
# THE EUTEF SIMULATOR MODEL: A HYBRID IMPLEMENTATION FOR OPERATIONS TRAINING AND VALIDATION

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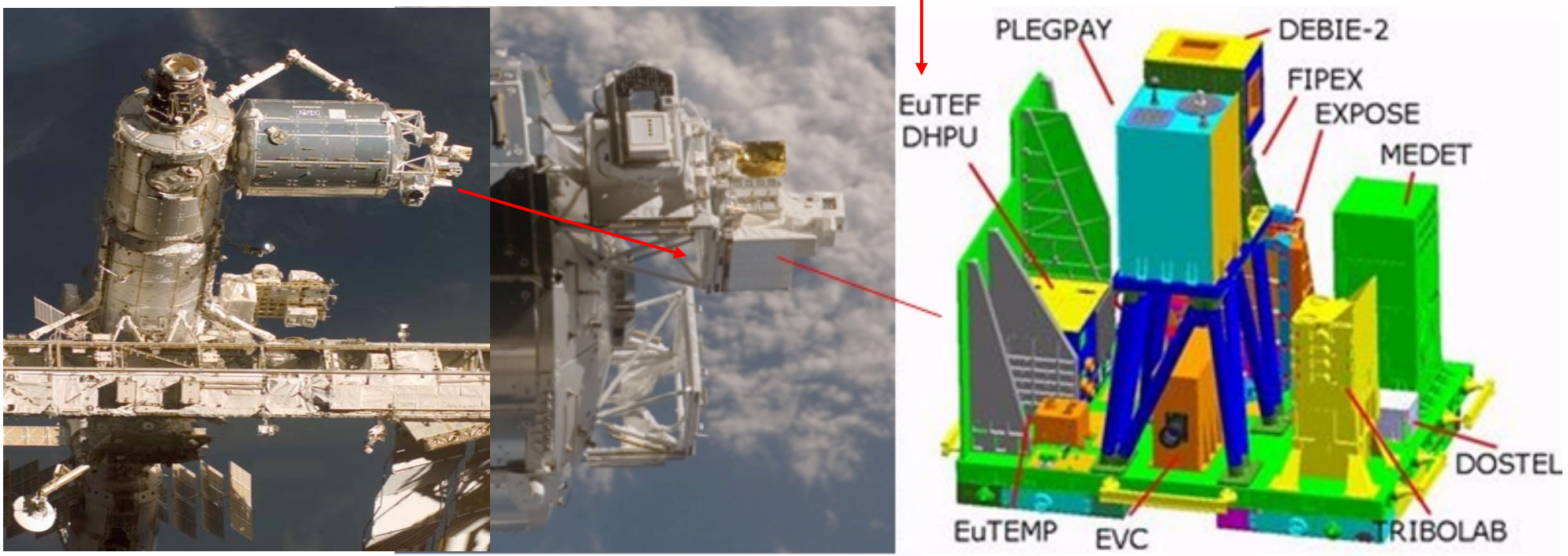
# Overview

- **Simulation Payload Utilisation Columbus**
  - European Technology Exposure Facility (EuTEF) Simulation
  - Simulation at User Support and Operation Centre(USOC)
  - Integration tools in infrastructure
- **EuTEF Simulator Model**
  - EuTEF Data Handling Power Unit (DHPU) central core
  - EuTEF hybrid approach
  - Project description
- **Software and Hardware Design**
  - Stimuli and monitoring hardware
  - Software design
- **Experiences and conclusions**

# EuTEF Simulation

- EuTEF external facility in orbit on Columbus with nine instruments (technology experiments) co-ordinated via EuTEF Data Handing Power Unit(DHPU)
- Engineering Model essential for validation while Flight Model in orbit and for EuTEF only EuTEF DHPU EM available

