



CLEAN AVIATION

ICAS 2022 – ID 0924

**SUSTAINABLE TECHNOLOGIES
FOR COMMERCIAL AIRCRAFT OF
TOMORROW –
INTEGRATED MULTIFUNCTIONAL
FUSELAGE DEMONSTRATOR**

**PRESENTED BY:
YORK C. ROTH, AIRBUS**

**SUPPORTED BY:
CA/ CS2 PLATFORM 2
CONSORTIUM**



**Co-funded by
the European Union**

- **Sustainability**
- **CleanAviation/ CleanSky2**
- **Multifunctional Fuselage Demonstrator (MFFD)**
- **MFFD Key Technologies**
- **Contribution to CleanSky2**
- **Conclusions**



CLEAN AVIATION

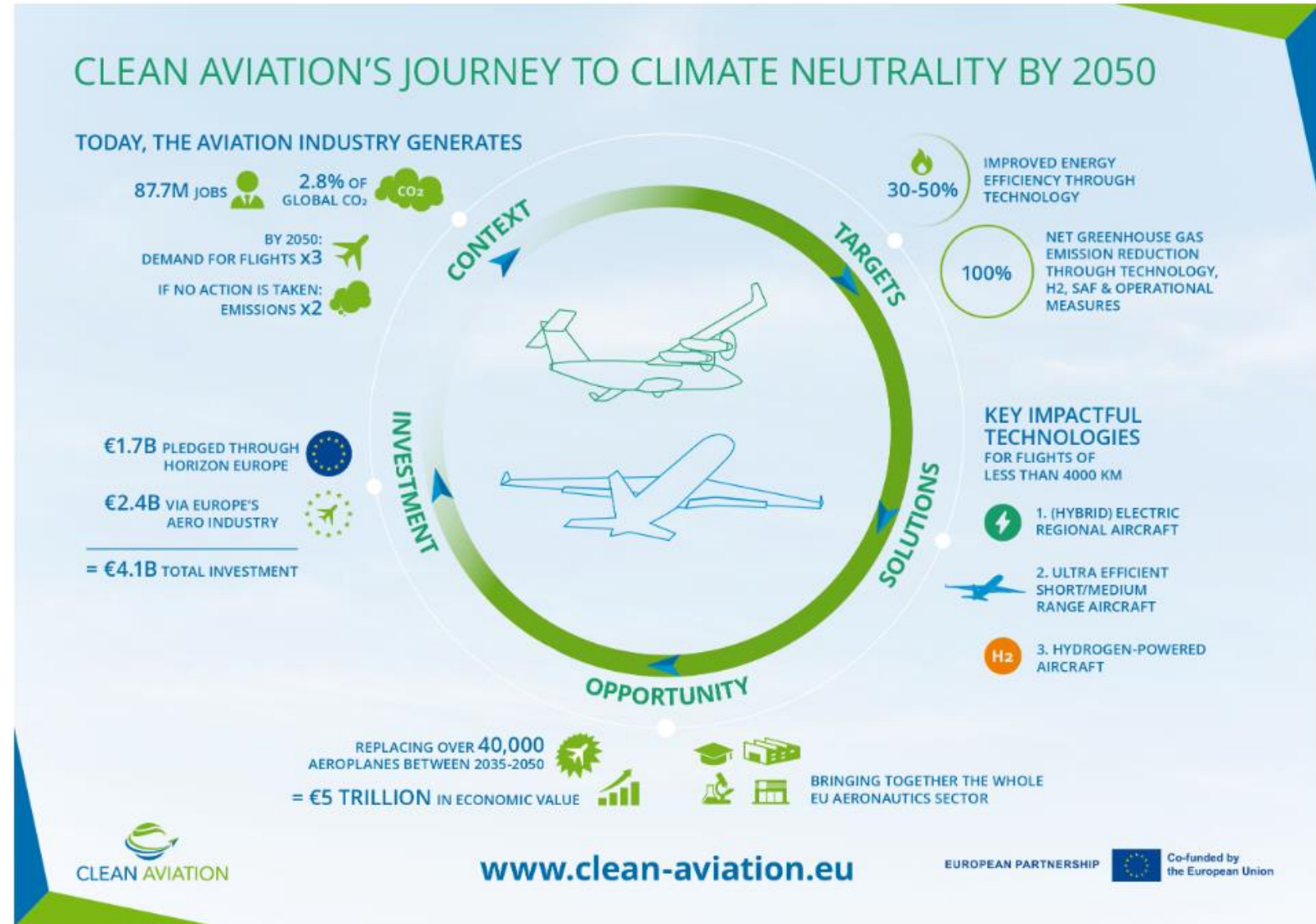
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**Co-funded by
the European Union**

“Treat the earth as though we intend to stay here”

by Sir Crispin Tickell



“

At Airbus, our ambition is to lead the decarbonisation of our sector and build the world's first **zero-emission airliner** by 2035. We're committed to this ambition as demonstrated by our new ZEROe aircraft concept designs.

