Development of NOVA Aircraft Configurations for Large Engine Integration Studies

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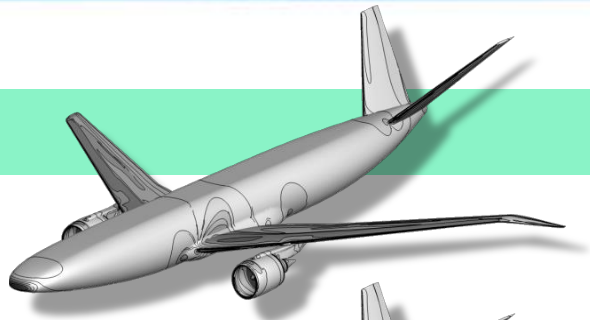
return on innovation

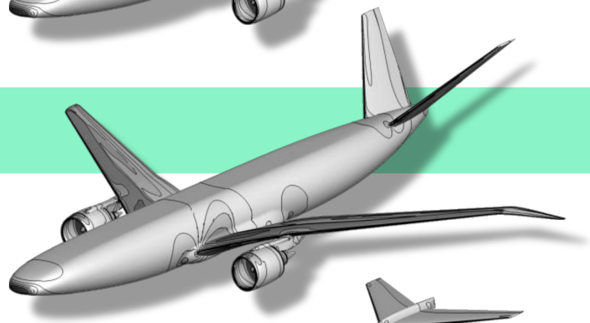
NOVA
Targeted architectures for UHBR

✓Baseline



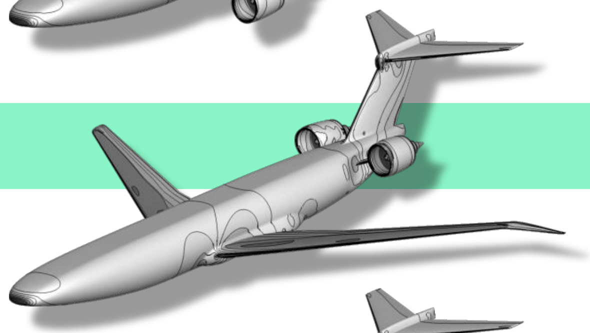
- ✓ UHBR engine
- ✓ Wide lifting fuselage
- ✓ High AR wing
- ✓ Downward oriented winglets

✓Gull wing



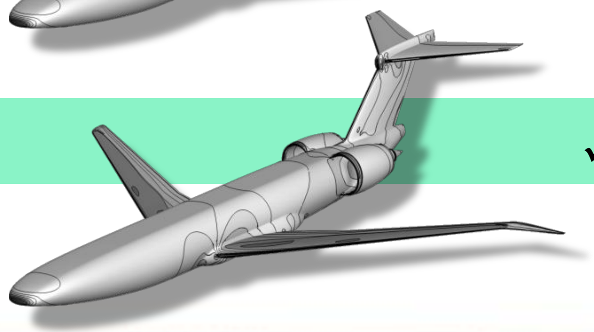
- ✓ Increased inner wing dihedral to limit landing gear length

