Embedded Success

European Research Program Clean Sky 2

Virtual Testing in Project MISSION

dSPACE GmbH

28th Nov. 2019

dSPACE GmbH · Rathenaustr. 26 · 33102 Paderborn · Germany

Agenda

1. dSPACE company overview
2. CleanSky 2 project
3. MISSION project
4. dSPACE in MISSION
5. Collaboration approach
6. Summary

What Does dSPACE Do?

- Develop tools (hardware and software) for developing control systems and electronic control units
- dSPACE = **d**igital **S**ignal **P**rocessing **A**nd **C**ontrol **E**ngineering

Who Uses dSPACE Tools to Develop Control Systems?

- Automotive industry (80% of our customers) ➔ Development partners

- Approx. 1,900 employees worldwide, including 1,500 engineers and software scientists
- 30 years of experience; privately owned, independent company, visionary founder
- Continuously growing R&D and engineering capacities and capabilities, investing in technology

dSPACE GmbH
Germany | Paderborn
Pfaffenhofen, Böblingen, Wolfsburg

dSPACE Inc.
USA | Detroit

dSPACE engineering d.o.o.
Croatia | Zagreb

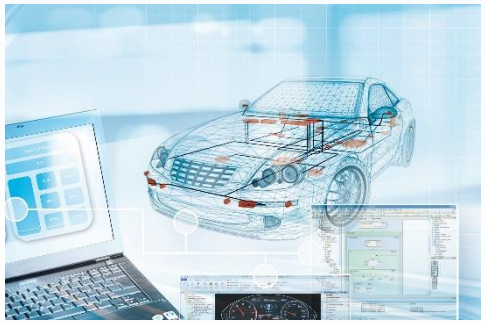
dSPACE Japan K.K.
Japan | Tokyo, Nagoya, Utsunomiya, Osaka

dSPACE SARL
France | Paris

dSPACE Ltd.
United Kingdom | Cambridge, Warwick

dSPACE Mechatronic Control Technology Co.
China | Shanghai, Beijing

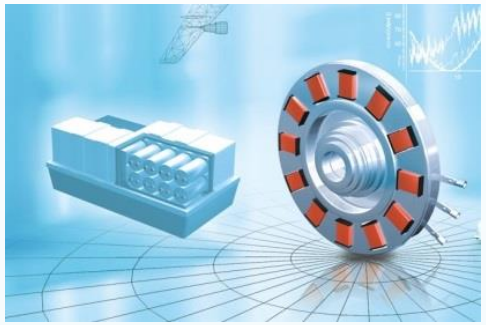
What Application Fields is dSPACE Involved in?



Automotive Industry

Aerospace

Medical Engineering



Electric Drives

Commercial Vehicles

Research and Education

Honda Aircraft

Avionics
for High Flyers

Validating the avionics components of the HondaJet

Without dSPACE's superb tools, service, and support, our small team would not have achieved what it has."

Benjamin Hager,
Honda Aircraft Company

Source: dSPACE Magazine 2/2015
https://www.dspace.com/shared/data/pdf/2015/6-11_flight_real_time_jp.pdf

