MADELEINE

OVERVIEW

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on behalf of the MADELEINE Consortium

ECCOMAS CM3 2021
22/01/2021

MADELEINE project,
Grant Agreement No 769025

MADELEINE Project

MADELEINE	**Multidisciplinary ADjoint-based Enablers for LargE-scale Industrial desigN in aEronautics**

Funding : 5.8 M€
Duration : 42 months
(2018 – 2021)

Objectives

Extend the scope of MDO to include *HiFi* simulations (*CFD, CSM, CAA, CHT)*

Fully exploit the adjoint capability to solve design problems with hundreds or thousands of design parameters

Increase the reliability of the adjoint solvers

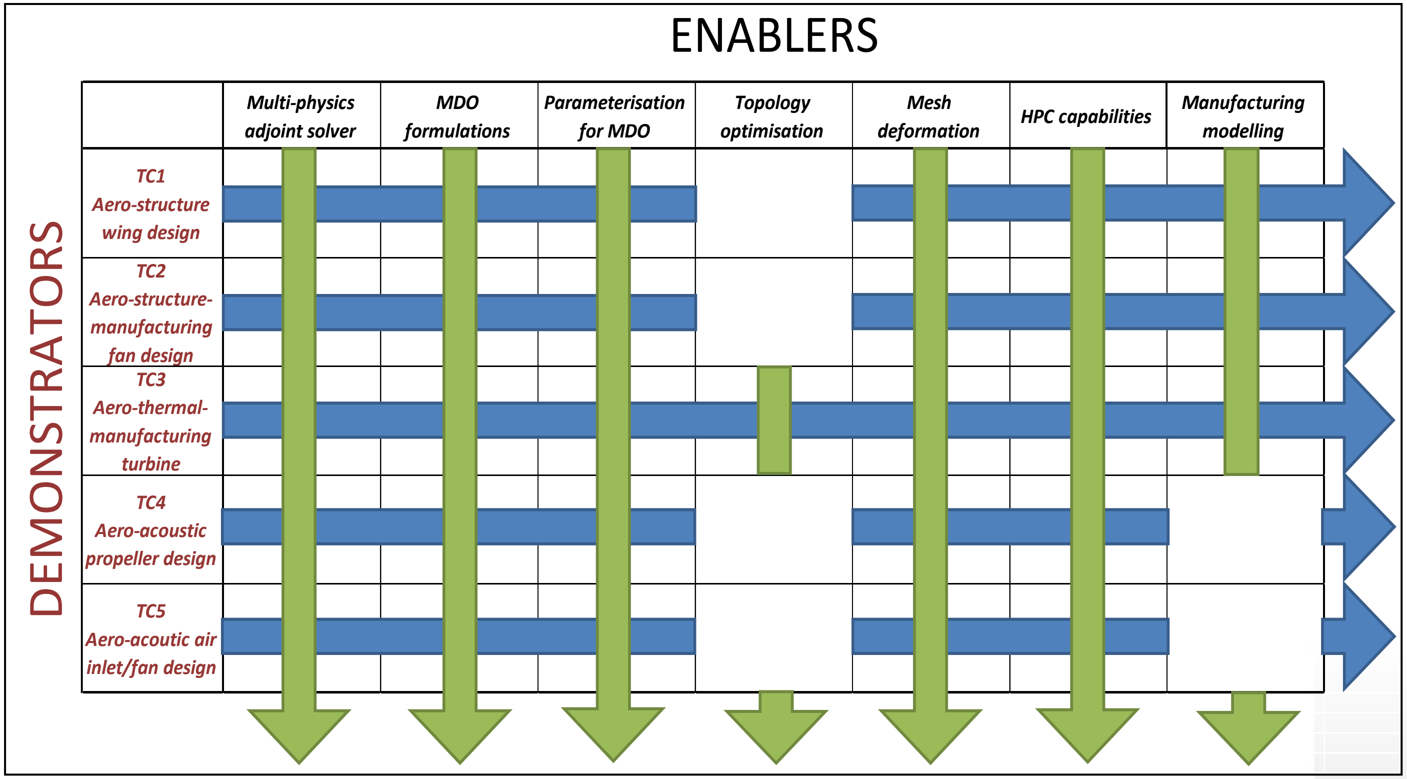
Extend MDO to efficiently include manufacturing criteria

