Hybrid Electric Regional Wing Integration Novel Green Technologies

HERWINGT

DEMO BOOKLET

CLEAN AVIATION

Co-funded by the European Union

Classification of Demonstrators

D1 - Hardware Demonstrators

1. Full-scale Outer Wing Box
2. Pylon-to-pylon Centre Wing Box
3. Flap demonstrator
4. Thermoset Leading Edge Multifunctional
5. Thermoset Leading Edge Baseline
6. Thermoplastic Leading Edge
7. Multifunctional Strut
8. End-to-End Impact Detection SHM System
9. Aeroservoelastic testing on high aspect ratio wing scaled half model
10. New Fuel System Integration
11. Induction Heating Ice Protection System
12. Integrated Fuel Vent System
13. Morphing Trailing Edge Flap
14. Morphing Aileron
15. Morphing Droop Nose
16. Functional testing in Wind Tunnel of the full-scale outer wing and morphing aileron

Classification of Demonstrators

D2 - Software Demonstrators

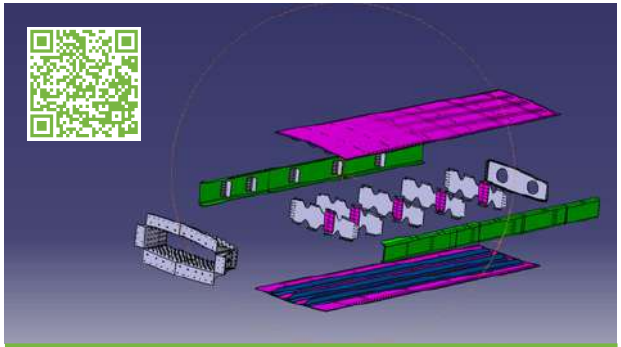
1. Nacelle preliminary Digital Mock Up
2. Actuator performances simulation models
3. Bird Strike Virtual Test
4. Novel High Aspect Ratio (HAR) full wing aero-structural Virtual Test

Acronyms

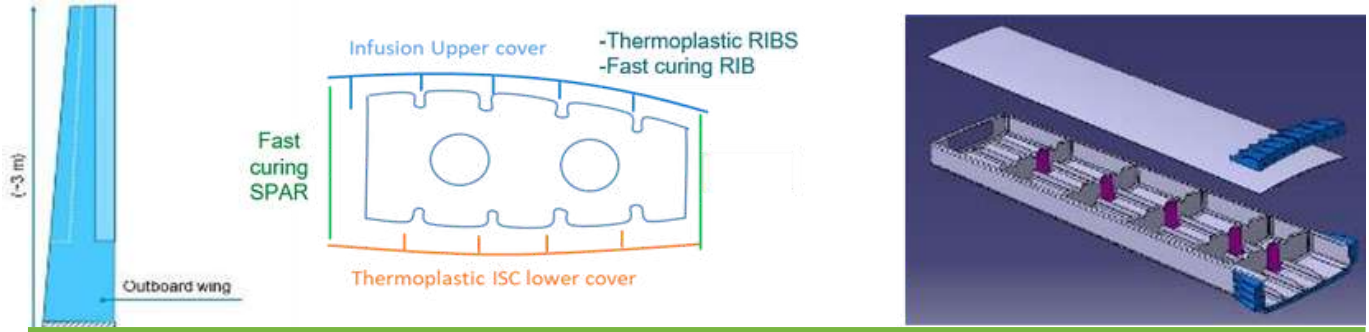
CDE: Critical Design Review
DAQ: Data Acquisition
EMA: Electro Mechanical Actuator
FQI: Fuel Quantity Indicator
HAR: High Aspect Ratio
ISC: In Situ Consolidation
LE: Leading Edge
LRI: Liquid Resin Infusion
PDR: Preliminary Design Review
SAF: Sustainable Aviation Fuel
SHMS: Structural Health Monitoring System
Tg: Glass transition temperature
TP: Thermoplastic
TP-ISC: Thermoplastic In Situ Consolidation
TRL: Technologies Readiness Level
OWB: Outer Wing Box

D1-1 Full-scale Outer Wing Box

The project has delivered a 3.2-meter-span OWB demonstrator that embodies the next generation of lightweight, cost-efficient wing design. The high aspect ratio (HAR) structure incorporates an innovative hybrid architecture, combining metallic closure ribs, thermoplastic internal ribs, a thermoplastic stiffened lower panel, fast-curing prepreg spars, and an infusion-molded skin panel.



HERWINGT Demo series, Outer Wing Box Demonstrator (E02)



Outer wing box demonstrator

Mature technologies

- ✓ LRI with modified epoxy resin to increase Tg and lightning strike performances.
- ✓ Thermoplastic ISC for low-curvature monolithic structural integration.
- ✓ Fast curing thermoset.



Mold tool for upper stiffed panel: Final fit check by LDO and HAI





Fast curing thermoset

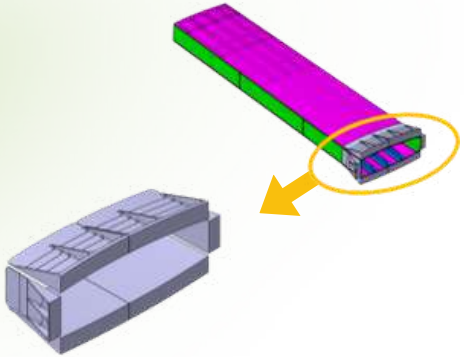


Front and Rear Spar demonstrators by GKN Fokker

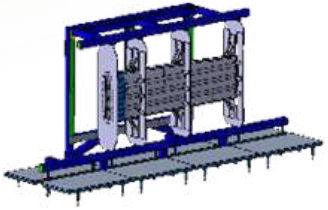


Drilling template

Metallic fitting for structural test



Assembly jig











D1-2 Pylon-to-pylon Centre Wing Box

Advanced Centre Wing Box Demonstrator tackles integration and manufacturing challenges

HERWINGT is advancing hybrid-electric aircraft integration through a semi-pylon-to-pylon multi-spar centre wing box demonstrator. Manufactured using one-shot Liquid Resin Infusion (LRI), the highly integrated structure consolidates skins, spars, stringers, and stiffeners into a HAR-configured design. The demonstrator will validate multi-spar architectures, assess manufacturing constraints, and support the structural maturation of next-generation aircraft.



