The Propulsion System of the LunarSat Microspacecraft

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LunarSat, the Lunar Academic and Research Satellite, is a micro-spacecraft that will orbit the Moon on a highly elliptical polar orbit with its perilune above the Lunar south pole area. Further measurements shall provide evidence regarding the existence of water ice in the lunar polar craters. LunarSat is designed by young engineers, scientists, and students from around Europe, with support from numerous institutions and space industry. It shall be launched as an auxiliary payload on an Ariane 5 ASAP platform and will have a mass of 120 kg in GTO. Another prime objective: the LunarSat mission is an educational and outreach project. The project aims at demonstrating that such a low-cost spacecraft can still make significant scientific and technological progress, and as is suitable as a first step toward a European lunar initiative.

The different orbital insertion phases for LunarSat mission and attitude control require a Dv amounting to 1300 m/s (in the worst case). According to the mission profile, these operations will be performed by a dual-mode propulsion system. This means that bi-propellant main engines and monopropellant attitude thrusters will use the same fuel: hydrazine. After conducting a trade-off regarding the influence of thrust and main engine mass on gravity losses during the injection firings, a four engine configuration (used in pulsing mode) has been selected. The injection firing from GTO into LTO was investigated as a reference because its Dv of about 760 m/s is most decisive concerning the g-losses.

This paper presents the baseline design of the LunarSat propulsion system, which is composed of:

- Four 22 N main engines using pure hydrazine (N2H4) as fuel and nitrogen-tetroxide (N2O4) as oxidizer, with a nominal specific impulse Isp=289 s
- Two mono-propellant (hydrazine) 1N attitude thrusters
- A tank-pressure-feed system
- Temperature sensors and heaters at critical points

A serial arrangement of hydrazine and NTO tanks offers several advantages compared to parallel tank expulsion. For example no active expulsion control is required and components like F/D valves and pyro-valves are much more lightweight than latch valves. On the other hand, the serial solution causes a predicable shift of the center of mass (CM) of the spacecraft during tank expulsion, which requires an active attitude control during main engine firing. The misalignment of the CM from the spacecraft geometrical center line is thus kept as small as possible.

Another essential characteristic of the LunarSat propulsion system is its wet mass which is composed of the sum of all single propulsion system component masses, their mechanical and electrical interfaces and the total required propellant mass. One of the most restrictive factors is "low-cost", i.e., essentially all components are commercial-off-the-shelf (COTS).