Hybrid , Pure Electric Flight

- Convincing to develop of electric flight

ACENTISS GmbH

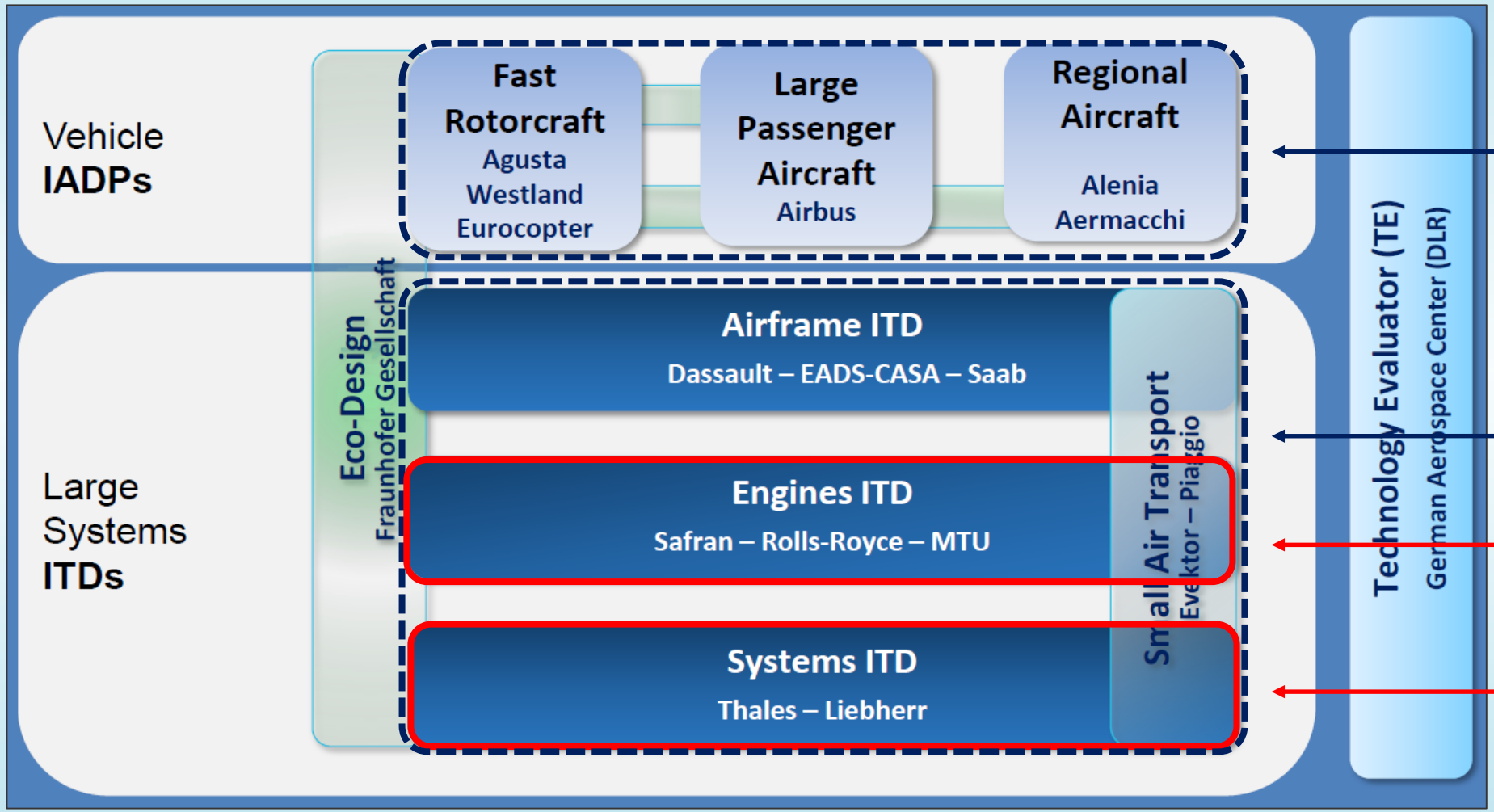
e-Genius S / University of Stuttgart

Clean Sky 2 (CS2)

- Currently largest European research program with budget of €4 billion (2014-2023)
- Funded by public-private partnership between European Commission and European aeronautics industry
- Program aims at developing innovative, cutting-edge technology for reducing
  - Gas emissions (CO_x and NO_x)
  - Noise levels produced by aircraft
  - Aircraft development time and cost
- Over 600 participating entities in 27 countries including prominent aircraft manufacturers, system suppliers and research organizations

Clean Sky

CS2 Program Overview



Innovative Aircraft Demonstration Platforms (IADPs)

Integrated Technology Demonstrators (ITDs)

Electric propulsion has been discussed on Engine ITD

Project MISSION is part of the Integrated Technology Demonstrator for Aircraft Systems

Hybrid Electric Propulsion and Electrical Systems in Demonstration area

- Hybrid Electric Propulsion

  It has been discussed on “Breakthroughs in propulsion Efficiency”.

