CLEAN AVIATION

INTERNATIONAL COUNCIL OF THE AERONAUTICAL SCIENCES 2022 CONGRESS

PROGRESS IN WING DESIGN, STATUS AND PERSPECTIVES

Stockholm, Sweden, September 4-9, 2022

ICAS2022_0926

Co-funded by the European Union

PROGRESS IN WING DESIGN, STATUS AND PERSPECTIVES

CLEAN AVIATION

PROGRESS IN WING DESIGN, STATUS AND PERSPECTIVES

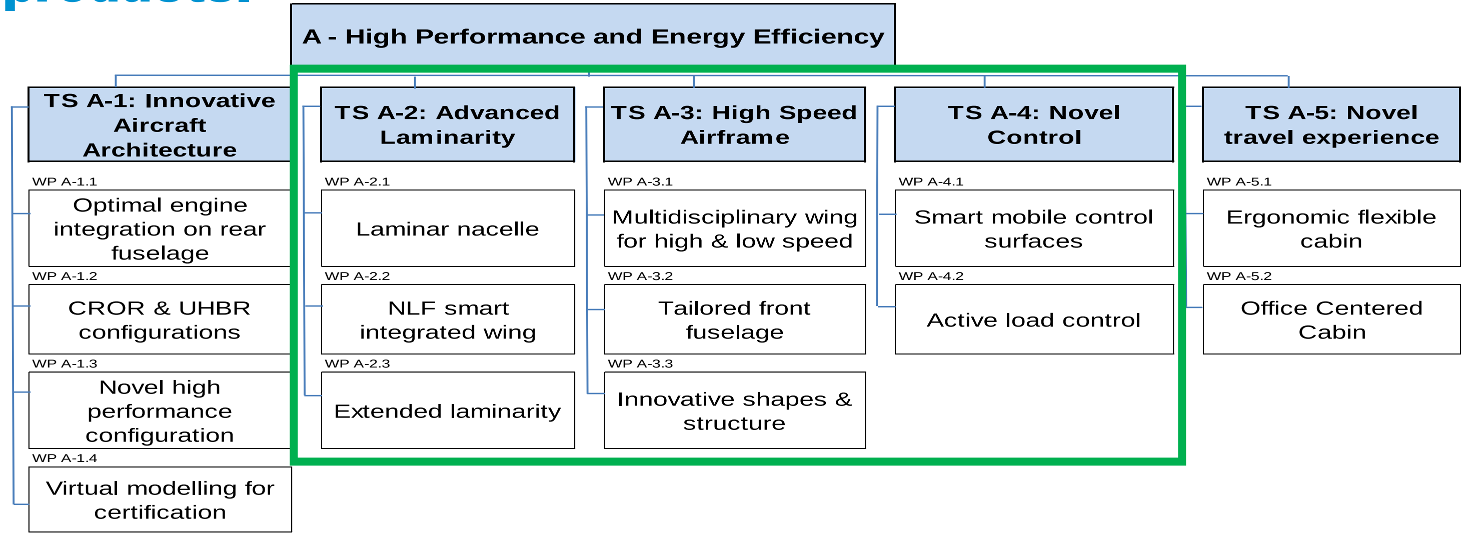
Jérôme LERY

Dassault Aviation

Co-funded by the European Union

I. PREAMBLE

- **The presentation describes the activities performed on Wings by the Leaders Airbus, Saab, and Dassault Aviation, and the Core Partners ONERA and DLR (NACOR consortium) in the frame of Clean Sky 2 Airframe ITD.**
- **The activities are covering various Technology Streams from the Airframe ITD “High Performance & Energy Efficiency” Activity Line, with the objective to mature wing technologies spanning from High Aspect Ratio (HAR), Natural Laminar Flow (NLF), composite structure, electrical wing ice protection systems, and active load and flutter control.**
- **Following ground testing that is being carried out under Clean Sky 2 Airframe ITD, technology maturation will continue under Clean Aviation to meet the 2030/35 EIS target for implementation in future products.**



