A "Rockoon" System For Efficient Small Payload Launches: A Proof Of Concept

By Joshua Cohen

Model Rockets

- Rockets and model rockets are identical, but are differentiated by scale and a few design factors
- Atmospheric flight, passive stabilization, short acceleration time, lightweight airframe
- Despite differences, model rockets are very important for rocket research- much easier to prototype

High Altitude Balloons

- Unmanned balloon lifted by helium or hot air to altitudes of up to 40 km
- Used worldwide for research by governments, research facilities, education, & for fun
- Robust flight systems capable of operating at extreme high altitudes and tracking the balloon during flight are very important

Rockoons

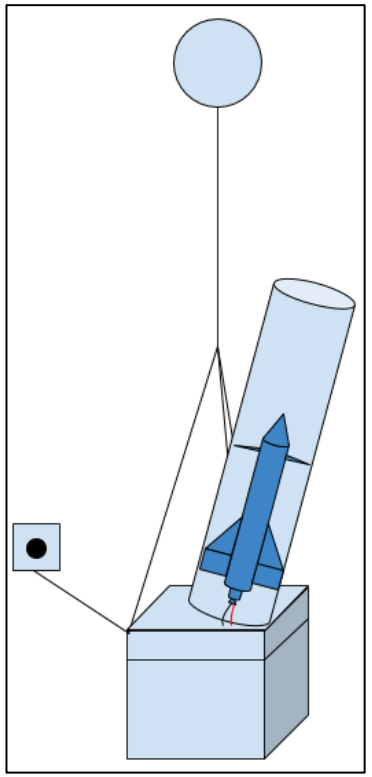
- Original concept dates back to 1949- lifting small rocket to high altitude to more efficiently achieve orbit
- Only recently became a potentially viable option to launch satellites into orbit (Cubesats, other small satellites)
- Has the potential to offer extremely low-cost access to Earth orbit

Cubesats

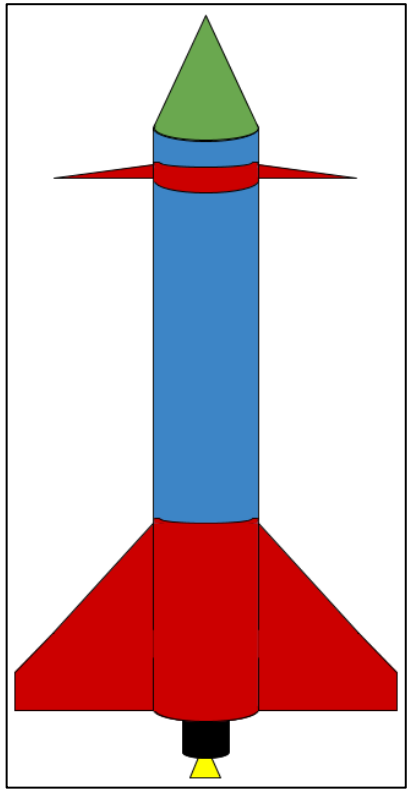
- Cubesats are satellites built in standard $10cm^3$ units ranging from 1 unit to 6 units in size
- Very small and lightweight compared to older satellite configurations, cheaper to launch- many are launched at one time in “rideshare” programs
- Despite low manufacturing cost it is still very expensive to launch a CubeSat into orbit

- Despite advancements in satellite technology (Cubesats) & spaceflight (Falcon 9 recoverable stage), the cost to get to orbit is prohibitively high
- Rockoon systems are highly promising for a reliable and low-cost system to bring small payloads to orbit, but have not gained significant traction in the spaceflight industry yet
- There has been previous research with rockoon systems, but very little data collected on actual gain in efficiency and the focus has been on large rocket launches
- A re-usable platform utilizing model rocket motors could conceivably be used by small research groups, schools and hobby organizations to launch CubeSats

