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Soil to Sail – Asteroid Landers on Near-Term Sailcraft as an Evolution of the GOSSAMER Small Spacecraft Solar Sail Concept for In-Situ Characterization

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ABSTRACT

Any effort which intends to physically interact with specific asteroids requires understanding at least of the composition and multi-scale structure of the surface layers, sometimes also of the interior. Therefore, it is necessary first to characterize each target object sufficiently by a precursor mission to design the mission which

then interacts with the object. In small solar system body (SSSB) science missions, this trend towards landing and sample-return missions is most apparent. It also has led to much interest in MASCOT-like landing modules and instrument carriers. They integrate at the instrument level to their mothership and by their size are compatible even with small interplanetary missions.

The DLR-ESTEC GOSSAMER Roadmap NEA Science Working Groups‘ studies identified Multiple NEA Rendezvous (MNR) as one of the space science missions only feasible with solar sail propulsion. The parallel Solar Polar Orbiter (SPO) study showed the ability to access any inclination and a wide range of heliocentric distances. It used a separable payload module conducting the SPO mission after delivery by sail to the proper orbit. The Displaced L_1 (DL1), spaceweather early warning mission study, outlined a very lightweight sailcraft operating close to Earth ,where all objects of interest to planetary defence must pass.
These and many other studies outline the unique capability of solar sails to provide access to all SSSB, at least within the orbit of Jupiter. Since the original MNR study, significant progress has been made to explore the performance envelope of near-term solar sails for multiple NEA rendezvous.

However, although it is comparatively easy for solar sails to reach and rendezvous with objects in any inclination and in the complete range of semi-major axis and eccentricity relevant to NEOs and PHOs, it remains notoriously difficult for sailcraft to interact physically with a SSSB target object as e.g. the HAYABUSA missions do.

The German Aerospace Center, DLR, recently brought the GOSSAMER solar sail deployment technology to qualification status in the GOSSAMER-1 project and continues the development of closely related technologies for very large deployable membrane-based photovoltaic arrays in the GOSOLAR project, on which we report separately.

We expand the philosophy of the GOSSAMER solar sail concept of efficient multiple sub-spacecraft integration to also include landers for one-way in-situ investigations and sample-return missions. These are equally useful for planetary defence scenarios, SSSB science and NEO utilization. We outline the technological concept used to complete such missions and the synergetic integration and operation of sail and lander.
We similarly extend the philosophy of MASCOT and use its characteristic features as well as the concept of Constraints-Driven Engineering for a wider range of operations. For example, the MASCOT Mobility hopping mechanism has already been adapted to the specific needs of MASCOT2. Utilizing sensors as well as predictions, those actuators could in a further development be used to implement anti-bouncing control schemes, by counteracting with the lander‘s rotation. Furthermore by introducing sudden jerk into the lander by utilization of the mobility, layers of loose regolith can be swirled up for sampling.

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