

ACOSIM

Application of co-simulation to support tests and operations

29 September 2020

▼ ESA/ESTEC TRP project:

- ▼ Project reference: AO/1-8777/17/NL/GLC
- ▼ Project duration: 2018 -2020
- ▼ Project budget: 600,000 EUR

▼ Consortium members:

- ▼ Prime Contractor: EMTech Space P.C.
- ▼ Sub-Contractors:

Thales Alenia Space Italia S.p.A,
TWT GmbH Science and Innovation,
Aarhus University



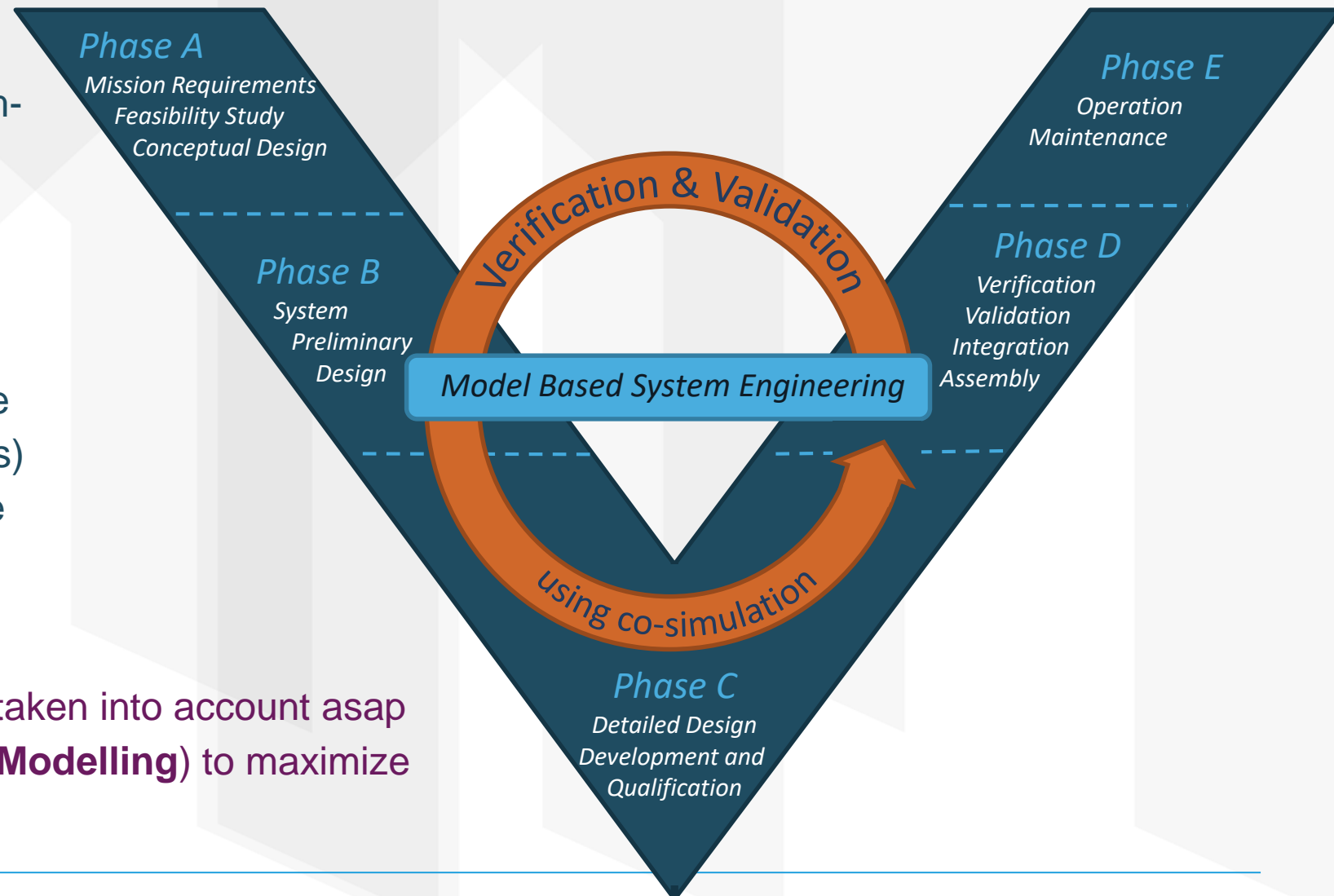
TWT GmbH
Science & Innovation



ACOSIM – Application of co-simulation to support tests and operations

High Level Objectives

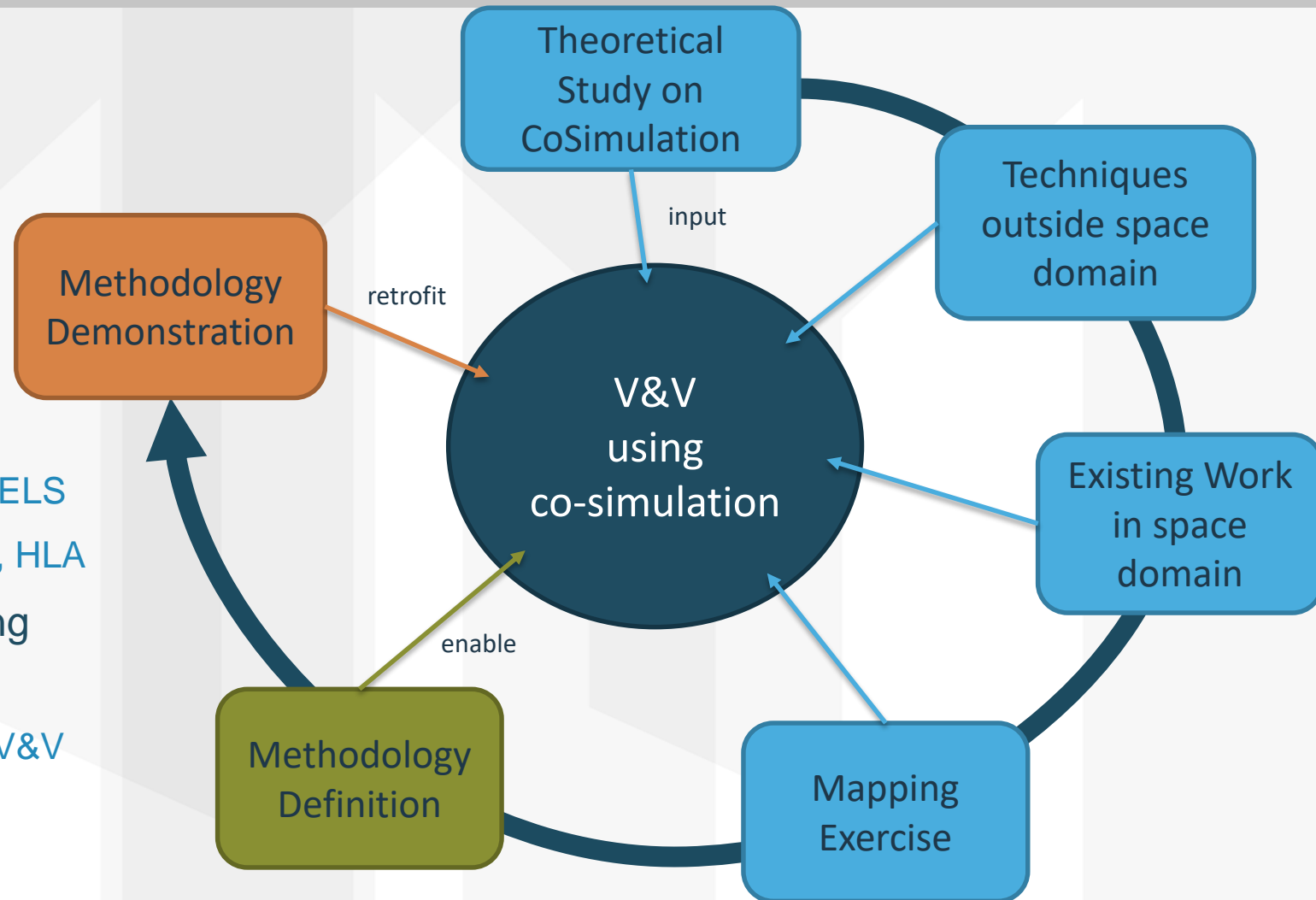
- ▶ **FMI* and Co-Simulation**, as enabling technology for the System-Level simulation
- ▶ Improve the current **Verification, Validation and Operations** processes