Co-funded by the European Union

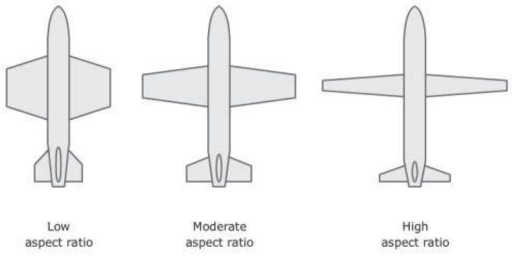
CLEAN AVIATION

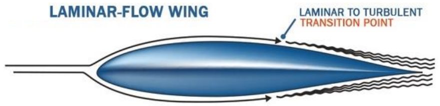
II. GLOBAL CONTEXT

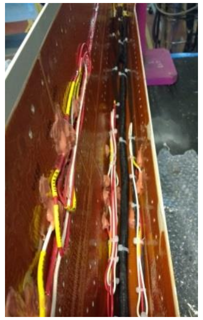
- The societal context requires transport players to significantly reduce their environmental footprint ➔ "Destination 2050 - A Route to Net Zero European Aviation" promotes a trajectory of carbon neutrality in 2050. It proposes to obtain a gain in C02 emissions up to 40% via aircraft and engine technological contributions.
- Aircraft current architectures, in particular the wings, do not allow to foresee significant gains.
- There is therefore a need to look for breakthrough architectures, offering fuel consumption gains of over ten%.
- Laminar High Aspect Ratio (HAR) wing architectures are able to meet these high level objectives by accepting a reduction in cruising Mach.

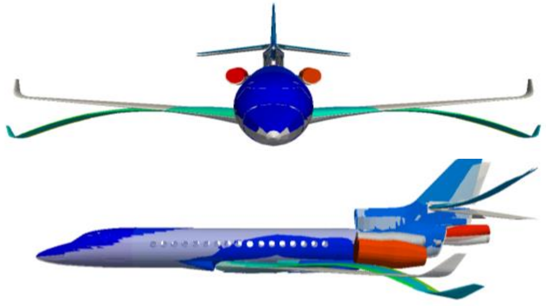
Co-funded by the European Union

III. GENERAL OBJECTIVES OF THE ACTIVITIES









- The technological building blocks necessary to reduce consumption are as follows:
  1. **A high AR associated with a reduced sweep angle**
  2. **Extensive Natural Laminar Flow (NLF) on the wing**
- Three other technological bricks are necessary to ensure the feasibility of the envisaged configuration:
  3. **Composite technologies to ensure both a reduction in mass and the feasibility of new planforms, in particular by making possible significant increases in aspect ratio while maintaining the adequate sweep for the targeted cruise speed**
  4. **An electrical ice protection, necessary in view of the large spans envisaged, and which must ensure the complete elimination before cruising of any ice possibly accreted on this NLF slat-less wing, and therefore without steps & gaps causing the separation of the flowing water**
  5. **The control of an A/C more flexible than the existing A/Cs due to the AR, and its flutter**

Co-funded by the European Union

CLEAN AVIATION

III. GENERAL OBJECTIVES OF THE ACTIVITIES

1 • High aspect ratio with objective value beyond 11: reduction in drag but increase in aircraft weight and more complex layout ➔ Limit the increase in weight

2 • Laminarity (NLF):
  - **Severe requirements in terms of surface quality (steps and gaps, waviness, junctions, etc.), more stringent on a wing with large surfaces to be treated**
  - **Need to implement industrial assembly processes adapted to laminarity constraints**

