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# CONCEPTUAL IMPROVEMENT OF A SOUNDING ROCKET FOR LONG HIGH-QUALITY MICRO-GRAVITY EXPERIMENTS

**Abstract**

Among the numerous existing sounding rockets, many solutions grant high micro-gravity quality (lateral and axial accelerations below $10^{-4}$ g) and some of them provide a long time interval available for experiments. However, few solutions also allow a low acceleration level (i.e. $a < 5$ g) on payload and structures during the ascending phase, thus making them unsuitable for carrying the most sensitive experimental apparatus. *BugsLightyear* is a sub-orbital sounding rocket, evolved from an existing solution, whose conceptual design aims to cope with the previously described market issue, by granting high micro-gravity quality and time, as well as low acceleration levels. Specifically, the current work proposes the evolution from a single stage, pressure-fed liquid-propellant sounding rocket (*MIURA 1*), towards a two-stage alternative configuration. This is achieved by employing an additional upper stage powered by a solid rocket motor, thus improving overall performance. The developed launcher can house payload masses between 50 kg and 150 kg, leading to an apogee ranging approximately between 430 km and 300 km and never exceeding a maximum acceleration of 5 g during the ascent. Furthermore, *BugsLightyear* is capable of granting up to nine minutes of high-quality micro-gravity level, suitable for a broad range of scientific experiments. Additionally, *BugsLightyear* is partially reusable since both the first stage and the payload capsule are recovered by means of a parachute recovery system, granting a vertical velocity at landing lower than 10 $m/s$. The work is supported by a Monte Carlo analysis, aimed to evaluate the robustness of the system, completed by a Circular Error Probability (CEP) analysis for the different impact locations resulting from perturbed initial conditions. Finally, using very high-TRL components, *BugsLightyear* promises to contain design and manufacturing costs, and pledges a very low time to market.

**Disclaimer:** the conceptual design presented in this paper is developed by a team of Master of Sci-

ence students of Politecnico di Milano. Neither the team members nor the specific design activity have been supported by *PLD Space*. The team members did not have any interaction or connection with the *MIURA 1* launcher design authority.

**Keywords:** low accelerations, high-quality micro-gravity, high TRL.