MODULAR AND SCALABLE BOOM DEPLOYMENT MECHANISM FOR DEPLOYMENT AND RETRACTION OF UP TO FOUR CTMS

Marco Straubel, Martin Hillebrandt, Martin E. Zander

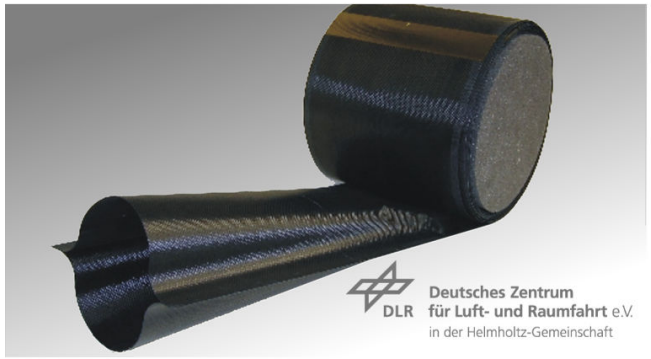
International Space Sailing Symposium, New York, USA, June 6th, 2023

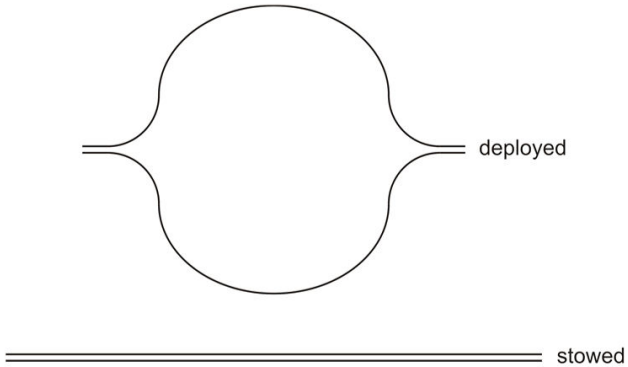
DLR

DLR's CFRP Booms

The Boom

Coilable Boom	Cross Section Change	Different Sizes

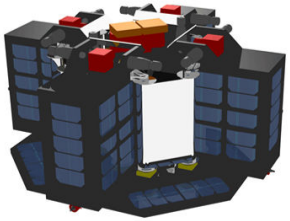




- DLR has been conducting research into roll-up masts made of CFRP for a good quarter of a century.

Past Applications

6x1.4m² SAR Antenna SM (2009)

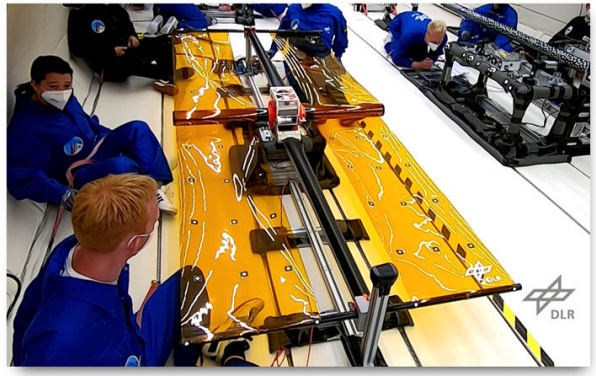


GOSSAMER-1 (2011)

4x4xm² Drag Sail booms out of 1U CubeSat Module (2014)

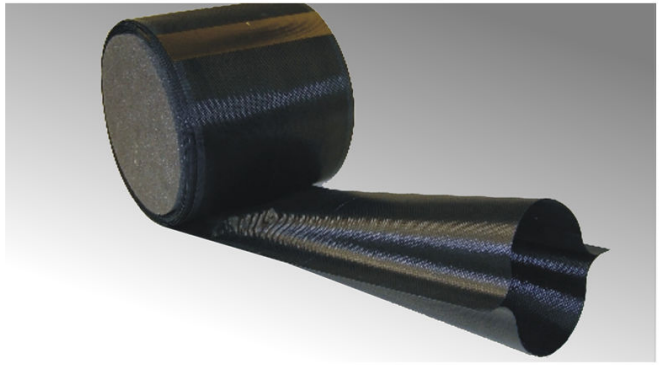
2m long camera mast deployed at DLR's parabolic flight campaign (2021)