✓Podded



- ✓ Engines mounted on aft fuselage side

✓BLI



- ✓ Engine inlet ingesting the fuselage boundary layer

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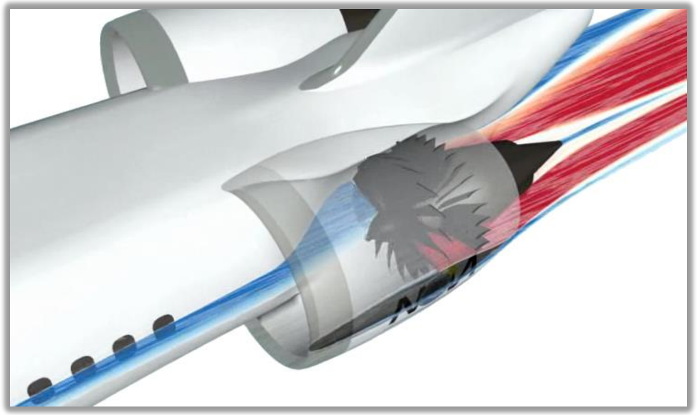
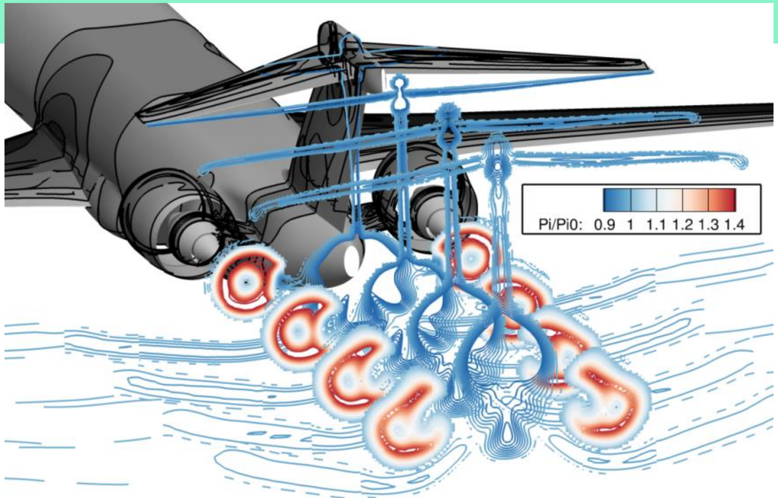
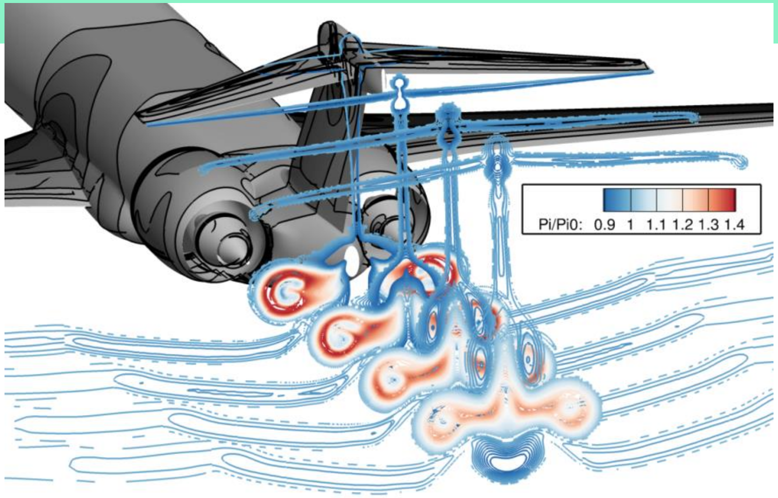
BLI configuration

- ✓ By embedding the engine into the fuselage, savings in fuel (due to reduced wetted area and jet/wake losses) and mass are expected
- ✓ **Deliberately « agressive » design:**
  - ✓ engine~40% burried
  - ✓ short inlet (inlet length/fan diameter ratio~1)

