A Multiple Payload Carrier for High Altitude Ballooning

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A multiple payload ballooning platform

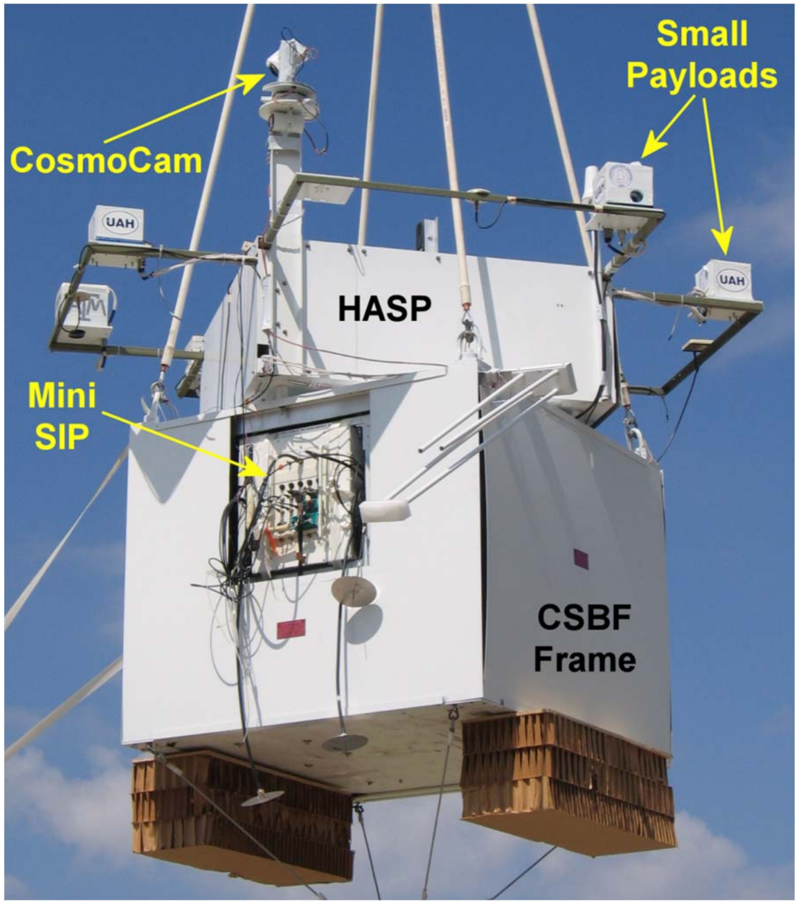
- The current scientific balloon flight model is that each experiment corresponds to a separate balloon payload.
  - This generally includes developing custom systems for the balloon payload as well as the experiment.
  - This development (or refurbishment) of balloon payload systems can add years and millions of dollars to the cost of an experiment.
- This model may need to be used for large aperture or heavy experiments.
- However, lighter, smaller packages could be clustered on the same platform and take advantage of common resources
  - A standardized power, telemetry and commanding interface enables the research group to focus on instrument development.
  - Potentially lowers overall experiment cost and improves turn-around time.

The High Altitude Student Platform (HASP) is a model multi-payload carrier

- HASP is the first balloon carrier specifically designed with a standard interface to carry multiple experiments to high altitude for an extended period of time.
- Operates as a partnership between the **NASA Balloon Program Office** (BPO) and **Louisiana Space Consortium** (LaSPACE)
  - BPO provides balloon, launch and flight services
  - LaSPACE maintains HASP & supports the student payloads
- Developed in 2005 to address a looming crisis in training the next generation of aerospace scientists and engineers.
- Provides a regular flight opportunity for student groups across the world.
- A multiple experiment balloon platform, similar to HASP, might have application beyond student training programs.

Major HASP Features

- Fly to an altitude > 36 km for a duration of ~20 hours
- Includes two major components
  - The upper frame (HASP) supports the multiple payloads
  - The bottom frame (CSBF frame) to support the balloon vehicle communication and support structure
- HASP includes a standard interface for each payload
  - Eight “small” experiments on booms and four “large” experiments on top
  - The HASP control electronics multiplexes and isolates the 12 experiments from the CBSF systems.



