CLEAN AVIATION

ODE4HERA

Open Digital Environment for Hybrid-Electric Regional Architectures

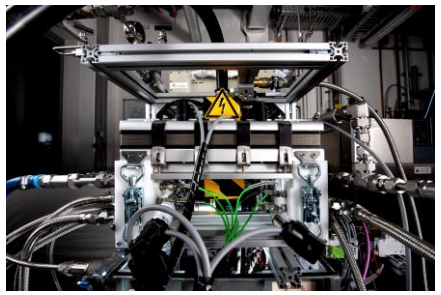
Project Overview

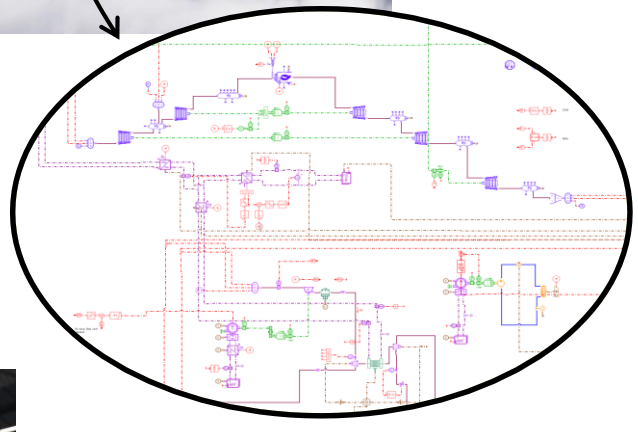
4th EU MDO Workshop

June 2025, Toulouse

Co-funded by
the European Union

Motivation

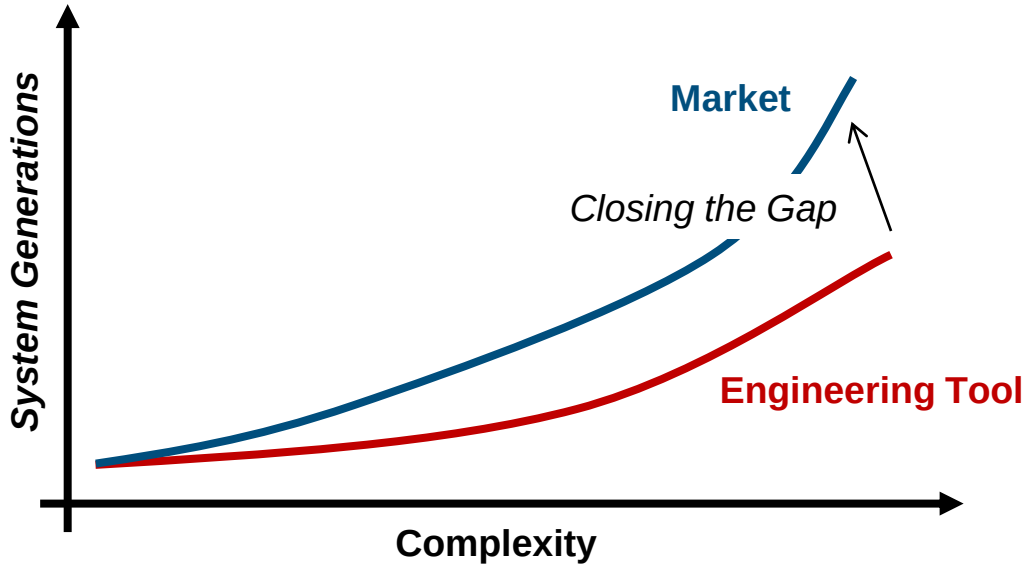




Model Parameters: 4800
Parametrization Mappings: ~ 23 millions

Hybrid-Electric Regional Architectures: **the Challenges**

- Aircraft System → higher level of **system complexity**
- Aircraft Technologies → introduction of **new hybrid-electric technologies**
- Functions Allocation → **Radical rethink** of established system functions allocation
- Design Process → extended **multi-disciplinary** design including **unconventional** disciplines
- Reference Procedures → **Lack of state-of-the-art** or pre-existing knowledge



Tim Weilkiens (OOSE) “Mastering SysMLv2 – From Simplicity to Formality”, OOSE Webinar and aligned with INCOSE “Vision 2035”

