# Project HERMES: Design and Development of a Proof-of-Concept Sounding Rocket With an Adaptive ML Simulation for Propulsive Landings

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Suborbital research access costs $30k-$90k per mission, pricing out universities and independent researchers. Current reusable rockets depend on throttleable liquid engines for landing, which are expensive to build and maintain. Solid rocket motors (SRMs) offer a simpler, cheaper alternative but cannot throttle, historically making propulsive landings rely on manual tuning across dozens of flights. HERMES addresses both problems: a two-stage proof-of-concept payload deployment rocket and a computational framework that replaces trial and error with machine learning. A physical two-stage rocket was designed, built, and launched across multiple SRM configurations. The secondary body deployed at apogee successfully, increasing total achieved apogee by 42.7% and validating the staging mechanism across flight configurations. The guidance framework consists of a 6-DOF simulation validated against flight data to within 0.17 m, a Monte Carlo optimizer, an extended Kalman filter estimating mass and drag in realtime, and a neural network correcting the ignition command every 0.5 seconds from current flight state. The HERMES ML system achieved 79.3% landing success computationally versus 25.5% for fixed pre-computed ignition across all fault intensity bands, eliminating the need for trial and error in development. If generalized and empirically validated, this framework could significantly lower the barrier to reusable rocket development, with a full-scale build estimated at ~$4,700 and ~$465 per launch, enabling universities and small organizations to pursue propulsive landing and suborbital research at a fraction of current costs. Future work includes full-scale empirical launches and development of a custom SRM propellant formula.

**Awards Won:**
NC State College of Engineering: Scholarship to attend NC State Engineering Summer Camp