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Author: Mr. Zhangrui Chen
Tsinghua University, China, chen-zr20@mails.tsinghua.edu.cn

Prof. Zhaokui Wang
Tsinghua University, China, wangzhaokui@tsinghua.edu.cn

DESIGN AND OPTIMIZATION OF ASCENT TRAJECTORY FOR A GLOBAL DELIVERY SYSTEM

Abstract

As the reusable space launch system has witnessed a milestone achievement and drastically reduced the cost of entering space, it is now feasible to establish a global arriving system. The mostly-reusable, low-cost, quick-response system is capable of sending payload to the requested location in less than an hour, thus possessing great potential in cargo delivery and public long-distance traveling. Meanwhile, air launch has been proven to be an effective approach to attain higher speed, making it a practical solution for the small launch vehicle to carry a larger payload. This work is focused on the ascent trajectory of an air-launch vehicle, which aimed to propose a possible flight procedure based on previous technology. The fourth-order Runge-Kutta-Fehlberg method is used to create a flight simulation model and give an iterative solution to the status of the launch vehicle during ascent, and the range of flight is calculated based on two-body theory. The vehicle is modeled to be a reusable liquid rocket attached with solid boosters, deployed from an aircraft at a certain altitude and speed. A design to shut down the engine in a certain order can meet the restriction of structure ratio and maximum overload, which is close in performance to the deep-throttling technology under development. A ground-launch system is taken as a control to give a direct view of the advantage of air-launch. A guidance law is designed to ensure the vehicle concludes its pitch before reaching the speed of sound. Comparison with ground-launch indicated that air-launch system can notably increase the range of flight, and is able to operate global delivery. A method of evaluating the efficiency of the air-launch system is presented in the research, in which the initial height and speed of air-launch are equivalent to extra delta-V of the vehicle, leading to different flight-range. The research implied that an initial speed increase to a lesser range efficiently gains extra delta-V, demonstrating the viability of a subsonic air-launch vehicle carrier. The accessible region of the subsonic and supersonic air-launch system is calculated and compared with the ground launch, suggesting the potential of air-launch-to-orbit using supersonic aircraft.