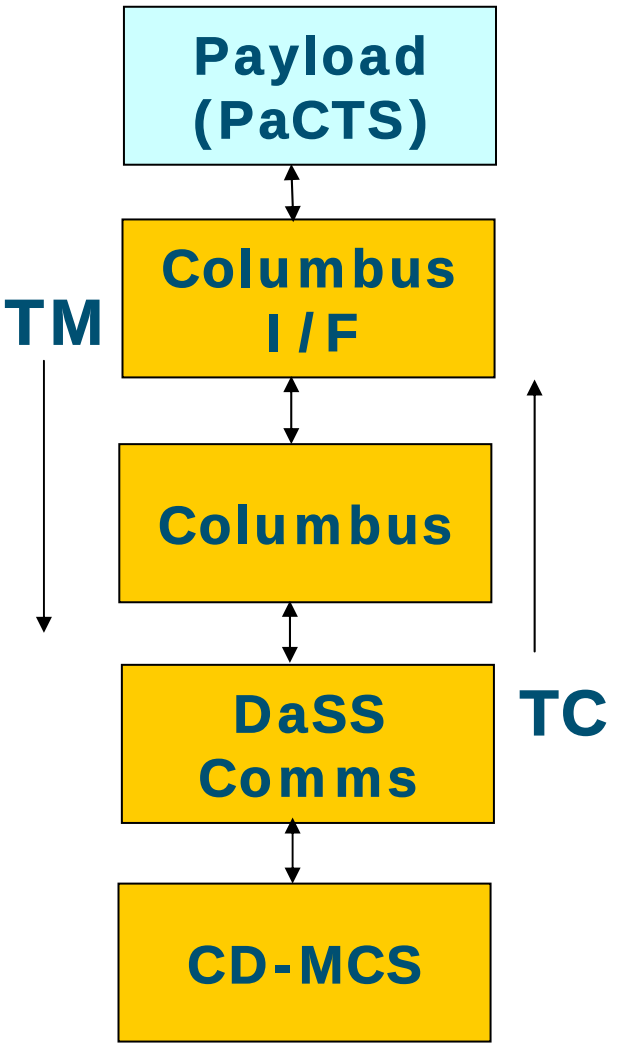


# Simulation at Erasmus USOC

- **Erasmus User Support Operation Centre (USOC) at ESTEC responsible for training and validation operations**
  - European Drawer Rack (EDR) – internal Columbus Facility
  - European Technology Exposure Facility (EuTEF)
- **Environment at USOC for operations**
  - Columbus Distributed Monitoring Control System (CD-MCS)
  - Standardisation and integration with other ground segment centres
- **Simulator objective for training and validation USOC**
  - Preparation and operator training
  - Validation of operational products (procedures, timelines)
- **Simulation used for testing local systems and configuration databases**
- **Generic tools (ESA provided) and payload specific tools(USOC)**

# Generic simulation tools

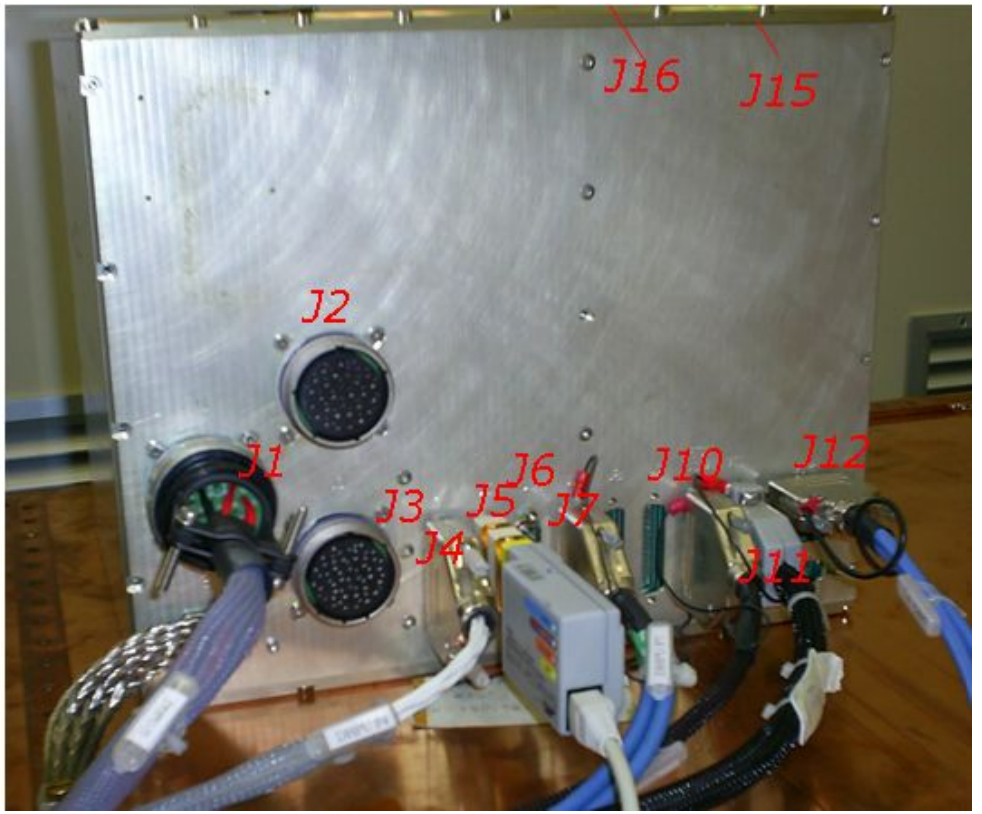
- **DaSS simulation**
  - Data Services SubSystem - DaSS
  - Simulation interface to Columbus Centre and up-/downlink developed by SESS/Col-CC
- **Columbus Simulator**
  - Java based simulation tool developed by SESS Germany
- **Columbus Emulator**
  - Interface to EM and Columbus (Astrium)
- **PaCTS**
  - Toolset including “Microgravity Advanced Research and Support Centre simulator”
- **Local simulation only**
  - EAC, Col-CC, NASA tools not included



# EuTEF DHPU EM central core

- EuTEF DHPU EM central core
- Columbus external and instrument internal interfaces

**Connectors:**
**J1: Power in**
**J2: Power instr. 1-4**
**J3: Power instr. 5-8**
**J4: Discrete cmd 28V**
**J5: Ethernet**
**J6: Temp. sensor**
**J7: Milbus to APM**
**J10: RS-422 Ground test**
**J11: RS-422 instr.**
**J12: Milbus to P/L**
**J15: Temp. sensor.**
**J16: Discrete sign. Instr.**

