MAY 2024

NEWSLETTER

ISSUE #1

HERWINGT

CLEAN AVIATION

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AIRBUS

Dear Reader,

I am glad to share with you Issue#1 of the HERWINGT Newsletter.

The Hybrid Electric Regional Wing Integration Novel Green Technologies (HERWINGT) project is one of the pioneers in the decarbonization of aviation. It aims to design a novel wing ideal for the future hybrid electric aircraft of the regional segment and to develop architectures, structures, and technologies that enable higher integration of electrical systems. These breakthrough solutions aim to achieve a 50% reduction in fuel consumption, at the aircraft (A/C) level, compared to a 2020 State-of-the-Art (SoA) A/C, in three different ways:

- Pioneering wing configurations and improved aerodynamics leading to drag reduction and enabling a fuel burn reduction of 15% at the wing component level, compared to a 2020 SoA wing.
- Wing structures, more integrated systems, and new material technologies resulted in a weight reduction of 20% at the component level, compared to a 2020 SoA wing.
- The development of technologies enabling the wing for a hybrid-electrical use case (H2/Batteries and fuel systems using Sustainable Aviation Fuels (SAF)).

Enjoy reading and become a member of the HERWINGT online community on our website and social media!

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Co-funded by the European Union

The project is supported by the Clean Aviation Joint Undertaking and its members. Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Aviation Joint Undertaking. Neither the European Union nor Clean Aviation JU can be held responsible for them.

Wing concept and architecture

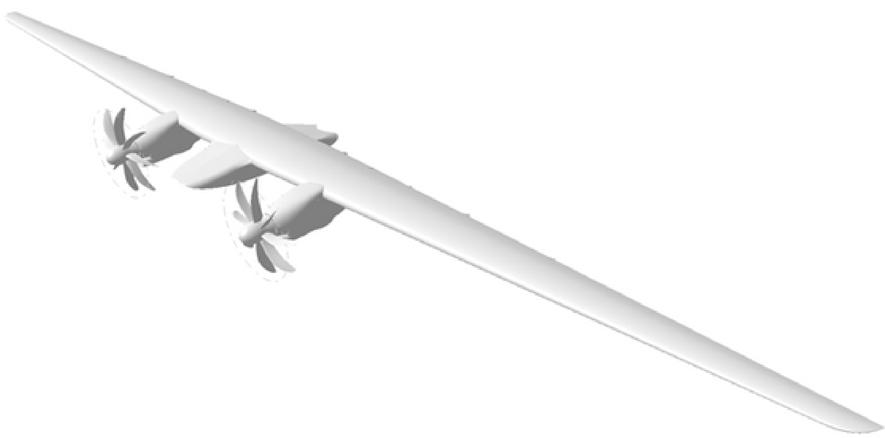
The overall scope of this work, forming Work Package 1 (WP1) led by Leonardo, focuses on defining a novel high aspect ratio wing aerodynamic and structural preliminary architecture, meeting Top Level Aircraft Requirements (TLAR) from the HERA project, able to host technology enablers following development and subsystem concept demonstrations. Requirements at AirCraft (A/C) level for this wing shall be taken by the HERA interface.
Two main wing configuration development workflows shall be considered for Hybrid Electric Regional A/C:

- Distributed propulsion wing configuration: Use Case B (UCB).
- Two Two-engine propulsion wing configuration: Use Case A (UCA).

For both configurations, the relevant requirements at A/C level shall be defined in Targeted Research Action (TRA)-´01, and then transferred here to perform trade-off studies for the following technological developments and demonstrations at wing level.

These wing configurations shall be the feedback to the HERA project for the following loops of novel A/C configuration studies. This shall be managed by WP 1, as well as all the outcome transmission of wing technological developments in HERWINGT to HERA.

WP1 is divided into three subtasks which will provide the new wing configurations' architectural design, based on iterative analysis and trade off studies put in place to converge to "optimal" new wing configurations for Hybrid Electric Propulsion Regional Aircraft. WP1 Outcomes shall be a set of detailed data and requirements at wing level, as well as specifications for the following development of technology enablers.



Wing concept and trade offs

The main activities of this sub-task include:

- Investigation of a population of High-Aspect Ratio (HAR) wings, among which one or several best candidates will be selected to perform aerodynamic optimization and refine the aero-servoelastic wing structural design.
- Multidisciplinary trade-off and optimization based on wing aerodynamic and structural configuration studies to define the final HAR wing, tackling the requirements at wing and A/C level.
- To provide the wing requirements, the wing structural design and the technology enablers with the needed preliminary concept data and results for HAR.