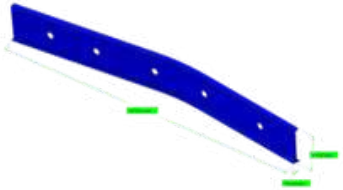
Wing box Assembly

Technology Roadmap









Composite parts manufacturing LRI upper and lower integrated panels

TRL3

Steering and high-thickness de-risking for LRI technology. Process and tooling defined for a highly integrated structure



TRL4

Validation of the infusion process for a highly integrated structure



D1-3 Flap demonstrator

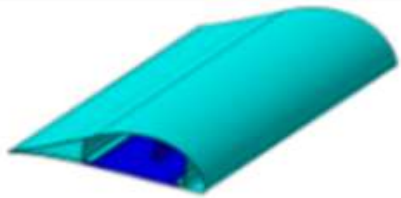
High-lift inner flap assembled in full demonstrator:

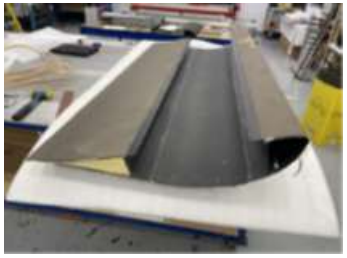
- Upper cover Liquid Resin Infusion (LRI) integrating leading edge and trailing edge (ALESTIS).
- Lower cover in Thermoplastic In Situ Consolidation (TP-ISC) with welded thermoplastic centre spar (ACIENG and FIDAMC).

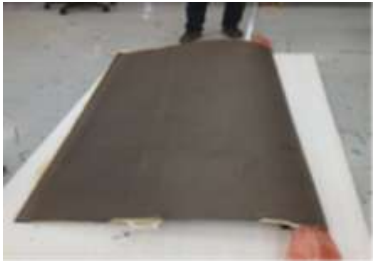
Innovation Objectives achieved:

Demonstrated novel manufacturing processes and concepts for highly integrated structures:

- Multi-spar concept.
- Leading-edge upper cover integration to understand challenges of its applicability to natural laminar flow.
- Maturation of highly integrated one-shot manufacturing processes.







Objectives achieved

Demonstrate novel manufacturing processes and concept for high integrated structures:

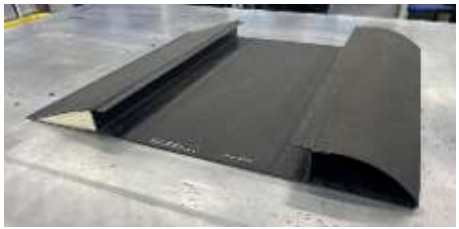
- ✓ Multispar concept
- ✓ Leading Edge upper cover integration to understand challenges of its applicability to natural laminar flow.
- ✓ Maturation of highly integrated one-shot manufacturing processes.





Upper skin







Spar



Lower skin

D1-4 Thermoset Leading Edge Multifunctional

- Leading Edge demonstrator with multi-functional capabilities, including bird-strike virtual test, Ice Protection System (IPS).
- Solid laminate, thermoset structure, Integral structure, out-of-autoclave (OoA) materials and processes, LRI.

Mature technologies

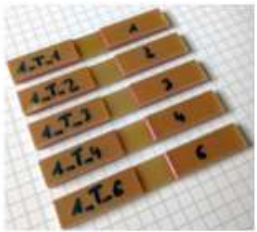
- ✓ New materials selection for aeronautical use
- ✓ Development of new structural concepts and architecture
- ✓ LRI Thermoset for monolithic multifunctional substrate integration
- ✓ Ice Protection System Structural Integration



Technology Roadmap

TR1-TRL2
Static allowables
Dynamic material properties
Panel impact testing for FE model validation





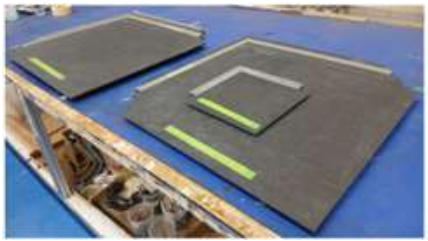


TRL4
Full-scale demonstrator



TRL3
Element



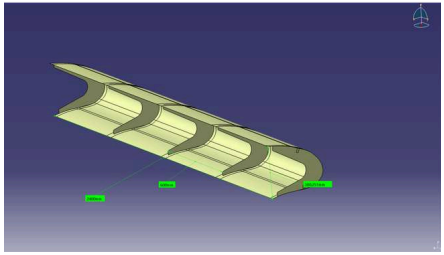


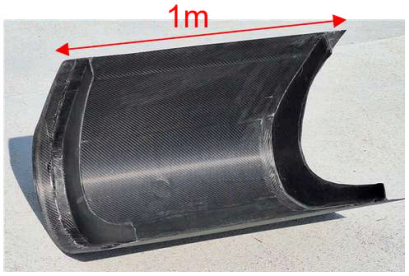


D1-5 Thermoset Leading Edge Baseline

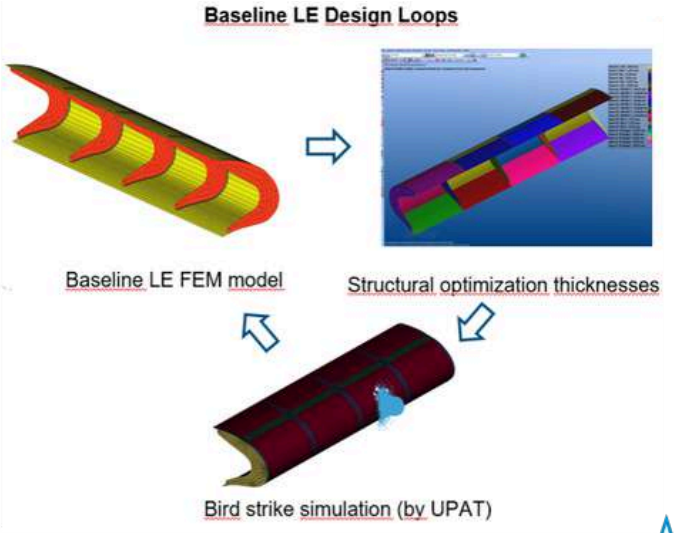
The Hybrid Leading Edge Demonstrator advances lightweight design and virtual validation

HERWINGT is advancing lightweight and sustainable aircraft structures through a leading-edge demonstrator manufactured using a hybrid sandwich-LRI approach. The programme validates innovative composite production methods and supports the industrialisation of next-generation aerostructures.