”

GUILLAUME FAURY, AIRBUS CEO



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AIRBUS

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CleanSky2 Joint Undertaking is a public-private partnership between the **European Commission and the European aeronautics industry** that coordinates and funds **research activities** to deliver significantly **quieter and more environmentally friendly aircraft**.

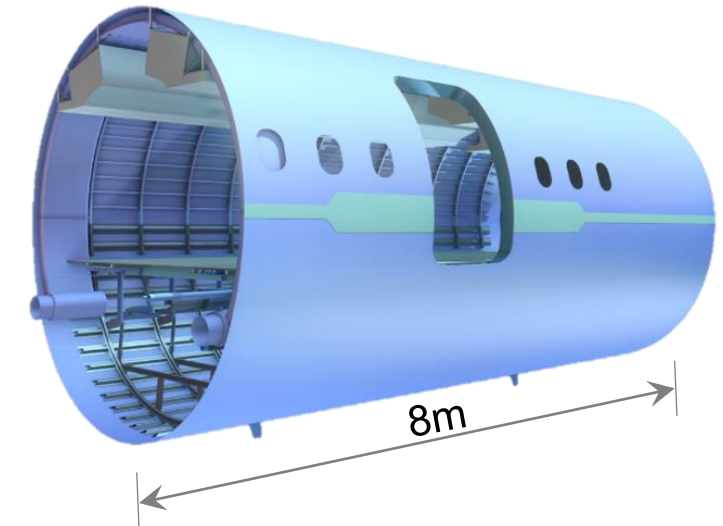
CleanSky2 (CS2) 1,755M€ total EU funding (2014-2023)

- ...
- **Large Passenger Aircraft (LPA)** program within CS2 “*Mature & validate technologies for the Next Generation LPA through **large Scale integrated demonstration***”: 492m€ EU funding
 - ...
 - **PF2: “Innovative Physical Integration – Cabin – System – Structure”**: 97m€
 - ...



CS2 LPA Platform 2 “Innovative Physical Integration Cabin – Systems – Structure”

- Cabin & Cargo Functions
- Non-specific cross functions
- **Multifunctional Fuselage Flagship Demonstrator (MFFD)**
 - **Large scale** integrated demonstrator
 - Modular fuselage build concept with **pre-equipped modules**, e. g. floor structures
 - **highly integrated cabin elements** designed for automation, e. g. crown modules
 - **thermoplastic composite** structures enabling welding and innovative assembly through **dustless joining**



Ambition ref to A321 ACF @ fuselage level
-1t weight
 -1m€ recurring cost
 @ rate 70-100 AC/ month

AERnnova

Fraunhofer

FIDAMC

SAFRAN

DLR

AIRBUS

PREMIUM AEROTECH

Fokker GKN AEROSPACE

TU Delft

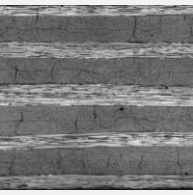
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ONERA THE FRENCH AEROSPACE LAB

DIEHL

SAAB

SAAB



[Ref. 14]

Objective

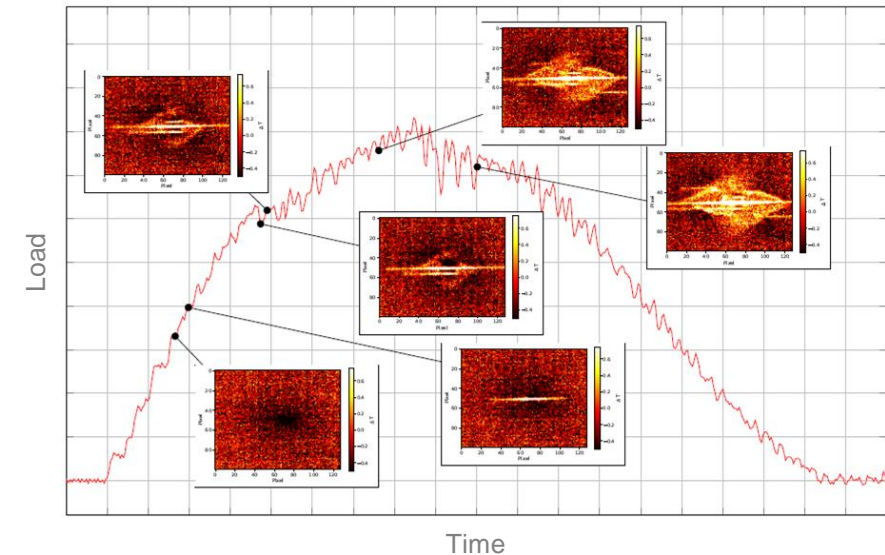
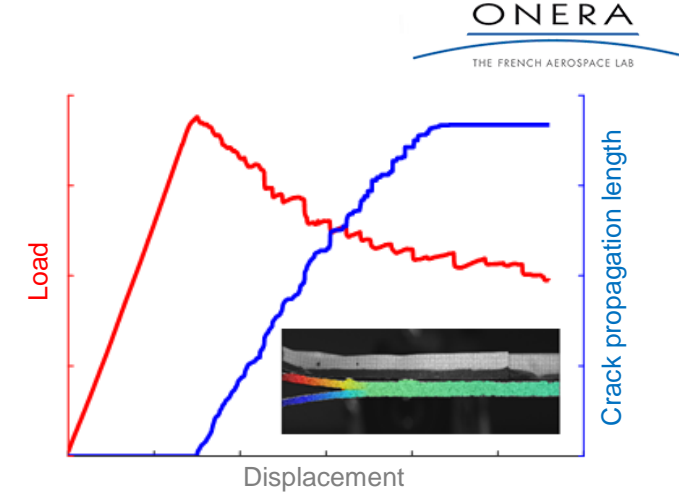
Experimental **characterization** and modelling of a **carbon fibre /thermoplastic composite** material at coupon levels