The final design of the Strut Braced Wing (SBW) was completed in October. Trade-off process for selecting the best compromise between SBW and Cantilever (CNT) wing configuration in cruise conditions was completed. SBW configuration is the selected result for twin engines with a high aspect ratio wing.

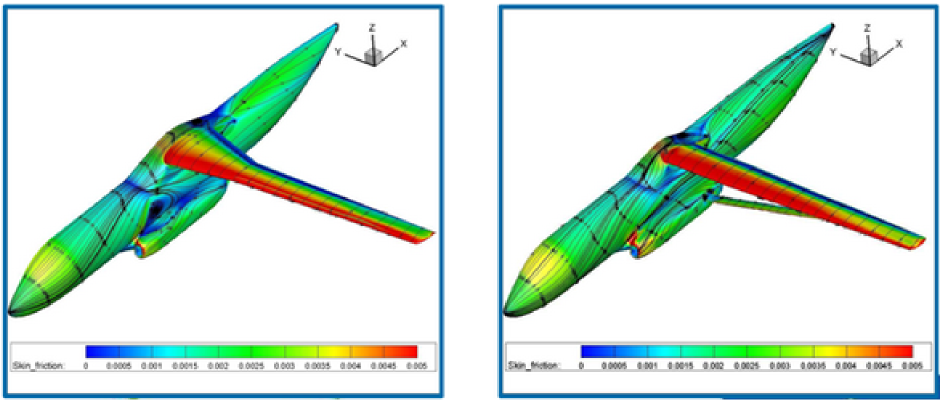


Figure 1. UCA CNT vs SBW preliminary trade-off results

Aerodynamics Design and Refinement

The aerodynamic design and refinement are tasks undertaken by CIRA aiming to design a high aspect ratio wing. New wing external surfaces will be designed and innovative solutions, such as morphing multifunction control surfaces and flow control devices integration, will be addressed since the beginning of the aerodynamics design. Both cruise and high-lift wing configurations will be considered. The main objective is to obtain a very highly efficient aerodynamic solution for a high aspect ratio wing.

Currently, two high-aspect-ratio wings, a cantilever and a strut-based, have been designed respectively by CIRA and TU-DELFT. The pressure distribution over the designed high-aspect ratio cantilever wing at cruise conditions and the efficiency achieved at both cruise and climb conditions are shown in Figure 2a and Figure 2b. The designed strut-based wing is reported in Figure 3. Mach number contours in the frontal plane of the wing and the skin friction coefficient on the junction surface are displayed on the left side, specifically under cruise flight conditions. Simultaneously, the efficiency attained during both cruise and climb conditions is depicted on the right side of the same figure.

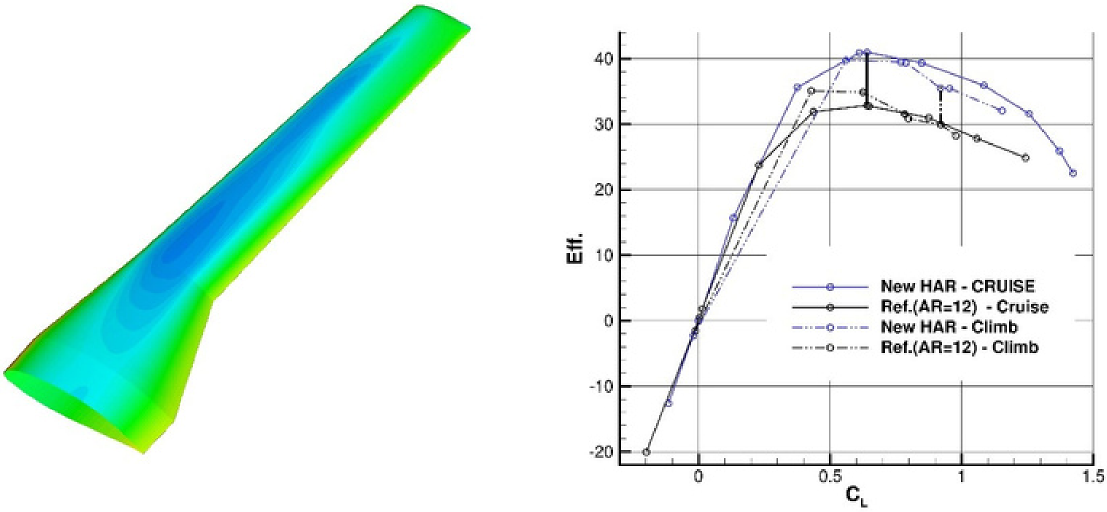


Figure 2. New designed high-aspect ratio cantilever wing: Pressure distribution at cruise (left); Efficiency at cruise and climb (right)