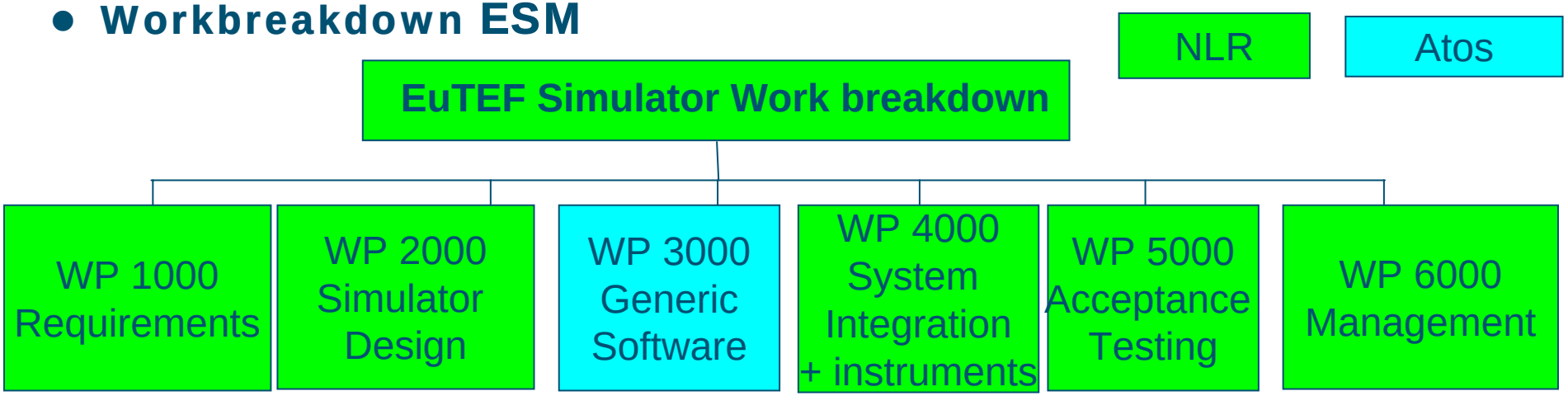


# ESM hybrid approach

- **EuTEF DHPU EM central core**
  - Available as part of development
- **Mimic conditioning and monitoring EuTEF DHPU EM**
  - Stimuli: power load, thermal environment(thermistors)
  - Data handling to instruments: RS-422 and Mil-Std-1553
  - External Columbus interfacing
- **Integrate development model Earth Viewing Camera(EVC)**
  - Realistic model TAXI interface images
  - Mil-Std-1553 interface
- **Interface to instrument Mission DataBase (i-MDB)**
  - Instrument MDB knowledge not available at start of project
  - Central reference for operational products
- **Difference with EDR approach**
  - EDR-PCDF System Simulator (all software)
  - EDR EM + instrument drawer models (all hardware)

