Partner activities:

AIRBUS

Airbus Operations

Airbus, as consortial lead of this project, pursues the goal of reducing the weight of CFRP fuselage shells by developing novel structural principles for rivet-free joining technologies. A central contribution from Airbus is the development and validation of a damage tolerance methodology, which is a fundamental prerequisite for the certification and deployment of these new design methods. Additionally, the company is developing high-rate capable surface technologies for automated inspection and paint preparation, as well as automated evaluation procedures for non-destructive testing (NDT) to secure serial production. The solutions developed within the project are intended to be available for the development of future short- and medium-range aircraft after the project concludes.

Fraunhofer IWS Fraunhofer IFAM

Fraunhofer IIFAM and Fraunhofer IWS are working on the development of inline pre-treatment and in-situ quality assurance methods for the cleaning/activation of CFRP surfaces, as well as an automated process chain for secure, high-rate capable, paste adhesive bonding of a thermoset CFRP fuselage longitudinal joint – from concept to a testable component – as an alternative to riveting. Fraunhofer IFAM contributes a module for calculating the damage tolerance of adhesive joints to the design and verification procedures for the new construction methods. To achieve this, IR emitters are spectrally modified using the DLIP (Direct Laser Interference Patterning) method to enable reproducible adhesive curing based on thermal convection. Additionally, an integrated tooling solution is being developed to allow temperature sensing and control, as well as the application of a defined contact pressure, precise bond line thickness adjustment, and control over the curing profile. Furthermore, feasibility studies are being conducted to assess the transferability of the process to fiber-reinforced plastics (FRP) with hybridized thermoplastic surfaces, enabling entirely new manufacturing routes for both existing and novel, disruptive aerospace components. Ultimately, a section of a real half-shell structure is to be joined in an automated process. Surface defects on CFRP-surfaces shall be detected and classified inline including localized pre-treatment and compensation to speed-up paint processes and to improve their efficiency. The aim is to replace time and cost-consuming post-processing and re-work to achieve high-rate capability.
In parallel, measurement methods are being upgraded in combination with automated evaluation methods in order to check the quality of pretreated surfaces for adhesive bonding processes. The development of high-rate capable production processes, along with the reduction of production waste and resource consumption, contributes not only to cost efficiency but also to the reduction of CO_2 emissions. Looking ahead, this approach opens

up new possibilities for environmentally friendly aircraft components and, in particular, offers the potential to revolutionize manufacturing methods in the aerospace industry through the integration of innovative in-situ quality standards and automated adhesive bonding processes.

DLR Institut für Bauweisen und Strukturtechnologie

DLR Institut für Systemleichtbau

In the joint research project HELIOS, DLR contributes in several subject areas to the goal of light-weighting CFRP fuselage shell structures. Regarding the boltless joining of thermoset-thermoplast parts, DLR develops hybrid welding processes while ensuring the structural performance. High-rate capable non-destructive test methods for quality assurance are also a domain of DLR in HELIOS. Furthermore, thermo-forming methods are further developed for the fabrication of cost-efficient and high-rate capable frames. Developments for the adhesively bonded longitudinal seam are supported and analytically assured by residual strength methods of DLR. In addition, DLR contributes to the development of novel design principles and performs a sustainability assessment of the new solutions over the entire life cycle.

INVENT

INVENT is introducing new manufacturing processes for thermoset skin shells with thermoplastic modification. Rivet-free joining processes, such as bonding and welding, are to be made industrially viable and capable of high-rate production. In addition, energy-efficient painting systems and innovative NDT methods are being developed to improve surface quality and testing speed. The aim is to develop scalable processes for hybrid component structures and to strengthen INVENT's position as a supplier of innovative lightweight construction solutions for Airbus programmes.

MICOR

In the HELIOS project, MICOR will develop a high-rate, IR-A-based emitter that can be used for adhesive curing of TS-CFRP fuselage longitudinal seams. For this purpose, tungsten emitters will be laser-structured and incorporated into the emitter to be developed by MICOR. The functional emitter prototype with the option of modular design, including control, will be used for automated, optimised longitudinal seam bonding and tested/integrated into the process chain within the project.

