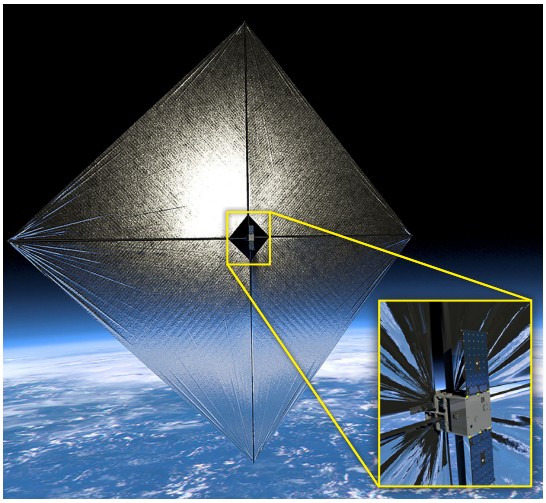
National Aeronautics and Space Administration

NASAfacts

Space Technology
Game Changing Development
Deployable Composite Booms

In recent years, NASA and other organizations have begun to use small satellites more and more as technologists have miniaturized spacecraft avionics. Small satellites can now be used for some missions previously reserved for larger satellites. Additionally, they have a lower manufacturing cost compared to larger satellites and can be mass produced more easily. In order to have an equivalent functionality to larger satellites, small satellites still need to carry deployable antennas, radiators, solar panels and other instruments. However, there are limited designs for compact, lightweight support structures that can be folded or rolled up for launch and then self-deployed in space to support these kinds of systems on small satellites.

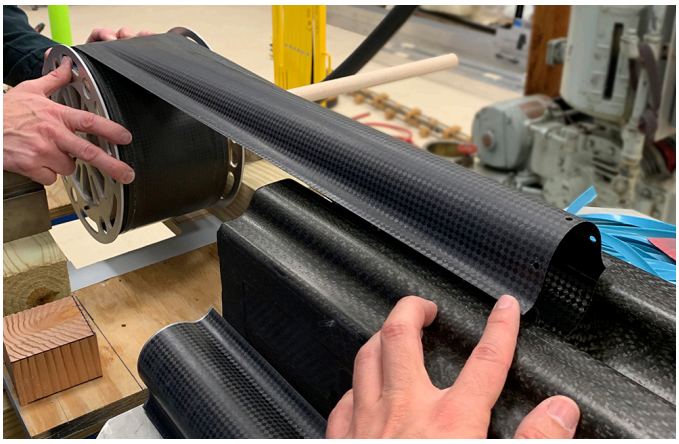
NASA's Deployable Composite Booms (DCB) project, led out of NASA's Langley Research Center (LaRC) in Hampton, Va., is answering this need for a lightweight, foldable/rollable structural material to enable large deployable systems on small satellites. The project is developing a family of thin-shell composite structural booms of various sizes targeting different volumetric needs of small satellites. Before launching a mission into space, these booms will be flattened and rolled onto spools, much like a carpenter's measuring tape, for compact stowage within the spacecraft. These booms can physically extend to lengths up to 54.5 ft (16.6 m) and support a wide range of small satellite deployable systems.



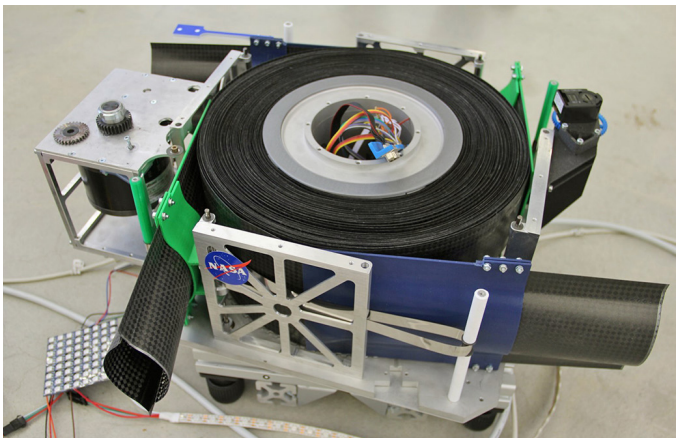
The next generation solar sail technology currently being developed for small satellites will use lighter and more thermally stable deployable composite booms. These will enable a sail architecture with a near constantly-tensioned four-quadrant sail (as depicted) throughout all mission stages. The Advanced Composites Solar Sail System (ACS3) is a flight experiment in low Earth orbit planned for 2021 that will demonstrate the functionality and measure performance of the DCB composite boom technology at a 40 percent length scale of future, larger, mission-capable solar sails on small satellites.