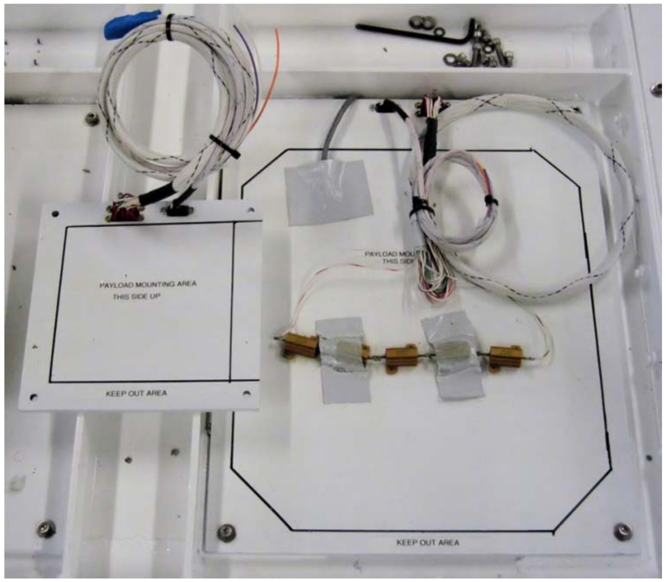
- Include CosmoCam for real time video during launch & flight

The standard HASP payload interface

- Different resources for “small” and “large” payloads.
- Mechanical interface is a ¼” thick PVC plate, including power and communication connectors, wiring pigtail and footprint.
- Power provided at ~30 VDC plus both uplink and downlink communication.

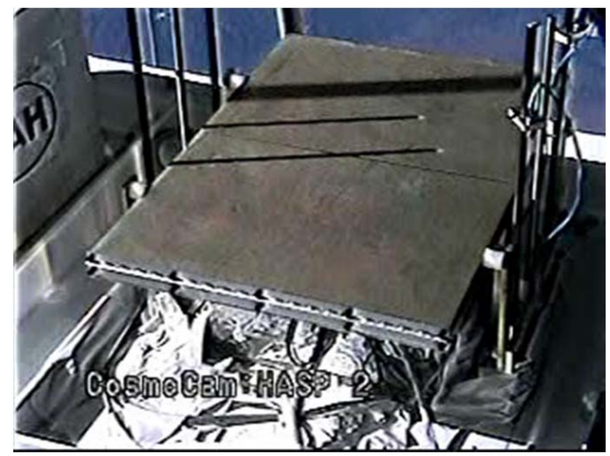
Table 1: Payload Interface Specifications (v2008)

Specification:	Small Payload	Large Payload
Total number of positions:	8	4
Maximum weight:	3 kg	20 kg
Maximum footprint:	15 cm x 15 cm	38 cm x 30 cm
Maximum height:	~30 cm	~30 cm
Supplied voltage:	29 - 33 VDC	29 – 33 VDC
Available current @ 30 VDC:	0.5 Amps	2.5 Amps
Max. serial downlink:	<1200 bps	<4800 bps
Serial uplink:	2 bytes per cmd	2 byes per cmd
Serial protocol	RS232	RS232
Serial interface:	DB9	DB9
Analog downlink:	Two @ 0 to 5 VDC	Two @ 0 to 5 VDC
Discrete commands:	2 to 4	2 to 6
Analog & discrete interface:	EDAC 516-020	EDAC 516-020



CosmoCam provides visual monitoring

- Real-time views of the payloads, the balloon and the Earth during launch, flight and termination.
- Provided and operated during the flight by Rocket Science, Inc. (www.cosmocam.com)
- Exciting live views showing the black of space and the curvature of Earth from the edge of space.
- Scientific value monitoring experiments that change their physical configuration.



Opening of MSU experiment
(8 times normal speed)

Typical Payload Development Schedule

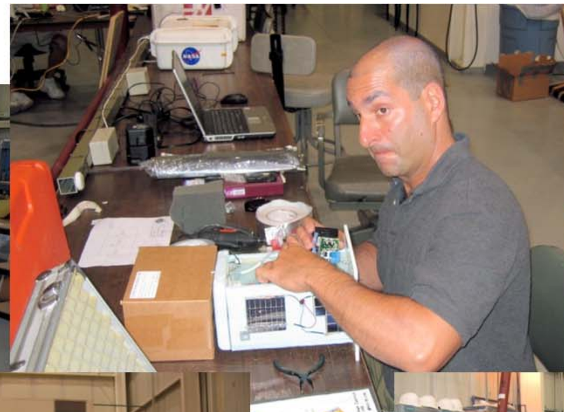
- Application process takes place in the fall
  - Release of CFP (Call for Payloads): October 1
  - Applications due: December 18
  - Selection announcement: mid-January