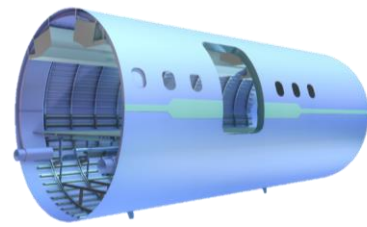
Fracture toughness

- ✓ Double Cantilever Beam, End Notched Flexure and Mixed-Mode Bending tests
- ✓ **Thermoplastic** composites: **superior G_{1C}** *
[*: ref. to carbon fibre/ epoxy composite]

Impact

- ✓ **Low velocity impact** tests
- ✓ Real time damage evolution measurements thanks to high speed thermal and optical cameras during impact
- ✓ **Smaller delaminated area** after impact*



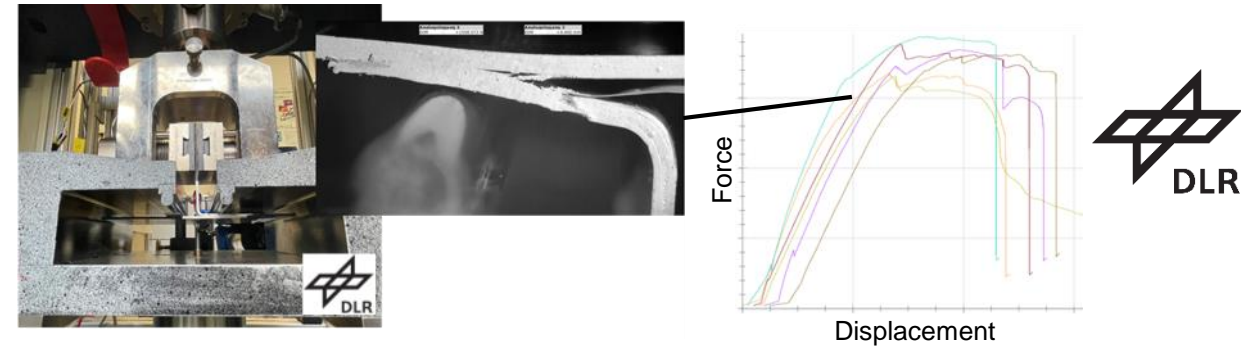
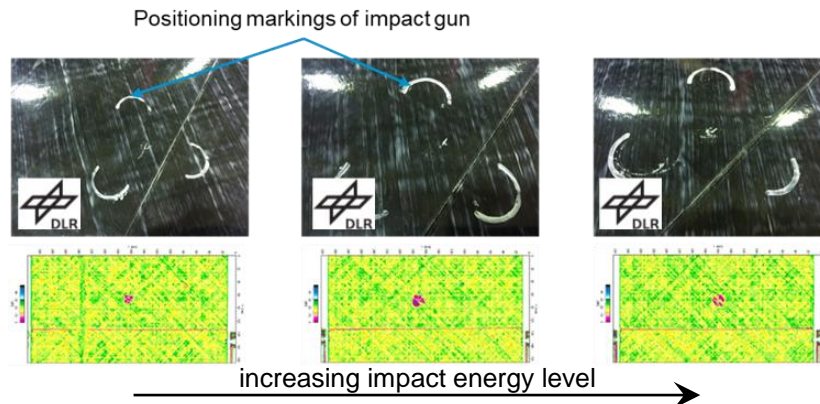


L-Pull investigation

- ✓ Mechanical tests of specimen series, e.g. **resistance welding** (Composites Technology Center, CTC) and **co-consolidation/infrared welding** (Premium Aerotec)
- ✓ **Benchmark of TP stringer-frame integration**