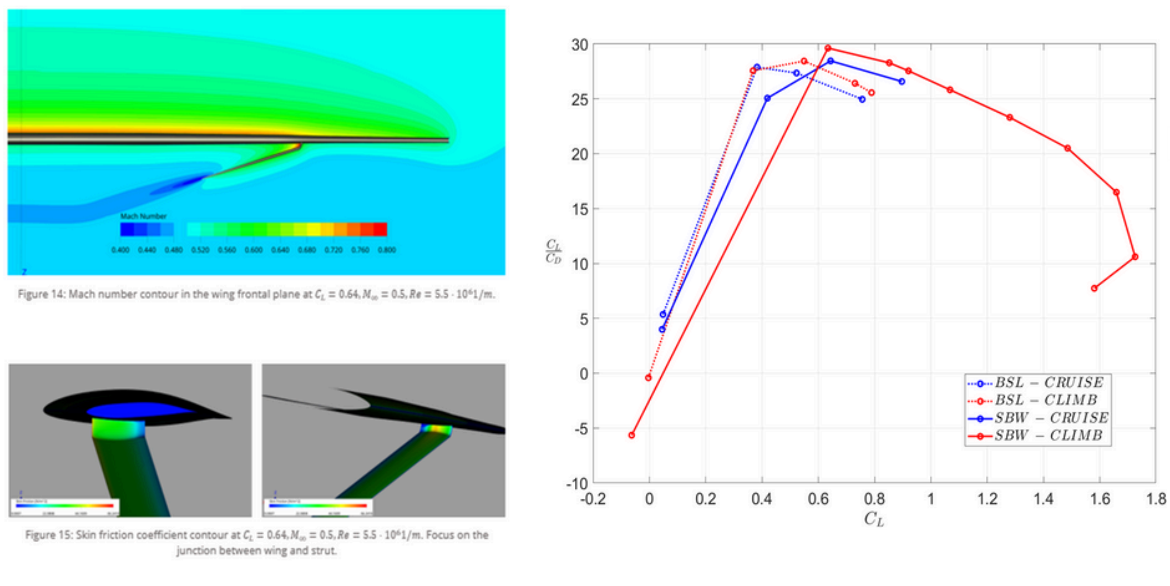


Figure 3. UCA SBW optimization to improve low-speed stall performance

Architecture and configuration for the wing

This task is dedicated to the following assignments:

- Distributed propulsion configuration wing: to provide WP2 (wing requirements) and WP3 (wing structural design) with wing Computer-Aided Design (CAD) models based on trade-off results provided by HERA aircraft architecture studies.
- High aspect ratio wing-trussed configuration finalization of relevant aeromechanical and aero-structural concepts, as input for Technology Enablers' development (WP 4), based on the wing geometrical and performance requirements outcomes from WP 1.1 and aerodynamic design (wing geometry, aero performances) from WP 1.2
- High aspect ratio cantilevered wing - aero-structural preliminary configuration multidisciplinary optimization. Novel Trailing Edge (TE) Flap Morphing concept.
- Conceptual design and optimization of a novel camber morphing flap concept.

