Developing Student Ballooning Research Programs at Minority Institutions

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Why student ballooning programs?

- Previous studies of future needs for U.S. national security, aerospace industry and other high technology areas indicate that there is a decline in the number of U.S. citizens training to become scientists and engineers.
- Attracting and retaining students into science, technology, engineering and mathematics (STEM) career is of paramount importance.
- Hands-on training programs, such as building a balloon payload, provide students with examples of and experience with applying classroom “theory” to real-world, practical problem solving.
- The greatest opportunity to expand the technical talent pool lies in participation of women and minorities in the workforce.
- As a result the Louisiana Space Consortium (LaSPACE) developed several different student ballooning programs.

Louisiana student ballooning research programs

- Louisiana Aerospace Catalyst Experiences for Students (LaACES)
  - Entry level uses small payloads (~500 g) with sounding balloon "vehicle"
  - This conference has a talk by a LaACES student team (6/23 @ 3:30 pm) and a detailed talk about LaACES itself (6/24 @ 10:00 am)
- High Altitude Student Platform (HASP)
  - Carry payloads developed by advanced undergraduate and graduate students to 120,000 feet for up to 20 hours
  - This conference has a talk about HASP as a multiple-payload carrier (6/23 @ 1:30 pm)
- 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 and started in 2007

The PACER program objectives

- Attract students from the ranks of minorities and women to science and engineering programs.
- Provide students with a research experience that builds skills, techniques and methodologies applicable throughout their science career.
- Establish a core of expertise at multiple HBCU institutions around which a local sustainable student research experience program can develop.
- Nurture and mentor these institutions as they implement their student research experience.

The PACER basic concept is built upon a LaACES foundation

- LaACES was the first student ballooning program that we developed almost eight years ago.
  - Includes the "Student Ballooning Course" lectures and activities as well as custom electronics kits
- Use a latex sounding balloon as the vehicle to carry student payload to the "edge of space"
  - Up to 12 pounds suspended without FAA waiver
  - Altitude up to ~100,000 feet
- Train students to use knowledge about the project life cycle and project management
- Guide students to "think the problem through"
- Students are exposed to skills not normally available in conventional classrooms.

The first part of the program is to build basic skills

- Proceed through the Student Balloon Course (SBC) lectures and activities
- Develop circuit building skills
- Learn about microprocessor programming
- Understand how to use, interface and calibrate sensors
- Develop knowledge of project management techniques
- Understand the ballooning environment, payload constraints and design
- Become familiar with various science topics appropriate for balloon payloads

The Student Balloon Course units

- The 30 lectures and 30 activities are divided into four major units

1. **Electronics** – Basic knowledge about circuits, sensor interfacing & data acquisition
2. **Programming** – How to control the BASIC Stamp, read & store data, interfacing to devices
3. **Project Management** – How to plan, manage and track the progress of a project
4. **Balloon Payload Design** – Facts and skills relevant to the successful development of a payload

- Plus there are usually some guest science lectures on topics appropriate for investigation by balloon payloads.

Next the students design and build their own balloon payload

- Apply skills learned in the fall to develop a small balloon payload
- Proceed through a project life cycle and apply project management techniques
- Written documents & presentations are required for Preliminary Design Review (PDR), Critical Design Review (CDR) & Flight Readiness Review (FRR)

Groups fabricating payloads

PACER08 after FRR

Differences between LaACES and PACER.

- The primary PACER goal is to establish a student ballooning research program at multiple minority serving institutions
  - Provide an affordable research experience at the institution which could then help attract and retain students in STEM fields of study.
- PACER has a nine-week summer session component.
  - What we do to LaACES students over a full academic year, we do to PACER students in eight (8) weeks!
- The summer session team usually is composed of a faculty mentor plus three students
  - The faculty mentor learns how to teach the material and then has three student assistants to help support the academic year program.
- We follow, mentor and support the institution for three years as the local student ballooning program is slowly established
  - Funding and other support is slowly ramped down as local support is established and ramped up.

