

## Context

- Long history of building simulators and simulator infrastructures
  - EGSE and SCOE systems
  - (Hard) real-time simulators
  - EuroSim as a product
  - (Geographically) distributed simulation
  - End-to-end solutions
  - Different application areas, from system definition to AIT to embedded
- Long history in satellite, robotics, subsystem and instruments AIT
  - ANS, IRAS, ERS, ISO, Beppo-SAX, ERA, H-P, MIPAS, SCIAMACHY, OMI
- Dutch Space is part of Astrium since 2006
  - Separate company within Astrium-Satellites
- Dutch Space acquired contracts for the RTS and AV-SCOE
  - Customers: Astrium France and Astrium UK

## Project characteristics

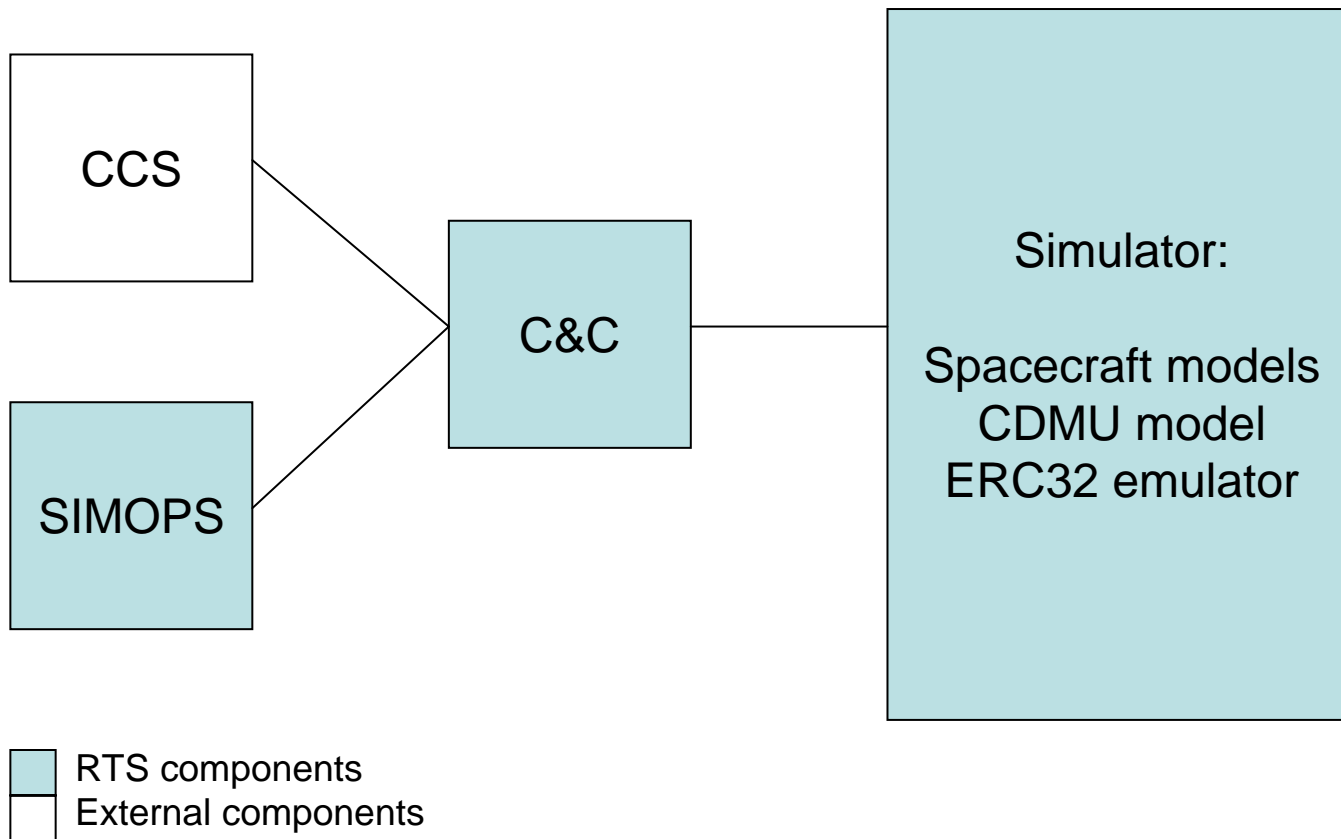
- Subcontractors involved
  - Terma, NLR
- Heritage
  - Herschel-Planck
  - EuroSim as basis
  - Astrium's SIMTG
- Challenges
  - One simulator for numerical and hybrid benches; simple switching
  - Integration of EuroSim with Astrium France infrastructure
  - High data bandwidth between RTS and AV-SCOE
  - And more ...