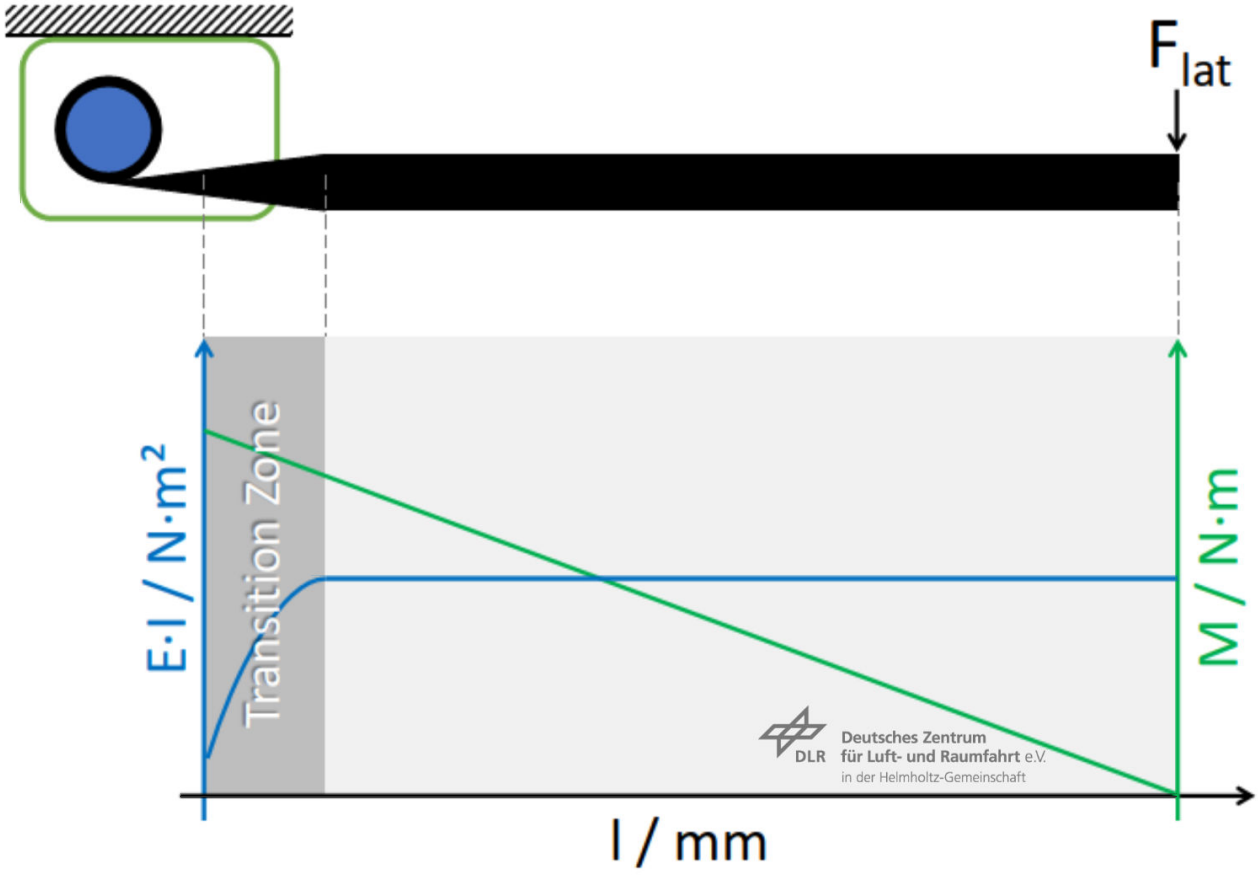
Deployable 23x23m² boom cross for cooperative NASA/DLR Solar Sail (2020)



4x1.5m² double-wing solar array deployed at DLR parabolic flight campaign (2021)