# Project description

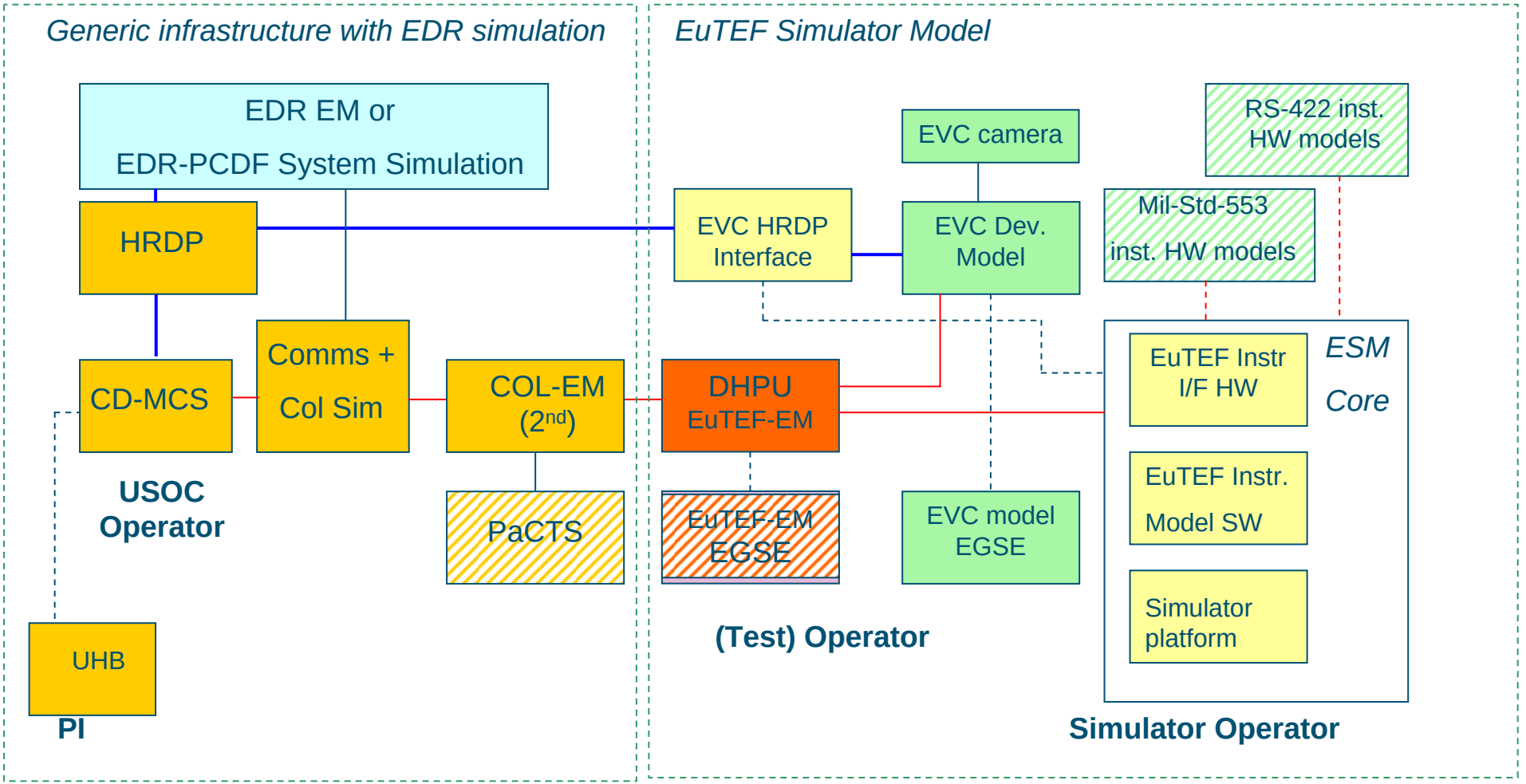
- **Workbreakdown ESM**




- **NLR main contractor, Atos Orgin subcontractor**

- **Funding as part of the Erasmus USOC infrastructure support**

# Integration in USOC infrastructure




Erasmus USOC subsystems

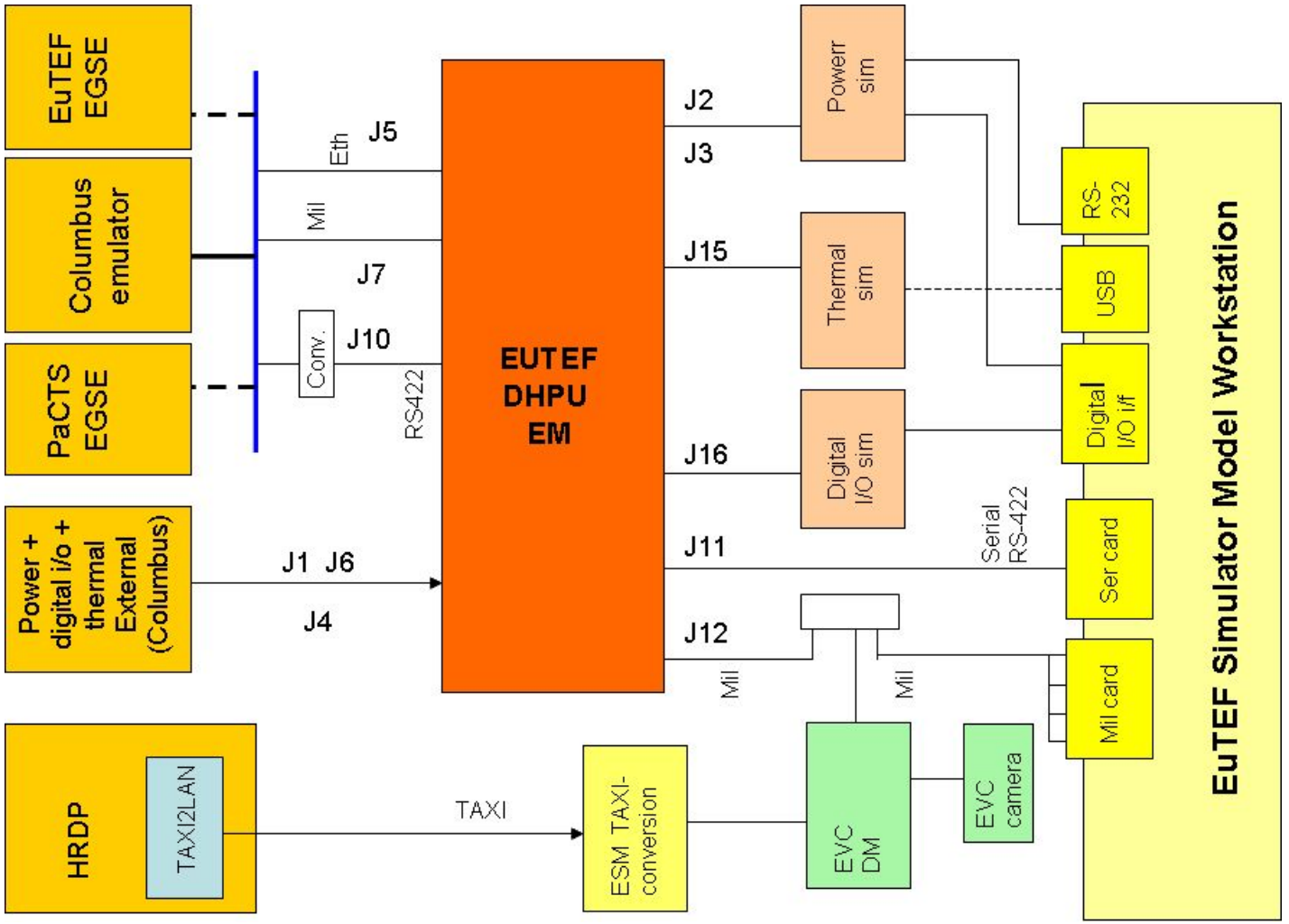
EDR EM .+ software sim.

Instrument HW

EuTEF EM

EUTEF simulator Developments

# Conditioning and monitoring




- Mil-Std-1553 instrument i/f
- RS-422 instrument i/f
- A digital I/O module for power-on
- Digital line detection
- Interface to resistors simulating temperatures

# Integration interfacing hardware

- **Earth Viewing Camera**
  - Hardware interface to convert electrical to optical TAXI for USOC interfacing
- **Power on detection**
  - Instruments started based on powering on of DHPU 28 V outlets
- **Thermal simulation**
  - Manual
  - Software control via relay board option
- **Power load**
  - Simulator control 4 loads
  - RS-232 I/F
  - Manual subset