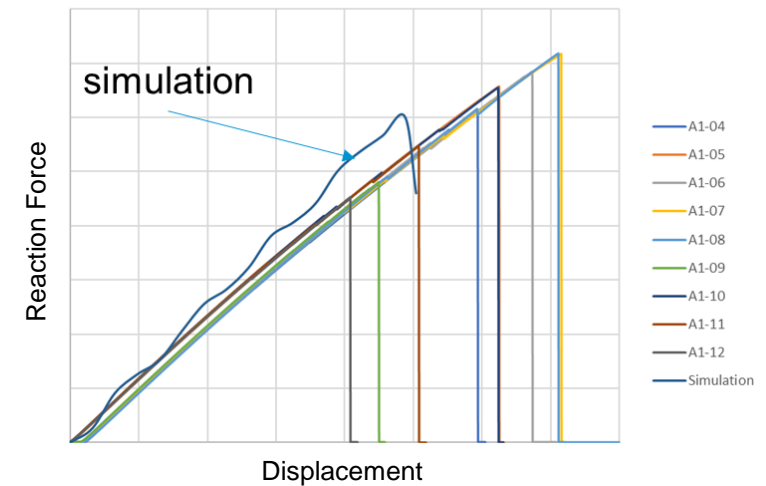
Lapshear investigation

- ✓ **Impact calibration** @ different energy levels, assessment of Barely Visible Impact Damages energies
- ✓ **Validation** of quasi-static simulation models
- ✓ **Benchmark of longitudinal joint**



L-Pull Test of Resistance Welded Specimen (CTC)

ICASUS A1-04 to A1-12 and Simulation, without AD



Lapshear investigation, experiments versus simulation

Manufacturing technology

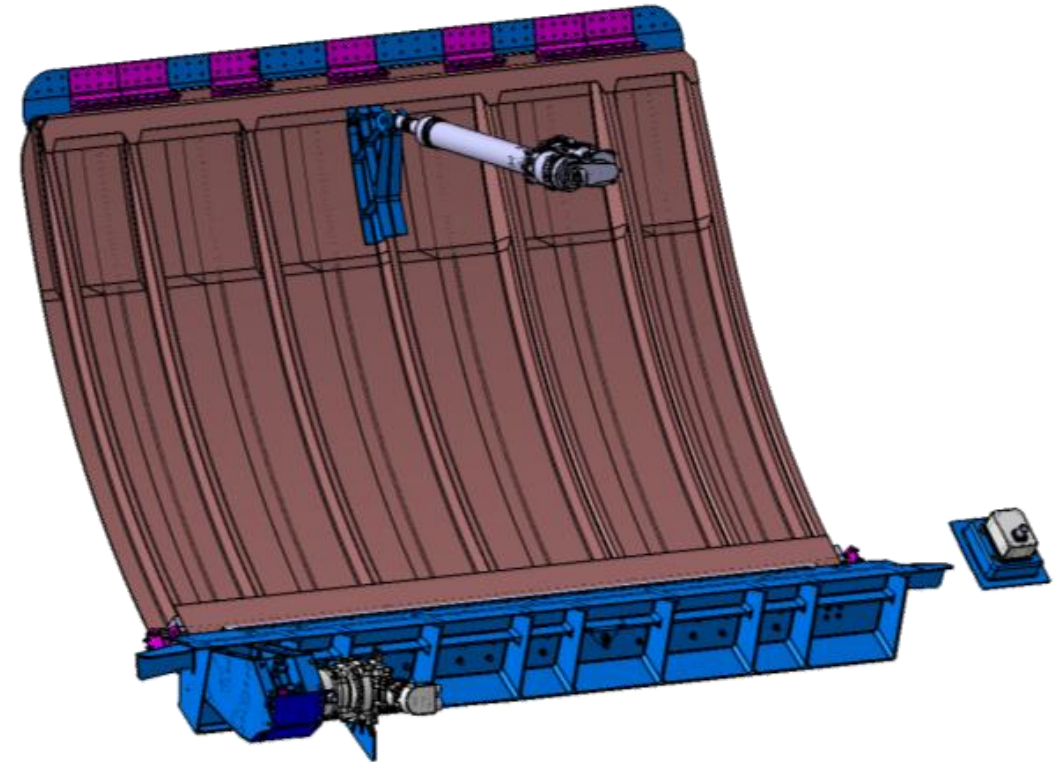
- ✓ **Vacuum infusion process** (Hexcel HiTape® & RTM6)
- ✓ Additively manufactured mould tool

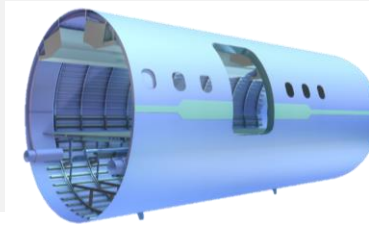
Door systems

- ✓ **Electromechanical actuation** system
- ✓ Innovative latch & lock system: **cassette with sliding latch bar** installed in the fuselage

