



The Louisiana Aerospace Catalyst Experience for Students (LaACES) Sounding Balloon Program

Louisiana Space Grant Consortium (LaSPACE)

Department of Physics and Astronomy
Louisiana State University
Baton Rouge, LA



Introductions – LaACES Management



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What is LaACES?



- Louisiana Aerospace Catalyst Experiences for Students
- A two-semester program that includes the Student Ballooning Course and building a payload
- Students develop science experiments and fly them to 100,000 feet
- Students gain practical skills in:
 - Electronics
 - Microcontroller programming
 - Project management
 - Writing and communication
- Target entry level students enrolled in Science, Technology, Engineering, or Mathematics fields (STEM)





LaACES Goal & Objectives



Goal:

“To inspire students to pursue STEM related careers”

Objectives:

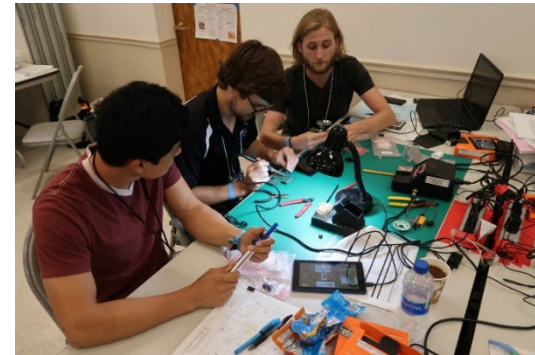
Provide students with an authentic flight project experience not normally available through the classroom

Develop student skills in electronics, real-time programming, communication, and project management

Guide students to work in teams and to use acquired knowledge to create a science payload for balloon flight

Students communicate their progress through required documents and presentations on a milestone schedule

Conduct annual flight operations where approved student team payloads are flown on a latex sounding balloon to an altitude of ~100,000 feet or the very “edge of space”





A Historical Look at LaACES



- Evolved from the pilot program ACES implemented with NASA funding during 2002-2003 academic year
- ACES involved only students at LSU
- NASA approved LaACES funding in February 2004
- Student Ballooning Course (SBC) developed in early 2004
- Over 68 flights since 2004
- Major revision of the LaACES electronics, lectures, and activities in 2018, field tested in 2019, and implemented in 2020-2021

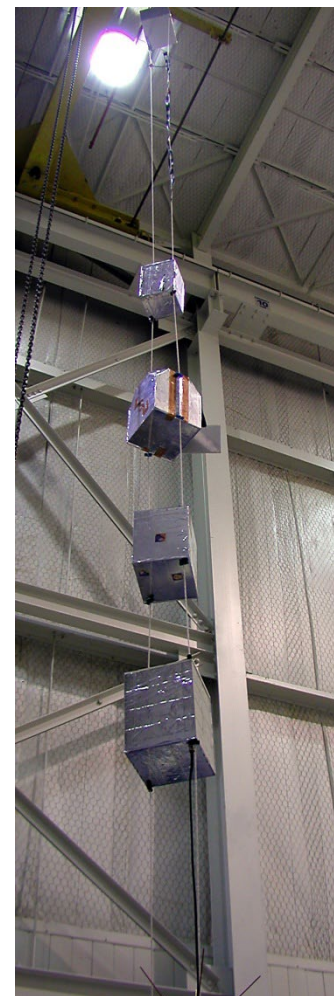




LaACES Structure



- Involves students from Institutions across the state
- Students are organized into teams of 3-4
- Fall semester consists of bi-weekly 2 hour “classes”
 - Meet Tuesday / Thursday from 6 pm to 8 pm
 - Lectures and follow-on related hands-on activities
 - Additional work in the lab to complete activities
 - Lectures and activities cover electronics, programming, payload design, project management, balloon payload design, and science
- Spring semester devoted to designing, developing, testing, and documenting a balloon payload
- Students expected to devote 10-15 hours per week and will have specific deliverables due on milestone dates





Fall Semester Tasks



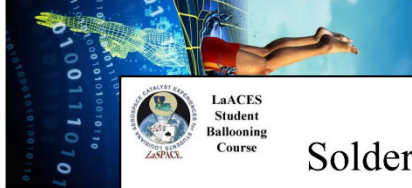
- Basic Electronics
 - Soldering
 - Reading schematics and datasheets
 - Prototyping, circuit building
- Microcontroller Programming
 - Digital and Analog interfaces
 - Designing data formats
 - Using GPS and SD cards
- Two major projects during fall are the SkeeterSat calibration report and the Capstone sensor report.