Concept of MADELEINE

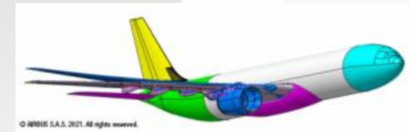
Focus on synergies between enablers and demonstrators

Enablers: methods and tools required to apply adjoint based MDO processes

Demonstrators: test cases representative of multi-physics industrial design problems



Wing design – Airbus XRF-1

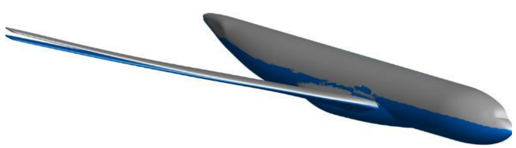


Challenges and objectives

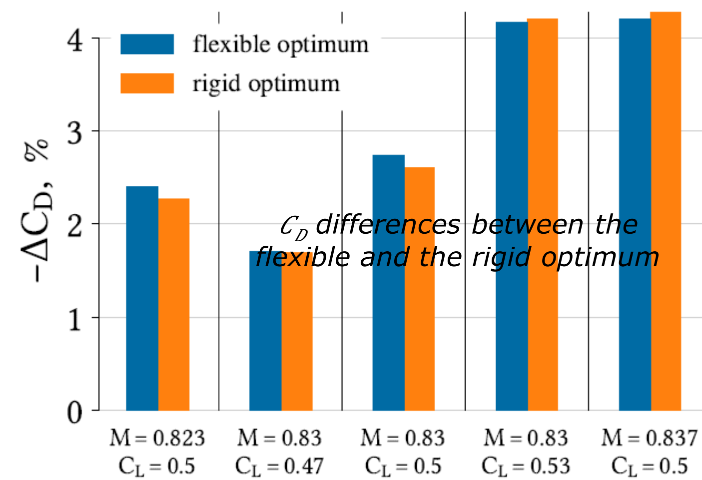
- Perform aero-structure flexible wing optimizations of a long range modern transport aircraft in a real industrial context
- Evaluate the benefits of engaging aero-elastic and structural criteria in aerodynamic optimization

Main Results

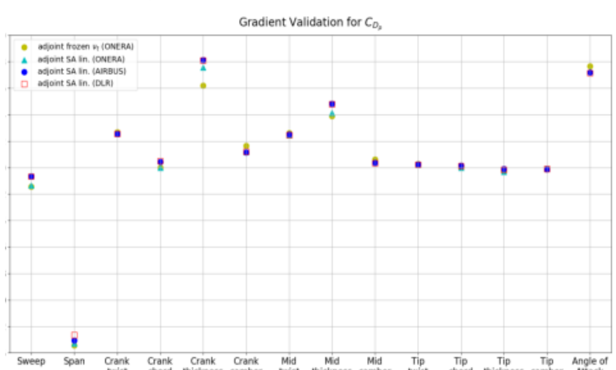
- Aero-elastic and aero-structure optimizations on a realistic configuration for different wing stiffness with representative load cases for structural sizing



Flight shape for two different wing stiffness



- Cross-validation of coupled sensitivities for different adjoint solvers but a unique parameterization



- Quantification of the benefits of engaging aero-elastic gradients in the MDO process in cruise (transonic)

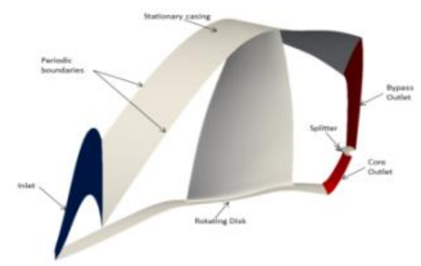
Fan design – Low-pressure fan blade

Challenges and objectives

- Perform **aero-structure-manufacturing fan blade optimizations** of a Ultra-High-By-pass-Ratio modern engine
- Take into account **real manufacturing uncertainties** in the design process