PACER is fully funded

- PACER is funded through May 2012 by the National Science Foundation, Physics Division, Education and Interdisciplinary Program
- There is extensive support for the summer session
  - Three instructors to teach electronics, software development and project management
  - Student stipend of $4,000 and a faculty stipend of $12,000
  - Travel between home institution and LSU as well as between LSU and CSBF for flight operations
  - Four bedroom, two bath apartment with laundry facility, kitchen and living room.
  - Teaching materials including the SBC “book”, electronics kits and up to $500 for payload parts.
- Each PACER institution also receives a three year sub-award
  - First year provides $10,500 and SBC kits for 12 students
  - Level of support ramps down during next two years as institution support ramps up

PACER Participants

Grambling State University (2007), Norfolk State University (2008)
Interamerican University of Puerto Rico – Bayamon (2008)
Albany State University (2009), Central State University (2009)
Knoxville College (2010)

The summer session is very intense

- All of the Student Balloon Course material and skill building activities occur during the first three weeks.
- Weeks four through eight then involve payload development
- There is a lot of report writing and presentation development
  - SkeeterSat "Calibration" report, Sensor Interface Report
  - Documents and "defense" presentations for PDR, CDR and FRR reviews.
- There are a variety of "extra-curricula" activities as well
  - Weekly science lecture and tours of local science facilities (e.g. LIGO)
  - Evening ham radio licensing sessions, weekend practical radio experience and amateur radio testing
  - Other weekend activities such as a 4th of July party
- Expect students to be on a regular schedule and to be on time
  - Minimum contact hours are 9 am to 4 pm Monday through Friday
  - Typical that the students work into the night and over weekends to make the deadlines.

Major PACER summer program activities by week

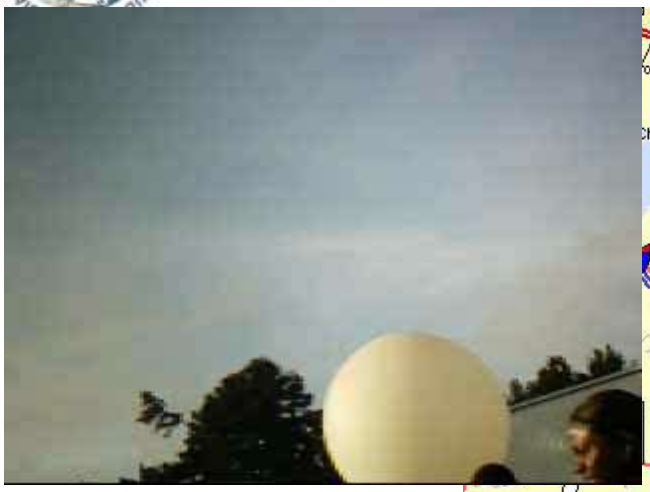
Week	Formal Activities	Informal Activities
1	Introduction, Begin Electronics, Construct SkeeterSat and BalloonSat, Begin Programming	Science Lecture
2	Sensor Interfacing, Serial Communications, Testing & Debugging, Power, System Design	Science Lecture, ham Radio Class, St. George Observatory Tour, Bar-B-Q
3	Mechanical Design, Thermal Issues, Near-Space Environment, Project Management	Science Lecture, Communication across the Curriculum (CxC) Resources, ham Radio Class
4	Work on payload, Prepare PDR document and Presentation	Science Lecture, Pennington Planetarium Tour, ham Radio Class, Highland Road Park Observatory tour, ham Field Day, LIGO tour
5	PDR, Work on payload, Prepare CDR document and Presentation	Science Lecture, ham Radio Class, July 4th Party, Free Weekend
6	CDR, Construct, Calibrate and Test Payload	Science Lecture, ham Radio Class, Mary Bird Perkins Cancer Center Tour (Medical Physics), ham Radio APRS "fox" hunting
7	Construct, Calibrate and Test Payload	Science Lecture, Lockheed Martin Space Systems Tour, ham Radio License Exam
8	Complete Payload, Prepare FRR Document and Presentation	Center for Advanced Microstructures & Devices (CAMD) tour, Science Lecture
9	PACER Flight Operations at the NASA Columbia Scientific Balloon Facility	