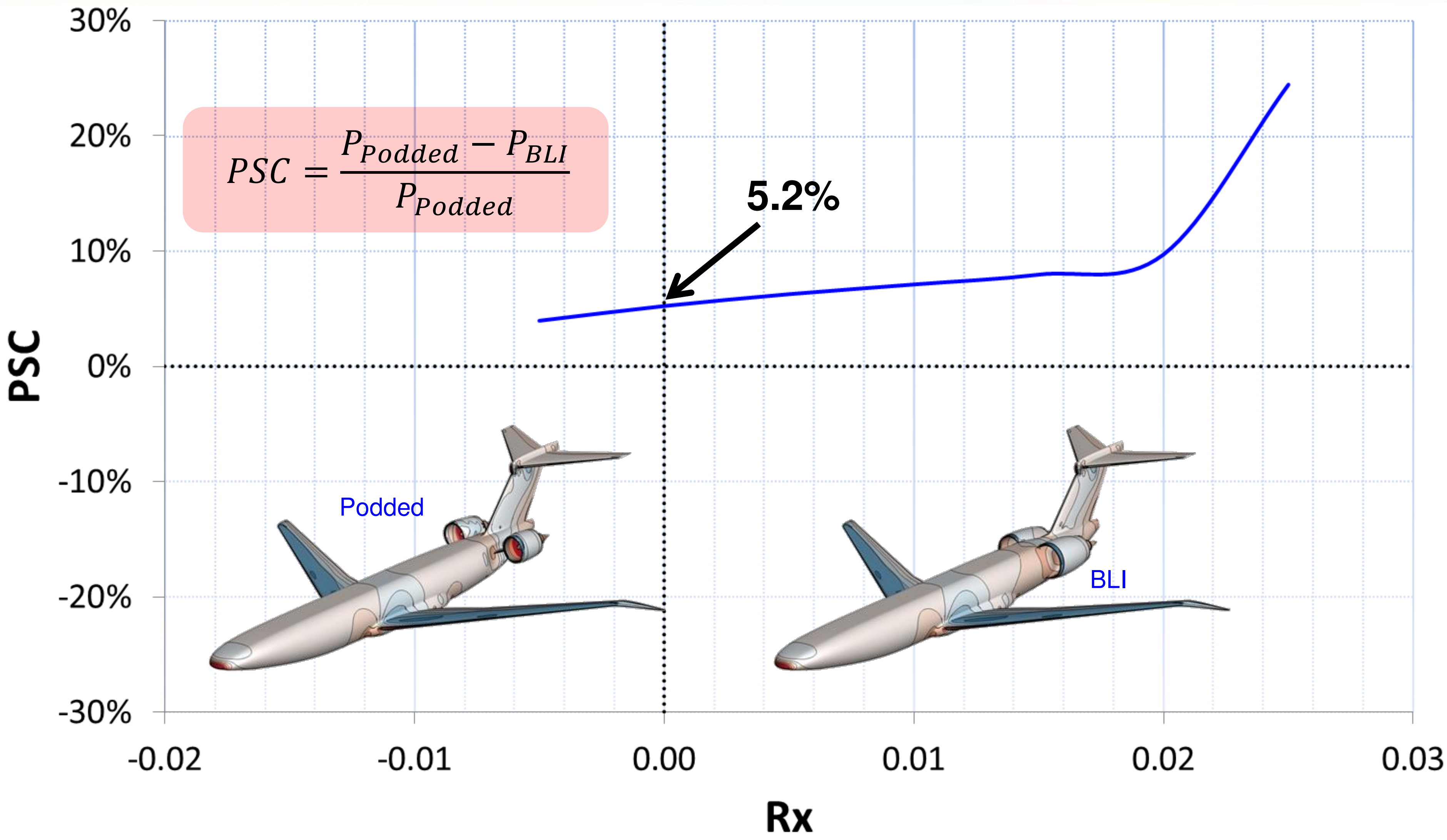






When ingesting the fuselage boundary layer, the engines tend to minimize the aircraft footprint in the surrounding airflow, indicating better thrust-drag balance

NOVA
Power saving VS stream-wise force



Outline

1. Introduction
   Context; why new engine integration concepts?

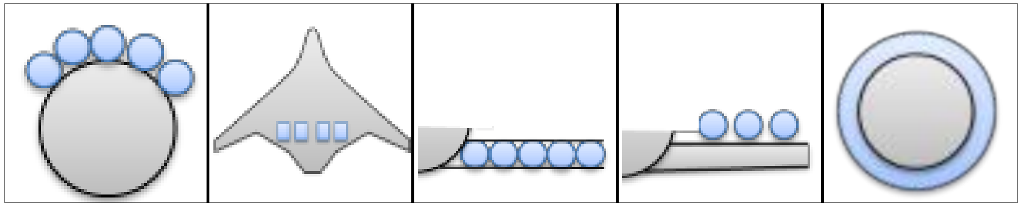
2. Boundary Layer Ingestion

3. Towards Distributed, Hybrid Electric Propulsion

4. Conclusions

BLI → Distributed propulsion → Electric propulsion

- Links between BLI and Distributed Propulsion :
  - Efficiency ↑ with fraction of BL ingested (D_w/D_A)
  - Many architectures can be envisaged:



(Source: A. Steiner et al., BHL, ICASE2012)

  - Distributed propulsion has additional advantages:
    - Redundancy/reconfiguration (safety)
    - Use differential thrust for control

- Links between Distributed Propulsion and (Hybrid) Electric:
  - Electric ducted fan is a enabling technology for multifan and “massively” Distributed Propulsion architectures
  - Distributed propulsion calls for separation of thrust and power production functions, making the use of hybrid energy source more natural.

