ACTIVE FLOW- LOADS & NOISE CONTROL ON NEXT GENERATION WING

ICAS von Karman Lecture

OVERVIEW AND RESULTS

AFLoNext

2ND GENERATION ACTIVE WING

Date: 09th of September 2021
Coordinator: Martin Wahlich
Airbus Operations GmbH

Presentation Outline

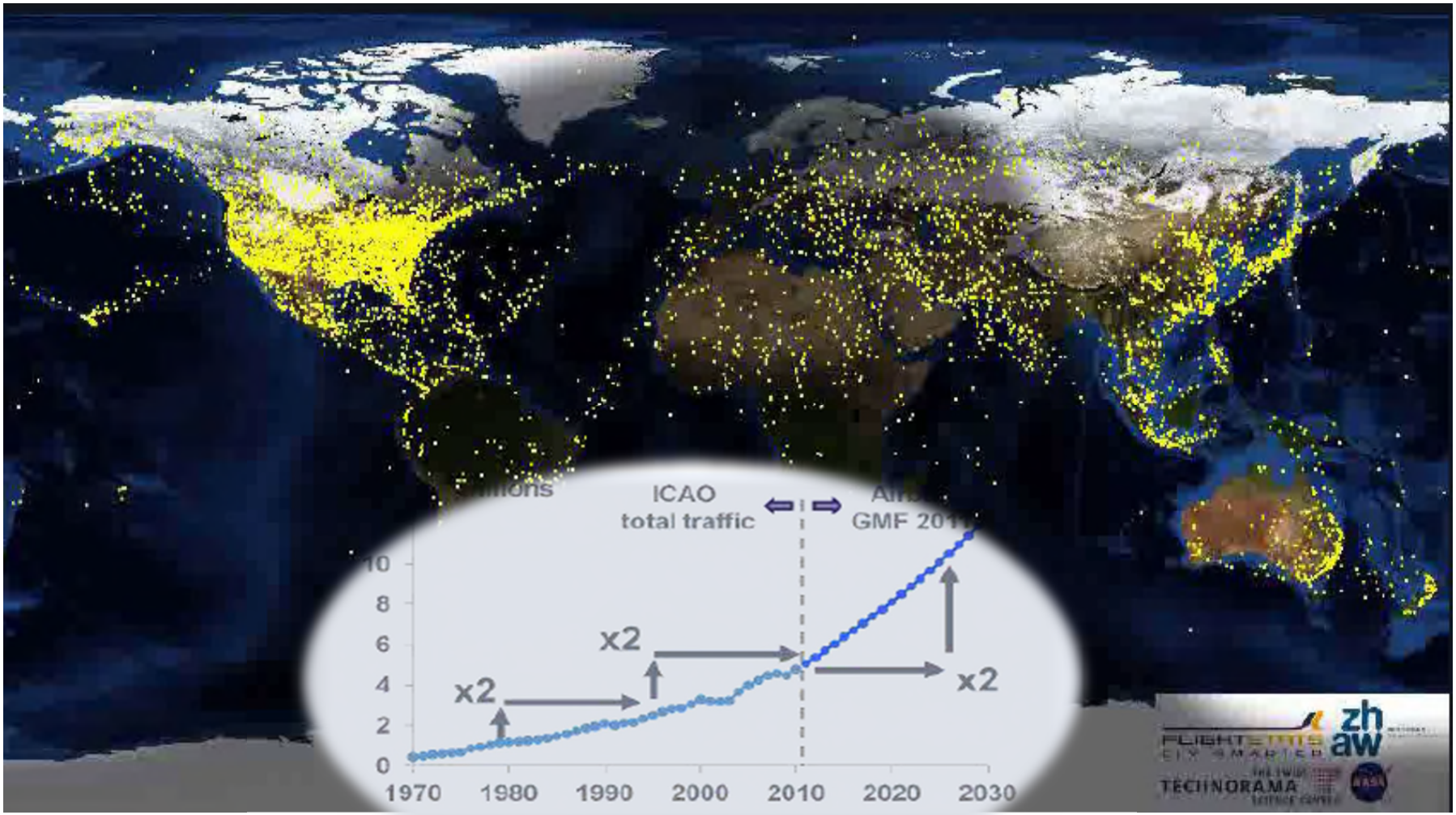
1. Motivation & Introduction

2. Project Set-up and Objectives of AFLoNext
   a) European Footprint
   b) General objectives
   c) Technology areas and objectives

