

PRESS RELEASE

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JEC WORLD – Sustainable and efficient production through automation and robotics from Fraunhofer IFAM in Stade, Germany

Automated machining and assembly of large lightweight structures on a 1:1 scale

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Stade, Germany, will be presenting automation solutions for sustainable production at the Leading International Composites Show JEC WORLD 2023 from April 25 to 27 in Paris at the joint booth of Composites United e.V. (Hall 6 | Booth Q 28 | Position 16).

- **Lightweight robotics modular system**
- **Assembly technologies for a lighter Clean Sky 2 aircraft fuselage of the future made of thermoplastic fiber-reinforced plastics (FRP)**
- **Automated pre-assembly of CFRP integral frames**
- **Automated rudder hinge assembly in aircraft vertical tail planes**
- **Efficiency-enhancing flow-line manufacturing for large CFRP components**

R&D services focus on machining and assembly of large lightweight structures made of various materials for the aviation and aerospace, wind turbine, commercial vehicle, rail vehicle, and agricultural sectors. Automated or semi-automated manufacturing solutions up to industrial scale are developed.

Pioneering concepts for current challenges

The 4500 m² research hall with an utilizable height of 15 m of Fraunhofer IFAM at the Research Center CFK NORD in Stade provides many large-scale research facilities which can be used flexibly and are equipped with robots, fixtures, and high-performance measurement technology. This makes it possible to relieve customers of the "upscaling" involved in the direct transfer of research results to their production, since Fraunhofer IFAM can validate the step from the laboratory to a production-analog environment with real components on a 1:1 scale on the institute's own premises as part of process and plant development.

New weight-saving materials and manufacturing processes not only increase efficiency and reduce costs in production, but also decrease energy consumption in operation, which in turn saves costs and promotes climate protection. However, the experts in Automation and Production Technology are also rising to the challenge of reconciling ergonomic workplace design in large-scale structural assembly with efficiency and sustainability. At JEC WORLD

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2023, they will provide insights into current application-oriented R&D results in the context of automated assembly, including machining and joining processes.

**Modular system with potential –
Cognitive production with modular lightweight robotics**

In the joint project "Cobots, Humans and Machines from Lower Saxony" (CoMMaNs 2), the researchers at Fraunhofer IFAM in Stade, together with their project partners, developed mobile lightweight robot systems for the efficient and sustainable assembly of aircraft components (Figure 1).

The aim of the R&D activities was to create a modular lightweight robotics toolkit that makes it possible to configure and reconfigure lightweight robot systems with reduced time and financial effort. This allows not only new systems to be projected at lower cost and with shorter delivery time, but also existing systems to be more easily adapted to changing conditions. The system modeling as well as the standardized interfaces are based on the open data exchange standard OPC UA and the standardized sequence control consists of capability-based software modules. Thus, a "Plug & Produce" as well as a fast and simple generation of control codes is achieved in production practice.

Other important components of the project are human-machine interface, which was realized using AR technologies, among others, technologies for fast and reliable referencing, mobilization of the robots, and development of some aerospace-related processes.

The developed technology components of the modular system have already proven themselves in exemplary applications. For example, the crimping of rivets on an aircraft fuselage shell and the drilling and screwing of riveted joints were successfully carried out on a 1:1 scale using the example of an aircraft vertical tail plane box.

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**Niedersächsisches Ministerium für Wirtschaft,
Verkehr, Bauen und Digitalisierung**

**Clean Sky 2 – "MFFD" – An aircraft fuselage of the future –
Assembly technologies for new fuselage designs with thermoplastic CFRP**

In Stade, Fraunhofer is currently building the Clean Sky 2 "Multifunctional Fuselage Demonstrator" ("MFFD") on a 1:1 scale (Figure 2). The significant weight reduction of the aircraft fuselage of the future results from a new design, which in turn is made accessible for this area of application by the use of thermoplastic fiber composites for the first time worldwide.

Increasing demand for aircraft and the need to reduce CO₂ emissions require new methods and technologies in the aircraft construction. For a significant increase in productivity on the one hand and environmental compatibility – through weight reduction – on the other, there is a promising approach: the combination of thermoplastic, carbon fiber-reinforced plastic (CFRP) aircraft structural elements, fairing parts and cabin system elements into an integrated structural module.

The Clean Sky 2 "Multifunctional Fuselage Demonstrator" ("MFFD") is investigating the technological and economic feasibility of welding-based assembly of highly integrated, thermoplastic aircraft fuselage structures. This includes the construction of a 1:1 scale demonstrator with various joint designs and welding processes in Stade, which is being developed together with international project partners. In addition to the welding process, the focus is on automated manipulation and assembly of the structures while maintaining the highest tolerance requirements.

Further information: <https://s.fhg.de/iG5>



**Co-funded by
the European Union**

**Positioning and drilling end-effector for automated, high-precision and quality-
assured pre-assembly of CFRP integral frames**

The automation solutions developed in the "Impuls" subproject "Tempo" ("Technologies for the efficient assembly and production of CFRP fuselage components") by Fraunhofer IFAM in Stade together with project partners have already been validated in a near-series environment on a full-scale prototype.

The positioning and drilling end effector newly developed for a portal system to automate the pre-assembly of stiffening elements (cleats) on CFRP integral frames (Figure 3) for the manufacture of aircraft fuselages enables production rate increases both with constant quality and at lower cost. In addition, the previous manual production requires more process steps.

