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Rocket Launch Simulation for a Multi-Mode Failure Prediction Analysis

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Abstract : The advancement of space exploration demands a robust space launch services program capable of reliably propelling payloads into orbit. Despite rigorous testing and quality assurance, launch failures still occur, leading to significant financial losses and jeopardizing mission objectives. Traditional failure prediction methods often lack the sophistication to account for multi-mode failure scenarios, as well as the predictive capability in complex dynamic systems. Traditional approaches also rely on expert judgment, leading to variability in risk prioritization and mitigation strategies. Hence, there is a pressing need for robust approaches that enhance launch vehicle reliability from lift-off until it reaches its parking orbit through comprehensive simulation techniques. In this study, the developed model proposes a multi-mode launch vehicle simulation framework for predicting failure scenarios when incorporating new technologies, such as new propulsion systems or advanced staging separation mechanisms in the launch system. To this end, the model combined a 6-DOF system dynamics with comprehensive data analysis to simulate multiple failure modes impacting launch performance. The simulator utilizes high-fidelity physics-based simulations to capture the complex interactions between different subsystems and environmental conditions.

Keywords : launch vehicle, failure prediction, propulsion anomalies, rocket launch simulation, rocket dynamics
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