On the Use of Black Foam Core for Thermal Control of High Altitude Balloon Payloads

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Explorer Post 632: BalloonSat

for

High Altitude Small Balloon Experimenter's Symposium (HASBE)

NASA GSFC

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Overview

Summary

Using Black Foam Core for thermal control worked well enough, but not as well as hoped.

- **Background**
- **Payload Heating Considerations**
- **Tests**
- **Flight 2005A**
- **Results**
- **Conclusions**

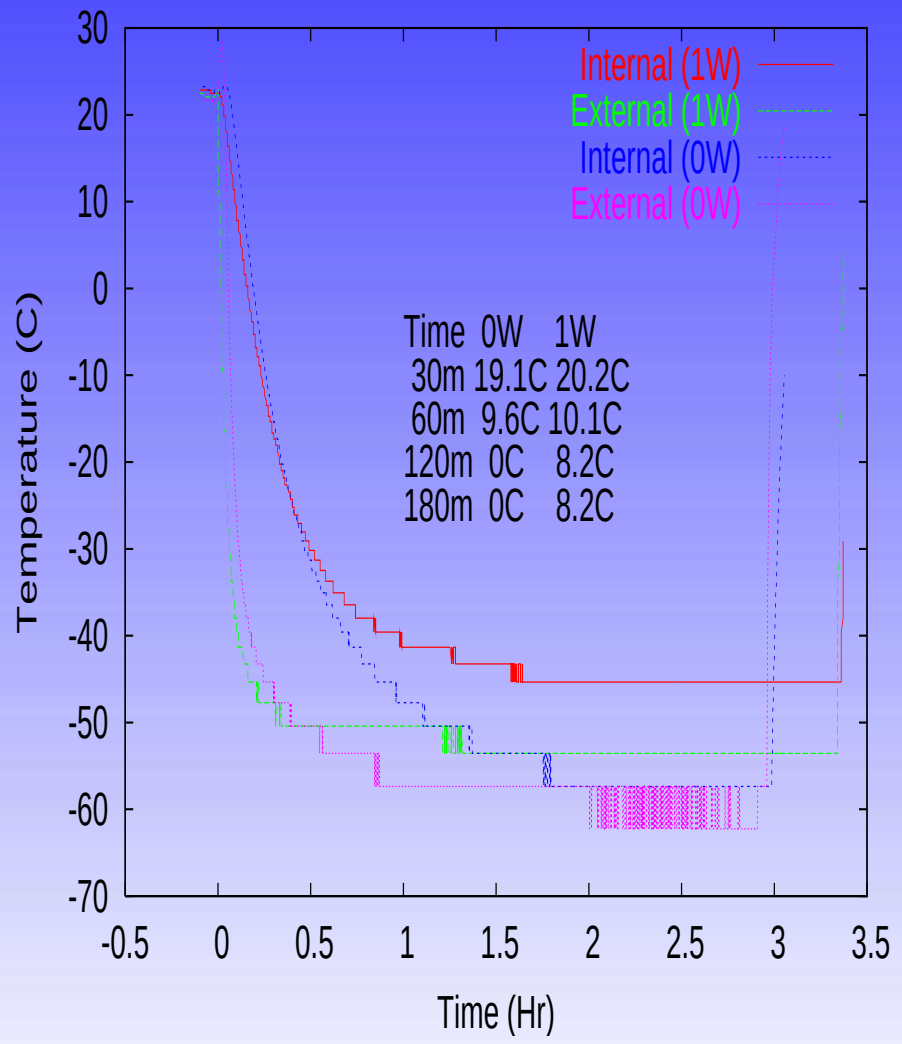
Background

NASA GRC has an interest in using high altitude balloon to calibrate Solar Cells to Space Solar Illumination (Air Mass Zero).

- **JPL uses NSBF, Palestine, TX**
  - Take data at 120 kft (~0.005 atmosphere)
  - Costs $5000/2x2 cm cell
- **NASA GRC uses Lear 25 Jet**
  - Take data near 50 kft (0.1 atmosphere)
  - Extrapolate data to 0 pressure
  - Costs about $3000/2x2 cm cell
- **Wayne State University (Dr. James Woodyard)**
  - SunTracker: Developing high altitude balloon payload for solar cell calibration.
  - <www.suntracker,eng,wayne,edu>
- **Explorer Post 632**
  - Principally an educational opportunity for high school students to experience a flight program
  - A chance for GRC to develop experience using high Altitude balloons.