LaACES
Student
Ballooning
Course

We live in an analog world so how do we create digital signals?

- Digital signals are generated by a change in voltage. Digital waves are not smooth because they only have two values, low and high.
- 0 is assigned to the lower voltage and 1 is assigned to the higher voltage. In Boolean Logic they represent true or false.



LSU 12/13/2018



LaACES
Student
Ballooning
Course

Soldering Tutorial

Soldering Safety:

- Again, situational awareness is key!
 - Be mindful of where you are and where hot items are.
 - Hair (get it out of the way)
 - Eye protection
- There is lead in the solder so wash your hands afterwards.



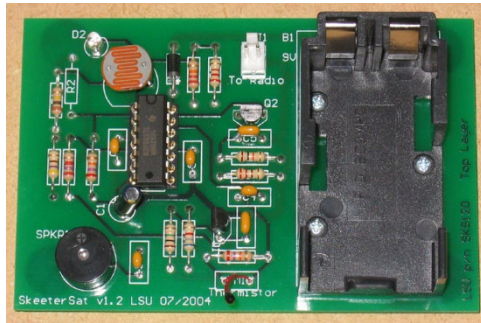
LSU 10/12/2010

Lecture 7

6

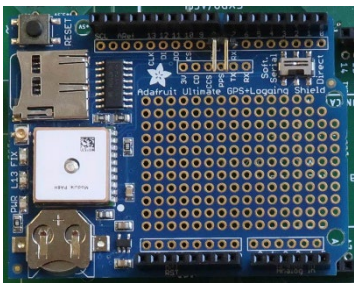
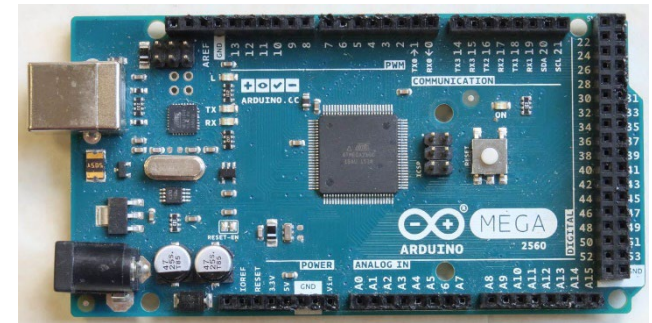


Fall SBC Hardware Components



SkeeterSat is an introductory circuit assembly activity where the output beep frequency is temperature dependent and the interval between beeps is light intensity dependent. Used to learn basic electronics, assembly, troubleshooting, calibration, and documentation.

Arduino Mega2560 is a powerful microcontroller with 54 digital I/O lines, 16 channels of 10-bit ADC, and plenty of memory for complex programs. Used for learning programming and as a payload controller.



Adafruit Ultimate GPS Logger includes a GPS receiver (validated to at least 100,000 feet), internal GPS antenna, external antenna socket, a battery backup coin cell holder, and a prototyping area. It interfaces with the Arduino Mega and is used for time stamping data and data logging.



Spring Semester Tasks



- Develop a realistic payload based upon the MegaSat stack
- Work as a team during payload development
 - In January develop a “Team Contract” to define roles and responsibilities
- Learn Project Management Techniques:
 - Writing Requirements, System Design, Tasks and Scheduling, Flowcharts, Risk Management
- Payload Design Unit:
 - Mechanical Drawings, Fabrication, Materials, Power Systems
- Payload Design, Development, Fabrication, Calibration, System Testing
- Thermal Vacuum System Testing at LSU
- Flight Readiness Review milestone and deliverable



