This project has received funding from the European Union's Horizon 2020 research and innovation framework programme under grant agreement No 815122

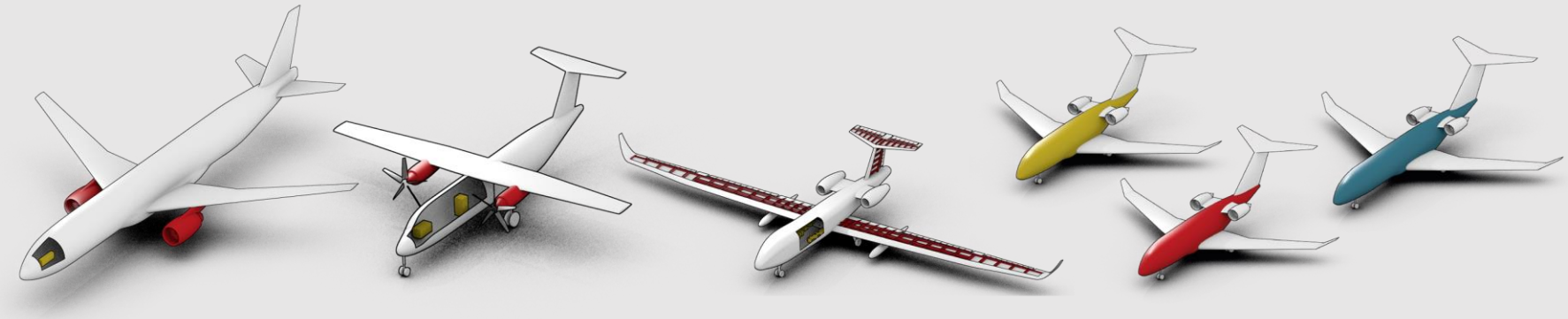
AGILE4.0

Towards cyber-physical collaborative aircraft development

German Aerospace Center (DLR) | *Jasper Bussemaker*

AGILE 4.0 Project Consortium

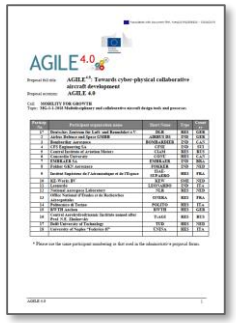
3rd European Workshop on MDO | 20 September 2022



AGILE 4.0

Towards cyber-physical collaborative aircraft development

AGILE4.0
Towards cyber-physical collaborative aircraft development



AGILE 4.0 project ambition:

"The high-level objective of AGILE4.0 is to bring ***significant reductions in aircraft development costs*** *and* ***time-to-market*** *through the implementation of an integrated cyber-physical* ***aeronautical supply chain****, thereby increasing the* ***competitiveness*** *of the European aircraft industry, from integrators and high-tiers suppliers to SMEs,* ***leading to innovative and more sustainable aircraft products****"*

Deutsches Zentrum für Luft- und Raumfahrt (DLR) · AIRBUS · BOMBARDIER · CFS Engineering · Concordia University · EMBRAER · Fokker (GKN Aerospace) · ISAE-SUPAERO · KE-works · LEONARDO · NLR · ONERA The French Aerospace Lab · Politecnico di Torino · ILR Institute of Aerospace Systems, RWTH Aachen University · TU Delft · Università degli Studi di Napoli Federico II