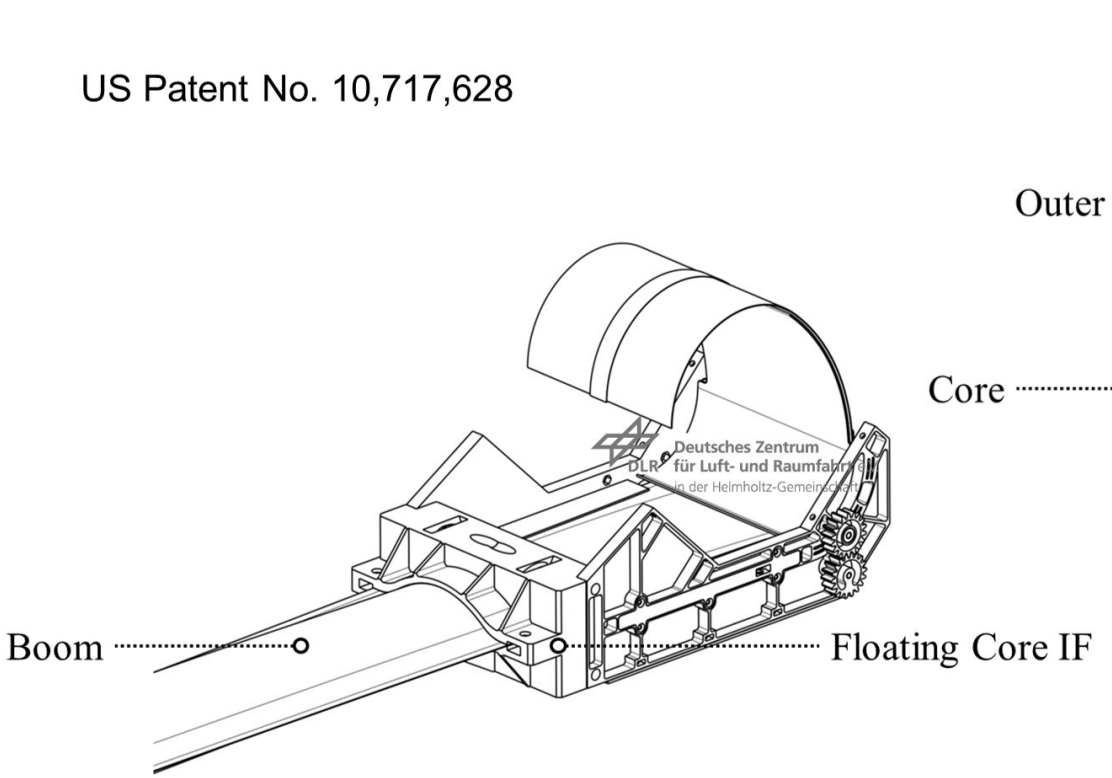
Boom to Mechanims Interface Stiffness

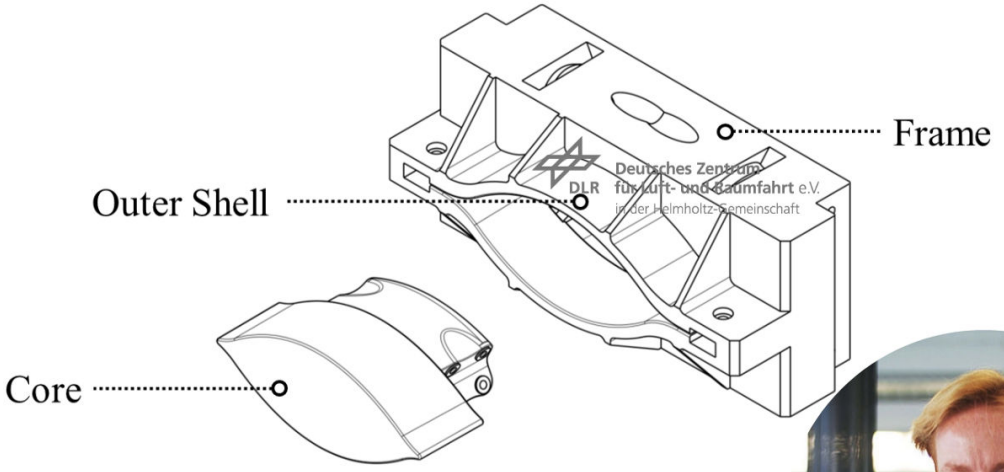




Floating Core Interface

US Patent No. 10,717,628

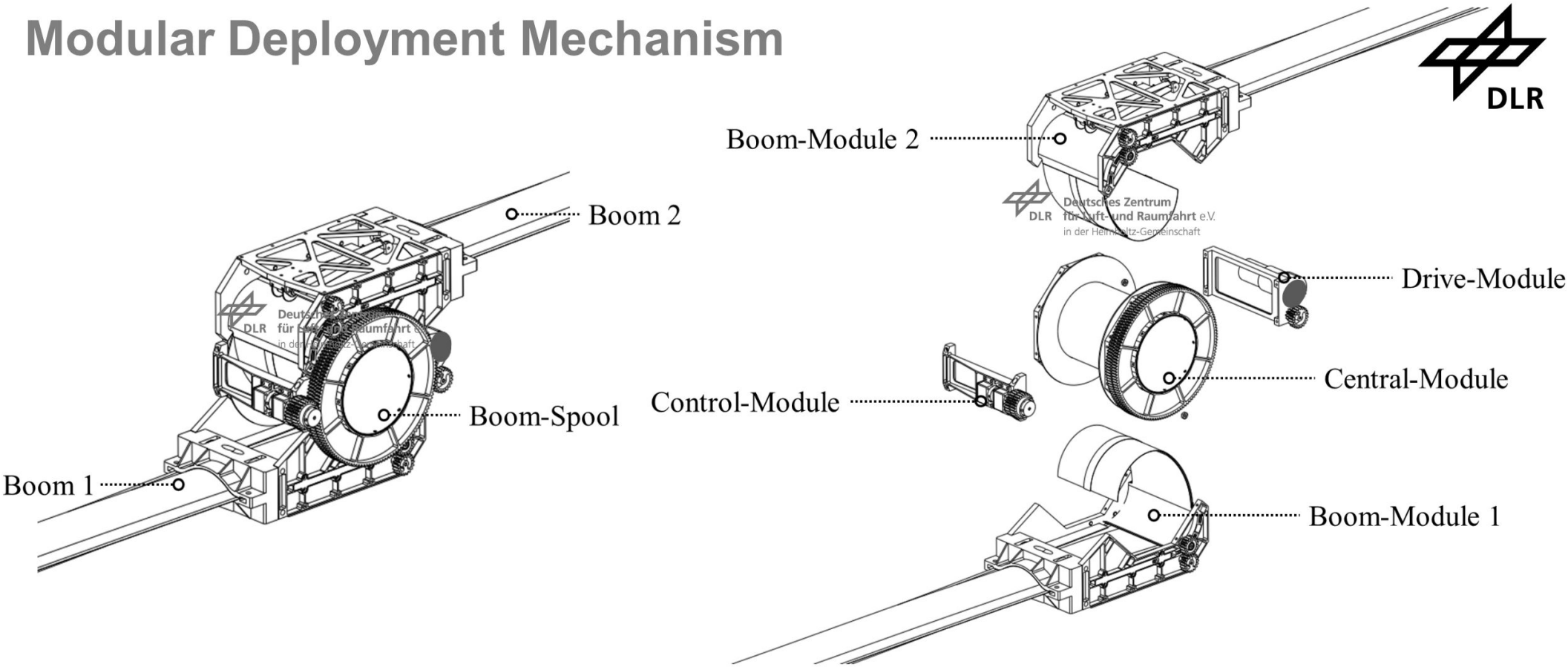




Dr. Martin Hillebrandt

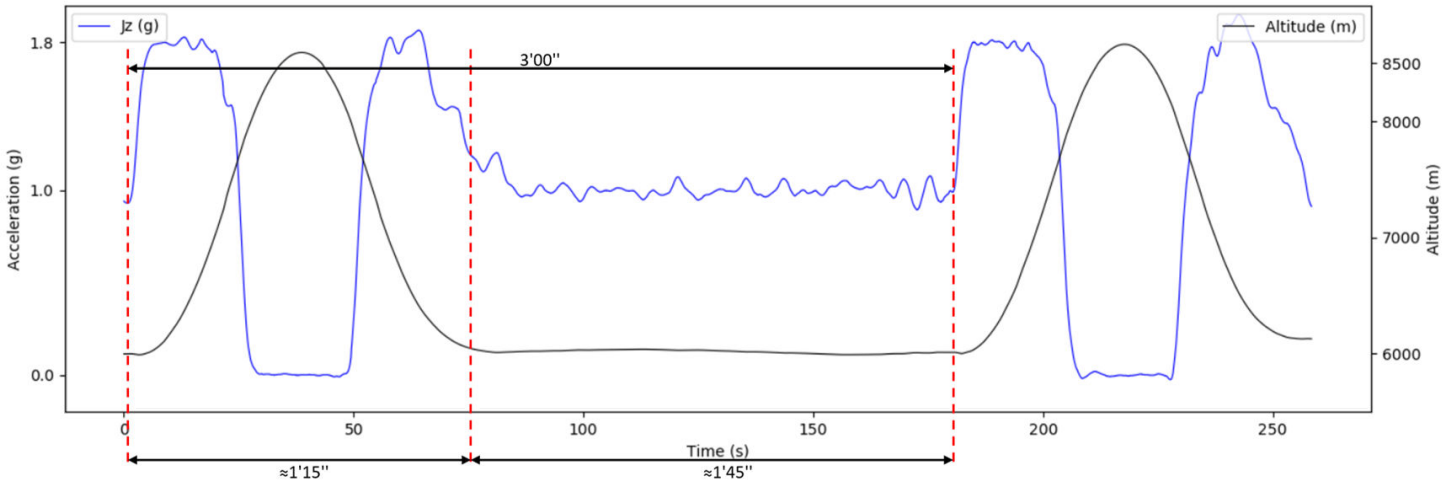
- Decisive for the structural performance is the patented “Floating Core Interface”
- Boom shell slides through small gap formed between an inside core and outside shell
- Improved shell support doubles bending strength

Modular Deployment Mechanism



- Modular mechanism design
- Deployment of one or two booms
- Hollow boom spool is part of the load carrying structure