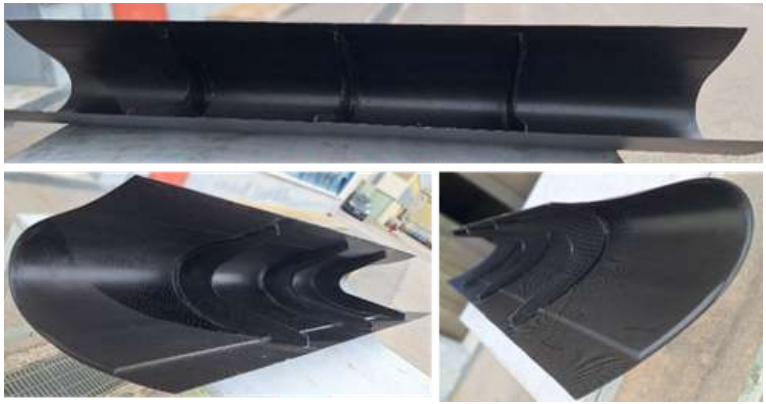




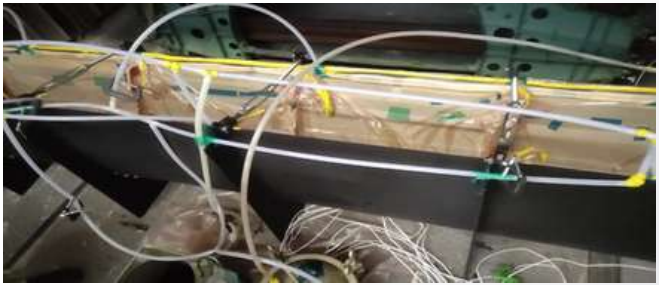
Thermoset LE demonstrator



HELLENIC AEROSPACE INDUSTRY



Full Scale LE Demonstrator



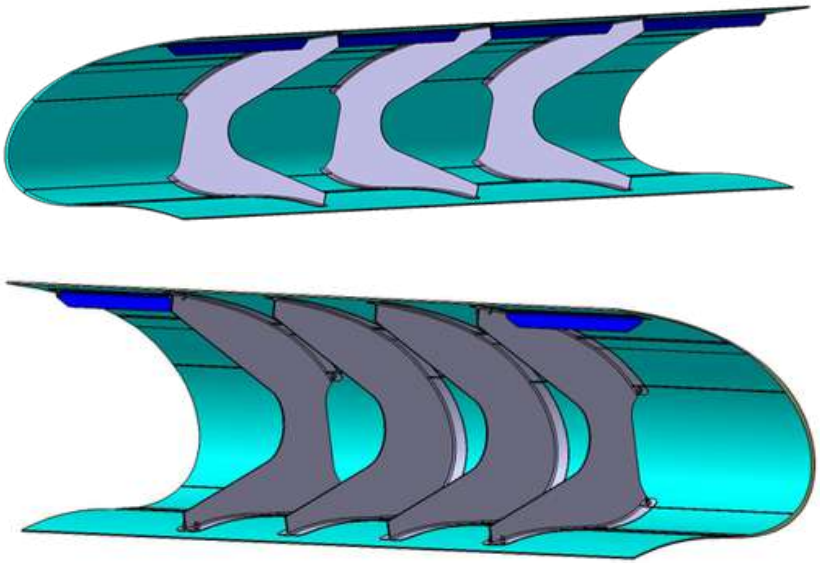


LE Demonstrator Tool

D1-6 Thermoplastic Leading Edge

A thermoplastic LE demonstrator is developed to mature advanced manufacturing technologies. Designed with highly curved geometries, the LE integrates most of its components using ISC techniques, enabling a streamlined, lightweight structure. Its architecture is driven by two key objectives: achieving minimum structural weight and maximizing internal space for system installation and routing.

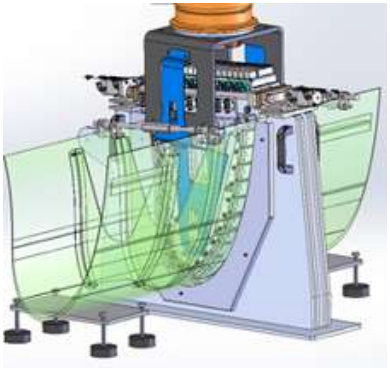
The project elevated multiple technologies from TRL3 to TRL5, reinforcing the role of thermoplastics in future-ready aircraft structures.



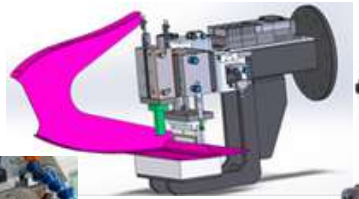
Leading-edge digital mock-up

Thermoplastic Welding for repairs and structural integration

- ✓ PID thermal control for the resistance welding system has been developed for the required thermal cycle, and its robustness has been validated.
- ✓ Fibre-reinforced and higher-melting-point 3D-printed parts fabricated for the simulated welding process.
- ✓ Robotized Induction Welding Solution has been tested.