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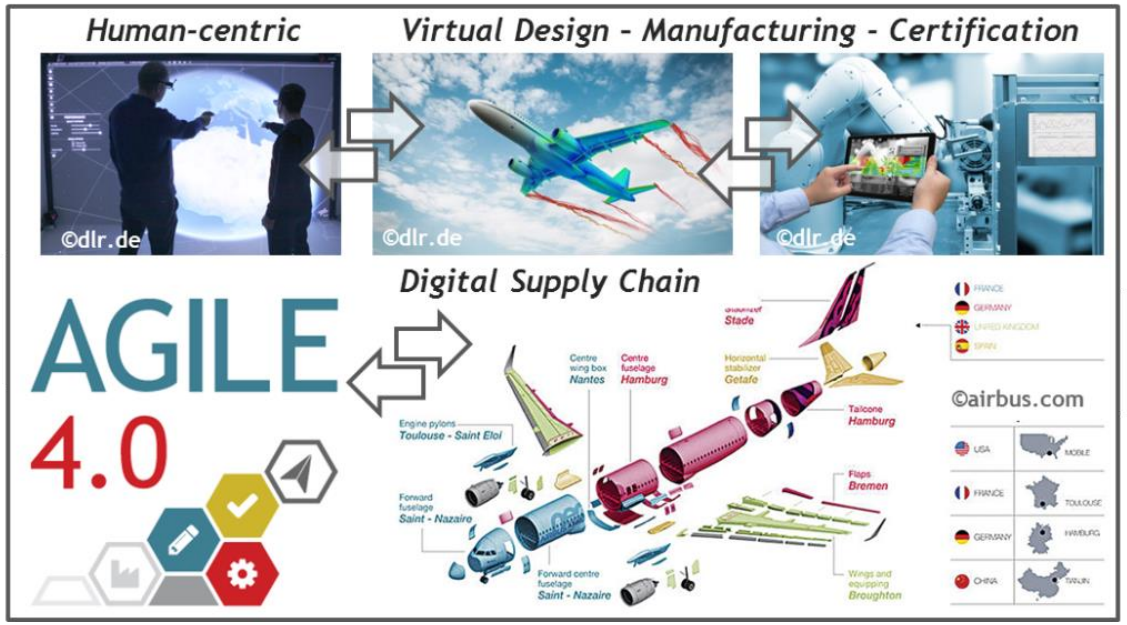


EU funded H2020 project: ***September 2019 – February 2023***

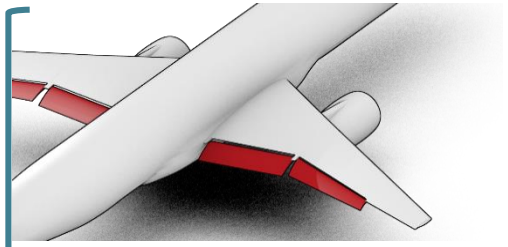
- *16 International Partners (EU, Brazil, Canada)*
- *Coordinated by DLR Hamburg*

Towards the next generation ***MBSE-MDO*** *accelerating the development of complex systems*

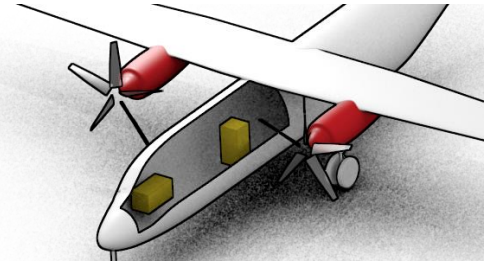
AGILE 4.0

Industrial-driven Applications

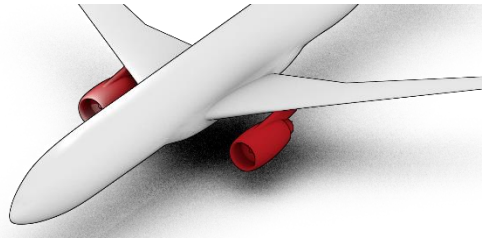
- MBSE Approach
- Ontologies
- Models
- Platforms
- Decision Making
- Optimization
- Competences



