Pressure Restraint Design for Inflatable Space Habitats

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Abstract

A large, inflatable space structure can be launched in its collapsed configuration to a destination in space where the structure is subsequently deployed to full size. Besides offering the attractive potential of smaller launch vehicle requirements and reduced payload fairing dimensions, inflatable space structures offer significant corollary advantages which have been clearly demonstrated by numerous gossamer spacecraft missions. The primary challenge of deployable space inflatable design is to demonstrate robust predictability of the inflatable's integrated gas barrier and pressure restraining structures. Gossamer spacecraft generally employ highly isotropic films simultaneously fulfilling structural and gas barrier roles. While these membranes adequately support the low shell loads of gossamer craft, their structural performance falls far short of the requirements for containment of the large volumes of life support atmosphere associated with habitat architecture.

Bigelow Aerospace Genesis and NASA TransHab are projects that set the current standard for inflatable space habitat technology. Genesis-1 and Genesis-2, launched in July 2006 and June 2007 respectively, feature restraint structures primarily designed, engineered and manufactured by Thin Red Line Aerospace, and are the first spacecraft on orbit to successfully incorporate flexible, high-stress, pressure shells. This paper uses Genesis project experience to present a developmental methodology for inflatable space habitat pressure restraint design with emphasis on the difficulty of structural and geometric reproducibility. Mathematical models for analysis reinforce the design process but meaningful analysis may only be selectively and cautiously applied; models attempting to prioritize the large number of variables characteristic of flexible, anisotropic structural constituents quickly become unwieldy and often unusable. Modelling assumptions must be rigorously matched to physical reality, and its limitations acknowledged to ensure timely transition to hardware testing.

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