SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS (D2)
Small Launchers: Concepts and Operations (7)

Author: Dr. Frank Schäfer
Fraunhofer EMI, Germany, frank.schaefer@emi.fraunhofer.de

Mr. Martin Schimmerohn
Fraunhofer EMI, Germany, martin.schimmerohn@emi.fraunhofer.de
Mr. Martin Rudolph
Fraunhofer - Institute for High-Speed Dynamics, Germany, mjbrudolph@gmail.com
Mr. Sebastian Herbrich
Fraunhofer EMI, Germany, sebastian.herbrich@emi.fraunhofer.de

LIGHT-GAS GUN LAUNCHER CONCEPT FOR HIGH-G PROOF MINIATURE SUBORBITAL PAYLOADS

Abstract

During the High Altitude Research Project (HARP) beginning of the 1960s, powerful powder guns were developed that eventually were used to launch projectiles with a mass of 84 kg at exit velocities of over 2200 m/s to an altitude of 180 km. The HARP project has proven as early as in the sixties that electronic systems can be designed to withstand acceleration loads of several 10.000 g's in the gun barrel and subsequently be used for acquisition of scientific data during sub-orbital flight. While the HARP project was not continued beyond 1967, a new type of acceleration technology has matured that offers much higher exit velocities than powder guns: two-stage light-gas guns.

Two-stage light gas guns are powerful accelerators, which are used e. g. for simulation of space debris and micrometeoroids on spacecraft components in a laboratory environment or for defense research. Exit velocities of up to 10 km/s have been reached with such guns for millimeter-sized particles. The current maximum performance of light gas guns operated by Fraunhofer EMI is to accelerate projectile masses in the kilogram range to velocities of several kilometers per second. Such accelerator performance is sufficient to cover the delta-v demand of sub-orbital missions. In parallel, electronic space systems have become smaller in size and can be designed robust to meet high-g requirements to some limits.

This paper investigates the concept of application of light gas guns for upper atmospheric research, hypersonic flight experiments, and re-entry experiments. Light-gas gun launcher technology is described and an overview of their current performances as well as a perspective on achievable performances in the future is given. Based on a range of preliminary projectile designs, possible flight trajectories are calculated. The high short-term acceleration loads have implications for the accommodation of the system electronics and the scientific payload which are discussed. A preliminary design of a system will be presented. Based on the findings, it is concluded that suborbital launch of miniature g-proof payloads is feasible with state-of-the-art technology.