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# PROGRESS ON THE LE-X CRYOGENIC BOOSTER ENGINE

**Abstract**

JAXA is planning to develop the next cryogenic booster engine called LE-X. With its higher reliability and reduced cost, LE-X is under study as the booster engine for the next primary launch systems in Japan1) . This paper reports the latest LE-X design, including engine system analysis, critical component designs and the technology development activities to mitigate engine development risks.

Based on our experience and proven success, the expander bleed cycle with cryogenic LOX/LH2 propellants is selected for the LE-X. In this cycle, a portion of high pressure hydrogen pumped by fuel turbomachinery is directed to the main combustion chamber cooling channels and then used to drive the turbines. This cycle has an inherent potential to avoid catastrophic engine damages, as well as to ensure the engine to be more simple and robust. In addition, since moisture doesn't exist in the turbine driving gas, LE-X precludes the "freeze locking" failure of the turbine at restart. Thus, it doesn't require the hot gas purge between tests, consequently simplify the maintenance operations. The engine is suitable not only for booster stage but also for upper stage which will require higher thrust level in future manned space missions.

The preliminary design of the LE-X engine system has been performed in the past several years2) 3) 4). The engine characteristics, its schematic diagram and 3D model are shown in fig.1. The Main Combustion Chamber (MCC) and the Fuel TurboPump (FTP) are recognized as potentially high development risk components. The MCC is the energy source for the turbine drive power and the heaviest component of the LE-X. Hot isostatic pressure (HIP) bonding technology is considered as a candidate to fabricate this long and heavy combustion chamber with significantly low cost. The turbine efficiency of FTP is one of the main drivers of engine performance. According to its configuration, LE-X FTP uses a high-pressure ratio supersonic turbine. High-fidelity CFD analysis and turbine rig test are to be conducted to verify the high-efficiency supersonic turbine design.

Technology development activities are currently under way to mitigate development risks. Such activities consist of several elements, which are the prediction of combustion instability, regenerative cooling

analysis, prediction of MCC life, turbine blade and impeller blade optimization for turbopumps and cavitation instability analysis of inducer. This paper also explains such activities in aspects of both numerical simulation and experiments.