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SPACE LAUNCH SYSTEM IMPLEMENTATION OF ADAPTIVE AUGMENTING CONTROL

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Given the complex structural dynamics, challenging ascent performance requirements, and rigorous flight certification constraints owing to its manned capability, the NASA Space Launch System (SLS) launch vehicle requires a proven thrust vector control algorithm design with highly optimized parameters to robustly demonstrate stable and high performance flight. On its development path to preliminary design review (PDR), the stability of the SLS flight control system has been challenged by significant vehicle flexibility, aerodynamics, and sloshing propellant dynamics. While the design has been able to meet all robust stability criteria, it has done so with little excess margin. Through significant development work, an adaptive augmenting control (AAC) algorithm previously presented by Orr and VanZwieten, has been shown to extend the envelope of failures and flight anomalies for which the SLS control system can accommodate while maintaining a direct link to flight control stability criteria (e.g. gain & phase margin). In this paper, the work performed to mature the AAC algorithm as a baseline component of the SLS flight control system is presented. The progress to date has brought the algorithm design to the PDR level of maturity. The algorithm has been extended to augment the SLS digital 3-axis autopilot, including existing load-relief elements, and necessary steps for integration with the production flight software prototype have been implemented. Several updates to the adaptive algorithm to increase its performance, decrease its sensitivity to expected external commands, and safeguard against limitations in the digital implementation are discussed with illustrating results. Monte Carlo simulations and selected stressing case results are shown to demonstrate the algorithm's ability to increase the robustness of the integrated SLS flight control system.

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