Paper ID: 77247
oral

IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Technologies for Future Space Transportation Systems (5)

Author: Dr. Giulio Molinari
Beyond Gravity, Switzerland, giulio.molinari@beyondgravity.com

Mr. Christoph Karl
Beyond Gravity, Switzerland, christoph.karl@beyondgravity.com
Dr. Alberto Sanchez Cebrian
Beyond Gravity, Switzerland, alberto.sanchezcebrian@beyondgravity.com

STRUCTURAL HEALTH MONITORING AS AN ENABLER FOR SPACE 4.0

Abstract

The analysis and design of space systems presents unique challenges, among which the high cost and virtually complete inaccessibility of the hardware for most of its lifecycle, and therefore the need for it to perform as planned from the outset.

To accommodate for these needs, space structures are sized with worst-case load envelopes, in combination with safety margins and knock-down factors to account for material and analysis uncertainties. This historical approach, while robust, leads to an overly conservative, and hence mass-intensive, design. This is exacerbated by the scarcity of comprehensive experimental measurements during the operation of these systems.

Precise knowledge of the actual loads would lead to improved designs, enabling a reduction of the required material, and thus to higher overall performance. Furthermore, the availability of accurate information on the actual characteristics of each structure (e.g., accounting for manufacturing deviations) would permit to ascertain its suitability for a specific mission profile. Continuous availability of these measurements throughout the whole lifecycle, both on the ground, during ascent and in-orbit, would permit to isolate unplanned and potentially detrimental events, allowing to implement corrective actions, in some cases even in real-time. This is of crucial importance for structures experiencing long-term utilization, such as spacecraft, human space habitats and reusable launch vehicles. Here, complete awareness of the exact mechanical characteristics and events experienced throughout the entire lifecycle is required, to accurately track the status and the remaining structural life, and to adapt the utilization (or repair strategy) accordingly.

This contribution presents our approach for the development of a structural health monitoring system, with particular focus on payload fairings. The selection of the most suitable monitoring techniques has been performed considering their effectiveness in detecting different types of events and physical phenomena, compatibility with the structures, complexity in integrating the required sensors, and possibility of establishing a distributed sensing network. In addition, the specificities of on-ground, ascent and in-flight operations were taken into account in the tradeoff, as the needs and constraints for each phase are very different.

The selected technique leverages fiber optic-based sensors, and its architecture has been defined with the aim of ensuring modularity, scalability, and applicability to different types of structures. The specific implementation of the system is currently being established, resulting in an exciting opportunity to develop and prove the functionality of a cutting-edge structural health monitoring system for higher value-added space products.