

Design and Manufacturing of a Multifunctional Highly Integrated Satellite Panel Structure

Authors:

Zhuzhell Montano Rejas, Ralf Keimer, Sebastian Geier, Michael Lange, Olaf Mierheim, Jan Petersen, Alexander Pototzky, Johannes Wolff

DLR Institute of Composite Structures and Adaptive Systems

ECSSMET 2021

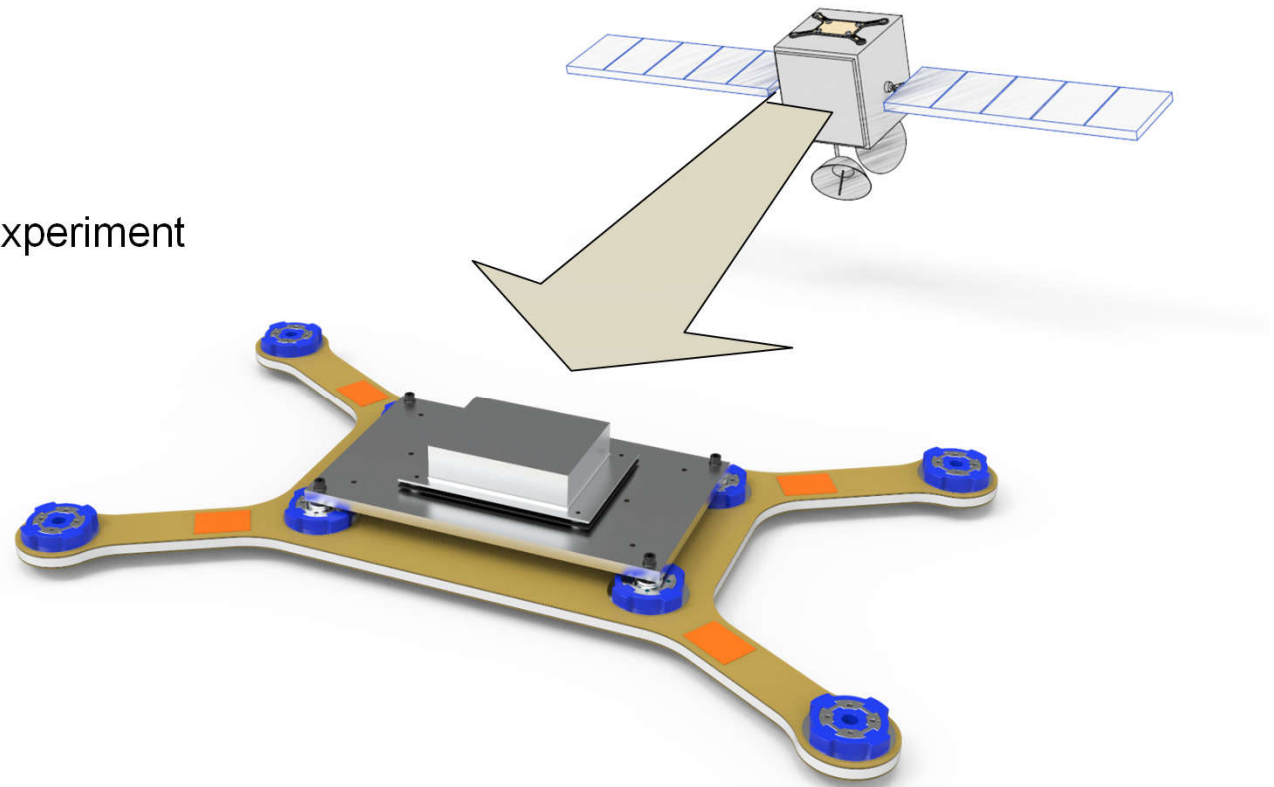
23.03.2021

A large, high-resolution image of the Earth from space occupies the right half of the slide. It shows a curved horizon with a blue atmosphere, white clouds, and green landmasses. The text "Knowledge for Tomorrow" is overlaid on the right side of the image in a white, sans-serif font.

Knowledge for Tomorrow

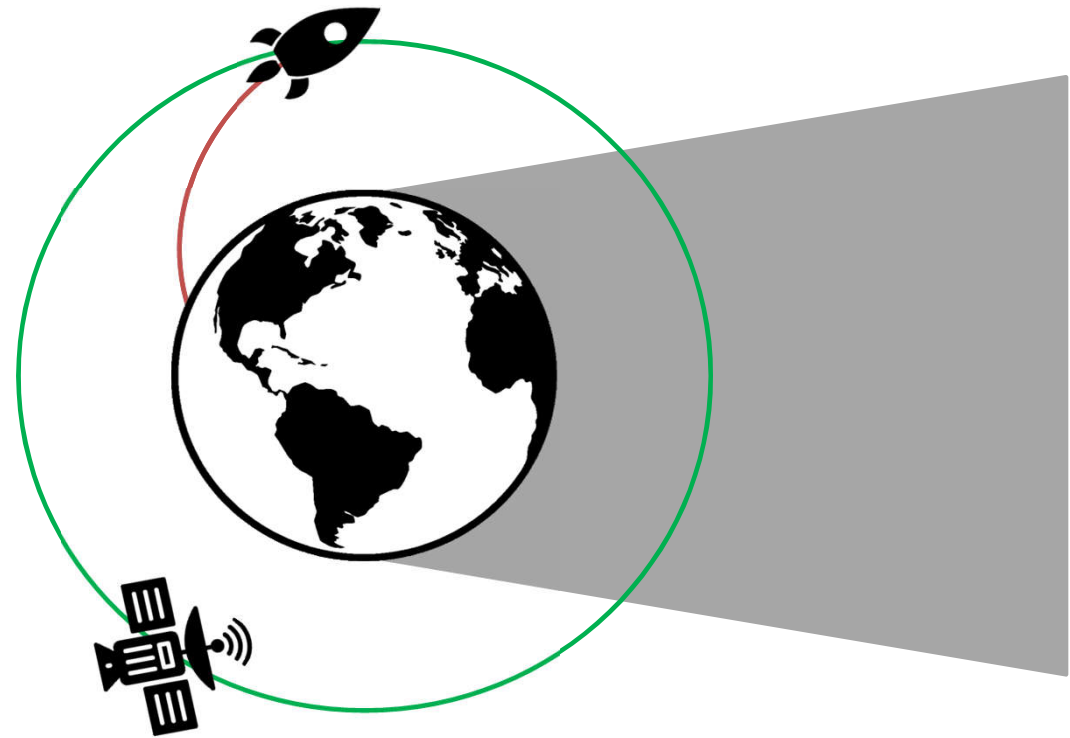
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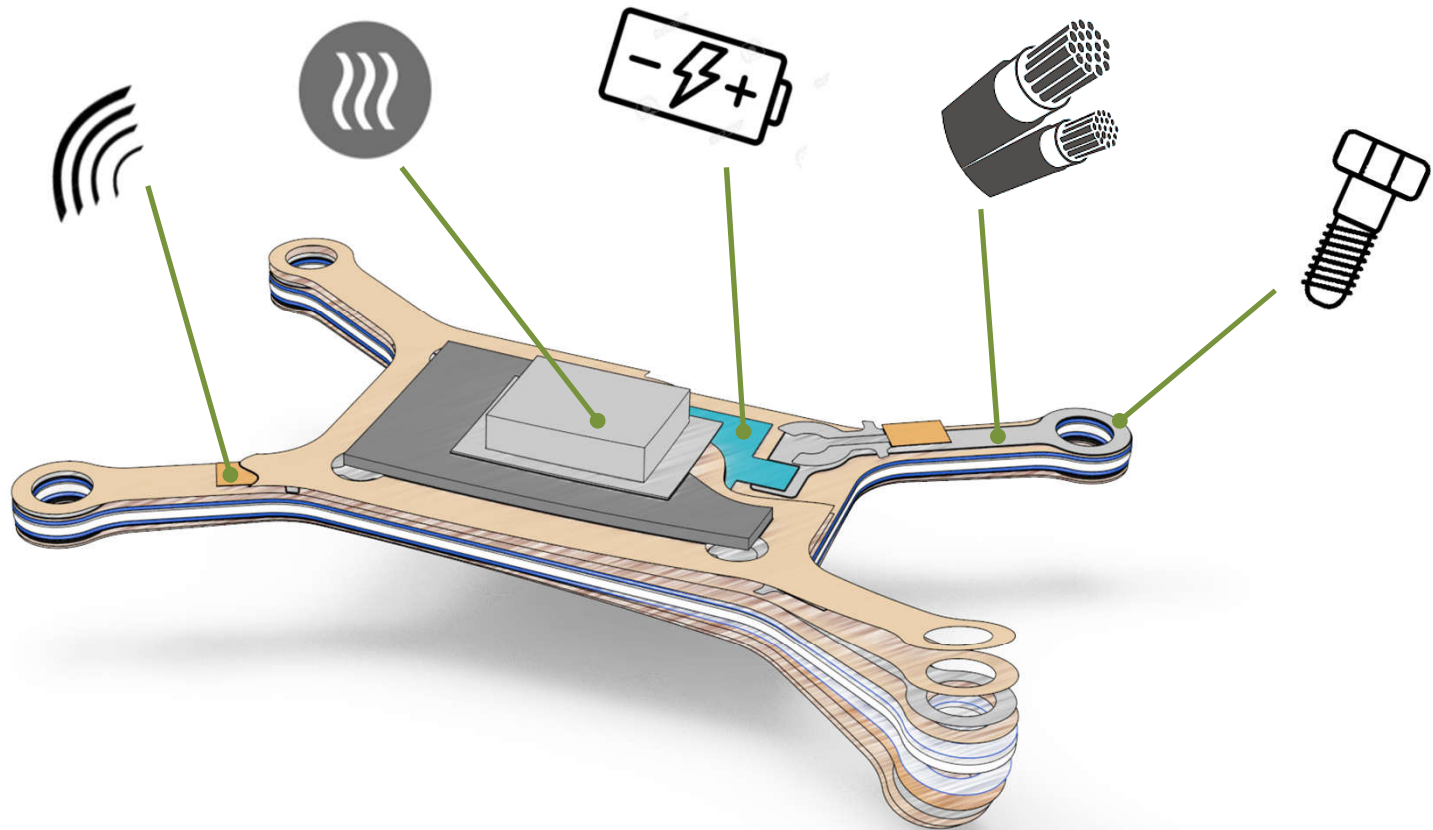
1. Introduction, Motivation & Overview