3. Achievements
   a) Hybrid Laminar Flow Control
   b) Active Flow Control
   c) Noise Control
   d) Vibration mitigation / control

4. Outlook & Conclusion

Motivation



World traffic growth

Motivation

- The worldwide traffic will significantly grow within the next decade.

- This makes it inevitable to reduce the ecological footprint of passenger aircrafts.

- AFLoNext has tackled four key topics leading to more environmentally-friendly aircraft:
  - → **laminarity** to reduce aircraft drag during cruise flight to reduce fuel burn .
  - → **active flow control** on local applications to increase aerodynamic performance during take-off and landing and to allow installation of more efficient engines.
  - → **passive noise control** technologies to reduce aircraft noise during take-off and landing.
  - → **vibration mitigation & control** to allow design of optimized airframe components to reduce overall aircraft weight.

PROJECT SET-UP AND OBJECTIVES

AFLoNext Statistics

40 Partners in 15 countries

Approx. **37 M€** total cost
23.6 M€ effective funding

Project top level ranked and assessed as “excellent”

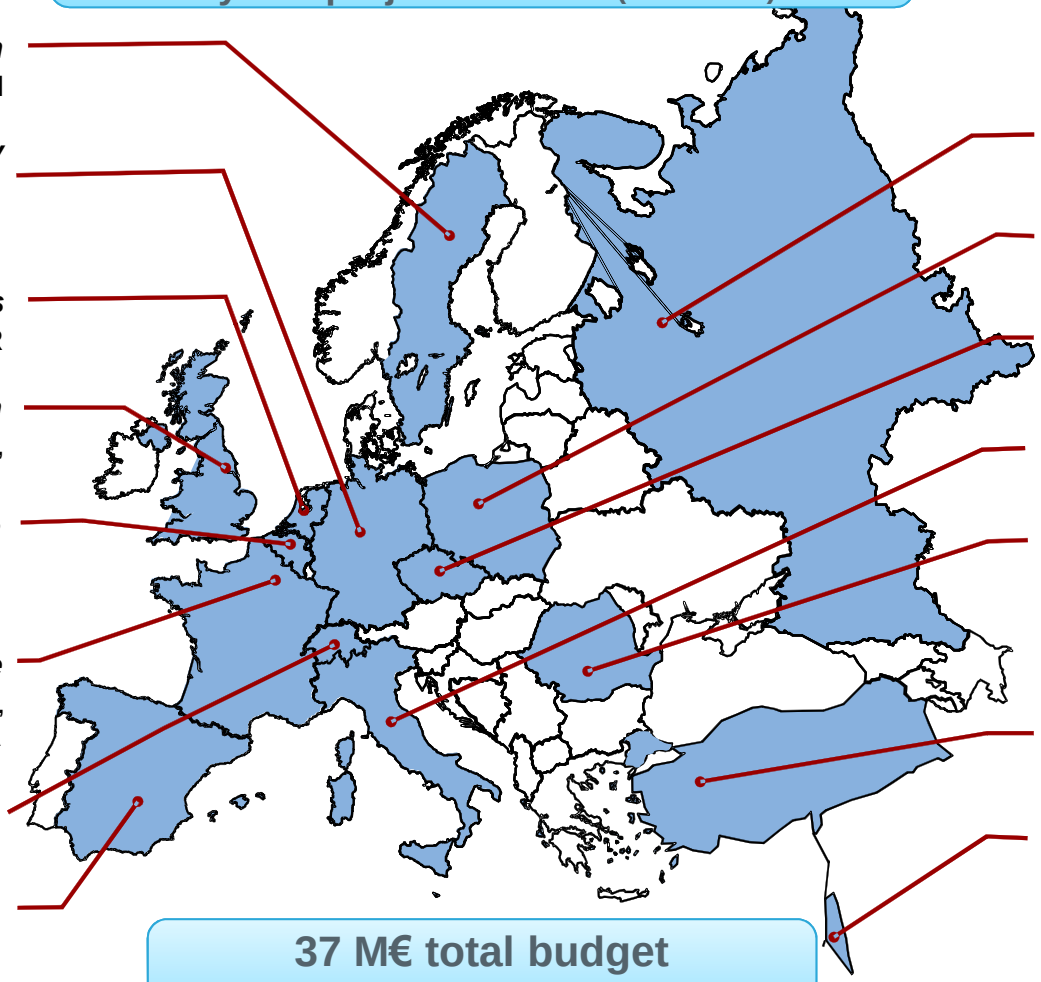
Project duration: **5 years** (2013-2018)

