H2020-JTI-CS2-CFP03-SYS-03-05

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Document n°	SYS-03-05 NSLGP D1.4
Issue date	31.07.2019
Project	NSLGP
EU project	737721

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Document n°	SYS-03-05 NSLGP D1.4
Document Title	**PUBLISHABLE REPORT**
Issue date	31.07.2019

Abstract:

Revision History Table		
Version n°	**Issue Date**	**Reason for change**
new	31.07.2019	First release

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Partners involved in the document

Nb	Member name	Short name	Check if involved
1	Israel Aerospace Industries	IAI	**V**
2	CirComp GmbH	CirComp	**V**

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1.1. Overview of the results and the project

The objective of the EU project NSLGP (Non Structural Landing Gear Parts) was to develop, manufacture and test non-structural landing gear parts for regional aircraft based on advanced carbon fiber composite material systems.

In this project, Liebherr was the Topic Manager, collaborating with Israel Aerospace industries (IAI) and CirComp GmbH. The target of this project was to achieve weight reduction, low cost serial production, and capability of the parts to integrate into automatic manufacturing processes.

The main output from the project was a full demonstration of the technology and manufacturing of composite door rod and door linkage components with advantages of reducing manufacturing costs and weight in comparison to metal parts, by selecting appropriate manufacturing technology and optimized design methodology.

The conceptual approach for a low cost product was dependent most of all on the preferred technology stream incorporating the following parameters:

- Integration to automated manufacture processing.
- Using aerospace approved materials and processes.
- Design optimization and assembly simplification.

Door linkage

Israel Aerospace Industries (IAI) has a proven track record of in-house design and development of a family of business jets as well as a wide range of other aerospace products. This includes all necessary design, analysis, testing, certification, manufacturing and assembly capabilities for composite structure. Most importantly, over the past 60 years IAI has been dealing with the challenging task of optimizing structural cost, safety and weight for low volume production of relatively small aircraft, one of the main objectives of the present strategic thrust.

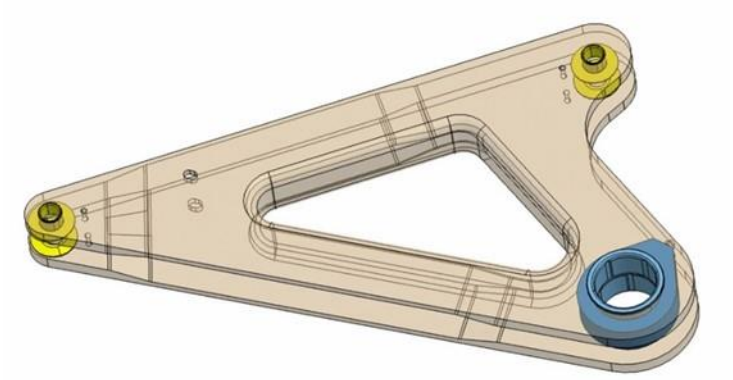
Currently, IAI is developing, manufacturing and testing non-structural complex parts for landing gear assemblies with the support of the EU Clean Sky 2 Framework. Automated preform preparation by TFP (Tailored Fibre Placement) and RTM (Resin Transfer Moulding) technologies are used in the manufacturing process with specific complex tools that can be adapted for automatic production.

The advantages of this process are:

- Freedom to design any fiber orientation allowing for a more optimal and efficient design.
- Reducing weight and cost (by reducing scrap material).
- Reduction of touch labour and improving repeatability of the preform layup.

Key parameters of the door linkage:

- Depth: 38.1 mm
- Length and Width about 420 x 250 mm
- Ultimate load in tension: 19,042N
- Ultimate load in compression: 59,082 N



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Door Rod

CirComp manufactures customized components from composite materials by using the CNC controlled filament winding, thermoplastic pultrusion or resin transfer moulding (RTM) processes. Throughout many years CirComp has gathered outstanding experience and knowhow in the field of manufacturing components from composite materials. CirComp is certified according to ISO 9001:2015, EN 9100:2018 and Nadcap.

One of their latest aerospace developments is a composite **AIRSTRUT®** for opening the landing gear doors of aircraft. The strut is characterized by its slim design in the area of force introduction and the high buckling stability in the center of the component. The load introduction is achieved by a form-fit connection. Compared to the approved aluminum rod the weight saving of the composite door rod is about 50 %.