- ▶ Promote **vertical reuse** (within one project between simulation facilities) as well as **horizontal reuse** (reuse from one project to another)
- ▶ Co-simulation aspects have to be taken into account asap (during MBSE and **System Level Modelling**) to maximize its benefits



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Project approach

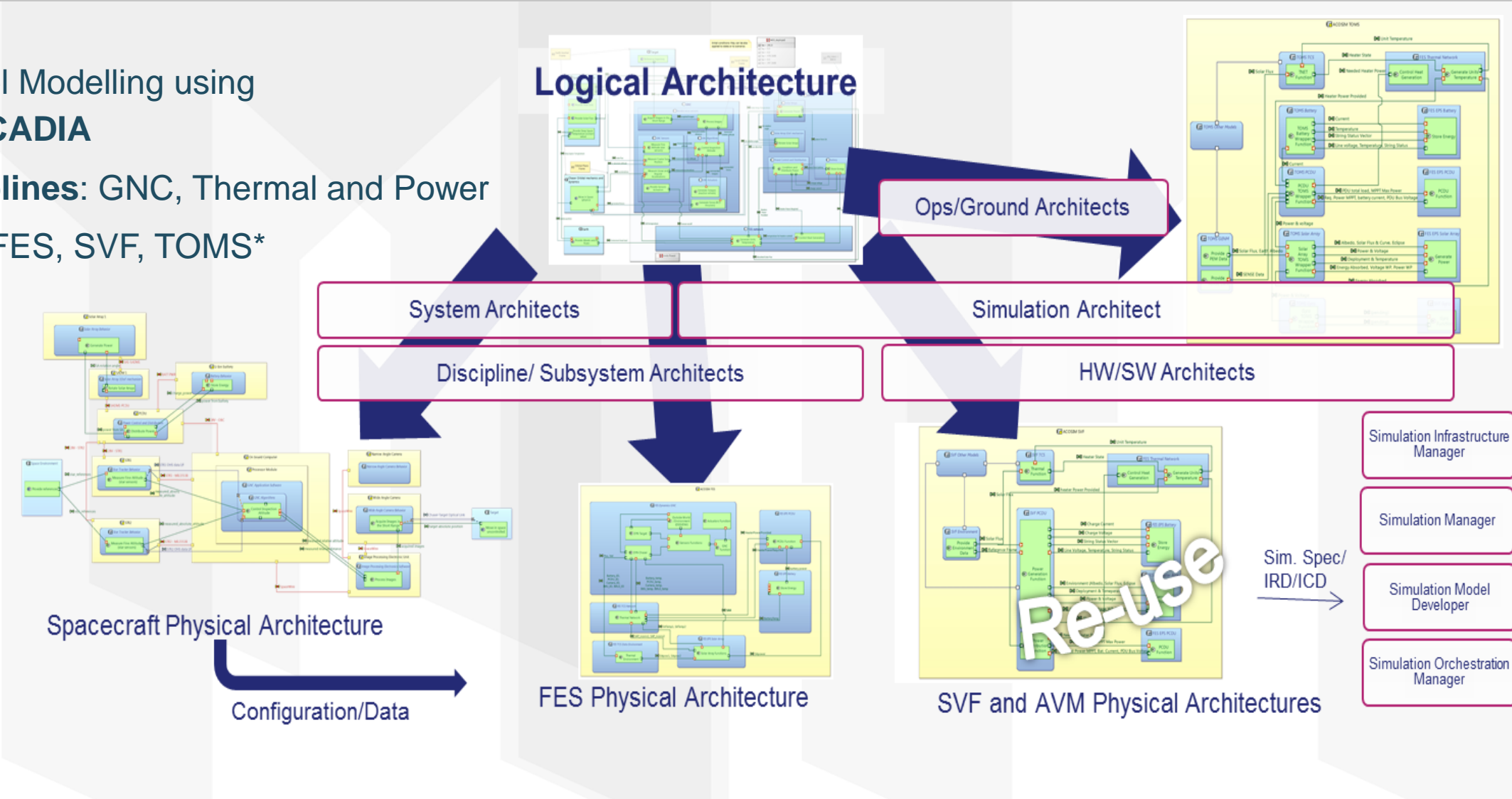
- Study Co-Simulation outside the space domain
 - Functional Mockup Interface (FMI)
 - Automotive projects
- Space domain previous work
 - ECSS-ETM-10-21, ECSS-ETM-10-23,
 - VSD, FSS-MBSE, NMM, SVTLC, MARVELS
 - ARCADIA/Capella, SMP2, REFA, SSRA, HLA
- New Methodology definition for V&V using co-simulation
 - Design V&V, Software V&V, Operations V&V
- Methodology Demonstration
 - 3 Proof of Concepts (FES, SVF, TOMS)