Project start: **1st of June 2013**
Project closure: **31st of May 2018**

Sources
www.aflonext.eu
www.cordis.europa.eu

The European Footprint of the Consortium

40 partners in 15 countries
5 years project duration (2013-2018)



Sweden
FOI, KTH

Germany
A-D, A-DS, AGI,DLR, FRAUN
IBK, INVENT, TUHH

Netherlands
ACQ, FOKK, NLR

United Kingdom
A-U, ARA, BAE, CITY,
AGI, GKN, UOM

Belgium
ASCO, COEX, SONA

France
A-F, CERF, DASS, LUP,
MBD, ONE, SLCA

Switzerland
CFSE

Spain
A-E, AERN

Russia
TSAGI

Poland
PW

Czech Republic
VZLU

Italy
CIRA

Romania
INCAS

Turkey
TAI

Israel
IAI, TAU

37 M€ total budget
23.6 M€ effective funding

Sources
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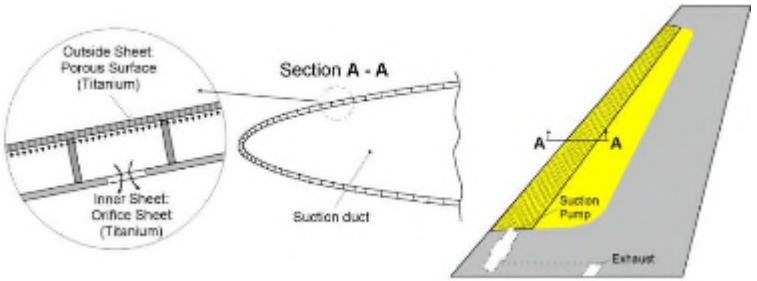
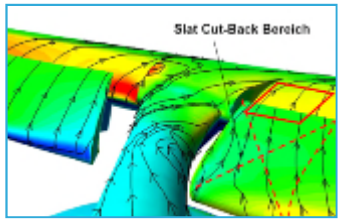
Objectives –general-

To mature and demonstrate promising flow control technologies up to high maturity levels to validate them later in a fully integrated large scale demonstrator approach such as in Clean Sky 2.

Hybrid laminar flow technology (HLFC)
for aircraft drag reduction



Active flow-control technologies
for local applications for performance increase
and improved environmental compatibility



Passive vibration- and noise-control technologies
for local applications for performance increase
and improved environmental compatibility

AFLoNext – Overview of Technology Areas & Streams

Hybrid Laminar Flow Control (HLFC)

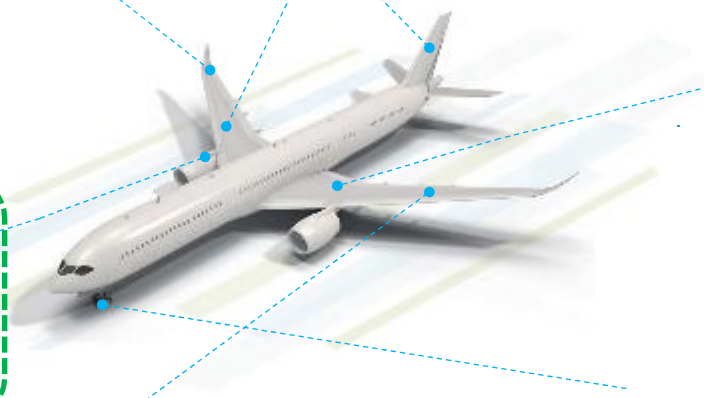
TS1 *Hybrid Laminar Flow Control on wing and fin*
Up to 9 % fuel saving