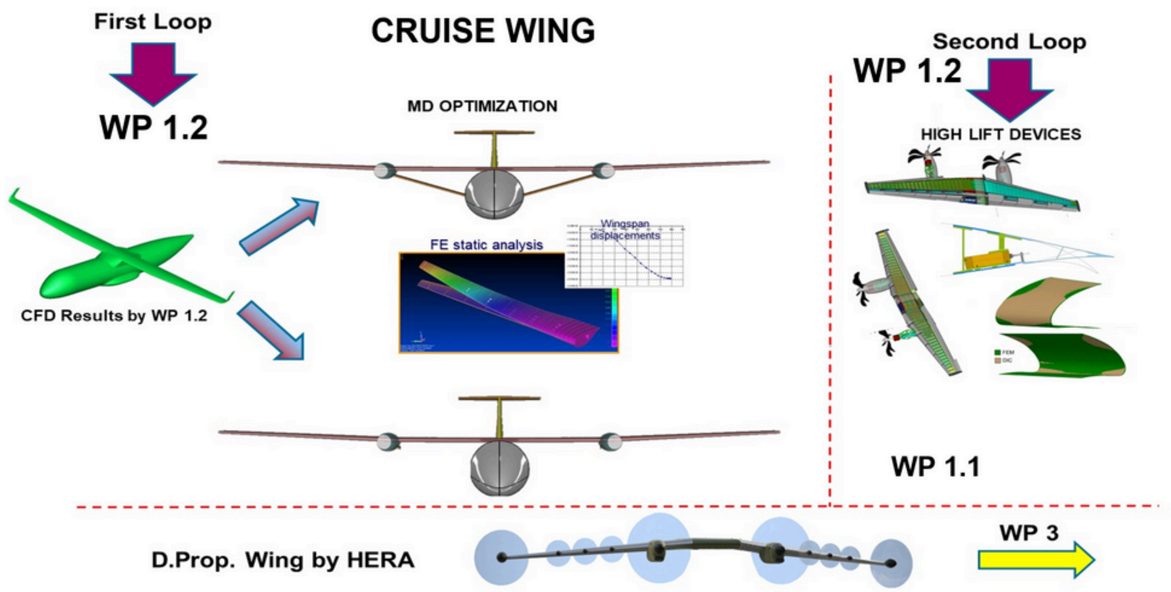


Figure 4. A schematic presentation of the WP1.3 tasks.

Cantilever wing:

HAR - cantilevered wing aero-structural preliminary configuration multi-disciplinary optimization was validated.

Strut-braced wing:

The final design of strut braced wing (SBW) was completed in October, including strut structural sizing based on EASA CS25 load cases. HAR wing - Strut-braced wing Aeroelastic tailoring has been validated.

Wing requirements

The main goal of this work package is to select and scale at wing level the Top-Level Aircraft Requirements (TLAR) from HERA TRA-01 project. Main wing characteristics and constraints will be defined in terms of structural, functional, integration and system requirements. Additionally, this work package will also define the requirements for the development and maturation of new technologies, to be integrated in the wing, from Technology readiness level 3 (TRL3) thru manufacturing, testing and assessment of demonstrators, up to TRL5.

Structural Requirements

WP2.1 includes the following assignments:

- Mechanical requirements for critical flight conditions accounting for material behaviour.
- Durability and environmental requirements, such as fatigue, erosion, accidental damage, etc. Selection of material will be made to ensure good strength, fatigue and fracture mechanics characteristics to get good residual strength per unit of weight to a reasonable cost. Selection will be assessed in comparison with the A/C of reference.
- Overall design guidelines. Dynamic concerns and lightning strike protection will be ensured as part of the structural design aspects to either avoid or reduce structural damage, explosion risks, and A/C system performance.
- Repairability. Definition of acceptable repair conditions to recover the required level of strength and stiffness both "in-shop" and "In-service" scenarios.

Functionality Definition and Requirements

Wing functionalities with foreseen incidence to power and carbon footprint reduction will be primarily considered. Other ecological criteria, such as acoustic contamination will also be considered.

Examples of new technologies to be studied:

- Morphing wing (Leading edge, flap and aileron).
- Structural Health Monitoring: Functionality deals with the capability to detect damaging events with potentially detrimental effects, locate the event in the structure within an accepted range of accuracy, characterize the event to prescribe potential criticality, and assess the presence of damages concerning a reference configuration.

Propulsion Integration Requirements

Hybrid propulsion engines of different types and dimensions will be assessed to get maximum flight efficiency.

Different options to attach the powerplant on the wing structure (i.e., pylon or mounting) will be part of the research.

Systems Definition and Requirements

HERWINGT projects will also study the integration of novel systems into the wing. Installation requirements will be defined for the following systems:

- Induction ice protection system.
- Fuel system compatibility with Sustainable aviation fuel (SAF)
- Active flight control system.

Wing structural design

Isabel Romero

AIRBUS

“Our high-level goals are, for starters, to define the requirements for the wing structural design, to develop the wing Digital Mock-Up (DMU) and its digital twin, and, finally, to develop the demonstrators detailed design”.

More specifically, in terms of the design requirements, AIRBUS is working on the design principles for thermostable Liquid Resin Infusion (LRI) integrated structures and on the design principles for thermoplastic integrated structures. Regarding the wing DMU and digital twin, AIRBUS is focusing on the structural schemes of the overall wing, the demonstrators’ structural schemes, the space allocation model (SAM) of the DMU, the GFEM overall wing, and the DMU of the overall wing. Finally, in terms of the wing component design, we plan to design in detail the demonstrators.