## Use case overview

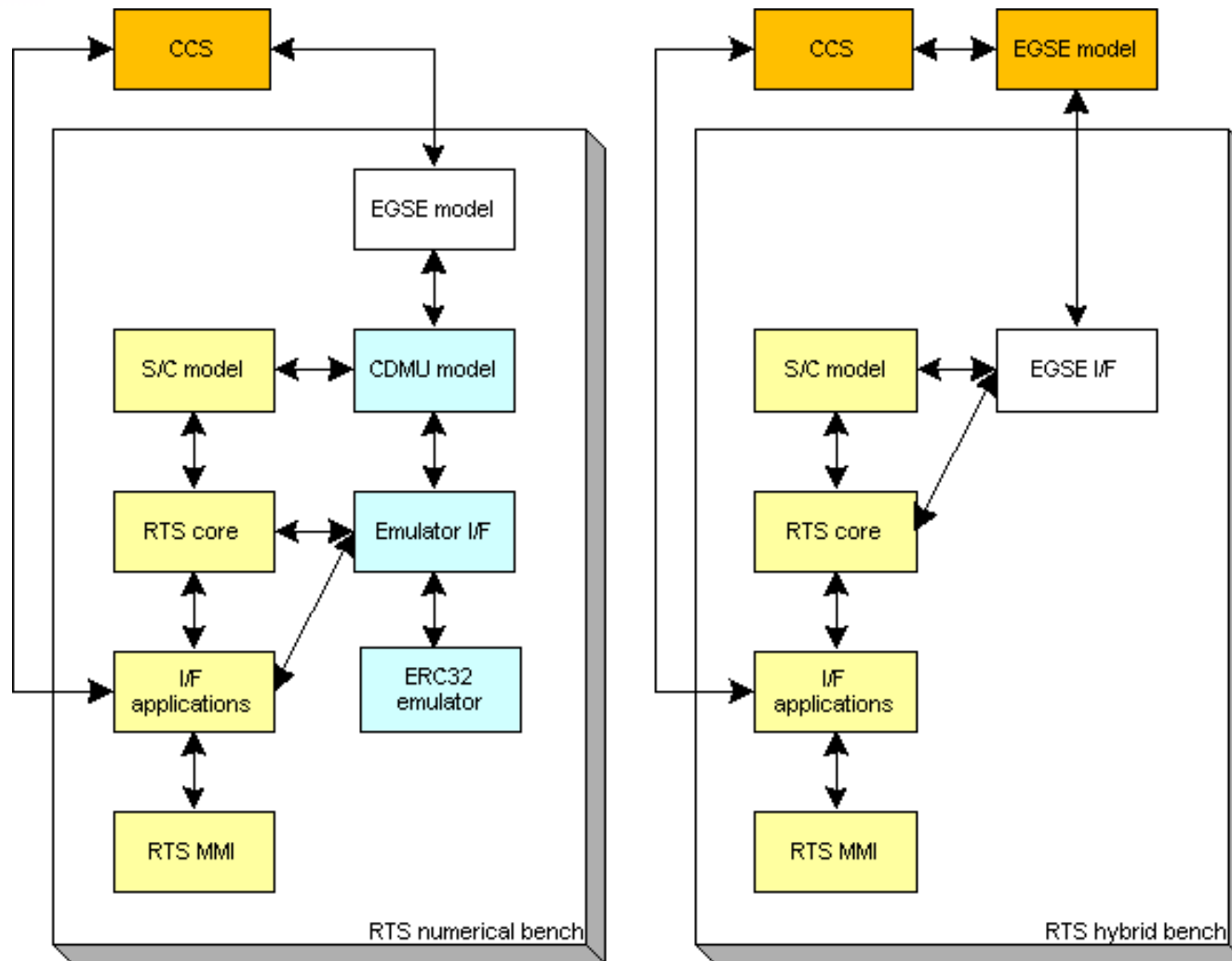
- Numerical bench
  - Software verification facility (SVF) for OBS development and test
    - Includes SIMERC32 instruction set emulator
  - Operations verification facility (OVF) for development of test procedures for spacecraft operations
    - SIMOPS DynamicJava test environment
  - SIMAIT for CCS script development for the hybrid bench (AIT of the PFM)
    - Essentially SVF with EGSE models added, open loop
- Hybrid bench
  - Onboard computer (OBC) always in the loop
  - Other equipment selectable, including the electrical interface unit (EIU)
  - Connect to other hard real-time EGSE (STR, FPA simulator)