TS2 *Active Flow Control on outer wing*
Up to 2% fuel saving

Noise Control

TS5 *Noise reduction on flap and undercarriage*
Significant A/C noise reduction during approach and landing

Active Flow Control (AFC)



TS3 *Active Flow Control on wing / pylon*
Enables integration of Efficient Ultra High Bypass Ratio (UHBR) engines

Vibrations mitigation / control on airframe

TS4 *Active Flow Control on wing trailing edges*
Up to 1-2 % fuel saving

TS6 *Vibrations mitigation / control in undercarriage area*
Significant weight reduction on landing gear door and components

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PROJECT ACHIEVEMENTS

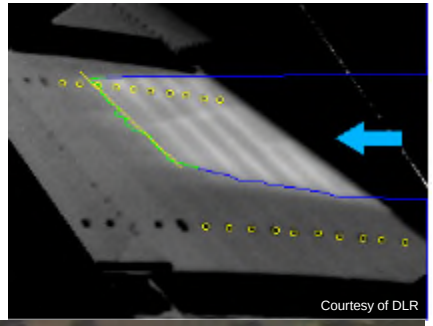
Hybrid Laminar Flow Control (HLFC)

Project Achievements
Hybrid Laminar Flow Control (HLFC)

1. Flight Test demonstration on a VTP
2. Ground based demonstration on a leading edge segment

Achievements

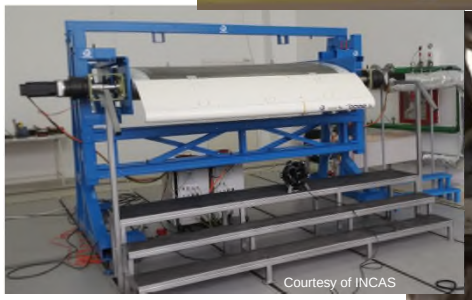
Flight Test successfully conducted April – May 2018
Simplified HLFC technology has been successfully demonstrated (first time in Europe).


Courtesy of DLR

Ground Test of wing segment was successfully conducted in March 2018
System integration was successfully tested


Courtesy of Airbus

Ice wind tunnel test was successfully conducted in August 2018
Krueger slat system and Wing Ice-Protection System was successfully tested


Courtesy of INCAS


Courtesy of Cira

Involved partners:
Airbus, DLR, CIRA, INCAS, GKN FOI, City University London, asco, Fraunhofer, Sonaca, AcQ Inducom, Politechnika Warszawska, IBK, ARA, INVENT, Dassault Aviation, NLR, TAI, Technische Universität Hamburg Harburg, ONERA, VZLU, Fokker Aerostructures

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Hybrid Laminar Flow Control (HLFC)

Project Achievements
Hybrid Laminar Flow Control (HLFC)

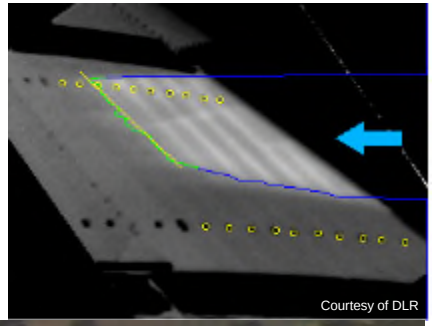
1. Flight Test demonstration on a VTP
2. Ground based demonstration on a leading edge segment

Spin-offs and acquired knowledge

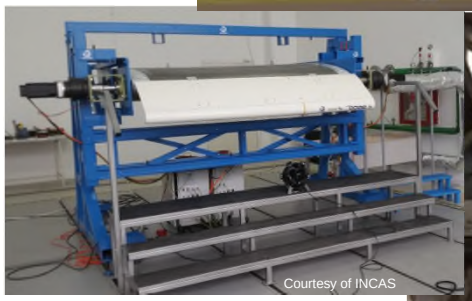
\ HLFC specific design and manufacturing methods, incl. validation of numerical methods, structural design principles / limitations.

