PROJECT:	3D HONEYCOMB FOR CURVED STRUCTURE MANUFACTURING				
ESA Contract N°:	**C4000122500**	EC Reference:	**0000006334**		
Doc. N°:	**0000006334_Executive Summary_1.0**	Date:	**16/05/2022**	Page:	**1** of **7**
Title:	**EXECUTIVE SUMMARY**				

Martin Pütz Digital unterschrieben von Martin Pütz Datum: 2022.10.26 10:53:30 +02'00'

DOCUMENT CHANGE RECORD

DATE dd-mm-yyyy	ISSUE	RESPONSIBLE	EFFECTED CHANGES AND REASONS	STATUS
12/05/2022	0.1	Marco Wittlich	Initial Creation	Draft
16/05/2022	1.0	Marco Wittlich	Issued Version	Issue

TABLE OF CONTENTS

ACRONYMS

EC	EURO-COMPOSITES ®
ECG	EURO-COMPOSITES Glass honeycomb
ECM	EURO-COMPOSITES Aluminium honeycomb
H/C	Honeycomb
VESPA	Vega Secondary Payload Adapter

1 Background and Purpose

The objective of this activity is to demonstrate the added technological and manufacturing values using 3D honeycomb for curved composite structures. The suitability of 3D honeycomb core technology shall be reviewed for space applications and shall demonstrate the manufacturing process with tests on samples, breadboards and a subscale demonstrator

The benefit of using 3D honeycombs for space double curved structures is the ease of manufacturing as less/no splicing or milling process is needed, which leads furthermore to a lower risk, better surface quality and easier lay-up process.

2 Case study 1

In the first case study an antenna reflector using the glass fibre honeycomb ECG-3D 5.0-64 and carbon prepreg face skins was produced. The design of the case study part was performed with input from the space industry.

In general, the honeycomb sheet could be formed successfully leading to a good cell opening and orientation. However, initially a 20 mm thick 3D honeycomb ECG-3D 5.0-64 should be used but the 20 mm thickness led to damages due to high material rigidity. Therefore, two 10 mm thick honeycomb sheets were used and bond together with an extra adhesive film.

The final part quality was satisfactory meeting dimensional stability requirement and surface quality. Despite further improvements are needed, the use of 3D honeycomb in this case study demonstrates the main advantage with respect to gain in manufacturing time and decrease complexity compared to conventional honeycomb.

3 Case study 2

For Case study 2 a VESPA structure using a ECM-P-3D 3.0-70 honeycomb and carbon fibre prepregs was manufactured. This VESPA structure was built in a 1:1 scale with a simplified manufacturing process and materials. The diameter of the structure is 2100 mm. The 3D honeycomb sheets have been used in the six segments of the middle section, which has a double curvature. The lay-up was done by hand and the honeycomb could be draped successfully on the lay-up tool.

The VESPA structure was successfully manufactured as per design with only one honeycomb sheet over the transition area of the structure. The lay-up of the 3D-aluminium honeycomb was successfully demonstrated for application with double curvature. Furthermore, a labor time reduction of around 40% could be achieved using a 3D honeycomb as middle segment instead of three separate cores.

4 Demonstrator

For a demonstrator a full-size antenna reflector was successfully manufactured using carbon fibres prepregs and one 20 mm thick ECM-P-3D 5.0-34 5056 PAA-CP honeycomb sheet. To bond the honeycomb to the carbon skin, an epoxy film adhesive was used. The 3D honeycomb has a cell size of 5 mm with a density of 34 kg/m^3. The lower density honeycomb was chosen, as it is more in line with classical honeycomb used for flight part manufacturing.

The carbon fibre prepreg lay-up was done manually and the curing performed in autoclave with a dedicated optimized cycle. A dedicated semi spherical mould was used as tooling to form the antenna reflector.

After the manufacturing a surface accuracy measurement, a modal test and a thermal elastic distortion test (TED) were conducted on the demonstrator.

Surface accuracy measurement
The surface accuracy measurement was conducted by HPS with a laser scanner with a grid about 600 measurement points. The mould and the manufactured antenna reflector were measured and compared to their CAD model.

The accuracy measurement of the mould (lay-up tool) shows overall compliant values. The comparison of the antenna reflector and the mould shows that the deviations of the antenna reflector are not caused by the mould.

Further investigations showed that the honeycomb direction is not align with the angle of deviations of the surface accuracy. The fibre angle on the other hand aligns well with the areas of surface accuracy deviations. As the prepregs were laid in one piece, which needed some force, the deviations may therefore occur due to tensions in the prepreg caused by the lay-up.

Modal test
The modal test (Impact hammer test) was conducted by HPS. The excitation point and predictions were determined by EC. The measured modes of the structure showed good agreement with the predictions provided by EC.

Thermal distortion test
The thermal distortion tests were conducted by Airbus D&S in Toulouse, France.
The measurement took place at following temperatures: 20°C, +100°C, -50°C.

With the differences of the measurements are the displacements determined. The displacement measurement shows different movement directions of the antenna reflector edges. By +100°C/20°C and -50°C/20°C are the movements contrary

The areas of displacement of the TED test are the same as the areas of the surface accuracy deviations. Especially the areas of larger deviations/movements are fitting well. In addition, the outwards deviations/movements are the same areas.

Conclusion
Besides the surface accuracy deviations, most likely due to introduced tensions, was the manufacturing of the demonstrator successful. The demonstrator shows that the aluminium honeycomb ECM-P-3D 5.0-34 5056 PAA-CP is suitable for a full-scale antenna reflector manufacturing.

5 Conclusion

Different 3D honeycomb cores have been tested and manufactured. The formability of three special honeycomb types was investigated in more detail and the application to actual flight parts was demonstrated.

- It was shown, that the cell geometry, developed by EC allows forming of honeycombs to 3D shapes.
- The forming of the honeycomb is mainly limited and influenced by different factors as: material, curvature radius 2D/3D, thickness, density, cell size.
- EC can offer different kinds of 3D honeycombs and is able to transfer the experience from this project to other 3D cores, if future applications require these.

In general, it can be summarized that the usage of a 3D honeycomb due to better formability enables the user to build parts with double curvatures and smaller bending radii, which are not feasible with hexagonal honeycombs, or need much higher effort to be used. The additional advantages are less splicing lines and/or no additional milling processes. Therefore, 3D honeycomb cores, have potential for labor time and cost reduction if the lower mechanical properties are acceptable.

Demonstrator antenna reflector