Six Days at the Edge of Space:

10 Years of HASP Balloon Flight Operations

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Primary Objectives of Program

- Establish a workforce development program in response to the looming crisis in training the next generation of aerospace scientists and engineers.
- Teach students how a modern science experiment is implemented from conception through data analysis
- Include models of all primary components that make up such an experiment
  - electronics, sensors, real-time programming, mechanical, management, documentation
- Provide flavor of real research to keep students interested in a science, technology, engineering career

LaSPACE Developed Several Components

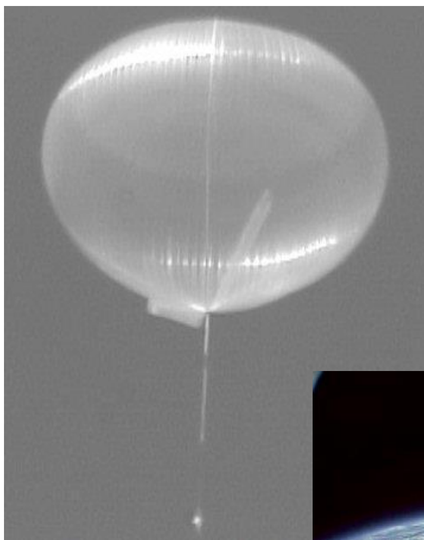
- **Started with 1st "Starting Student Space Hardware Programs" workshop organized by the Colorado Space Grant (C. Koehler) in 2002**
- **Louisiana Aerospace Catalyst Experiences for Students (LaACES)**
  - Entry level uses small payloads (~500 g) with sounding balloon "vehicle"
  - More than 10 years engaging Louisiana institutions and students
  - Exported to other states across the country.
- **Physics & Aerospace Catalyst Experiences for Students (PACER)**
  - Focus on establishing LaACES-like programs at minority institutions
  - Bring teams to LSU for 9-week intensive summer workshop then mentor institutions during academic year
  - Funded by NSF from 2007 through 2013
- **Wallops Ballooning Experience for Educators (WBEE)**
  - Focused on high school teachers for two years of operation.
- **High Altitude Student Platform (HASP)**
  - Carry student payloads to 124,000 feet for up to 20 hours
  - For advanced undergraduates and graduates
  - Support student "thesis" projects
  - Supported by NASA Balloon Program Office, Louisiana Board of Regents, LaSPACE, and LSU

High Altitude Student Platform (HASP)

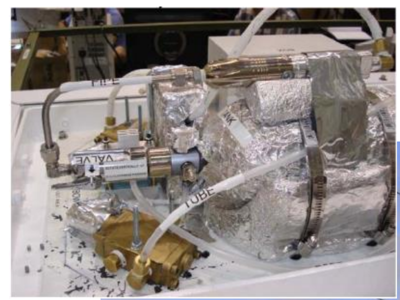
A Partnership between the **NASA Balloon Program Office** (BPO) and **Louisiana Space Consortium** (LaSPACE)

Provide undergraduate and graduate students with an annual near-space flight opportunity

950 lb. payload carries 12 student payloads to 120,000 feet for about 17 hours using a 11 mcf polyethylene, zero-pressure balloon.