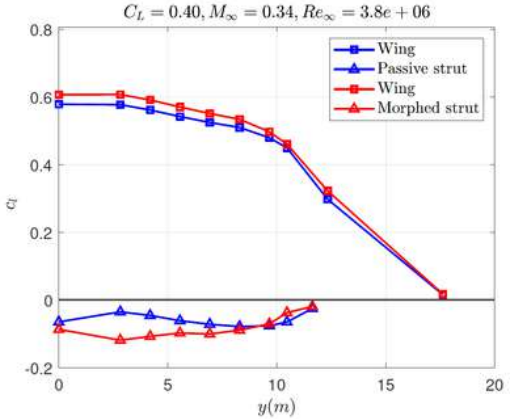




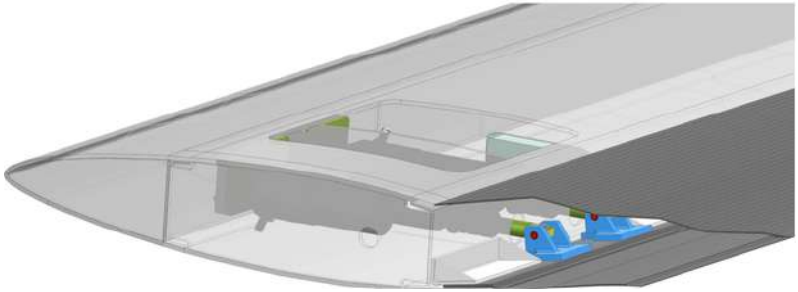
D1-7 Multifunctional Strut

Morphing Strut Demonstrator Enables Next-Generation Aerodynamics

HERWINGT is advancing adaptive aerostructures through a multifunctional morphing strut demonstrator that validates the functionality of an innovative trailing-edge technology under flight-representative deformations. The technology aims to improve aerodynamic efficiency across a range of cruise and climb conditions.



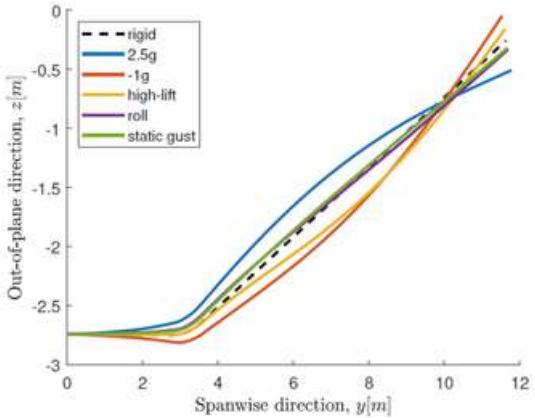
Optimized aerodynamic loading across different conditions due to the morphing strut



Morphing mechanism comprising a tailored-thickness trailing-edge skin that slides within a slot on the pressure side

Aerodynamic drag reduction due to morphing control surfaces

A 1.6 m long full-scale morphing strut section was tested under worst-case curvature conditions.
The morphing mechanism was actuated, and the actuation loads and achieved morphing shapes were measured.



Strut deformation in different load conditions



Strut-box section subjected to bending loads using metallic arms to reproduce the deformed curvature of different loading conditions

D1-8 End-to-End Impact Detection SHM System

Smart Monitoring for Future Aircraft Structures

HERWINGT is advancing intelligent aerostructures through an End-to-End SHM system capable of real-time damage detection and structural assessment. The technology supports condition-based maintenance strategies and contributes to safer, more efficient, and self-monitoring aircraft designs.



Aerodynamic structural health monitoring components

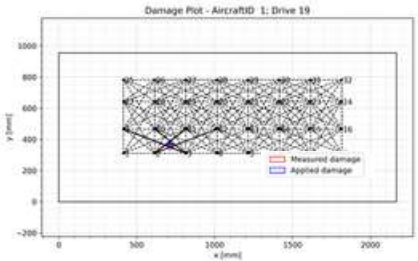
SHMS development for structural integrity prevention

Impact Testing & damage detection testing

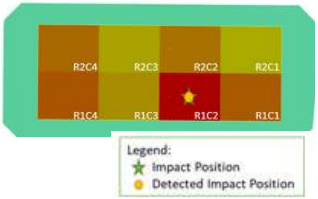
- ✓ Performed Impact Detection using a low-energy impact hammer.
- ✓ Performed Damage Detection using artificial damage.
- ✓ Performed Impact Detection using impact gun.
- ✓ Performed Damage Detection using impact gun.

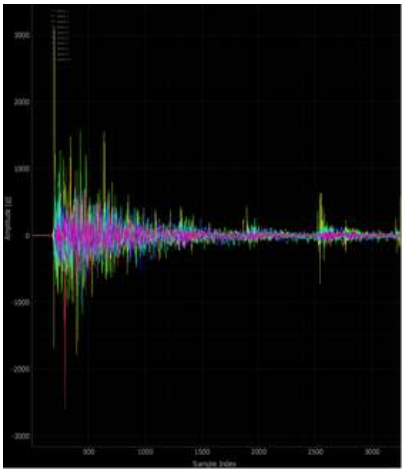






Damage Detection using Artificial damage



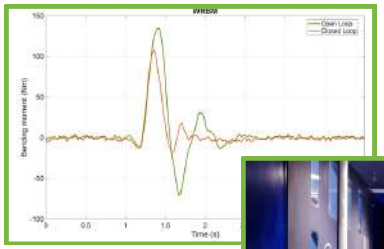


Impact Detection using impact hammer

D1-9 Aeroservoelastic testing on high aspect ratio wing scaled half model

Enabling Lighter Wings Through Smart Load Management

HERWINGT is advancing innovative load alleviation technologies that reduce structural loads and support lighter wing designs. Validation through scaled aeroelastic testing brings these solutions closer to application in future sustainable aircraft.







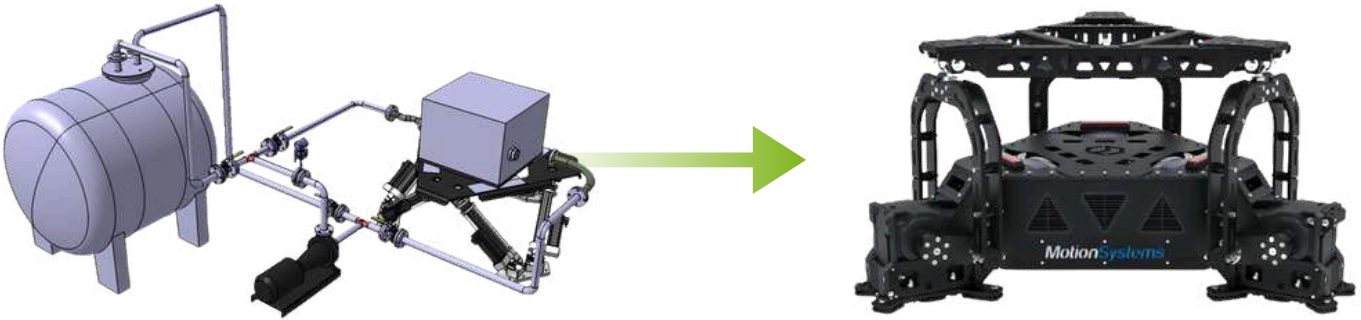
Experimental validation of Gust Loads Alleviation active Control Law by means of simulated tuned gust excitation in wind tunnel on a flexible scaled wing model.