Weights

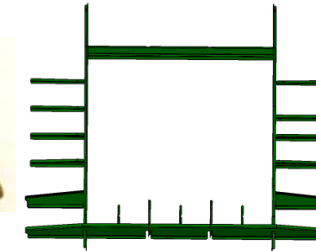
- ✓ **Cargo door** product 39kg (\approx -20% ref. to sheet metal design)
- ✓ Equipment: 20kg
- ✓ Fuselage installation 24 kg





Cargo door surround structure

- ✓ Press forming technology
- ✓ Induction welding for subassemblies

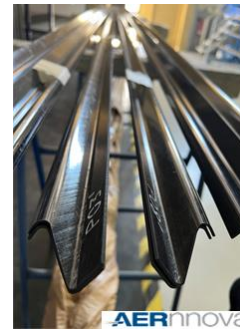


AERnnova

FIDAMC

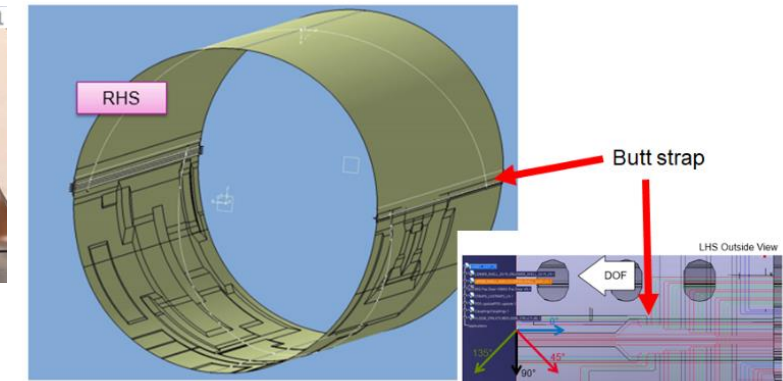
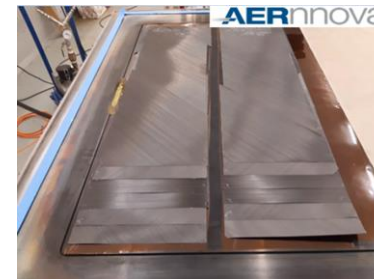
Upper shell stringers

- ✓ Continuous compression moulding
- ✓ Z cross-section, straight and with joggles.



Butt straps for Major Component Assembly

- ✓ Hand layup on self-heated table.
- ✓ Flat tapered straps to weld the upper and lower shells





[Ref. 9, 12]

Upper Skin

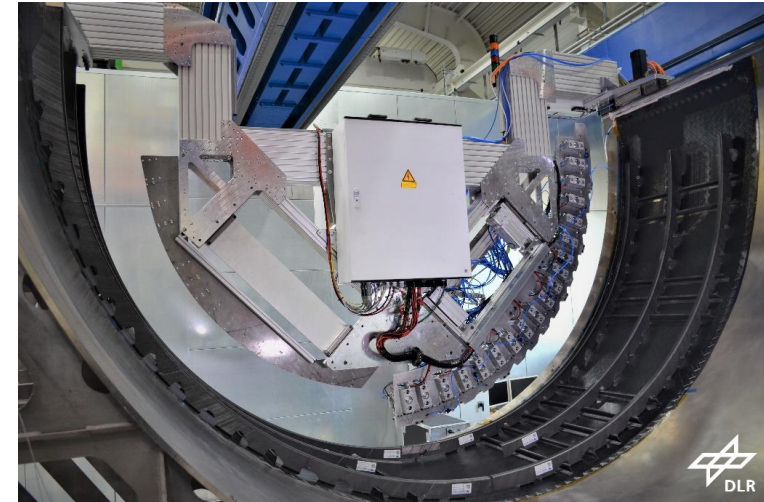
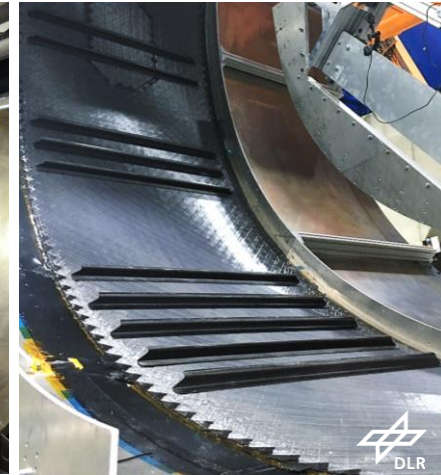
- ✓ In-situ advanced fibre placement of thermoplastic composites
- ✓ One-step, inline quality inspected tape placement → up to 40% lead time reduction through vacuum bagging avoidance

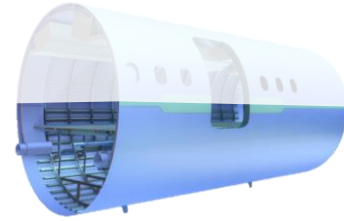
Stringers

- ✓ Continuous ultrasonic welding to skin – *a world's first!*

Frames

- ✓ Tape placed preforms compression molded to C-frames
- ✓ Resistance welding to join frames → potential up to 5min cycle times per frame integration.





