Space Technology
Game Changing Development
Deployable Composite Booms

State of the art deployable structures are mainly being designed for medium- to large-sized satellites. The lack of reliable deployable structural systems for low cost, small volume, rideshare-class spacecraft severely constrains the potential for using small satellite platforms for affordable deep space science and exploration precursor missions that could be realized with solar sails. There is thus a need for reliable, lightweight, high-packaging efficiency deployable booms that can serve as the supporting structure for a wide range of small satellite systems, including solar sails for propulsion.

The Deployable Composite Boom (DCB) project within Space Technology's Game Changing Development Program is currently investigating a new class of advanced deployable shell-based composite booms to support future deep space small satellite missions using solar sails. NASA’s road map to low-cost solar sail capabilities consists of increasing the size of composite booms to enable sailcrafts with a reflective area of up to 2000 m² housed aboard small satellite platforms. This project aims to develop new 14 m class composite booms and scalable fabrication methods for even longer ones. NASA and the DLR Institute of Composite Structures and Adaptive Systems will jointly develop one or more shell-based deployable composite boom concepts satisfying very small satellite requirements, and demonstrate capabilities via analysis and test. A final goal is to mature at least one boom concept to a technology readiness level 5/6.

At NASA’s Langley Research Center, in Hampton, Va., researchers are advancing the next-generation of solar sail technology for small interplanetary spacecraft, having recently developed and tested an engineering development unit (EDU) of a 90-m² solar sail system that fits inside a 3U (20- by 10- by 15-cm) volume space, or about the size of a child’s shoebox. The Advanced Composites-based Solar Sail System (ACS3) is supported by four 7-m lenticular composite booms made from ultra-thin carbon fiber reinforced composite materials and has a deployer designed to increase deployment reliability by minimizing risks observed in earlier concepts, such as blossoming, jamming or boom root buckling. This proving-ground technology project is being funded by NASA’s Advanced Exploration Systems Program. The current goal is to increase four times the area of the solar sail by using the composite booms under development by the DCB project that could enable an exploration mission to an Earth orbiting asteroid of interest to NASA.

The Near-Earth Asteroid (NEA) Scout is a CubeSat, or small satellite, that will use a solar sail harnessing solar pressure to propel the spacecraft. It is launching on the inaugural flight of NASA’s Space Launch System planned for 2018. NEA Scout will be the size of a large shoebox and weigh less than 30 pounds. The metallic rollable booms that will deploy the solar sail and keep it taut will need to expand to about the size of a school bus. The next generation solar sail technology currently being worked on will use lighter and more thermally stable deployable composite booms. These will enable a sail architecture with a near constantly-tensioned four-quadrant sail (as depicted) throughout all mission stages.
The EDU functional testing included full-scale deployment to demonstrate performance of the complete boom and boom deployer system during all stages of deployment: at the beginning where the maximum loading on the motor is expected; in the middle where the maximum coil blossoming should occur; and at the end where the maximum loading on the boom is expected. Several varied testing conditions were implemented resulting in success, and it was determined that the deployment mechanisms and booms performed well during all phases of deployment, and that the booms could be loaded to the required levels. As part of the DCB project, a similar functional testing campaign will be repeated for the larger deployment system to be developed.

The ultra-lightweight nature of the rollable booms made from state-of-the-art thin-ply composite materials enables a scalable solar sail design that can achieve a 10-percent higher characteristic acceleration than current 6U CubeSat solar sail designs of the same sail size, such as NASA’s NEA Scout. Such difference will continue to increase as the area size of the solar sail is scaled up. This system will be a faster, more agile sailcraft that can extend the capabilities of these relatively low-cost, small solar sails.

Deployable composite boom concepts are being designed to meet the unique requirements of small satellites, maximize ground testability, and permit the use of low-cost manufacturing processes that will benefit scalability. They must be scalable for use as elements of hierarchical structures (e.g., trusses), allow long duration storage, have high deployment reliability, and have controlled deployment behavior and predictable deployed dynamics. These types of booms, which are a cross-cutting space structures technology, will also enable high power solar arrays, large antennas for high data rate communications, and high Delta-V propulsion systems to be included on small CubeSat/secondary payload-class spacecraft.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA’s Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/