Payload Flight Requirements and Bases

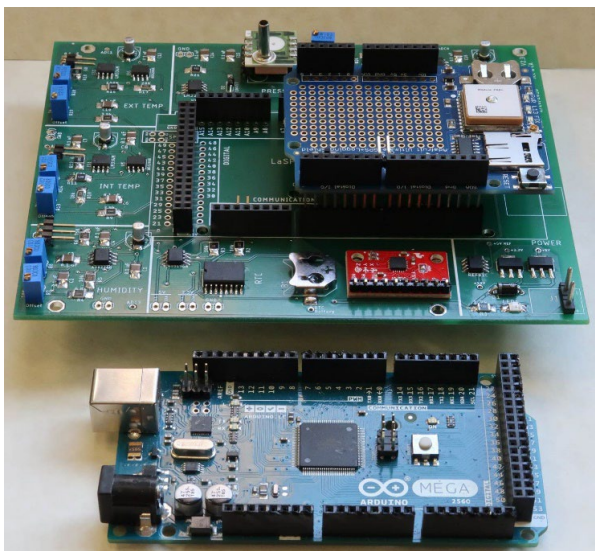


	Requirement	Basis
Weight	Payload mass shall be less than 500 grams	FAA Total Weight Limit/FAA Individual Payload Limit
Density	Smallest payload surface must be larger than 10 in ²	FAA Density Limit
Physical Interface	Payload shall have 2 vertical penetrations through the entire payload : -17 cm apart center to center -Inner Diameter 0.7 cm to 1.0 cm (to allow for plastic grommet) - Greater than 1 cm from any payload wall	Flight String Interface Integration
Data	Enough data storage for 4 hours of recording	2.5 Hours of flight + setup time
Power	Enough power capacity for 4 hours	2.5 Hours of flight + setup time



LaACES MegaSat Stack

- The core of the payload **will** be the LaACES MegaSat that includes
 - Two temperature sensors, one humidity sensor, one pressure sensor, 3-axis accelerometer, 3-axis gyroscope, and a real-time clock with backup battery
- Payload controller will be the Arduino Mega.
- Will have the Adafruit Ultimate GPS Logger shield for GPS data throughout the flight and recording NMEA data on a SD card.



LaACES MegaSat payload stack

- The prototype area on the Adafruit GPS shield or a separate proto-shield board can be used to interface with other sensors.
- Construction of MegaSat shield is done in parallel with other required activities
- The team will need to include in planning
 - The components that will be part of the payload
 - Time needed to construct the MegaSat shield
 - How to interface additional sensors to the Mega



Management and Communication



- Management and communication are key components of successful projects
- Communication skill building is embedded in LaACES
 - How to use and maintain your **Laboratory Notebook**
 - Technical report writing
 - Payload design reviews, documents, and presentations
- Project Management and team-work are common in the technical workforce.
 - The project management lifecycle and structure
 - System design
 - Developing the project tasks, schedule, and costs
 - Risk management
 - Developing your team contract