CLEAN AVIATION
Co-funded by the European Union

In a nutshell

7 M€

EU Funding

8.9 M€

Total Project Cost

12

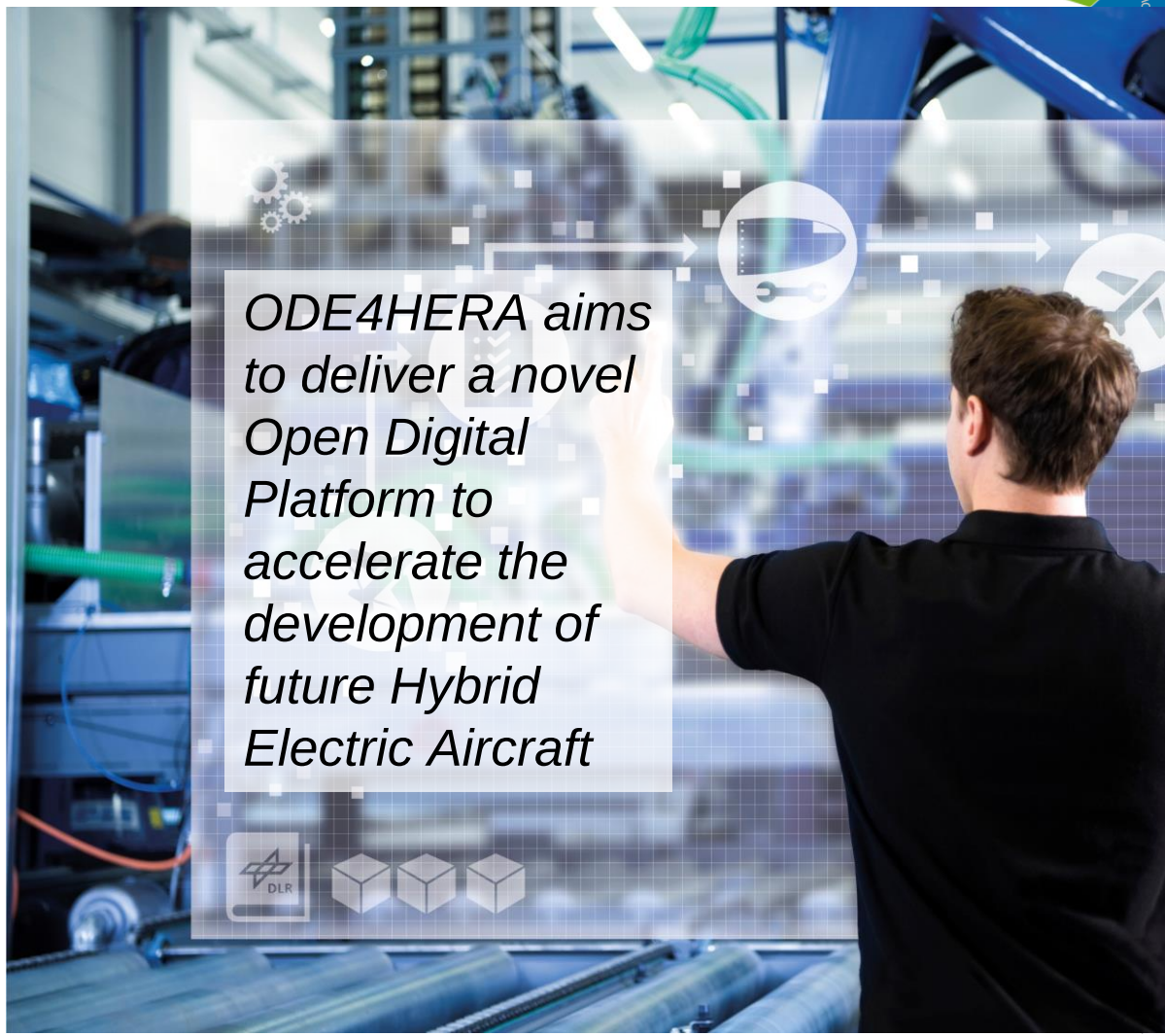
Beneficiaries*

5

Countries

36

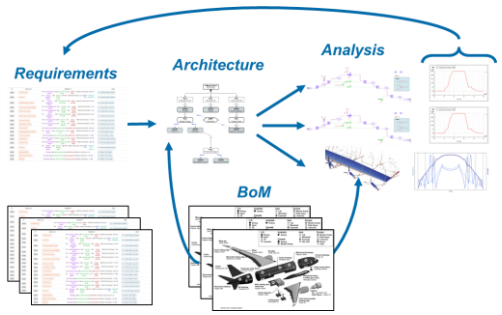
Months duration



* 15 partners including affiliated entities

Partners

Project Outcomes



- Automated virtual verification of configured aircraft
- Automated architectural optimization of configured aircraft
- Design data management integration with aircraft life-cycle management

ODE4HERA Open Digital Platform

Armade
Teamcenter Siemens
Simcenter
ALORISE
OpenModelica
VOLTA
KPI
Cameo Systems Modeler
ADORE
MDAx
MDO Workflow Design Accelerator
GEMSEO
RCE
modeFRONTIER
HEEDS

Requirement Management
System Architecting
Design & Optimization
Virtual Integration, Verification and Validation
Test Prototype
Build

Simcenter Amesim
Siemens
MATLAB
Simulink
Descartes
JSBSim
Open Source Flight Dynamics
JPAD

Project Outline

03/2025 SNA Inter. Version
03/2026 SNA Final Version

10/2025 ODP First Assessment
12/2026 ODP Final Assessment

ODP: Open Digital Platform

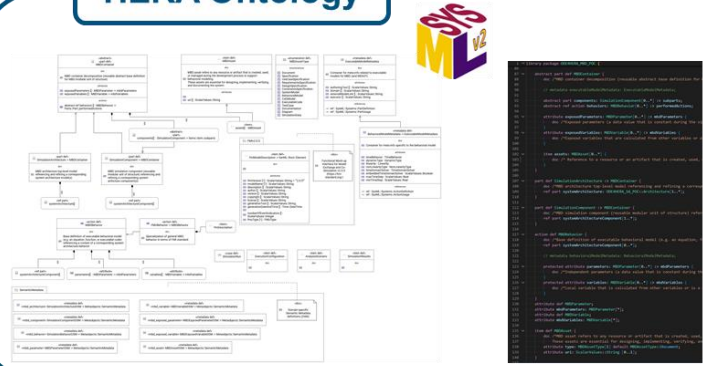
SNA: Solution Neutral Architecture

Platform Requirements & KPI → **Platform Solution-Neutral Architecture** → **Platform Development** → **Platform validation through Application Cases** → **Roadmap for Industrial Scale Up** → **CA: Phase 2** / **Industrial Exploitation**