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MBSE approach

- System Level Modelling using Capella/ARCADIA
- Three disciplines: GNC, Thermal and Power
- Three SSF: FES, SVF, TOMS*

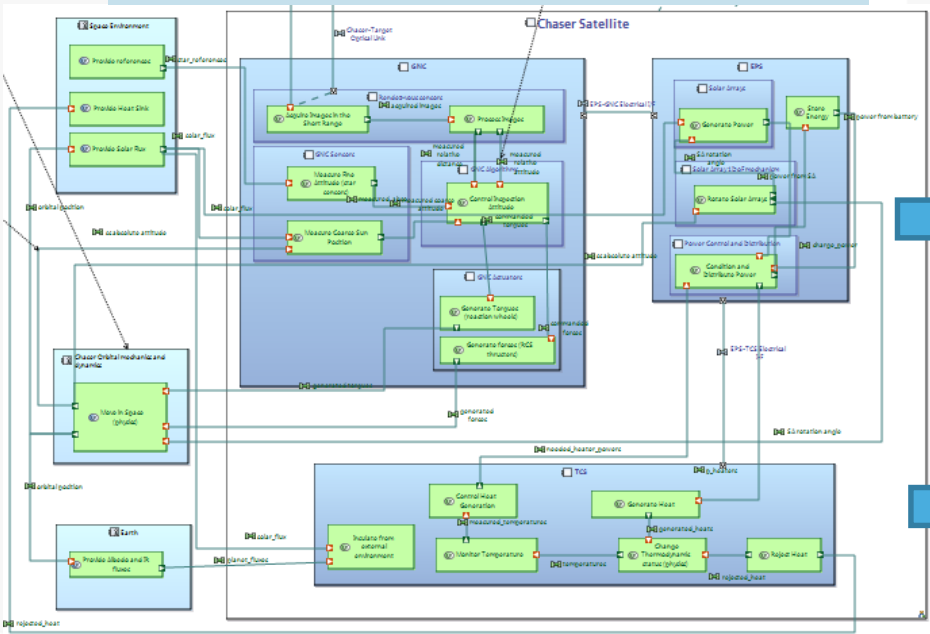


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MBSE approach

- Capella Design Analysis for Co-Simulation and Tracking with SADM (developed in NMM*)
 - Bridge the gap between System Modelling and System Repository
 - Track dependencies/changes → interfaces, models, simulation models, configuration files, test data etc.

System Level Modelling (Capella)



Automated population

Template generation

Dependencies Management (SADM)