  In 2019, in the field of the hybrid electric propulsion, the design and development of several key technologies (generator, power electronics, electrical motors) will continue.

  Intermediate test results of the hybrid electric propulsion system will be reported.

- More Electrified and Full Electrified

Ref-Code	Theme	Demonstration area
1A	Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Architectures
1B		Ultra-high Bypass and High Propulsive Efficiency Geared Turbofans
1C		Hybrid Electric Propulsion
1D		Boundary Layer Ingestion
1E		Small Aircraft, Regional and Business Aviation Turboprop
2A	Advances in Wings, Aerodynamics and Flight Dynamics	Advanced Laminar Flow Technologies
2B		Regional Aircraft Wing Optimization
3A	Innovative Structural / Functional Design - and Production System	Advanced Manufacturing
3B		Cabin & Fuselage
3C		Innovative Solutions for Business Jets
4A	Next Generation Cockpit Systems and Aircraft Operations	Cockpit & Avionics
4B		Advanced MRO
5A	Novel Aircraft Configurations and Capabilities	Next-Generation Civil Tiltrotor
5B		RACER Compound Helicopter
6A	Aircraft Non-Propulsive Energy and Control Systems	Electrical Systems
6B		Landing Systems
6C		Non-Propulsive Energy Optimization for Large Aircraft
7A	Optimal Cabin and Passenger Environment	Environmental Control System
7B		Innovative Cabin Passenger/Payload Systems
8A	Eco-Design	
9A	Enabling Technologies	
	Technology Evaluator	

Project for Electric Propulsion

- Electric hybrid propulsion

Ground Test Bench has been *TRL4 in 2019, and it will reach TRL5 in 2022, TRL6 in 2023.

Level	Technology Readiness Level
4	Validation in laboratory environment
5	Validation in relevant environment
6	demonstration in a relevant environment (ground or space)

State of play as of December 2017

CDR PDR CoR — FT Testing/GT — ET = Enabling Technology

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End / TRL Maturity	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
					Demonstrator /Technology Streams Maturing Over Time									
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Architectures	UHPE Integration	tbd	tbd										
				TRL Maturity										
		LPA-01-D2: Advanced engine integration driven fuselage ground demo	3	6				◆		◆		△		
				TRL Maturity				TRL3		TRL4		TRL5	TRL6	
		ENG - Demonstrator 1 WP A-1.2 UHBR configuration	1	6		◆	◆		◆					
				TRL Maturity					TRL4		TRL5	TRL6		
		ENG - Demonstrator 1 WP A-1.2 CROR configuration	1	5				△						
				TRL Maturity	TRL4				TRL5					
	Ultra-high Bypass and High Propulsive Geared Fans	ENG - Demonstrator 5 - VHBR – Middle of Market Technology	5	6			◆		◆					
				TRL Maturity					TRL3		TRL4		TRL5	TRL6
		ENG - Demonstrator 6 - VHBR – Large Turbofan Demonstrator UltraFan™	5	6				◆	◆	△			△	
				TRL Maturity					TRL3		TRL4		TRL5	TRL6
		ENG - Demonstrator 2 - UHPE	5	5			◆	◆	◆	◆		△		
				TRL Maturity						TRL3			TRL4	TRL5
		ENG - Demonstrator 4 - Adv. Geared Engine Configuration (HPC-LPT)	5	5					◆	◆	△			
				TRL Maturity						TRL3		TRL4	TRL5	
		LPA-01-D8: Radical Configuration Flight Test Demonstrator	1	6							◆	◆	△	
				TRL Maturity					TRL4		TRL5	TRL6		
		LPA-01-D10: UltraFan Flight Test Demonstration	4	6					◆		◆	◆		
				TRL Maturity					TRL4		TRL5	TRL6		
		LPA-01-D3: Validation of scaled flight testing	1	4										
				TRL Maturity						TRL3	TRL4			
	Hybrid Electric Propulsion	LPA-01-D9: Hybrid Electric Ground Test Bench	4	6										
				TRL Maturity				TRL3		TRL4			TRL5	TRL6
	Boundary Layer Ingestion	Boundary Layer Ingestion	tbd	tbd										
				TRL Maturity										
	Small Aircraft, Regional and Business Aviation Turboprop	ENG - Demonstrator 3 - Business aviation / short range Regional TP Demonstrator	5	5		◆	◆	◆		△				
				TRL Maturity						TRL3		TRL4	TRL5	
		ENG - Demonstrator 7 - Small Aircraft Engine Demonstrator	5	6			◆	◆	△	△				
				TRL Maturity			TRL3	TRL4	TRL5	TRL6				
		ENG - Demonstrator 8 - Reliable and more efficient operation of small turbine engines	5	4		◆	◆	◆	△					
				TRL Maturity		TRL3			TRL5					