- Development and tests of a multifunctional, highly integrated Satellite Panel Structure (SPS)
- Motivation:
 - Reduce weight and volume
 - Save launch costs
 - Have more space for payload or experiments
 - Simplify assembly and add modularity
- Panel prototype: five integrated systems
- Operational Scenarios:
 - Launch
 - Orbit



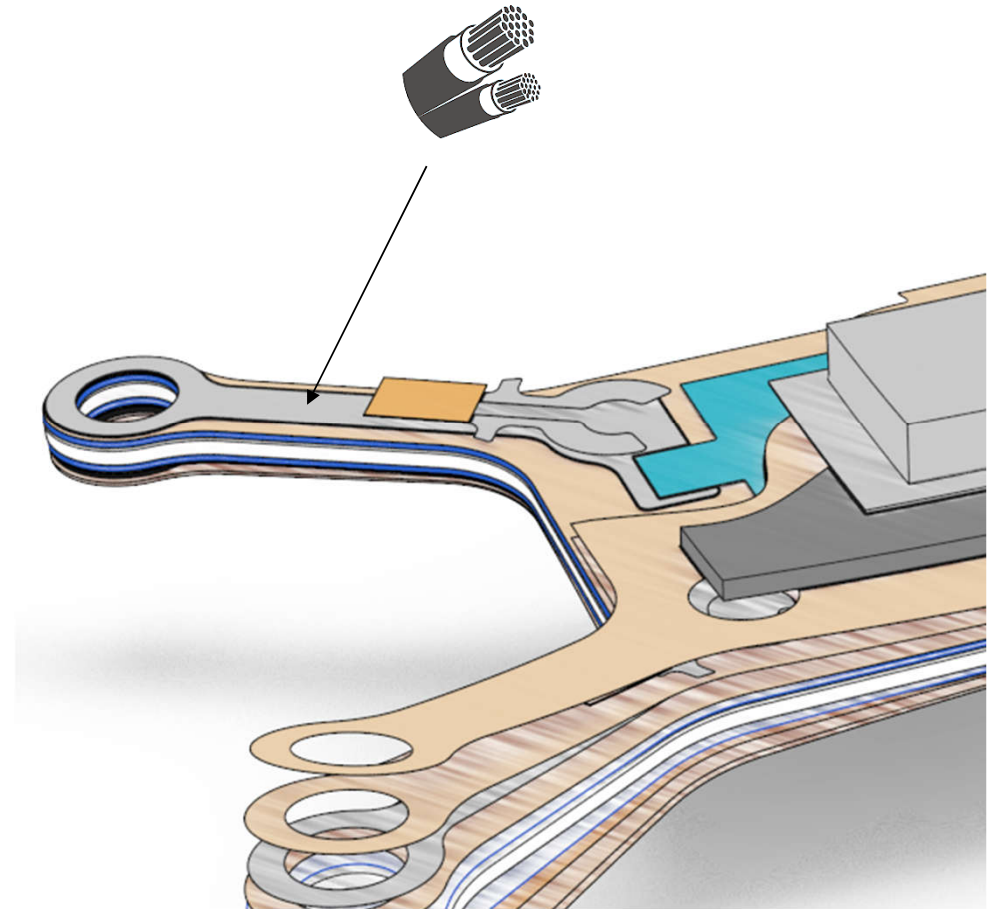
1. Introduction, Motivation & Overview

- Integrated Systems:
 - Integrated Circuits
 - Thermal Control System & Thermal Experiment
 - Multifunctional Inserts
 - Energy Storage System
 - Vibration Control System



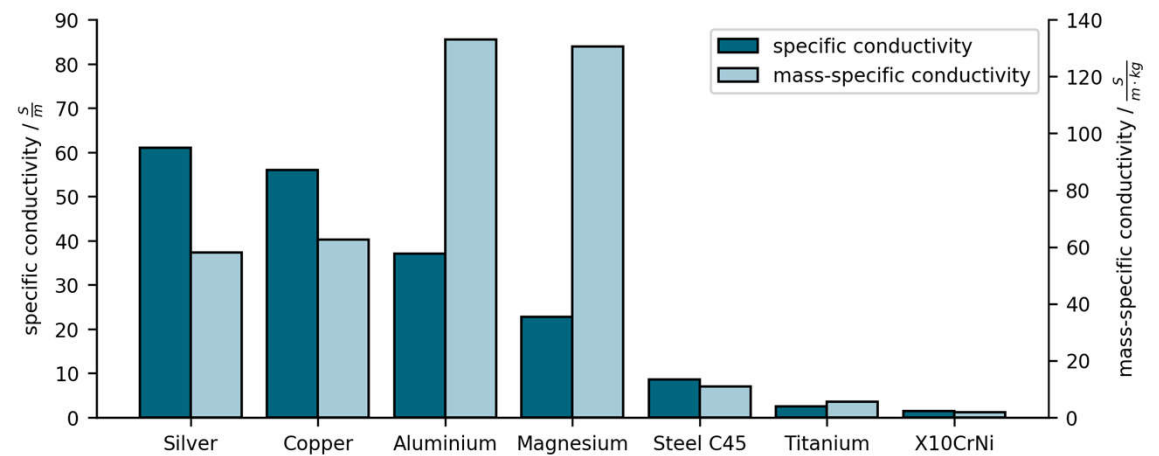
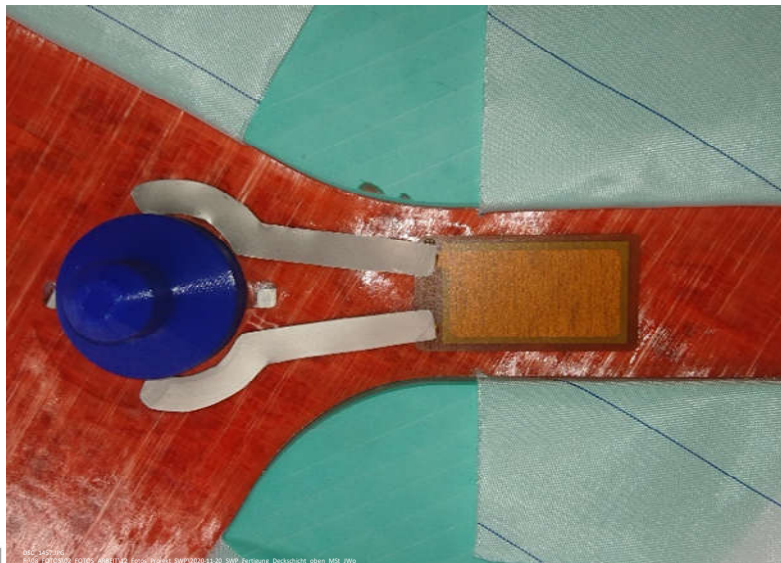
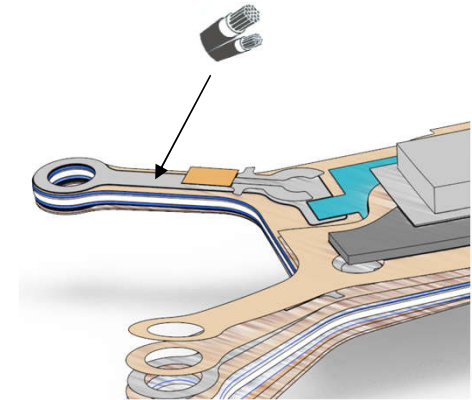
2. Integrated Systems