Airframe components flap\HTP



On-board systems Propulsions



Propulsion, cabin, avionics, winglet

Production

FOKKER AEROSTRUCTURES

1 *Manufacturing*

EMBRAER

2 *Supply chain*

Certification

BOMBARDIER

3 *Electrification*

EMBRAER

4 *Maintenance*

AIRBUS

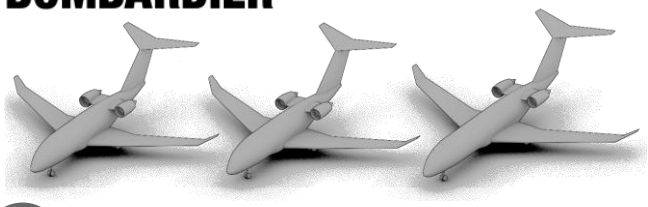
5 *Certification*

Upgrade

LEONARDO

6 *Retrofitting*

BOMBARDIER

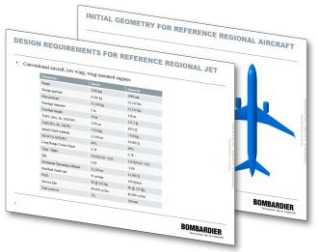


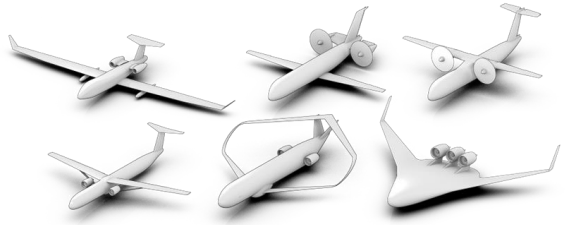
7 *Family concept*

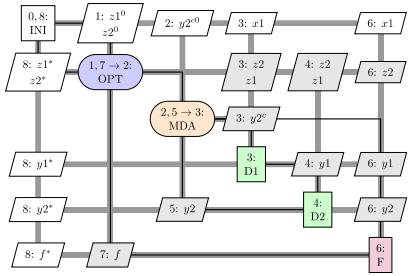
Systems Engineering Approach for the Development of Aeronautical Systems

System of Interest

given policy & needs	*given goals & capabilities*	*given scenarios & requirements*	*given architecture & requirements*	*given design space & objectives*
System Identification	**System Specification**	**System Architecting**	**System Synthesis**	**System Exploration**
Capabilities & Objectives	*Requirements & ConOps*	*Architecture Alternatives*	*Integration & Validation*	*Design and Optimization*







*upstream architecting **SE** (document or model based)*

Accelerating

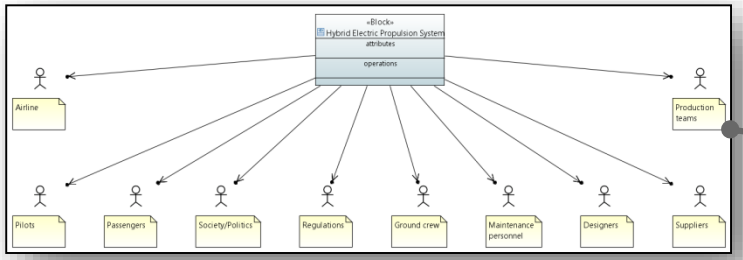
*downstream product design **MDO***

AGILE 4.0

Shifting from document based to Model Based Engineering Approaches (MBE)

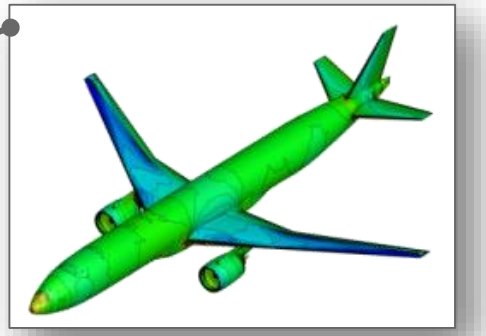
System Identification → System Specification → System Architecting → System Synthesis → System Exploration