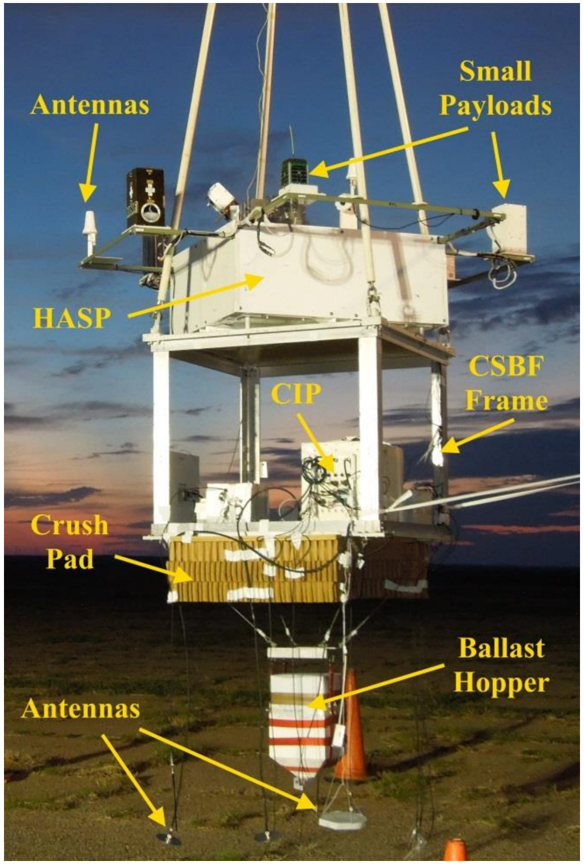


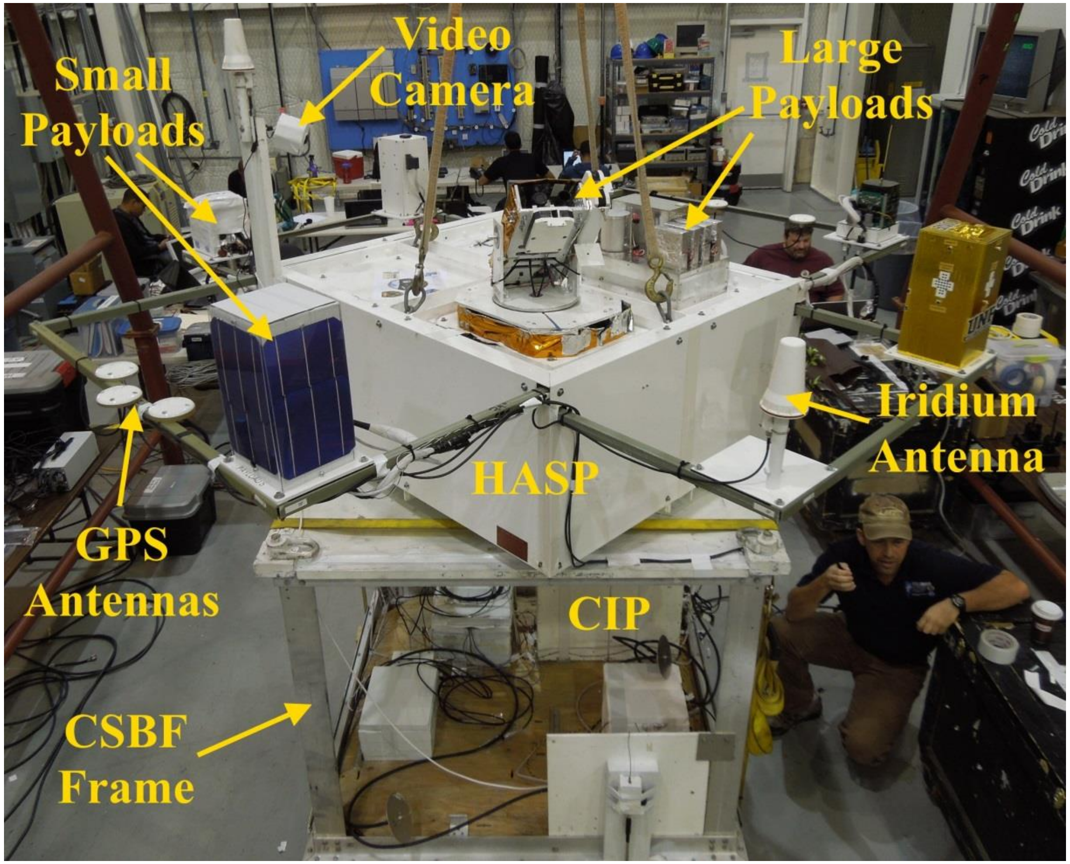
Ten flights since 2006 have carried close to 90 payloads developed by students around the world