Presently, AIRBUS has already defined the design guidelines along with the center wing demonstrators’ structural schemes and the demonstrators geometries. In terms of the wing component design, the demonstrators' concept design has been accomplished. The next figure shows a preliminary design of leading-edge demonstrators.

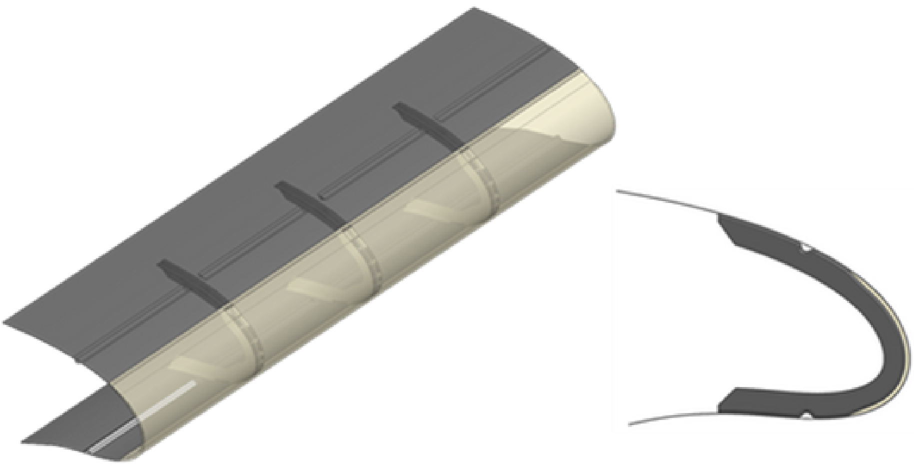


Figure 5. Thermoset Leading Edge Multifunctional

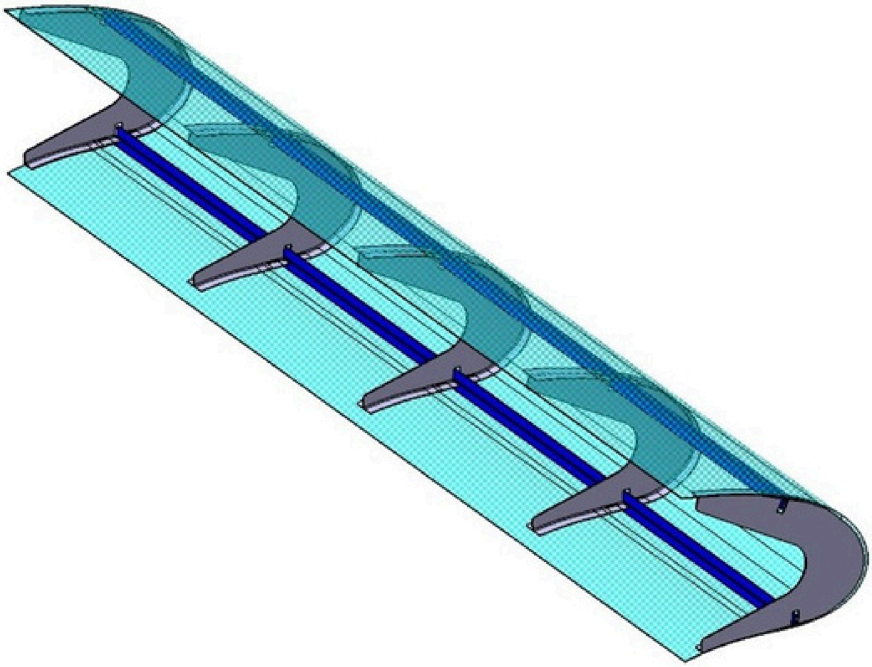


Figure 6. Thermoset Leading-Edge Baseline

The following steps involve finalizing the design principles and requirements, advancing with the DMU of UCA and UCB, and making progress on the detailed design of the demonstrators.

Figure 7. The Use Case A (UCA) and Use Case B (UCB) the HERWINGT is focusing on.

Technology enablers

Joost Koopman
Project Manager at Fokker GKN Aerospace

"The main objective of the technology enablers is to validate and mature technologies identified as enablers for HER wing objectives fulfilment, starting at a TRL3 level up to TRL5 at the end of the project".

The focus is on the following:

- lightweight manufacturing technologies, which lead to weight savings to be able to reduce CO_2 requirements in operation
- improved recyclability

Additionally, structural concepts applicable to morphing structures and associated surface control devices are to be matured.