Stakeholders

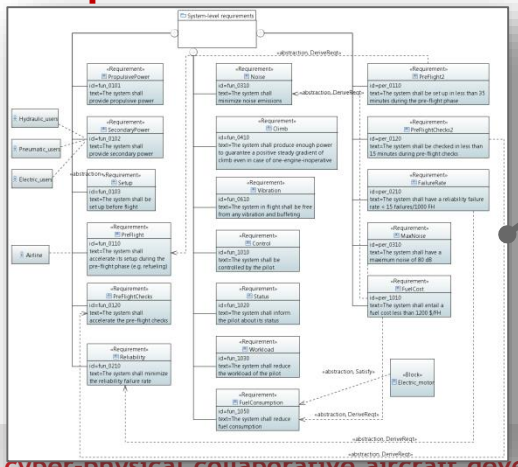


Source of Truth

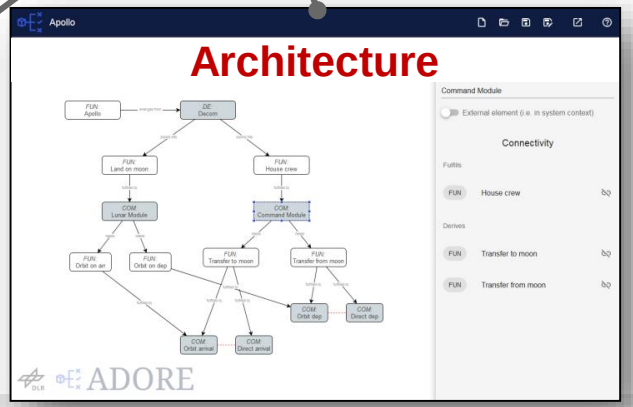
Disciplinary Capability



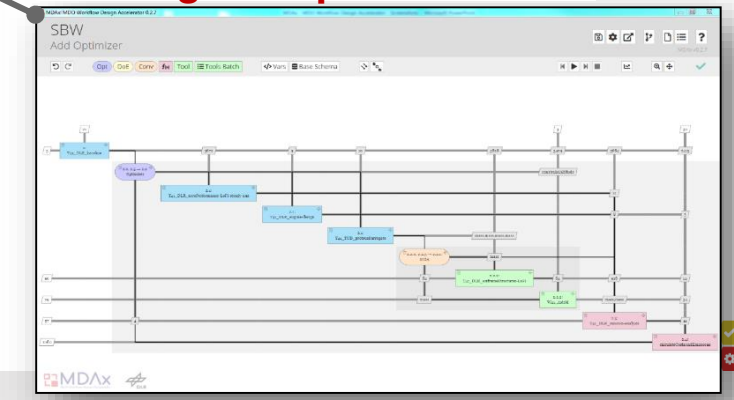
Requirements



Architecture



Design & Opt. Process



The Operational Collaborative Environment

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Papyrus

SysML environment – representation of stakeholders, needs and requirements model

Capella

Modeling environment – representation of operational scenarios model

KADMOS

MDAx MDO Workflow Design Accelerator

MDAO workflows modelling environments

SMR

WhatsOpt

Definition and sharing of executable surrogate models

MBSElib

Automatic generation of SysML models

given policy & needs → **System Identification** → *given goals & capabilities* → **System Specification** → *given scenarios & requirements* → **System Architecting** → *given architecture & requirements* → **System Synthesis** → *given design space & objectives* → **System Design**

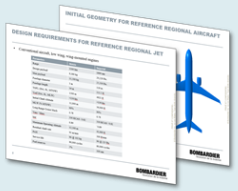
BRICS

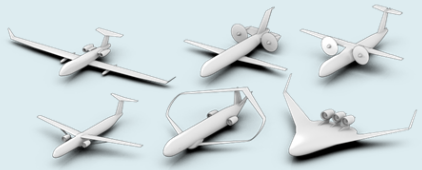
Enabling cross-organization collaborative simulation workflows

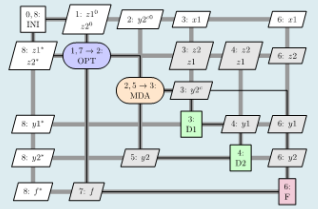
RVF

Requirements verification

KPI







Capabilities & Objectives | *Requirements & ConOps* | *Architecture Alternatives* | *Integration & Validation* | *Design and Optimization*

