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GNC DESIGN AND VALIDATION FOR PINPOINT LANDING ON PHOBOS

Abstract

This article describes the design and analysis of an autonomous Guidance Navigation and Control (GNC) for Phobos Sample Return mission for the Descent and Landing phase. It outlines the main drivers for the design choices including operational constraints, pinpoint landing requirements, environmental conditions: Sun exposition and day duration on Phobos, complex three body dynamics, initial knowledge and dispersions.

Two strategies have been selected to meet the tight requirements within the previously mentioned constraints for the GNC, with different levels of autonomy: one relying on a priori knowledge from ground-based navigation through features based recognition to initiate the autonomous GNC with a direct descent scenario, another one relying on autonomous absolute navigation performed during an hovering phase with an additional ground operations check and go command to initiate the descent itself with autonomous GNC and relative navigation.

The autonomous GNC for the descent and landing phase relies on relative navigation based on unknown landmarks tracking and altimeter measurement for the translation and on Star Tracker and gyro for the attitude navigation. The translation guidance is optimized on ground to find the best compromise between Image Processing (IP) requirements, time of descent and delta V consumption. The 6 degree of freedom (DOF) control is based on RCS thrusters to control both attitude and translation through 6DOF actuation.

The GNC for the two strategies, which differ mainly from the tuning and mode management perspectives, have been extensively tested through Monte Carlo campaign and sensitivity analyses. The main outcome of these analyses are presented here to show both performance and robustness of the design relative to model errors and uncertainties as gravity, thruster performance, camera field of view, variety of landing sites. In addition to these analyses some high added value tests have been performed with high fidelity model for Phobos shape to generate realistic images.