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SAILING TOWARDS UNFOLDING EVENTS – DLR THIN MEMBRANE DEPLOYMENT TECHOLOGIES FOR SOLAR SAILS AND LARGE SPACE STRUCTURES IN RESPONSIVE PLANETARY DEFENSE APPLICATIONS

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ABSTRACT

On the background of the highly successful flight of the first interplanetary solar sail, JAXA's IKAROS, and with NASA's upcoming NEASCOUT nanospacecraft solar sail, there is a rising interest in large lightweight structures in space. Deployable membrane or 'gossamer' structures can provide very large functional area units for innovative space applications which can be stowed into the limited volumes of launch vehicle fairings as well as ESPA or ASAP secondary payload launch slots, depending on the scale of the mission. Large area structures such as solar sails which have been studied for many decades require a technology that allows controlled and safe deployment.
Scientific as well as commercial mission require demonstrated reliability, i.e., TRL 6 or higher. A reliable technology that enables controlled deployment was developed in

the GOSSAMER-1 solar sail deployment demonstrator project of the German Aerospace Center, DLR. Its functionality was verified in various laboratory tests to qualify the hardware for a first demonstration in low Earth orbit. We provide an overview of the GOSSAMER-1 hardware development and qualification campaign. On its engineering models, all aspects of the deployment were tested at ambient conditions. The key components and mechanisms of this technology were subjected to environmental qualification testing, enabling future flight use of an innovative stowing and deployment strategy for a controlled deployment. The stowing and deployment strategy was verified by tests with an engineering qualification model using one complete of the four Boom Sail Deployment Units (BSDU) of the DLR GOSSAMER concept, two membrane sections, and two simulated BSDUs. This efficient approach was possible due to the inherent symmetry of the design. Test-as-you-fly procedures included vibration tests, venting, thermal-vacuum tests, and ambient deployment. In these tests the deployment strategy proved to be suitable for a controlled deployment of gossamer spacecraft, and deployment on system level was demonstrated to be robust and controllable. The GOSSAMER-1 solar sail membranes were also equipped with small thin-film photovoltaic arrays to supply the core spacecraft.

Beyond solar sailing, which is a uniquely performant method of propulsion when it comes to asteroid rendezvous missions, we explore other use cases for thin membrane-based structures in planetary defense and related missions. In these we consider the small spacecraft based solutions for mass and volume efficient designs as developed in the DLR-ESTEC GOSSAMER Roadmap and ASTEROIDFINDER/SSB studies, and implemented in our small spacecraft missions such as AISAT-1 and MASCOT.

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