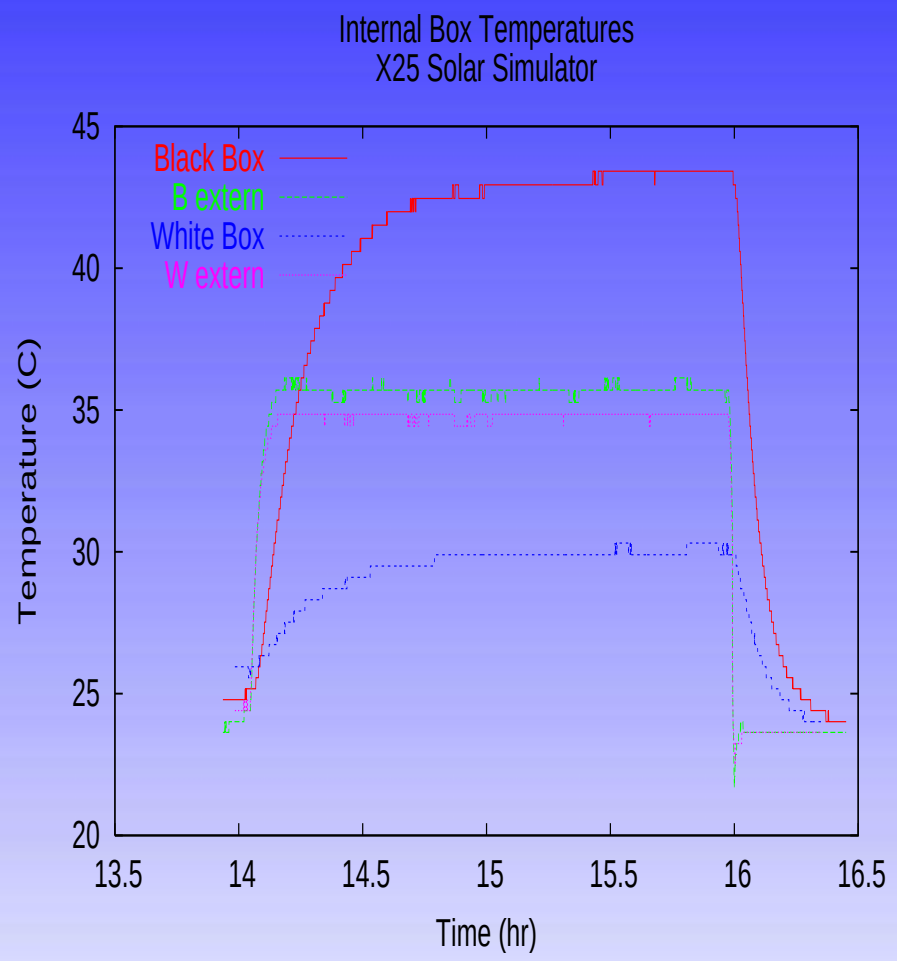
Heating Requirements

- Need a reasonable internal operating temp, preferably >0C, to ensure electronics and battery operation.
- Initial testing suggested a 1 Watt heater would raise the temperature 8C.
- About 7 to 10 Watts needed to keep interior warm in -50C tropospheric temperatures.



Heating Requirements

- **9 Watts for 3hrs**
  - 1 A @ 9V
  - 3000 mA-hr x 3 3V Li Batteries
  - 6 to 9 - CR123 Li Batteries
  - 102 to 153 g
- **Sun Intensity at AM0 (Air Mass Zero) and Re = 1 au is 1367 W/m2**
- **7in x 7 in surface can receive up to 43 Watts**