RCE

Executing simulation workflows

ADORE

System Architectures generation, modelling and visualization

MULTILINQ

Bridging System Architectures to MDAO

KE-chain

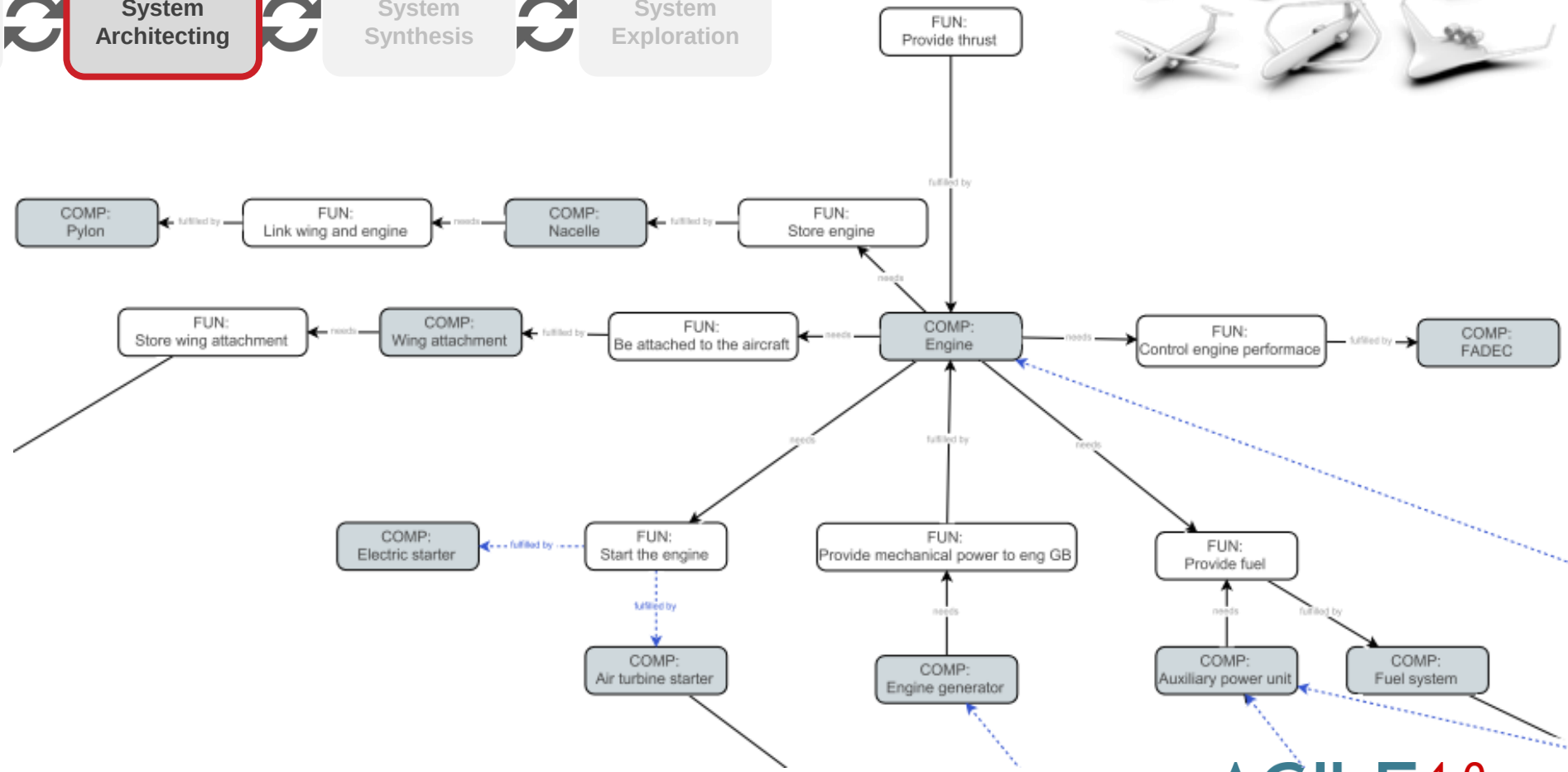
Web-based collaboration and process integration platform