Bitstream
TAXI conversion

Power-on

Thermal

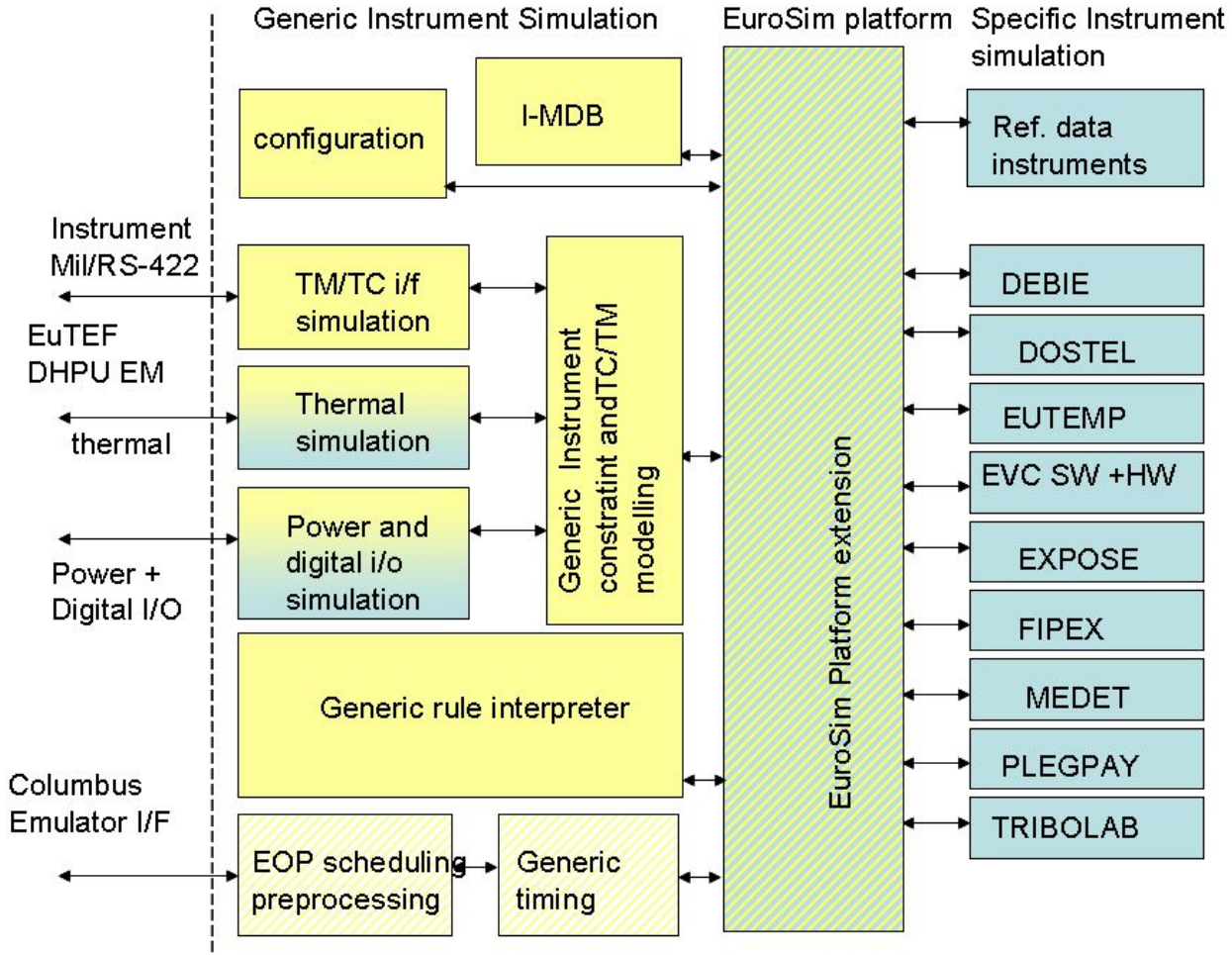
Power load

ESM controlled

Manual

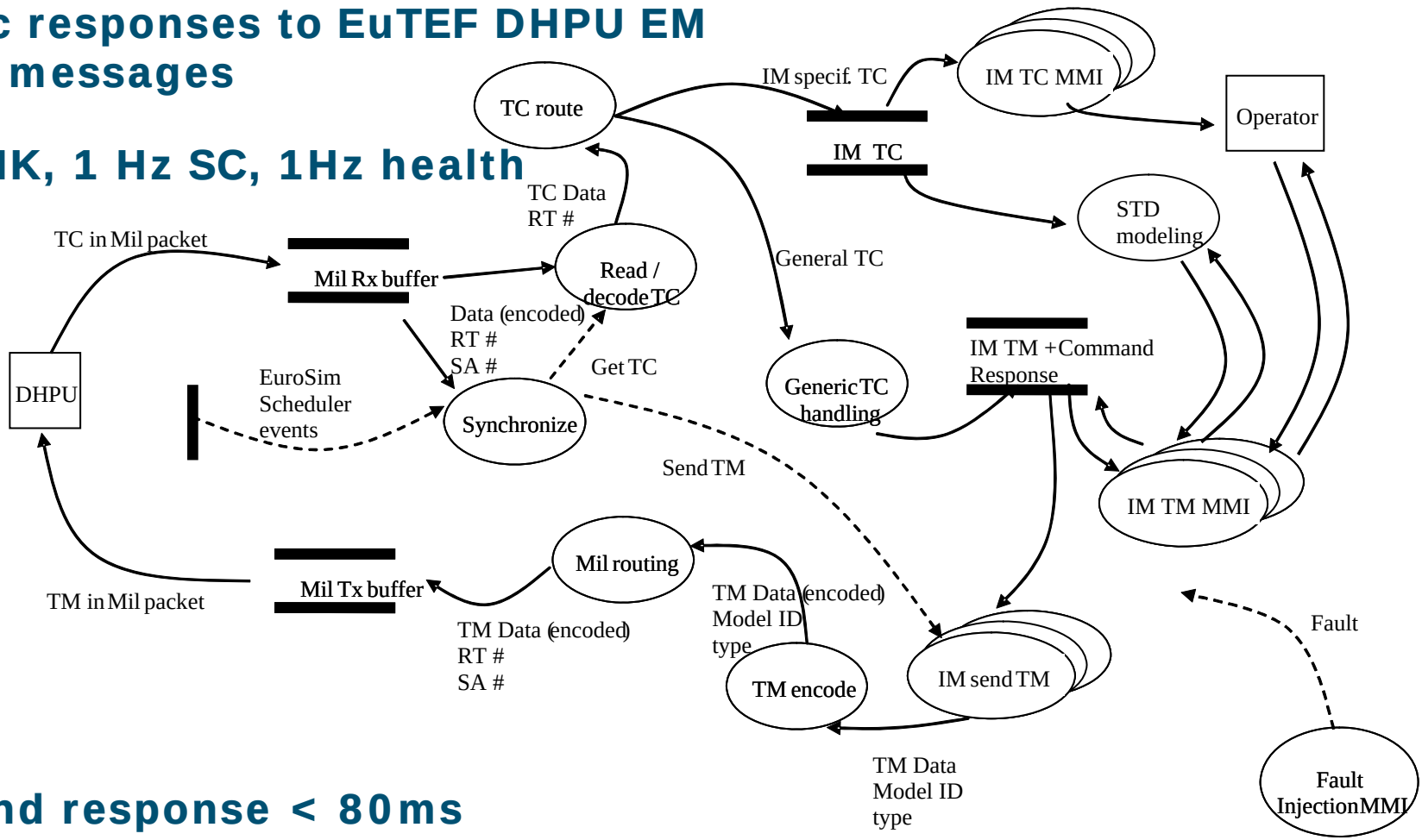
# Software ESM Workstation design

- The generic EuroSim based platform (green / yellow line pattern)
- The generic EuTEF instrument interface software (yellow)
- Specific EUTEF instrument modeling software (blue)



# Generic SW Mil-STD-1553 simulation

- **Realistic responses to EuTEF DHPU EM request messages**
- **0.1 Hz HK, 1 Hz SC, 1Hz health**