Distributed Electric Propulsion studies

in the AMPERE Project

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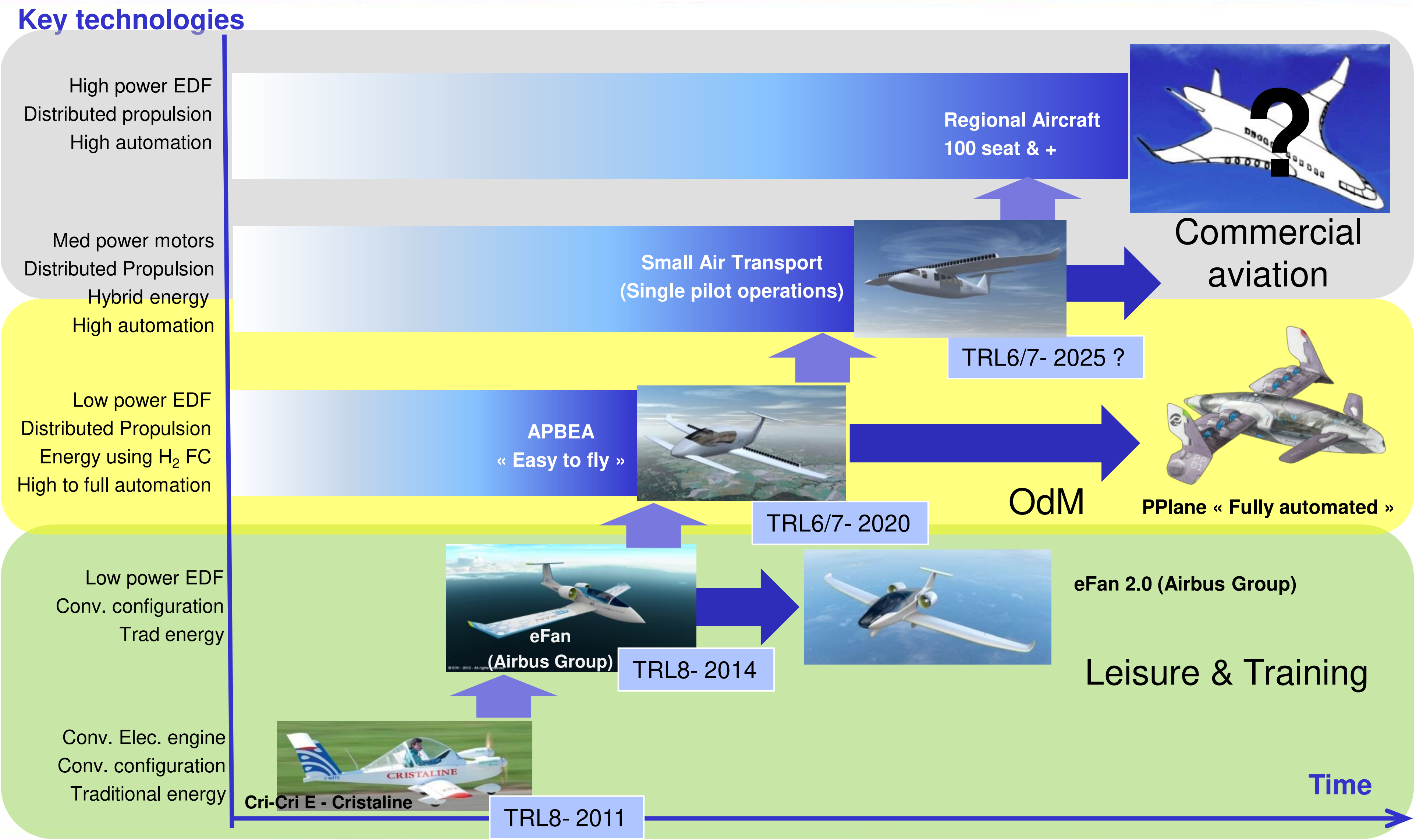
Technologies and associated A/C concepts roadmap



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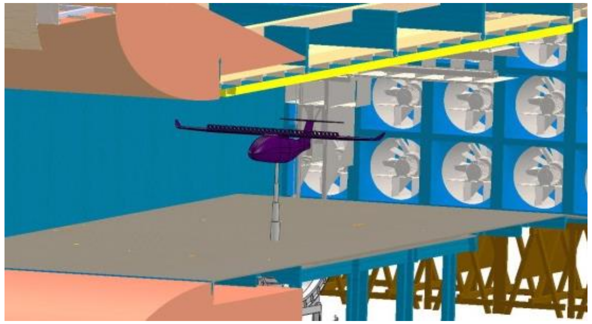
✓**Objective:** Increase maturity of DEP technology

- ✓Aerodynamics of Electric Ducted Fan (EDF) integration
- ✓A/C Control/command through EDF and conventional moving surfaces (considering potential resizing)

✓***Means:*** Numerical and experimental approaches

- ✓Aerodynamic design of EDF integration
- ✓Wind tunnel experiments
  - ✓L2 very low speed WT (Lille, France)
  - ✓Powered 1:5 scale Mock-up with on the shelf components



- ✓Control Law definition using both control surfaces and EDF
- ✓6DoF Simulation tool using aerodynamic model and Control law for robustness analysis and demonstration

