Paper ID: 25014
student

SYMPOSIUM ON COMMERCIAL SPACEFLIGHT SAFETY ISSUES (D6)
Commercial Space Flight Safety and Emerging Issues (1)

Author: Mr. NamKyung Yoon
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of

Prof. Jaemyung Ahn
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of

TRAJECTORY OPTIMIZATION OF LAUNCH VEHICLE CONSIDERING INSTANTANEOUS IMPACT POINT

Abstract

In this paper, an ascent trajectory of launch vehicle arising from Instantaneous-Impact-Point (IIP) consideration is optimized. IIP is defined as a touch down point under the assumption of immediate end of propelled flight. Malfunction of launch vehicle can damage people's life and property so precise IIP information is important. This information can help flight safety officers for range safety operation during launch; for example, officers can issue flight termination command based on IIP information. Traditionally, the range safety requirement has been satisfied by fixing azimuth heading or detouring the residence area when optimizing the trajectory of launch vehicle. However, in this paper, IIP constraints are considered explicitly in a trajectory simulation to see how changes of trajectory affects performance of launch vehicle.

The mass, pitch and yaw angles to construct ascent trajectory are optimized to meet the IIP requirements and orbit insertion requirement. Trajectories of launch vehicle are simulated with 3 degree of freedom motion and IIP is calculated in this module. Constraints include flight constraints such as IIP, expansion ratio, maximum dynamic pressure, and maximum angle of attack and LEO mission requirement constraints such as altitude, inclination angle, flight path angle, and velocity of target orbit.

Trajectory optimization is an optimal control problem. There are two well-known numerical methods, direct and indirect methods, that convert optimal control problems to parameter optimization problems. This paper uses a direct method that parameterizes states or control of continuous problems and directly uses numerical method to optimize performance index. Among many direct methods, Sequential Quadratic Programming (SQP) are chosen because it is known as the efficient method for solving nonlinear programming. After SQP runs with trajectory simulation, optimal payload mass, pitch and yaw angles are obtained in each phase. These results can change the trajectory of launch vehicle to maximize their performance and obtain safe trajectory.