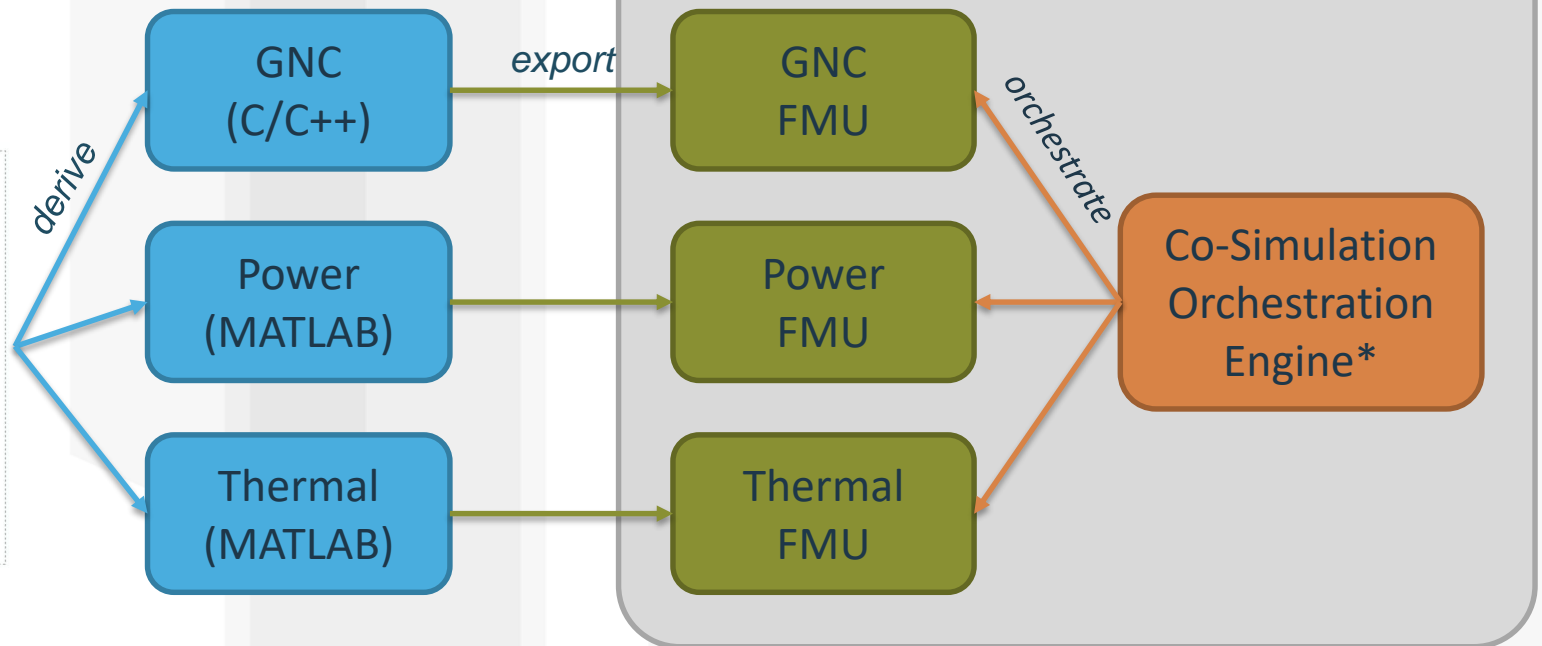
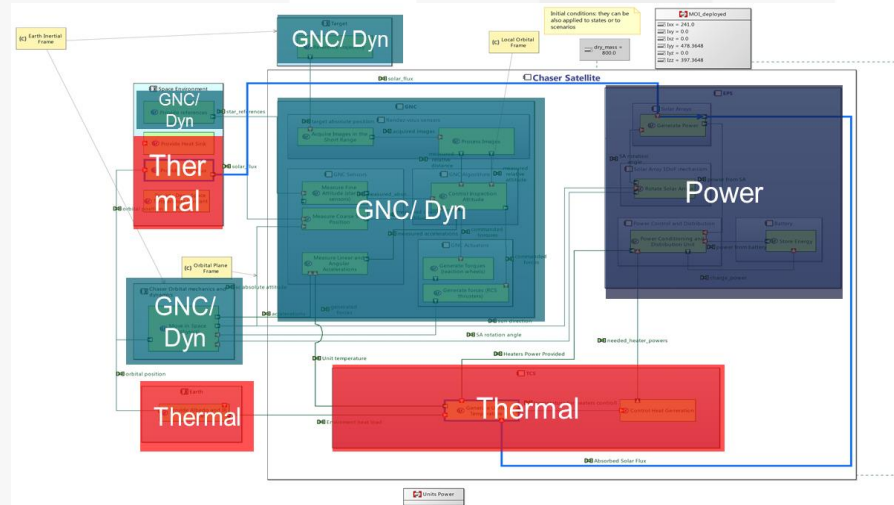
FMI model description

```
<?xml v
<fmiModelDescription xmlns="http://www.fmi-standard.org/2008/01/..."
<CoSimulation modelIdentifier="{modelName}"
  canHandleVariableCommunicationStepSize="false" ...
</CoSimulation>
<LogCategories><Category name="logAll" /> ... </LogCategories>
<ModelVariables>{{#each variables}}{{#if fmi}}
  <ScalarVariable name="{name}"
    valueReference="{fmi.valueReference}"
    causality="{fmi.causality}"
    variability="{fmi.variability}" >
    <{{fmi.descriptor}} {{#if input}}start="{value}"{{/if}}
    {{#if parameter}}start="{value}"{{/if}} />
  </ScalarVariable>{{/if}}{{/each}}
</ModelVariables>
<ModelStructure> ... </ModelStructure>
</fmiModelDescription>
```


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PoC 1: Co-Simulation in Functional Engineering Simulation

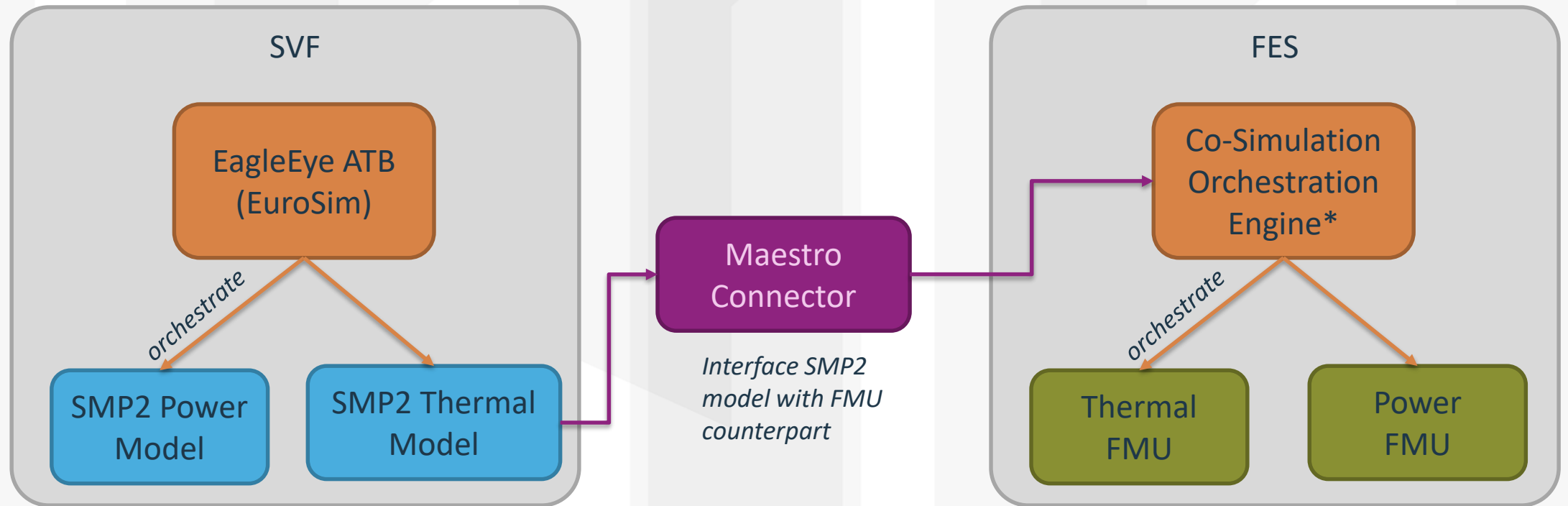
- Collaborative Functional Engineering Simulator
- GNC, Thermal & Power models co-simulation
- FMI based co-simulation orchestration