01/2024
Start of the Project

12/2026
End of the Project

HERA Ontology

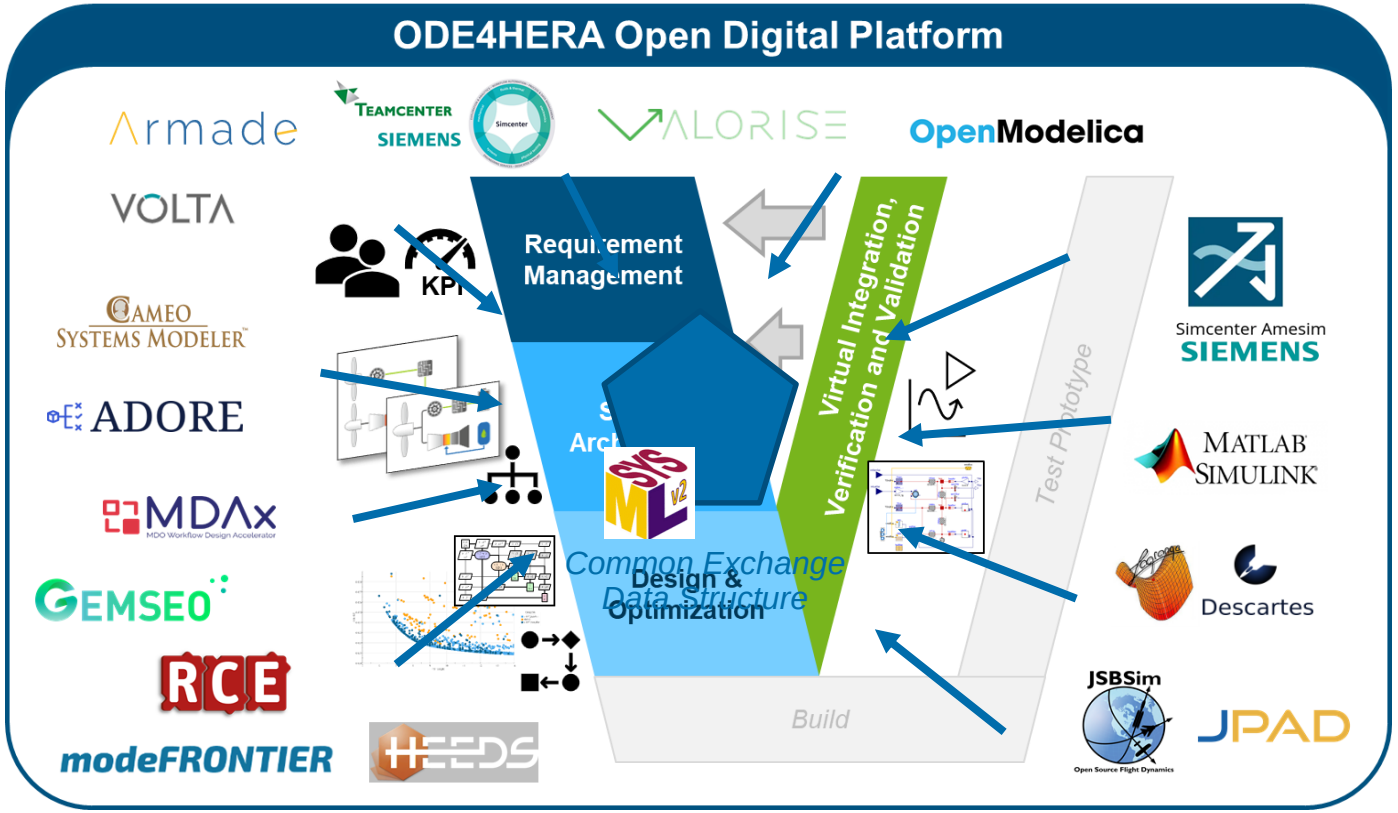


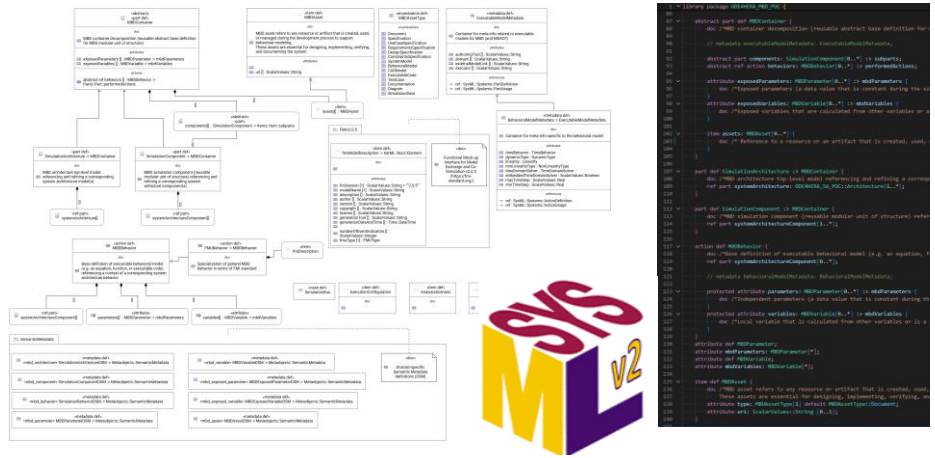
Platform Proof of Concept

PLM : Teamcenter with TcSim	Reqs Mngt : Armade
Simulation : Simcenter Amesim	System Arch.: ADORE
LEONARDO WP4 Application Case : HER Aircraft	AIRBUS WP5 Application Case : HER Aircraft
Ontologies: Model Based Design and PLM oriented	Ontologies: Requirements management and System Architecting
Development of the prototype !	Development of the prototype !