Key parameters of the door rod:

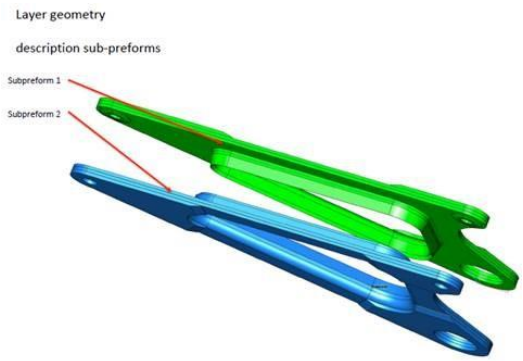
- Eye to eye length: 1.302 mm
- Outer diameter in the rod center: 38 mm
- Outer diameter at the rod body end: 26,2 mm
- Ultimate load in tension: 17.466 N
- Ultimate load in compression: 12.664 N

1.2. Innovation

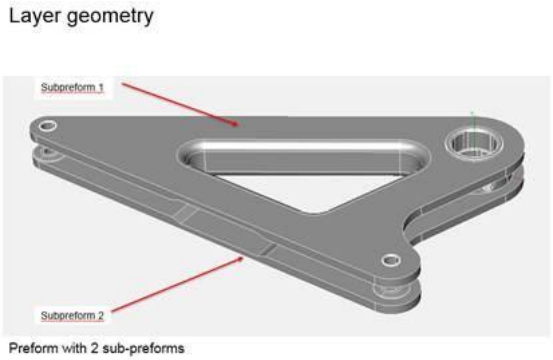
The NSLGP project innovation activities were:

- Automated process-using innovative technology TFP (Tailored Fibre Placement) for the door linkage and FW (Filament Winding) for the door rod.
    - Automated foam core manufacturing for the door rod.
    - New slim design for the load transmission area of the door rod
- One shot linkage component after injection.
- Assembly without extra machining – door linkage assembly preform with inserted bushings before RTM process
- Optimization of manufacture (using two sub-preforms with overlap technology to prepare one preform assembly for rtm injection) as shown below.

Initial step for the overlap technology



Final step



Preform with 2 sub-preforms

1.3. Exploitation and dissemination in the project

Dissemination

Figure 1 shows a 3D-Model of the final composite door rod.

Figure 1: Door rod demonstrator

The composite door rod was presented to the public for the first time at the Paris Air Show in 2019 (see Figure 2).

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Figure 2: Paris Air Show 2019

Publication of Brochure

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Exploitations

IAI intended to use the projects results for further developments of landing gear composite parts, the project help IAI to discover new technologies which will help IAI for further developments of structural parts, project innovation of making parts by automated process will help IAI and CirComp to reduce cost and make more projects available, the knowledge and experience of assembly without extra machining will optimize the manufacture process.

Figure 3: Composite Door Rod demonstrator manufactured by CirComp

Figure 4: Door rod demonstrator

1.4. Conclusion of the project

The main output from the project demonstrates the technology and manufacturing of composite parts like the door rod and the door linkage with the aim of reduced manufacturing costs. This is concurrent with improvements in design and manufacturing ability, optimized design methodology and advanced manufacturing technology which lead to lower component weights. This results in a significant reduction of fuel consumption which in turn mitigates Life Cycle Cost and environmental pollution.

Those objectives according to this report were achieved and are summarized. The weight of parts and serial production cost were analysed as well.

The impact of the manufacturing methods and material selection procurement which were used in this project minimize the aircraft weight and cost while maximizing utility, lower the environmental impact (fuel and energy), making travel costs less expensive and strengthening European competitiveness.

The ideal situation is:

- Scrap of parts was minimized using the methods illustrated in the report
- Lighter door rods and door linkages lead to reduction of structural weight compared to metallic parts, reducing pollutant production. IAI and CirComp are able to use highly automated manufacturing processes for the composite parts which leads to lower manufacturing costs.

The aim of this proposal was mainly to develop, manufacture and test non-structural landing gear parts for aircraft based on advanced carbon fiber material systems. IAI and CirComp contributed to the

success of this EU project and are able to supply parts manufactured with new technology to LIEBHERR.

Key facts regarding cost and weight:reduction of composite production cost of about 20% compared to state-of-the-art composite strut and reduction of composite production cost of about 15% compared to a composite door linkage using conventional processing.

- Reduction of structural weight after the prototype manufacture of about 31.7% with respect to metallic reference weight on the door linkage and 52% with respect to the door rod (without rod ends).
- Reduction of overall life cycle costs of the aircraft parts of about 20%

The conceptual approach during this project was based on low cost product with minimising weight.

Both companies were involved in the selection of the main preferred technology stream presented in this project. IAI and Circomp were considering the cost and weight parameters using a full break down description for weight and cost analysis. The use of automated manufacturing processes was also considered for each configuration.

Two demonstrator door linkages and door rods were manufactured.

A significant engineering effort was expended by both companies during the technologies selection phase.

Manufacture tools were constructed using state of the art engineering methods to achieve the project objective, development steps like using aerospace approved materials and processes and an option for automation technology and optimization were aids to the manufacturing technology.

The mean value of the composite door rod weight without rod ends is 624,5 g which results in a weight saving of 52 % compared to the aluminium door rod.

Door linkage weight of the as-manufactured item including bushings was 1600 g resulting in a weight saving of 31.7 % compared to the aluminium door linkage, fulfilling the NSLGP targets.

Beside the weight saving minimising the cost of serial production was achieved in line with the NSLGP objective.