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SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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# MISSION ANALYSIS FOR AN ADVANCED SOLAR PHOTON THRUSTER

**Abstract**

Being propelled only by solar radiation pressure, solar sails enable a wide range of challenging high-$\Delta V$ missions. Currently, the most extensively discussed solar sail design concept is the flat solar sail. A disadvantage of this design is the coupling between the attitude of the light-collecting sail area and the thrust direction, because the effective light-collecting sail area decreases as the sail pitch angle increases. The compound solar sail is an alternative solar sail design concept that decouples the two functions of a solar sail, *light collection* and *thrust direction*. It has first been proposed in the Russian literature in the 1970s and was then re-introduced by Forward in 1990, who coined the name Solar Photon Thruster (SPT). In the SPT concept by Forward, a large Collector is always facing the Sun and reflects the incident light onto a small Director (Simple Solar Photon Thruster, SSPT). Alternatively, the Collector may reflect the light first onto a smaller Reflector and the Reflector reflects it then onto the Director, which is positioned between the Collector and the Reflector (Dual Reflector Solar Photon Thruster, DR SPT). In both cases, the full Collector area can be used for light collection. The thrust direction depends only on the pitch angle of the small Director, which can easily be varied due to its small moment of inertia. In contrast to the flat solar sail, large Director pitch angles do not reduce the projected light-collecting area.

Neglecting multiple reflections and shadowing effects, however, the previous compound solar sail design concepts suffer from optical oversimplifications. In this paper, we introduce an innovative design concept called the Advanced Solar Photon Thruster (ASPT). This design concept does not suffer from those oversimplifications, but requires a more detailed design analysis and mathematical description, which will first be given in the paper. Afterwards, the ASPT's performance is analyzed and compared to the flat solar sail's performance for three exemplary distinctive space mission scenarios: an Earth-Venus rendezvous, where the solar sails have to spiral towards the Sun, an Earth-Mars rendezvous, where the solar sails have to spiral away from the Sun, and an Earth-asteroid (1996FG3) rendezvous. The investigated solar sails have realistic near-term characteristic accelerations ranging between 0.1 and 0.2 $\mathrm{mm/s^2}$.