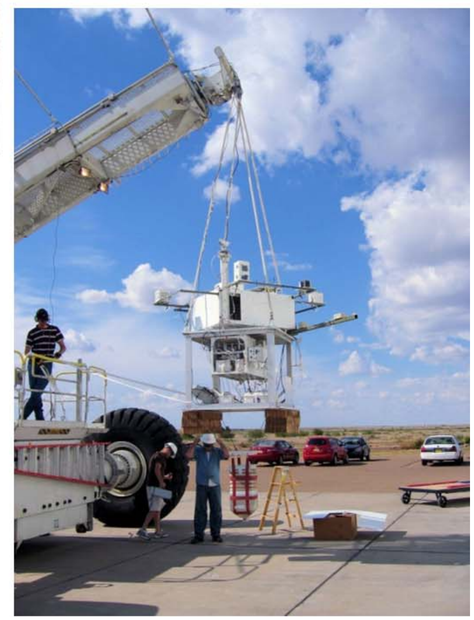
- Payload development takes place in the spring
  - Require monthly status reports and telecon meetings
  - Preliminary thermal / vacuum test the 3^{rd} week of May

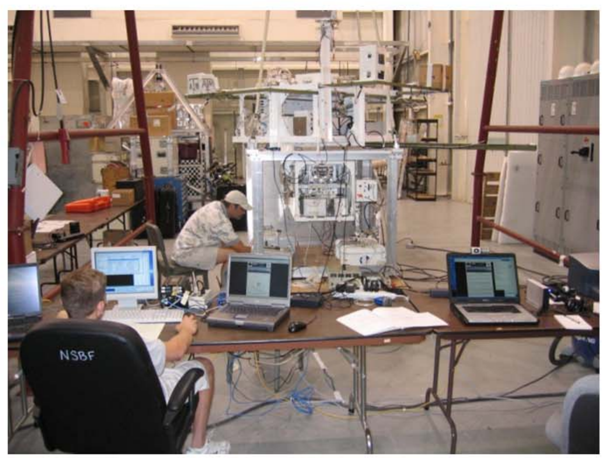
- Integration occurs during 1^{st} week of August
  - Use the Columbia Scientific Balloon Facility (CSBF) in Palestine, Texas
  - Must pass a thermal / vacuum test to be flight certified
- Flight Ops take place around Labor Day
  - Use the CSBF balloon launch facility in Ft. Sumner, New Mexico

ConUS flights launched from Ft. Sumner NM

Typical Pre-launch Preparation





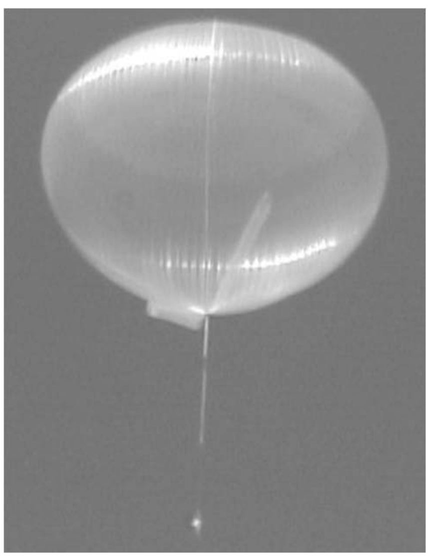


HASP Launch Preparation

Typical HASP Flight

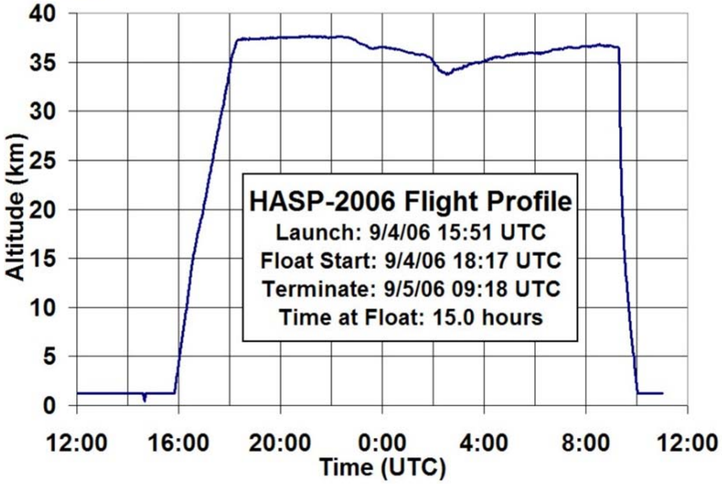
- HASP is a medium weight payload
  - Total suspended weight is 2,000 pounds
  - Use a 11 million ft^3 zero pressure balloon
- Usually launch just after dawn
  - Require ground, low level and high altitude winds to cooperate

