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Guidance and Control for Spacecraft Planar Re-Phasing via Input-Shaping and Differential Drag

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Abstract: This paper proposes a solution to the problem of re-phasing circular or low eccentricity orbiting, short-distance spacecraft, by integrating existing analytical guidance solutions based on input-shaping and analytical control techniques for differential drag based on Lyapunov theory. The combined guidance and control approach is validated via numerical simulations in a full nonlinear environment using Systems Tool Kit. The results show promise for future onboard implementation on propellant-less spacecraft.

Keywords: *input-shaping; differential drag; re-phasing.*

Mathematics Subject Classification (2010): 70Q05, 93B52, 93C10, 93C40, 93D05.

1 Introduction

Small spacecraft flying in close proximity for scientific, commercial, and defense applications, are increasingly appealing to space services providers and researchers (see [1–4]). In fact, for certain applications they are preferable to larger single spacecraft, due to their lower cost, and the inherent redundancy, in general, of a multiple-spacecraft system [5]. However, spacecraft solutions, such as those based on the CubeSat format, present a new set of design challenges, mainly related to the vehicles' limited size and power. The ability to incorporate thrusters and carry on-board propellant is extremely limited on nano-spacecraft weighting a few kilograms [6]. A valid alternative for planar maneuvering of spacecraft relative motion at low Earth orbits (LEO) is represented by atmospheric differential drag, where the differential accelerations necessary to control the satellites are generated by varying the relative cross-wind surface area. C.L. Leonard [7] introduced

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