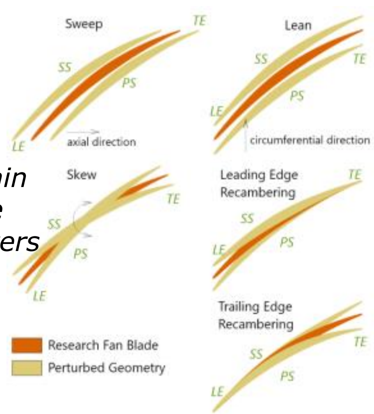
Main Results

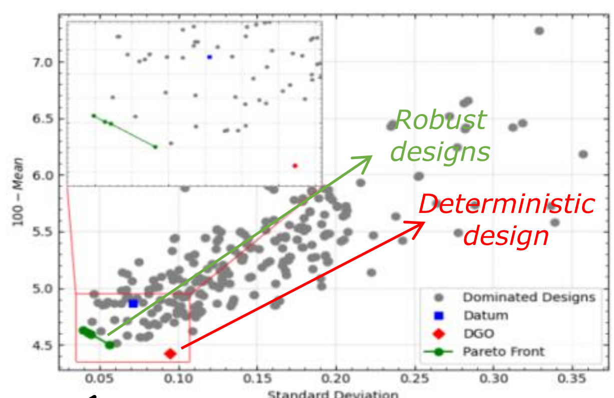
- Impact of the structural constraints on the aerodynamic fan blade efficiency using engineering-based parameterization
- Robust fan blade design with uncertain shape parameters defined from GOM scan of manufactured blades



VITAL fan blade configuration

Uncertain shape parameters





Robustness increase

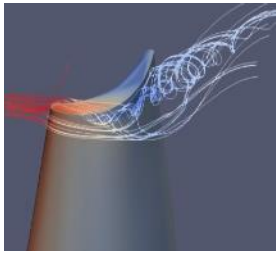
- Aero-structure optimizations are required to obtain feasible fan blade shape
- The use of UQ based on real shape uncertainties is key to have robust design with a very limited performance degradation

Turbine design – High-pressure turbine blade

Challenge

- Perform aero-thermal-manufacturing turbine blade optimizations of a Ultra-High-By-pass-Ratio modern engine
- Explore larger design space

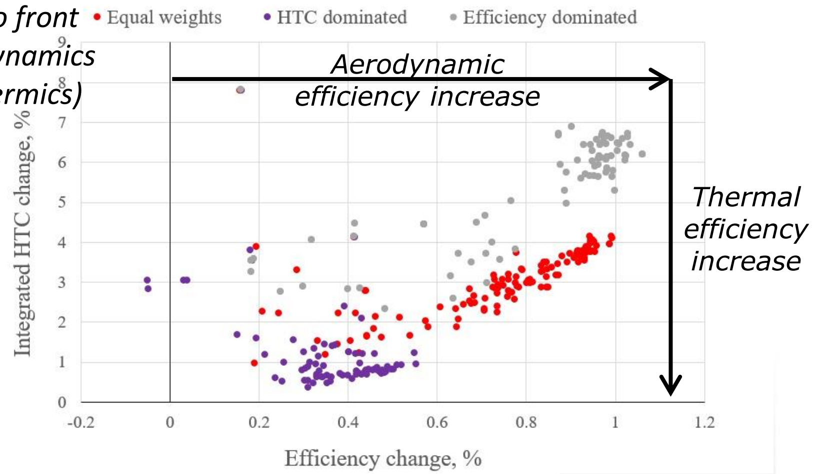
MT1 turbine fan blade configuration

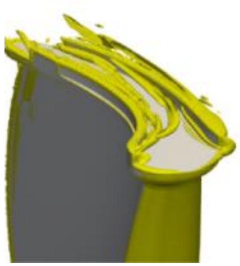


Main Results

- Comparison of turbine tip aerodynamic optimization using engineered-based parameterization vs Topology Optimization (Δ 0.3% in terms of efficiency)
- Bi-objective aero-thermal optimizations

Pareto front (aerodynamics vs. thermics)



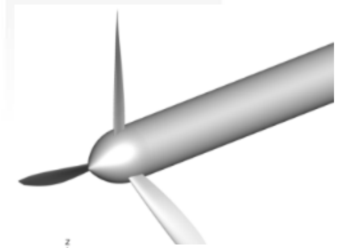


Topology Optimized Winglet-Squealer tip

Propeller design – CTOL/VTOL propeller blade

Challenges and objectives

- Perform aero-acoustic propeller blade optimizations of modern turbo-propulsor engine
- Evaluate the benefits of engaging aero-acoustic criteria in aerodynamic design using unsteady simulations