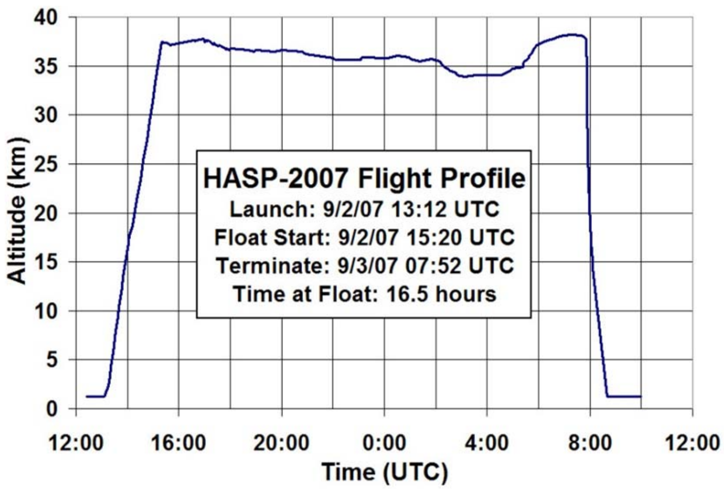
speed



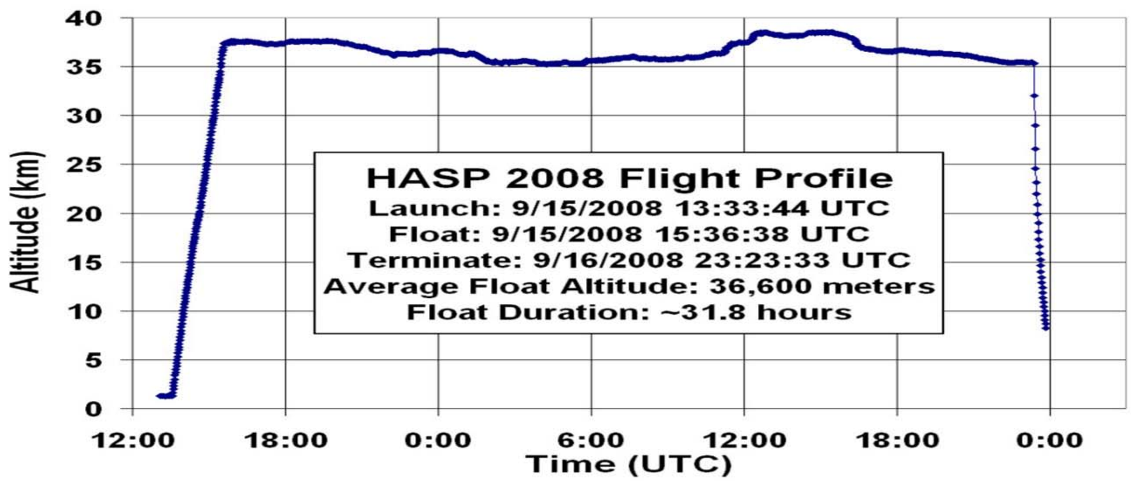
- Flight lasts about 17 hours
  - Takes about 2 hours to get to ~36 km (~120,000 feet)
  - Take about 45 minutes to come down on parachute
  - Get a day and some night in “space”
- HASP has now flown four times
  - Total time at float is more than 75 hours
  - Expect to continue flights each year