SWMS DIGITAL INNOVATIONS

SWMS enhances the CAESA CAM environment with algorithms for double-double laminates and variable-angle tow (VAT) to program AFP/ATL processes. A digital twin links design and manufacturing simulations with production via bidirectional interfaces (e.g., FEM export/APIs), enabling closed design-for-manufacture loops. For the adhesively bonded longitudinal seam, SWMS develops automated process programs including gap adaptation as well as tolerance and quality strategies to achieve a robust, high-rate and resource-efficient process chain. Solutions are validated on representative demonstrators; in parallel, energy and material impacts are assessed through LCA. In this way, SWMS contributes to lower structural weight, shorter lead times and reduced emissions.

Technische Universität Braunschweig

Within the joint research project HELIOS, the TU Braunschweig is developing a design methodology with the aim of deriving manufacturing tolerances at an early stage while simultaneously reducing the effort required for experimental testing. In addition, TU Braunschweig is validating the approach of virtual testing for paste-bonded longitudinal joints. This approach is based on a static analysis of the strength and failure behaviour, taking manufacturing boundary conditions into account. Furthermore, TU Braunschweig is developing fast computational methods for the numerical determination of residual strength as a contribution to the comprehensive damage tolerance assessment. Finally, the integration of crack stopper elements into the longitudinal joint is being investigated. Regulatory authorities explicitly name these as one of three required options for the certification of rivet-free adhesive layers in primary structures. Moreover, crack stopper elements, which reduce the stress in the adhesive layer, can also increase the static joint strength. This makes them an attractive manufacturing alternative to complex scarfing and stepping of the joining partners. Therefore, another goal of the TU Braunschweig is to find a modelling strategy to consider crack stopper elements in the virtual tests. After the project concludes, the methods shall be available for the development of future short- and medium-range aircrafts.

TUHH

The TUHH (Hamburg University of Technology) contributes to the joint research project HELIOS with a focus on simulation and experimental testing for the development of holistic design solutions for CFRP skin-shell components. In the area of simulation, the focus is on the simultaneous optimisation of profile parameters of the frames (ribs/spars) and stringers, the laminate structure, and the skin laminate design, taking into account novel, damage-tolerant material systems ("Double Double"). Experimentally, the TUHH conducts service life and fatigue tests on the components using a university-owned hexapod testing facility to validate the processes.

Universität Stuttgart
Institut für Flugzeugbau

In this sub-project, a fatigue crack growth simulation for application to a bonded longitudinal seam will be adapted, expanded, and validated. The aim is to ensure that the fatigue simulation is not used individually to evaluate damage, but is integrated into a simulation chain with contributions from the partners WE, TUBS, DLR, and IFAM, which simulate impact damage, allows it to grow using the fatigue crack growth simulation, and can then evaluate the static residual strength. A user-defined material model is used to calculate the fatigue crack growth. One goal is to expand this such that different material data can be used for tensile and compressive stresses. This offers the potential to deliver more accurate results in the areas of stiffeners and load introduction elements. Thus, fatigue crack growth simulation contributes to the assessment of the damage tolerance of bonded joints.

Wölfel

The subproject HELIOS-Wölfel focuses on the further development and validation of a simulation-based verification methodology for the damage tolerance of rivet-free fiber composite joints. The main objective is the creation of a continuous simulation chain covering the phases of initial damage (impact), fatigue, and residual strength, thereby largely complementing or replacing physical tests. Wölfel is particularly responsible for the advancement of the impact module, the integration of the individual modules into a robust process chain, and their transfer to larger structures such as longitudinal joint designs or wide single-lap shear (WSLS) specimens. Through experimental validations, the applicability of the methodology will be demonstrated and its integration into industrial design processes prepared. In doing so, Wölfel contributes to more efficient and resource-saving development and manufacturing processes in the aviation industry