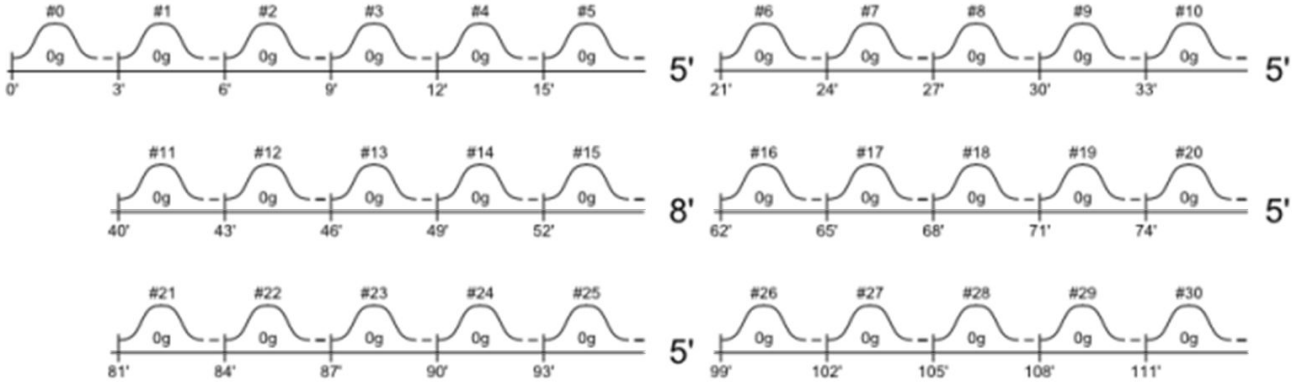
Zero-G Test Environment



Vertical acceleration and altitude over time

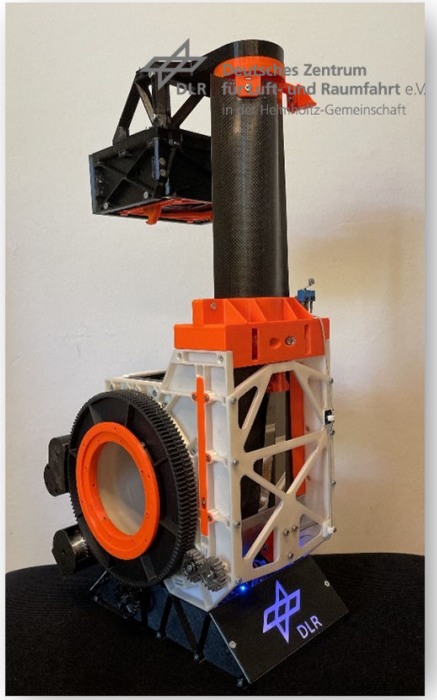
~~Zero-G~~ Micro-G Quality

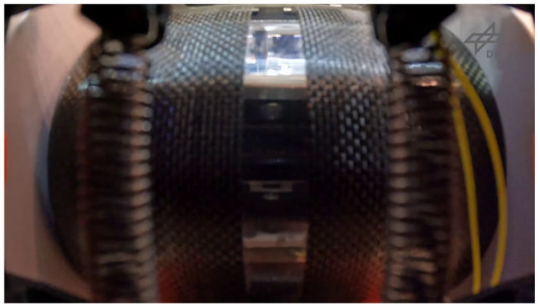
- vertical axis: $|a_z| < 0.02g$
- longitudinal axis: $|a_x| < 0.01g$
- lateral axis: $|a_y| < 0.01g$