Manufacturing enablers

The main concept of the manufacturing enablers is to validate and mature technologies to be used in the Outer Wing Box (OWB) demonstrator. For the stiffened thermoplastic lower cover of the OWB, in-situ laser automated fibre placement technology will be used. For the front and rear spar of the OWB, a fast-curing thermoset manufacturing process will be used. Currently, the technology development plans have been issued and are in execution for both technologies up to Target Readiness Level (TRL)4. After completion of the technology development plans and reviewing of the results, the demonstrator manufacturing will be initiated.

Structural design and analysis enablers

The validation and maturation of the structural technologies identified in the frame of the wing structural design task is the main objective. It will be pursued through dedicated structural design and analyses based on the different technology requirements.

In essence, the primary objectives of this task are as follows:

- Explore lightweight manufacturing technologies to achieve weight savings, contributing to a reduction in CO2 emissions during operation.
- Investigate technologies with lower energy requirements, comparing autoclaves and ovens for efficiency.
- Explore the viability of reusable materials, focusing on both thermoplastics and the reusability of thermoplastics.

More specifically, the HERWINGT partners involved in this task will undertake, first, the following subtasks:

- The release of drawings for the manufacturing of elements and subcomponents. This involves providing detailed and finalized drawings that serve as comprehensive guides for the manufacturing process.

- Structural design and evaluation of two critical components in two phases: enhanced morphing droop nose and full-scale, large bandwidth morphing aileron. The first phase is related to the structural design and assessment of improvements made to the morphing droop nose, enhancing its functionality and performance. The second phase is the structural design and assessment of a full-scale aileron with a wide range of morphing capabilities, ensuring it meets the required structural integrity standards.

- The release of a detailed manufacturable design of the multi-functional strut

- The development of a structural design and system integration of the camber morphing flap.

- The structural design for the integrated fuel vent complete/ summary of morphing aileron/flap/strut concept design activities.

Propulsion integration

In this task, led by AIRBUS, the target is to develop the propulsion integration both from the system and the structural point of view. The adaptation of the new propulsion configuration in the center wing section will be the purpose of a detailed study and a center wing box demonstrator in a pylon-to pylon extension will be proposed for this purpose.

In addition, AIRBUS aims to manufacture and assemble a pylon-to-pylon multi-spar center wing box section plus upper and lower skins, integrating a hybrid-electric propulsion mounting system interface. Such pylon-to-pylon multi-spar centre wing box section will be developed through a new out-of-autoclave manufacturing process of a complete wing using Automated Fiber Placement (AFP), for complex geometries, with sweep and dihedral breaks, including a torsion central box, one single component including lower skin, spars and stringers and compatible with low-cost material. Moreover, an additive manufacturing process to obtain models for the manufacture of low-cost carbon fiber molds will be considered.

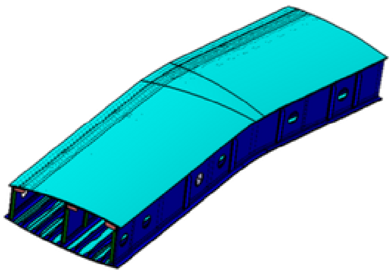


Figure 8. Pylon-to-pylon Center Wing Box

Furthermore, AIRBUS targets a defining a regional nacelle configuration to improve technological solution linked to design development. Another objective is to define an acoustic liner treatment for the propeller-nacelle interaction noise mitigation. Afterwards, it will follow the evaluation of the aerodynamic impact of the nacelle/wing integration as well as nacelle aerodynamic design optimization. In that frame, it is necessary to execute structural simulations of the nacelle integration and mount.

Currently, the pylon-to-pylon multi-spar center wing box (Fig.8) demonstrator manufacturing and assembly build processes have been defined. Lower integrated panel manufacturing tooling is currently ongoing. Additionally, the de-risking test for maximum thickness has been successfully passed. The next steps are to complete the manufacturing tooling, to define a detailed manufacturing and assembly process, and to initiate the nacelle integration study.

Wing Systems

This WP will cover the detailed design of the systems involved on the wing from the input of WP1 and WP2 (Concept, Architecture, and Requirements). System Maturation activity is part of this WP and its implementation in the final system is to be potentially integrated into a Demonstrator (WP7) and tested in WP8. Activities will be focused on the key systems identified as relevant for the established fuel burn and weight reduction targets: such as the integration of Sustainable Aviation Fuels (SAF) fuel, bleedless integrated ice protection systems, or Structural Health Monitoring (SHM) systems. The activity will be focused on key systems identified as relevant for the established fuel burn and weight reduction targets: such as the integration of Sustainable Aviation Fuels (SAF) fuel, bleedless integrated ice protection systems, or Structural Health Monitoring (SHM) systems.