Application Cases

The HERA Ontology





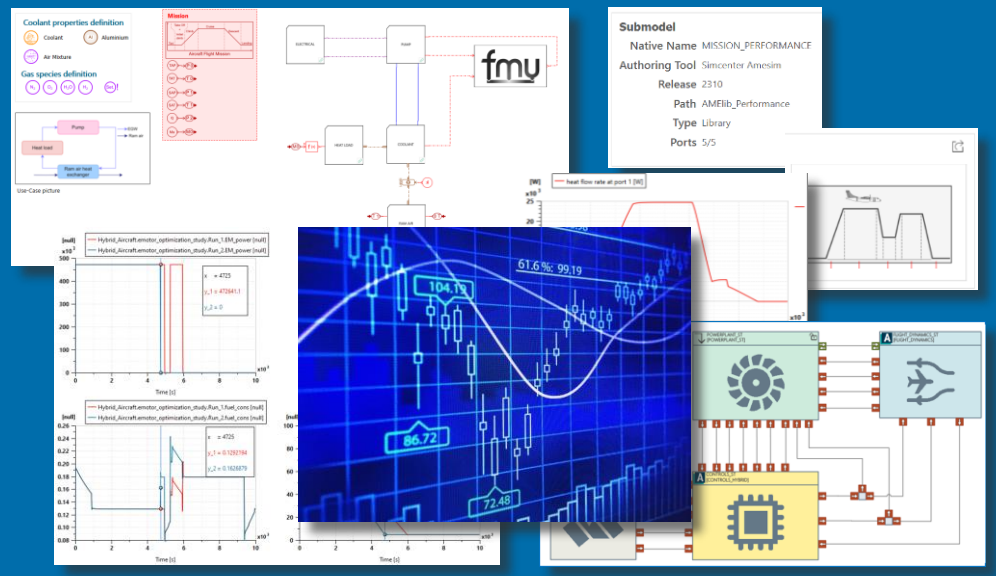
***Ontology**: **shared understanding** of the **domain of interest** used as a **unifying framework**.*

- is a **solution-neutral description** of all data generated in the development process
- provides a **common data structure for exchange** among all platform modules
- **reduces number of interfaces** among platform modules
- **facilitates extension** and tailoring of platform according to designer needs and context
- **foster adoption** of platform and associated methodologies outside project boundaries

Linking **MBSE** with **Design and Simulation**

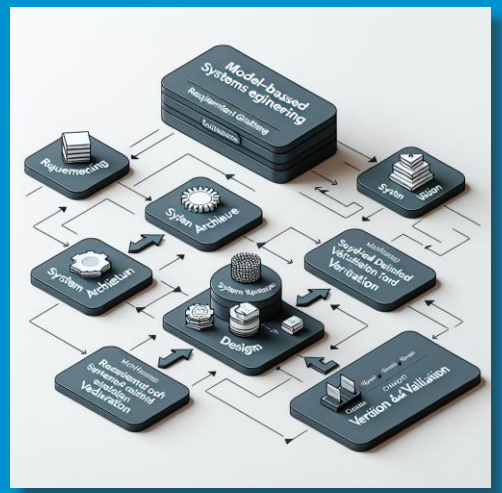
Goal: support **integration** of **executable Design and Simulation models** into MBSE (but not to replace MDO or MBD)