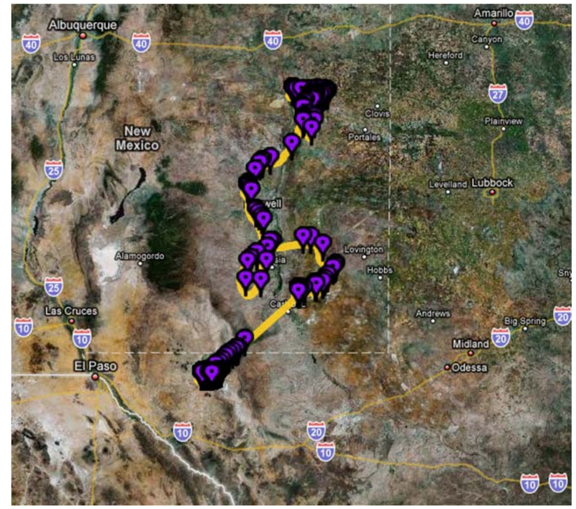
HASP 2006 & 2007 Flights

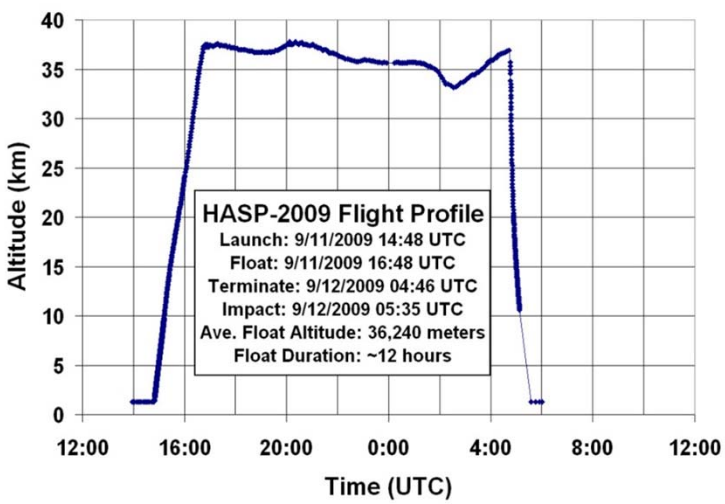




HASP 2008 & 2009 Flights





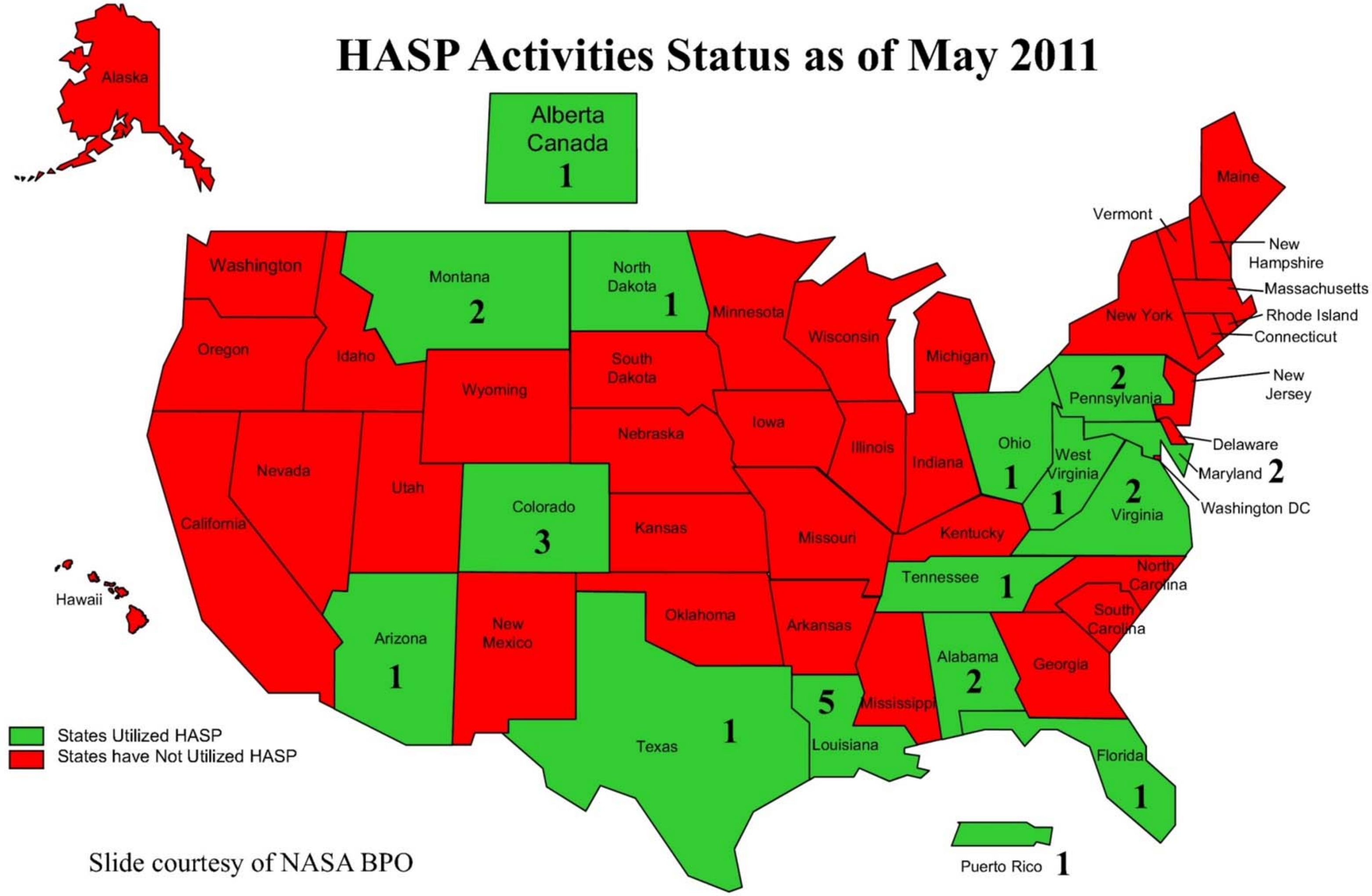


The HASP system is very robust

- CSBF recovery personnel are usually at the payload within hours after landing.
- Several features lessen impact damage
  - Suspension cable threaded through PVC pipe to minimize chance that the pin plate and flight train will collapse on the payloads.
  - Fiberglass booms absorb some impact on payload tip over.

- Many of the outrigger booms and payloads survive impact.
- Sometimes there is damage to a few of the solar shields.
- Internal electronics is fully functional after each flight.

HASP has involved teams from across the U.S. and now includes international teams



Many individual experiments have flown on HASP over the years

- HASP was flown each year from 2006 through 2009
- The 2010 flight has been delayed until August 2011
- The HASP 2011 will fly about one week after HASP 2010
- To date close to 370 students from 27 institutions across 14 states plus Puerto Rico and Alberta, Canada have been involved in developing a HASP experiment.