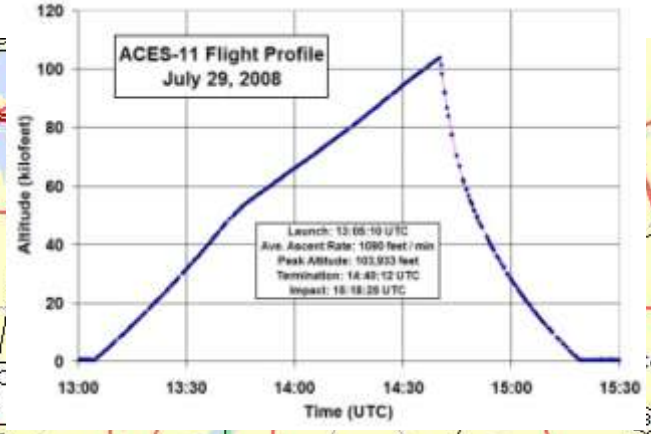
Week 9 is for balloon flight operations

- Drive on Sunday about six hours from Baton Rouge to reach Palestine, Texas whish is the home of the Columbia Scientific Balloon Facility (CSBF).
- On Monday we arrive at CSBF to prepare all payloads and the sounding balloon vehicle for launch
- Tuesday is for flight operations
  - We generally arrive at CSBF by 6 am and launch by about 7:30 am
  - Following launch we track the balloon from our chase vehicles throughout the flight, termination and landing
  - Recovery time is dominated by gaining access permission from land owners
- Wednesday is provided for data analysis and talk preparation
- Thursday is for presentation of the science talks and return to Baton Rouge