Flight Certification Requirements



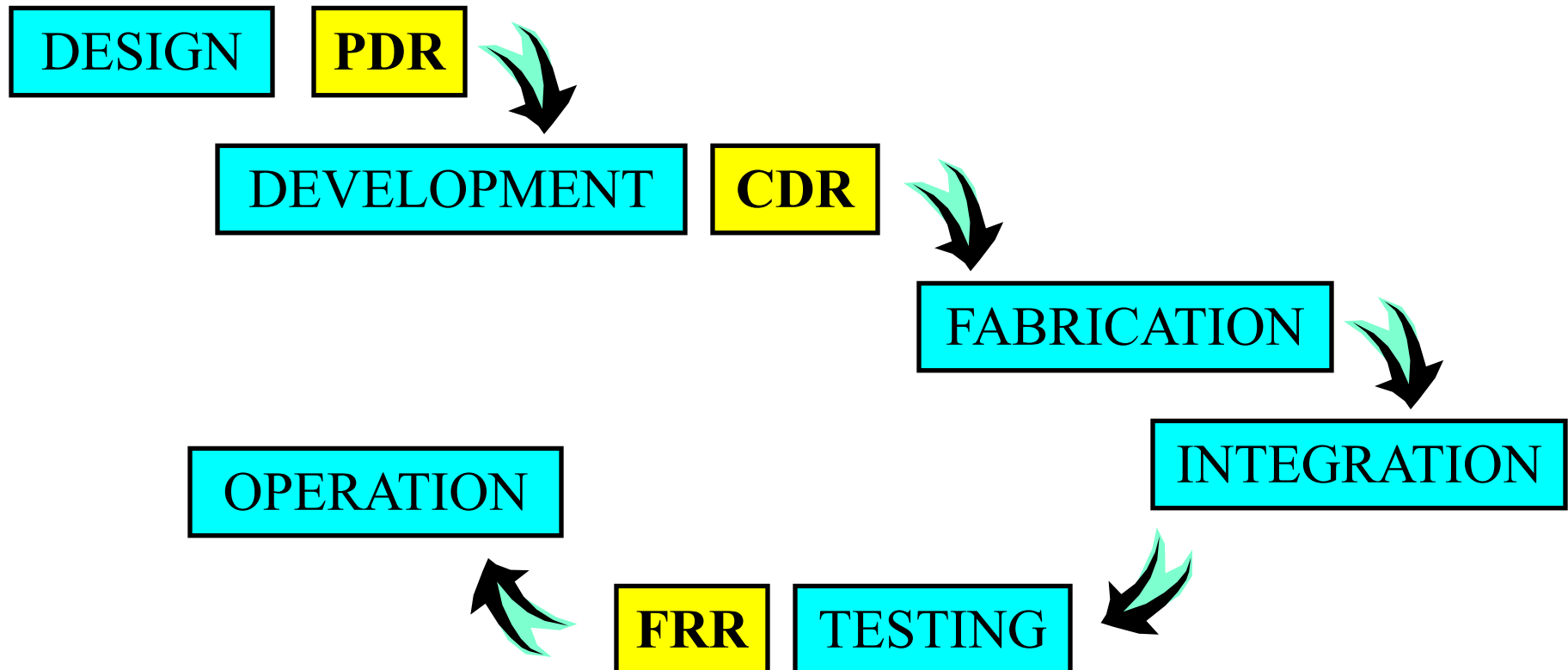
Student Teams will need to complete the following in order to be allowed to fly:

1. PDR, CDR, and FRR documents must be delivered by the milestone date and approved by LaACES Management
2. Payload must complete a thermal / vacuum system test in April
3. Deliver a payload meeting all flight string requirements
4. Successful FRR Defense, must be approved by LaACES Management



Project Phases & Major Reviews

- All projects complete roughly the same phases from inception to completion

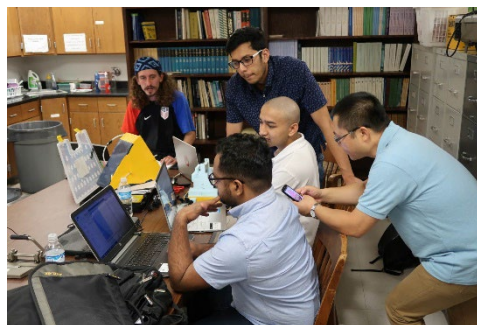




Thermal / Vacuum System Test



- Use LSU thermal / vacuum chamber to simulate the extremes of balloon flight
- All LaACES teams from across Louisiana come to this system test in late April
- All payloads are supposed to be flight ready and configured for flight
- Payloads are cold-cycled and heat-cycled while under the vacuum equivalent of 100,000 feet
- Test data is analyzed and presented by the end of the day by all teams





Milestone Deadlines for LaACES 2026-2027



Deadlines

Temperature Calibration Report
Capstone Report

October 16, 2026
December 2, 2026

Pre-PDR

February 7, 2025

PDR

February 14, 2025

Pre-CDR

April 4, 2025

CDR

April 3, 2027

Thermal / Vacuum Test (at LSU)

April 16, 2027

FRR – Document

May 10, 2027

LaACES Launch Trip

May 16, 2027 – May 21, 2027

FRR Defense Presentation (at CSBF)

