GALLOGLY COLLEGE OF ENGINEERING
SCHOOL OF AEROSPACE AND MECHANICAL ENGINEERING
The UNIVERSITY *of* OKLAHOMA

BOEING

Payload Carrying Carbon Fiber 2-Stage Rocket

BOOMER ROCKET TEAM

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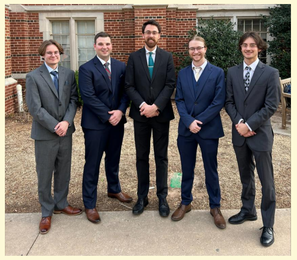
Advisor: Dr. Srikanth Bashetty



Background

The Argonia Cup is a high-powered collegiate rocketry competition that challenges students to design, build, and fly a rocket to meet specific objectives within design constraints.

Design Constraints

- Must be a 2-stage rocket
- Must carry a golf ball payload
- Must launch with 2, 12 ft "1515" launch rails
- Maximum total impulse of 5120 N•s
- Minimum liftoff thrust-to-weight ratio of 5:1
- Maximum apogee of 45,000 ft AGL

Engineering Standards

- National Association of Rocketry's High Powered Rocket Safety Code
- Any motors used will only be purchased by those holding proper certifications
- The rocket will be made of only lightweight materials, and ductile metal when needed.
- The rocket must be equipped with an electrical launch prevention switch

Objectives

Launch a two-stage rocket with a payload of golf balls while staying within the constraints of the Argonia Cup regulations. This entails:

- mid-flight sustainer motor ignition
- successful deployment of recovery systems
- survival of ground impact

To achieve a competitive score in the Argonia Cup, the team further identified objectives based directly on the Argonia Cup's scoring equation:

$$\text{Score} = \text{Apogee}_{\text{sustainer}} * (n/10+1)$$

These objectives are:

- achieve highest altitude possible
- carry the maximum payload possible

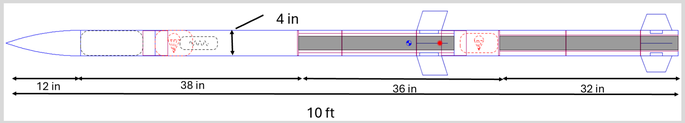
Above: Nose Cone Mold
Below: Payload Bay Tube

Mandrel

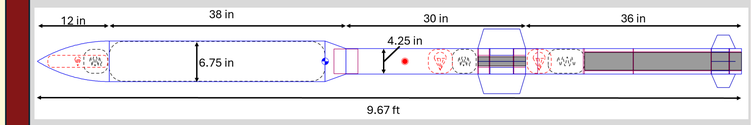
Finished Body Tubes

Design Process

- OpenRocket software was used to make and simulate each of the rocket designs. The preliminary design can be seen below.



- Designs included a 4 in body tube for both the booster and sustainer.
- Variation between designs involved sizing of the payload bay.
- Different diameters were first tested to determine the size of the payload bay.

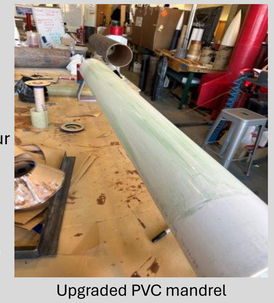


- Due to the use of non-standard mandrels during the manufacturing process, the diameters of the body tubes and the payload bay were bigger than expected.
- We had to manufacture other parts like the centering rings, bulkheads, and nosecone differently due to the non-standard industry body tubes.
- Final payload capacity: 256 golf balls
- Total length: 10 ft
- Booster motor: AeroTech L1420, 4,603 N·s of impulse.
- Sustainer motor: AeroTech H999, 320 N·s of impulse.
- Total impulse: 4,923 N·s.

Manufacturing Process

- Our first attempt at manufacturing a carbon fiber tube resulted in the cardboard tube we had used as a *mandrel* (the frame for a carbon fiber layup) adhering to the carbon fiber tube itself
  - While we eventually got the mandrel out of our tube, it was destroyed in the process, so we knew we needed to improve.
- On our following layups, we exchanged the cardboard for a PVC tube that we had sanded and waxed for smoothness.
- This change in the manufacturing process greatly increased the quality of our final product
  - Each subsequent layup we worked to further eliminate defects and errors in our method
- We also employed a new method of sanding.
  - By mixing epoxy with powdered glass microspheres prior to sanding, micro-abrasions on the surface of the tube could be eliminated much easier
  - Resulted in an even smoother finish before we applied the paint

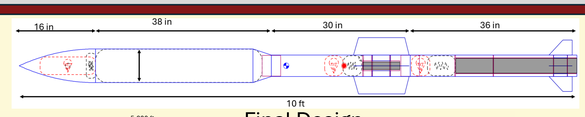
Removal of the cardboard



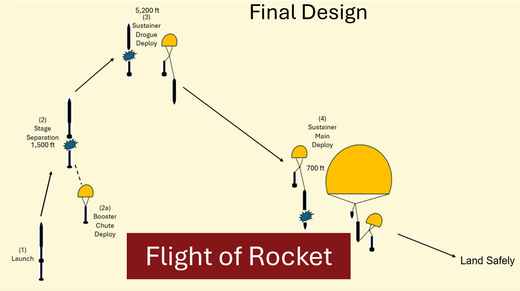
Upgraded PVC mandrel

Results

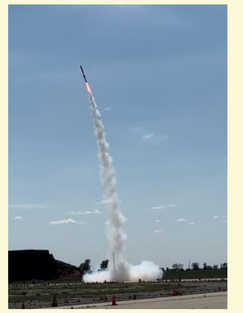
- Nosecone split in half during first ground test:
  - "Main event": stage separation of nosecone from payload tube
  - Solution: carbon fiber wrap around cone to bear high internal pressure during event (black powder charge)
- All other ground tests were successful
- Due to stability issues, "*Pointy End Up*" was unable to fly in the Argonia Cup competition:
  - Final CG of the rocket and its second stage was farther aft than predicted
  - Solution: Larger fins on both booster and sustainer
- Additional improvements undertaken:
  - Shoulder tabs on nosecone for easier pre-flight assembly
  - Redesigned forward bulkhead mount (bears shock of main parachute deployment and inflation)
- The final design of the rocket is shown below
- Expected apogee: 5,250 feet
- Expected score: 133,875 pts



Final Design



Flight of Rocket



Rocket Mid-Flight

Rocket After Recovery

Ground Test of the "Main Event"

Conclusions and Future Work

Using methods for carbon fiber body tube manufacturing and known procedures for model rocket construction, the Boomer Rocket Team was able to

- Construct a rocket capable of carrying a 256-golf ball payload at an expected altitude of 5250 feet.
- Utilizing the TeleMega flight controller a successful two-stage flight is expected.
- The simulations generated from the OpenRocket program preview a stable rocket.
- Through many different design processes and iterations, a final design was reached that maximized the potential score for the Argonia Cup.
- Future work includes participating in upcoming rocketry competitions that will build on previous designs.