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PROPELLANT SLOSHING BEHAVIOR DURING THE LANDING IGNITION PROCESS OF THE
LOX/LCH₄ REUSABLE LAUNCH VEHICLE "ZQ-3"**Abstract**

The ZhuQue-3 (ZQ-3) launch vehicle, developed independently by LandSpace Technology Co., Ltd., a commercial space launch provider in China, is the Chinese 1st reusable launch vehicle model utilizing liquid oxygen methane propellant for its first stage. The recovery phase of the reusable first stage entails complex operations, including large-angle attitude adjustments via engine gimbaling, main engine cutoff, grid fin deployment, engine restart, and main engine shutdown. Throughout this phase, the propellant undergoes significant sloshing accompanied by outflow. Liquid sloshing and vehicle rotation increase the risk of gas ingestion at the feed-line, which can critically impair engine reignition safety. Using computational fluid dynamics (CFD) simulations to analyze propellant behavior during this process, a criterion is proposed based on whether the liquid volume fraction at the outlet exceeds 99