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Author: Mr. Hirokazu SUZUKI
Japan Aerospace Exploration Agency (JAXA), Japan, hirokazu@chofu.jaxa.jp

SYSTEM DESIGN OF ROCKET PLANE USING DYNAMIC INVERSION THEORY

Abstract

JAXA is studying an air-launched Rocket Plane Experiment Vehicle to obtain new technologies, which are cost reduction, safety and reliability improvement. During concept study phase, the most important things are to ascertain realization of flight experiment and to dig up lurked risk within short period by more precise analysis. The concept study is basically done by the aerodynamic characteristics estimation, the flight analysis, and the mass estimation. Because we need a lot of time to design a control system, the flight analysis is usually executed by three degree of freedom without the controller. This analysis is insufficient to do the FEM analysis for the mass estimation. Therefore, the vehicle mass is estimated based on the statistical approach. Clearly, it has low reliability as a result of obtaining by this classical approach. This paper proposes a new flight analysis method to use the system design of the rocket plane. The new method is combination of the optimal trajectory design and the dynamic inversion theory, and it is performed by six degree of freedom with the guidance and control law. The proposed method accomplished 95% reduction of the workload by comparing with the classical approach. The method has also a superior advantage that it can be easily adopted for the other vehicle and various missions. Moreover, the result supplied sufficient technical data, the gust response of the vehicle, maximum control surface deflection state, and so on, to do the FEM analysis for the mass estimation. Finally, it was discovered that the vehicle will become an uncontrollable state just after the separation from the mother ship if the vehicle has asymmetric aerodynamic force or the offset of the center of the gravity in the body y-axis. In the near future, the FEM will be done to estimate the vehicle mass; then the second loop system design will be conducted to improve the vehicle characteristics. The proposed flight analysis method will contribute to the shorter period and to the more precise analysis of the system design. Moreover, the newly proposed method dug up successfully the lurked risk which was almost impossible to detect by the classical design method.