Design & Simulation

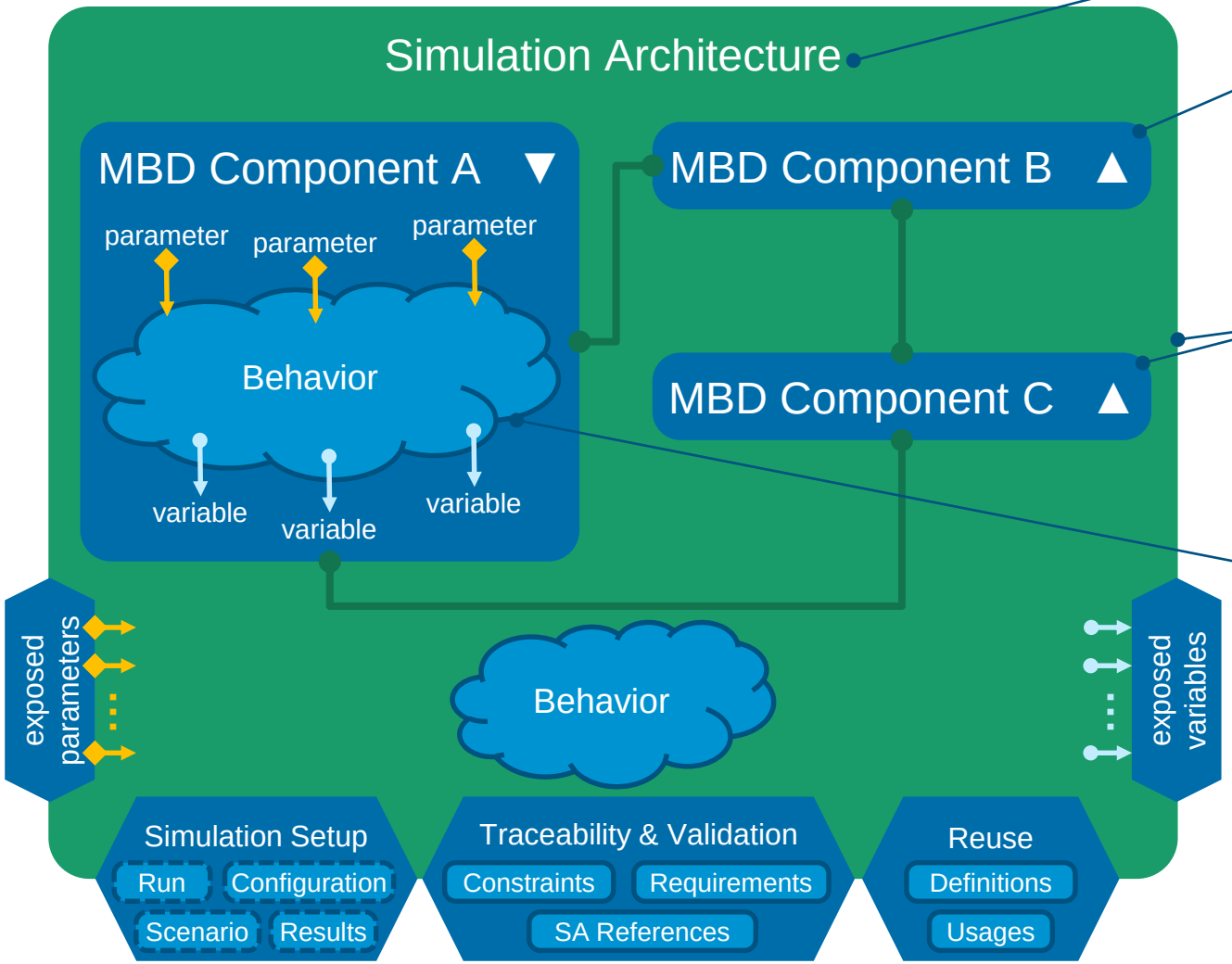


ODE4HERA ontology

MBSE



The Domain-Specific MBD Ontology Main Concepts




```
part def SimulationArchitecture :> MBDContainer {
    doc /*MBD architecture top-level model referencing and refining a corr
    ref part systemArchitecture: ODE4HERA_SA_POC::Architecture[1..*];
}
```

```
part def SimulationComponent :> MBDContainer {
    doc /*MBD simulation component (reusable modular unit of structure) re
    ref part systemArchitectureComponent[1..*];
}
```

```
abstract part def MBDContainer {
    doc /*MBD container decomposition (reusable abstract base definition f

    // metadata executableModelMetadata: ExecutableModelMetadata;

    abstract part components: SimulationComponent[0..*] :> subparts;
    abstract ref action behaviors: MBDBehavior[0..*] :> performedActions;

    attribute exposedParameters: MBDParameter[0..*] :> mbdParameters {
        doc /*Exposed parameters (a data value that is constant during the
    }
    attribute exposedVariables: MBDVariable[0..*] :> mbdVariables {
        doc /*Exposed variables that are calculated from other variables o
    }

    item assets: MBDAsset[0..*] {
        doc /* Reference to a resource or an artifact that is created, use
    }
}
```

