Team Hot Air

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ABSTRACT

Pilots currently rely on standardized, often outdated constants and government-provided models to determine flight readiness, including density altitude, oxygen requirements, fuel needs, and expected aircraft performance. These values are typically not derived from direct experimental measurements and are updated infrequently. Team Hot Air addresses this gap by developing a high-altitude experimental payload (DemoSat) to collect real-time atmospheric and performance data across varying altitudes. The system integrates temperature, pressure, humidity, and acceleration sensors with an Arduino Uno, onboard battery, and solar charging system to measure environmental conditions and energy performance both in-flight and against ground controls. The project also evaluates oxygen partial pressure, battery life, solar charging efficiency, and aircraft performance trends as altitude changes. Stakeholder input from helicopter, hot air balloon, and fixed-wing pilots guided test priorities, emphasizing solar energy performance, atmospheric density effects, oxygen availability, and aerodynamic behavior. The experiment is expected to validate and refine existing atmospheric models while providing updated empirical relationships for density altitude and oxygen availability. It is also anticipated that higher altitudes will improve solar charging efficiency and reduce aerodynamic drag effects on balloon performance. Ultimately, Team Hot Air's DemoSat aims to improve the accuracy of pilot calculations and enhance decision-making for multiple classes of aviation operations.

BACKGROUND

Hot Air Balloon Stakeholder

- Density Altitude
- Oxygen patrial pressure

Fixed Wing Stakeholder

- Aircraft performance
- Properties of air
- Acceleration

Helicopter Stakeholder

- Efficiency of solar panels

MEASUREMENTS

- Density Altitude
- Oxygen Partial Pressure
- Solar Charger Rate
- Aircraft Performance
- Properties of Air
- Battery Life

METHODS AND EQUATIONS

- The flight resulted in an actual air density result of 77,017.292 kg/ft^3 while the standard calculation was 82,702.16 kg/ft^3
- Equations for Partial Pressure of oxygen: Po_2 = 0.2095(P(total)-(RH/100)(P(sat))
- Solar panels method : Compare from both flight and control panels and see how much the panels charged
- Temperature conversion: Fahrenheit to Celsius (°C = (°F - 32) × 5/9)
- Temperature conversion: Celsius to Kelven (K = °C + 273.15)

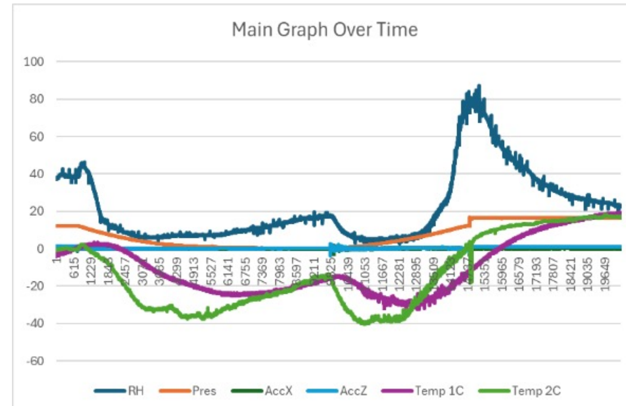
	Time	Temp1F	Temp2F	RH	Pres	AccX	AccZ	Temp	Temp	Temp	Temp
7222	4E+06	-10.49	-14.89	7.46	0.45	0.065	0.139	-23.6056	-26.05	249.5444	247.1
7223	4E+06	-10.49	-14.89	11.24	0.45	0.065	0.095	-23.6056	-26.05	249.5444	247.1
7224	4E+06	-10.49	-14.89	11.24	0.45	0.08	0.11	-23.6056	-26.05	249.5444	247.1
7225	4E+06	-11.37	-14.89	11.24	0.45	0.11	0.169	-24.0944	-26.05	249.0556	247.1
7226	4E+06	-11.37	-14.89	11.09	0.45	0.036	0.169	-24.0944	-26.05	249.0556	247.1
7227	4E+06	-11.37	-14.89	11.09	0.45	0.125	0.125	-24.0944	-26.05	249.0556	247.1
7228	4E+06	-10.49	-14.89	10.93	0.45	0.006	0.184	-23.6056	-26.05	249.5444	247.1
7229	4E+06	-10.49	-14.89	10.77	0.45	0.051	0.125	-23.6056	-26.05	249.5444	247.1
7230	4E+06	-10.49	-14.89	11.24	0.45	0.08	0.154	-23.6056	-26.05	249.5444	247.1
7231	4E+06	-11.37	-14.89	11.09	0.45	0.11	0.125	-24.0944	-26.05	249.0556	247.1
7232	4E+06	-10.49	-14.89	10.93	0.45	0.021	0.139	-23.6056	-26.05	249.5444	247.1
7233	4E+06	-10.49	-14.89	11.24	0.45	0.065	0.169	-23.6056	-26.05	249.5444	247.1
7234	4E+06	-11.37	-14.89	10.77	0.45	-0.068	0.125	-24.0944	-26.05	249.0556	247.1
7235	4E+06	-10.49	-14.89	10.93	0.45	-0.024	0.169	-23.6056	-26.05	249.5444	247.1
7236	4E+06	-11.37	-15.77	11.4	0.45	0.036	0.228	-24.0944	-26.5389	249.0556	246.6111
7237	4E+06	-10.49	-14.89	11.09	0.45	0.051	0.169	-23.6056	-26.05	249.5444	247.1

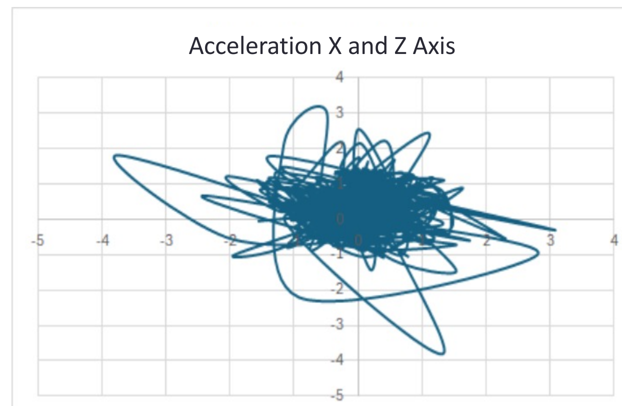
- Image 1 (Left): Control panels read 0.62 Volts after flight
- Image 2(Right): Flight Panels read 1.706 Volts after flight
- Image 3(Center top): Raw data from the payload with Temperature conversion: Fahrenheit to Celsius (°C = (°F - 32) × 5/9)
- from Fahrenheit, Celsius, and Kelvin in that order

RESULTS

- Air density calculations were 7% lower compared to standardized calculations.
- Oxygen partial pressure calculations were 10% lower compared to standardized calculations indicating a lower threshold of oxygen use compared to FAA regulation.
- Solar Pannels charged 2.7 times faster at high altitude compared to ground control tests.

RESULTS





CONCLUSIONS

- Air density calculations are useful for climatic atmospheric conditions.
- FAA's required use of oxygen levels are too low; oxygen partial pressure is a crucial calculation that should be used.
- Solar panels are a practical choice for charging necessary components in upper atmosphere conditions.