Integrated Circuits



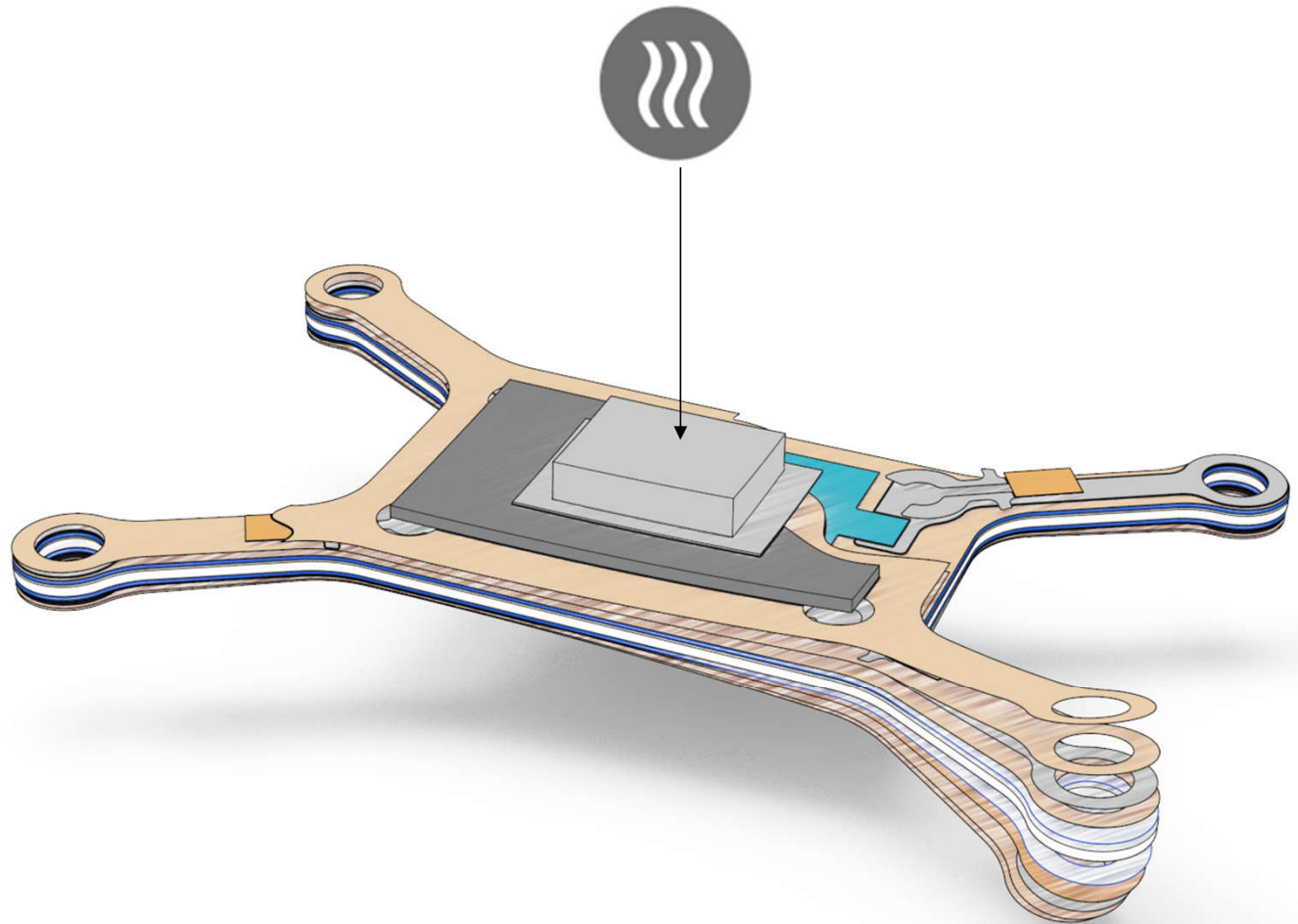
2. Integrated Systems: Integrated Circuits

- Wiring harness for power supply & data connection between components & satellite
- Fully integrated thin metal foils to avoid laminate undulations
- Current material choice: Steel (X10CrNi)



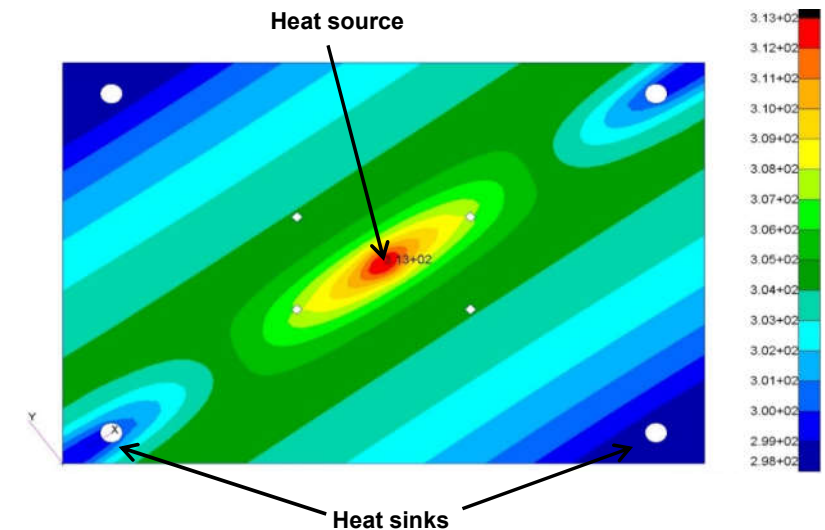
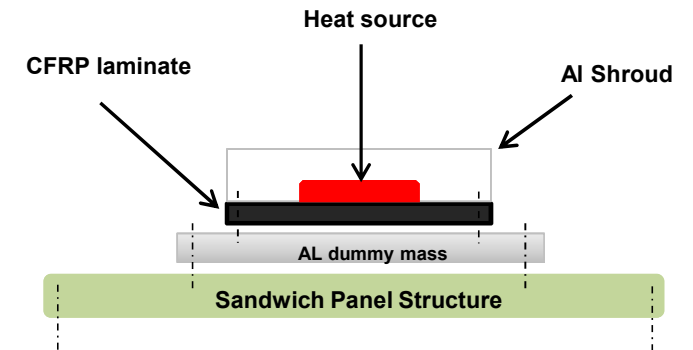
2. Integrated Systems