Balloon Flight Operations

Typical sounding balloon flights





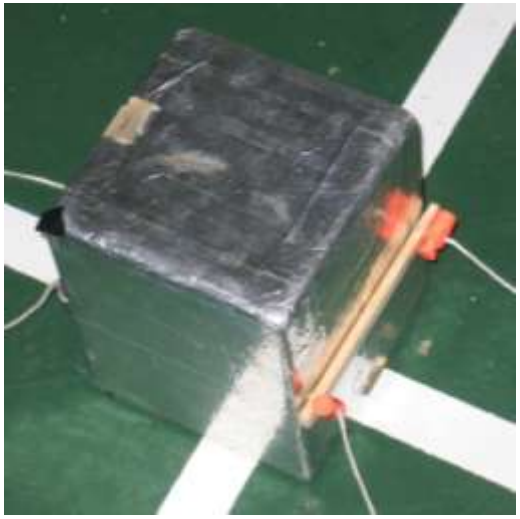
Example PACER Payloads

CSU - DAP

GSU HATPaC

IAU-P.R. MicroTrak

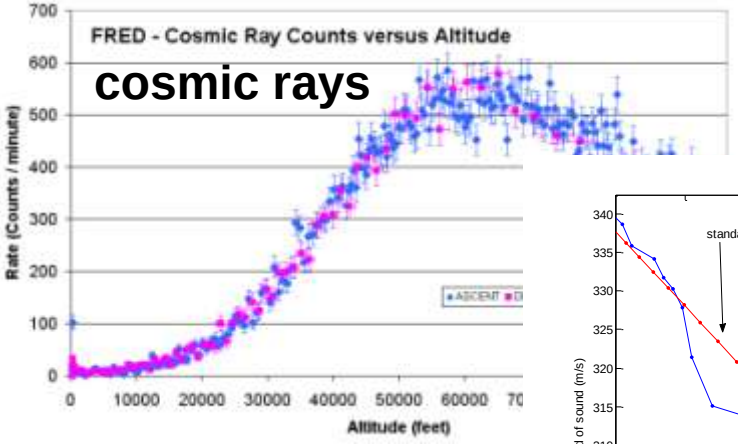
IAU-P.R. Albedo

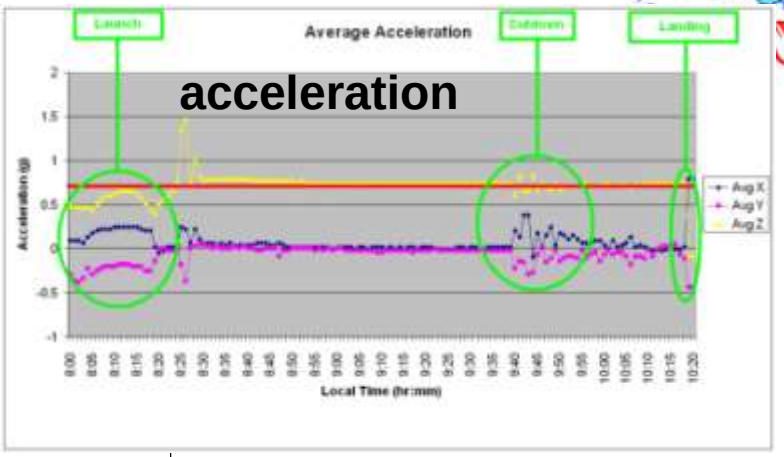


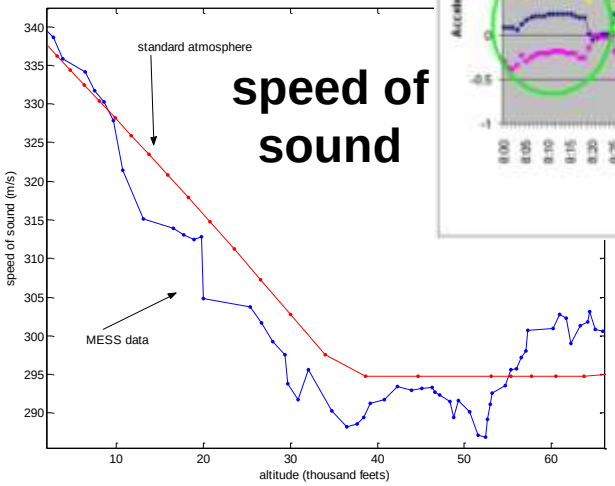
ASU - SABRE

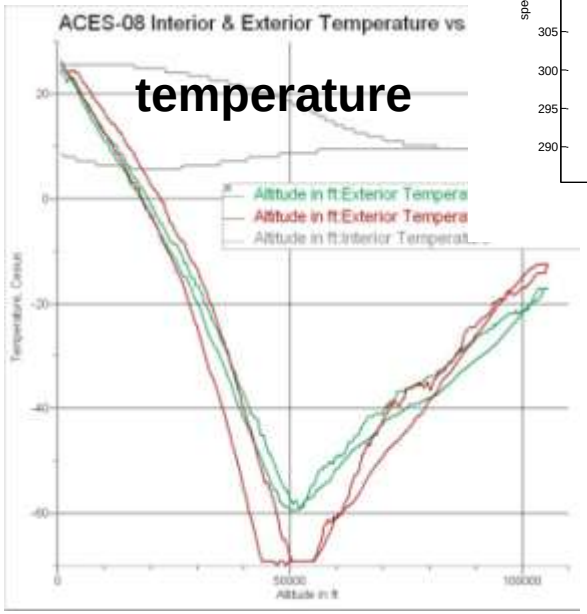
IAU-P.R. Accel

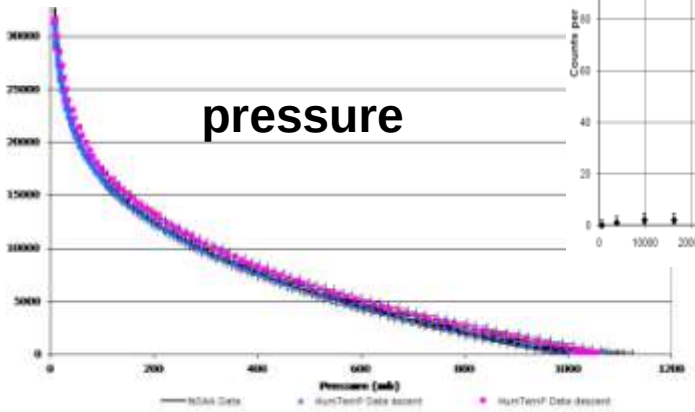
Some of the science that can be done

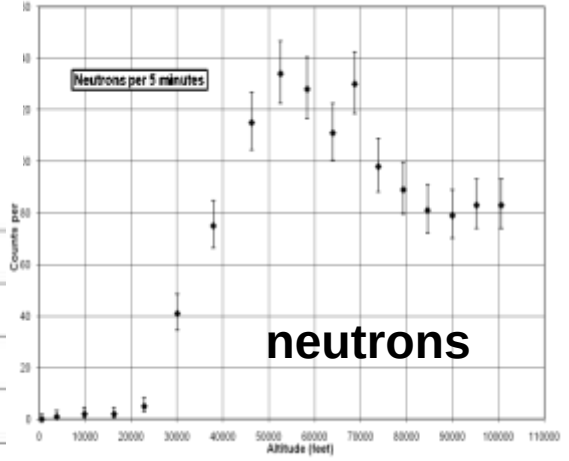




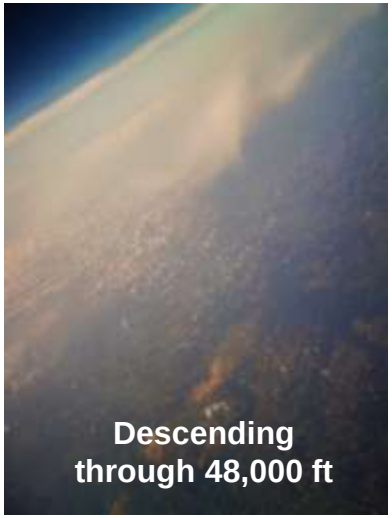


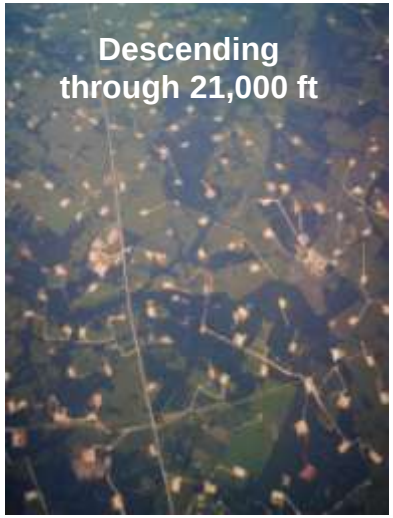






and of course pictures …
(from the GSU HATPaC payload)





The summer session is very successful

- Solicit feedback from participants at the end of the summer session.
  - Rate on scale of 1 (poor) to 5 (excellent) content, clarity, delivery of SBC lectures, activities, reviews and extra-curricular events
  - Overall rating averaged over all participants is about 4.5
- Feedback also includes written comments

  "This is a very ambitious and rewarding program."

  "Valuable program. Students need more opportunities like this to expand their understanding of what science and being a scientist is all about."

  "I learned a lot of information that I think will be useful to me in the future."

  "I learned work ethics and how to work with others."

  "It was a very intense program and very helpful in many ways."
- Getting this kind of feedback allow us to conclude that we are close to "getting it right".

Academic year program

- Following the initial "training" during the summer we maintain contact and support with each institution for about three years
  - The intention is to help institutionalize the student ballooning program
  - Provide a sub-award and SBC electronic kits to help defer some of the start up costs
  - Maintain contact through regular teleconferences, site visits and regular email
- While the summer session is convincingly successful, we have had more mixed results with the academic year program
- All institutions have had problems with recruiting and retaining local students
  - A typical academic year cohort appears to be about 3 to 4 students
  - Student seems to have great difficulty completing the SBC and payload development activities in one year
- May be a bit premature to draw conclusions as only one institution, GSU, has completed the three year mentoring