[Ref. 6, 7, 8, 13]

Lower Skin [\[https://www.youtube.com/watch?v=WBGQgHvZc-g\]](https://www.youtube.com/watch?v=WBGQgHvZc-g)

- ✓ **2 Thermoplastic skin segments** (Automated Fibre Placement) **co-consolidated** in Autoclave
- ✓ weight 280 kg → **world's largest thermoplastic part!**

Stringers

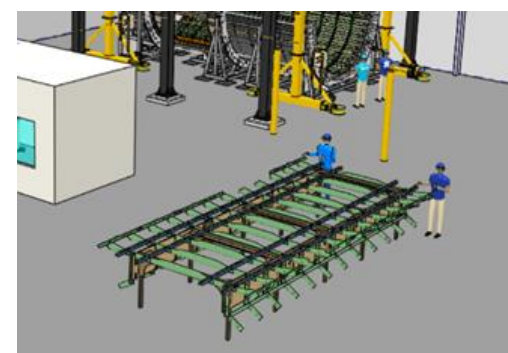
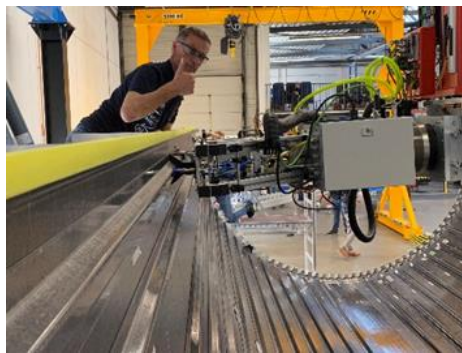
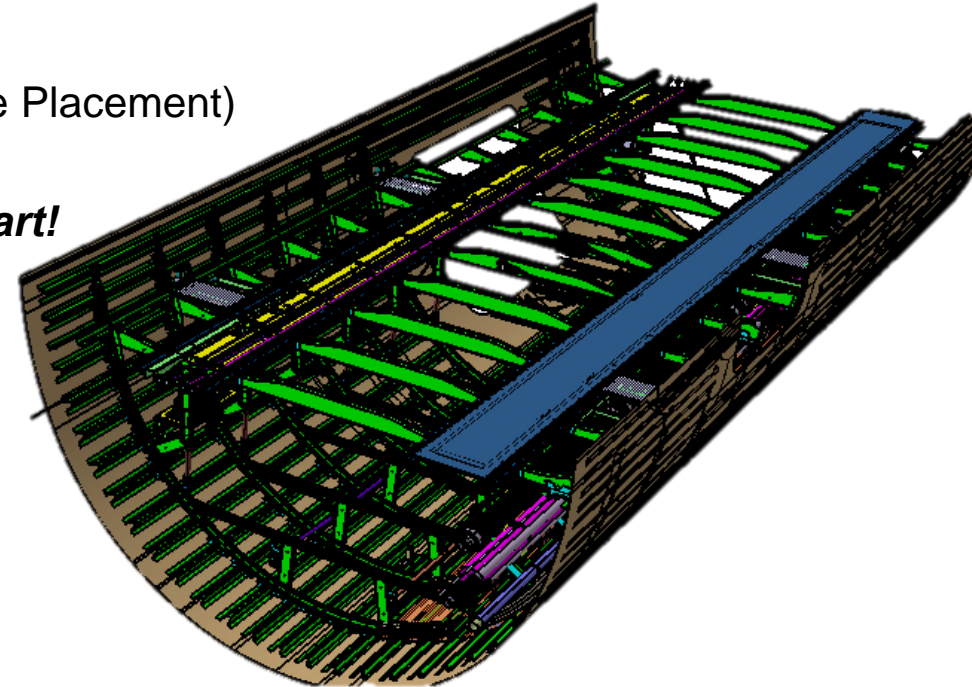
- ✓ automated **Pick&Place**
- ✓ **conduction welded** to skin

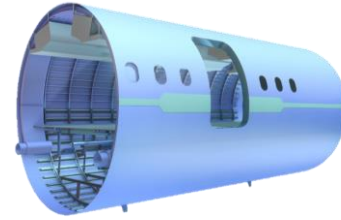
Clips ultrasonic welded to skin

Frames conduction welded to clips

Floor grid including systems assembled out of jig

Automated drilling of **cargo door surround** structure





[Ref. 10]

