Payload Stabilization System for Improved High-Quality Photography

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INTRODUCTION

Experimental payloads on high altitude balloons are subject to significant atmospheric turbulence, resulting in both payload rotation and swing. This turbulence makes it difficult to achieve a high-quality video recording from any balloon-based system in the lower atmosphere, especially a 360° video which requires relative stability to ensure effective post-processing. In particular, experiments that rely on targeted footage have often been hampered due to erratic video footage caused by random payload movement at altitude. Here we discuss a project that reduces both swing and rotation of payloads on high altitude balloon missions. We show how to create a system that can be used to record high-quality photography and video, which can supplement experiments where stabilization is needed. During the Total Solar Eclipse of 2017, a high altitude balloon payload was configured to record photos and video from the upper atmosphere using a custom-built camera rig. The rig carried and stabilized seven cameras in such an arrangement that their individual footage could be stitched together into a smooth 360°, panoramic video, with minimal image fluctuations due to atmospheric turbulence.

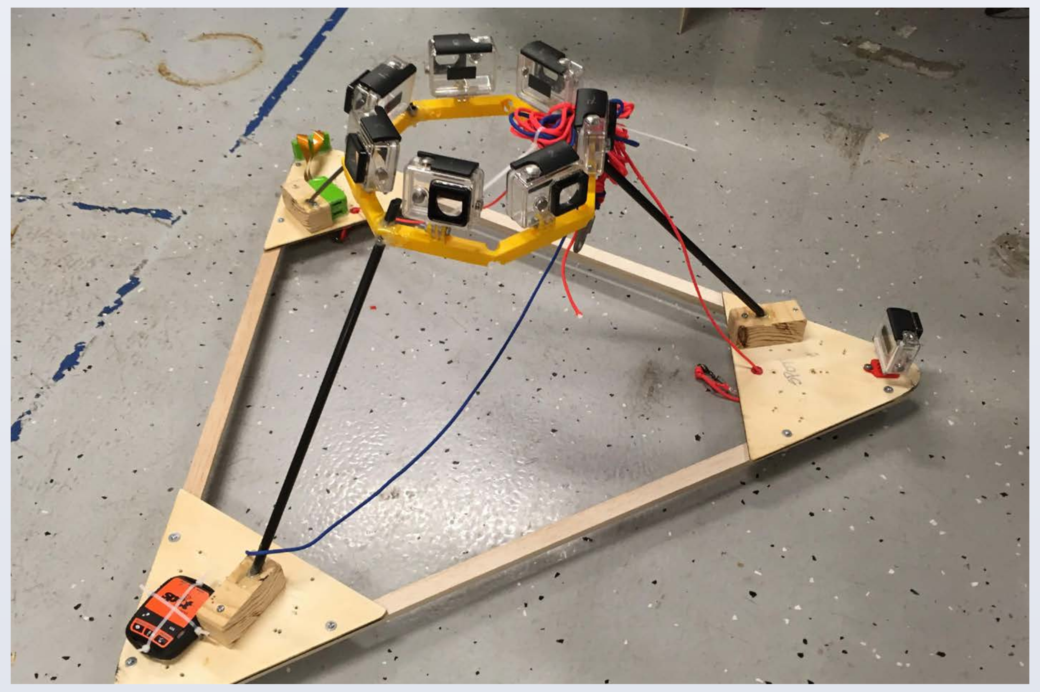
OBJECTIVES

- Drastically reduce the rotation and pendulum swinging of the payload, associated primarily with wind
- Improve video quality on HAB flights
- Improve effective post-processing of a 360° video
- Improve collection of stabilized data on ascent