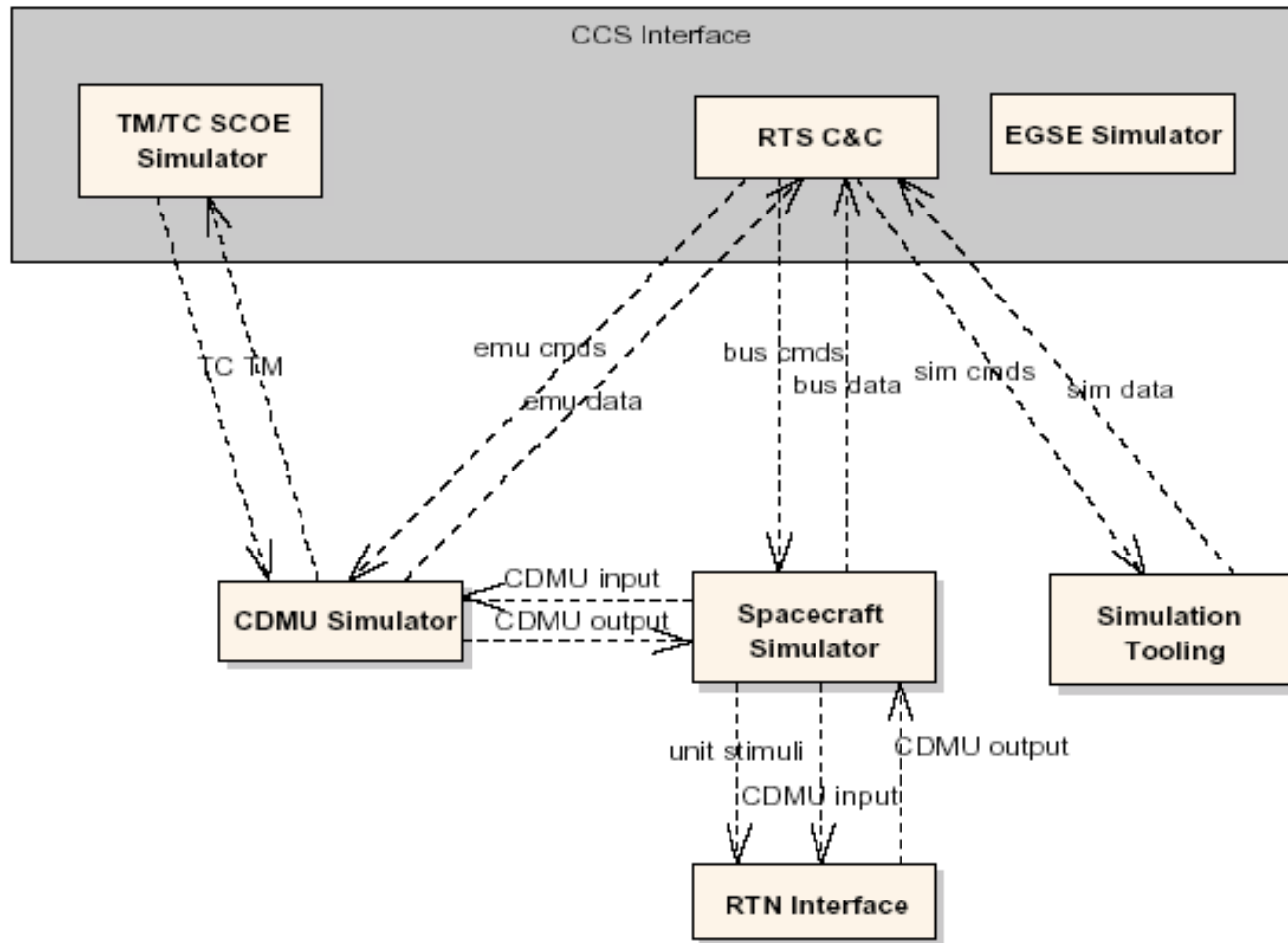
## RTS top level components



## **SIMOPS and C&C**

- **Command & Control**
  - Central RTS component
  - Started at boot-up
  - Provides the command & control interface to CCS and/or SIMOPS
  - Handles a simulation session
  - Relays TM/TC packets between client and CDMU model (i.e. implements TMTC SCOE router)
- **SIMOPS**
  - Provides DynamicJava test environment (IDE)
  - Break-point/single step functions
  - Plugin capability
    - RTS Plugin
    - TM/TC Plugin
  - Configuration file defined by user