HASP is a Multi-Payload Balloon Platform

- Support up to eight payloads < 3 kg and four payloads < 20 kg per flight
- HASP supplies payloads with serial downlink & uplink in near real-time, 32 VDC @ 2.5 A power, discrete commands, analog downlink.
- CosmoCam provides real-time video of payloads and environment



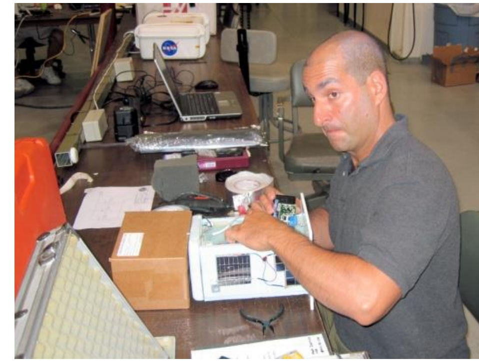


Camera provides visual monitoring in real time

- 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. (early HASP flights) and by CSBF (most recent HASP flights)
- 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): Early Oct.
  - Applications due: Mid - December
  - Selection announcement: mid-January
- Payload development takes place in the spring
  - Require monthly status reports and telecon meetings
  - Preliminary thermal / vacuum test the 3rd week of May

- Integration occurs during 1st 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

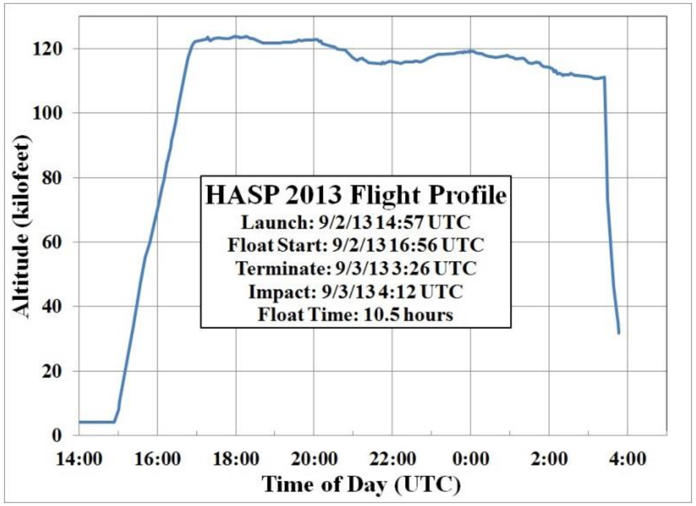
ConUS flights launched from Ft. Sumner NM