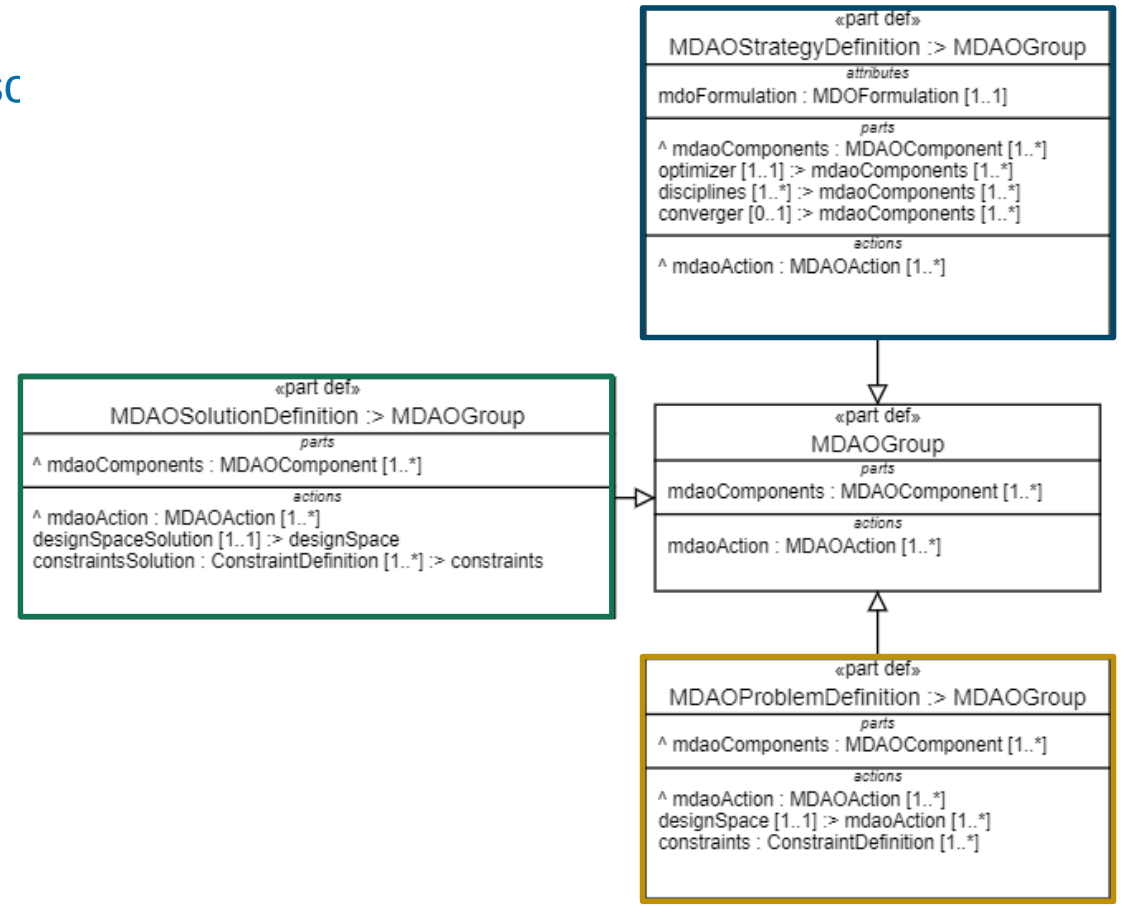
```
action def MBDBehavior {
    doc /*Base definition of executable behavioral model (e.g. an equation
    ref part systemArchitectureComponent[0..*];

    // metadata behavioralModelMetadata: BehavioralModelMetadata;

    protected attribute parameters: MBDParameter[0..*] :> mbdParameters {
        doc /*Independent parameters (a data value that is constant during
    }
    protected attribute variables: MBDVariable[0..*] :> mbdVariables {
        doc /*Local variable that is calculated from other variables or is
    }
}
```

```
action def FMUBehavior :> MBDBehavior {
    doc /*Specialization of general MBD behavior in terms of FMI standard*/
    item fmiDescription: 'FMIv2.0.5'::fmiModelDescription;
}
abstract ref action fmuBehaviors: FMUBehavior[*];
```

The Domain-Specific MDO Ontology
Main Concepts

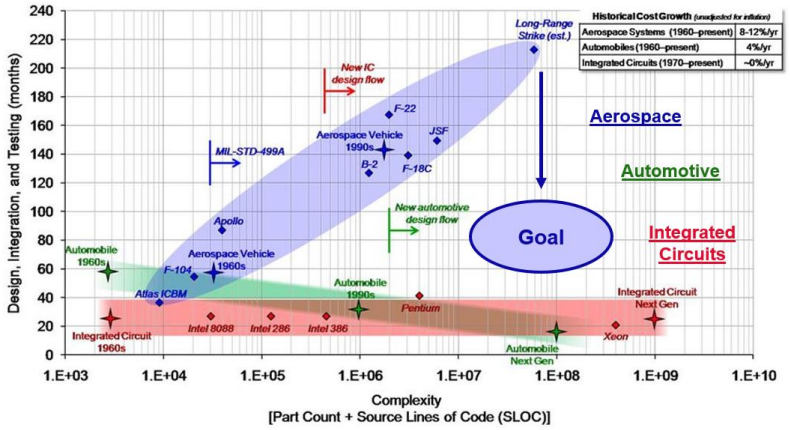
MDAO ontology composed of 3 top concepts:

- **MDAO Problem Definition**: specify the problem to be sc
  - the design space,
  - the objective functions
  - the constraints.
- **MDAO Strategy Definition**: specify the needed MDAO architecture to answer the problem
  - the disciplines,
  - the optimizer & formulation,
  - the converger
- **MDAO Solution Definition**: specify the optimum
  - Objective functions optimum
  - Constraints value at the optimum
  - Design variables value at the optimum