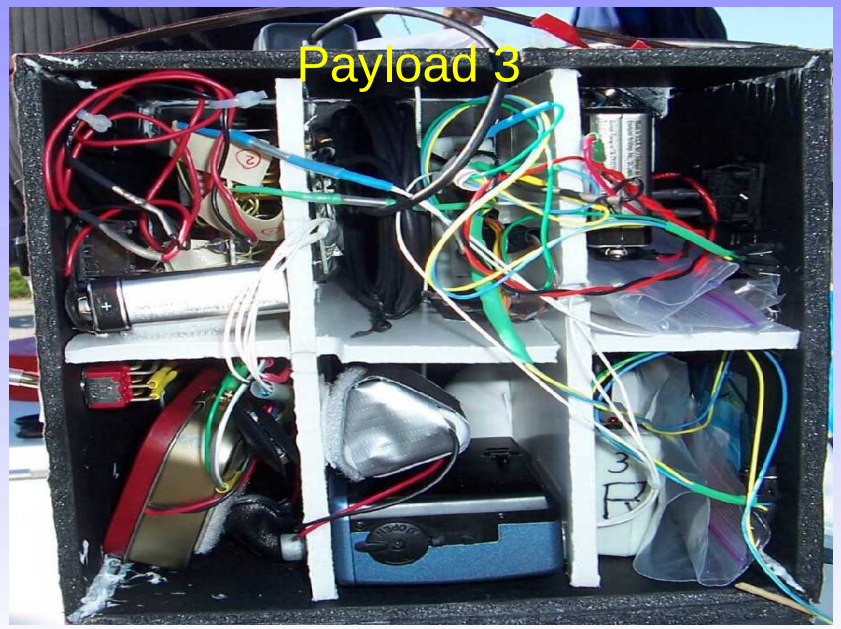


Temperature Measurements

- **8 Bit HOBO data logger Internal Temperature Sensor, about 0.5C resolution,**
  - functions well to -40C,
  - resolution deteriorates below -40C

- **Also used 1000 kohm RTD's**
  - In series with 820 ohm resistor
  - Powered by HOBO 2.5V
  - Measure voltage across RTD
  - Low resolution with 8 Bit HOBO
    - 2.5 C resolution

Payloads



Telemetry

- **On Payload 1**
  - Kenwood TH-D7
    - 446.025 Mhz
  - Garmin GPS15 engine
  - 70 cm 5/8 wave wire w/ Cu coated Kapton Ground Plane
- **Payload 3**
  - Pocket Tracker
    - 144.34 Mhz
  - Garmin GPS15 engine
  - 2m J-Pole antenna
- **Car 1**
  - 2m/70cm dual-band magnetic mount
  - Kenwood TH-D7
  - No additional preamps/filters
- **Car 2**
  - 2m mag mount
  - 70cm mag mount
  - Kenwood TH-D7
  - No additional preamps/filters

Telemetry 2
NASA GRC Base Station

Intended for Satellite reception

- **2m M2 2MCP14**
  - 14 element Yagi
  - Circular Polarized
  - M2 PS-2m Polarity Switch
  - 2m filter
  - Mast mount Pre-amp
    - Ar2 Comm Products MSP144

- **70 cm two phased M2 440-18 yagis**
  - 70 cm filter
  - Mast mount pre-amp MSP432

Flight 2005A, 9 Apr 2005

- **Launched from Tiffin, OH at 10AM EDT**
  - 41:06.28 N 83:09.42 W
- **Reached 97400ft, 12:00:33**
  - 40:55.79 N 82:37.35
- **Recovered Payloads near Ganges, OH about 12:50 (Landed 12:22)**
  - 40:53.79 N 82:33.37 W
- **Had one failure probably temp related**
  - Camera in Payload 2 (of 3) stopped after 45kft.
  - Battery was dead at recovery. CR-2 Li battery
  - P-2 was smaller, had some blue plastic parts.

Planned for 105 kft
5300g gross lift
1500g Balloon
2700g payload
1100g to 1300g lift