Thermal Control & Thermal Experiment



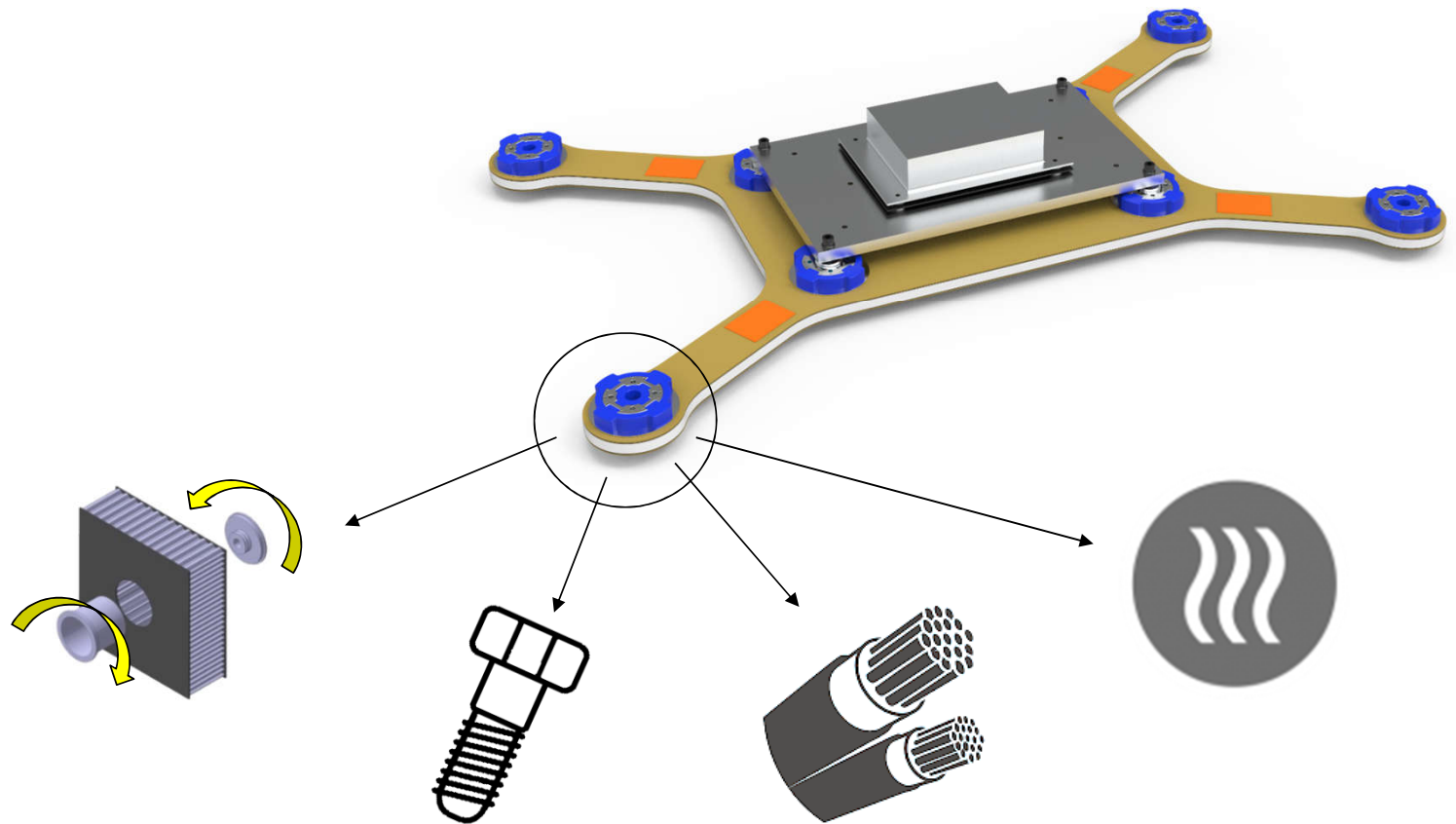
2. Integrated Systems: Thermal Control & Thermal Experiment

- Demonstration of thermal control functionality of CFRP structures
- Heat source: Micro controller & amplifiers of vibration control system
- At a panel level: heat transfer through structure and inserts, which allow a dedicated heat transfer between facesheets
- Test scenario:
 1. Pre-Test with a heating foil as heat source and an IR camera
 2. Determination of the temperature with the help of a sensor network in a thermal vacuum chamber
 3. General test with controller circuit board as heat source and experiment mounted as payload



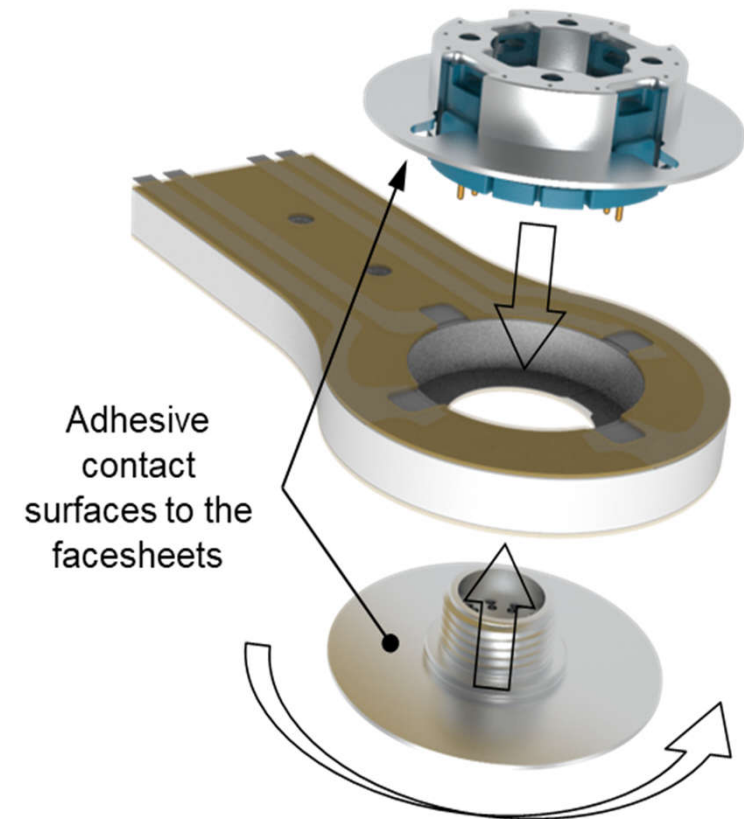
2. Integrated Systems

Multifunctional Inserts



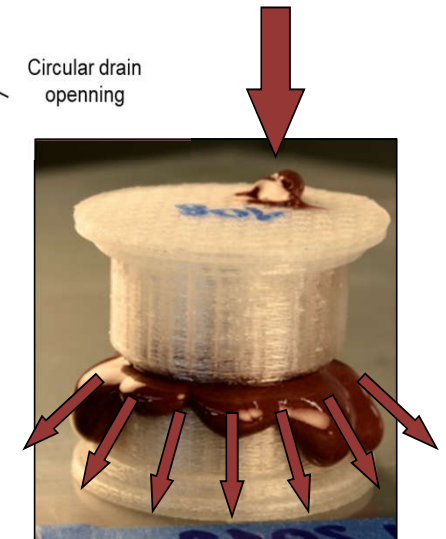
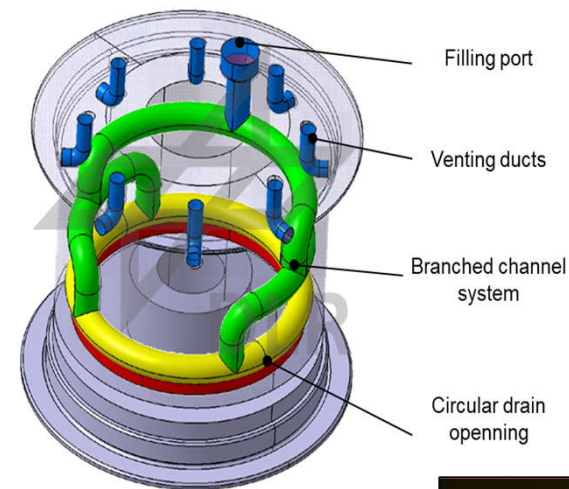
2. Integrated Systems: Multifunctional Inserts