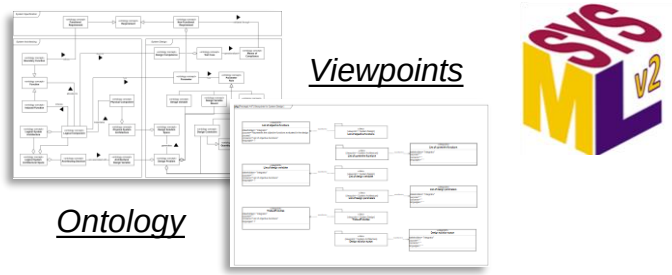


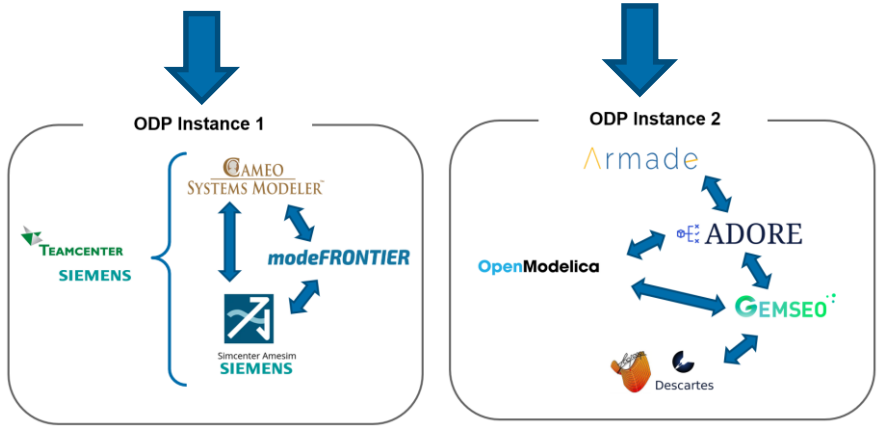
ODE4HERA Demonstrator Strategy

PoCs coverage

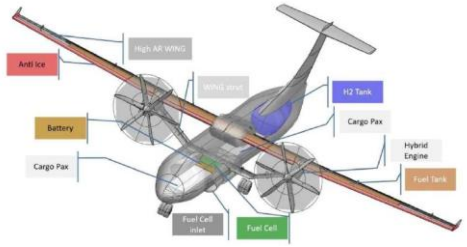


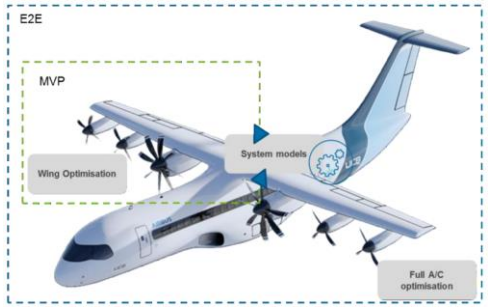
Solution Neutral MBSE Framework* for data exchange across the entire development process





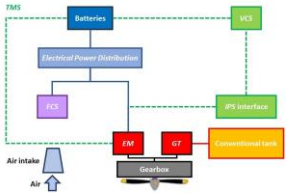
One application case for each ODP pilot implementation verifying the ODP expected performance



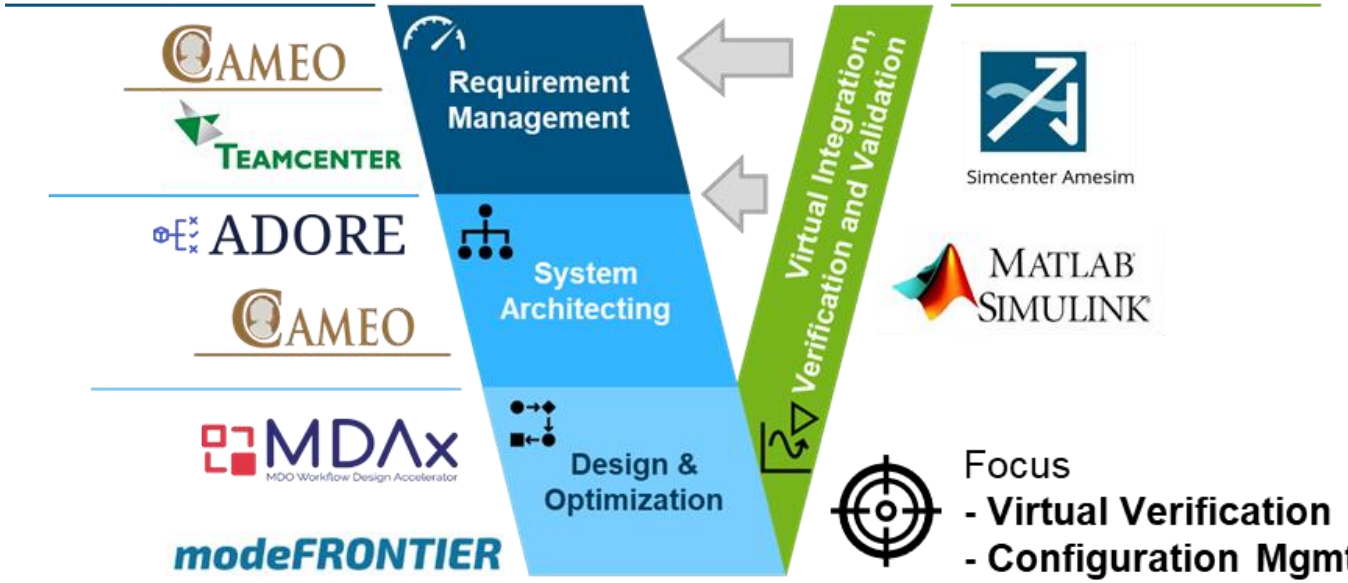


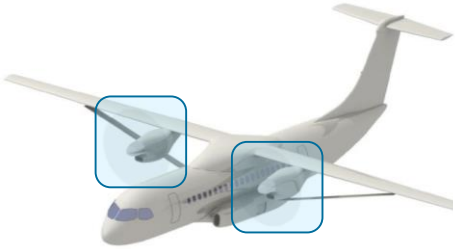
Two different pilot implementations of the Open Digital Platform compliant with the solution neutral MBSE Framework

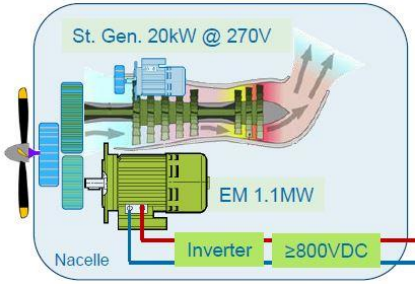
Application Case 1 Overview



Sol
On-Board System







***AC1* Purpose:** Demonstrate the *Open Digital Platform* (*ODP*) performance and maturity at *TRL 5* via a pilot case demonstration;

AC1 Description: *Application Case 1* (*AC1*) design the *Powertrain* on-board systems including the *Thermal Management System* and is based on *Use Case A* (*UCA*) from *HERA* project.