Flight Path

Picture 5
Picture 6
Picture 7
Picture 8
Picture 9
Picture 10
Picture 11
Picture 12
Picture 13
Picture 14
Picture 15
Picture 16
Picture 17
Picture 18
Picture 19
Picture 20
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Picture 24
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Picture 26
Picture 27
Picture 28
Picture 29
Picture 30
Picture 31
Picture 32
Tiffin
Seneca
Center
Swander
Republic
Scipio
Reedtown
Bismarck
Havana
Huron
Olena
Hartland
North Fairfield
Fitchville
Centerton
Attica
Caroline
Bloomville
Willard
New Haven
Greenwich
Berwick
St Stephens
Carrothers
Plymouth
Mccutchenville
Mexico
Lykens
New Washington
Waynesburg
Chatfield
Sycamore
Shiloh
Rome
Adario
London
Wilkins Air Force Station
Tiro
Smithville
Ridgeton
Shelby
Sulphur Springs
Brandywine
Spore
West Liberty
Crawford
Oceola
Bethlehem
Epworth
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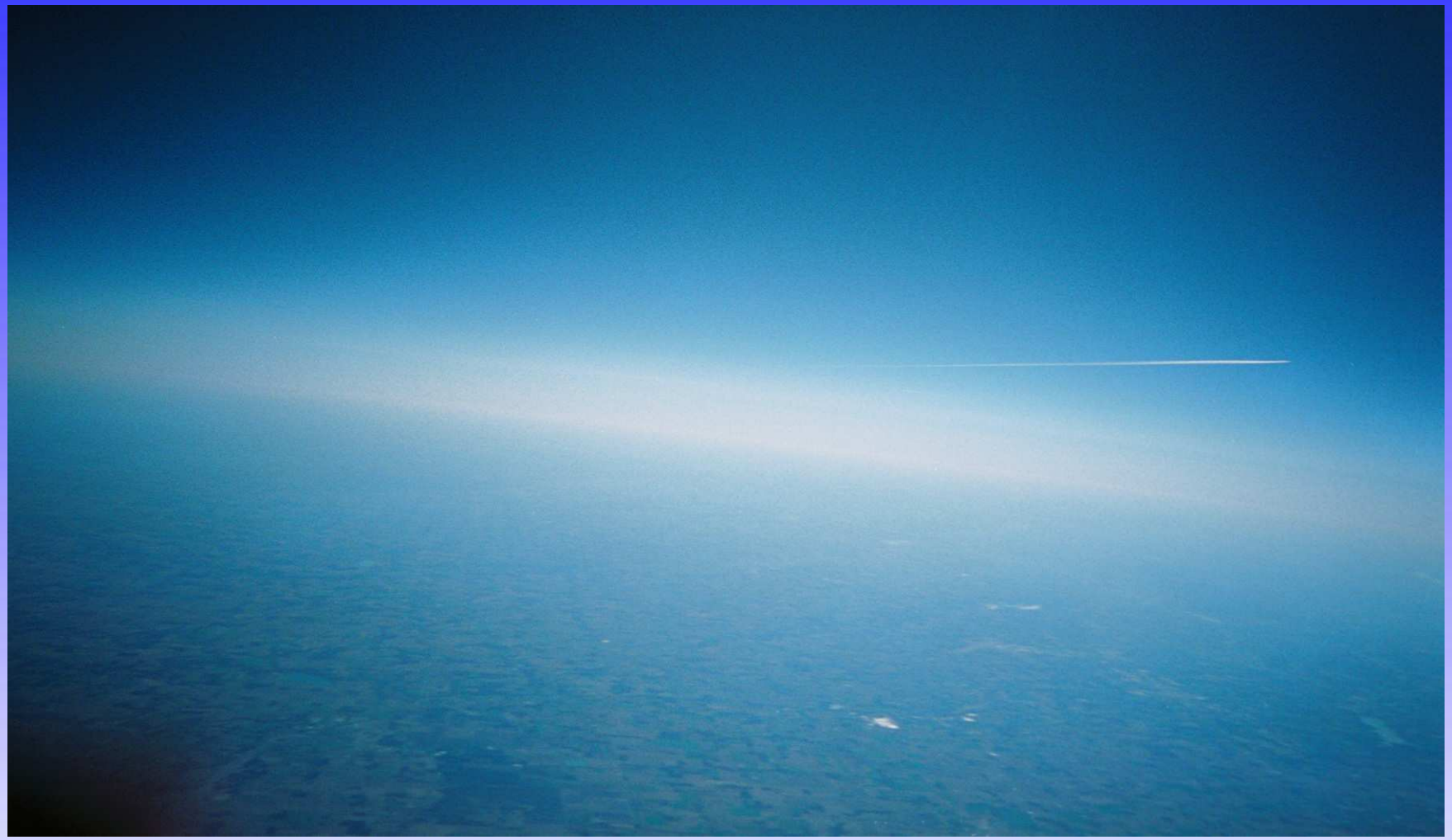
Horizontal View



