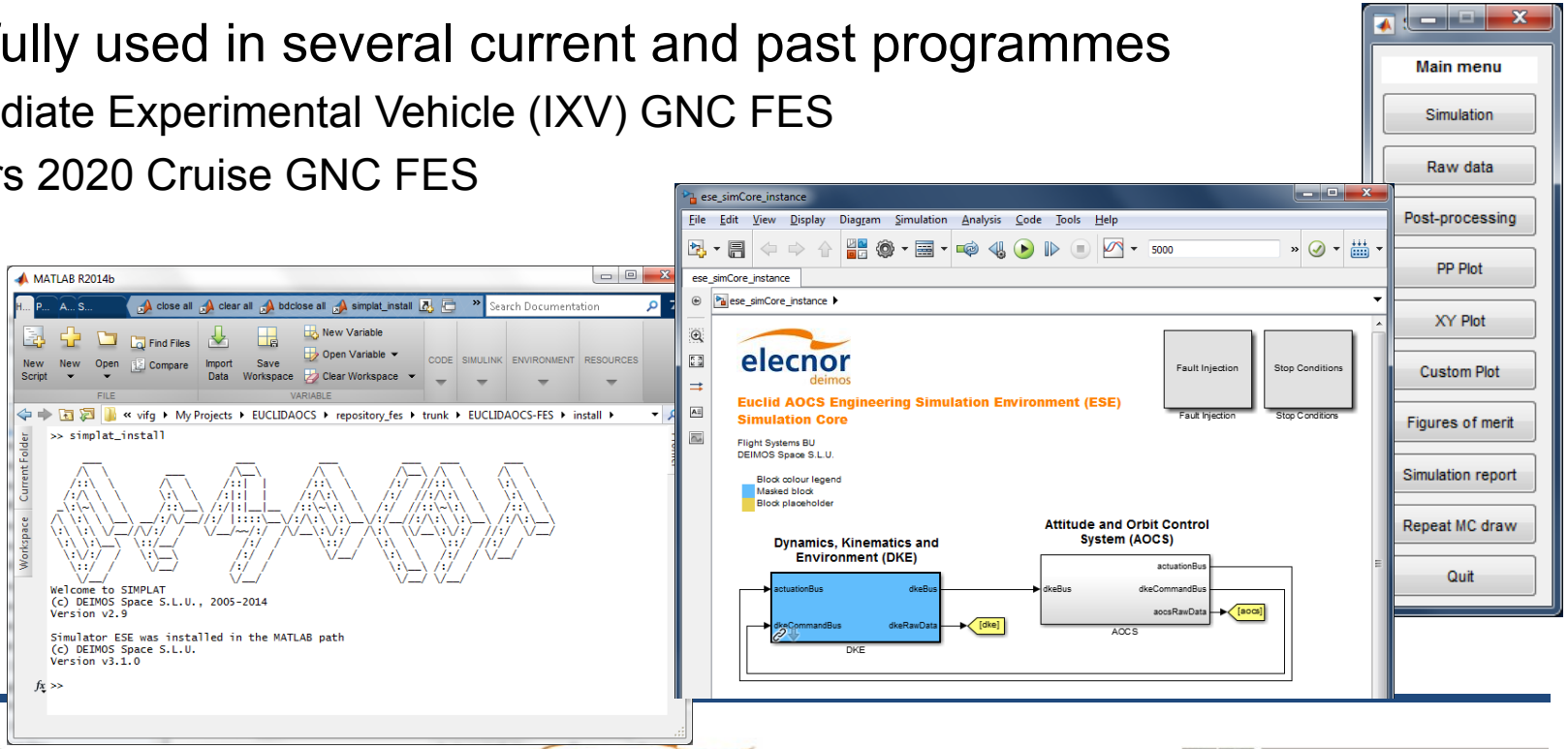
ESE - Modeling challenges

Modelling challenges	Solutions
• Modelling of stringent pointing requirements (e.g. 25 milli-arcseconds relative pointing error in science mode)	• Accurate modelling of attitude dynamics • High fidelity models of AOCS units
• Use of reaction wheels at low speeds	• Coupled attitude dynamics model • High fidelity model of the reaction wheel provided by the supplier
• The AASW cannot be isolated from the CASW, posing requirements on the CASW in support of AASW verification.	• Emulation of some CASW functions required to validate the AOCS algorithms

