Design Optimization for a Student-Built Sub-Orbital Rocket

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Nomenclature

$M_0^{+\circlearrowleft}$ Moment in the x-axis (N m)
T^0 Torque (N m)
θ Angular position (°)

I. Introduction

High-powered rockets, (def) have been operated by numerous student organizations around the world for several decades. The development of such launch vehicles offer education opportunities to students who often perform in engineering competitions, such as IREC or NASA's Student Launch. Student built rockets have also hosted scientific payloads. Finally these vehicles can be testbeds for novel technologies...

The Portland State Aerospace Society (PSAS) is an engineering student organization and citizen science project located at Portland State University dedicated to developing low-cost, open-source, and open-hardware high-powered rockets and avionics systems with special interests in venture class launch vehicle technologies and nanosatellites.[?] In 2015 PSAS initiated a project to build and fly the first student built rocket above the so-called 'Von Karman line', by most definitions the dividing line between the Earth's atmopshere and outer space.

Numerous design challenges for a rocket designed for this mission.

Difficulty of aerospace MDO, design coupling. The trajectory problem.

II. Methods

Discussion of objective statement. Summary of statement and constraints. Trajectory simulation. Tank mass/ volume. Simplex search algorithm. (Choice of initial vertices, Additional contraction cases in 4D-space), issues with convergence, non-dimensionalization, multi-modality of response surface, parameter sensitivity (table of minima vecotrs). Benchmark with scipy. Tables of minima vectors.

```
from math import sqrt, pi, exp, log, cos
import numpy as np
import csv

# A simple forward Euler integration for rocket trajectories
def dry_mass(L, dia):
    m_avionics = 3.3                             # Avionics mass        [kg]
    m_recovery = 4                               # Recovery system mass [kg]
    m_payload = 2                                # Payload mass         [kg]
    m_tankage = 20.88683068354522*L*dia*pi # Tank mass Estimation [kg]
    m_engine = 2                                 # Engine mass          [kg]
    m_feedsys = 20                               # Feed system mass     [kg]
```

```
    m_airframe   = 6                          # Airframe mass          [kg]
    return (m_avionics + m_recovery + m_payload + m_tankage
    + m_engine + m_feedsys + m_airframe)    # Dry mass               [kg]
```

III. Results

Discussion of converged results, implications for design of LV4

IV. Future Work

Model improvements: tanks mass/volume, other dry mass contributions, experiment with global optimization schemes, drag improvements, post-hoc analysis.

V. Conclusion

Focus on novelty of the problem.

VI. Appendix

References

[1] Mahoney, Erin. *CubeSat Launch Initiative: 50 CubeSats from 50 States in 5 Years*. NASA, April 9, 2015. http://www.nasa.gov/content/cubesat-launch-initiative-50-cubesats-from-50-states-in-5-years.