LOUISIANA SPACE CONSORTIUM LaSPACE

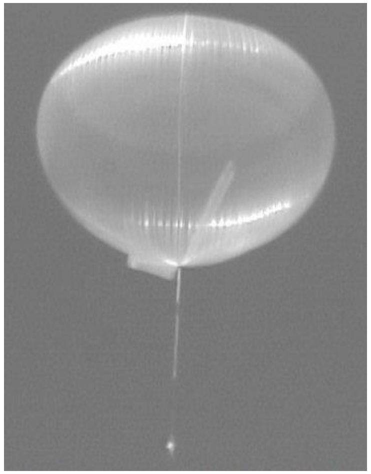
Typical Pre-launch Preparation

HASP Launch Preparation

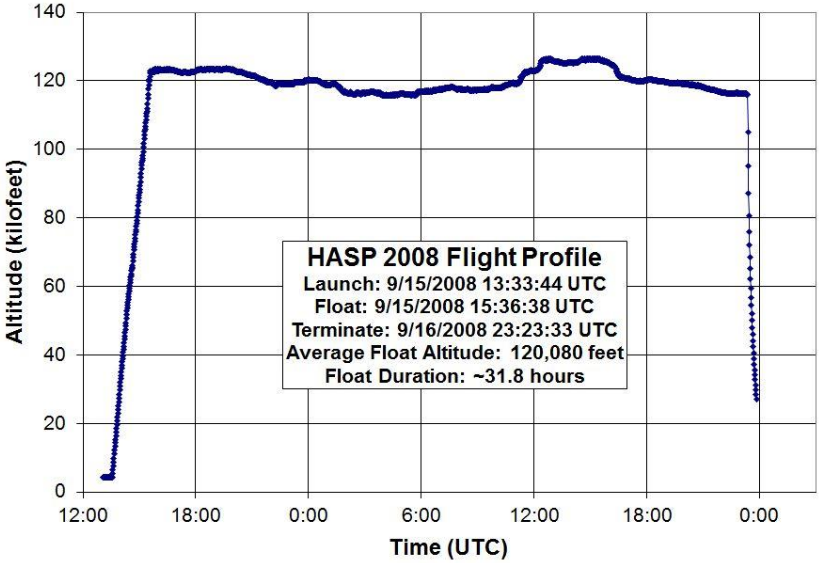
Typical flight from Ft. Sumner, NM

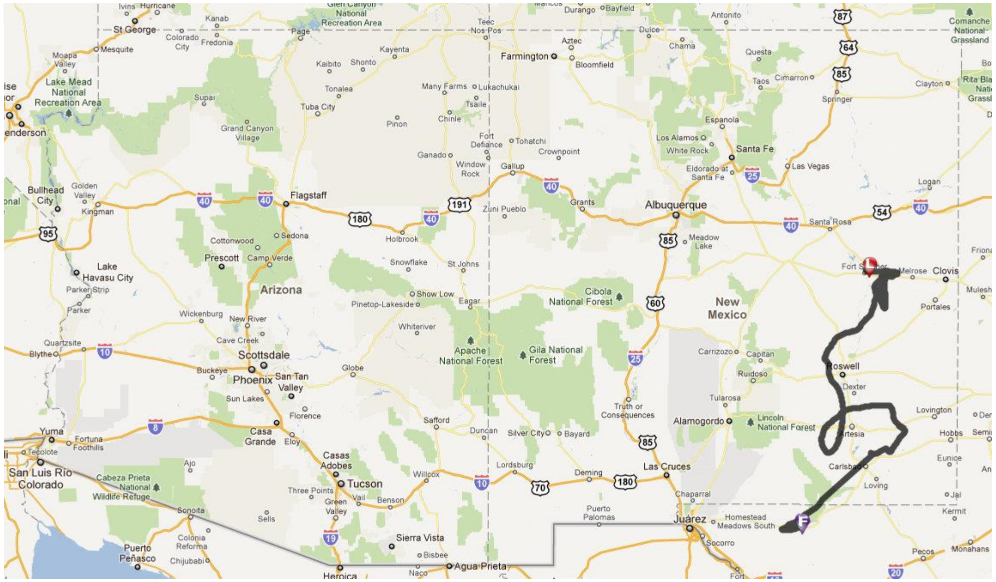


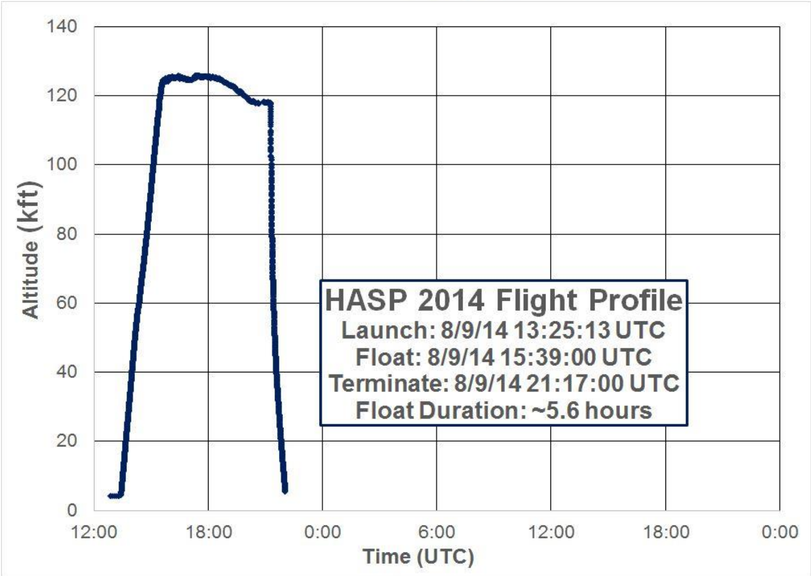
- Usually launch just after dawn (require ground, low level winds to cooperate).
- Flight lasts about 15 hours (2 hours to get to float, 45 minutes to come down on parachute).
- Typically fly across New Mexico and land in western Arizona.