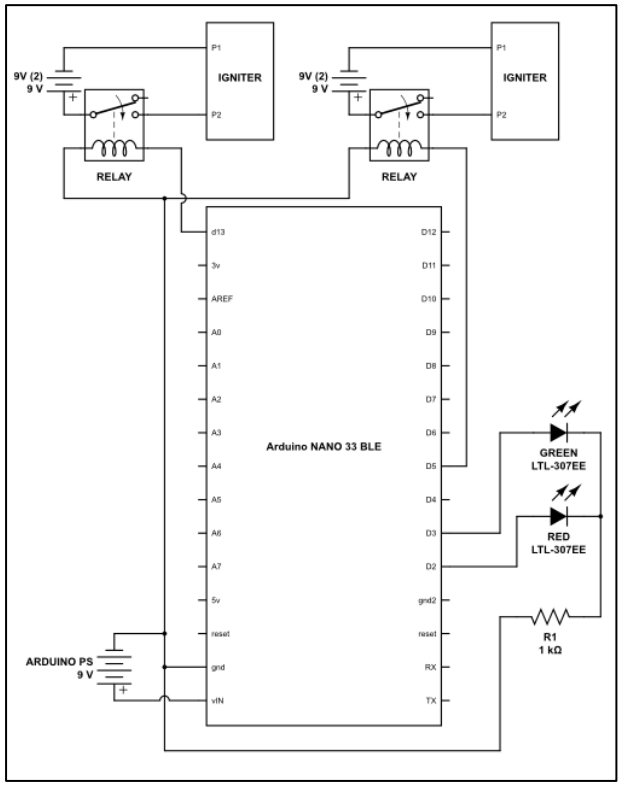
Design Requirements	Design Limitations
1. A stable launch platform that can be a payload for a high-altitude balloon 2. A rocket that can effectively launch from the platform at the anticipated altitude 3. A flight control system with a launch control system that can use sensors to determine if current conditions are suitable for launch & a remote ignition system to light the engine 4. A balloon release system to allow for easier recovery of the launch platform	• All components must be easily purchasable or 3D printable • The weight of the platform and rocket must not exceed 2 kg • Both platform & rocket must be able to safely descend from altitudes over 10 km, and must be individually trackable • Rocket must be able to transmit flight data to enable collection in the case of a failure to recover • The rocket must be compatible with an E30-7T composite propellant motor • The platform must be able to safely support the rocket & all electronics in high altitude weather conditions without tilting more than 10 degrees in any direction



