

Requirements and Challenges in Certifying a Human-Rated Inflatable Space Structure

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Abstract

NASA's Next Space Technologies for Exploration Partnerships (NextSTEP) program¹, a collaboration with partners in the aerospace industry, is currently developing the next generation of space habitats for missions beyond low Earth orbit. Initial missions in cis-lunar space will help mature these designs and technologies for future exploration missions to the Moon and Mars. Several of the habitats proposed under the NextSTEP program are softgoods inflatables that provide the advantage of a high packaged-to-deployed volume ratio versus rigid vessels. These multi-layered shell structures use a combination of high-strength webbing, cordage and fabric, and include a variety of shapes and structural architectures. Softgoods habitats must meet both the stringent set of requirements applied to human-rated pressure vessels designed for long duration space missions, and the additional unique requirements of a packageable, textile structure with higher variability and non-linearity in the materials and less flight heritage than a rigid shell counterpart. Prior to the NextSTEP program, a standard for certifying human-rated softgoods vessels for space did not exist, and factors of safety² used for habitable softgoods were inherited from airship criteria³ from the 1940's, with little additional guidance on the tests, data, and documentation needed for certifying a softgoods habitat for spaceflight. Over the last year, a NASA standard was written to address this need and will be used as the basis for evaluation of the softgoods habitat designs proposed under the NextSTEP program. This report details the development of the certification requirements for human-rated, inflatable space structures, including guidelines for qualification testing of softgoods materials, components, and full-scale articles. An updated approach to defining a design factor for these structures is proposed that takes into account material strength and load variability, number of test samples, and the effects of damage and degradation over time. A discussion of NASA research on stochastic finite element modeling of softgoods structures is also included to illustrate some of the ongoing challenges in integrating analysis into the certification process for these structures. This work provides NASA and its industry partners with a robust approach to evaluating and qualifying human-rated space inflatables for long duration space missions. Habitable inflatables carry huge potential to fundamentally alter our capabilities to live and work in-space and on planetary surfaces by providing substantially more available volume for future missions than would otherwise be possible with current rigid structures.

References

- [1] Crusan, J.C. *et al.*, "Deep space gateway concept: Extending human presence into cislunar space," 2018 IEEE Aerospace Conference, Big Sky, MT, 2018, pp. 1-10.
- [2] NASA-STD-5001, NASA Technical Standard: Structural Design and Test Factors of Safety for Spaceflight Hardware, Rev B, 2016.
- [3] Airship Design Criteria, FAA-P-8110-2, 1995.