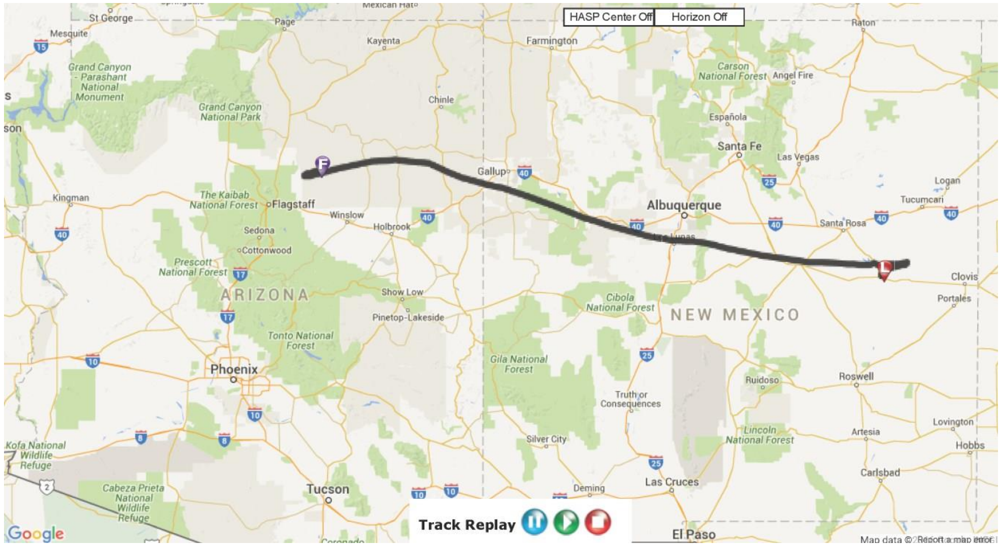


Longest in 2008, Shortest in 2014







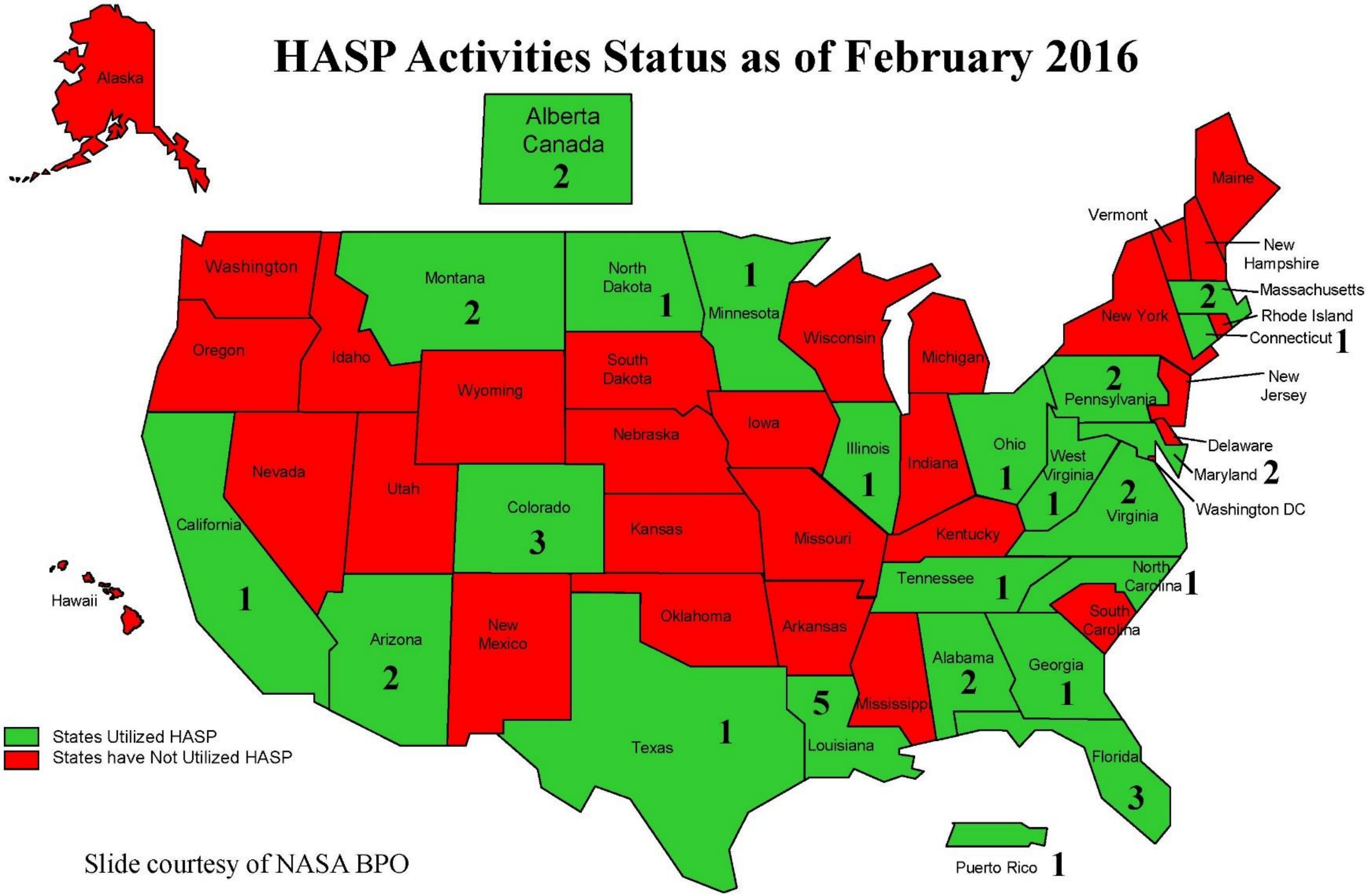


The HASP system is very robust

- 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 supports students across the country



Since 2006, HASP has flown close to 90 student-built payloads engaging over 840 undergraduate and graduate students from 39 universities, colleges, and