Development of a Fully Reusable and Autonomously Landing Suborbital Launch Vehicle

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Throughout the past decade, significant aerospace research has focused on bending the cost curve of space exploration through the development of reusable boosters. However, the investments in reusable technology have been primarily directed towards the development of cost savings for large, orbital class boosters. This has left the smaller, lower-powered launch market without reusable technology which has resulted in relatively high launch prices. The development of technology capable of returning and landing smaller rockets could dramatically reduce launch costs. To achieve this goal, I worked towards developing hardware and software that enables a small booster to propulsively land, ready to be reused. The launch vehicle (rocket) that I have engineered utilizes Thrust Vector Control (TVC) to stabilize and slow itself on descent. The TVC propulsion system is accurately controlled by a custom-developed flight computer which runs on a 180 MHz ARM Cortex-M4 processor and contains all necessary sensors and control interfaces. Flight control software was developed to utilize Proportional Integral Derivative (PID) control loops to stabilize and control the vehicle. The PID coefficients were determined through the development of a mathematical model to simulate the vehicle's flight with six degrees-of-freedom. Rigorous ground testing was conducted before attempting real-world landing tests of the system. Additional hardware was also designed, built, and tested to support the landing and reusability of the rocket. My project analysis indicates that the successful development of this system shows significant potential to save costs for smaller launch vehicles by enabling them to propulsively land and be reused.