Table 2: Payloads Involved with HASP Since 2006

Year	Launch Date	Float Duration (hours)	Students	Payloads		
				Accepted	Flown	Success
2006	9/4/06	15	25	8	8	6
2007	9/2/07	16.5	70	11	10	8
2008	9/15/08	31.8	96	13	12	6
2009	9/11/09	12	50	10	6	6
Total 06 to 09		**75.3**	**241**	**42**	**36**	**26**
2010	***8/29/11***	0	57	10	0	0
2011	***9/6/11***	0	70	11	0	0
Total 06 to 11		**75.3**	**368**	**63**	**36**	**26**

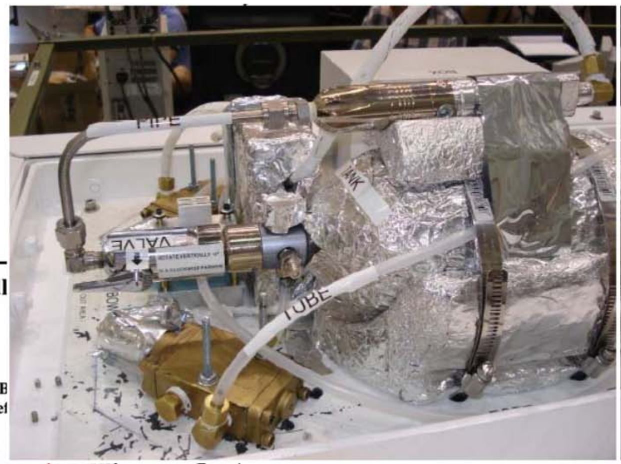
The success rate for HASP payloads is reasonably good

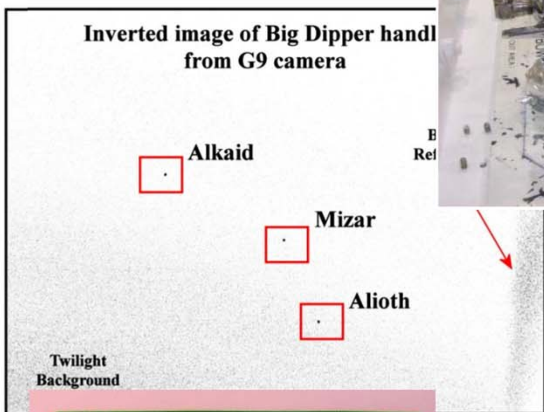
- **Accepted payloads** are those that survived the initial application review and were assigned a seat on HASP
  - There are a total of 63 accepted payloads from 2006 through 2011
  - There were 42 accepted payloads from 2006 through 2009
- **Flown payloads** are those that where attached to HASP at the time it was launched
  - There were 36 flown payloads from 2006 through 2009
  - This is 86% of the accepted payloads
- A payload is defined to be **successful** if at least 50% of the proposed sensors obtain analyzable results for at least ¼ of the balloon time at float
  - There were 26 successful payloads from 2006 through 2009
  - This is 70% of the flown payloads.