minority serving institutions located across 22 continental U.S. states plus Puerto Rico and Alberta, Canada.

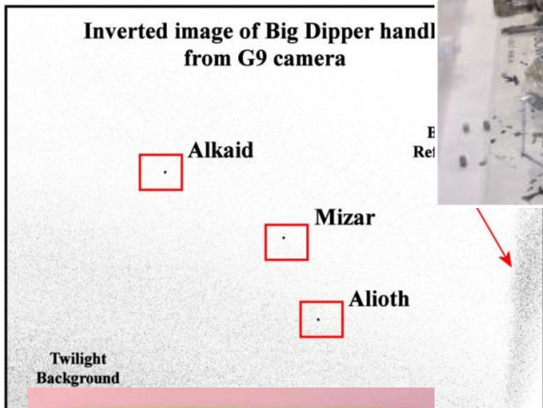
HASP flown almost every year since 2006

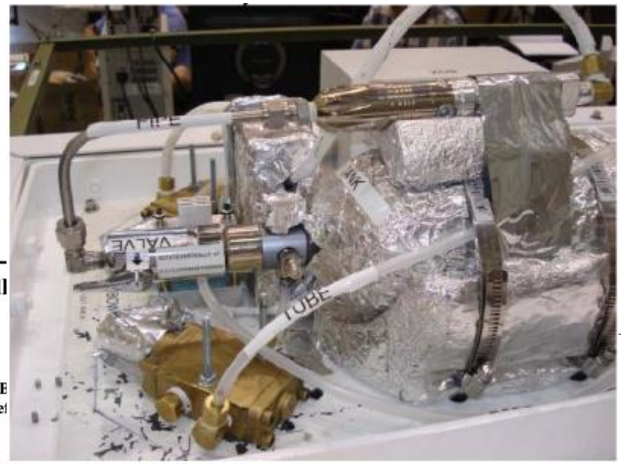
Over ten flights HASP has accumulated 147 hours or **over six days at the edge of space**. This is an average of about 15 hours at float per flight.