May 17, 2027



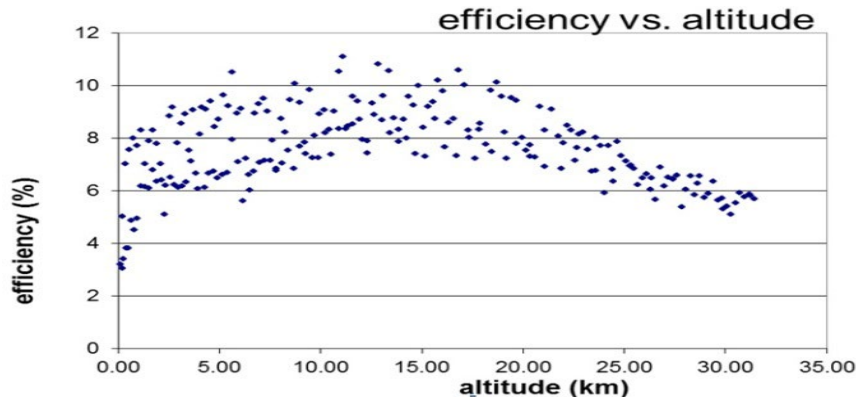
Example Science topics



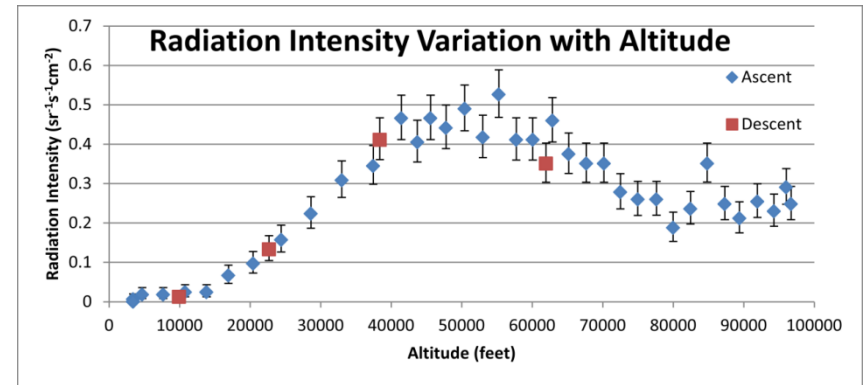
1. Radiation Intensity as a function of altitude
2. Measure intensity of UV bands as function of altitude to deduce properties of ozone layer
3. Directly measure concentration of O_3 , NO_x , CO_x gases as a function of altitude using solid state sensors
4. Develop a system to measure air flow (e.g. hot wire anemometer) at high altitudes (i.e. very low pressure).
5. Investigate methods to optimize atmospheric temperature measurements
6. Investigate thermal flow and conductivity of boundary layer around payload
7. Develop an inertial sensing system which will provide sub-minute of arc orientation knowledge



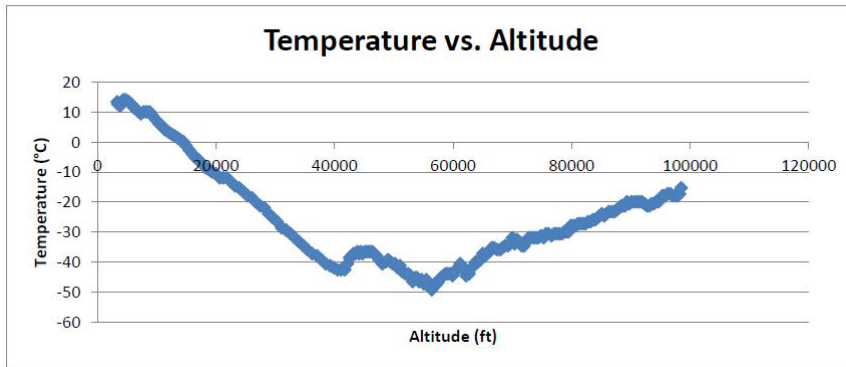
Different Science Topics can be Investigated



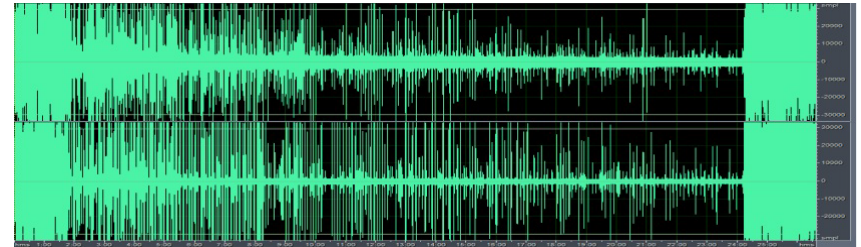
ACES07: Solar Cell Efficiency vs Altitude.