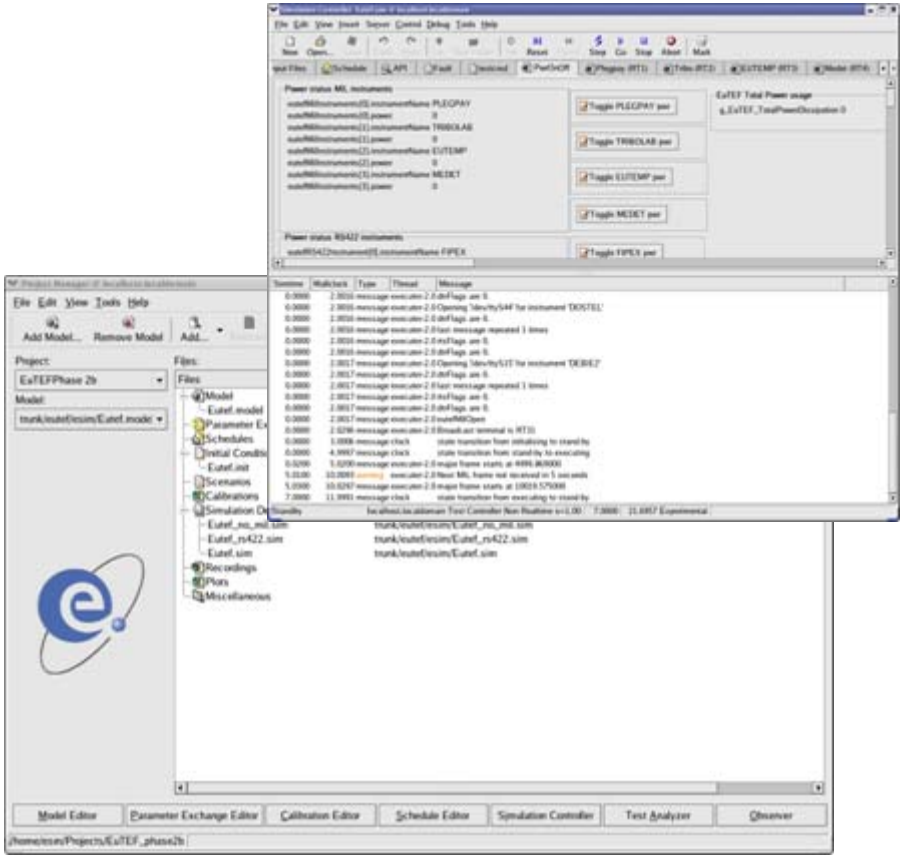

- **Command response < 80ms**

# Payload Models using generic scripts

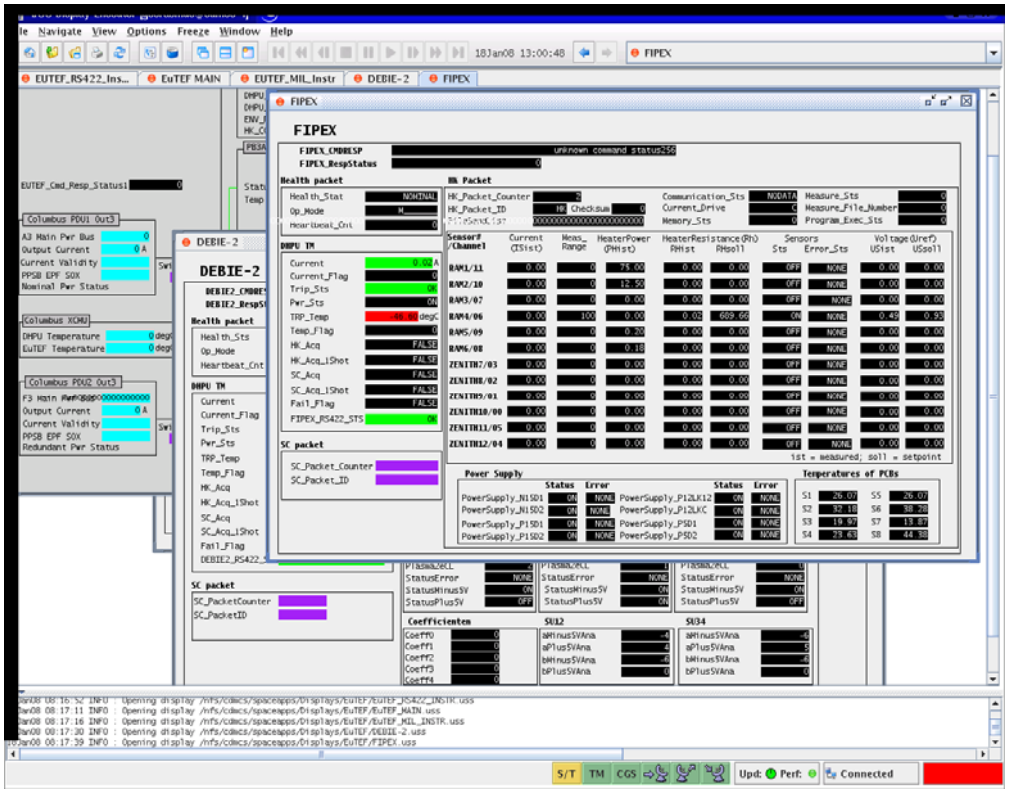
- **Perl Script for i-MDB import and generation of C-functions**
  - Input extracted from CD-MCS operations interface
- **State Transition Diagram**
  - EVENTS, CONDITIONS, ACTIONS
- **PERL script**
  - STD conversion to C-code for integration with EuroSim models

```
PART OF SYNTAX STD-files
definitions = 'DEFINITIONS:', '\n',
