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PW-SAT2 DEORBIT SAIL POST-DEPLOYMENT EFFECTIVENESS ANALYSIS

Abstract

This paper presents the results of the confrontation of the pre-launch analysis of the deorbit sail effectiveness with the post-mission data. Additionally, the analysis and discussion of the effectiveness of the PW-Sat2 sail for deorbiting other small satellites platforms is conducted. Furthermore, the discussion of general pros and cons of the deorbit sail technology is presented taking also into account sails usefulness for satellites which already have propulsion. Finally, the issue of sails increasing the instantaneous collision probability, in context of space debris mitigation, is discussed. Presented analysis shows decrease in cumulative probability.

Initial sail effectiveness analysis was performed to assess the feasibility of the use of PW-Sat2 sail on micro and small satellites. Several popular micro and small satellite platforms available on the market were taken into account and analysed for their orbital lifetime on a range of popular orbits with and without sail. Random tumbling of the satellite with the full size 2x2m sail was assumed. Results show that there are some combinations of popular orbits and platforms for which the orbit lifetime is longer than 25 years and PW-Sat2 sail would make them compatible with 25-year guidelines.

Thanks to PW-Sat2's on-board cameras, it is possible to monitor the sail's condition. Initial photos taken immediately after sail deployment showed a perfect surface, three days later images showed several holes in the sail's surface. Analyses identified thermal stress to be the most probable cause for holes appearing. Thanks to further images it was possible to determine that surface degradation slowed and achieve a stable condition in a few weeks. Sail photos allowed to estimate the sail's area lost $(40 - 45\%)$.

Orbit degradation progressed slower than expected pre-launch. By fitting the results of orbit propagation to the actual orbital evolution it was possible to determine the actual effective drag area of PW-Sat2. Preliminary analyses performed 3 months after sail deployment showed that the effective drag area of the PW-Sat2 sail is around $0.9m^2$. A decrease of 55% from nominal $2m^2$ (random tumbling) is due to both the lost sail's area and unfavorable rotation.

Results were compared with the visually estimated lost sail area. On-board gyroscopes readings, experimental Sun sensor readings and variation in communication conditions allowed to estimate the rotation rate of the satellite to be confronted with the random tumbling assumption.

These post-deployment results were used to update aforementioned analyses, enriching the discussion on drag sail technology with experimental results.