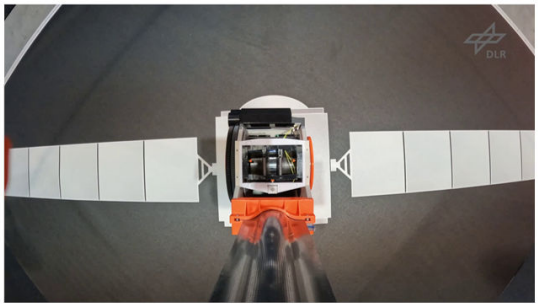


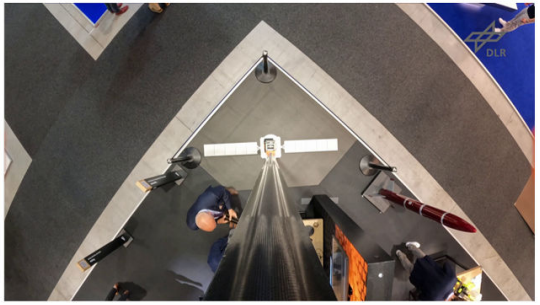
Flight day schedule

Show-Off at ILA and Space-Tech Expo in 2022

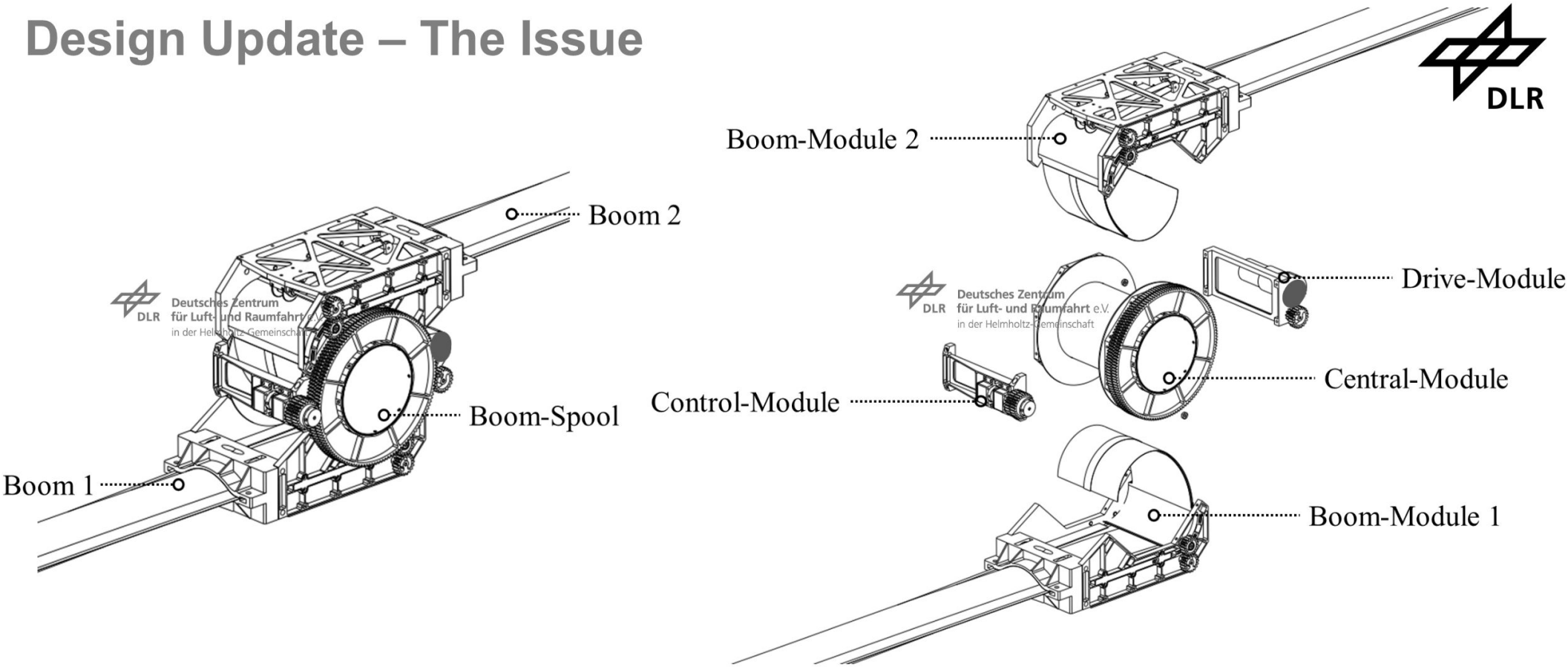






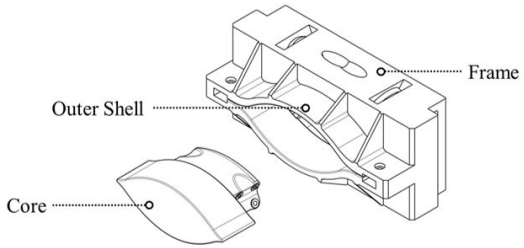


Design Update – The Issue

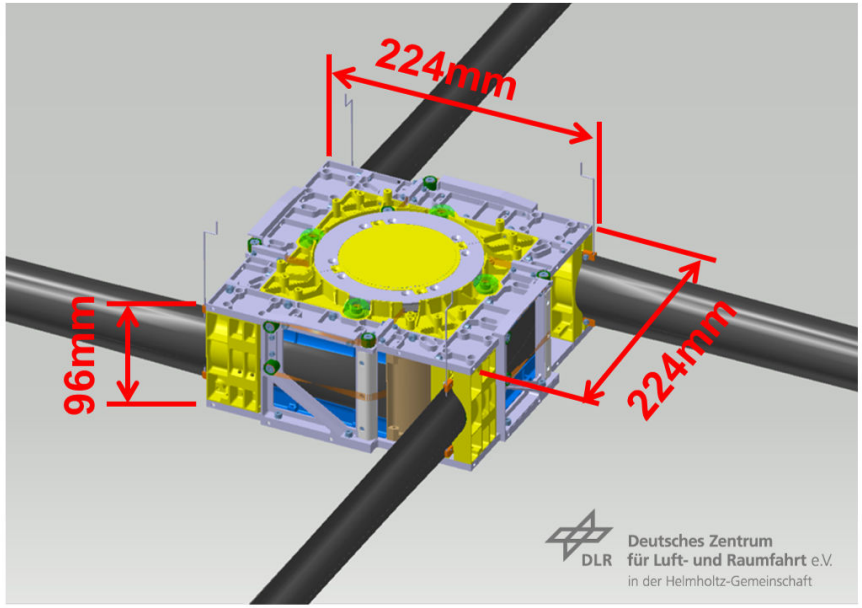


- Modular mechanism design only possible up to 2 booms
- Control- and Drive Modules preventing to add two more boom modules
- Braking devises induce vibrations and wears too much over time