Platform

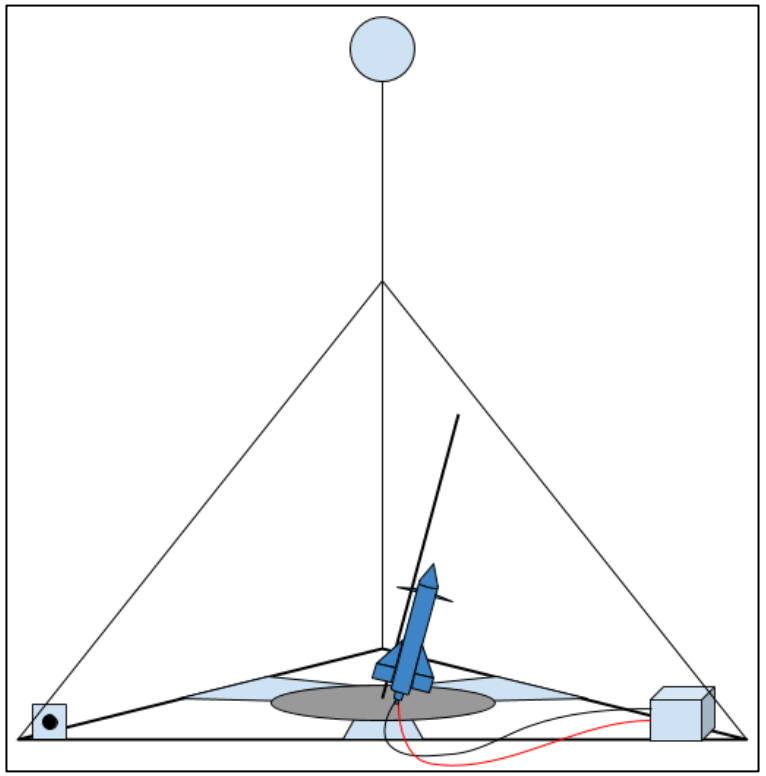


Rocket

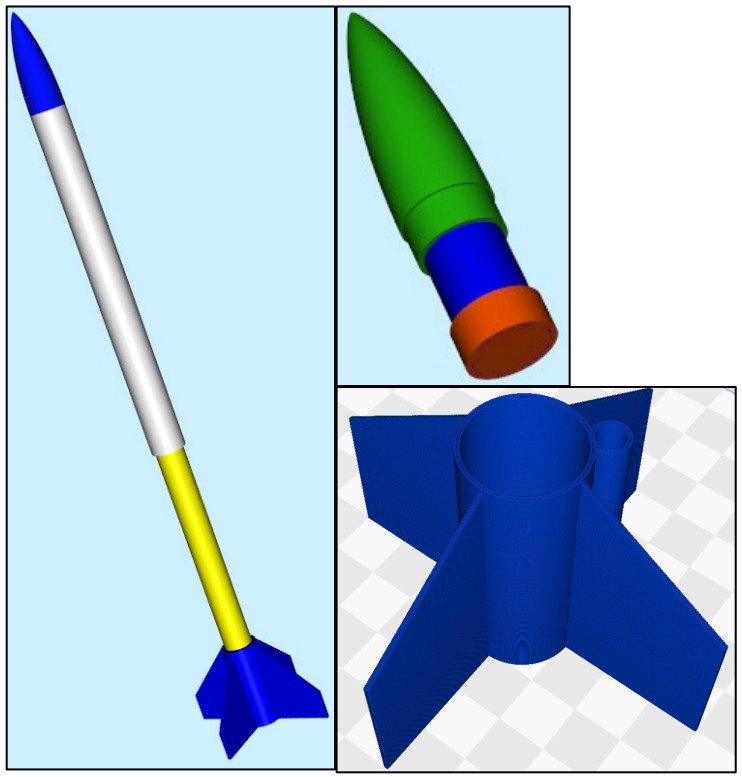


Flight Control System

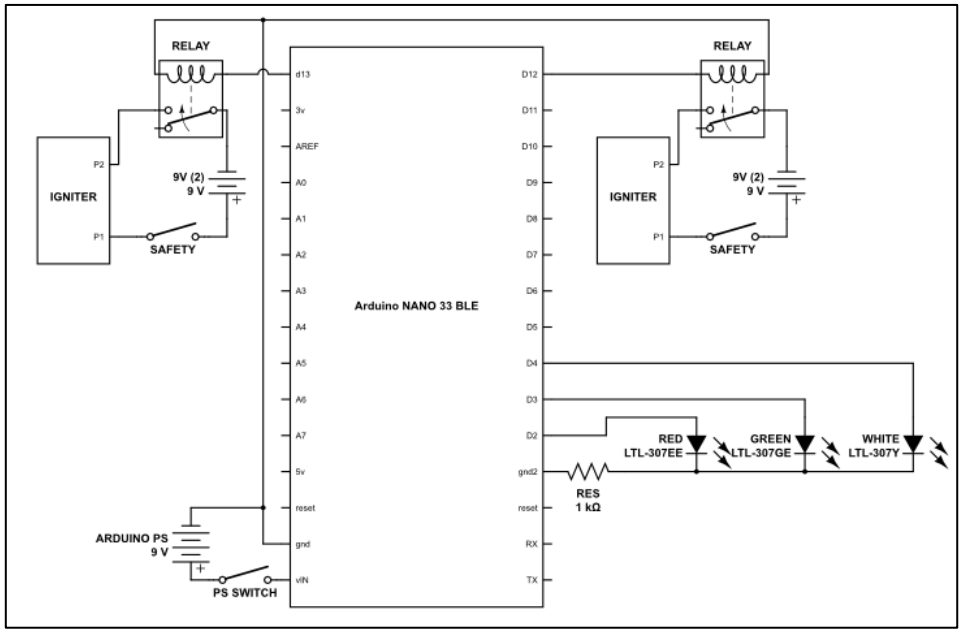
First Iterations- Never saw flight



Platform

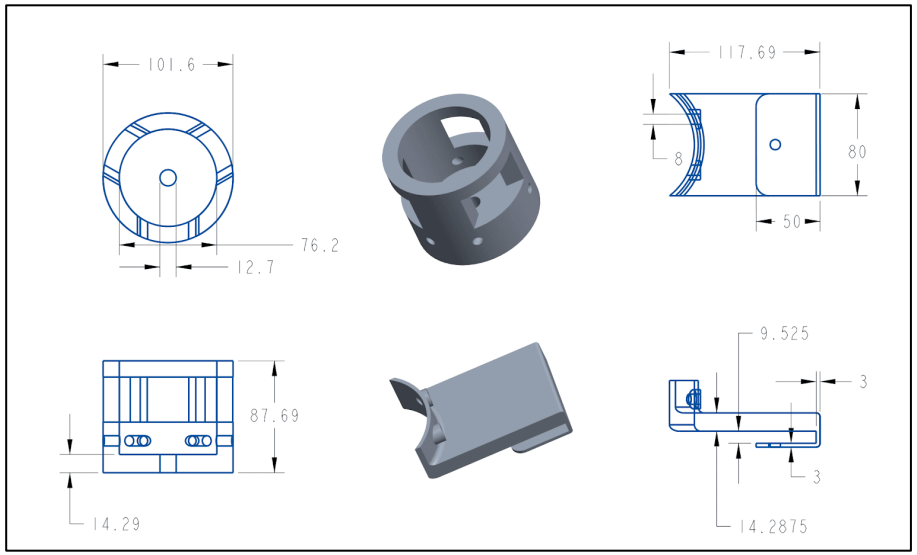


Rocket

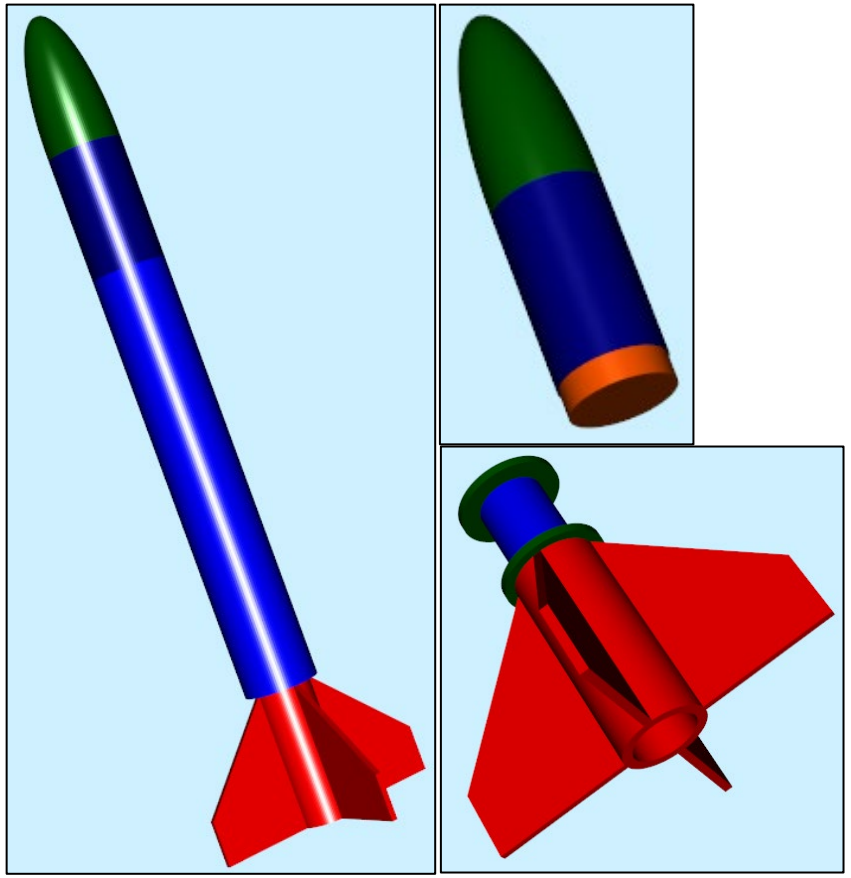


Flight Control System

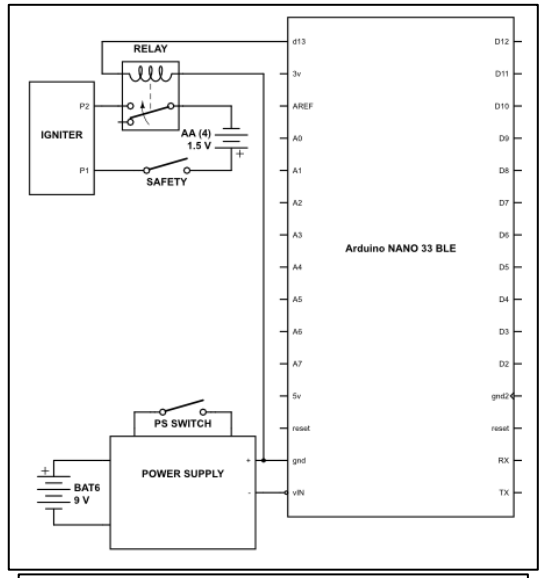
Second Iterations- Tested in flight

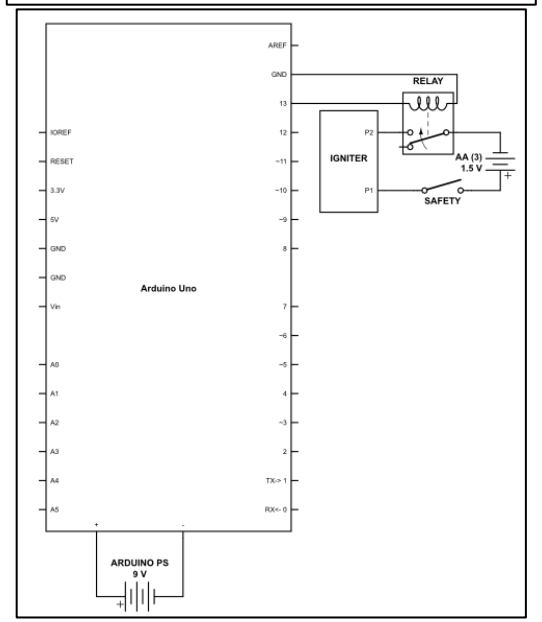


Platform Components



Rocket



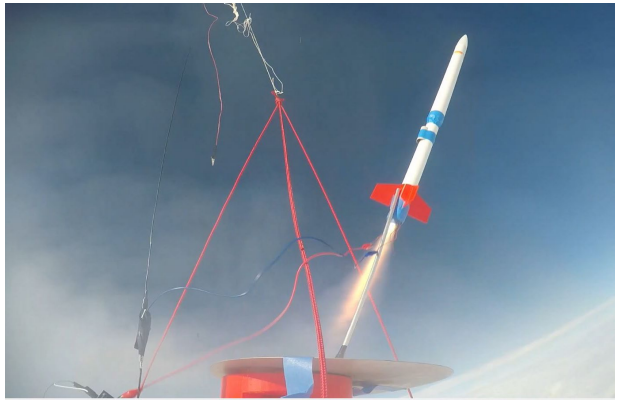


Flight Control Systems

Third Iterations- Final designs