Source : Clean Sky 2 Joint Undertaking DEVELOPMENT PLAN

MISSION[1] – Project Consortium

[1] Modeling and Simulation Tools for Systems Integration on Aircraft
[2] Model-in-the-Loop, [3] Virtual Processor-in-the-Loop
[4] Software-in-the-Loop, [5] Hardware-in-the-Loop

United Technologies Research Center

UTRC Ireland
UTRC ALES Italy

Key Experience: Aircraft systems technologies & integration

Project Role: Design & optimisation platforms, multi-domain modelling, MIL[2], VPIL[3]

UTC Aerospace Systems

Motor Drives System Centre
Goodrich Actuation Systems

Key Experience: Aircraft system design, production & certification (system supplier)

Project Role: Requirements definition, system design & testing

esi get it right®

ESI ITI GmbH

Key Experience: Systems engineering & simulation software (SimulationX)

Project Role: Modelling & simulation environment, process & tool integration, MIL

dSPACE

dSPACE GmbH

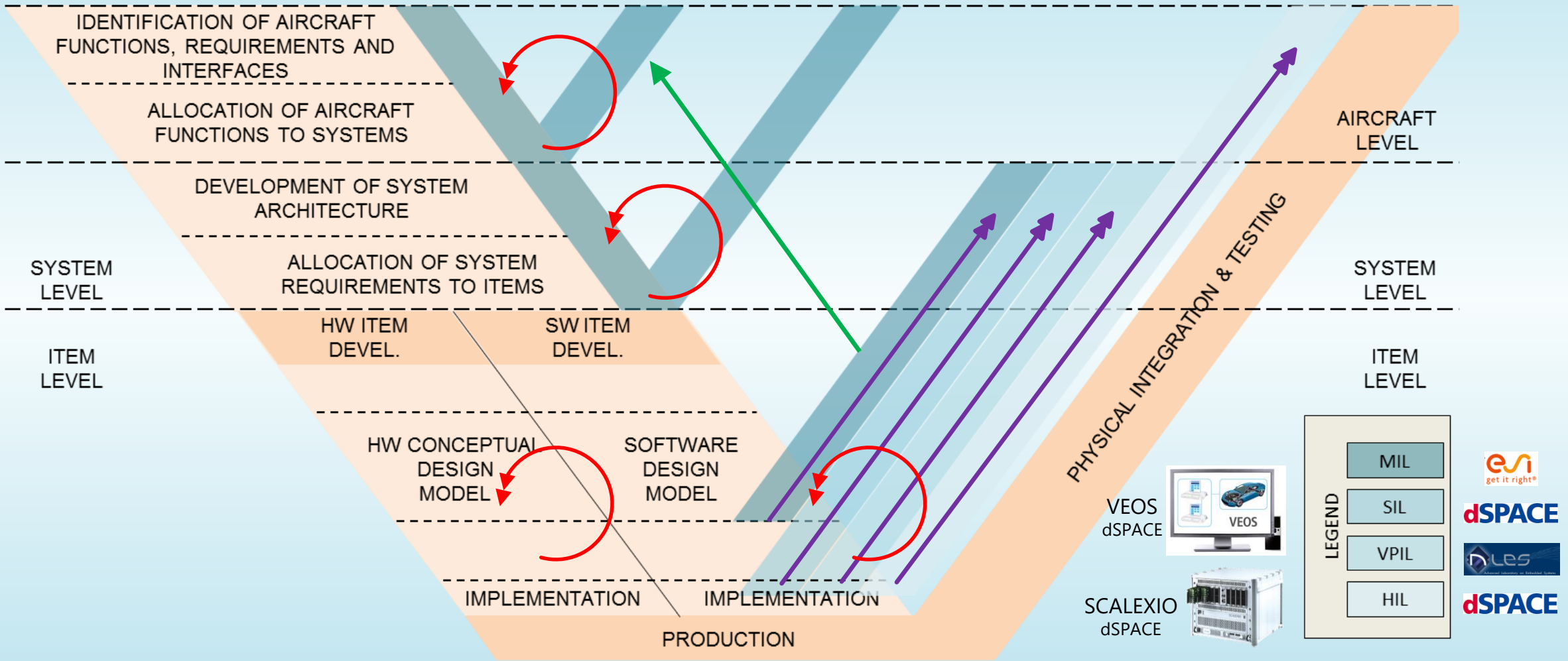
Key Experience: ECU development & test, engineering tools, real-time simulators

