Paper ID: 53959
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (9)

Author: Mr. Benjamin Margolis
NASA Ames Research Center, United States, benjamin.margolis@nasa.gov

Dr. Wendy Okolo
NASA Ames Research Center, United States, wendy.a.okolo@nasa.gov
Dr. Sarah D'Souza
National Aeronautics and Space Administration (NASA), Ames Research Center, United States, sarah.n.dsouza@nasa.gov

CONTROL DESIGN & SENSITIVITY ANALYSIS FOR A DEPLOYABLE ENTRY VEHICLE WITH AERODYNAMIC CONTROL SURFACES

Abstract

Precision landing of high mass payloads (≥ 2 metric tons) on Mars or returning sensitive samples from other planets to specific Earth locations are driving the development of an innovative NASA technology called a Deployable Entry Vehicle (DEV). A DEV enables a relatively large aeroshell to be stowed within a reduced diameter for launch and later deployed to provide a low-ballistic coefficient entry system. Traditional entry systems rely on small reaction control thrusters mounted on the back shell for guidance and control (G&C). In contrast, DEVs have no back shell so a current challenge is the design of advanced G&C systems that enable a DEV to meet precision landing requirements.

This paper will describe the design and simulation-based validation of a control algorithm for a mechanically deployed rigid DEV architecture called ADEPT. This study is part of a NASA technology development effort to design, build, and test feasible G&C systems for DEVs. In this study, a novel application of aerodynamic control surfaces will be used to track angle of attack (α) and sideslip angle (β) guidance commands. Neither a control architecture primarily using aerodynamic control surfaces nor an α-β guidance have been feasibly integrated on a re-entry vehicle with a low lift-to-drag ratio.

A multi-input multi-output state feedback controller is designed based on Linear Quadratic Regulator (LQR) optimal control methods. This control design is chosen because with minimal effort, it can be adapted to varying missions and vehicle configurations, particularly those utilizing aerodynamic effectors. Furthermore, the LQR provides a mechanism that allows us to specify which and how much of a control variable to use to achieve tracking performance requirements.

Models of the ADEPT vehicle with control surfaces and the control algorithm will be implemented in simulation. The performance and robustness of the control system will be evaluated by simulating the tracking of guidance commands. Initial results show success finding the control deflections to maintain constant guidance commands and tracking a time-varying, nominal guidance command trajectory at different points in the flight envelope. These results will be extended to a Monte Carlo study with perturbations to the vehicle and atmospheric properties.