c_definitions, '\n'
'ENDDEFINITIONS', '\n' ;
c_definitions = <any C code in global scope> ;
event = 'EVENT:', event_trigger, '\n',
[ 'CONDITIONS:', conditions, '\n', ]
[ 'RESPONSE:', response_statement, '\n', ]
[ 'COMMENT:', quoted_string, '\n', ]
'ACTIONS:', '\n',
c_statements,
'ENDACTIONS', '\n' ;
```

# User interfaces



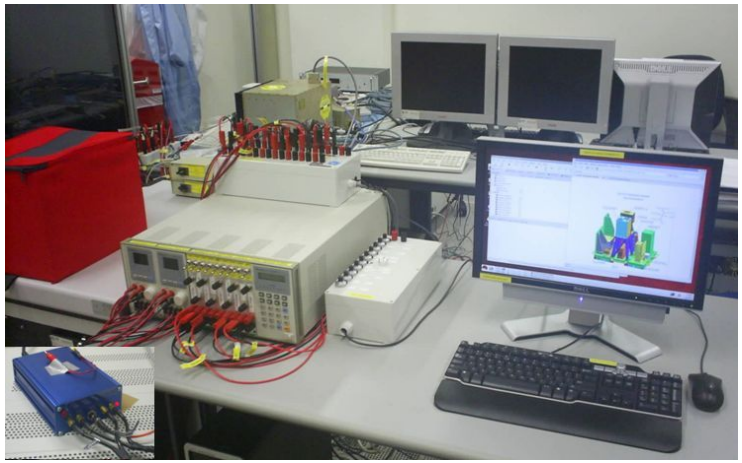
Simulator interface (EuroSim)



EuTEF Operator interface (CD-MCS)

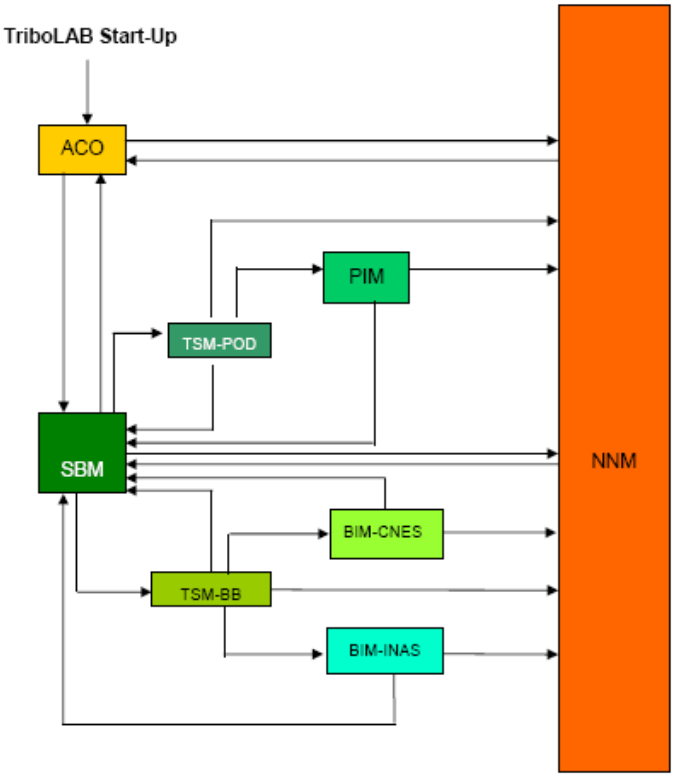
# Experiences (1)