Project Role: Virtual testing, SIL[4], HIL[5]

MISSION – Scope and Objectives

- **Improve design capabilities** at aircraft and system level through integrated multi-physics modelling and multi-objective optimization
- Achieve significant **reductions in development time, cost and rework** throughout the design and verification process
- **Support technology integration** and demonstration within Clean Sky 2 through an open and neutral environment for integration of various technologies
- **Target wide dissemination** of the developed framework to strengthen its exploitation plan through regular interaction with framework stakeholders

MISSION – Virtual Testing Overview



Liebherr Test Bench – Smart Electrical Wing

Objectives of system supplier

- Development of electrical wing architecture
- Dedicated demonstration facility

dSPACE contributions

- Cockpit control digitization
- Spatially distributed test system
- Flexible, scalable, modular actuator control interface
  - Simulation of one or more actuators possible
- Electrification of actuator test rig
  - Drive side (available) and load side (planned)

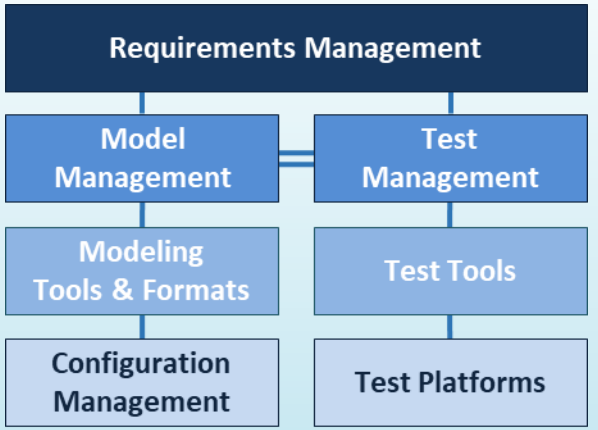
Summary and Outlook

- MISSION aims at providing a **seamless and integrated workflow** from aircraft design to verification across different modelling domains and virtual testing environments

- **Solving real problems** of the aerospace industry through close collaborations with aircraft manufacturers and system suppliers

- Ongoing commitment: **Virtual testing demonstrators** with aircraft system suppliers in Clean Sky 2 ITD Systems
  - HIL* testing of Power Drive Electronics (PDE) for electrical actuation
  - High-voltage e-load emulation to enable early stand-alone testing of PDE on electrical power level (real device under test)
  - More efficient development processes for aircraft electrification by using state-of-the-art virtual testing technologies

*HIL : Hardware-in-the-Loop



Thank you for listening!

Important Information!

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