\ HLFC specific systems for in-flight monitoring

\ Different system layouts for aircraft system integration and anti-ice system.


Courtesy of DLR


Courtesy of Airbus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Active Flow Control (AFC)

Project Achievements
Active Flow Control (AFC)

1. **Full scale wind tunnel testing of different AFC systems**
2. **Development and integration of different AFC systems**

Achievements

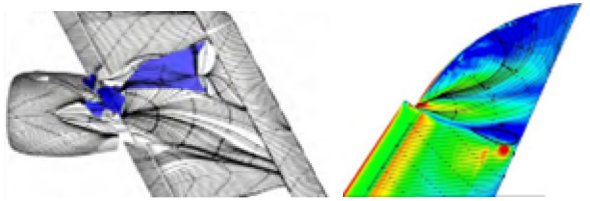
Wind tunnel test at TSAGI successfully conducted

High potential of AFC on local application was shown recover high-lift performance lost due to UHBR integration.

Wind tunnel test at TSAGI

Application of AFC on outer wing and on wing trailing edge successfully demonstrated

Potential of AFC identified as enabler for more aggressive outer wing design.


CFD simulations

Involved partners:
Airbus, DLR, CIRA, INCAS, ARA, FOI, CIRA, Fraunhofer, Dassault, NLR, ONERA, TSAGI, IAI, Tel Aviv University, BAE Systems, VZLU

Active Flow Control (AFC)

Project Achievements
Active Flow Control (AFC)

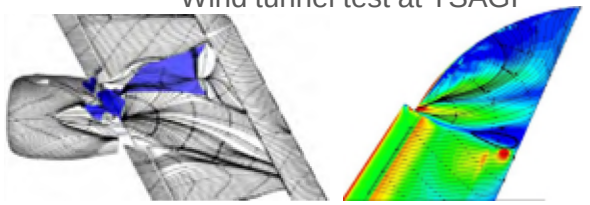
1. **Full scale wind tunnel testing of different AFC systems**
2. **Development and integration of different AFC systems**

Spin-offs and acquired knowledge

\Different AFC actuator principles designed and tested (PJA, SJA, Hybrid-PJA, Tile, SAOB).

\Validation / benchmark of different CFD methods and codes with respect the AFC simulation.

Wind tunnel test at TSAGI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Noise Control

Project Achievements
Noise Reduction

Development & flight test of noise reduction devices.
- Flap and main landing gear area-

Achievements

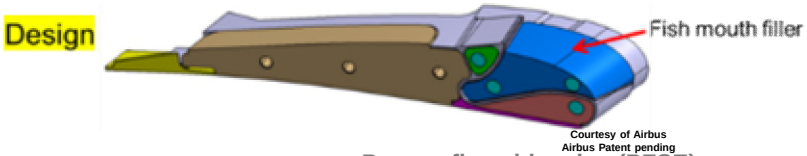
Flight test for Porous Flap Side Edge have been conducted
Reduction of flap noise using a PFSE was successfully demonstrated

Flight test of landing gear modifications have been conducted in 2019 within the frame of LN ATRA project
Reduction of landing gear noise was successfully demonstrated.

Torque link mesh fairing

Break cover

Leg door fairing



Porous flap side edge (PFSE)

Involved partners:
Airbus, DLR, SAFRAN Messier Bugatti Dowty, Fokker Aerostructures
Dassault Aviation

Noise Control

Project Achievements
Noise Reduction

Development & flight test of noise reduction devices.
- Flap and main landing gear area-

Spin-offs and acquired knowledge

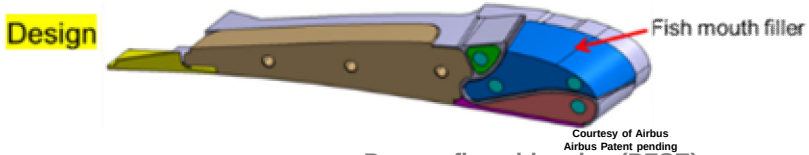
\Direct application for aircraft manufacturer partly possible.

