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ORION GN&C DETECTION AND MITIGATION OF PARACHUTE PENDULOSITY

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New techniques being employed by Orion guidance, navigation, and control (GN&C) using a reaction control system (RCS) under parachutes are described. Pendulosity refers to a pendulum-oscilatory mode that can occur during descent under main parachutes and that has been observed during Orion parachute drop tests. The pendulum mode reduces the ability of GN&C to maneuver the suspended vehicle resulting in undesirable increases to structural loads at touchdown. Parachute redesign efforts have been unsuccessful in reducing the pendulous behavior necessitating GN&C mitigation options. An observer has been developed to estimate the pendulum motion as well as the underlying wind velocity vector. Using this knowledge the control system manuvers the vehicle using two separate strategies determined by a wind velocity magnitude threshold; at high wind velocities the vehicle is aligned with the wind direction and for cases with lower wind velocities the vehicle is aligned such that it is perpendicular to the swing plane. Pendulum damping techniques using RCS thrusters are discussed but have not been selected for use onboard the Orion spacecraft. The techniques discussed in this paper will be flown on Exploration Mission 1 (EM-1).

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