These DCB booms will enable high-power solar arrays, large antennas for high data rate communications, large drag augmentation devices for rapid end-of-life deorbiting, and propellantless continuous low-thrust propulsion systems to be included on small satellites. These new thin-shell composite booms are inexpensive to manufacture and have the ability to be packaged in very small volumes for a long period of time without becoming distorted in shape. Additionally, the DCB team has performed functional testing on the booms that shows they deploy controllably and reliably and maintain the intended structural performance and shape once deployed. These DCB booms are 75 percent lighter and experience 100 times less in-space thermal distortion than equivalent available thin-shell metallic booms. This additional boom performance enables engineers to increase significantly the size of solar sails on small satellite platforms, which could more than triple the propulsion performance of state-of-the-art solar sail structures for small satellites under development.

The DCB team is aiming to qualify several of its boom concepts to be considered ready for flight by mid 2021. This will prepare the technology for possible use on future deep-space small satellite missions. The DCB booms will ultimately enable a variety of science and exploration precursor missions for small sailcraft, including communication relays between the Earth and Moon, asteroid and planetary reconnaissance, and space weather early warning platforms for human exploration support.



54.5-ft (16.6-m) boom partially coiled on a 7-in. (18-cm) diameter spool.



Four 54.5-ft (16.6-m) booms co-wrapped inside the DLR-developed deployment mechanism (top plate removed).

Partners

The German Aerospace Center (DLR) is a collaboration partner on the DCB project and is performing structural characterization testing of the DCB developed boom. DLR is also developing the boom deployer mechanism for demonstrating the functional performance of the booms, particularly packaging and deployment, in a simulated space environment. The University of Central Florida is also supporting testing and modeling of the thin-ply composite laminate materials and representative boom forms for characterization of viscoelastic behavior as they need to package for a long period of time without permanent distortion.

Currently, DCB technology is being infused into a small solar sail system — called the Advanced Composites Solar Sail System (ACS3) — for flight testing circa 2021. The ACS3 payload, being developed at LaRC, is about the size of a shoebox. The 30-ft by 30-ft (9-m by 9-m) square solar sail consists of four triangular aluminum-coated plastic membrane sails supported by four 23-ft (7-m) composite booms provided by the DCB project.

The ACS3 spacecraft will be deployed and tested in low Earth orbit, where a suite of onboard digital cameras will obtain images of the solar sail during and after deployment to assess the shape and precision of the deployed solar sail and composite booms. The collected ACS3 flight data will be used to design future larger-scale solar sail systems based on the DCB boom technology. The ACS3 technology project is funded by NASA's Small Spacecraft Technology Program.

In addition to this work, DCB's larger 54.5-ft (16.6-m) booms and deployer mechanism unit could enable a scaled-up, mission-enabling 5000 ft^2 (465 m^2) solar sail version of the ACS3 system to be flown in the near term in a larger platform, such as a 27U cube satellite (1 ft^3 (0.03 m^3) in volume), which is about twice the size of the current ACS3 satellite. LaRC's technology road map to an affordable demonstration of solar sail capabilities consists of increasing the size of these rollable thin-shell composite booms to enable testing sailcrafts with a reflective area of up to 21,500 ft^2 (2,000 m^2) housed on small satellite platforms.

DCB is also in discussions with other NASA projects and the Air Force Research Laboratory to support flight experiments of deployable systems that could benefit from its boom technologies and is licensing some of the invented boom technologies to industry for commercial exploitation.

Milestones

October 2019 — The DCB team completed fabrication of five composite booms that are roughly 5.1 in (13 cm) tall when flattened and 54.5 ft (16.6 m) long.

November 2019 — The DCB team delivered the composite booms to DLR for use in packaging and deployment testing with the DLR's engineering model boom deployer mechanism.

June 2020 — The DCB team completed computational model development and model correlation with test data from DLR's stiffness/strength testing of DCB delivered booms.

The Game Changing Development (GCD) program is part of NASA's Space Technology Mission Directorate. The GCD Program aims to advance exploratory concepts and deliver technology solutions that enable new capabilities or radically alter current approaches.

For more information about GCD, please visit
www.nasa.gov/directorates/spacetech/game_changing_development

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