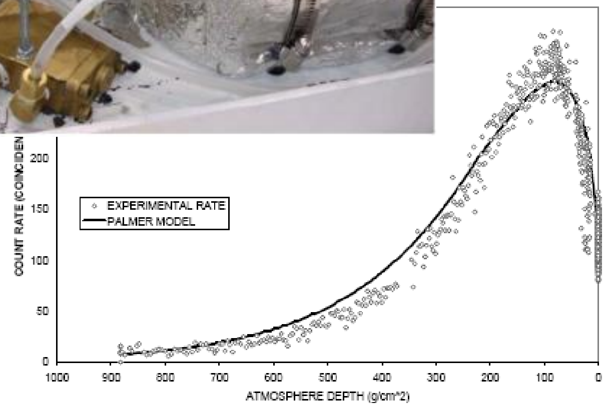
Payloads Involved with HASP Since 2006						
Year	**Launch Date**	**Float Duration (hours)**	**Students**	**Payloads**		
				Accepted	**Flown**	**Success**
2006	9/4/06	15.0	25	8	8	6
2007	9/2/07	16.5	70	11	10	8
2008	9/15/08	31.8	96	13	12	6
2009	9/11/09	12.0	50	10	6	6
2010	8/31/11	8.0	78	11	8	8
2011	9/8/11	15.7	117	11	5	5
2012	9/1/12	8.8	93	14	11	10
2013	9/2/13	10.5	101	12	10	10
2014	8/9/14	5.6	103	10	7	7
2015	9/7/15	23.1	107	12	10	9
Total 06 to 11		**147.0**	**840**	**112**	**87**	**75**

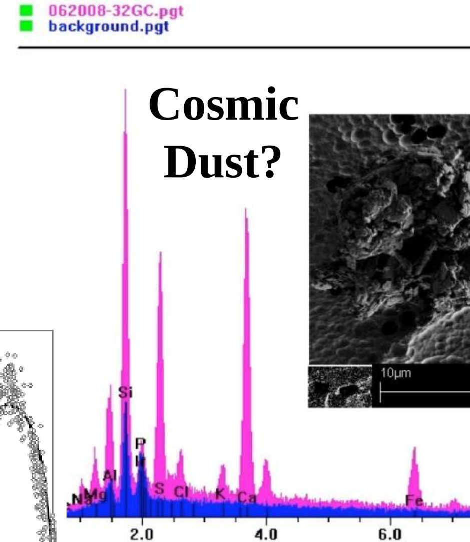
General Topics of Investigation by HASP Payloads