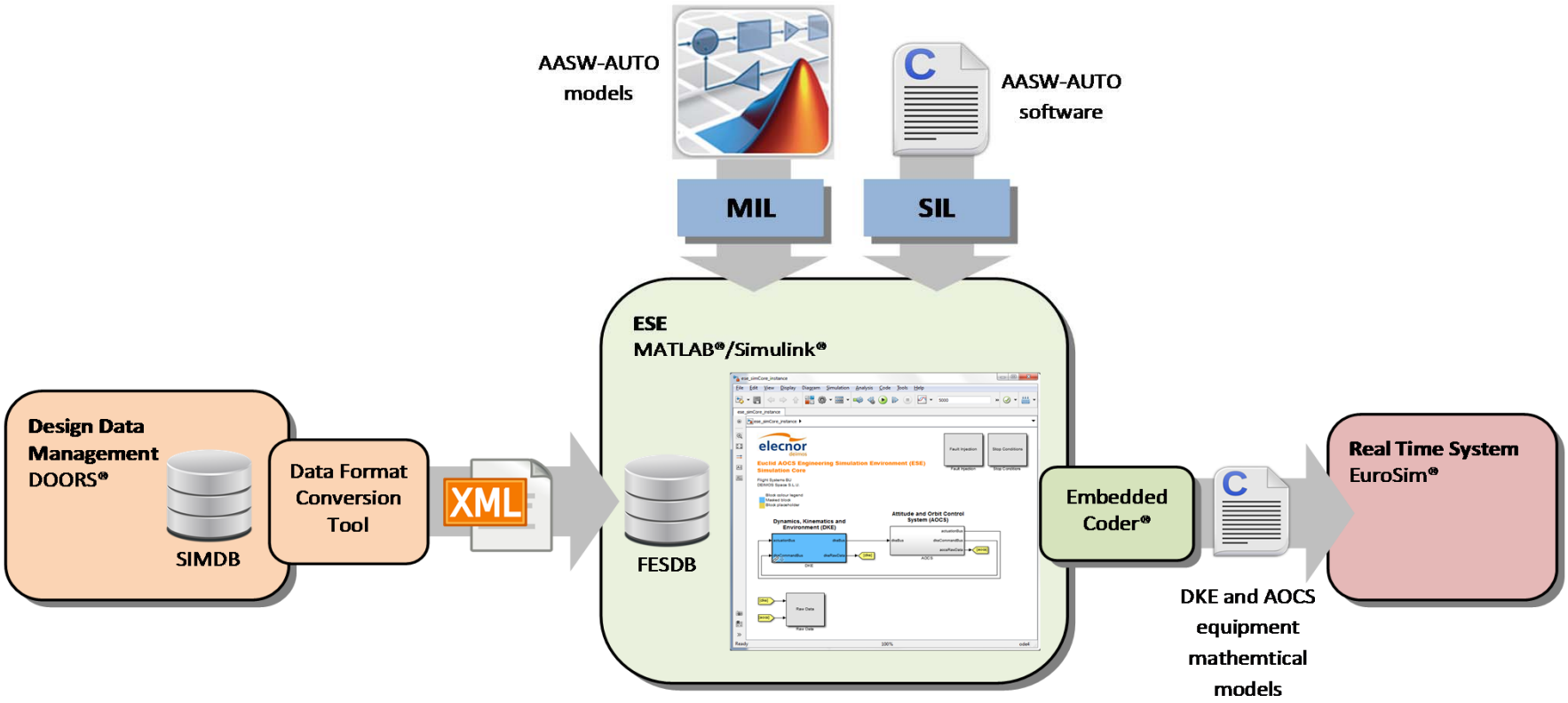
ESE - Design

- Based on SIMPLAT is a reusable, fexible and cost-effective simulation infrastructure for FES development based on MATLAB/Simulink

- Successfully used in several current and past programmes
  - Intermediate Experimental Vehicle (IXV) GNC FES
  - ExoMars 2020 Cruise GNC FES