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PoC 2: FES – SVF co-simulation

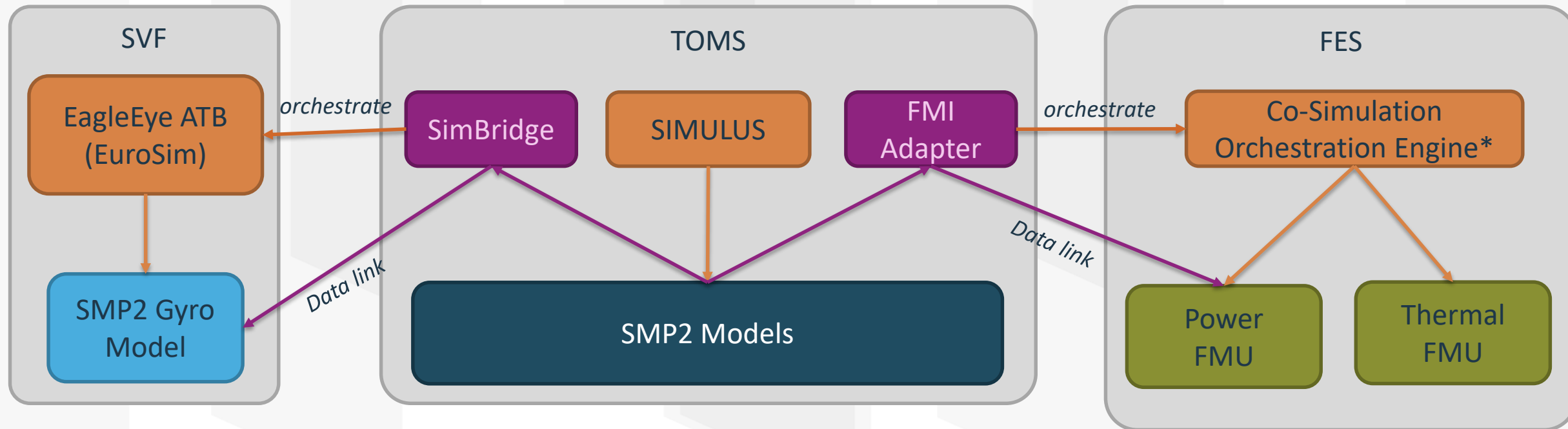
- Collaborative Software Validation Facility
- Thermal & Power models co-simulation
- SMP2/FMI based co-simulation orchestration



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PoC 3: FES – SVF – TOMS co-simulation

- Collaborative Training, Operations and Maintenance Simulator
- Thermal, Power & Gyro models co-simulation
- SMP2/FMI based co-simulation orchestration



- ▶ New **Verification & Validation Methodology** using co-simulation
- ▶ **FMI** standard in the space domain
- ▶ **MBSE** approach to enable co-simulation from early phases
- ▶ 3 PoCs developed
 - ▶ FES (GNC, Power & Thermal)
 - ▶ SVF – FES
 - ▶ TOMS – SVF – FES
- ▶ **Co-Simulation Software Enablers** developed:
 - ▶ Capella – SADM interface → system model dependencies' tracking
 - ▶ Maestro Connector → SMP2 – FMI Orchestrator interface
 - ▶ SimBridge for EuroSim → SIMULUS – EuroSim interface
 - ▶ FMI Adapter for SIMULUS → SIMULUS – FMI Orchestrator interface

Thank you for your attention!



“We are what we repeatedly do.
Excellence then, is not an act, but a habit.”
Aristotle



EMTECH
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www.emtech.global

32 Korinthou Str. & S.Davaki, 14451, Athens, Greece
tel.: +30 2106528527 fax: +30 2106528717 em: info@emtech.global



HUBCAP

HUBCAP: An Online MBSE Collaboration Platform

Peter Gorm Larsen, Hugo Daniel Macedo, John Fitzgerald, Holger Pfeifer, Martin Benedict, Stefano Tonetta, Angelo Marguglio, Lorenzo Franco Sutton, Sergio Gusmeroli, George Suciú Jr. and Prasad Talasila