AGILE 4.0

Architecture Modeling: Engine Retrofit

Deutsches Zentrum für Luft- und Raumfahrt

System Identification → System Specification → **System Architecting** → System Synthesis → System Exploration



ADORE

Source: M. Mandorino et al., "Regional jet retrofitting design: from stakeholders' needs and system's requirements to MDAO workflow formulation", ICAS 2022, Stockholm, SE.

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Architecture Decisions

Deutsches Zentrum für Luft- und Raumfahrt

ADORE

System Identification → System Specification → **System Architecting** → System Synthesis → System Exploration

Architecture Decisions

#	Operation	Subject	Options
1	Fulfill function	Avoid presence of ice	Electro-thermal IPS, Pneumatic IPS, Bleed air IPS
2	Fulfill function	Control flight control surfaces	MEA FCS, AEA FCS, Conventional FCS
3	Fulfill function	Provide compressed air	Wing inlets, Auxiliary power unit
4	Fulfill function	Provide compressed air	Engine, Wing inlets, Auxiliary power unit
5	Fulfill function	Recharge battery	Engine generator, APU generator
6	Fulfill function	Start the engine	Air turbine starter , Electric starter
7	Fulfill function	Store hydraulics circuits	Fuselage, Wing
8	Fulfill function	Store pneumatics circuits	Fuselage, Wing
9	Assign attribute value	Nacelle -> Shape	Elliptical, Circular
10	Assign attribute value	Wing -> Winglet type	Sharklet, Fences, Whitcomb

System of Interest

Aircraft

Enabling System

Retrofitted Aircraft

DLR ADORE KE-chain AGILE 4.0

Source: M. Mandorino et al., "Regional jet retrofitting design: from stakeholders' needs and system's requirements to MDAO workflow formulation", ICAS 2022, Stockholm, SE.

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MDAO Workflow Formulation

Deutsches Zentrum für Luft- und Raumfahrt

MULTILINQ

Components	QOIs	Tools: AERO RSM	AERODYNAMICS	COSTS	ENGINE	NOISE	OBS	PERFORMANCE	SFC SENSITIVITY	Structural RSM
AEA FCS	FCS Mass						✓			
APU generator	Electrical Generation Mass						✓			
Air turbine starter	Electrical Generation Mass						✓			
Aircraft	Aircraft Price			✓						
Aircraft	Certification EPNL Noise					✓				
Aircraft	DOC			✓						
Aircraft	Design Range							✓		
Aircraft	Landing Distance							✓		
Aircraft	Maximum Take-Off Weight						✓	✓		✓
Aircraft	Retrofitting Cost			✓						
Aircraft	Take-Off Distance							✓		
Aircraft	Typical Range							✓		
Autopilot	Automatic Flight System Mass						✓			
Auxiliary power unit	APU Mass						✓			
Batteries	Electrical Generation Mass						✓			
Bleed air IPS	DeIcing Mass						✓			
Conventional FCS	FCS Mass						✓			
Electric power system	Electrical Distribution Mass						✓			
Electric starter	Electrical Generation Mass						✓			
Electro-thermal IPS	DeIcing Mass						✓			
Engine	BPR				✓					
Engine	Engine Price			✓						
Engine	Number of Compressors				✓					
Engine	TT0				✓					
Engine generator	Electrical Distribution Mass						✓			
Environmental control system	Air Conditioning Mass						✓			
FADEC	Automatic Flight System Mass						✓			
Fuel system	Fuel Mass							✓		

System Identification → System Specification → System Architecting → System Synthesis → **System Exploration**

