Similarity Rules for Scaling Solar Sail Systems

Stephen L. Canfield , James W. Beard, III, John Peddieson
Tennessee Technological University, Cookeville, TN 38505, USA

Anthony Ewing
Ewing Research, Nashville, TN, 37215, USA

Greg Garbe
In-Space Propulsion, Marshall Space Flight Center, Huntsville, AL, USA

Future science missions will require solar sails on the order 10,000 m^2 (or larger). However, ground and flight demonstrations must be conducted at significantly smaller sizes (400 m^2 for ground demo) due to limitations of ground-based facilities and cost and availability of flight opportunities. For this reason, the ability to understand the process of scalability, as it applies to solar sail system models and test data, is crucial to the advancement of this technology. This report will address issues of scaling in solar sail systems, focusing on structural characteristics, by developing a set of similarity or similitude functions that will guide the scaling process. The primary goal of these similarity functions (process invariants) that collectively form a set of scaling rules or guidelines is to establish valid relationships between models and experiments that are performed at different orders of scale. In the near term, such an effort will help guide the size and properties of a flight validation sail that will need to be flown to accurately represent a large, mission-level sail.