PROJECT PARTNERS

Aarhus University

Fortiss GmbH

Fundazione Bruno Kessler

University "Lucian Blaga" of Sibiu

Research Institutes of Sweden

Politecnico di Milano

Controllab Products

Verified Systems International

Technology Transfer Systems

Newcastle University

Virtual Vehicle Research

KTH Royal Institute of Technology

Engineering Ingegneria Informatica

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Unparallel Innovation

BEIA Consult

Validas



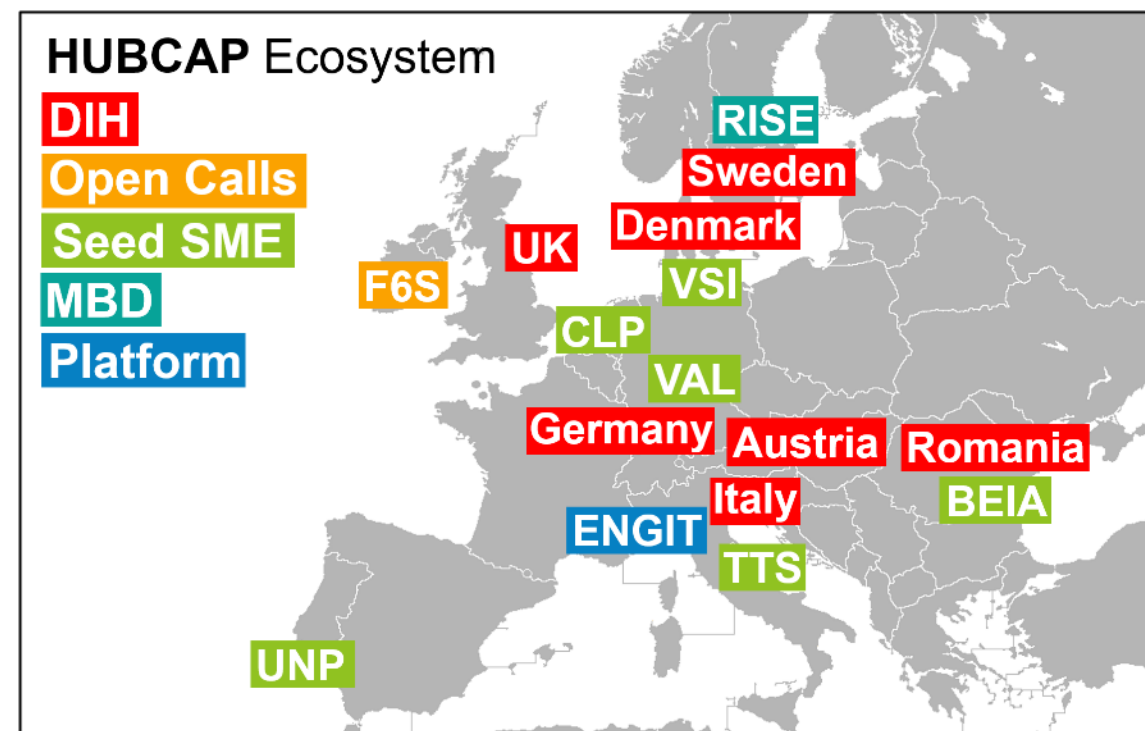
ABOUT HUBCAP



HUBCAP

• Who we are

- **Innovation Action** co-financed by the European Commission, DT-ICT-01-2019 Smart Anything Everywhere initiative.
- **Coordinator** Aarhus University, Denmark
- **Project duration** January 2020 - December 2022, 36 months
- **Total EC contribution** EUR ~7.95M
- HUBCAP will provide a one-stop-shop for European SMEs wanting to join the Cyber-Physical Systems (CPS) revolution using Model-Based Design (MBD) techniques.
- **Vision** Lower barriers for SMEs to realize the potential of growing autonomy in CPS by accessing advanced model-based design (MBD) technology, providing training and guidance.





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ABOUT HUBCAP

• What we offer

Network of DIHs:

- Inventory of service offerings
- Ecosystem building
- Cross-DIH collaboration
- Network sustainability

Seed SMEs

- Enabling quicker start for the platform
- Early-stage prototypical usage of HUBCAP
- Awareness-raising demonstrations

Collaboration Platform:

- Cloud-enabled, based on DIHIWARE
- “Access to” and “Collaborate with”:
 - Ecosystem
 - Community-building
 - Marketplace
 - **Sandbox**

Open Calls

- Engage early-adopters
- 3 open call series

Model-Based Design:

- Populating the platform
- Enabling model-based services in sandbox
- Multi-user, validation and logging capabilities





HUBCAP

HUBCAP OPEN CALLS

HUBCAP has a €3.2 million equity-free fund for SMEs to experiment and innovate with digital technologies



Call #1 Pull

Does your SME/midcap provide existing and marketable CPS & MBD tools and services? Integrate your asset in the HUBCAP platform and find potential new customers and collaborators in the subsequent open calls.

1000€
per SME



Call #2 Experiment

Is your SME/midcap looking to embrace digital innovation? Connect with a supplier from the HUBCAP platform and receive tailormade support and services to co-create and experiment with CPS & MBD tools.

30,000€ to 75,000€
per consortium of 2 SMEs



Call #3 Innovate

Develop and implement highly innovative and challenging CPS & MBD experiments. Create new products and services and benefit from business and technical support from the HUBCAP experts for highest impact.

Up to 200,000€
per consortium of 2-3 SMEs

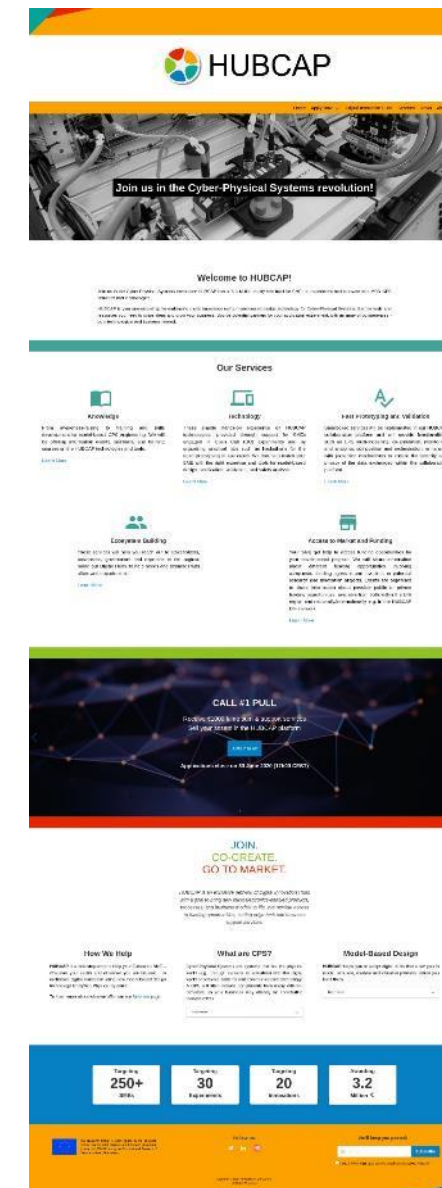
Non-EU/SMEs are also welcome to share their assets, but cannot apply to the OCs!