ACES16: Cosmic Ray Intensity as a function of Altitude



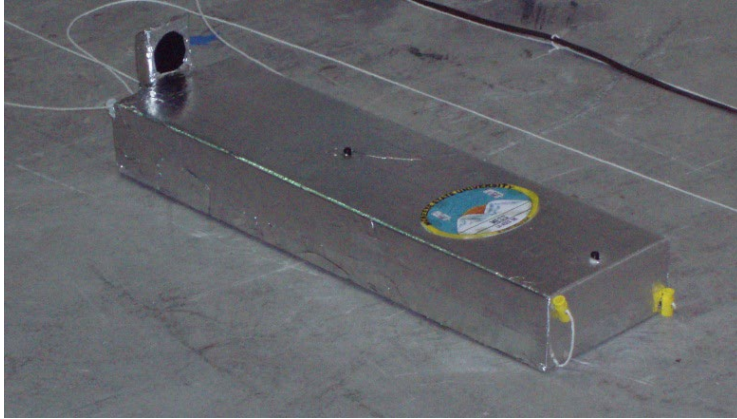
ACES16: Team Space Cadets, Temperature Altitude Profile.



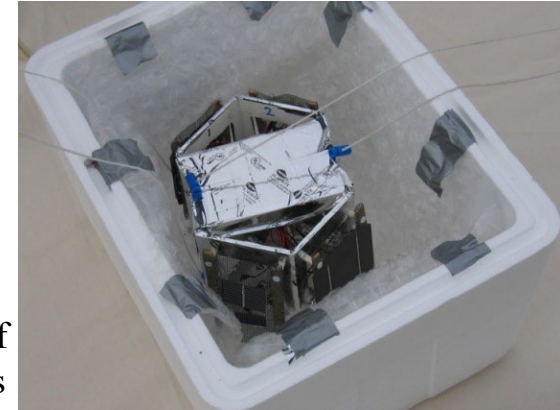
ACES06: Sound Waveform from Tropopause (ascent) back through the Tropopause (descent.)



Completed Payloads



ACES09-10:
McNeese State
University



ACES12:
University of
New Orleans



ACES06: Louisiana State
University



ACES16:
Louisiana
State
University



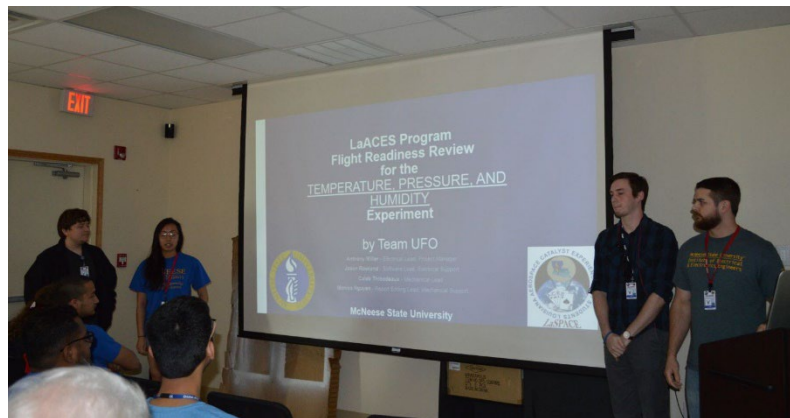
LaACES Launch Week



- For 2025 National Scientific Ballooning Facility in Palestine, TX will host the LaACES Launch
- Launch date set for the fourth week in May
- Must successfully complete FRR prior to flight