A wide variety of topics have been investigated

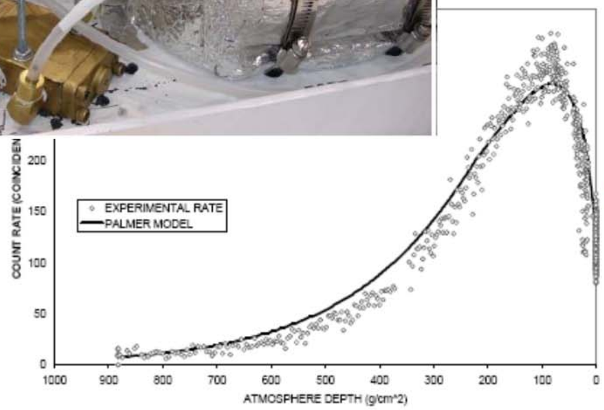
Table 3: General Topics of Investigation by HASP Payloads

Topic	Number
Various Investigations of Cosmic Rays	9
Testing of Various CubeSat Prototype Subsystems	6
Remote Sensing Investigations	6
Attitude Determination Prototype Systems and Components	5
Studies of Using Optical Telescopes on Balloon Platforms	5
Thermal Imaging of the Balloon	5
Solid State Ozone Sensor Prototype Testing	4
Capture and Analysis of Stratospheric Dust	3
Radiation Detector Prototype	3
Recoverable Data Capsule Prototype Test	3
Student Training	3
Biological Sampling and Testing	2
Magnetic Field Prototype Sensor Testing	2
Investigations using a Microwave Detector	2
Radio Telemetry System	2
Rocket Engine Nozzle testing	2
Development of a Gamma Ray Burst Detector	1
Testing of an Infrared Detector Prototype	1

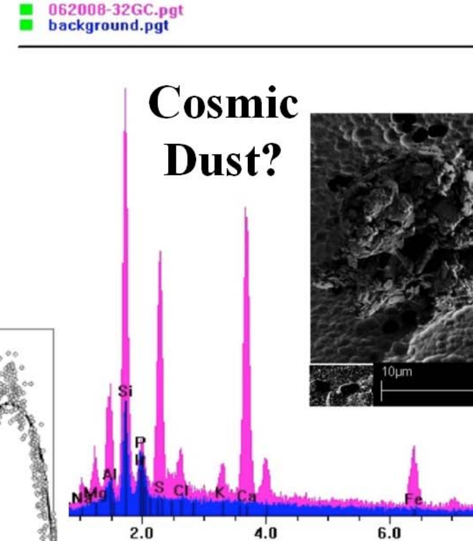




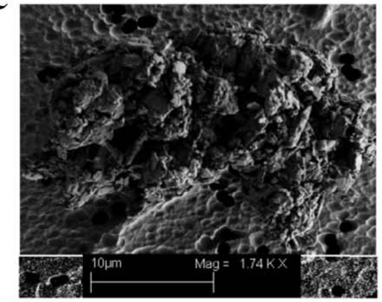
Inverted image of Big Dipper handl
from G9 camera
Alkaid
Mizar
Alioth
Twilight
Background



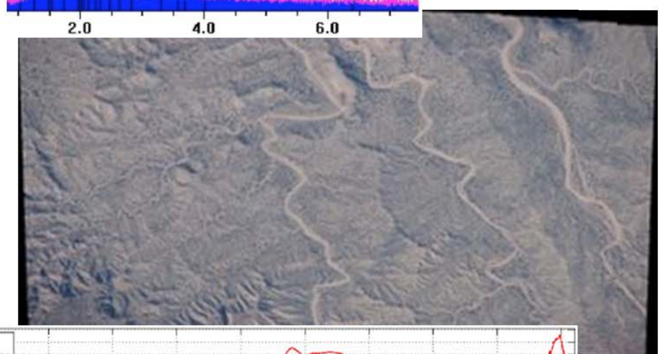
EXPERIMENTAL RATE
PALMER MODEL
COUNT RATE (COINCIDEN
ATMOSPHERE DEPTH (g/cm^2)