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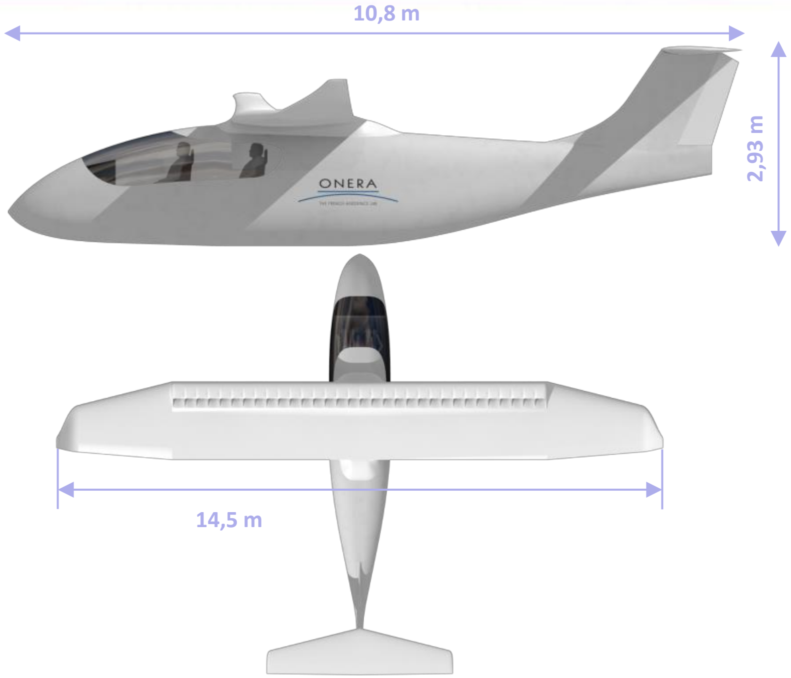
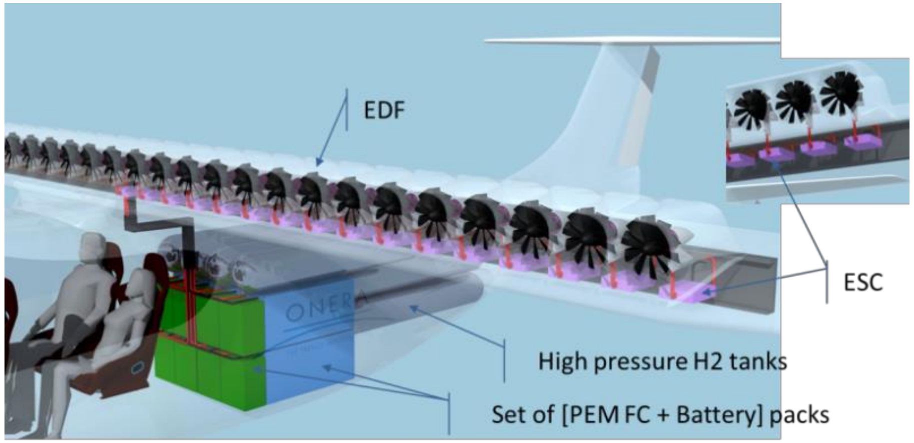
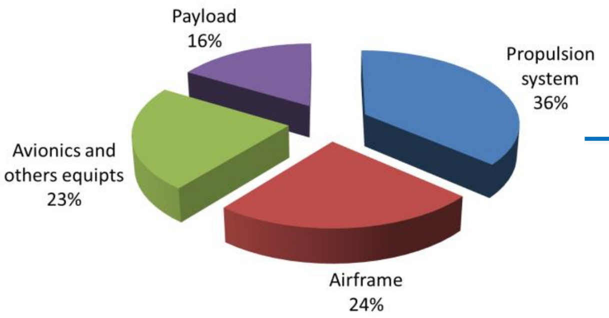
Aircraft Pre-design