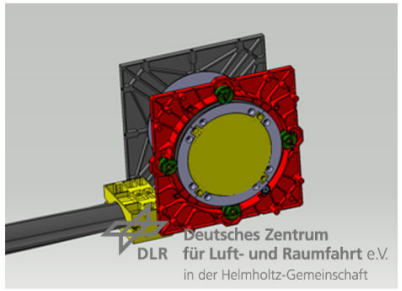
Design Evolution

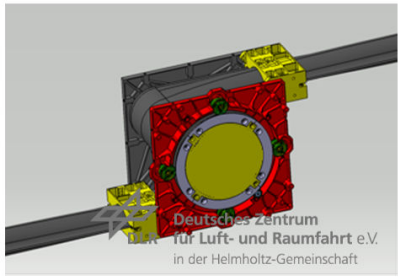


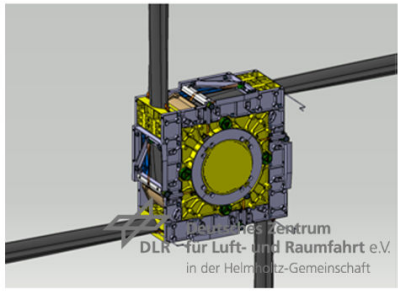
Still using Floating Core Concept



4-boom deployment unit fitting 2x2-Unit CubeSat standard

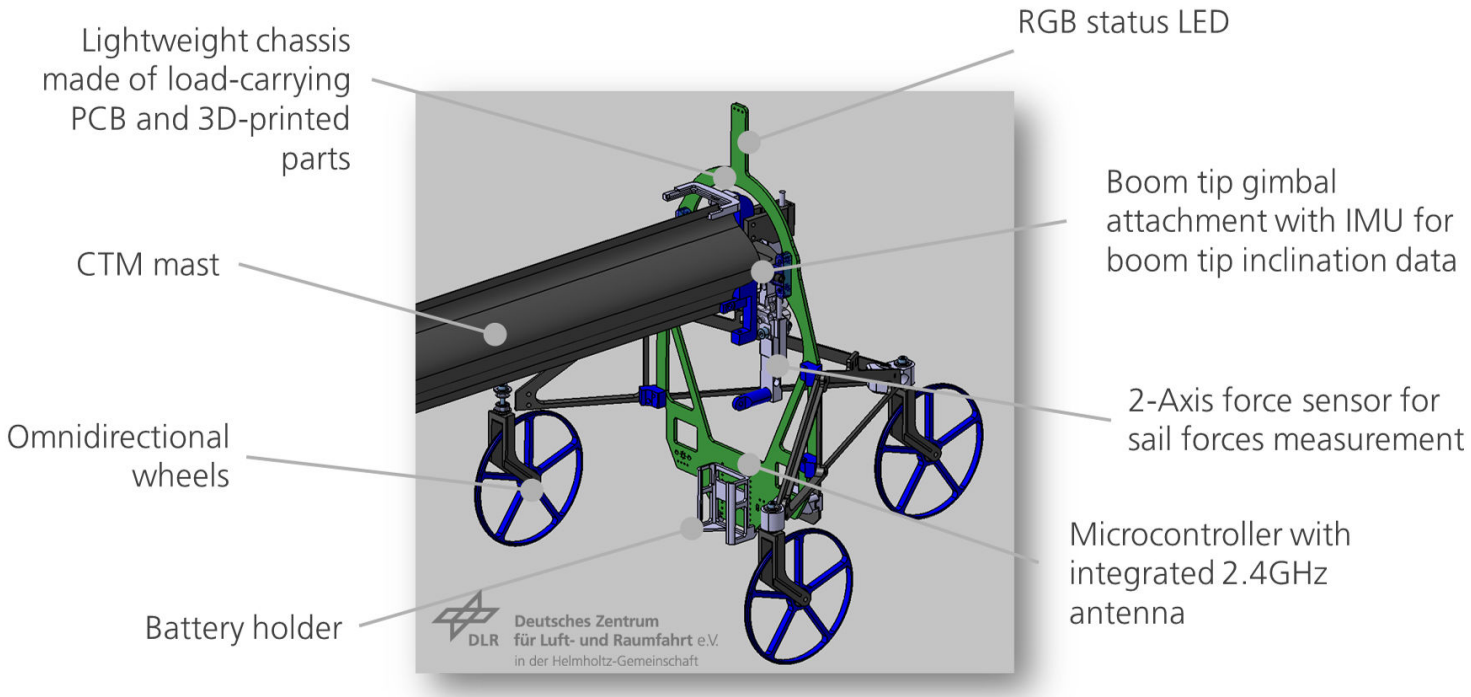






Side Development – Boom Tip Sensor Nodes

- Gravity offloading
- boom tip gimbal interface
- Measure
  - sail forces
  - Boom tip angles (heading, roll, yaw)
- Battery driven (3h up-time)
- Data transferred with 2.4GHz RF-link at 8Hz data rate