3 • Composite wing technologies

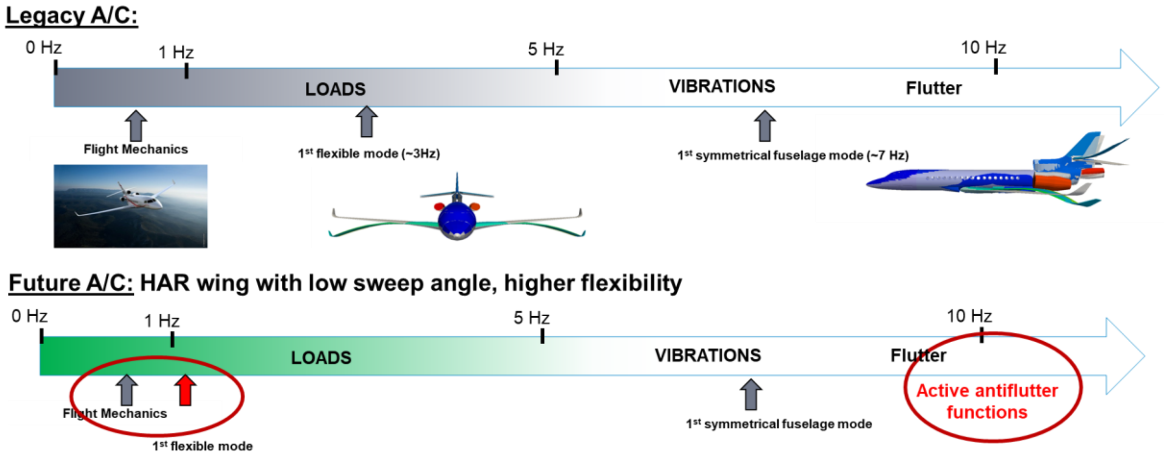
4 • Mastering of the electric ice protection system, which brings constraints on the design of the wing; several specific issues to be tackled:
  - **Identification of the length of chord to de-ice versus laminarity**
  - **Energy balance improvement**
  - **Certifiability Vs. SLDs**
  - **Integration of heater mats in the leading edge**
  - **Compatibility of the electrical balance Vs. available engine offtake**

5 • The control of an A/C more flexible than the existing A/Cs due to the AR, and its flutter

Co-funded by the European Union

Airframe ITD: Active Load Control WP

- Flexible Wing and Flutter Controls Challenges:
  - **The increase in flexibility leads to a modification of the frequency distribution of the wing vibration modes:**
  - **In addition, the classic management of flutter by passive solution, costly in mass, is to be avoided.**