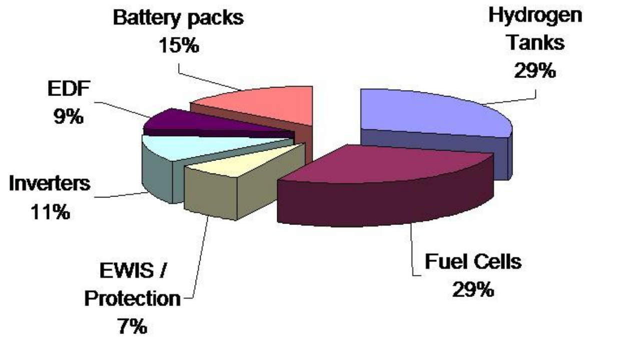


Example of arrangement of electrical propulsion architecture





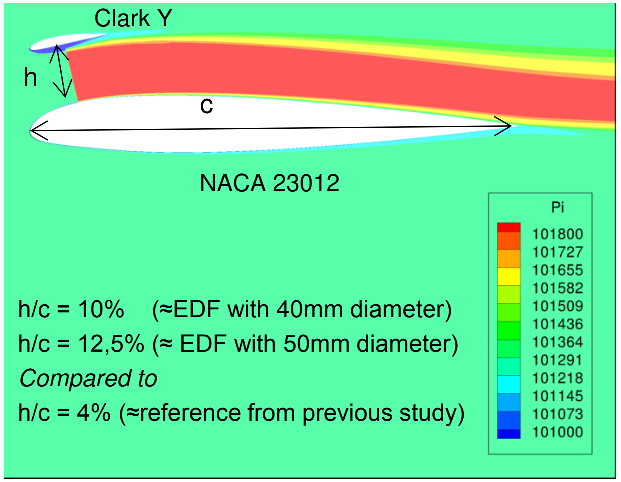
Estimated MTOW ~2400 kg

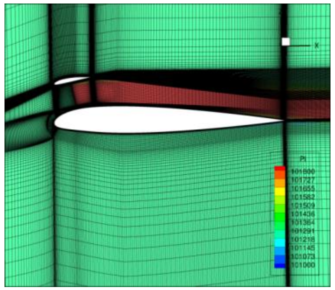


Estimated weight of advanced power architecture (Propulsion) ~890 kg

Numerical investigation of DEP with blowing effect (2D)

Preliminary investigations



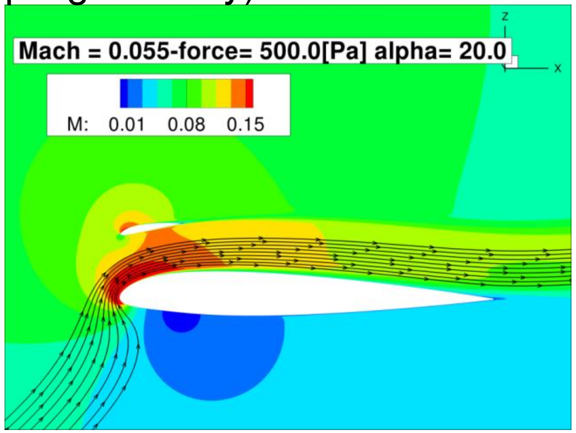


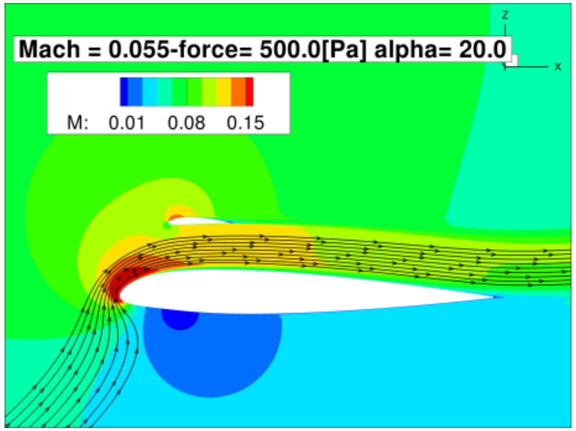
Actuator disk →

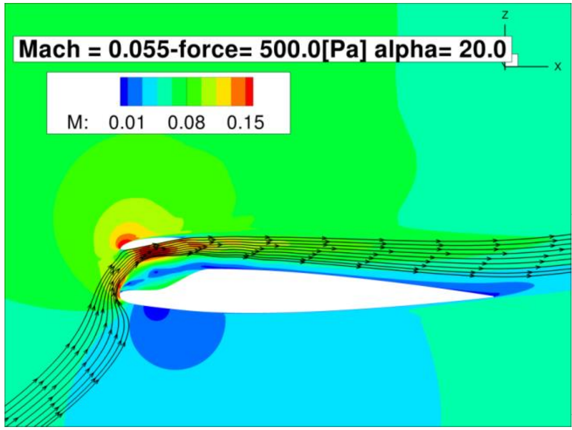
Imposed pressure variation

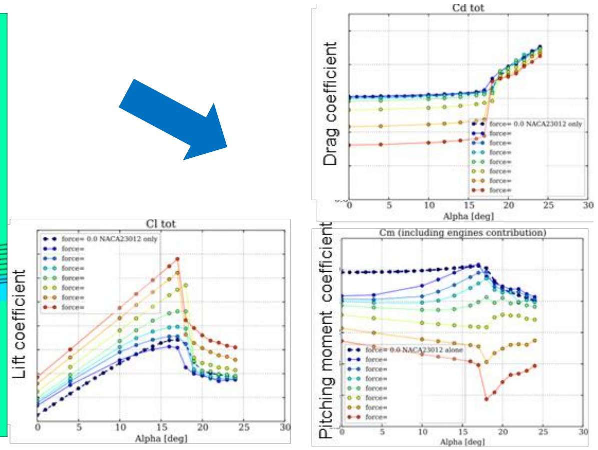
Engine location sensitivity analysis

Selection criteria upon Cz_{max}, stall behavior (stability and progressivity)