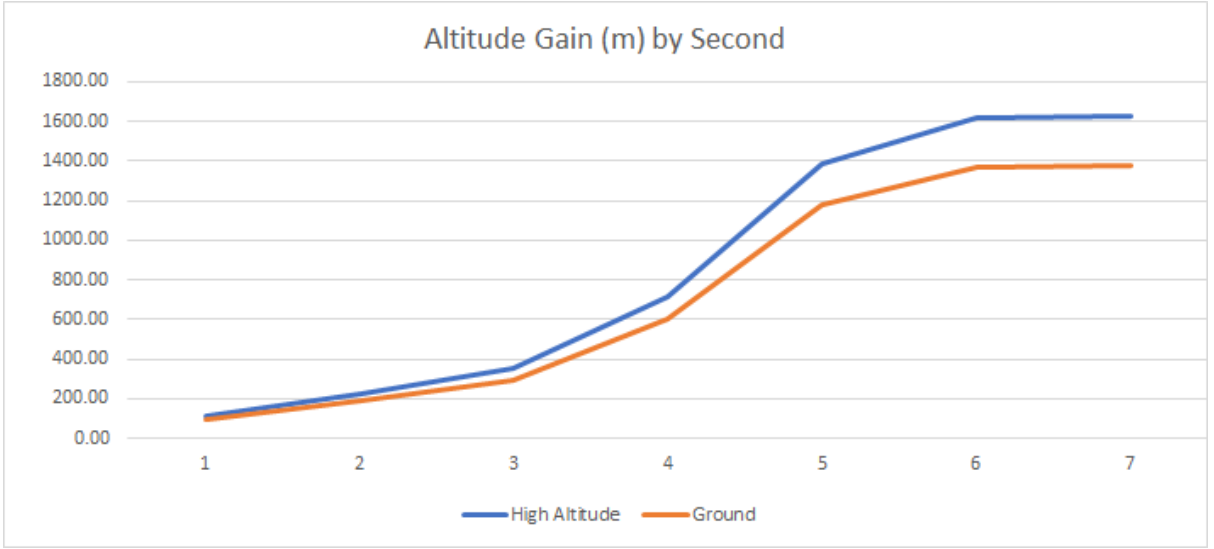
- Two successful launches with the final iterations of the designs - one from the ground and one from an altitude of 2,667 m from the rockoon system
  - One successful launch with 2nd iteration designs from a height of 5,920 meters (no flight data collected due to loss of rocket)
- Ground launch peak change in height: 439 m
- High altitude peak change in height: 493 m
- Ground launch max altitude: 439 m
- High altitude max altitude: 3,160 m

Ground Launch (Control)


Launch from 5,920 meters


High-Altitude Launch

- Multiple launches from the ground and from high altitude demonstrated significant gain in efficiency
- +70 m difference in peak change in height between ground launch & launch at 2,667 m
- Total altitude achieved by rockoon launch is only achievable from the ground with a 54mm Level 2 high power certified engine



Vantage point from high-altitude launch

- Technical difficulties with the satellite trackers used to track & recover the rocket and platform made recovery difficult- future tests will use a more robust tracking system, such as a more robust flight computer onboard the rocket.
- A more comprehensive flight control system that would allow for greater control of launch vectors and more accurate flight path tracking.
- Launching at higher altitudes with larger engines will amplify the efficiency gain significantly but introduce additional engineering challenges such as protecting the components from environmental conditions and the need for more comprehensive stabilization (active and/or passive) of the rocket due to the lack of air pressure.
- Future tests at higher altitudes with the goal of reaching the Kármán line

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