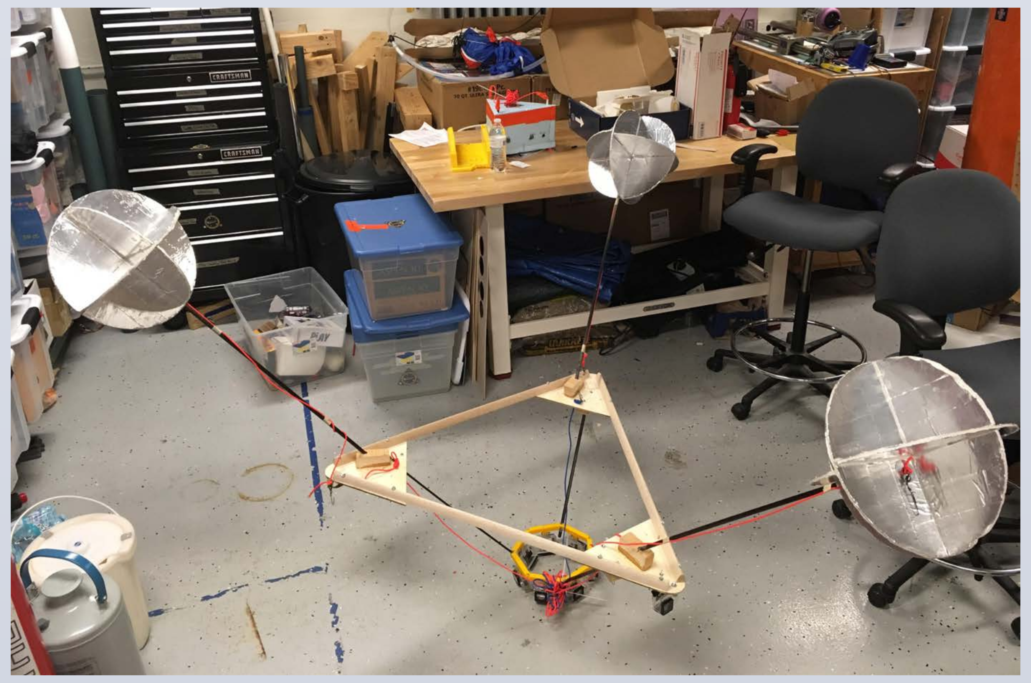
METHODS

Triangular Base Payload

A triangular base design allowed for a 3D-printed camera mount to be centered within a wooden base using solid carbon fiber rods, which were glued to wooden supports using epoxy. To achieve a lightweight and durable solution, balsa wood was used.



Based on previous designs from the University of Minnesota, stabilization paddles were made out of lightweight foam board and adhesive aluminum tape. By using aluminum tape, paddles acted as radar reflectors. Stabilizers were attached to solid carbon fiber rods, which extended ~30° horizontally downward from the bottom of the triangular base and glued to a wooden support using quick dry glue.

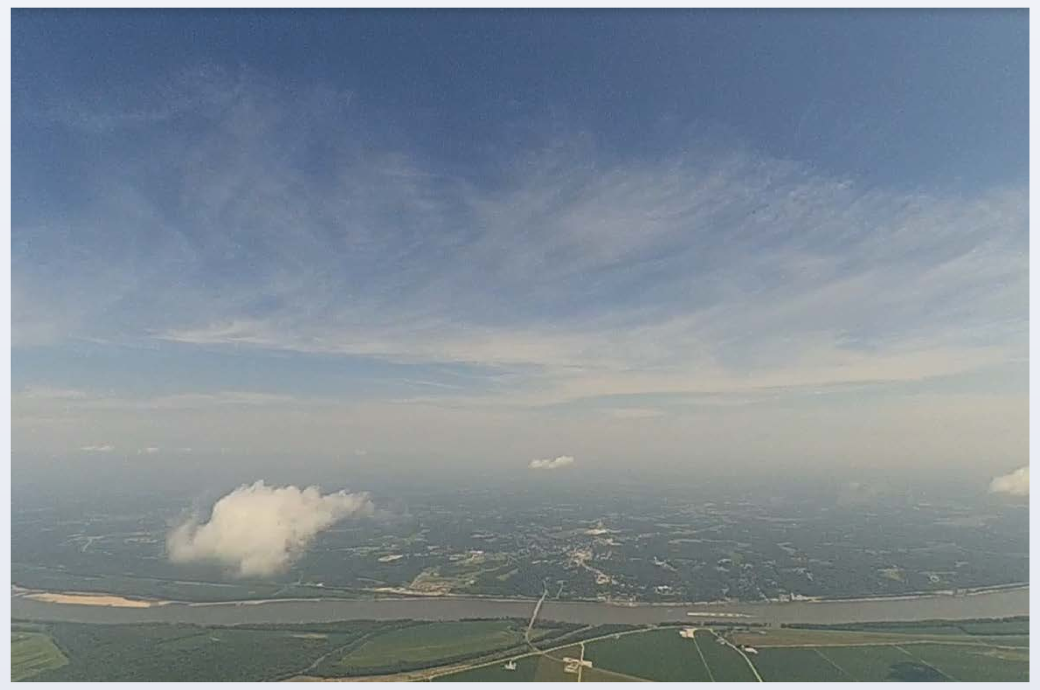


Scientific Sensor Payload

In addition, the payload consisted of scientific sensors, including a High Accuracy Temperature Sensor (MCP9808) connected to Arduino Uno.