Application Case 2 Overview

Sol
Overall Aircraft Architecture

Armade

ADORE

CAMEO

MDAx
MDO Workflow Design Accelerator

GEMSEO

Requirement Management

System Architecting

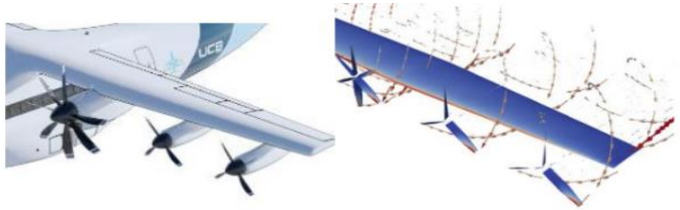
Design & Optimization

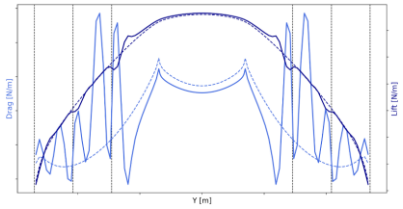
Virtual Integration, Verification and Validation

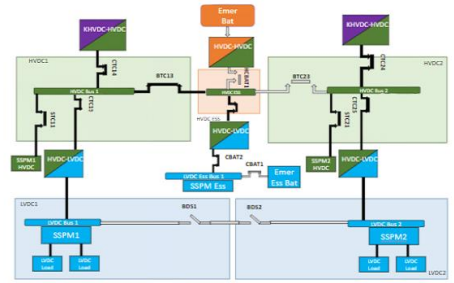
OpenModelica

MATLAB SIMULINK

Focus
- **Multi-Fi Optimization**
- **Architecture Optimization**



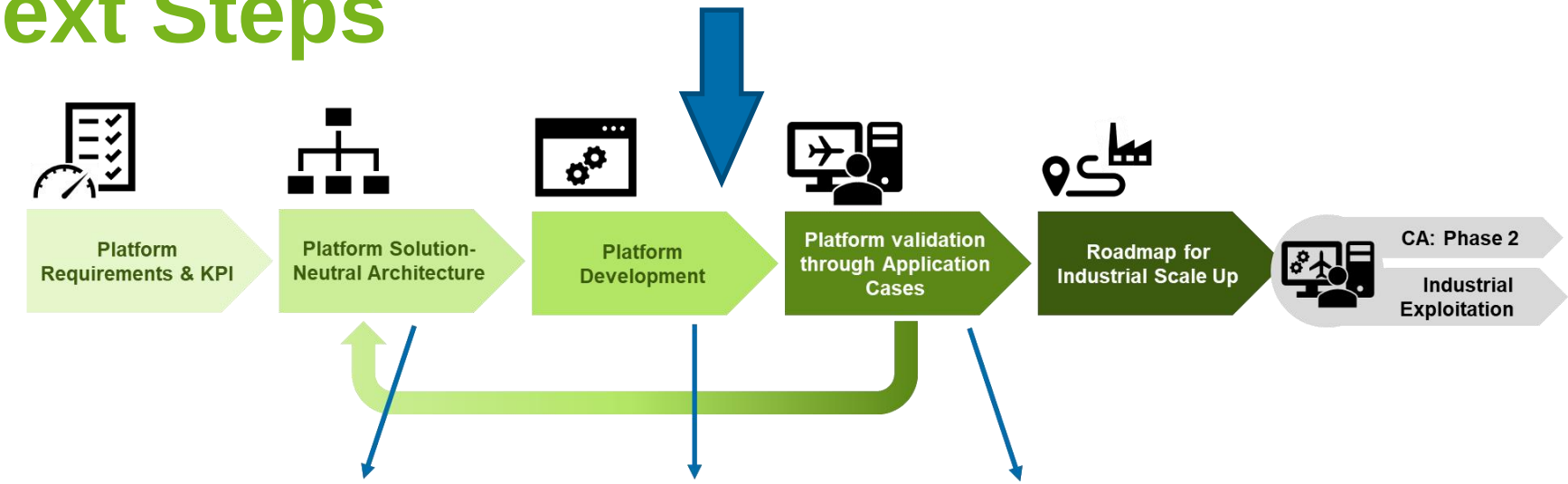




AC2 Purpose: Demonstrate the *Open Digital Platform* (*ODP*) performance and maturity at *TRL 5* via a pilot case demonstration;

AC2 Description: *Application Case 2* (*AC2*) main focus is on performing *concurrent aircraft and systems sizing* through Multi-Disciplinary Optimization and *Uncertainty Quantification*. AC2 is based on *Use Case B* (*UCB*) from *HERA* project and

Next Steps



Second Development Loop
2026

HERA Ontology V1: Completed

To be published on ODE4HERA Zenodo Community by end on June 2025
https://zenodo.org/communities/ode4hera/

ODE4HERA Open Digital Platform V1

To be released by end of September 2025

First Platform Performance Assessment

To be completed by end of 2025

CLEAN AVIATION

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Thank you!

ODE4HERA

First Thematic Workshop

30 September – 1 October,
ZAL Tech Center, Hamburg

ODE4HERA

Grant ID 101140510

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LinkedIn: https://www.linkedin.com/company/ode4hera

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