KADMOS MDAx MDO Workflow Design Accelerator

ADORE

Design Competences

System Components

Input & Output ⟷ Quantity of Interest

MULTILINQ

Enabling System

Retrofitted Aircraft

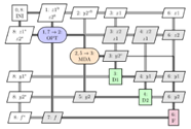
cpacs A Common Language for Aircraft Design

AGILE 4.0

MDAO Workflow Formulation

Deutsches Zentrum für Luft- und Raumfahrt

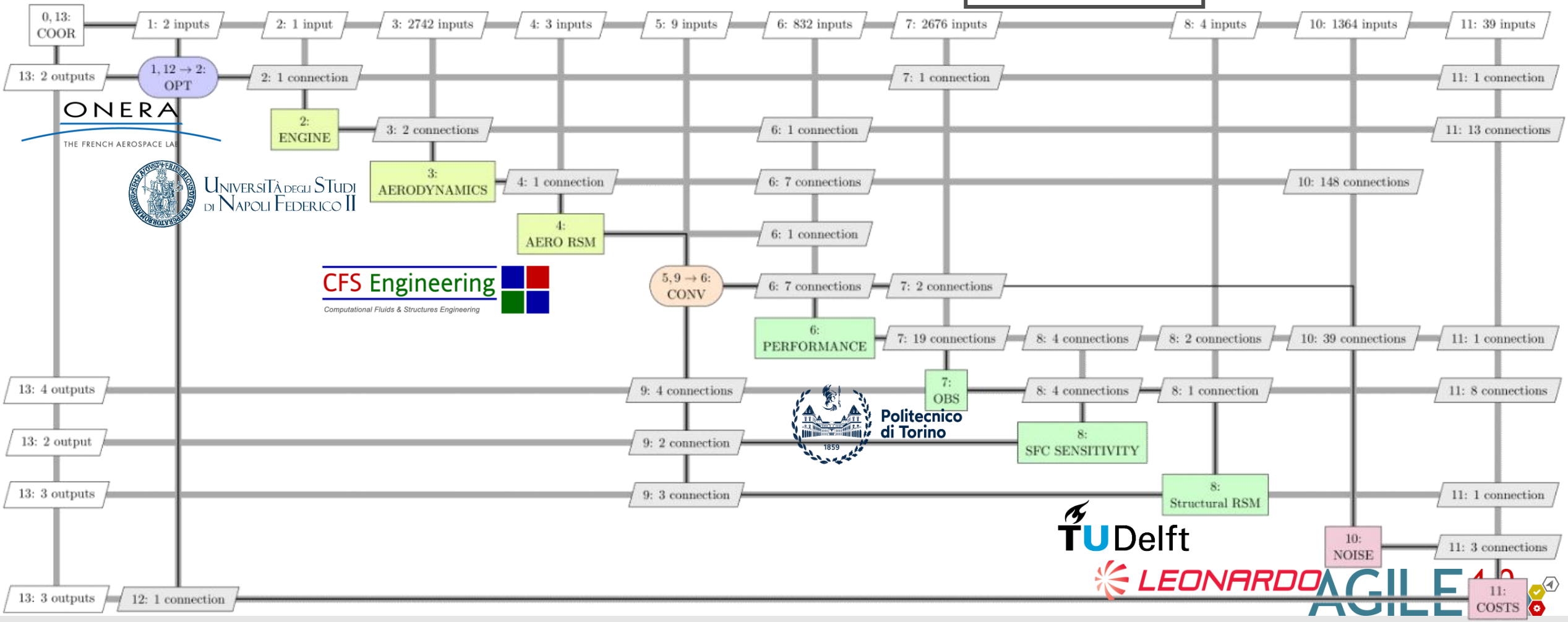
System Identification ⟳ System Specification ⟳ System Architecting ⟳ System Synthesis ⟳ **System Exploration**



Enabling System
Retrofitted Aircraft

KADMOS

cpacs
A Common Language for Aircraft Design



Thank you for your attention!
Thank You !

More information:

- www.agile4.eu
- ZENODO
- LinkedIn

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