ESE - Overview



ESE - Integration with System Engineering

- The Euclid Design Data Management (DDM) includes the Simulation Database, consisting of
  - spacecraft dynamics and environment (DKE) parameters
  - AOCS equipment performance and I/O parameters
- SIMDB is stored in the IBM® Rational® DOORS®
- A conversion tool exports SIMDB to XML format loadable by the ESE
- Parameter changes to be performed in DOORS and exported to the ESE

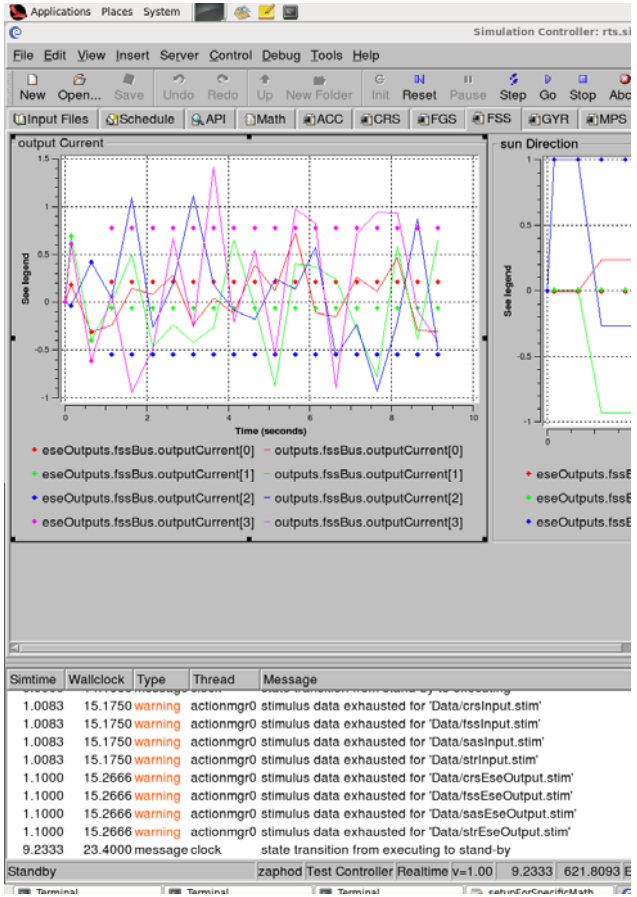
ESE– Generation of mathematical models

The ESE provides the following models for the RTS:

- DKE (Dynamics, Kinematics and Environment) model, including RWL dynamics and internal torque perturbations (NISP, RSU, HGA)
- AOCS actuators: RCS, MPS, RWL
- AOCS sensor units: IMU, CRS, FGS, SAS, FSS, RWL tachometer

Converted to C code with Embedded Coder ®

- Integrated without modifications in EuroSim ®
- Verified in EuroSim with reference data from ESE



ESE– Software-In-the-Loop

- The ESE supports both Model In the Loop and S/W In the Loop verification
- In SIL configuration, the AOCS auto-coded SW is exercised in closed loop
- SIL testing provides confidence that the AOCS auto-code performs as expected
- SIL testing in the ESE allows:
  - Monte Carlo simulation
  - Failure testing
  - Faster than real-time simulations (long duration scenarios)
- AASW-AUTO generated code is integrated in the ESE with S-Function wrappers

Real Time Simulator (RTS)