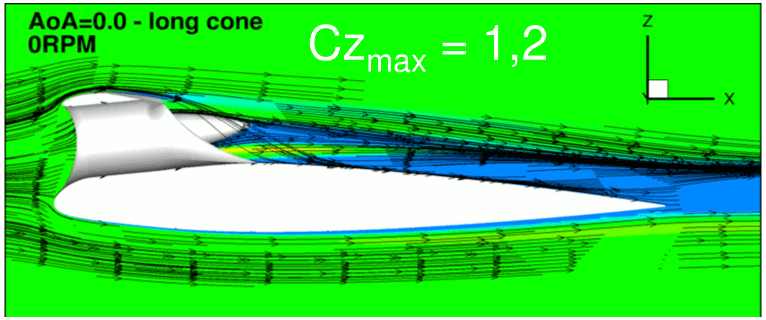


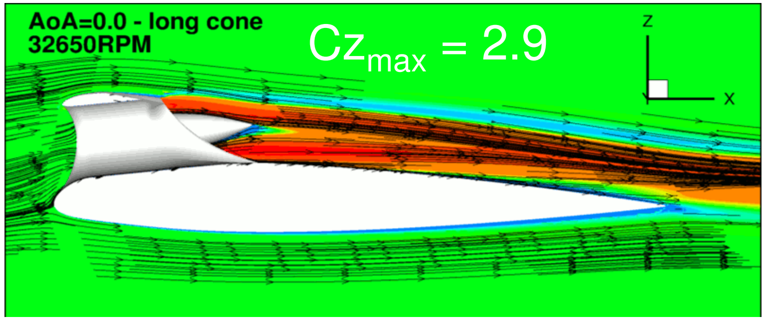


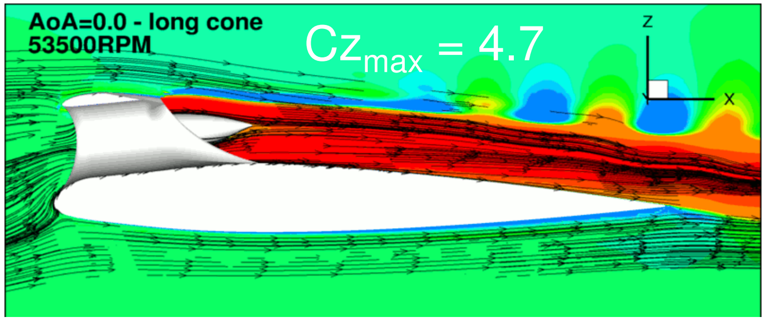


CFD RANS 2D

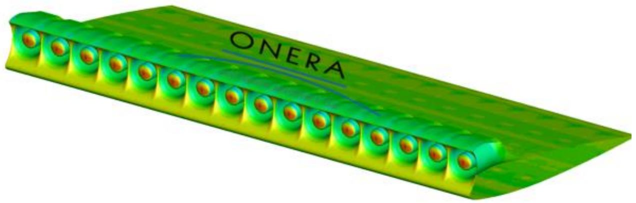
Numerical investigation of DEP with blowing effect (3D)

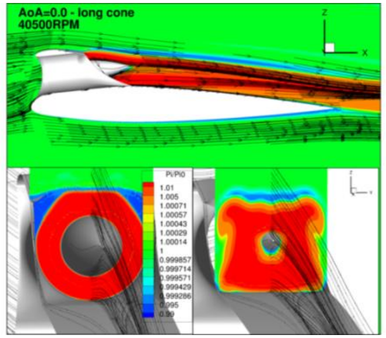






- CFD 3D computations, viscous, stationnary (RANS), on a wing section with 1 EDF (which models a wing with an infinity of EDF)





- Fan modelled by an actuator disk (pressure gap)
- Guide vanes integrated into computations
- 3D effects integrated to handle «squaring the circle» issue (to go from a circle section to an square one)