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


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


VALVE
TUBE


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


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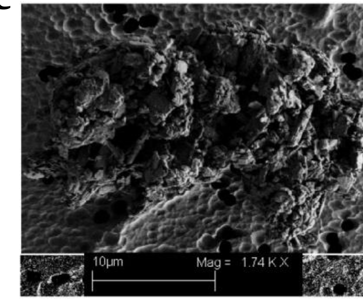
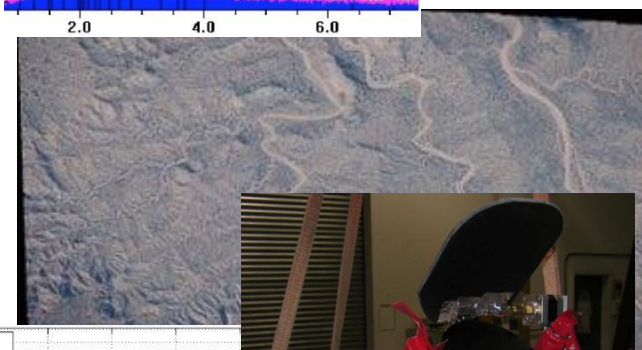
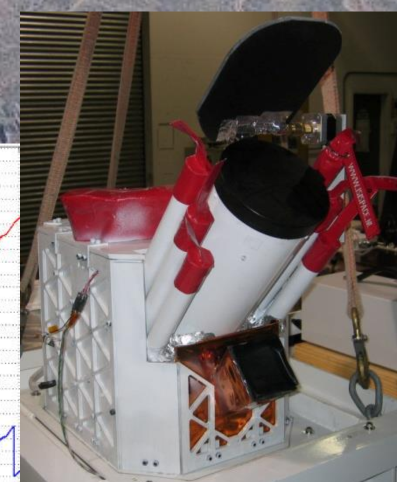
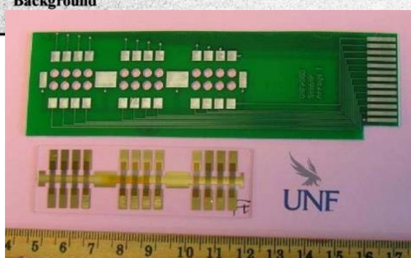
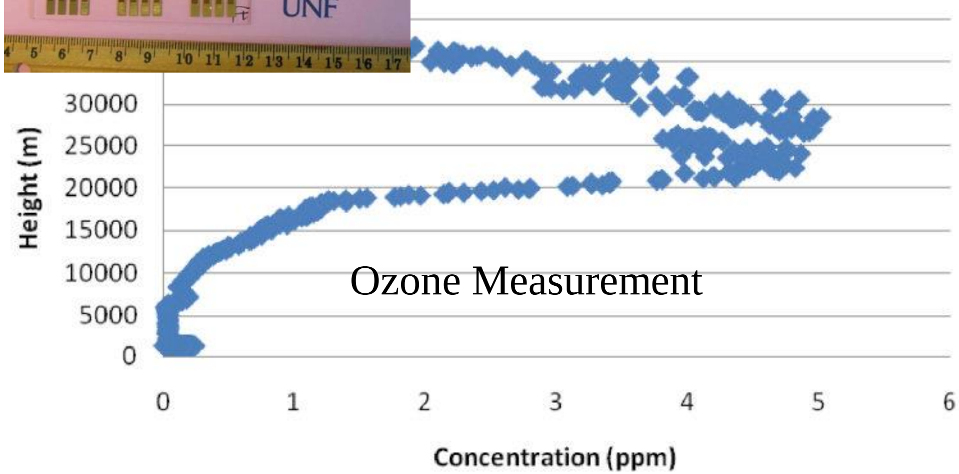
2.0
4.0
6.0

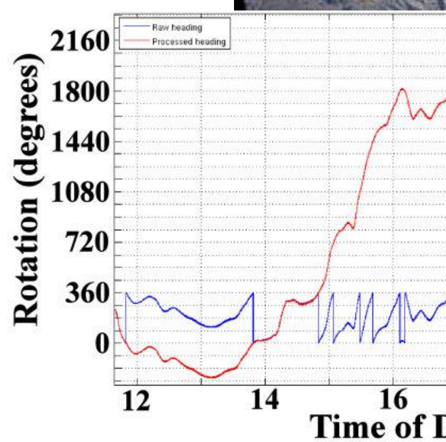

10µm
Mag = 1.74 K X






UNF


Height (m)
Concentration (ppm)
Ozone Measurement


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

Conclusions

- Balloon technology has evolved to the point where student groups can now have regular access to the near-space environment.
- Many states, with the help of the National Space Grant program, have developed student ballooning programs that help train the next generation of scientists and engineers.
- HASP has been highly successful in helping student teams from across the nation gain experience in developing flight payloads.
  – 840 undergraduate and graduate students from 39 universities, colleges, and minority serving institutions located across 22 continental U.S. states plus Puerto Rico and Alberta, Canada
- Over the last ten years (2006 through 2015) we have accepted 112 student team applications for flight
  – Of these 112 selected applications 87 make it to flight (78%)
  – Of the 87 flown payloads 75 are successful (86%)