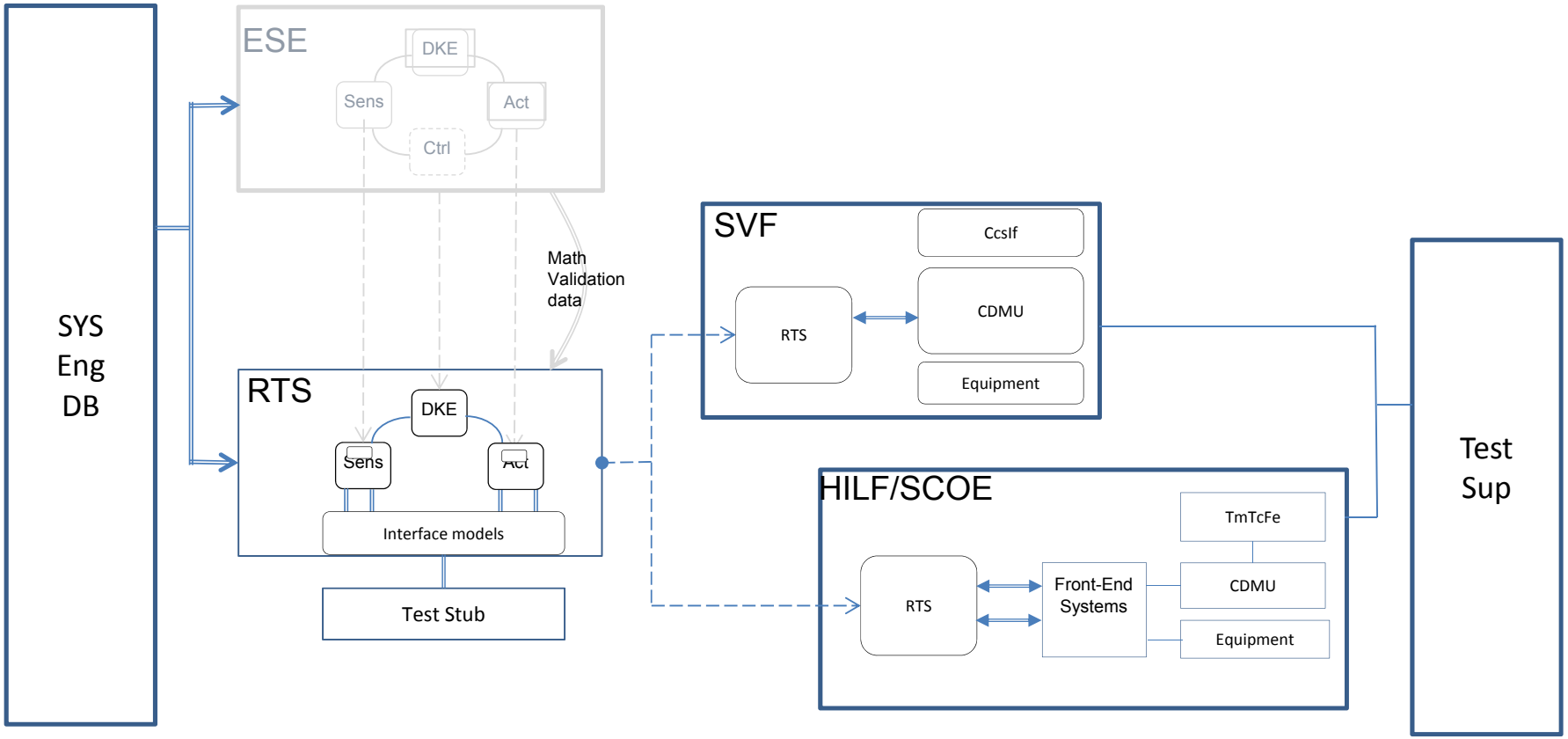
RTS Challenges

1. Verification approach requires well comparable SVF and HILF results
2. SVF/HILF will arrive late, support needed for RTS model development
3. Variations in HIL/SIL usage creates configuration challenge
4. HIL requires synchronization to different timelines, Simulator vs CASW
5. Closed loop models with high frequencies (120Hz) require load balancing