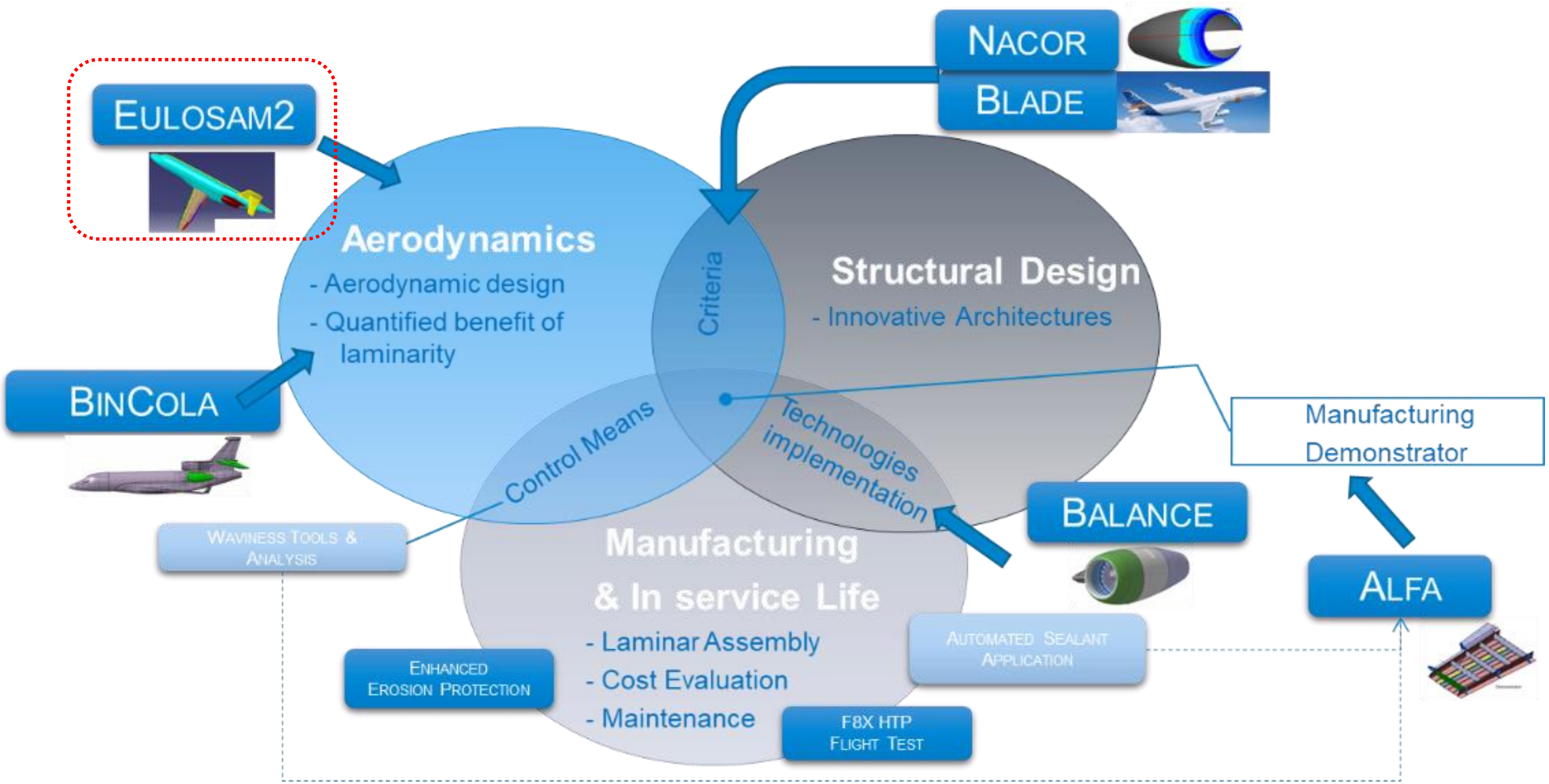


- Objectives:
  - **To rethink the strategy / methodology of the flexible aircraft in a global way for the best compromise between flying/handling qualities and aircraft weight**
  - **To study, apply and evaluate this active control strategy making it possible to control the dynamics of the flight of a flexible aircraft**
  - **To identify the impacts of the Flight Control System (FCS) on the overall architecture, and in particular the hardware (control surfaces, actuators, sensors etc.)**

Co-funded by the European Union

IV. ACTIVITIES CARRIED OUT IN CS2
MULTIDISCIPLINARY APPROACH FOR NLF APPLICATION

Airframe ITD / LPA IADP: NLF application requests a multidisciplinary approach



Co-funded by the European Union

IV. ACTIVITIES CARRIED OUT IN CS2
NLF HTP STUDIES

3 AXIS DEVELOPMENT

CS1 SFWA
CS2 AIRFRAME TS A-2

Aero Criteria

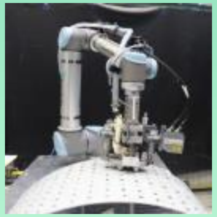
- F/T PH F7X s/n 001 (SFWA)
- Aerodynamic Design
- Evaluation of laminar area extension and drag benefit
- Definition of the criteria's
- F/T A340 BLADE
- Transonic WTT NACOR (AIRFRAME)

ONERA THE FRENCH AEROSPACE LAB — AIRBUS

CS2 AIRFRAME TS A-2

Techno Dev.

- 3 topics:
  - Anti-erosion (L/E)
  - Shielding of countersunk fasteners heads
  - Steps and gaps treatment
- Durability F/T F8X s/n 401
- Automated HTP assembly



Fraunhofer

CS2 LPA

Industrial Demo.

- Integration of technological bricks
- Compromise between performances and manufacturing costs
- Manufacturing of 4 leading edge sections (with different types of composite) by NLR, finishing works and assessments performed by Dassault (works ended in 2021)

nlr — ALFA

Co-funded by the European Union

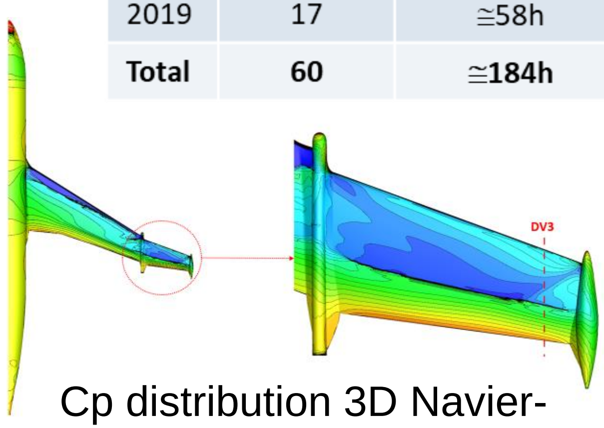
IV. ACTIVITIES CARRIED OUT IN CS2
NACOR ACTIVITIES