UERA D1-9 model Aeroservoelastic Tests
during GLA Tests at PoliMi Bovisa premises (June, 3-12, 2026)

D1-10 New Fuel System Integration

Enhancing Fuel Management Technologies

ADS Getafe is advancing fuel measurement and monitoring through rigorous testing of its Fuel Quantity Indicator system. The programme validates performance under representative operating conditions, including SAF use, contributing to safer and more efficient aircraft operations.



Fuel Quantity Indicator System Integration

D1-11 Induction Heating Ice Protection System

Electromagnetic Ice Protection for Next-Generation Leading Edges

HERWINGT is validating an advanced electromagnetic ice protection system based on induction heating through integration with a multifunctional composite leading-edge demonstrator. Full-scale testing in representative icing conditions will assess de-icing performance, structural integration, and technology readiness for future aircraft applications.







The HERWINGT team by ADS, Ikerlan, AIN and INTA spent the week starting the 23rd August performing Icing Wind Tunnel tests at Rail Tec Arsenal (RTA) in Vienna to prove the concept of thermoelectric heating by induction. For this purpose, a wing model 2,4 m span and 2.0 m chord was built, including a thermoplastic leading edge made by HAI, which was adapted to include the induction by Ikerlan and a resistive thermoelectric device designed by INTA to serve as a reference for comparison. The leading edge was split into four heating sections; 2 for induction and two for resistive, so that testing time could be optimised at the expense of a campaign real-time management a bit more complex. As a late surprise, a small section of the model was painted with a treatment to understand the possible effects on heating.

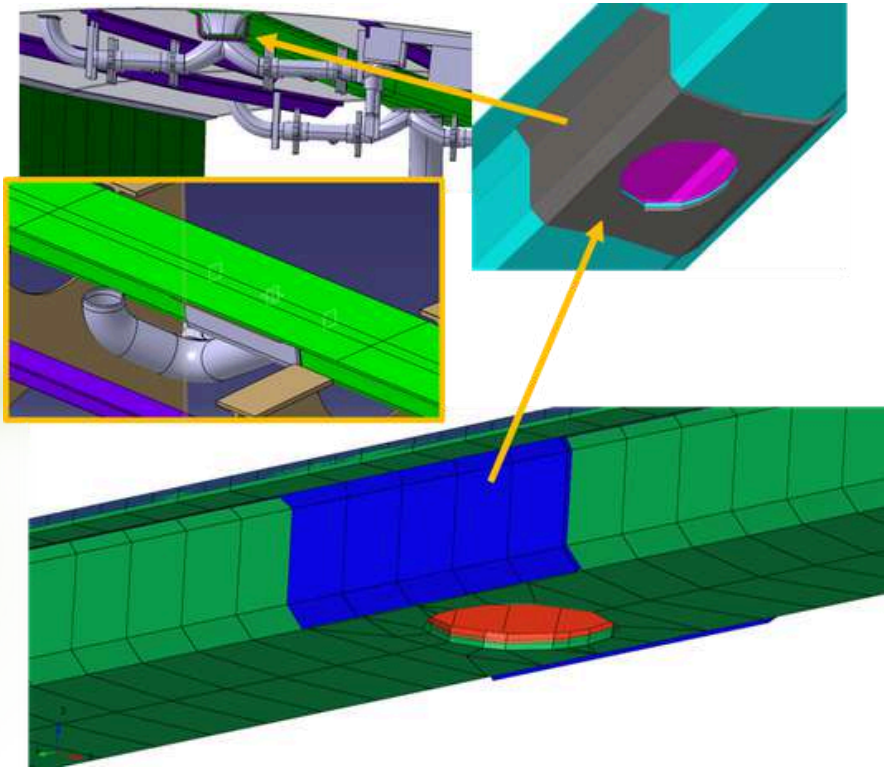
The testing campaign was performed at the RTA Small Test Section covering a wide range of icing conditions from -10 degC to -30 deg C. The campaign provided the team with a valuable opportunity to assess how inductive and resistive heating perform under representative icing conditions. The week was filled with surprises, experiments, technical discussions, and excellent teamwork, including the visit from EASA.



D1-12 Integrated Fuel Vent System

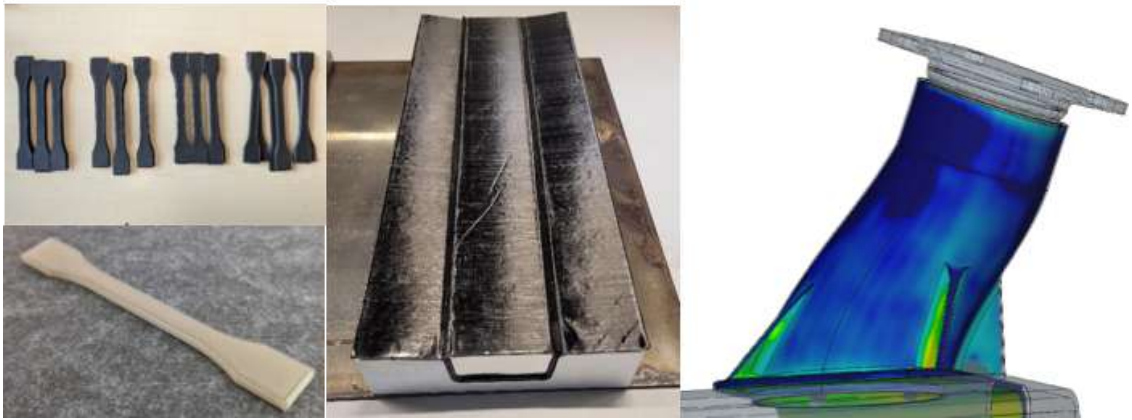
Integrated Composite Fuel Vent System Demonstrator

HERWINGT developed a multifunctional composite fuel vent system integrated within the wing upper skin, combining structural reinforcement and fuel venting capabilities in a single solution. The demonstrator validated innovative design concepts, manufacturability, and performance through dedicated pressure testing, supporting the next generation of lightweight, highly integrated aircraft structures.