RTS Approach

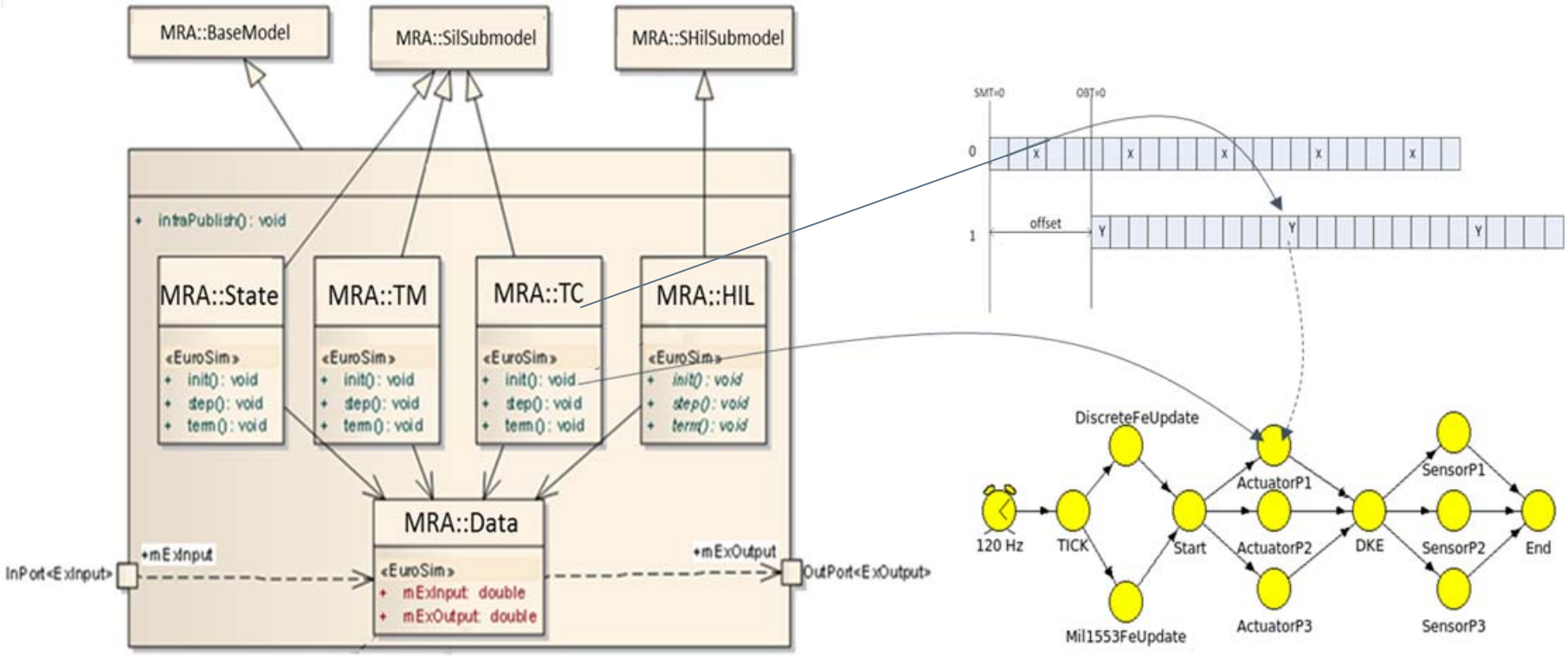
- Single RTS as re-usable building block, embedded in SVF and HILF
- New Model Architecture solving timeline and model mode switching
- Front-End models to separate model from CDMU interface (HIL, SVF..)
- Test Stub for model development and validation prior to SVF/HILF integration