Co-funded by
the European Union

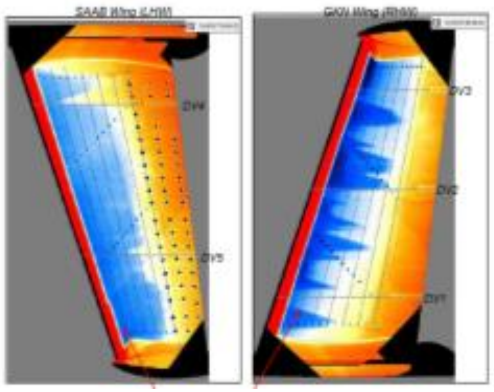
IV. ACTIVITIES CARRIED OUT IN CS2
BLADE DEMONSTRATOR

Year	Number of Flight	Number of Flight hours
2017	23	64h05
2018	20	61h21
2019	17	≅58h
Total	**60**	**≅184h**

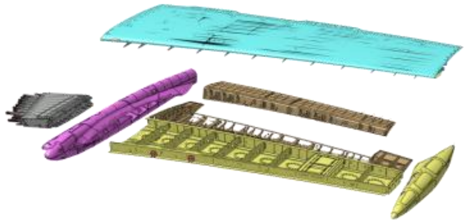
- **BLADE started in CS SFWA i.e. design, manufacturing**
- **BLADE flights and data analysis performed under Airframe ITD**
- **Flight test data exploitation still on-going (bare wings / wings with imperfections) until mid 2022**
- **Surface imperfection tests are key to secure manufacturing criterias of future laminar wings**
- **Laminarity criteria (steps, gaps, waviness) reset thanks to BLADE FT analysis**



Cp distribution 3D Navier-Stokes computation with prescribed transition



1st flight: 26 Sept. 2017



Co-funded by the European Union

V. OUTLOOK FOR FUTURE ACTIVITIES

- To continue the developments to meet NLF criteria and to elaborate/identify the associated industrial assembly processes i.e. adapted to laminarity constraints
- To continue to work on the maximal aspect ratio achievable thanks to composite materials/structures and active load & flutter alleviation
- To continue the activities to study, apply and evaluate an active control strategy to ensure control of the dynamics of the flight of a flexible A/C; in particular, to continue the activities to identify the impacts of the FCS on the overall architecture, in particular:
  - **Control surfaces**
  - **Actuators**
  - **Sensors**

Co-funded by the European Union

AUTHORS / ACKNOWLEDGEMENT

Jérôme Lery
Head of Program
Clean Sky 2 Coordination
DASSAULT AVIATION
R&D and Advanced Business - Future Falcon Technology

Jérôme Lery has worked for more than 30 years at Dassault Aviation. He has held numerous functions, especially at the General Technical Directorate where he started in 1988 as engineer in Aerodynamics. He dealt with Radar and Infrared Signature, aeromechanical stores integration, as well as Military support. In 2000, he took part in the Joint Venture between Dassault Aviation and BAe Systems, EAeS LTD, and acts since then as Project Manager. He moved in 2006 to the New Technologies, Materials, and Testing Department of the Aerostructure Engineering Directorate, to take the lead of the Eco-Design Airframe platform of the European project Clean Sky. In 2016, he moved to its current position in the Future Falcon Technology Department of the R&D and Advanced Business Directorate. Since early 2019, he coordinates all Clean Sky 2 activities for Dassault Aviation; in particular, he is coordinating the Clean Sky 2 Airframe ITD with Airbus Defence and Space and SAAB.

These research activities received supporting funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation program under grant agreement No. No. 945521 (Airframe ITD). This publication reflects only the author's views and the European Union is not liable for any use that may be made of the information contained therein.

Co-funded by the European Union

CLEAN AVIATION

ENGAGE
with US!

www.clean-aviation.eu

Visit our online stand at
https://cleansky.virtualfair.be/

Co-funded by
the European Union