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Author: Mr. Adam Okninski
Universidad Nacional de Asunción - Facultad Politécnica, Poland

Mr. Jan Matyszewski
Warsaw Institute of Aviation, Poland

ON OPTIMIZATION OF SOUNDING ROCKETS FOR MICROGRAVITY RESEARCH

Abstract

Despite the emergence of the reusable suborbital space vehicle market, expendable sounding rockets remain the main tool for conducting atmospheric research. Existing rockets are based on earlier proven designs and often utilize old military solid rocket motors. Therefore commonly non-optimal, in terms of performance for a given payload, configurations are utilized. With rapid developments in the field of hybrid rocket technology, not only short duration thrust propulsion systems should be considered. This paper presents a methodology for finding close-to-optimal, in terms of launch mass minimization, design configurations for small unguided sounding rockets. A numerical, multidisciplinary approach is used. During the optimization process vehicle sizing, stability issues analysis and corresponding aerodynamics modeling is done. The implemented flight simulation module is simplified due to unknown, during the conceptual design phase, rocket mass distributions along vehicle major axes. Special attention is given to propulsion system sizing and thrust level selection. This paper presents optimization of sounding rockets with lift capabilities equivalent to sending payloads of up to 50 kilograms above the Von Karman line. Three main groups of rocket configurations are considered: single-stage, two-stage and main stage with boosters. The ultimate aim of this paper is to present methods to improve sounding rocket performance at the early stage of design, to enable conducting more efficient microgravity research. Various concepts, such as using different expansion ratio nozzles for different payload envelopes and masses, are discussed. Numerous sensitivity studies for typical objective functions are shown. Optimization results for maximizing the apogee of a small sounding rocket are presented. Due to the lack of published corresponding research, guidelines for future new sounding rocket developments, based on numerical investigations, are given.