Euclid AOCS Verification Facility Overview

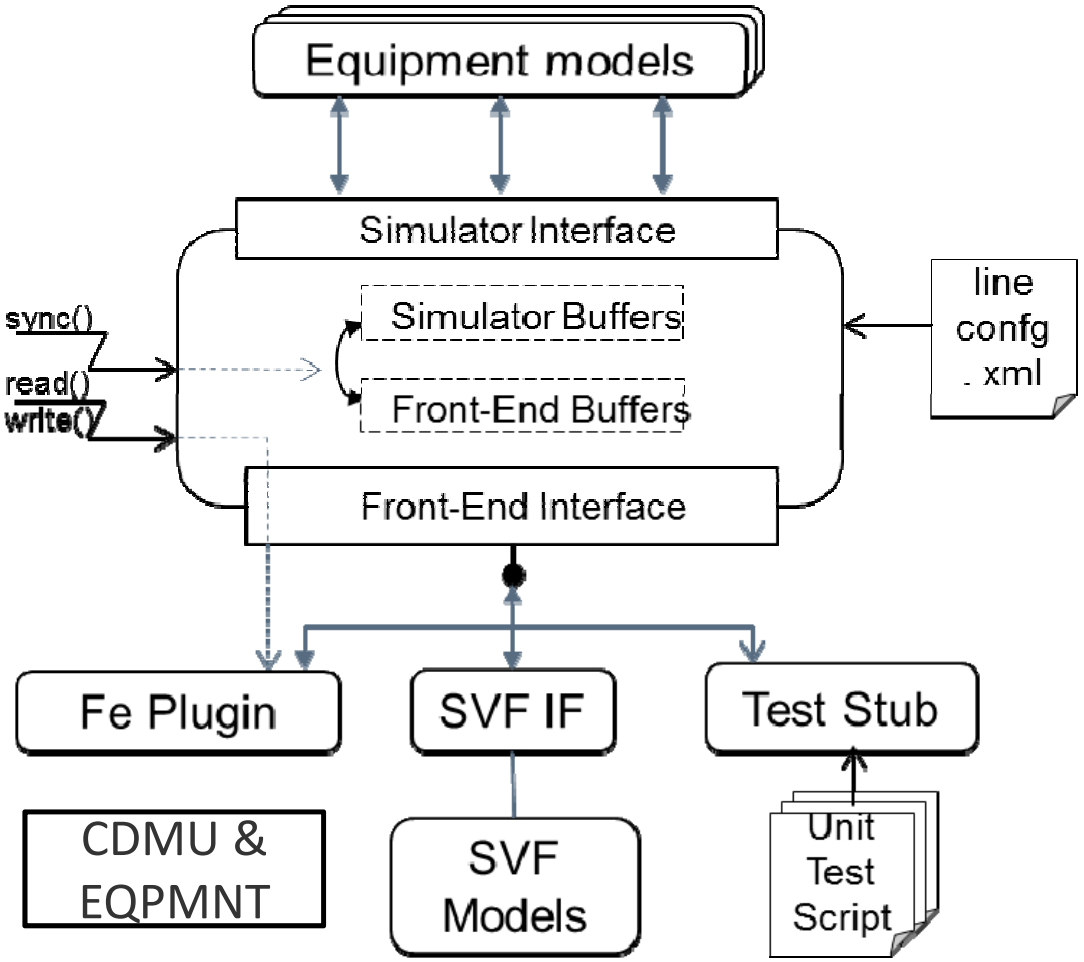


RTS - New Model Architecture

Solving timelines and HIL/SIL switching



RTS - Front-End Models

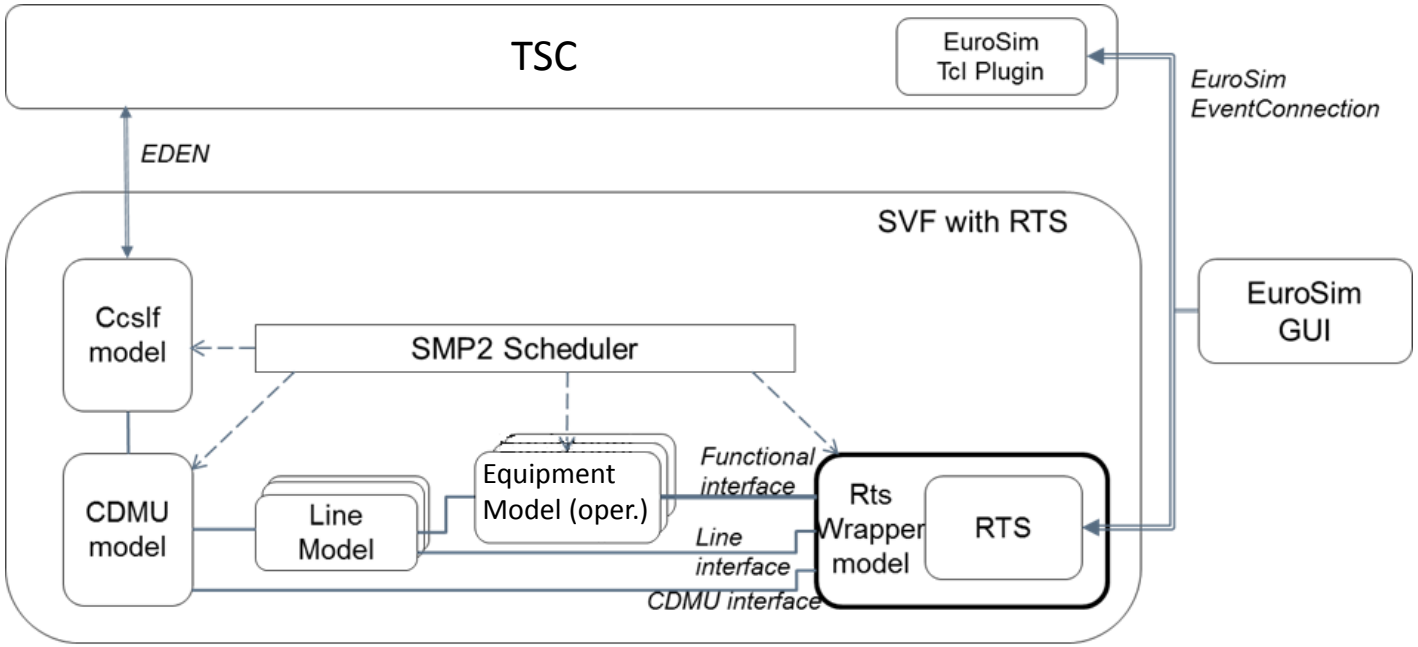