The positioning and drilling end effector fulfills the tasks of receiving various cleats, positioning them on different integral frames and simultaneously double drilling both components. The compactly built end effector can be picked up by the portal system used as well as by standard industrial robots. It can be controlled via a system PLC and receives its global position data from imported CAD data of the components. The new assembly situation is adapted via a quick upstream measurement using a laser tracker. The innovative technology enables a reliable process and high positioning accuracy. The measuring technology integrated in the end effector documents exactly the required contact pressure as well as many other parameters for monitoring the optimal conditions for the pre-assembly of the cleats on the integral frame. This guarantees online quality assurance.

The end effector developed for the pre-assembly, positioning, and drilling of frames can also be used for the assembly of components in other industries, such as wind turbines-, rail vehicle-, commercial vehicle-, automotive- or shipbuilding, by adapting the mounting system.

Video and further information: <https://s.fhg.de/s4X>

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Agile production technologies for CFRP box structures – Automated rudder hinge assembly in aircraft vertical tail planes

By using agile production technologies for CFRP box structures, researchers at Fraunhofer IFAM in Stade optimized the production processes of aircraft vertical tail planes in the joint project "FastFlexMont 2".

With the aim of no longer interrupting the assembly of rudder hinges to the Vertical Tail Plane (VTP) box by long waiting times, Fraunhofer IFAM experts and partners have developed application and curing of shim material (gap-filling material; Figure 4) as a parallel process. Automated and digitally networked processes enable volume-accurate metering and application as well as precise shaping and edge smoothing of the shim. Only after the gap filling has cured, the completely shimmed rudder hinge is inserted into the vertical tail plane.

Thus, in addition to agile manufacturing, the parallelization of work steps makes it possible to reuse technical resources and consequently increase productivity while at the same time reducing costs.

Further information and video: <https://s.fhg.de/8u5> and <https://s.fhg.de/zL5>

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Efficiency-enhancing flow-line production of large CFRP components – Trend-setting mobile holding fixture for flexible pick-up, alignment, and transport of components

A further milestone with regard to agile production technologies – the new mobile holding fixture developed by Fraunhofer IFAM in Stade together with project partners can flexibly hold various large components, such as aircraft tail planes or landing flaps, in different types up to eight meters in length, align them precisely and sustainably, and transport them (Figure 5).

This joint research project ("UniFix"; "Universal mobile component clamping and fixing device for the processing of fiber composite structures") is also all about weight-reducing large CFRP structures on a 1:1 scale for aircraft construction. Focused on machining processes in the production flow, this holding fixture is able to significantly relieve a machining line of time-consuming, non-value-adding secondary activities by passing through various process stations in advance with the optimally and precisely aligned large components, at which preparatory work can be carried out in parallel and simultaneously.

This flow-oriented production makes it possible to reduce throughput times and thus increase productivity, efficiency and cost-effectiveness, and consequently competitiveness in the international market. The advantages of flow-oriented manufacturing lie primarily in the reduction of manual handling operations and non-productive time. In addition, there are increases in efficiency through specialization of the individual plants, reduced throughput times due to harmonized cycle times, as well as an associated reduction in buffer stocks and faster reaction to process deviations.

Further information and video: <https://s.fhg.de/Zq5> and <https://s.fhg.de/89K>

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Further Information

- **Website**
www.ifam.fraunhofer.de/en/stade
- **Flyer**
<https://s.fhg.de/7wp>
- **Trade fair**
Find out more – visit us at the JEC WORLD 2023 in Paris from April 25 to 27, Hall 6, Booth Q 28, Position 16 (joint booth of Composites United e.V.).

Photos

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www.ifam.fraunhofer.de/en/Press_Releases/Downloads.html



Figure 1 | Caption

Transfer of currently manually performed drilling processes at CFRP vertical tail planes to mobile Cobots (© Fraunhofer IFAM).

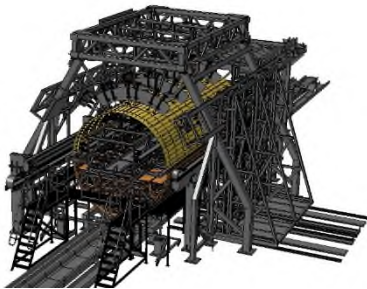


Figure 2 | Caption

Aircraft fuselage of the future: The Clean Sky 2 Multifunctional Fuselage Demonstrator (MFFD) in detail. It is currently being realized at Fraunhofer at the Research Center CFK NORD in Stade on a 1:1 scale with project partners (© Fraunhofer).



Figure 3 | Caption

The positioning and drilling end effector developed by Fraunhofer IFAM in Stade during the automated positioning of a cleat on the integral frame (© Fraunhofer IFAM).

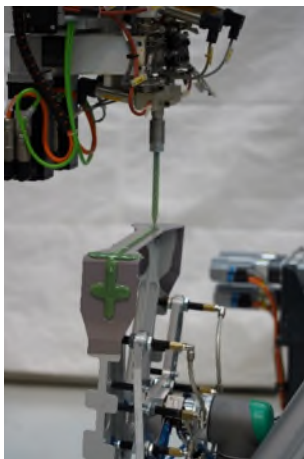


Figure 4 | Caption

Automated rudder hinge assembly in aircraft tail planes – Automated on-demand shim application to compensate component tolerances: a lightweight robot guides a rudder hinge under the dispensing system for liquid shim application (© Fraunhofer IFAM).



Figure 5 | Caption

The first station of the "UniFix" flow line: The newly developed mobile holding fixture, which is operated by virtually coupled AGV systems, transports the robustly held CFRP vertical tail plane element into the camera arena, where the shape retention of the holding fixture is checked (© Fraunhofer IFAM).