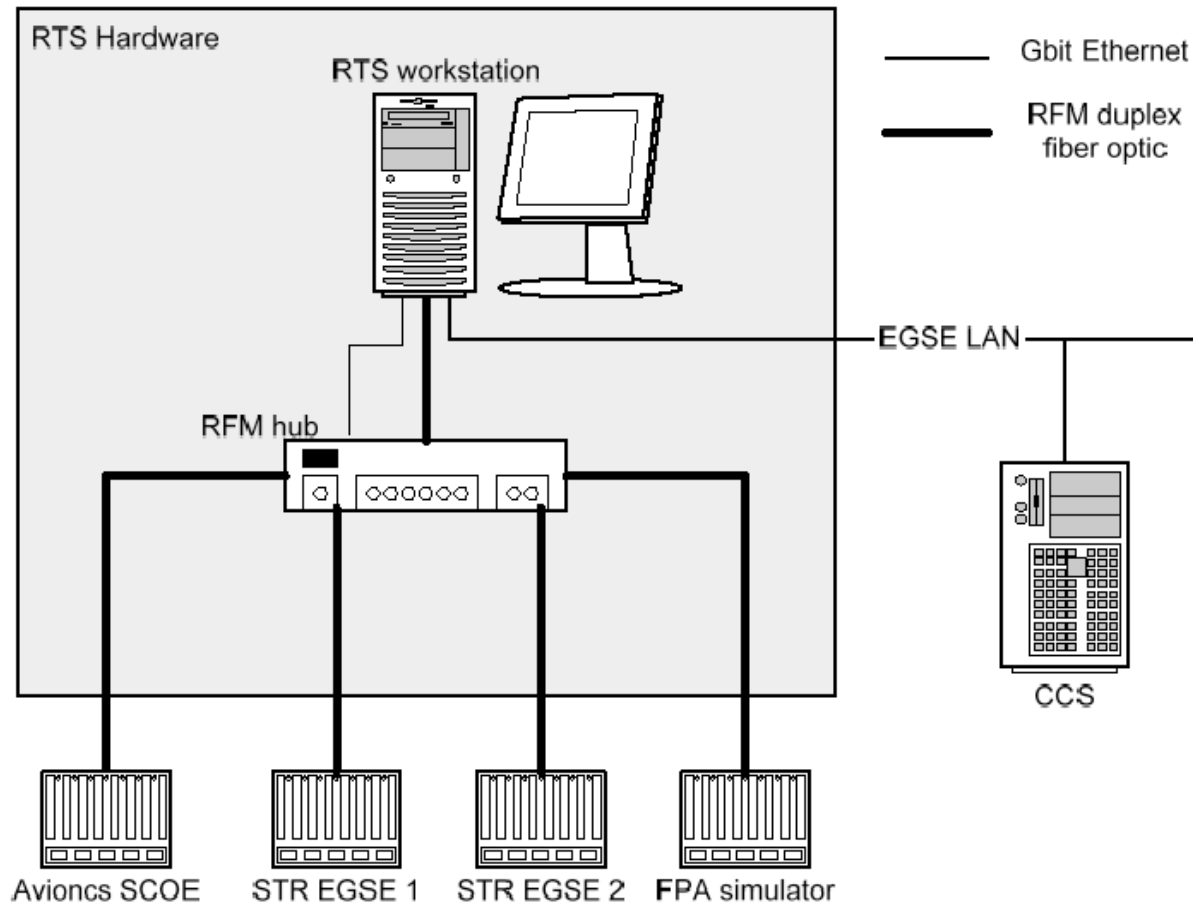
## EuroSim integration with SIMTG

- Full ERC32 emulation (SIMERC32) allows for running exact OBS images, i.e. without modifications
  - Full implementation of the HW/SW-ICD
  - Only 1 user interface for numerical and hybrid bench; same for testing
- Difference between numerical and hybrid bench is a single configuration file
  - Defines automatically which interfaces and models/equipment are active
  - Activation at start-up of the session
- Dual scheduling of 64 Hz timelines for  $T_{ref}$ 
  - Simulation time reference: numerical bench without CCS, RTS local clock
  - CDMU reference time: either hybrid bench (CDMU SCET unit) via AV-SCOE, or numerical bench with CCS (CDMU/SCET simulated), through Mil-bus sync
  - Special precautions to ensure valid data exchanges