HUBCAP Collaboration Platform

Model-Based Design of Cyber-Physical Systems: HUBCAP!

- Limit initial investment for newcomers (get an online sandbox capability, free to use)
- In particular SMEs typically closely collaborate/deliver to larger organisations (collaboration platform, pay as you go rather than licences per seat)
- Getting SMEs started with first projects using MBD (DIHs will support for these, but since they have different strengths get them to collaborate)
- Getting funding enabling investment (open calls)
- Can we also use this to start filling the collaboration platform (the seed SMEs + first open call round)





HUBCAP

HUBCAP Collaboration Platform

The Tools Catalogue

HUBCAP HUBCAP

Catalogues / Tools Catalogue

TOOLS

Search for snippets, click on caret

Tool HUBCAP Tool

INTO-CPS APPLICATION
The INTO-CPS Application is the fronted of the INTO-CPS Tool Chain. It is used to configure and run FMI-based c...

OVERTURE
he Overture community supports the modelling method The Vienna Development Method (VDM) which is a s...

AUTOFOCUS3
AutoFOCUS3 is a model-based tool and research platform for safety-critical embedded systems. It builds on a gener...

OPENMODELICA
OPENMODELICA is an open-source Modelica-based modeling and simulation environment intended for industrial a...

OCRA
A command-line tool for the verification of
DRAFT

XSAP
xSAP is a tool for safety assessment of
DRAFT

Send Report





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HUBCAP Collaboration Platform

The Models Catalogue

HUBCAP HUBCAP

Catalogues / Models Catalogue /

MODELS CATALOGUE

Search for snippets, click on caret

Model

THREE TANK WATER TANK

The three-tank water tank model is based upon a standard 20-sim example, and is developed to explore the impact ...

LINE FOLLOWER ROBOT

This example was originally developed in the DESTACS project. The model simulates a robot that can follow a line painted ...

TRIPLE MODULAR GENERATOR

The Triple Modular Generator represents a power generator with Triple Modular Redundancy. It can be used to try vario...

FORTISSIMO (FF1)

The model represents software-defined functions in the scale 1:10 miniature car "fortissimo" ("ff1" for short) developed ...

MULTIPLE EMERGENCY VENTILATOR

Dynamic Models of the Multiple Emergency Ventilator, a 10+ bed low-cost medical ventilation system. These models we...

ADAPTIVE CRUISE CONTROL

The model represents a set of software-defined functions that implement an Adaptive Cruise Control. It manages t...