There are some encouraging signs

- During 2010-2011 Grambling State University completed the full PACER program
  - Retained a 4 student team that developed their own balloon payload which was flown during May 2011
- IUPR (Puerto Rico) has used PACER to expand the aerospace training opportunities available to its students
  - Worked with other groups on the island to launch balloon payloads
  - Has their own funded CubeSat program and has developed payloads for flight on HASP.
- Albany State University developed their own balloon payload and also flew their own balloon vehicle.
  - Flight occurred on April 11, 2011
  - Assisted by LSU personnel
  - First PACER institution to have end-to-end capability for their own balloon program.

Conclusions

- PACER has been implement at LSU to test a concept for helping to establish student ballooning research programs at multiple minority serving institutions across the country.
- PACER includes a number of key features intended to foster institutionalization of ballooning programs.
  - Intense nine week summer session an institution team in core skills and balloon payload development
  - Each team is composed of a faculty mentor as well as students
  - Maintain contact and support with institution for three years.
- Summer session is proven to be highly successful
- Not clear how well a PACER-like ballooning program can be established at a minority institution
  - Very low numbers of students recruited and completing payloads
  - Several institution have achieved major milestones within the last year.
  - May be premature to evaluate how well PACER can migrate a student ballooning program into a minority institution.

Acknowledgements

- PACER has direct support from the National Science Foundation under grants PHY-0653423 and PHY-0902271
- Various aspects of PACER are supported by other agencies
  - Louisiana Space Consortium that is funded by NASA (NNG05GH22H)
  - Louisiana Board of Regents and Louisiana State University
- The NASA Balloon Program Office and the Columbia Scientific Balloon Facility provide extensive support.
  - Directly support PACER balloon launches
  - Also support the HASP program as described at this conference by T.G. Guzik, 6/23 @ 1:30 pm
- The Student Balloon Course (SBC) used by PACER was development under the LaACES program
  - See talk by M. Stewart, 6/24 @ 10:00 am
  - See talk by A. Spring, 6/23 @ 3:30 pm