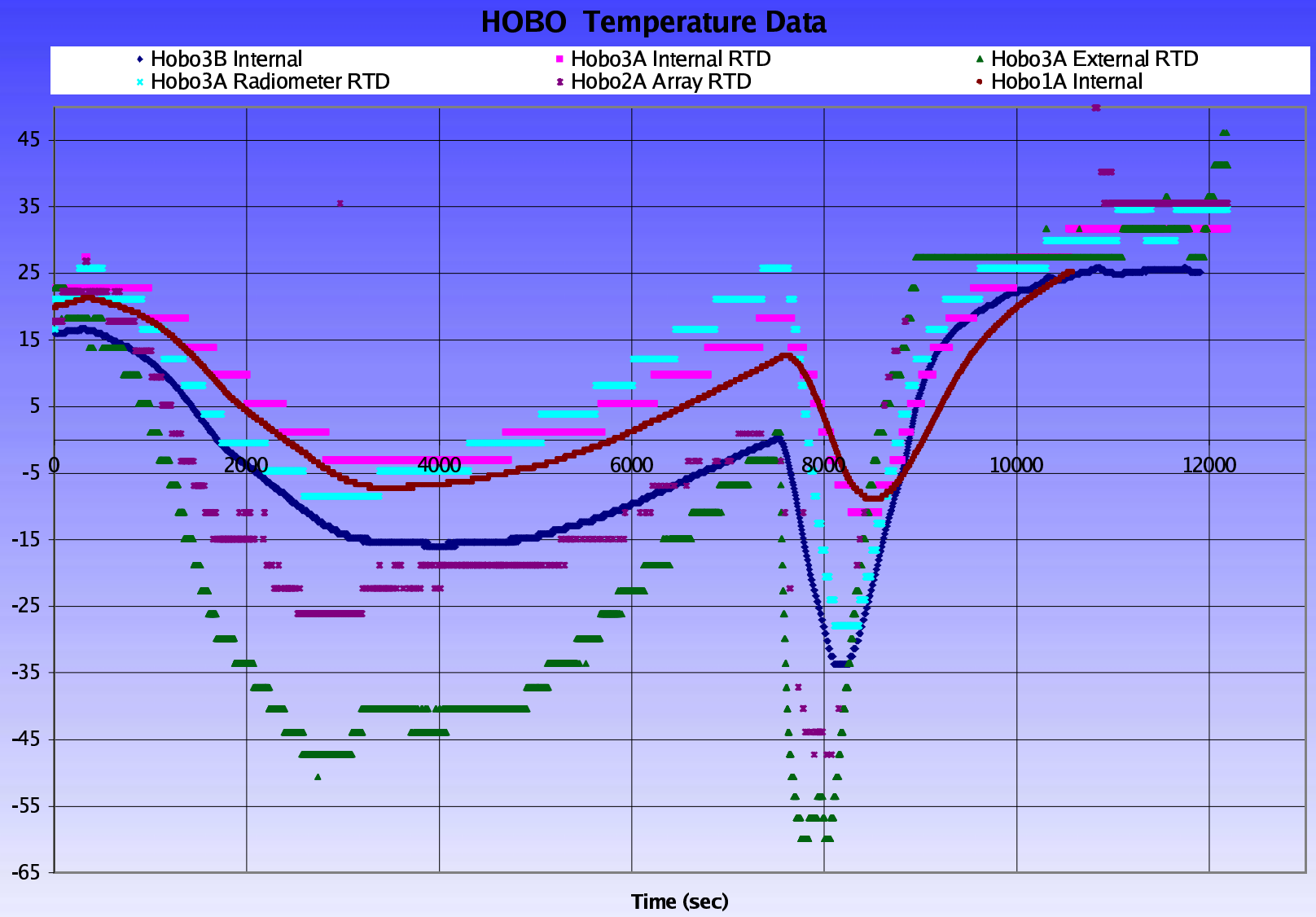
09 Apr 2005 14:35 UTC 11000m
Final photo @ 13500m

Vertical Camera

09 Apr 2005 15:38 V24
40:55.9 N, 82:43.30 W
79500 ft, 24400m

Results

RTD Temperature Data



Results

- **Measured external Temperatures of -48C**
- **Payload 1**
  - Most 'enclosed' of the three payloads
  - Ascent: -7C
  - Descent: -9C
- **Payload 2 No internal temperature**
  - Smallest Payload, 2W from solar array
  - Camera Opening
  - Camera failed above 45 kft
  - Camera Battery was Dead when retrieved
- **Payload 3**
  - Openings for Camera, Dust Collection PCV Duct
  - Ascent: -4 (top) to -16 (near base)
  - Descent:-10C to -33C

Discussion

- **For the most, part the payloads stayed warm enough**
  - Payload 1 looked good
  - Payload 2 had a problem, perhaps too small
  - Payload 3 got cooler than desired
    - But continued to function!

- **Black Foam Core offers External warming**
  - Through a layer of insulation
  - Not effective when cold air is drawn into Pay-load.

Conclusions

- **Black Foam Core Construction can be used in some applications.**
  - Significant Mass Savings by removing heating system
  - Works well for relatively enclosed payloads.

- **Not effective for 'Open' Payloads**
  - Insulation reduces effectiveness at warming incoming cold air.