- Insert elements with integration of multiple functions:
 1. Fast & reliable installation and bonding process:
 - Insertion and bolting of already pre-assembled components
 - Uniform potting feed by internal distribution channels
 2. Lightweight load transfer due to minimized insert diameter
 3. Electrical conductivity
 4. Defined heat transfer



2. Integrated Systems: Multifunctional Inserts

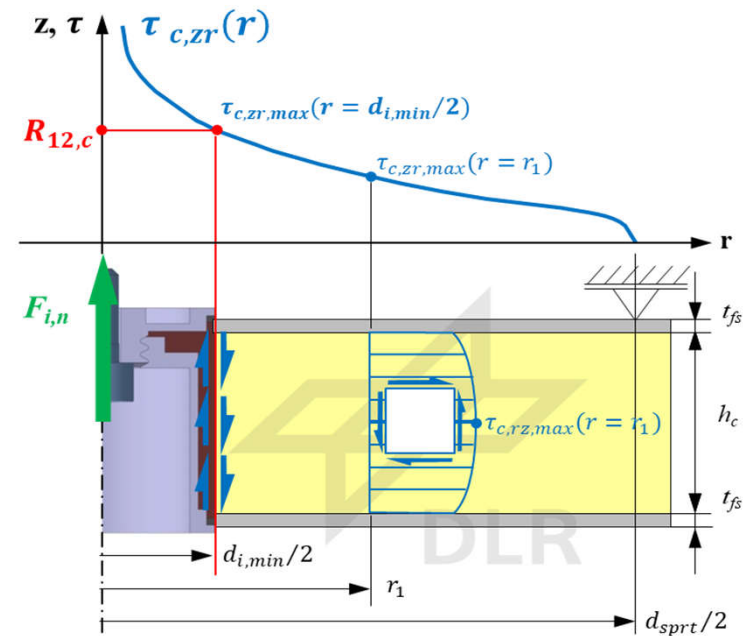
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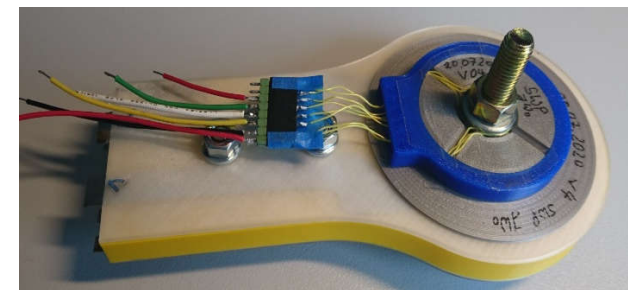
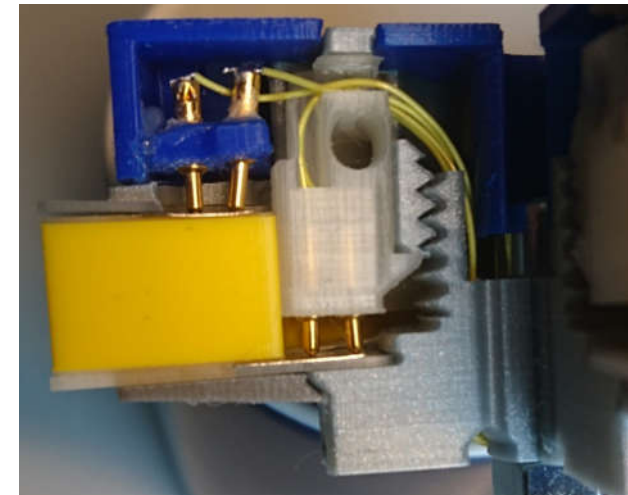
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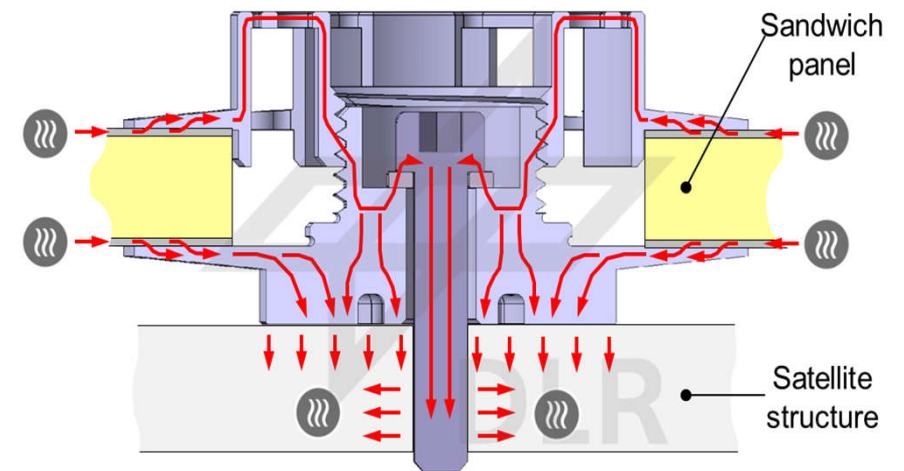
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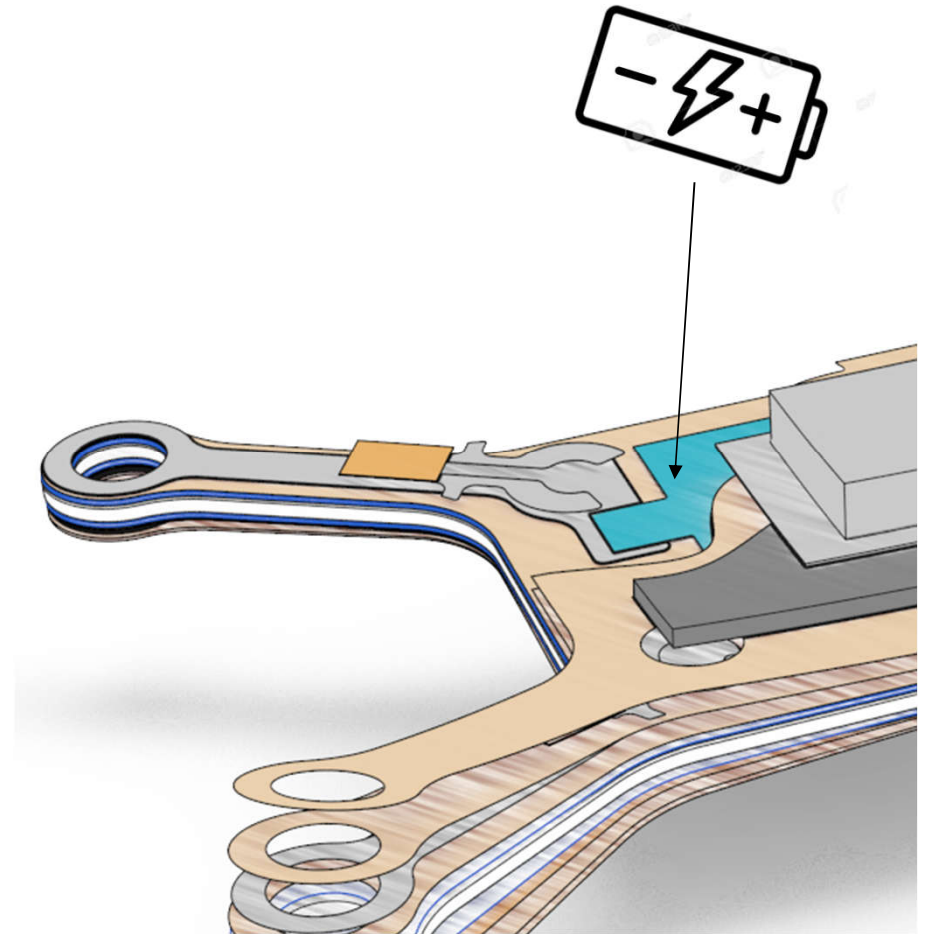
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2. Integrated Systems

