GUARDIANS OF THE STRATOSPHERE
Final Presentation

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PRIMARY MISSION OVERVIEW

Mission: Generate power from wind turbines and measure the speed of sound.

Hypothesis: As wind speed increases, the power created by the wind turbines will increase, however higher density air will also lead to more power. Therefore, the team expects to find that the optimal altitude for power generation lies between these two factors.
Mission Purpose

An increasing interest in renewable resources has led people to look towards wind power as an alternative to fossil fuels. A source of massive wind energy is the jetstream, which this mission investigated. Space-Copter measured wind power with a small turbine to see if jet stream wind farms would be a viable option for future energy production.

The second mission of Space-Copter was to measure the speed of sound through the different altitudes. Super sonic flight brings challenges with incredible turbulence and stability issues. Knowing how this factor changes is essential to high speed travel.
Flight went as expected. Met minimum requirement: all sensors recorded data. Launch went as predicted by the team, besides low burst altitude.
Evolution of Design

Over the course of the semester, many different designs were modeled and created before the final flight design was officially created.

The following slides show a certain “evolution” of the team’s balloonsat.
Design Flaws
With four fans in one chamber, air flow would be restricted for the other three fans. Also, this model would prove to be massively overweight. There’s also not a whole lot of space for other hardware.
Design Flaws
This is a very unnatural and inefficient design. With so much open space, wind would not properly flow through the chamber on the bottom. Also, this would be greatly overweight.
Design Flaws
This was supposed to be the flight model, but there was a lot of empty space that was not allowing the box to properly orient itself. After complete construction, it was determined that it would not fly due to weight issues.
This was the final, flown model. There are not too many differences from the actual structure, besides the placement of batteries.
This is the structure flown, it was 74 grams over the original budgeted weight.
As one can see, the wind speeds around the flight path are fairly calm, even in the jet stream.

Conditions were not optimal for proper analysis.
Minimum Wind Speeds to Spin Fan: 4.3 m/s

Fan is on the brink of turning, returning low voltage

All three peaks correspond to frequency surges
Power vs. Time

Altitude between 29,128 and 30,477 ft

Directly corresponds to the jetstream
Speed of Sound Data

Minimum Temperatures in the Tropopause Correspond with Malfunction

Approximate peak altitude

The sonar sensor was malfunctioning, reading very low occasionally
Sonar Sensor Verification

The sonar sensor was verified by inserting the balloonsat into a plastic bag and changing the pressure. The sensor was properly responding to the changes.

![Graph showing Speed of Sound vs. Time with Pressure constantly changing and Pushing on bag during test]
Pressure Data

Pressure decreases on ascent and then increases on descent as predicted.
Temperature Data

Inside:
Min: 15 degrees
Max: 57 degrees

Outside:
Min: -50 degrees
Burst: 20 degrees
Max: 57 degrees
Humidity Data

Humidity spiked during descent because of condensation.

[Graph showing RH (%) over time with annotations for Tropopause, Burst, and Landing.]
Accelerometer Data

Remained stable throughout flight until burst
Best Pictures
Failure Analysis: Sonar Sensor

Sonar sensor malfunctioned at peak altitude, corresponding with external temperatures reaching lows of nearly -40 degrees Fahrenheit.

RETESTING: The team was able to recreate the malfunction with dry ice, causing the sensor to flatline again. The team believes the quartz oscillator was the malfunctioning unit as temps became extremely low. As shown in the final graph, the sensor also gave off incorrect data when exposed to wind and noise. If the sensor were to be used again, the team would slightly alter the structure to keep the oscillator warm.
Failure Analysis: Low Wind Speeds

Wind speeds were much lower than expected - fan did not spin for most of the flight

RETESTING: We re-tested minimum speed needed to get fan spinning

4.3 m/s

Wind Tunnel minimum speed was 4.7 m/s

CONCLUSION: Wind speeds in the upper atmosphere were mostly below 4.3 m/s
Conclusions

The jet stream contains much more power than other layers of the atmosphere. Our hypothesis was correct, and there is a good possibility to make wind farms in the jet stream.

Sonar data, though disrupted, followed a downward trend with increasing altitude which was expected.
Payload landed undamaged and ready to fly again.

Payload should be stored in a dry place, humidity may ruin the sensors.

To prepare payload for flight, replace batteries, reseal the box, and flip the switches.
Thank You!!
Appendix: Message to Fall 2015

Be ready to...

• Turn in assignments on time;
• Commit lots of time to this class;
• Be challenged;
• Fail (probably more than once...);
• Work really hard;
• Get organized and plan ahead;
• Meet people and make friends;
• Get comfortable in the ITLL;
• Have fun!
Appendix: Lessons Learned

What would you have done differently if you could do this over?
We would have chosen different components for our experiments, (fan with less resistance, sonar sensor rated for low temperature.)
Designed box to be more aerodynamic.

What could you have done to get different results?
Launch on a more windy day.
Appendix: RFP Compliance

Space-Copter flew two Arduinos, two additional experiments using two additional sensors, a camera, an American flag, and contact information.
Space-Copter landed ready to fly again.
The flight string went through a plastic tube through the middle of Space-Copter.
Minimum internal temperature was +15°C.
Total mass was 1074g.
All purchases were made though Chris Koehler.
Everyone had fun and no one was hurt.
## Appendix: Budgets

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Source</th>
<th>Mass (g)</th>
<th>Count</th>
<th>Flight Mass (g)</th>
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<tr>
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<th>Item</th>
<th>Cost</th>
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<th>Unit Cost</th>
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<th>Price</th>
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<th>Weight</th>
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<td><strong>Total</strong></td>
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