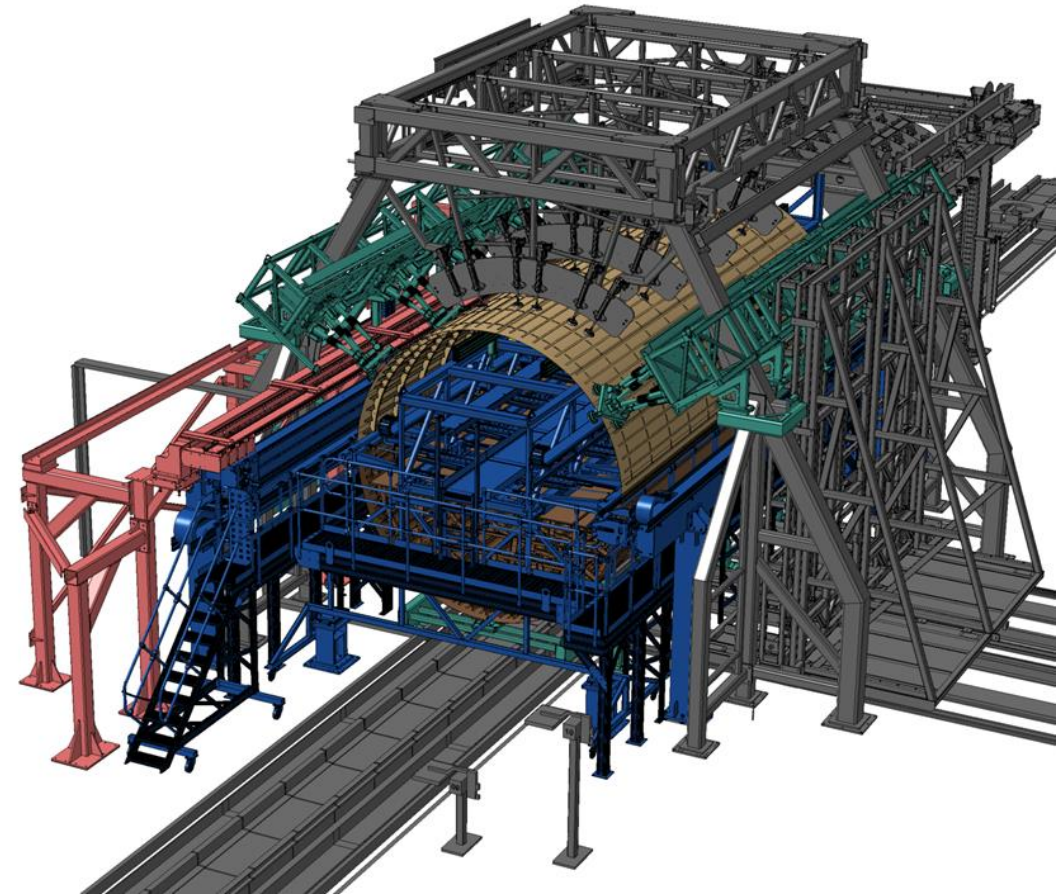
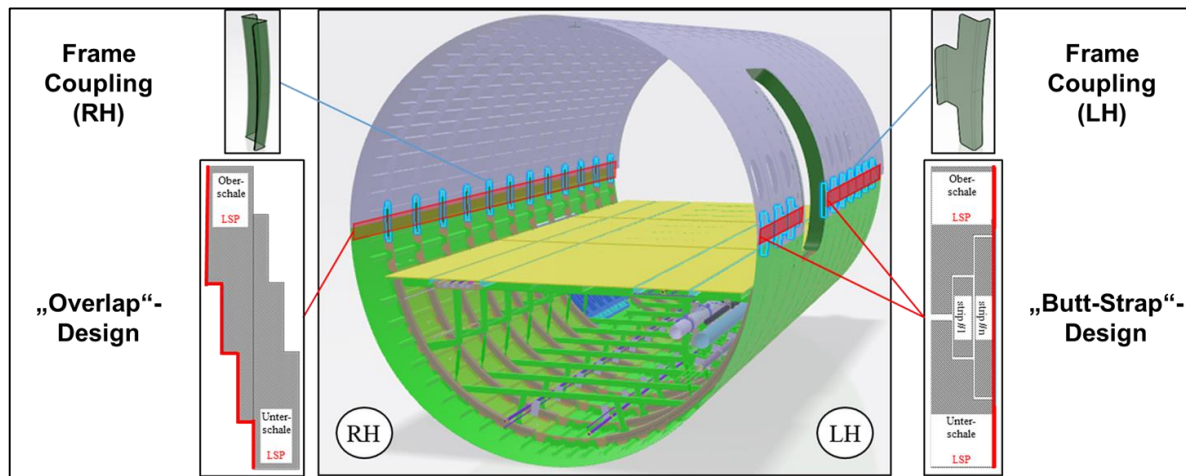
Longitudinal joints → 2 technologies for shells marriage