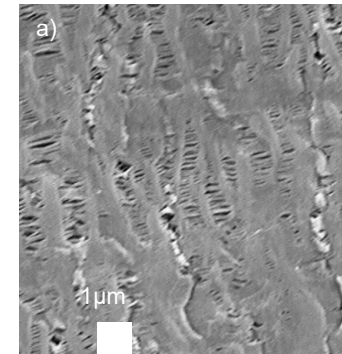
Energy Storage System



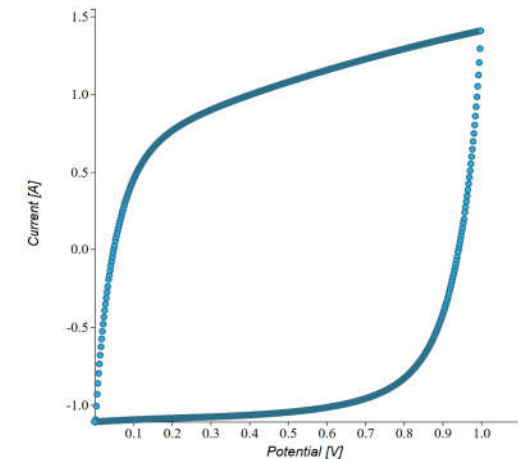
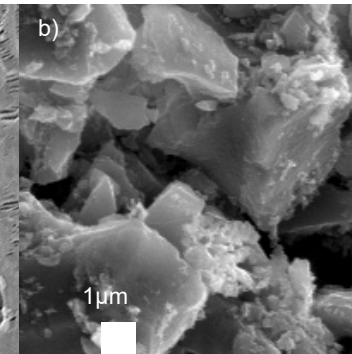
2. Integrated Systems: Energy Storage System

- Two integrated thin film supercapacitors (ITFC)
 - Reversible storage mechanism of electrostatic indicated ion diffusion → maintenance free
 - Ideal for integration in structural components
- Materials:
 - Two 24 μm thick aluminum collectors which are coated with 116 μm of activated carbon
 - An electrode area of 593 cm^2
 - Approach reaches 90% of the mechanical properties of the neat composite
- Electrolyte can be treated up to 3 V without showing any irreversible electrochemical reactions

Activated carbon electrode



Separator micro structure

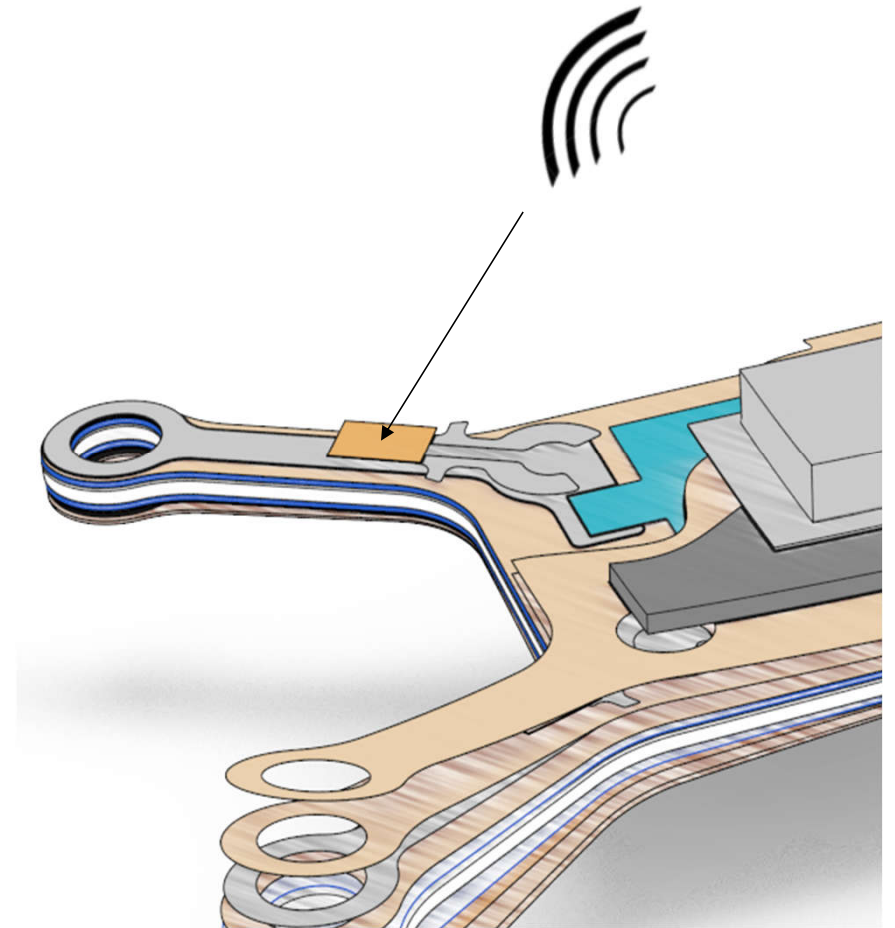


Cyclic voltammetric analysis of the electrophysical properties of the ITFC at 20mV/s



2. Integrated Systems

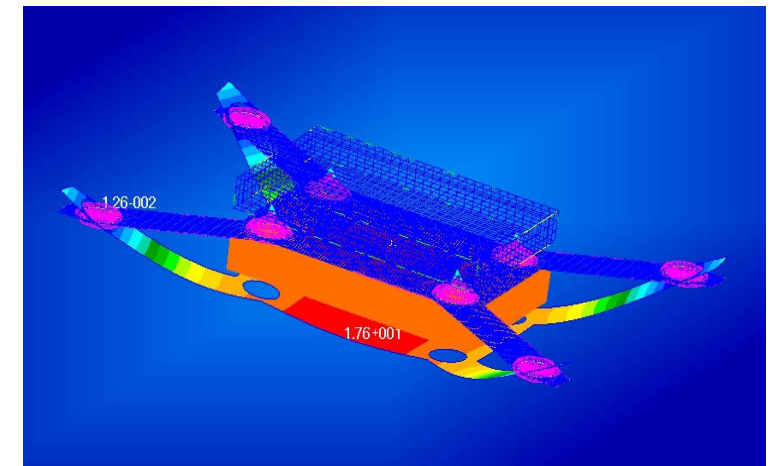
Vibration Control System



2. Integrated Systems: Vibration Control System

- Components integrated in the panel and as a part of the test payload :

| | |
|--------------|---------------|
| Actuators | Accelerometer |
| Controller | Filter |
| Power-supply | Cabling |
- Integrated circuits and inserts:
 - Provide power from energy storage system
 - Send control signal from circuit board (payload) to actuators
- System designed to act on the first eigenmode of the panel, a fundamental bending mode

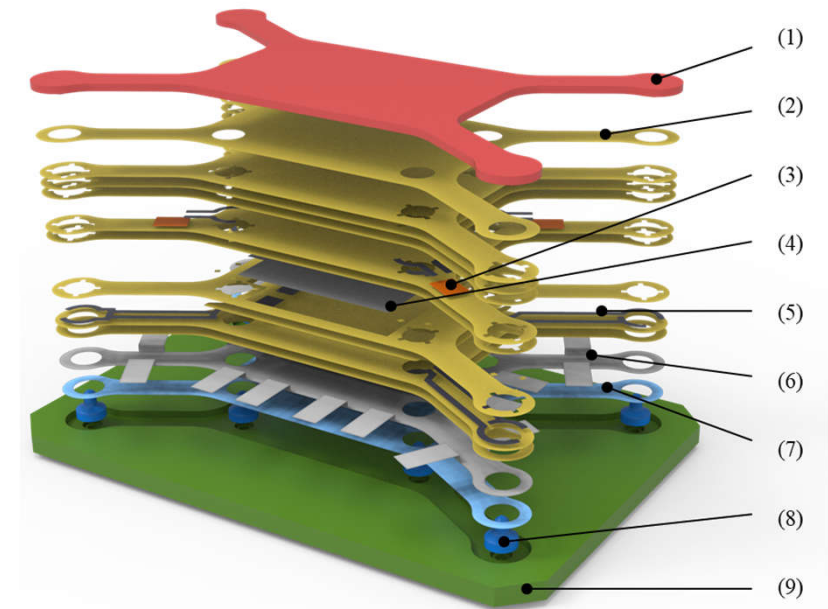


First Eigenmode, with colors indicating displacements



3. Prototype Manufacturing

- Sandwich Structure: Composite top & bottom facesheets & a foam core
 - All Systems are integral parts of the facesheets
 - Inserts also pass through core
- Special measures for manufacturing:
 - Very accurate positioning necessary
 - Near net shape manufacturing
 - Low curing temperature GFRP prepreg system
 - Protection of contacting surfaces



| No. | Designation of components |
|-----|---------------------------------|
| (1) | Silicon pressure cap |
| (2) | GFR-Prepreg-Layer |
| (3) | Piezo actuator element |
| (4) | Supercapacitor |
| (5) | Steel conductor, wiring harness |
| (6) | Peel ply |
| (7) | Release film |
| (8) | Positioning cone |
| (9) | Molding tool |