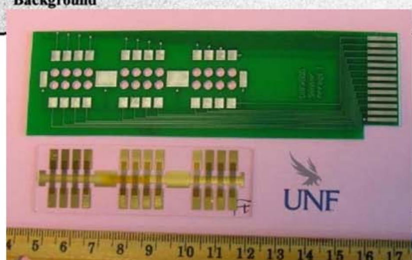


062008-32GC.pgt
background.pgt
Cosmic
Dust?
Si
Al
Mg
P
S
Cl
K
Ca
Fe
2.0
4.0
6.0



10µm
Mag = 1.74 K X





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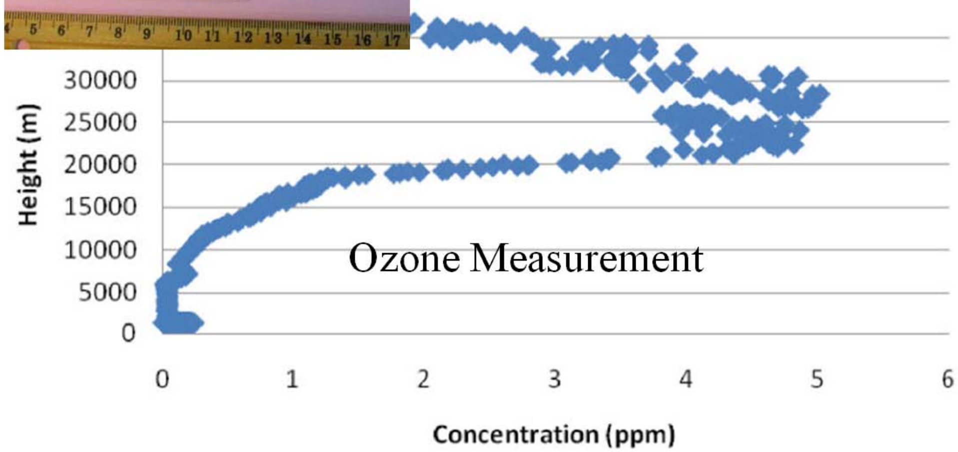
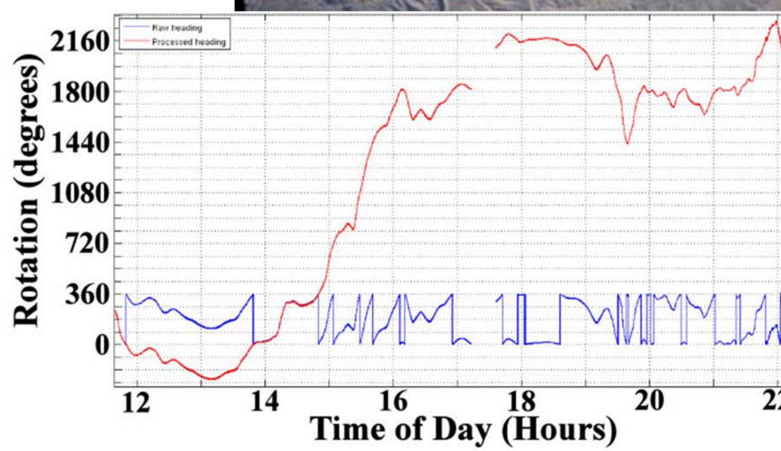


Ozone Measurement
Height (m)
Concentration (ppm)



Raw heading
Processed heading
Rotation (degrees)
Time of Day (Hours)

Conclusions

- HASP is the first balloon platform to support multiple independent experiments using a standard interface.
  - Originally developed to help address the looming crisis in aerospace workforce development
  - Four flights between 2006 through 2009 with two more scheduled for fall 2011
- The standard mechanical, power and communication interface supports payload needs.
- Modular design isolates the multiple payloads from the balloon vehicle improving flexibility.
- More than 60 payloads have been accepted for flight on HASP
  - Of these we expect about 85% will make it to flight and about 70% of flown payloads will be successful.
- HASP systems are very robust and we plan to fly twice within a period of about one week this fall
- Lessons-learned from HASP are applicable beyond student training and can be scaled to support heavier more complex instruments.