\Use of new manufacturing methods for flying parts

Break cover

Torque link mesh fairing

Leg door fairing



Porous flap side edge (PFSE)

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Airbus, DLR, SAFRAN Messier Bugatti Dowty, Fokker Aerostructures
Dassault Aviation

Vibrations mitigation / control on airframe

Project Achievements
Vibration mitigation / control

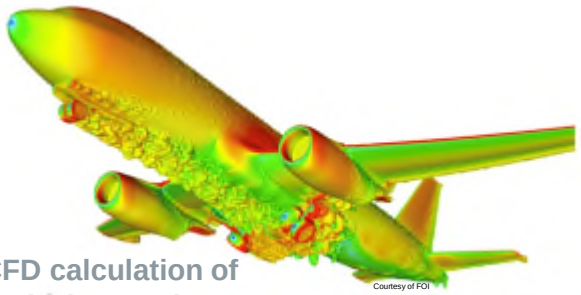
1. Development of numerical simulation methods
2. Design of devices reducing vibration level
3. Flight test validation

Achievements

\ ***Numerical model for prediction of vibrations has been developed.***

\ ***Devices to reduce vibration level on MLG-Door were designed, built and successfully tested.***

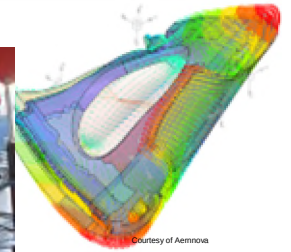
\ ***Flight Test successfully conducted April – May 2018***



CFD calculation of wake interactions

Prediction methods of vibrations have been developed and validated.
Passive Devices have been designed and built.
Validation by means of flight test was conducted.

Ground vibration test at DLR



FEA model of main landing gear door

Involved partners:
Airbus, DLR, COEXPAIR, CFS Engineering, SAFRAN SLCA, SAFRAN Messier Bugatti Dowty, Aernnova, CERFACS, KTH, FOI, ONERA

Vibrations mitigation / control on airframe

Project Achievements
Vibration mitigation / control

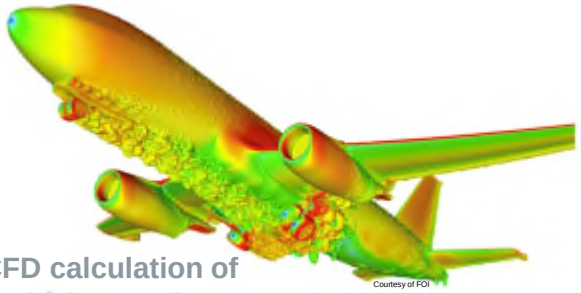
1. Development of numerical simulation methods
2. Design of devices reducing vibration level
3. Flight test validation

Spin-offs and acquired knowledge

\ Use of new design and manufacturing methods for flying parts (monolithic nose landing gear door).

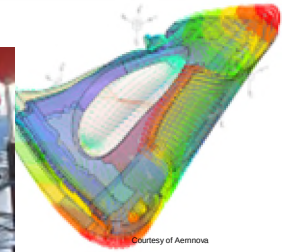
\ Possible direct usage of devices for A/C manufacturer (VGs and Spoiler on MLG-door)

\ Validation of different CFD-Methods and codes.