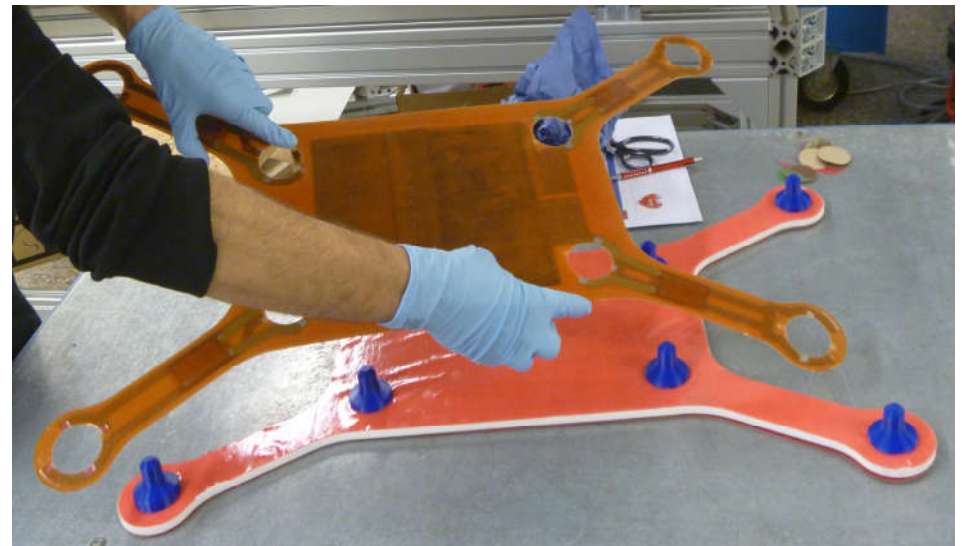
3. Prototype Manufacturing

- Facesheet Manufacturing



Vacuum build-up of a facesheet in the molding tool

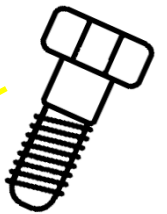
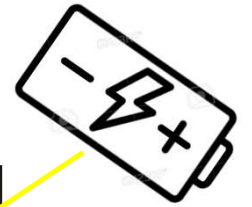
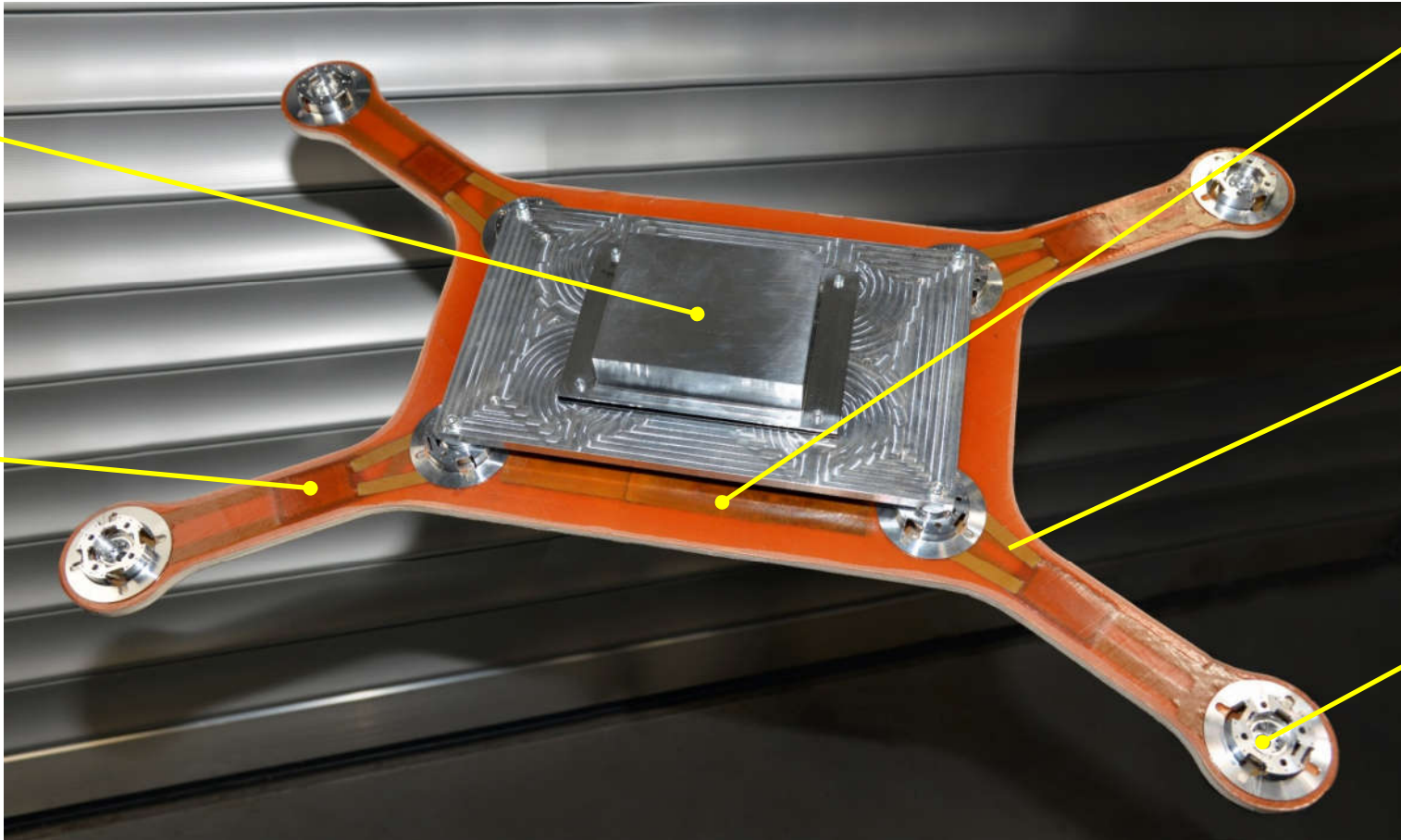
- Sandwich Panel Assembly



Attachment of top facesheet onto a glue film layer (red), foam core (white) and lower facesheet. Alignment with help of positioning cones (blue).



