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Title

RELIANCE - Design, Manufacturing and Testing of the Breadboard Engine

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Abstract

RELIANCE is a bi-propellant rocket engine in the 6kN thrust class using hypergolic propellants (MON-3 and MMH). Its first application is intended to be as main propulsion for ESA's European Large Logistics Lander (EL3), recently renamed Argonaut. New technologies such as electric pumps (E-pumps), additive manufacturing, advanced physics modelling and high precision control will provide an engine with completely new capabilities.

The Breadboard engine is the first full-scale model of RELIANCE to be designed, manufactured and tested. It will validate critical functions such as high performance and stability at all operating points, wide throttleability (between 50% and 117% thrust), full control and high precision in thrust regulation and ignition in vacuum. The goal is to reach TRL5 in 2023.

The scope of the Breadboard engine is limited to the thrust chamber assembly, including the injector and regeneratively cooled combustion chamber. It is designed so that its main characteristics will be representative of the flight model, also in terms of manufacturing process. The nominal chamber pressure will be 45 bar, corresponding to 4700N of thrust and an Isp of 249s at the nominal point at sea level.

The Breadboard engine includes a liquid-liquid fixed pintle injector that will provide good performance and stable operation over the wide throttle range. The combustion chamber will be regeneratively cooled by axial channels in a dual-loop configuration, with both the oxidizer and fuel used as coolants. Moreover, part of the fuel will be injected through separate holes to provide film cooling. A fully regeneratively cooled nozzle will be specifically designed for atmospheric testing (no nozzle skirt will be included for Breadboard testing).

The E-pump systems will be developed and tested separately before being introduced into the engine system. Meanwhile, to enable Breadboard engine testing, a high-pressure and high-thrust test facility is being built at Nammo UK. This will provide both propellants with the same mass flows and pressures as at the outlets of the E-pumps, in the whole throttle range thanks to specific throttle valves. This approach allows testing of the Breadboard engine in a high-pressure-fed mode without the E-pumps first, and to progress safely to full system testing afterwards, thus reducing the risks and development time.

The article will present the final design of the RELIANCE Breadboard engine, with focus on the key components, its manufacturing process and all the steps that will lead to its hot fire test campaign.

References

[1] Boiron A. et al., Reliance, A Throttleable and E-Pump-Fed Bi-Propellant Engine For Exploration Missions. Space Propulsion Conference 2022, Estoril, May 2022. SP2022_146