SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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OPTIMUM MANEUVER OF AIR LAUNCH ROCKETS

Abstract

Air launch is one of the innovative ways of delivering payloads into orbit. In this method, rockets are taken up to high-altitude by a conventional horizontal-takeoff aircraft and launched in air. This method can have many advantages in terms of performance, cost, flexibleness and so on, compared with a conventional ground launch. For air launch system, various ways of carrying and separating are conceivable, for example “internally carried” and “air-drop”. This study focuses on horizontal-air-launched winged rockets. Horizontal-separated and winged rockets can fight with lift force. It’s a new concept rocket entirely different from conventional rockets that are launched vertically or nearly vertically from the ground. The purpose of this research is to find the optimum maneuver of this new concept rocket - a winged rocket which is launched in air horizontally and flights with lift force. In this study, rocket was modeled as a point mass with a constant thrust that moves in the gravitational field of a flat earth. At first, the condition for the flight-path angle that maximizes the final total energy of the rocket was obtained by variational approach. The angle of attack was considered as a manipulated variable and the infinitesimal change of the flight path angle with impulse input was calculated. When the change in the altitude of total energy is insensitive to the infinitesimal change of the flight path angle, the condition maximizes the final total energy. In the method described above, the initial attitude of the rocket was not considered. Since, in case of horizontal air launch, the initial attitude does not satisfy the optimum condition stated above. Then, for the next, the trajectory of the rocket from launching to getting on the condition stated above was optimized with the adjoint method. Here the evaluation function was the total energy at undetermined terminal time and the optimum solution was obtained with repeated computation of time-reversal integration. By jointing above two results, the optimum maneuver was obtained. In this presentation, details of calculation and results will be shown.