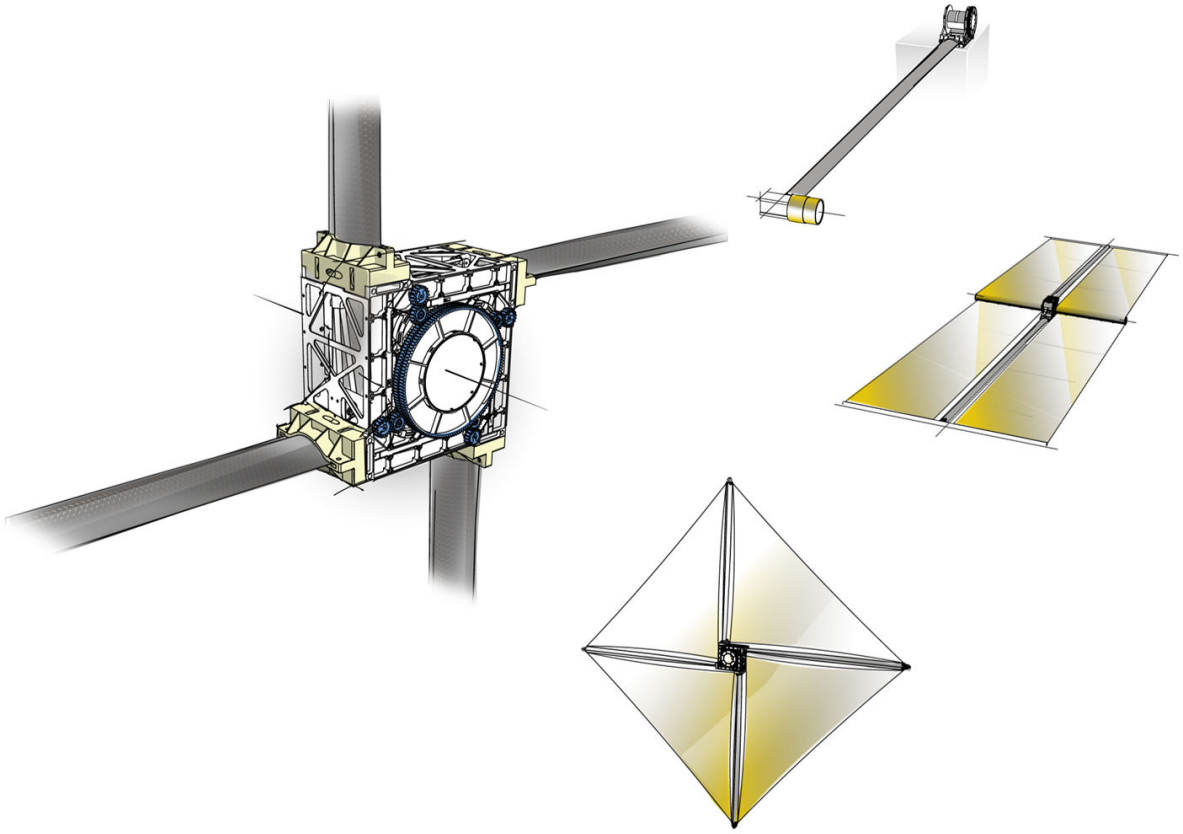


Conclusion

- Underlying concepts verified in µG
- Novel modular deployer suitable for 1, 2, 3 or 4 CTMs
- First tests look promising
  - Stable deployment and retraction

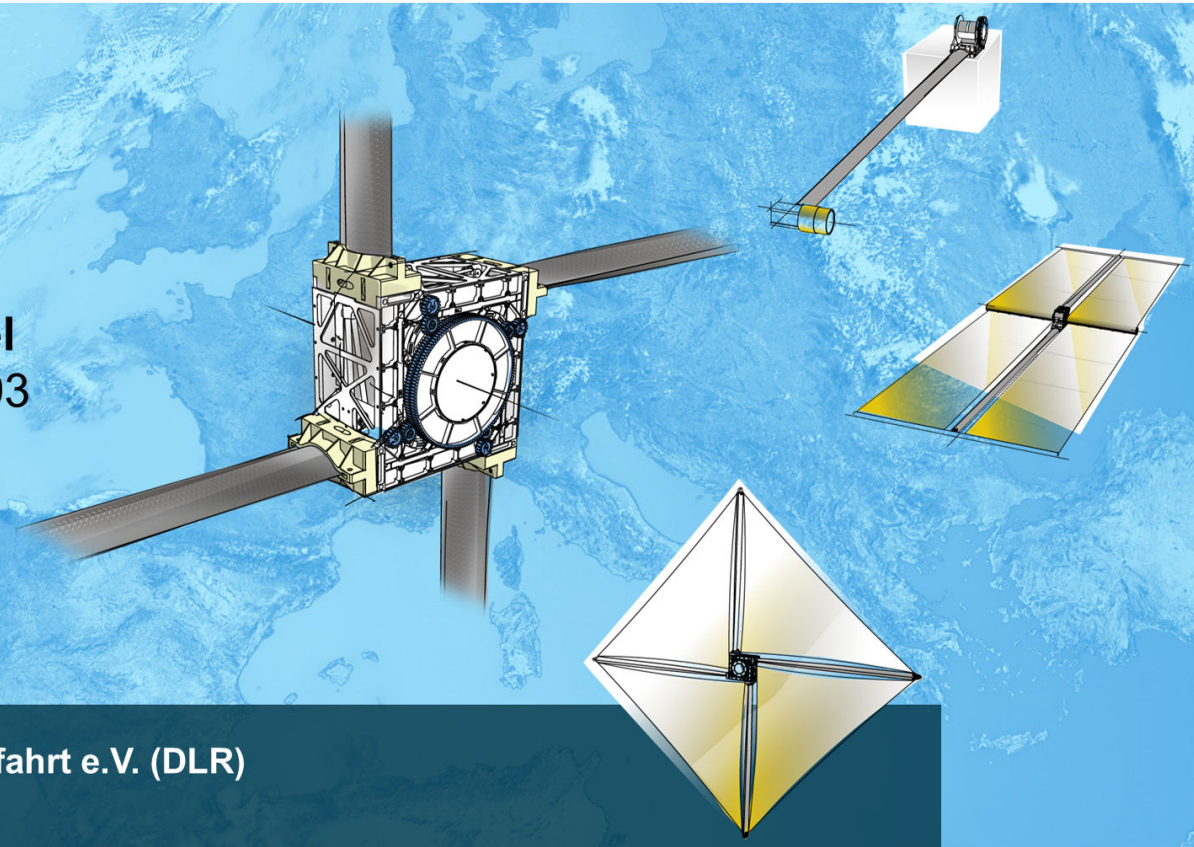
Outlook

- Sail Deployment Test at Gama-site planed for Aug 2023
- Qualification test (TVAC, shaker) foreseen for end of 2023
- Plans for different launches using this technology
  - 4-mast system for Gama
  - 1-mast systems as camera masts



Point of contact

Dr.-Ing. Marco Straubel
Phone +49 531 295-2393
marco.straubel@dlr.de
www.DLR.de/FA



Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
German Aerospace Center

DLR Institute of Lightweight Systems
Lilienthalplatz 7
38108 Braunschweig
GERMANY

DLR