Objectives achieved

- ✓ Mechanical testing of material samples under a kerosene environment has finished for PPSU and PEEK.
- ✓ Manufacturing of stringers with tooling is ongoing, and pre-testing with internal overpressure was successful.
- ✓ Additive manufacturing of connector elements for demonstrators is ongoing.
- ✓ Testing of the first and second Demonstrator is finished.



D1-13 Morphing Trailing Edge Flap

Camber Morphing Flap Demonstrator Advances Adaptive Wing Technologies

HERWINGT developed a camber morphing flap demonstrator to validate advanced adaptive wing concepts and enhance aerodynamic efficiency. Through comprehensive ground testing, including static, dynamic, and fatigue evaluations, the programme is maturing morphing technologies toward integration in next-generation aircraft.



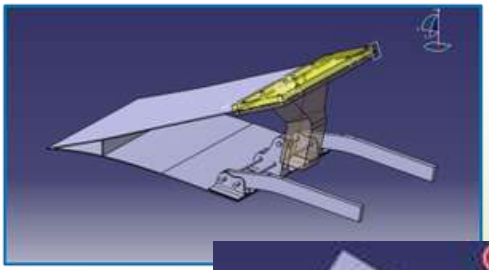


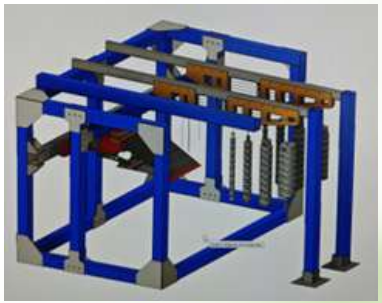


Aerodynamic drag reduction due to morphing LE & flap

Technical Progress & Achieved Objectives

- ✓ Comprehensive test matrix including dynamic, functional, & static tests defined.
- ✓ Dynamic hammer tests to be performed in clean and morphed configurations, with/without external loads, to identify modal properties.
- ✓ Functional and static tests validate actuation performance and structural response through progressive loading up to operational and limit conditions.





Watch the HERWINGT Demo Diaries

CIRA
Italian Aerospace Research Centre

D1-14 Morphing Aileron

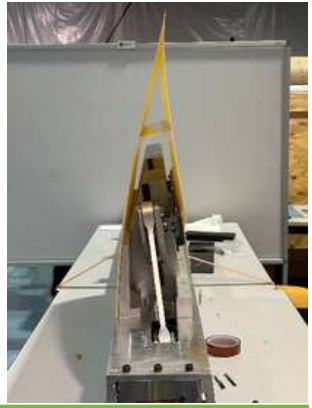
HERWINGT Demo series, E03: Wing testing with high-bandwidth ailerons

Full-Scale Morphing Aileron Demonstrator for Adaptive Flight Control

HERWINGT developed a full-scale morphing aileron demonstrator to validate next-generation adaptive flight control technologies. Through comprehensive structural and functional testing, the programme will assess aerodynamic performance, structural integrity, and technology maturity, supporting the integration of morphing control surfaces into future aircraft.







Morphing aileron full scale demo



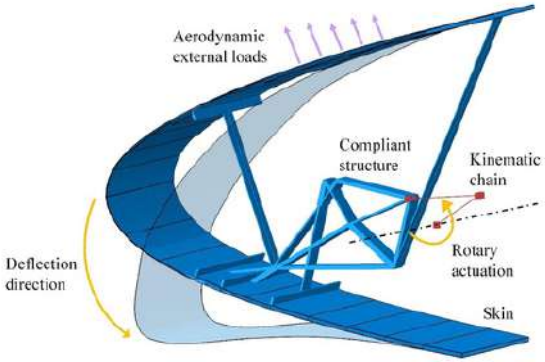
Full-scale morphing aileron structure installed on the dummy wing box designed and manufactured by HAI

D1-15 Morphing Droop Nose

Morphing Droop Nose Demonstrator Advances High-Lift Technologies

HERWINGT developed a fully compliant morphing droop nose demonstrator to validate next-generation high-lift aerodynamic concepts. A design of a fully compliant morphing droop nose for high-lift flight conditions, extending the solution already developed and tested in the CS2 Airgreen2 project to HERWINGT and achieving TRL5.

Experimental validation by means of fatigue tests on a full-scale limited-span demonstrator has been completed.



Morphing Droop Nose functionality concept



Morphing droop nose demonstrator installed on the MTS universal testing machine for cyclic fatigue testing.

D1-16 Functional testing in Wind Tunnel of full scale outer wing & morphing aileron

Morphing Aileron Demonstrator Advances Wind Tunnel Validation

HERWINGT validates an active morphing aileron demonstrator through low-speed Wind Tunnel (WT) testing on a representative outer-wing assembly. The campaign assessed aerodynamic performance, actuation efficiency, and system responsiveness, advancing morphing flight-control technologies toward integration in next-generation aircraft.