New fuel system integration

The objective is to assess the status of compliance for legacy and current aircraft against SAFs requirements, and to identify gaps, next actions, and needs to close those gaps as much as possible, as well as compatibility with new aircraft under development. A concept definition and intent of use for SAF's shall be established to pronounce on the technical maturity of current aircraft fuel systems and technologies and to identify future needs to achieve such concept definition. The use of SAFs will result in analysis and research on the compatibility of fuel systems materials and equipment performance with the new type of certified SAFs.

Ice protection

WP6.2 activities will start with the definition of the requirements for the induction system as well as for the surface treatment, and the definition of the test strategy and integration with the structure. It includes a final assessment on the achievement of the requirements in terms of performance, integration with structure, installation, durability, etc. and a comparative analysis with other architectures applied for ice protection. The prototype to be tested in the ice wing tunnel will be designed, delivered to the tunnel, and assembled and integrated with the induction system

Flight controls integration

Proposed within this task are flight control surface solutions for the wing, encompassing a fixed integrated flap and actuation for both morphing and non-morphing structures. This work aims to deliver integrated trailing-edge solutions as part of the comprehensive wing package. Collins will engage in active collaboration with the representative for wing structure to advance studies in alignment with the aircraft's objectives.

The proposed tasks include:

- To examine different methods for integrating actuators specifically within the Aileron for the morphing solution.
- To select the optimal configuration, considering the wing structure and its primary actuation systems.
- To create and refine detailed main models for describing performance.

Structural Health Monitoring

IIn the frame of this task, the focus is to develop an end-to-end impact detection Structural Health Monitoring (SHM) system and conduct the integration, validation, and verification of the system up to Technology Readiness Level 5 (TRL5). AIRBUS will take charge of creating the database for SHM results, encompassing the entire test pyramid.

IIn addition, DLR will develop robust SHM arrays with integrated piezoceramic transducers and electronic components for the integration into Carbon Fiber Reinforced Plastic (CFRP) structures, as well as modular Data Acquisition (DAQ) hardware and software in collaboration with FHG for acoustic ultrasonic-based SHM. Test campaigns for the SHM system and the validation of simulation methods for damage reconstruction will be performed.

Demonstrators

The primary goal of this task, forming WP7, is the execution/manufacturing of the entire set of demonstrators. The plan entails:

Centre Wing Box Components:

- Multifunctional, structural integrated fuel vent system in thermoset composite
- Induction heating ice protection in the wing
- Flap components in different technologies
- Thermoplastic / Leading Edge (LE)
- Thermoset LE

Outer Wing Box components:

- Upper panel in Liquid Resin Infusion (LRI), with T shape stringers
- Internal wing ribs in LRI
- Metallic closure ribs
- Thermoplastic internal ribs
- Thermoplastic lower stiffened panel
- Resin Transfer Molding (RTM) wing box front and rear spars
- Infusion technology skin panel
- Metallic Dummy LE and Trailing Edge (TE) structures
- Morphing aileron and morphing drop nose

Find out more details about HERWINGT's demonstrators by visiting the corresponding tab of the project website: https://herwingt-project.eu/technology/demonstrators

Testing and validation

The main goal of the testing and validation task is to demonstrate the wing design performances and maturity at TRL5, at the full wing system level, through relevant tests and ground demonstrations. The following tests will be performed: Non-Destructive Tests on manufactured items, structural tests, functional system tests, wind tunnel tests, and development and validation of a virtual test approach, capable of reducing the wing design cost, time, and complexity. The main results of this task will be available in the third year of the HERWINGT project, however, we have started with the definition of the requirements for each test while we are waiting for the demonstrators' designs to be completed.

The following steps are the definition of the final requirements, the test plan definition and boundary condition, and the initiation of the preparation of testing facilities/laboratories.

