2024

IAF MATERIALS AND STRUCTURES COMMITTEE

Introduction

The IAF Materials and Structures Committee was established more than three decades ago. The Materials and Structures Symposium, coordinated by the Committee, provides an international forum for discussing recent advancements and assessment of the latest technological achievements in space structures, structural dynamics, and materials, particularly in relation to space transportation, space vehicles, and orbital infrastructures. Currently, the IAF Materials and Structures Committee has approximately 40 members, with at least 30 actively involved in the annual organization of the IAC Congresses

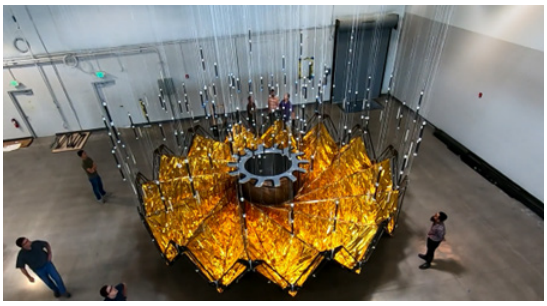
Summary

As in the entire space sector, the field of materials and structures is undergoing constant evolution and advancements. Over the last years, there has been a growing trend towards further miniaturization of satellites and the development of small launchers has been observed. Cost-efficient, sustainable and reusable space transportation solutions, as well as in orbit manufacturing and assembling technologies, have been discussed as prerequisites for the commercial use of the low Earth orbit (LEO) ecosystem. Lightweight design is continuously evolving through the use of new materials, new production technologies, and advancements in computational optimization methods. The evolution of the Clean Space Initiative has been observed, featuring advancements in efficient structures, mechanism designs as well as robotic orbital support services. Eco-friendly designs and reusability are key factors in promoting clean space.

Highlights

Deployable and dimensionally stable structures:

The key technical developments in the field of deployable and dimensionally stable structures, over the last year, involve many structural systems, including origami-inspired designs that enhance compactness and reliability. These designs are being increasingly utilized in large structures of telescopes and antennas, including the NASA Starshade project, whose 10m prototype was deployed at the end of 2023, and small satellites, like CubeSats with deployable solar arrays and antennas of DCUBED. Other significant advancements include the realization of very large solar panels, such as the recently installed 14.2m-long solar arrays on the NASA Europa Clipper mission, which are the largest ever built for any NASA mission, and the largest ever produced for an interplanetary probe. Another promising deployable technology making strides is the concept of solar sail system, which reached a milestone on 29 August 2024, when the 80-square-metre solar sail aboard the NASA-developed Advanced Composite Solar Sail System (ACS3) successfully deployed.



Starshade. Credits: NASA.

Deployable Origami solar panel for Cubesat. Credits: DCUBED.

Space Structures and Materials for Extreme Environment:

Advanced materials and structures designed for extreme temperature applications are essential for the storage of cryogenic propellants. Applications for space transportation and long-term storage require efficient thermal insulation.

Applications in the hypersonic range of the re-entry require efficient high-temperature resistant materials. This includes carbon-carbon and ceramic matrix composites, ultrahigh temperature-resistant ceramics, ablative materials, ceramic tiles, and other passive or active insulation concepts. Together, these materials and innovative structural concepts are vital for propulsion systems, launchers, hypersonic vehicles, entry vehicles, aero-capture and power generation. The full spectrum of material, design, manufacturing and testing aspects needs to be mastered.

Recently, interest in reusable launchers or stages has significantly increased, partly due to the emergence of various mega-constellations that require multiple launches. This demand has triggered new developments in innovative thermal protection systems and cryogenic insulation, focused on partial or complete reusability. Additionally, the renewed trend in space exploration toward the Moon, Mars, Ice Giants, and other planetary bodies is creating a need for materials that can withstand diverse and challenging environments in terms of temperature, pressure, and gas composition.

Thermal control:

Thermal control of spacecraft is always a challenging topic, not only for satellites but also for launcher upper stages with long ballistic phases.

Current research performed at the Moscow Aviation Institute on spacecraft thermal control systems promotes new types of heat pipes that can function effectively in any geometric position, both in the field of gravity and in zero gravity.

Future Outlook

New challenges and solutions in the industrialization of the launcher and spacecraft industry are emerging, driven by the seamless integration of digitalization, automation versatility, and artificial intelligence (AI). This convergence of technologies is propelling a new era of efficiency, reliability, and innovation, reshaping the design, manufacturing, and operation of launch vehicles. It promises to redefine the capabilities and economics of accessing space amid intense competition. A keynote on this topic will be given by Jean-Matthieu Guimard from ArianeGroup in the new session C2.7 of the IAF Materials and Structures Committee during the IAC in Milan 2024.

Current space exploration programs, both those underway and those announced, are increasing efforts and investments aimed at enhancing the protection of not only electronics, materials and structures but also, in the long-term, human life - an essential requirement for future manned missions. These considerations explain the growing interest and ongoing work related to various forms of protection in space against radiation and extreme environmental conditions.

In view of the above, it is clear that space manufacturing and extraterrestrial construction will become increasingly relevant in the future. In this context, in the Session C2.5 of the IAF Materials and Structures Committee, the *Paolo Santini's Memorial Lecture* will be given at the IAC 2024 in Milan by Dr. Raymond G. Clinton from NASA, the title of which is "In Space Manufacturing and Extraterrestrial Construction - How Did We Get Here? - Where Are We? - Where Should We Be Going? - THE CHALLENGE: Will We Be Ready?"

The Materials and Structures Committee is actively keeping pace with these transformative changes.

Committee Activities

The technical presentations presented at the Materials and Structures Symposium during the IAC Congresses have consistently attracted a large audience within the scientific community, making the Symposium one of the most popular at the IAC. In the coming year, the Materials and Structures Committee will propose some initiatives to engage researchers and engineers from new emerging countries in the aerospace sector.

For the IAC 2024 in Milan, the Materials and Structures Committee has organized a collaborative technical session C2.10 with the Space Power Symposium to foster interdisciplinary cooperation between different Symposia working on topics, for which synergies from different symposia can bring an added value.