Deformed shapes in WT configuration



Morphing aileron (D1-14)

POLIMI's large Wind Tunnel facility

Dummy wingbox (HAI)



Large demonstrator movement to WT test section



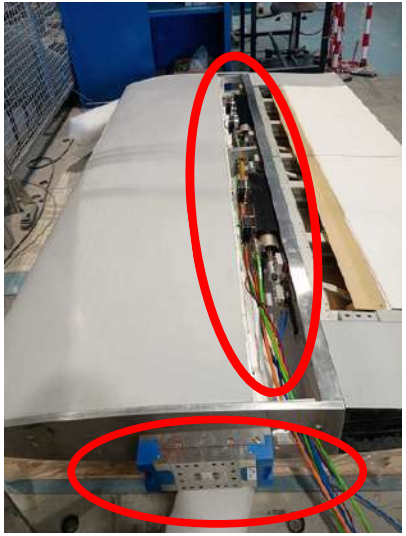
POLIMI and Siemens Team



Servo-actuated morphing ailerons

POLITECNICO MILANO 1863

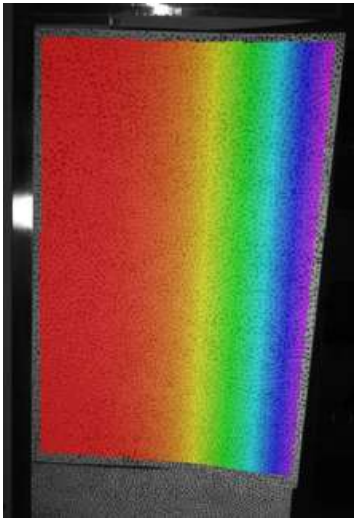
Watch the Gusts, control surfaces, and a wind-tunnel model built to test the future of regional aviation



RUAG balance and motor measurements



DIC measurements by SIEMENS

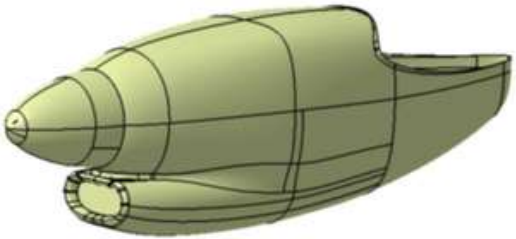


Deformed shape identification by SIEMENS using DIC

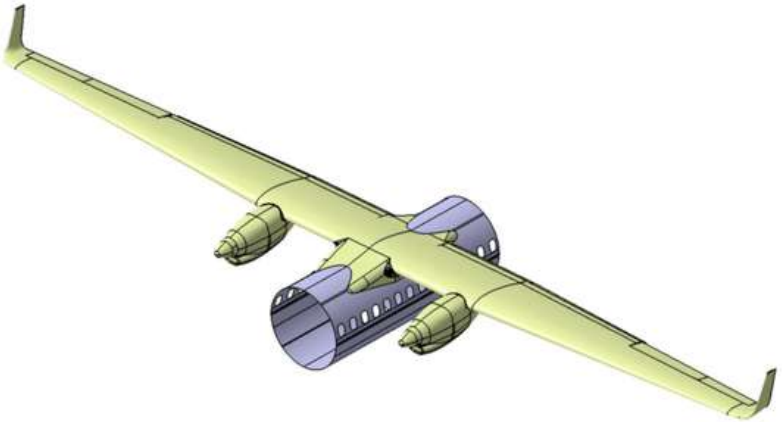
D2-1 Nacelle preliminary Digital Mock Up

Innovation objectives achieved

We defined the regional nacelle configuration to enhance the technological solution associated with the design development process. Additionally, the aerodynamic impact of nacelle-wing integration was evaluated, along with the optimization of the nacelle aerodynamic design



Digital mock up of the UERA Nacelle shared by HERA project for the D2-1 (Nacelle) simulation

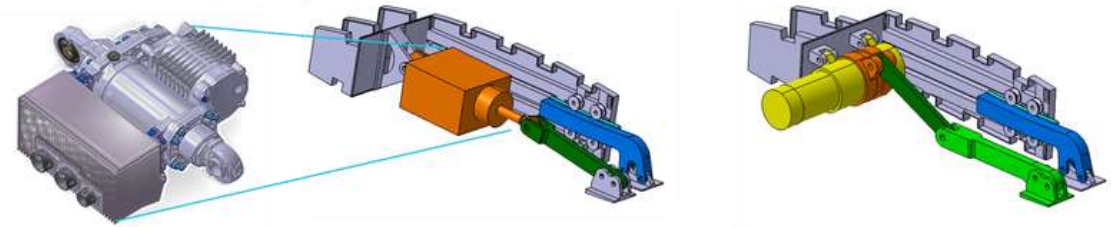


Digital mock up of the UERA wing with the integration of the nacelle shared by HERA project for the D2-4 (Full wing virtual test) simulation

D2-2 Actuator performances simulation models

Based on POLIMI data for the Aileron (D1-14) and CIRA data for the Morphing Flap (D1-13), the following models and datasets were delivered:

- **3D installation model** including weight, geometry, and key dimensions to support wing integration and compliance verification.
- **Performance models and supporting datasets** for dynamic performance assessment, including thermal constraints across duty cycles and reliability evaluations of the selected technologies and configurations.
- **EMA sizing dataset** for the morphing system, consolidating key parameters such as weight, 3D envelope, thermal behavior, reliability, and associated risks.
- **Integration of the Morphing Aileron Actuator performance model** into the Wing Aileron Performance Model.

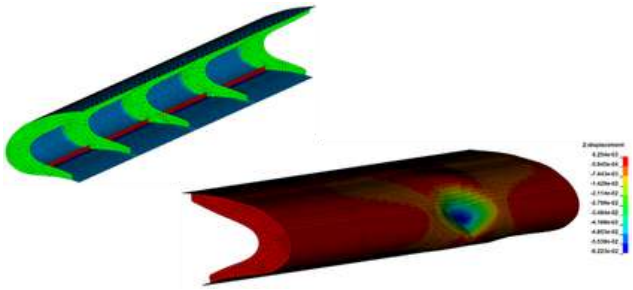


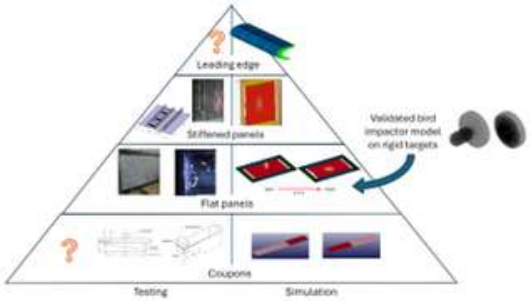
D2-3 Bird strike Virtual Test

D2-3 is focused on virtual testing methodology based on a building-block, multi-scale approach, as demonstrated in the case of bird-strike simulation of demonstrators D1-5 Thermoset Leading Edge (LE) Baseline and, as a second target, D1-4 Thermoset Leading Edge (LE) Multifunctional.