Solving docking in SVF, HILF and Early Development

Configurable FE Models available with EuroSim Mk6

Software Validation Facility (SVF)

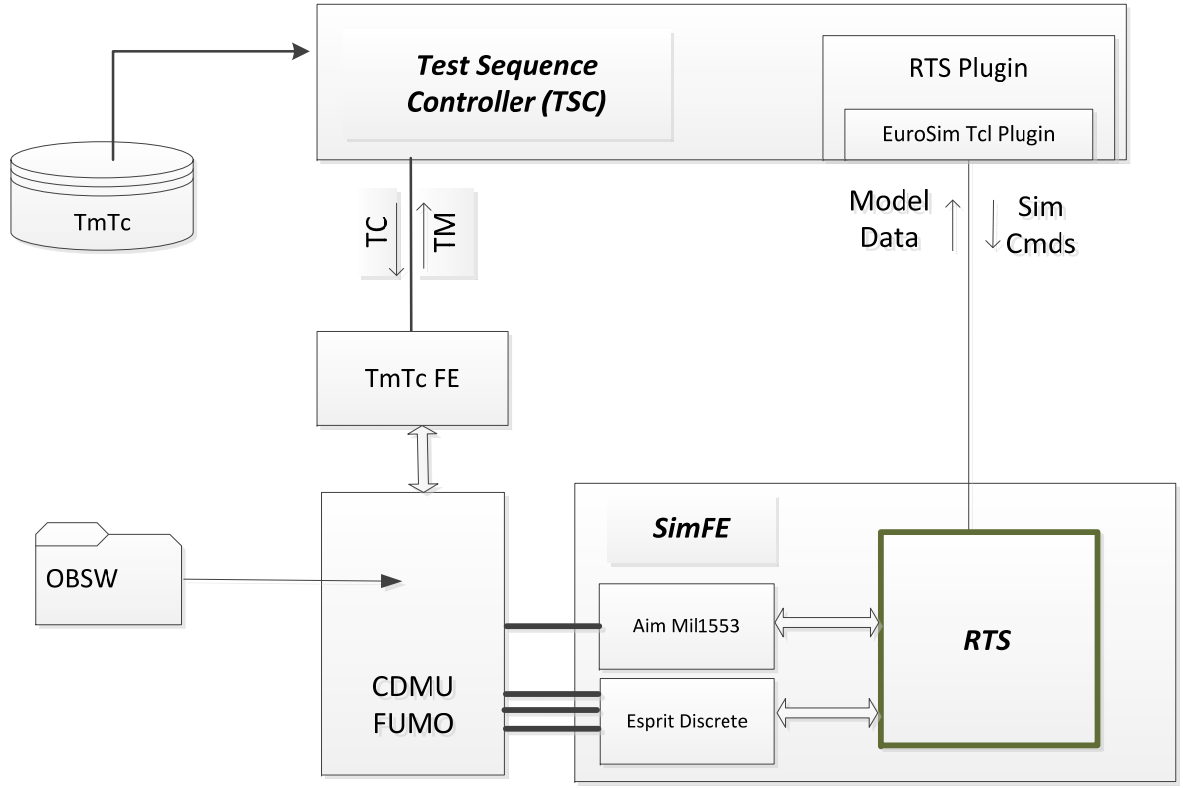
RTS simulator integrated as 120Hz SMP2 model in Euclid SVF