## Further EuroSim application in the RTS

- Two categories of models
  - CDMU model + ERC32 emulator
  - Spacecraft models
- Both running inside EuroSim simulation environment
  - Model variables can be accessed from SIMOPS scripts
  - Simulation Controller can connect to a running simulator
  - Logging and recording provided by EuroSim
  - Breakpoints on 64 Hz intervals: simulation block/execute states
- Four types of “responder models” for the S/C simulator
  - Mil-Std-1553B, SpaceWire, PacketWire, discrete (miscellaneous)
  - Kind of router between equipment models and CDMU simulator or AV-SCOE
  - Interface selection is embedded in the responder models
  - Therefore, equipment models are identical for both configurations
  - One parameter, one configuration file reconfigures consistent configuration

# RTS system architecture

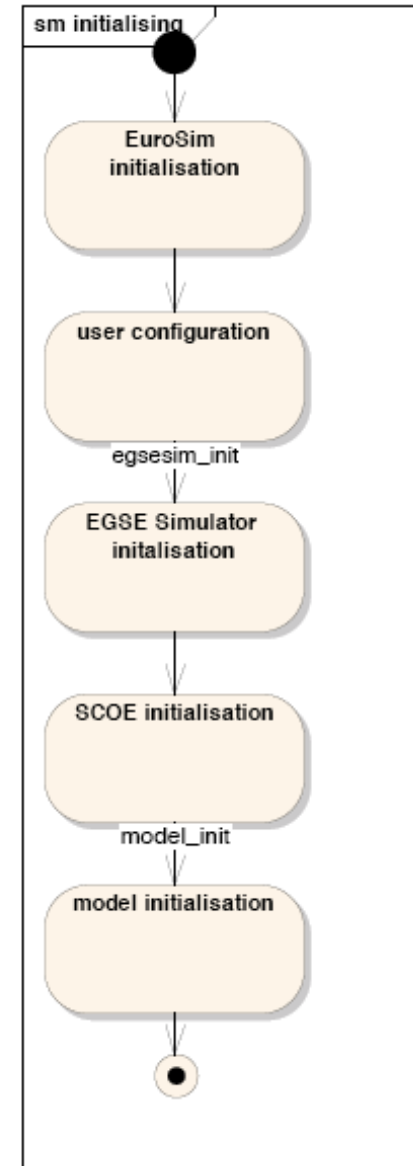
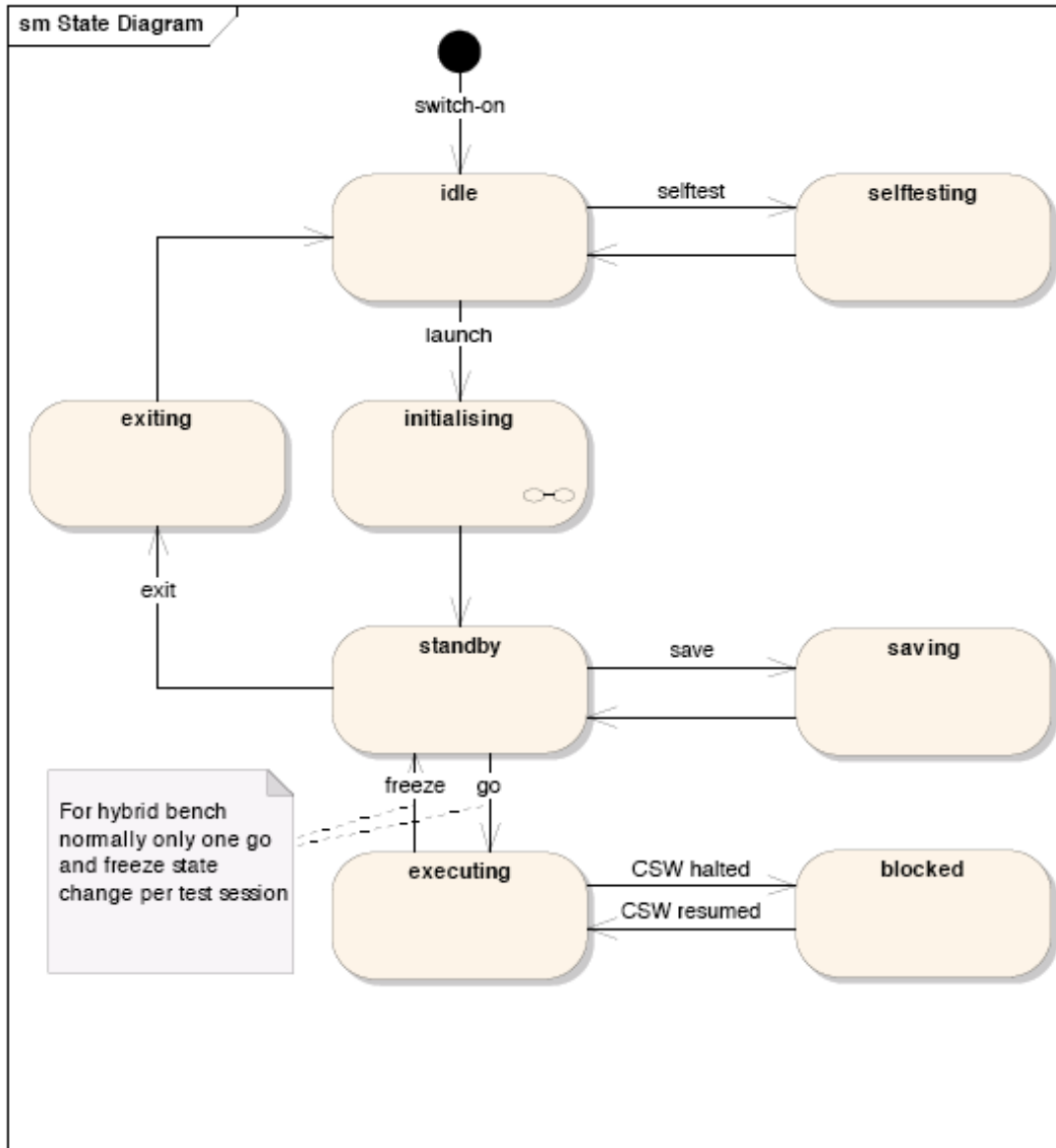


