

## The LEROS 4: A High Thrust Spacecraft Engine for Interplanetary Applications

**Authors :** I. Coxhill, P. Stiles, R. Westcott

**Abstract :** This paper provides a comprehensive overview of the LEROS 4 high-thrust apogee engine, intended for use on interplanetary spacecraft. The LEROS 4 rocket engine is a nominal 1.05 kN thrust engine, burning MMH and MON-3 with an Isp of >317s. The engine can be considered an enhanced thrust version of the conventional ~400N apogee engines used on many telecommunication platforms. The motivation for the development of this engine was the need for high-performance, high-thrust propulsion, particularly where gravity losses are high - typical of interplanetary maneuvers. There are a limited number of commercially available engines in the ~1kN class with a high specific impulse. The LEROS 4 engine aimed to fill this gap and provide a flexible engine for high-thrust applications. Two variants of the engine were developed out of the main programme: the LEROS 4 and the LEROS 4-ET. Whilst the LEROS 4 has a nominal thrust of 1.05kN, the ET (Extended Thrust) version operates at a nominal 1.31 kN, albeit at higher inlet pressure. This paper charts the design and development of the engine through the initial concepts, hot fire testing at sea level, hot fire testing at altitude, all the way through to engine qualification for ESA (European Space Agency). In addition to the engine itself, the test facilities in which the engine is tested are discussed. As the LEROS 4 has an unusual thrust level, there are few facilities in the world that can efficiently test an engine at this thrust level. Accordingly, Nammo designed and built a vacuum test facility that allows testing up to 1.5kN of thrust to accommodate the LEROS 4 program. Some unique features of this test facility are explained in the paper. The paper also discusses the in-flight experience of the inaugural flight (the LEROS 4-ET on board the Firefly Blue Ghost lunar lander) and the ongoing LEROS-4 qualification program for ESA, targeted at the EnVision mission to Venus. Finally, the paper summarises the achievements to date and presents a detailed specification of the performance capability.

**Keywords :** apogee, hypergolic, interplanetary, MMH, MON-3, rocket engine, spacecraft

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