- ✓ Overlap design → Ultrasonic welding
- ✓ Butt strap design → Laser welding

Frame couplings

- ✓ Resistance welding

Automated plant system





Objective

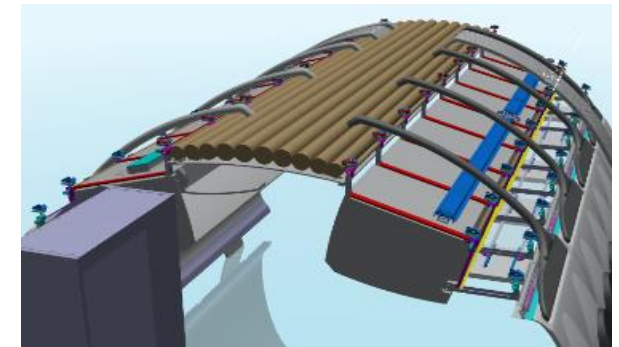
Test opportunities of a semi/- automated **integration of a large cabin system** equipped in a **standardized airframe**

Expected benefits

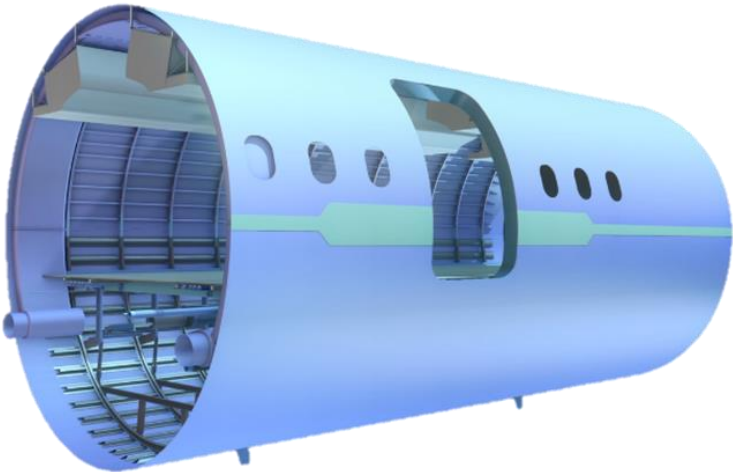
- ✓ “0” **customization** at airframe
- ✓ weight reduction > 60kg
- ✓ work load reduction > 70h

Key element: development of sub-structure

- ✓ airframe/cabin **adaptive layer** and carrier of **standardized system components**
- ✓ **power/data backbone integration** in the crown module
- ✓ ATA 21 (**air conditioning**) **system integration** as key enabler for cabin modularization and fast installation



MFFD technologies



- **Thermoplastic** composite parts **enabling welding**
- **Dustless assembly** with less rivets
- **Pre-equipping** of modules
- ...

Weight reduction

Assumption for a typical Single Aisle Aircraft (SA)

[rough order of magnitude without snowball effects]

- 20kg → -1kg fuel = - **3,15kg CO₂ emissions**

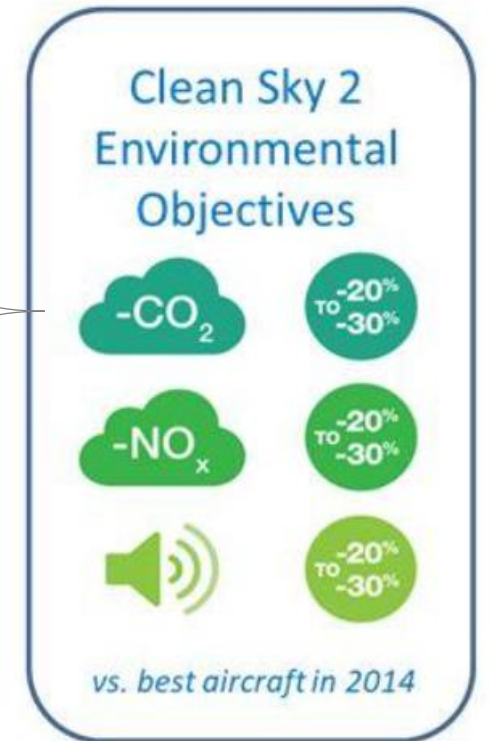
MFFD ambition

-1t weight

Potential

- **1 SA flight with MFFD weight saving**
→ - 158kg CO₂ emissions
- **1 SA per year** ≈ Ø 1,600 flights
→ **-252t CO₂ emissions**

Weight target will be achieved!



Ambition

- CleanAviation climate neutrality by 2050
- Airbus to built the world's 1st zero-emission airliner by 2035
- CleanSky2 environmental objectives: 20-30% CO₂, NO_x and noise reduction

Multifunctional Fuselage Flagship Demonstrator pushing the limits

- 8m large scale integration of competing technologies
- Thermoplastic composites enabling welding & dustless joining
- Pre-equipped modules
- Delivery date: 2023



Enabler = Strong European partnership & the Joint Undertaking!

**Thanks to
our
partners!!!**















CS2-LPA Platform 2: Innovative Physical Integration Cabin – System - Structure

<https://www.cleansky.eu/large-passenger-aircraft>

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Disclaimer

- The results, opinions, conclusions, etc. presented in this work are those of the author(s) only and do not necessarily represent the position of the JU; the JU is not responsible for any use made of the information contained herein.





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