- **Integration with on-going developments**
  - Phased approach
  - Training and familiarisation in parallel
- **Instrument MDB import**
  - Performed several times during development for new updates
- **EuTEF DHPU EM use**
  - Essential for on-board debugging
  - Dependency on availability
- **Real-time vs non real-time**
  - Timelined operations involved separate development Space Applications Services, Belgium, partner in Erasmus USOC
- **Change to 24-hours operations**
  - ESM use for new operators



# Experiences (2)

- **Options to integrate experiences during flight operations**
  - Reuse FM experience via i-MDB validation
  - During operations limited developmen
- **Integration of Earth Viewing Camera**
  - Hardware references essential
  - Software simulation backup
- **Additional instrument Models available**
  - Compatility allowed integration
  - Software simulation for fault-injection
- **TRIBOLAB state model**
  - Procedure validation
- **Software simulation DEBIE-2**
  - Mix of software and hardware model use for debugging of interfaces



# Conclusions

- **Hybrid approach challenging**
  - Realism EuTEF DHPU EM hardware required
  - Additional instrument models appreciated
  - Software simulation essential tools
- **Generic and payload specific simulation tools**
  - All used in USOC environment for operations training and validation
- **Flexibility demonstrated**
  - Configuration changes
  - Resolution of issues during preparation and flight operations with integration of lessons learned

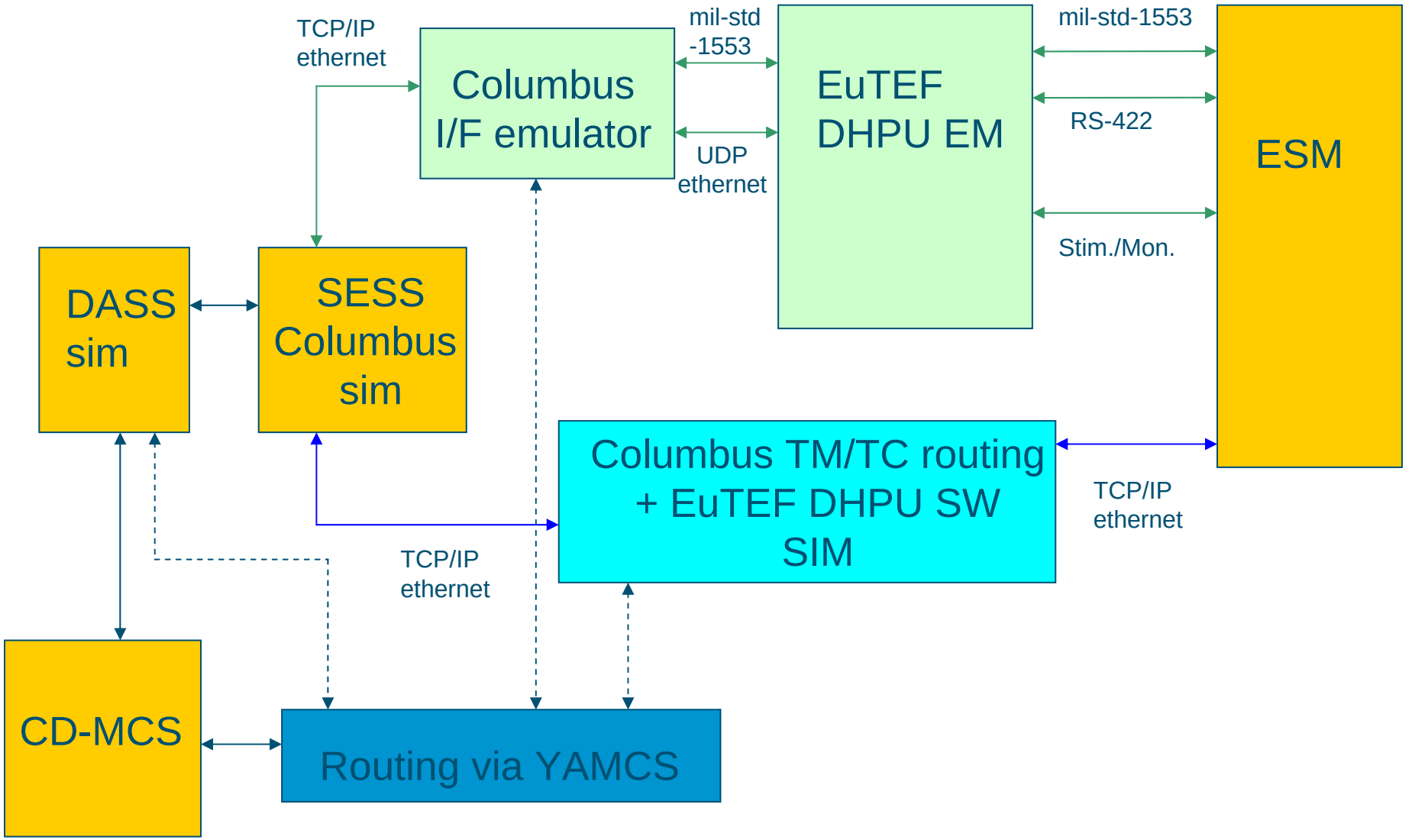
# Closure

- **Thanks for your attention**

- **Questions/comments?**

- **Acknowledgements**
  - ESA contract no. 13980/99/NL/PG: WO-14 realised with Dutch national support for the Erasmus USOC
  - Carlo Gavazzi Team for support use of EuTEF DHPU EM
  - Support at NLR on hardware and software integration
  - Operators at Erasmus USOC for inputs

# Backup option for EuTEF DHPU EM



# instrument-MDB and facility MDB

- **PaCTS related MDB for DHPU EM, i-MDB for ESM**