Send Report



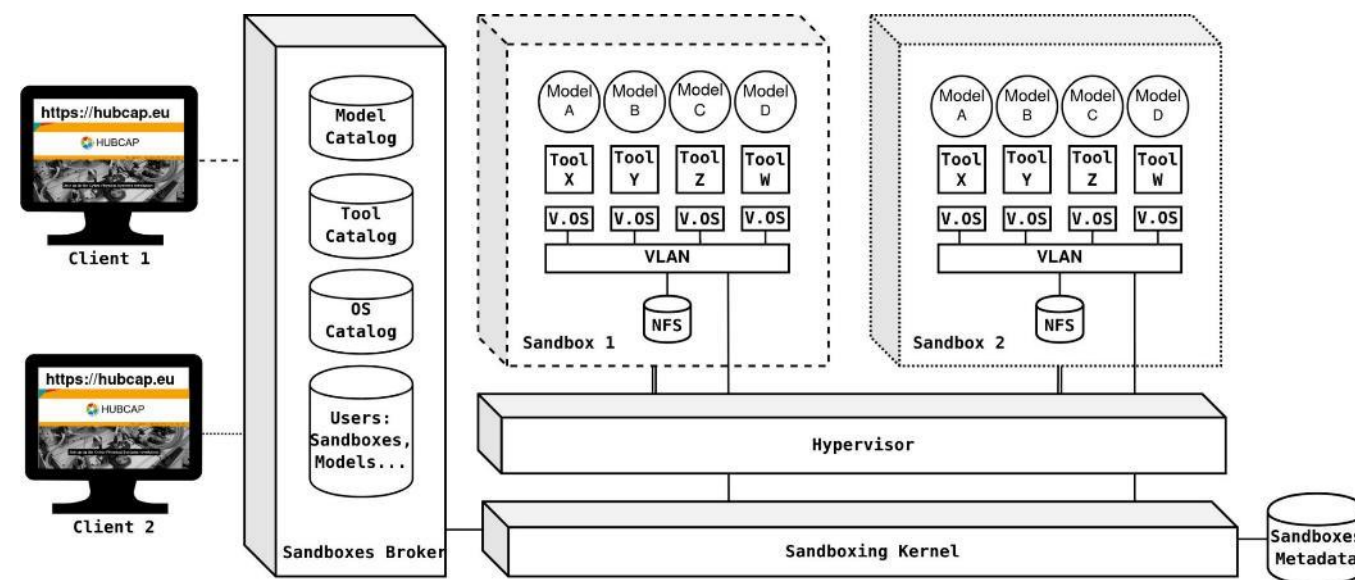
HUBCAP Collaboration Platform



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The Sandbox

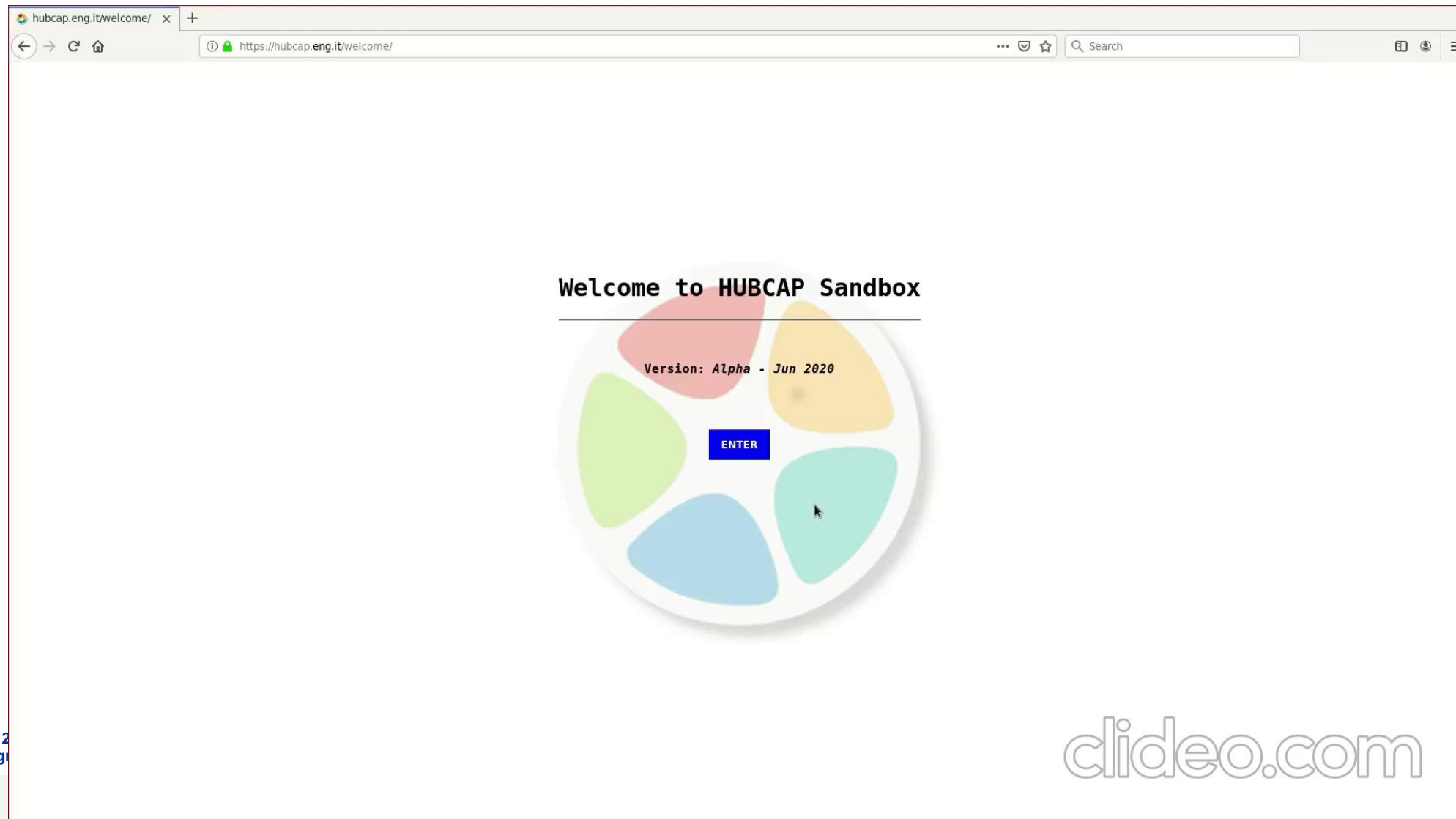
- Enables Interaction between:
 - Tool Providers
 - Users/SMEs
- Ready-to-use
- Pay-as-you-go



Demonstrating the Sandbox Setup



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The Sandbox Collaboration Possibilities



HUBCAP

hubcap.eng.it/sandbox/

https://hubcap.eng.it/sandbox/sandboxes/resume/hugodm

hugodm [provider] INTO-CPS-Demo1t Overture-2.7.5-RC2t

Connected to QEMU (20200624-205828-138986018_INT0-CPS-Demo1t) Ctrl Alt Win Tab Esc Fullscreen

Project: Three Tank - /nfs/...

Project: Three Tank - /nfs/toolsdata/hugodm/tutorial_1

File Edit View Window Help

DOES FMUS 3DAnimationFMU threewatertank1 threewatertank2 WaterTankController MODEL-CHECKING MODELS threestank WaterTankController MULTI-MODELS 3D Experiment1 Non-3D RESOURCES SYMUL ThreeTank_MM ThreeTank_MM_3D TEST-DATA-GENERATION TRACEABILITY

INT0-CPS > 3D > Experiment1

Configuration Edit Basic Configuration Visibility Stabilization Live Plotting Results Saving Others Post-Processing Simulation Co-Simulation Engine, version 1.0.4, online at http://localhost:8062/version. Run

COE Console COE Log Trace Daemon Log

Go Home Logout Destroy sandbox

Browse... No file selected. Upload archive

Choose a .tar.gz or .zip archive

Download archive

Tool name

Tool Description

Save as a tool

Invite as guest

adrianp basg dariop frankz pbraghieri pietrog pinov plutino plutone prasad

HUBCAP Collaboration Platform



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Concluding Remarks

- HUBCAP Project
- Open Calls for EU SMEs providing or interesting in MBD of CPS
- A Cloud-Based Collaboration Platform for Model-Based Design of Cyber-Physical Systems
- Join us:
 - <https://www.hubcap.eu/>
 - https://twitter.com/hubcap_eu
 - <https://www.linkedin.com/company/hubcap-eu/>

