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CONCEPTUAL DESIGN OPTIMIZATION OF WINGED SUBORBITAL VEHICLES FOR HIGH-SPEED POINT-TO-POINT TRANSPORTATION

Abstract

Reusable space transportation technologies can be applied not only to orbit insertion of payload but also to high-speed point-to-point transportation on Earth. It would revolutionize the long-distance passenger transportation by making intercontinental flight duration less than an hour. Such applications have been proposed over many years, whose examples include SpaceLiner of DLR and Big Falcon Rocket of SpaceX.

This paper investigates the conceptual designs of fully-reusable winged suborbital vehicles with rocket propulsion for high-speed point-to-point transportation. This study especially focuses on the simultaneous optimization of vehicle and flight trajectory in order to explore promising design solutions. Such multidisciplinary treatment is effective to this study, since the vehicle design and trajectory are coupled in more complicated way than conventional launchers and aircraft. To this end, numerical analysis models of the rocket engine performance, vehicle mass, aerodynamic characteristics, aerodynamic heating, and flight trajectory are prepared. Then, the optimization of the vehicle size, engine design parameters, and flight trajectories are performed to minimize the lift-off mass of the vehicle for a designated mission. This system design optimization is extensively conducted for different missions (e.g., flight range and the number of passengers), several system concepts (e.g., single stage or two stage), and varied design constraints (e.g., maximum temperature). The results obtained quantitatively clarify the technology goals and associated issues that must be solved in future research activities. In additions, the detailed discussion is given on the characteristic oscillating glide phase observed in optimized flight trajectories.