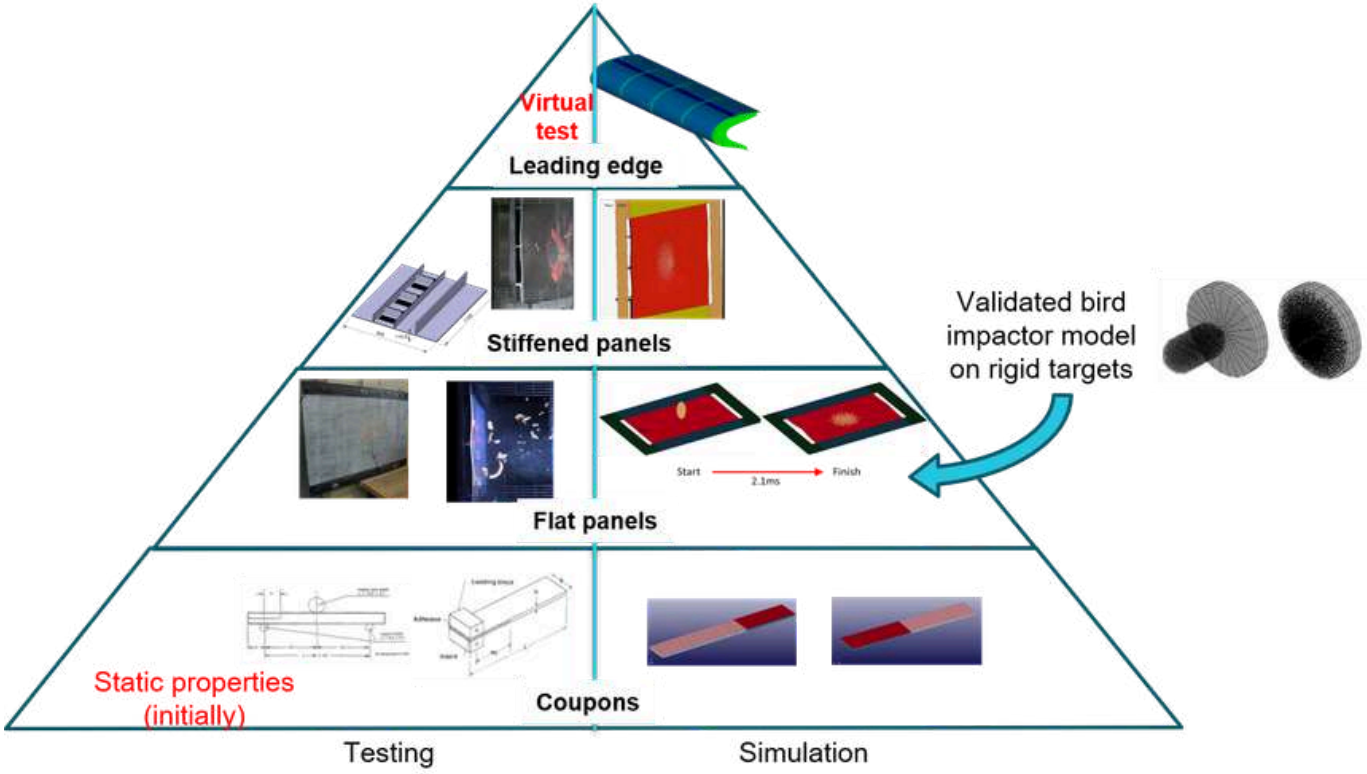
Innovation objectives achieved

A comprehensive bird-strike simulation methodology, incorporating all relevant structural details, was developed and successfully demonstrated for a thermoset leading-edge (LE) application. The bird model was validated, and the methodology was verified at coupon, structural-detail, and panel levels. Comparative assessments of material models and their impact on LE skin sizing were performed, while the criticality of interface modelling was identified and evaluated. In addition, the effects of strain-rate-dependent material properties on bird-strike response were thoroughly assessed.





D2-3 Bird strike Virtual Test



D2-4 Novel High Aspect Ratio full wing aero-structural Virtual Test

Innovation objectives achieved

- Virtual assessment of new UERA wing aerodynamic drag reduction under various flight conditions.
- Virtual assessment (through nonlinear aeroelastic simulations) of new UERA wing active load alleviation under different load conditions.



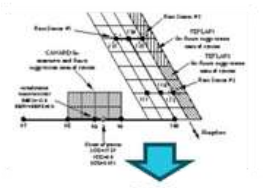
CAD geometry received from Leonardo

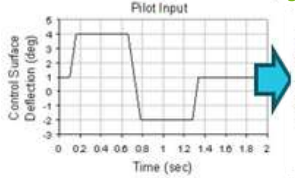
Wing Requirements	Value
Wing efficiency Cruise E=(CL/CD) _CR CL=.63	41
Wing efficiency Climb E=(CL/CD) _CL CL=0.87	39
Wing CL_MAX_{Clean}	1.7
Wing CL_MAX_{TO}	2.3
Wing CL_MAX_{LA}	2.8

UERA Wing Geometry and requirements update

	n	V_{EAS} (kts)	V_{EAS} (m/s)	C_{Lw}	AoA_{body} (deg)	AoA_{wing} (deg)
POINT A	2.50	193.04	99.31	1.65	10.77	12.77
POINT C	2.50	250.40	128.82	0.99	4.82	6.82
POINT D	2.50	313.00	161.04	0.64	1.75	3.74
C-Gust	2.72	250.40	128.82	1.07	5.58	7.59

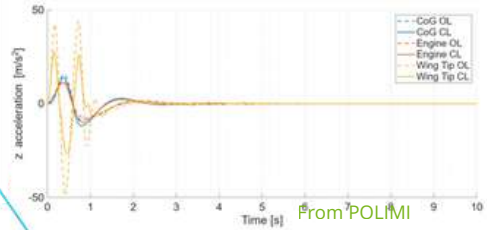
Aerodynamic drag reduction due to high aspect ratio





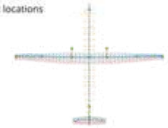
Aeroelastic example from Simcenter ZONA





From POLIMI

Figure 13: Accelerations at different locations



Aerodynamic load alleviation due to flight control laws optimization

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