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Development of Active and Passive Approaches for Stabilizing Weather Balloon Payloads to Improve High-altitude Video Collection

J. Stark, Q. Booker, A. Roberts, T. Marshall, M. Downey, T. McKinney
- UAH College of Engineering

Introduction

High Altitude Visual Orientation Control (HAVOC) is proposed to stabilize high-altitude balloon payloads using cold-gas thrusters. Balloon payloads are naturally unstable during flight, thus improving the stability of balloon flights is valuable for high atmospheric studies.

Key Findings

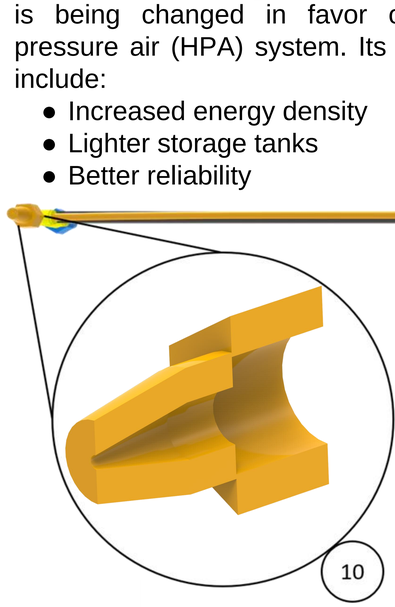
A preliminary flight test was conducted at an altitude of 15 kilometers.

- Successfully limited payload rotational velocity to a predefined maximum of approximately 75 degrees/second for a period of 70 seconds (see figure below)
- Demonstrated the possibility to develop an advanced payload that can control its orientation

Payload Overview

The prototype payload used a small amount of liquid CO_2 as propellant. This is being changed in favor of high-pressure air (HPA) system. Its benefits include:

- Increased energy density
- Lighter storage tanks
- Better reliability

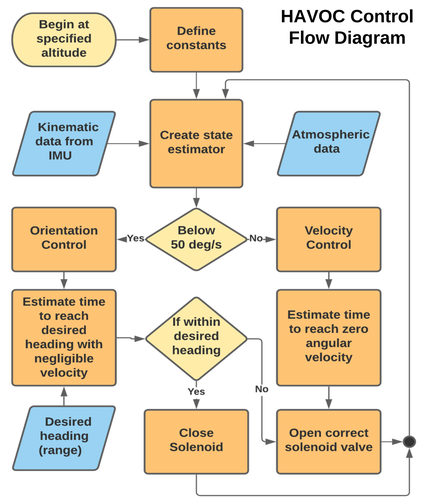


Active Control Scheme: Solenoid valves are used to control the flow of pressurized propellant into two sets of nozzles by generating torque in either a clockwise or counter-clockwise direction. This active stabilization works to counteract external torques experienced during flight.

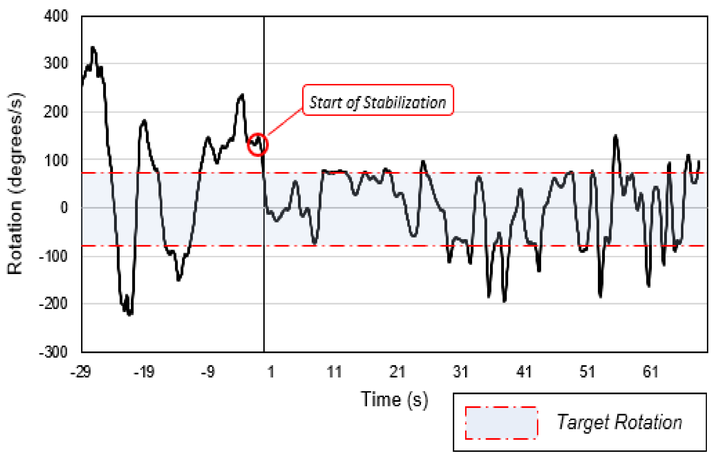
Passive Control Scheme: A cylindrical payload body passively improves stability by deflecting high speed winds, reducing external torque. This also allows for better balancing of payload mass making active stabilization more effective.
Large lever arms increase torque produced by the nozzles.

Control Framework

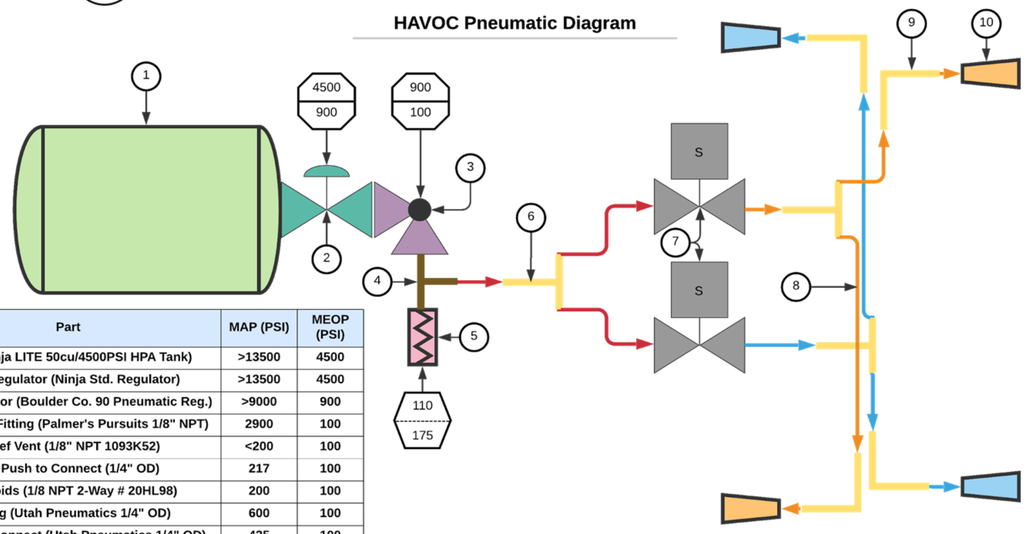
The HAVOC approach utilizes two closely linked state-space control loops. The velocity control is activated when the payload is spinning rapidly, while the orientation control is used for more precise pointing of the payload once the velocity is low enough. The HAVOC system continually estimates how long it needs to open its solenoid valves to reach its desired state and will leave them open until that state is reached. This process is detailed in the figure below.



Rotational Velocity v. Operational Time



HAVOC Pneumatic Diagram



#	Part	MAP (PSI)	MEOP (PSI)
1	Tank (Ninja LITE 50cu/4500PSI HPA Tank)	>13500	4500
2	Tank Regulator (Ninja Std. Regulator)	>13500	4500
3	Sys. Regulator (Boulder Co. 90 Pneumatic Reg.)	>9000	900
4	Tee MxFxF Fitting (Palmer's Pursuits 1/8" NPT)	2900	100
5	Relief Vent (1/8" NPT 1093K52)	<200	100
6	Tee Push to Connect (1/4" OD)	217	100
7	Solenoids (1/8 NPT 2-Way # 20HL98)	200	100
8	Tubing (Utah Pneumatics 1/4" OD)	600	100
9	L Push to Connect (Utah Pneumatics 1/4" OD)	435	100
10	Nozzle (Custom 3D print)	200	100

For more information:
Visit: https://sites.google.com/uah.edu/shc-havoc/home
Email: jbs0033@uah.edu or space@uah.edu

Impact/Conclusions

Instruments that require precise stability could now be utilized on balloon payloads that were previously too unstable. HAVOC will allow for higher quality videos and other data collection from high altitude balloons that will further fuel the public's interest in Atmospheric Science.

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