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ARMEL: ARCHIMED RECOVERY METHOD FOR LAUNCHER

Abstract

Recovering the space launcher stage is one of the major challenges for reducing the cost of access to space and developing the space industry. Several recovery methods have been proposed and few are operational. Each method seeks to reduce the constraint in terms of mass, trajectory, and complexity of the recovery system on the launch mission. The objective of this article is to present a space launcher stage recovery concept based on Archimedes' principle. The study focuses on the lower stages which complete their propulsion on sub-orbital trajectories which allow a direct return to Earth. The central element of the recovery system is the balloon initially folded into the stage during the propulsion phase. After cut-off the stage engine, it is deployed in the upper atmosphere with pressurizing gas from the propellant tank. This inflation of the balloon provides a ballistic coefficient which reduces the thermal stress on stage during atmospheric reentry. In a lower atmosphere, residual fuel in the tank is used to heat the air in the balloon and create lift according to Archimedes' principle. This lift reduces and cancels the vertical speed, allowing hovering over the sea. Depending on the amount of residual fuel, this hovering can last a few hours, long enough to be joined by a recovery boat. It is the boat that features the maintenance facility. The main advantage of this method is to reduce the requirement on stage. The rocket engine is note restarted after there propulsion phase. The balloon inflation gas and heating fuel are already in the stage and became useless at the engine cut-off. The recovery by boat is softer than splash-down above parachute and avoid the exposure of technical components at a water immersion. The paper studies the general design, recovery procedure and constraints of the methods. It defines the key points for sizing the system according to the mass of the stage, the re-entry speed and the propellant used (kerosene, hydrogen, methane). Several case studies, based on existing launchers, are presented in comparison with other recovery methods.