➡ Cz_{max} in 3D close to 4.7 instead of 5.7 with 2D CFD assessment

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Testing in ONERA L2 WT

- ✓ Tests were ended early 2017
- ✓ Analysis on going

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1. Introduction

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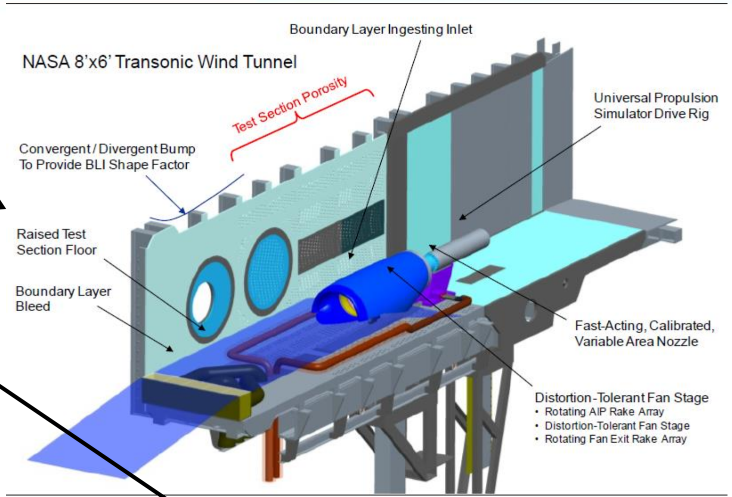
4. Conclusions:

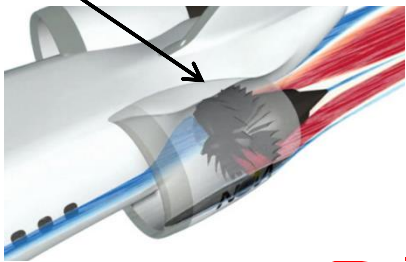
   Future challenges of BLI and DEP

Conclusions:
Main challenges of BLI

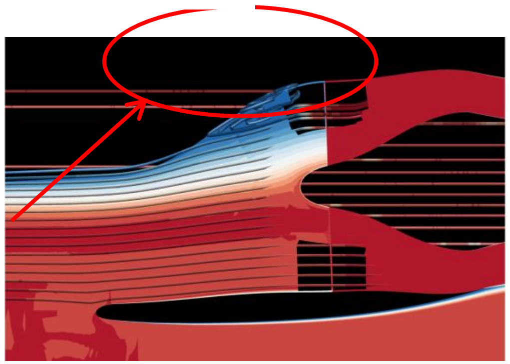
- ✓ *Experimental proof of benefits in transonic conditions*



- ✓ *Design fan/OGV tolerant to distortion*
- ✓ *Aero-elastic behaviour of the fan with distortion*



- ✓ *Design air inlet suitable for all operating conditions (Active Flow Control)*

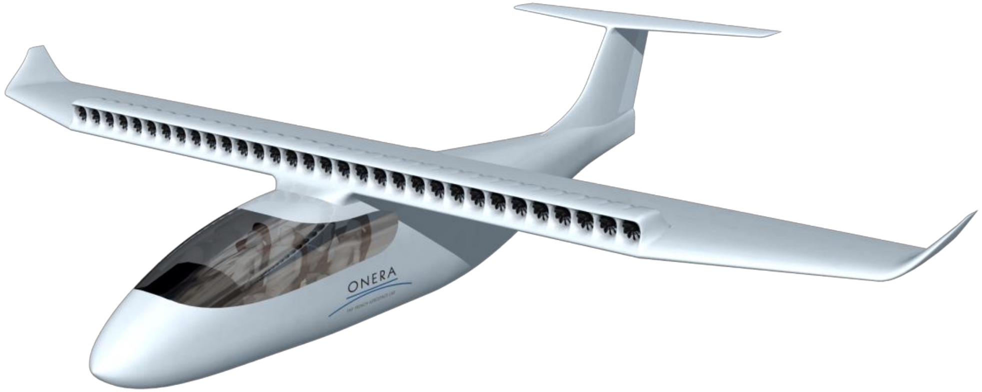


Flow separation with short inlet

- ✓ *Impact of BLI engine integration architecture on structure and mass*
- ✓ *Aero-acoustic characterisation of BLI configuration*

Conclusions:
Main challenges of Distributed Propulsion

- ✓ *Performance in transonic conditions*
- ✓ *Experimental proof of benefits at Low-Speed (Take-off and Landing)*
- ✓ *Impact of DP architecture on structure and mass*



- ✓ *Engine integration issues*
  - ✓ *Thermal aspects for large passenger Aircraft*
  - ✓ *Electromagnetic compatibility*

Thanks for your attention.
Any questions?

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