Paper ID: 14276
oral

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (2) (2)

Author: Mr. Satoshi Ueda
Japan Aerospace Exploration Agency (JAXA), Japan, ueda.satoshi@jaxa.jp

Dr. Finn Ankersen
European Space Agency (ESA), The Netherlands, Finn.Ankersen@esa.int
Mr. Alvaro Martinez Barrio
European Space Agency (ESA), The Netherlands, Alvaro.Martinez.Barrio@esa.int

ROBUST CONTROLLER DESIGN METHODOLOGY FOR PLANETARY LANDING SYSTEM CONSIDERING 6 DEGREES OF FREEDOM

Abstract

A planetary landing system employing a soft landing method requires sufficient control performance because the landing function has a limitation of tolerable mechanical load which is mainly dominated by residual velocities before contact. Considering the nature of planetary landing mission, the system must be designed with sufficient robustness for uncertainty to maintain stability and performance. In addition, Guidance, Navigation and Control system design need to consider limitations of thruster such as maximum force or characteristic of pulse firing. This paper presents a methodology for designing a controller which meets the requirements of performance, thruster capability and robustness. The equations of motion for a rigid vehicle, expressed as the translation of its center of mass and rotation about the center of mass, decouple into two vector equations each of which has 3 dimensional vector. For controller design and evaluation, internal dynamics like sloshing behavior need to be considered as well as 6 degrees of freedom rigid body dynamics. As a framework of controller design, Mu Synthesis is used to ensure robustness. Initially, single-input single-output (SISO) control problem is constructed for single degree of freedom; e.g. vertical position control. For construction of a generalized plant, disturbances to the spacecraft are assigned as inputs to the generalized plant; a control signal as well as a performance signal is assigned as an output from the generalized plant; that makes the designer be able to handle the control signal within the thruster characteristic with the condition of modelled uncertainty. Then, SISO generalized plants are appended to form an augmented generalized plant; i.e. multi-input multi-output (MIMO) generalized plant for 6 degrees of freedom. By designing a controller using Mu Synthesis for the MIMO generalized plant, 6 degrees of freedom closed loop system ensures robustness for disturbances from coupling dynamics as well as disturbances within each degree of freedom. As an example, proposed methodology is applied to a Mars landing system controller design. The simulation result shows that designed controller maintains required performances with sufficient robustness; it is compared with the result of the simulation in case classical PD controller is applied. The methodology proposed in this paper is applicable not only to a planetary landing system but also to another type of spacecraft which has similar limitations; this leads to an advanced technology for future manned vehicle, like a lander of planetary exploration mission.