Euclid SVF by SpaceBel based on Basiles, SMP2, ISIS

Hardware in the Loop Facility (HILF)

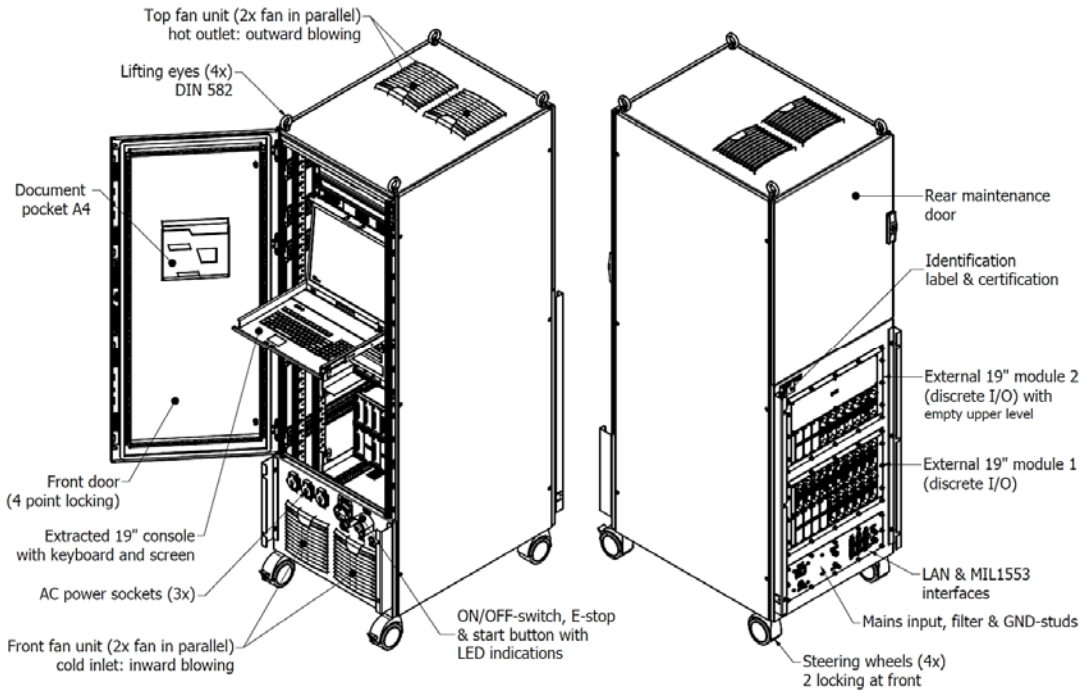
RTS simulator integrated as executable on Simulator Front-End



EGSE - Simulator Front-End

Mid-Plane solution

- Signal Boards to RTS
  - Analog ,Digital, Serial ,Pulse, Tacho
  - RTS connection via RT Ethernet
- Router Boards to S/C
  - Easy straight cable harness
- Adapter Boards for COTS



RTS Host

- Supermicro server
- AIM Mil1553 PCIe card
- Real-Time Ethernet to signal boards

AIT by Advionics

EGSE – New ESPRiT TMTC Front-End

Roots in ATV program

Project independent

- NeoSat, Metop SG, Euclid

Improved Hard- and Software

- Latest SOC technology
- Capacity for future enhancements
- Improved system outfit
- Eden, C&C, NDIU ready

Summary & Status

Summary

- ESE based on SIMPLAT providing MIL and SIL simulations, as well as generation of RTS math models and fully integrated with Design Data Management.
- RTS based on EuroSim Mk6, utilizing a new model architecture and front-end Models. Docks as single building block in both Basiles SMP2 SVF and ESPRiT based SimFE
- SimFE integrates RTS with AIM MIl1553, ESPRiT Discrete FE and TMTC FE forms HILF and AOCS SCOE for AVM/PFM

Status

- ESE and RTS to be finalized with latest model update (April).
- SVF and HILF deliveries upcoming (May).
- HILF assembly will follow (May/June)

Questions?