The Potential for Solar Tracking and Observation On-board a High-Altitude Balloon Platform

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Outline of Presentation

Mission Overview

The Fundamentals of Balloon Based Observation
  ◦ High Altitude Student Platform
  ◦ General Design
  ◦ The Cameras
  ◦ Attitude Determination and Control

The Challenges of and HELIOS III’s Methodology for Balloon Based Observation
  ◦ Ensuring Proper Positioning and Alignment of System
  ◦ Reflection Mitigation
  ◦ Thermal Management
Mission Overview

Mission Statement:
- The mission of the Hydrogen-Alpha Exploration with Light Intensity Observation System III is to develop an accurate Sun tracking system to capture high quality hydrogen alpha images of the Sun while taking into consideration the challenges encountered by previous iterations of the project.

Previous Iterations
- HELIOS I (2012)
- HELIOS II (2013)

Currently in the early stages of implementation
Acronyms Used

ADCS – Attitude Determination and Control System
FOV – Field of View
HASP – High Altitude Student Platform
HELIOS – Hydrogen-Alph Exploration with Light Intensity Observation System
H-alpha – Hydrogen Alpha
NASA – National Aeronautics and Space Administration
PID – Proportional, Derivative, Integral
The Fundamentals of Balloon Based Observation
High Altitude Student Platform

Sponsored by the Louisiana Space Grant Consortium and the NASA Balloon Program Office

Launched out of Fort Sumner, New Mexico in late summer

Platform reaches a maximum float altitude of 36km for 15-20 hours

Platform supplies power, data downlink and command uplink capabilities

- Power: 30V with a max of 2.5A
- Serial: 4800 Bd

HASP has 12 payload positions: 4 large and 8 small

- HELIOS III was accepted as a large payload
General Structure

Two major structural sections:

- Base structure
- Camera structure

Base structure overview:

- Will house the power board, a motor, various processors, and wires
- Constructed of Aluminum 6061

Camera structure overview:

- Will house the telescope, ADCS and science cameras, photodiode arrays, and a second motor
- Constructed of Acrylic and 3D-printed plastic
Cameras

HELIOS III will fly two cameras

Science Camera:
- Responsible for H-Alpha images
- Use a Maksutov-Cassegrain telescope for a focal length of 625 nm
- Currently deciding between a powered and unpowered filters for H-alpha
  - Powered has a .8nm bandpass but uses 10W
  - Unpowered has a 7nm bandpass, so not true H-alpha
- FOV of .696° by .568°

ADCS Camera:
- Responsible for image processing pictures
- Will utilize neutral density filter to decrease incoming light intensity
- FOV of 22.9° and 17.2°
Cameras (Expected Images)

SCIENCE CAMERA

ADCS CAMERA
Attitude Determination and Control

ADC system locates the Sun and positions the cameras to the Sun

System components:
- Phi and theta 3D printed photodiode arrays
- Phi and theta stepper motors with motor drivers
- ADCS camera

Sun-tracking system:
- Position system on theta plane based on theta photodiode readings
- Position system on phi plane based on phi photodiode readings
- Capture image of Sun with ADCS camera and run image processing software
- Calibrate photodiodes in accordance to ADCS Sun location
- Capture image of the Sun in H-alpha with science camera
The Challenges of and HELIOS III’s Methodology for Balloon Based Observation
Alignment of the System

Three components are used for Sun tracking:
- Photodiode array oriented on theta axis
- Photodiode array oriented on phi axis
- ADCS camera mounted in camera housing

Misalignment of components leads to misalignment of science camera with respect to the Sun

Error of the system must be less than 0.196° theta by 0.069° phi
- If exceeded, the sun will not be completely within FOV of the science camera
Alignment of the System

Structural:
- Base structure must be level
- Camera structure must not warp and must be level
- Photodiode arrays on both axes must be aligned to center of ADCS camera
- ADCS camera must be aligned with science camera
- Telescope must be in line with science camera
- Camera structure supports located close to center of mass to ensure proper weight distribution

Testing and Mitigation:
- HELIOS III will test to ensure alignment
- Small alignment errors will be corrected by the ADCS Sun tracking code
Reflections

Challenge:

- Photodiodes susceptible to reflections
  - The balloon
  - Camera boom
  - Supporting cables
- Bias on the phi axis towards the balloon
- Camera takes images of space above the Sun instead of images of the Sun
Reflection Mitigation

Hardware:
- Theta photodiode housing baffled in front
- Phi photodiode housing baffled in front and on either side

Software:
- ADCS pictures will be used to model the readings of the photodiodes against the location of the sun
- A model will be used to correctly interpret photodiode readings
- PID control law will be employed

This should ensure that the science images are accurately centered on the sun
Thermal

Payload will experience temperatures ranging from -50 °C to 50 °C

Expected sources of heat:

1. Primary external heat from direct sunlight
   - Rotation of the platform means all sides of payload will experience direct sunlight
2. Primary internal heat load from power board
3. Secondary internal heat load from processors, motors, and electrical components

Low temperatures are not a major concern

Minimal heat dissipation due to negligible convection in a low atmosphere environment
Thermal Management

Heat will be mitigated by:

1. Thin aluminum plates attached to the support pillars of the base structure
   ◦ Increase surface area for radiation
   ◦ Thermal epoxy will be used to ensure thermal conductivity of plates to main structure

2. Monitoring of temperature of the power board and other electrical components
   ◦ Power MOSFET switches will cut overheating lines until temperature drops below limit

3. Temperature data will be transmitted to ground and analyzed
   ◦ If multiple systems begin to overheat, blackout period will commence and will restart after a predetermined period of time
Conclusions

Primary mission to create an affective and accurate Sun tracking system

Problems:
- Alignment
- Reflections
- Thermal Management

Integration: August 4th through August 8th in Palestine, Texas

Expected Launch Date: September 1st in Fort Sumner, New Mexico
Questions?

THANK YOU FOR LISTENING