CFD calculation of wake interactions

Ground vibration test at DLR



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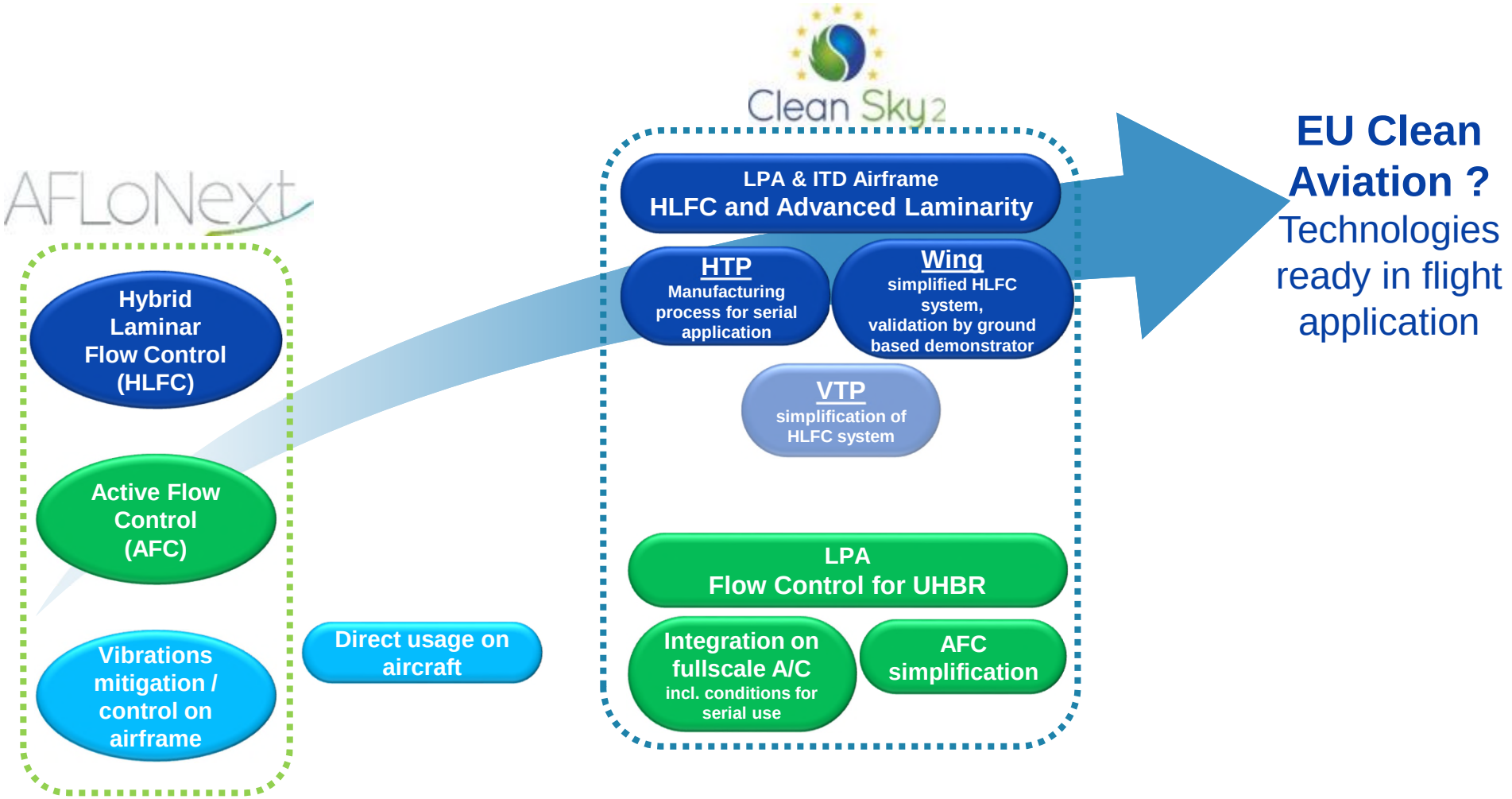
OUTLOOK & CONCLUSION

Outlook and Conclusion



Outlook and **Conclusion**

Summary

\ Strong engagement of AFLoNext partners / participants were always visible.

\ All AFLoNext main Objectives are achieved.

\ All AFLoNext results are contributing the to reduce overall ecological footprint of passenger aircrafts.

\ AFLoNext has delivered outstanding technical results,
which are enablers and foundation of several actual and future research activities.

\ The next logical step will be the handover of the most promising flow control technologies to research and development projects in order to further mature them to make these technologies available for serial aircraft within the next decade.

THANK YOU VERY MUCH FOR YOUR ATTENTION

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 604013, AFLONEXT project.