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Qualification Tested Technologies of the GOSSAMER-1 Solar Sail Deployment Demonstrator for Planetary Defence and Small Solar System Body Science and Applications

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ABSTRACT

Thin membrane based “gossamer” structures are used in many innovative space applications, some of which have been proposed for planetary defence applications, e.g. solar sails, large lightweight photovoltaic generators, solar concentrator reflectors, Yarkovsky/YORP modification wraps or devolatilization containers around small asteroids or boulders. All of them require a technology that allows their controlled and thus safe deployment. Before employing such technologies for science missions, it is customary and usually required to demonstrate reliability by achieving a Technology Readiness Level of six or higher through verification testing.

The development of the GOSSAMER-1 project of the German Aerospace Center, DLR, intended to create all technologies for solar sail deployment and prove them on a (5 m)² demonstrator with scaleability to (20 m)². As part of the DLR-ESTEC Gossamer Roadmap, the stepwise development towards solar sails of at least (50 m)² was envisaged. Thus, many technologies were designed from the start with re-use in a next-generation spacecraft in mind.
The design is based on a crossed boom configuration with triangular sail segments. With a combination of folding and coiling, it is ensured that the deployed sail area can be held taut between the partly deployed booms. During deployment, four deployment units with two spools on which the sail is mounted (a half segment on each) moves away from the central bus unit, the center of the deployed sail.
The GOSSAMER-1 concept through its solar sail heritage specifically addresses the requirements of interplantary missions by separating units which are only required for deployment, to lighten the final spacecraft configuration.

The GOSSAMER-1 project was discontinued before achieving flight status and the effort and team redirected towards thin-film deployable photovoltaic generators in the follow-on GOSOLAR project on which we report separately. However, a full qualification of all GOSSAMER-1 technologies was completed recently. A reliable technology that enables the controlled deployment underwent verification of its functionality with various laboratory tests to qualify the hardware for a first demonstration in low Earth orbit.

We present an overview of the GOSSAMER-1 hardware development and testing. Employing engineering models, all aspects of the deployment were tested under ambient environment. Several components were also subjected to environmental qualification testing. A qualification model for environmental testing was built and underwent qualification testing. It consisted of one boom and deployment unit, two membrane quadrants, and a representative set of interfaces to the central bus unit.
Innovative stowing and deployment strategies for a controlled deployment and the required mechanisms are described. The tests conducted provide insight into the deployment process and allow a mechanical characterization of this process, in particular the measurement of the deployment forces. Deployment on system level could was demonstrated to be robust and controllable, within the constraints set by the test facilities.

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