Structural and functional testing

In this phase, our objective is to showcase the performance and maturity of the wing design, reaching TRL 5 at the full wing system level through comprehensive tests and ground demonstrations. The primary stages of this task include:

- Definition of the requirements
- Test plan for functional and structural tests
- Execution of structural tests

Wind tunnel tests

This task encompasses two main objectives:

- Conducting wind tunnel tests in two different facilities, each with distinct characteristics: large size and low speed, and smaller size and higher speed. The first test will be realized by POLIMI and the second one by TUD.
- Executing a testing campaign on a full-scale induction heating ice protection system, which will be assembled and tested in the ice wind tunnel at RTA facilities.

Virtual tests

The primary objectives of this task are as follows:

1. Development and validation of a virtual test approach aimed at reducing the wing design cost, time, and complexity.
2. Demonstration of the virtual testing methodology on the novel wing demonstrator through:

    - Virtual testing and validation of wing demonstrator components at lower scale levels to minimize more expensive testing at the top testing pyramid, i.e., the full wing.
    - Virtual testing of the entire wing demonstrator in static and stationary conditions to validate structural weight and aerodynamic performance (drag reduction), compared with Topics requirements.

Results assessment

This work package addresses the objectives outlined in the innovative wing call by Clean Aviation Joint Undertaking, focusing on:

- Technologies and the concept of eco-efficiency Wing concept impact in terms of:
  Weight reduction. Target:**20%**

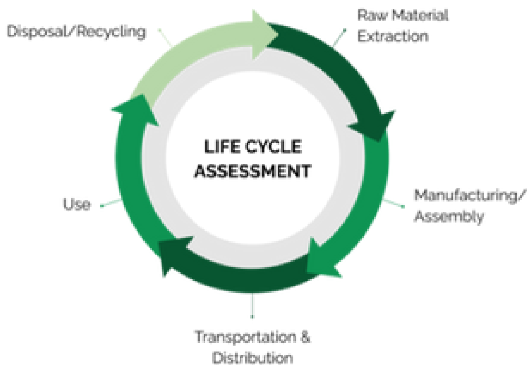
- **Fuel Burn reduction**. Target: **15%**
  - Green product viability
  - Certifiability
  - Market potential

Eco-design and data collection

In this task, the main priorities are:

- To conduct a quantitative Life Cycle Assessment (LCA) for a set of technologies and their respective demonstrators in accordance with the ISO 14040 standard.

- Preparation of templates for all demonstrators and technologies:
  - Bill of material/bill of processes
  - Manufacturing flowchart
  - Inventory templates for LCA preparation



- Data collection from all partners in charge of demonstrators and techno-bricks of these relevant inputs:
  - LCA scope definition
  - Life Cycle Data Collection (first iteration)
  - Life Cycle Data Collection (final iteration)

- Extrapolation exercise to a full aircraft wing.

Impact monitoring

In this phase of the project, we will focus on examining the influence of the proposed solution concerning a 2020 state-of-the-art reference, adhering to the specified guidelines:

- 20% weight reduction
- 15% fuel burn reduction
- Green product viability: Life Cycle and Life Cycle Cost Cycle Assessment
- Certifiability
- Market potential

Figure 9. The two wing cases HERWINGT is working on

Certification

Finally, we will pursue the development of a certification plan for the wing concept and wing technologies, as outlined in the project proposal, with INTA leading this task and the involvement of EASA contributing as a third Party.

Events

The HERWINGT consortium had its first annual meeting at the Clean Aviation premises in Brussels Belgium. This milestone event concluded on February 21, with the reviewers commending the diligent efforts of the consortium. After the successful completion of the meeting, the HERWINGT partners have rolled up their sleeves working intensively, first, on sustaining the flow of virtual architecture and design, aligned with the HERA project inputs at the wing level. This is essential for delivering a cohesive wing solution aligned with the aspirations of a regional aircraft. Second, the HERWINGT partners have been focusing on clarifying and simplifying the impact monitoring process with an emphasis on wing weight reduction. The third goal is to elaborate the rationale for the weight-saving potential of each HERWINGT key technology while developing a metric applicable to compare technologies with the state-of-the-art for the various components of the wing leading to feedback into the architecture work at the wing level.

Furthermore, the dynamic individuals from the HERWINGT project consortium, including Massimiliano Russello from AIMEN (Fig. 10) and Coro Garcia from M.Torres, took the initiative to showcase the project's advancements. In that frame, they presented the HERWINGT poster and leaflet at the prestigious JEC World 2024 exhibition held in Paris, France.

Figure 10. Representation of the HERWINGT project from the AIMEN partners.

HERWINGT

CLEAN AVIATION

A pioneering wing design for a hybrid-electric regional aircraft with a maximum capacity of 100 seats and a range of 500 km to 1000 km

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