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SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

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SYSTEM CONCEPT DEVELOPMENT FOR MULTIFUNCTIONAL ELECTROMAGNETICALLY ACTUATED AND SUPPORTED SPACE STRUCTURES

Abstract

Spacecraft designers have long been faced by two contradicting objectives: reduce spacecraft mass to minimize prohibitive launch costs while simultaneously making structures as dimensionally large as possible to maximize their performance. Structures that benefit from being as large as possible include primary telescope mirrors, parabolic antennas, solar arrays, solar sails, and starshades. The three main approaches to minimizing spacecraft mass are at the component level (reducing component mass), at the architecture level (designing a single subsystem that performs functions normally allocated to multiple subsystems), or a combination of the two. Most traditional mass reduction uses the first approach, often focusing on lightweighting the vehicle's structure because it is a large proportion of the spacecraft's dry mass. This research will pursue the third approach via tradespace exploration and concept maturation for a new electromagnetic structural subsystem that also performs other spacecraft bus and payload functions.

With the support of consecutive Phase I and Phase II grants from the NASA Innovative Advanced Concepts (NIAC) program, we are investigating the use of interacting high-temperature superconducting electromagnets for actuation, positioning, and support of large space structures. Not only does this technique aim to create a very light structure while maximizing the objective spatial dimension, but the electromagnets can also perform ancillary functions like vibration and thermal isolation, lossless energy storage, reversible actuation, and generation of a strong, localized magnetic field. We are exploring both the feasibility and viability of electromagnetic structures via the modeling and exploration of a multidimensional tradespace of designs. This assessment is grounded by detailed analysis of three specific mission applications: torque coils for satellites in geostationary orbit, a large deployed loop antenna for precipitation of protons out of the inner Van Allen belt with electromagnetic ion cyclotron (EMIC) waves, and a next generation space-based observatory with electromagnetically deployed and formation flown elements. These mission applications were selected to provide a maturation pathway for superconducting technology in space and to represent a cross-section of potential multi-functional allocation to the electromagnetic structure subsystem.

The study of formation flight with electromagnets has historical precedent: two programs, EMFF and RINGS, built and ran testbeds for the contactless relative actuation of multiple spacecraft using electromagnets. In contrast, our technology is designed for intra-vehicular actuation and positioning. We plan to integrate electromagnetic structures with electromagnetic formation flight in our space-based observatory use case to showcase a number of the possible electromagnetic functions on spacecraft.