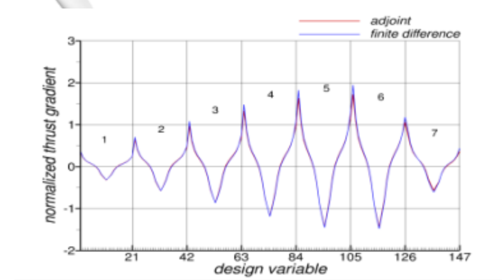


HAD-1 ONERA geometry

Main Results

- Validation of adjoint-based sensitivities

Comparison of adjoint and finite differences gradients wrt shape parameters

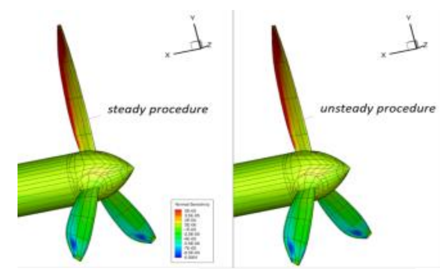


- Design space exploration using innovative parametrization as Vertex Morphing

Vertex Morphing parameterization

- First steady and unsteady aero-acoustics optimizations

Steady and unsteady sensitivities

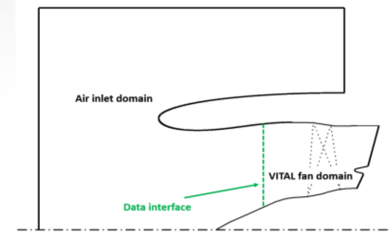


Rolls-Royce | University of Southampton | National Technical University of Athens

Air inlet/fan design – Generic air intake/VITAL

Challenges and objectives

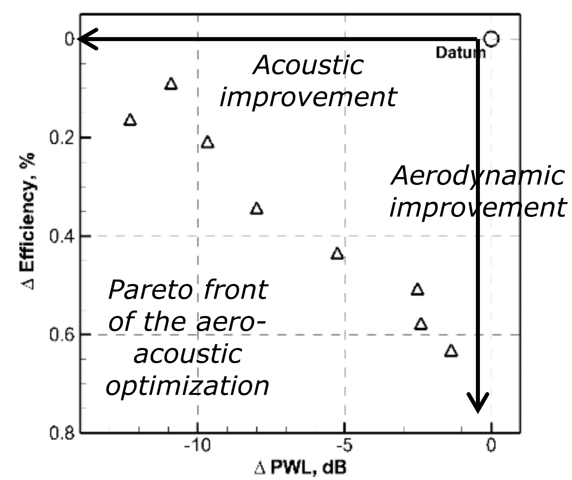
- Perform simultaneously aero-acoustic air inlet and fan blade optimizations of a Ultra-High-By-pass-Ratio modern engine
- Evaluate the benefits of the coupled optimization process



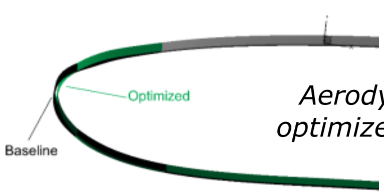
Air inlet and fan domains decomposition

Main Results

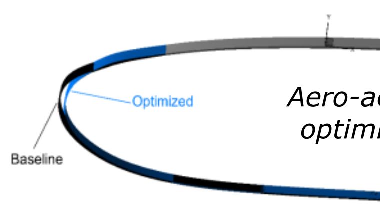
- Validation of the aero-acoustic sensitivities based on CFD simulation with FW-H analysis
- Bi-objective aero-acoustic fan blade optimizations



- Aero-acoustic inlet optimization



Aerodynamic optimized shape



Aero-aerodynamic optimized shape

Conclusions

- MADELEINE: several teams working closely together on representative industrial test cases for different design objectives (airframe; fan, turbine or propeller blades; air inlet), each test case benefits from the others,
- Development of several multi-physics and multi-disciplinary adjoint solvers (aero-structure, aero-acoustics, aero-thermal)
- Development of advanced UQ approaches using the adjoint capability
- First MDOs demonstrating the interest of engaging multi-disciplinary adjoint solvers to address complex industrial design problems
- Aerodynamic robust design demonstrating the benefits of using the adjoint technology to increase the number of uncertain parameters

Meet with us

VIRTUAL PUBLIC MADELEINE WORKSHOP

November, 25th and 26th 2021

(registration mandatory)

And stay tuned!

Website: https://www.madeleine-project.eu/

www.linkedin.com/company/madeleine-project

MADELEINE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 769025.