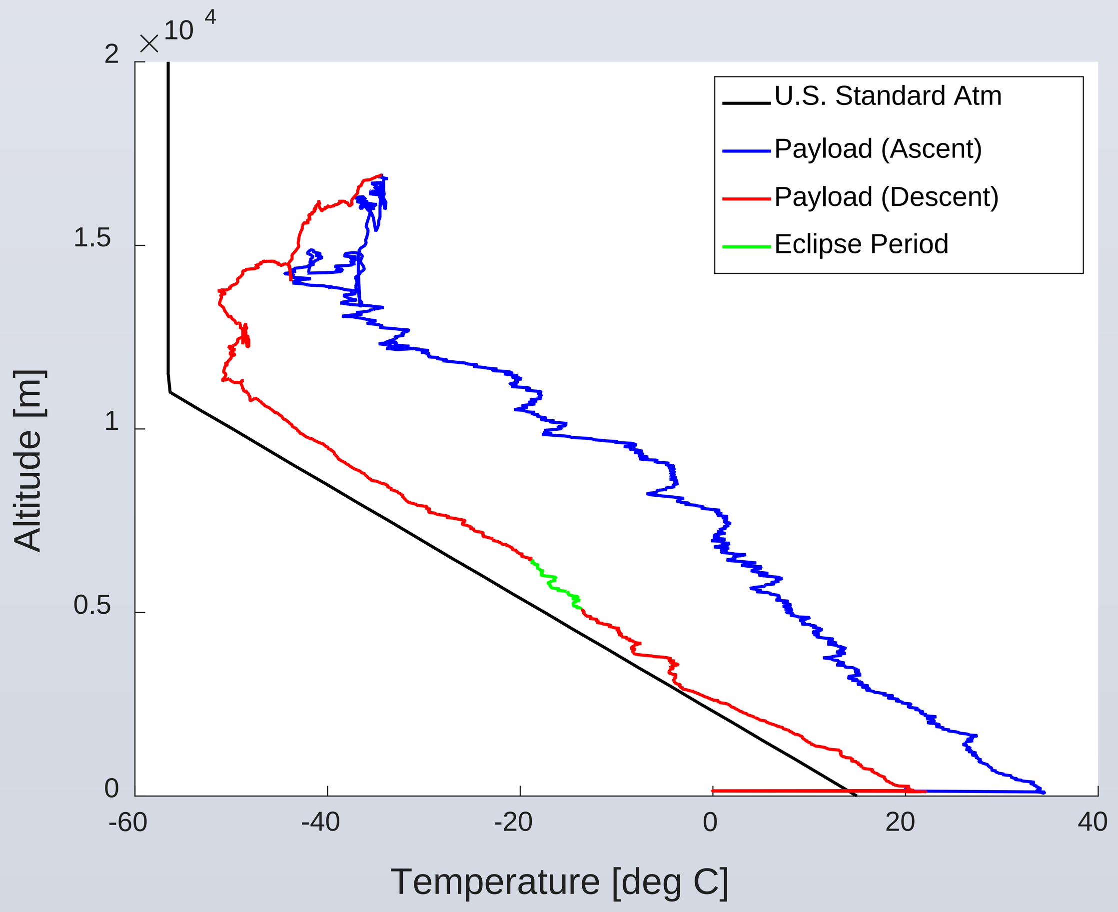
RESULTS

Payload Stabilization System



- Significantly reduced payload swing, especially evident at lower altitudes where footage from previous flights was blurred
- Less effect on spin, which continues to be problematic
- Notably-improved stabilizer durability; all survived landing.

Temperature Trends During Eclipse



- Gradual decrease/increase of ambient temperature throughout the eclipse period
- No sudden temperature drop during totality
- Temperature difference of approximately 20°C between ascent and descent
- Match with U.S. Standard Atmosphere trends

CONCLUSIONS

Despite a premature balloon burst and in-flight camera failure, the UIUC mission successfully demonstrated the feasibility of a stabilized 360° video rig. Additions to the University of Minnesota stabilizer design, including a larger triangular base and solid carbon fiber rods, yielded particular improvements in payload durability.

Key takeaways for future missions include:

- Repeated success in reducing payload swing via stabilizers, but improvements needed to mitigate spin rate
- Success of triangle-based, suspended camera rig design, which demonstrated excellent durability in the air and upon landing
- Need for pre-flight balloon inspection
- Need for additional cameras to generate true stitched 360° video footage
- Need for pre-flight battery testing to ensure longevity in sub-zero conditions

REFERENCES

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