## Avionics SCOE characteristics

- Can be used in stand-alone mode
  - Using elementary RTS
  - Embedded models for closed loop behaviour of models with freq. > 64 Hz (e.g. micro propulsion system)
  - PCDU replacement when flight PCDU is not yet available
- Can be used in open and closed loop modes
  - Responder models being reused
  - Test script defines use modes and models
- Reflective memory interface to the RTS
  - Timed burst transfer
- High bandwidth data transfer (SpaceWire, PacketWire)
- Electrical Interface Unit simulation
  - Flight unit not yet available

## Avionics SCOE characteristics - cont'd

- Standard interface checkout system for SCOE and all cabling
  - In-house development
- Special SpaceWire monitoring developed by NLR
  - Kind of snooping interface
  - No influence on signal, timing (as e.g. in wormhole routing)
  - Buffering of large data streams



## RTS configuration

- RTS selection
  - Numerical or hybrid bench: argument to the “launch” command
- Spacecraft model selection
  - For each model: disable, simulated, stimulus model for flight equipment
- Spacecraft simulator initial value selection
  - Command set, or load initial condition file
- CDMU simulator initial value selection
  - Similar mechanism as for s/c simulator
- SCOE simulator selection
  - Define for each SCOE simulator whether it will be started or not
- SCOE simulator definition
  - Defines the command-response list for SCOE simulators
- Several other commands (not further treated here)

## Summary

- Effective integration of EuroSim simulation environment in Astrium SIMTG
- Highly effective architecture, using same executables for numerical and hybrid benches, configured through single parameter settings
- Single onboard software (OBS) image for numerical and hybrid benches
- Full S/C simulator, including P/L simulation towards OBS
- Dual scheduling mechanisms with internal or external clock
- High data bandwidth interface between RTS and AV-SCOE
- Real-time SpaceWire interfaces
- Non-intrusive SpaceWire monitoring