3. Prototype Manufacturing

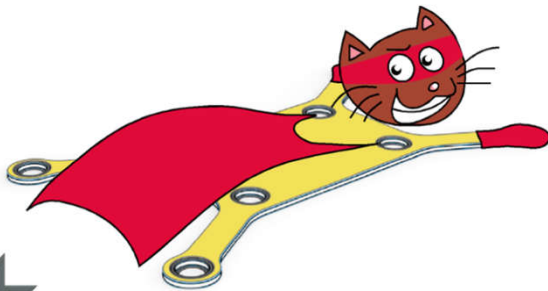
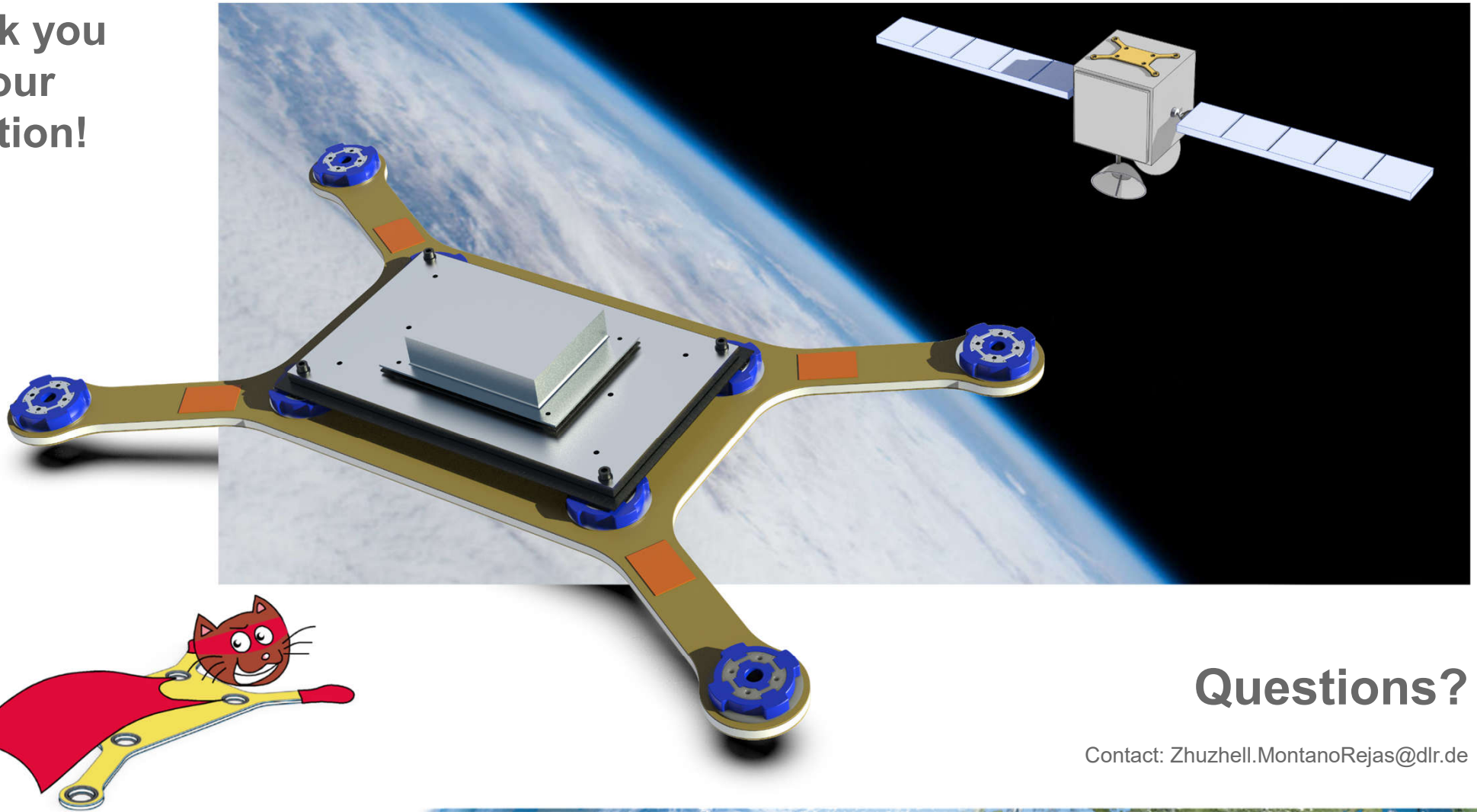


4. Next Steps, Conclusions & Outlook

- Current status:
 - First function tests have been performed for the subsystems
 - First structural tests have been performed
- Next steps:
 - Verification and validation of developed models
 - Model update and manufacturing of a second prototype
 - Function tests for the panel system
 - Thermal-vacuum chamber tests & shaker tests for space qualification
- Final goal:
 - Qualify and certify all the integrated subsystems
 - Qualify and certify the multifunctional sandwich panel for future implementation in **space applications**



Thank you
for your
attention!

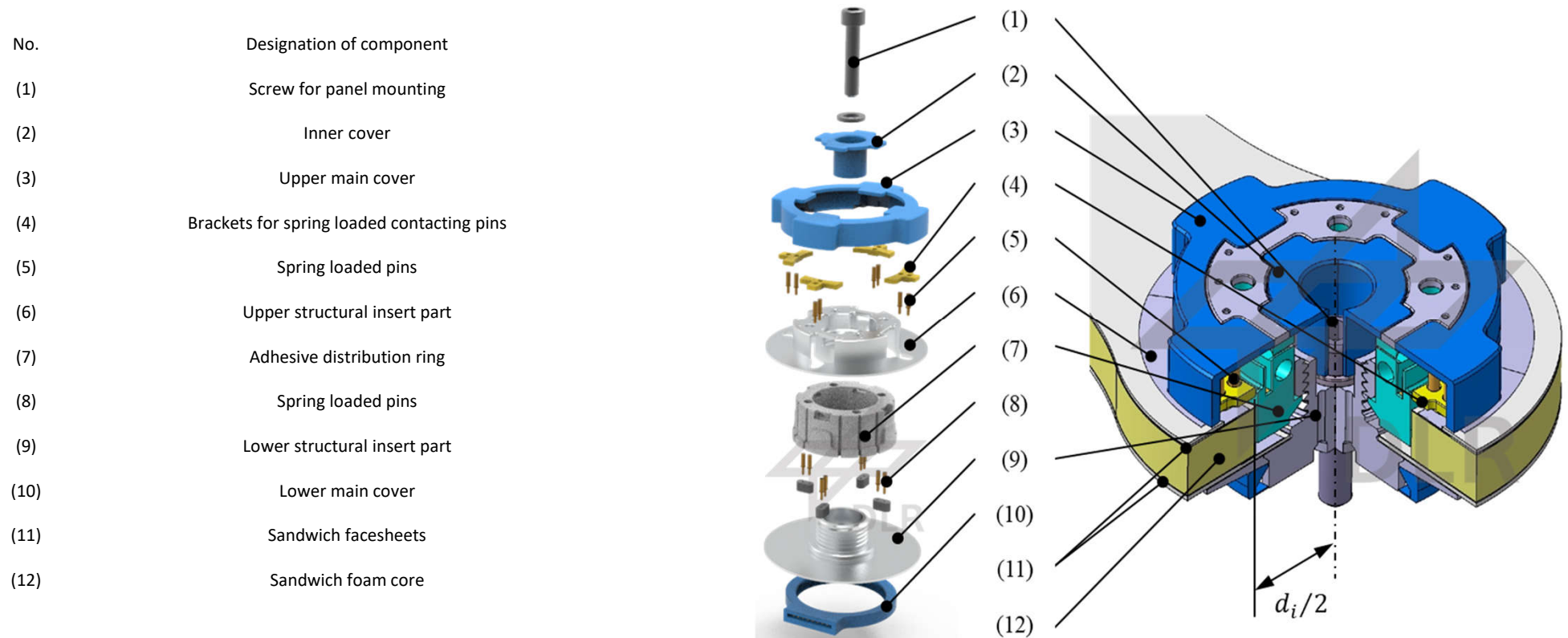


Questions?

Contact: Zhuzhell.MontanoRejas@dlr.de



2. Integrated Systems: Multifunctional Inserts



2. Integrated Systems: Vibration Control System

1. Four piezo amplifiers, providing up to 100 V to the piezoceramic actuators. These amplifiers can drive one pair of actuators in bending mode.
2. The filter and analog amplifier are used to filter the sample rate of the digital to analog converter and to adjust the voltage level to the input of the piezo amplifiers.
3. The voltage regulator is used to regulate the voltage coming from the energy storage system to a constant 5 V, needed by all other components.
4. The accelerometer is used to observe the vibration of the payload and thus the panel. It was placed on the circuit board as the board itself is mounted in the payload.
5. A microcontroller with analog to digital converter and digital to analog converter. This part is used to run the control-algorithm.