ACES-01 was assembled and tested in this NSBF hanger



Students presenting their FRR



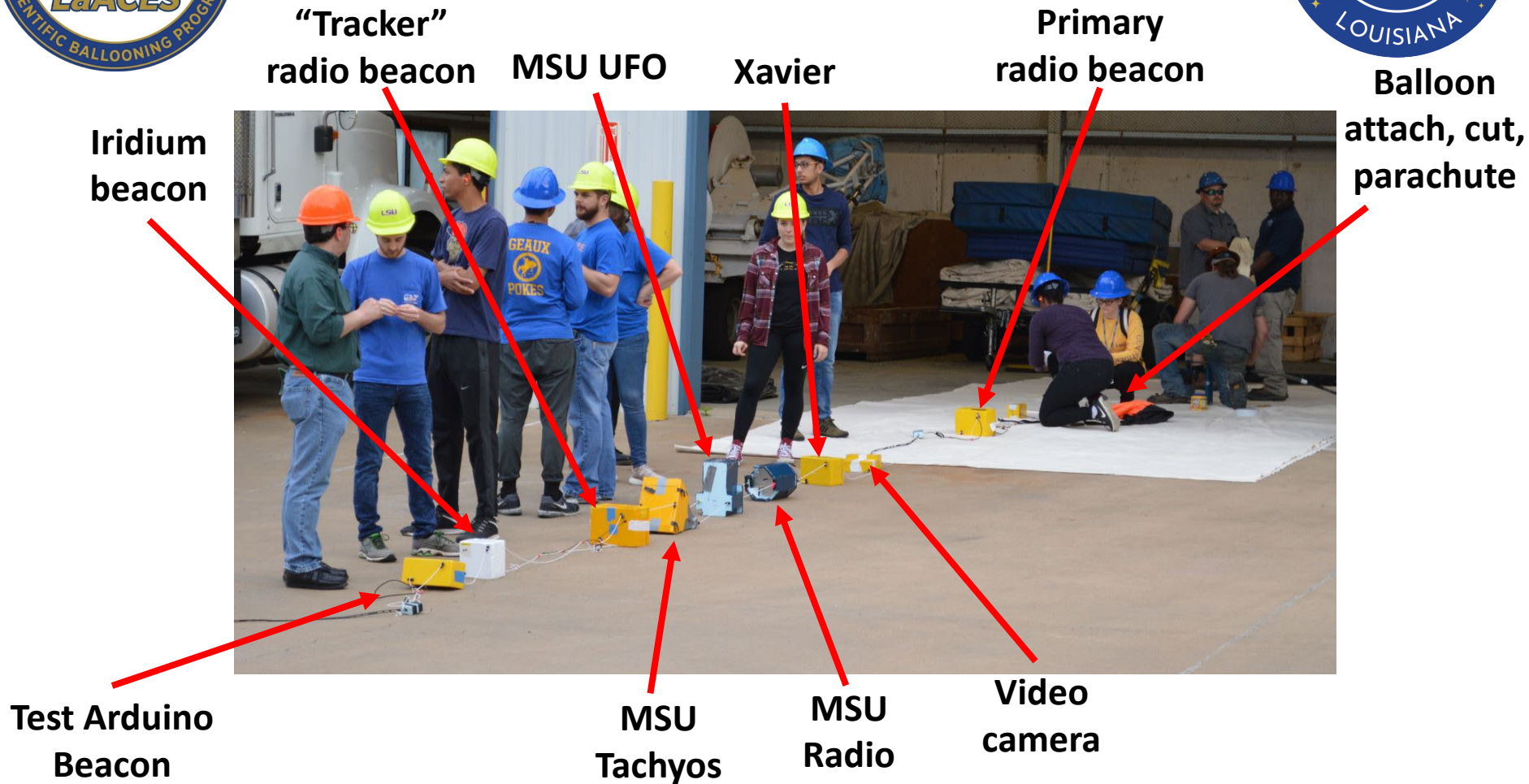
Launch Preparation

- Teams perform last minute fixes, adjustments and initializations
- Payloads must be on the flight string by Monday afternoon in order to be flown





A Typical Flight String



ACES-60 total suspended weight: 4.960 kg or 10.9 pounds



Launch Day



- Can begin early Tuesday morning at 5 AM
- Teams make final payload flight preparations (power on, tape box shut)
- Teams will assist in inflation and holding the flight string for launch
- Countdown... Launch!









Tracking The Payload

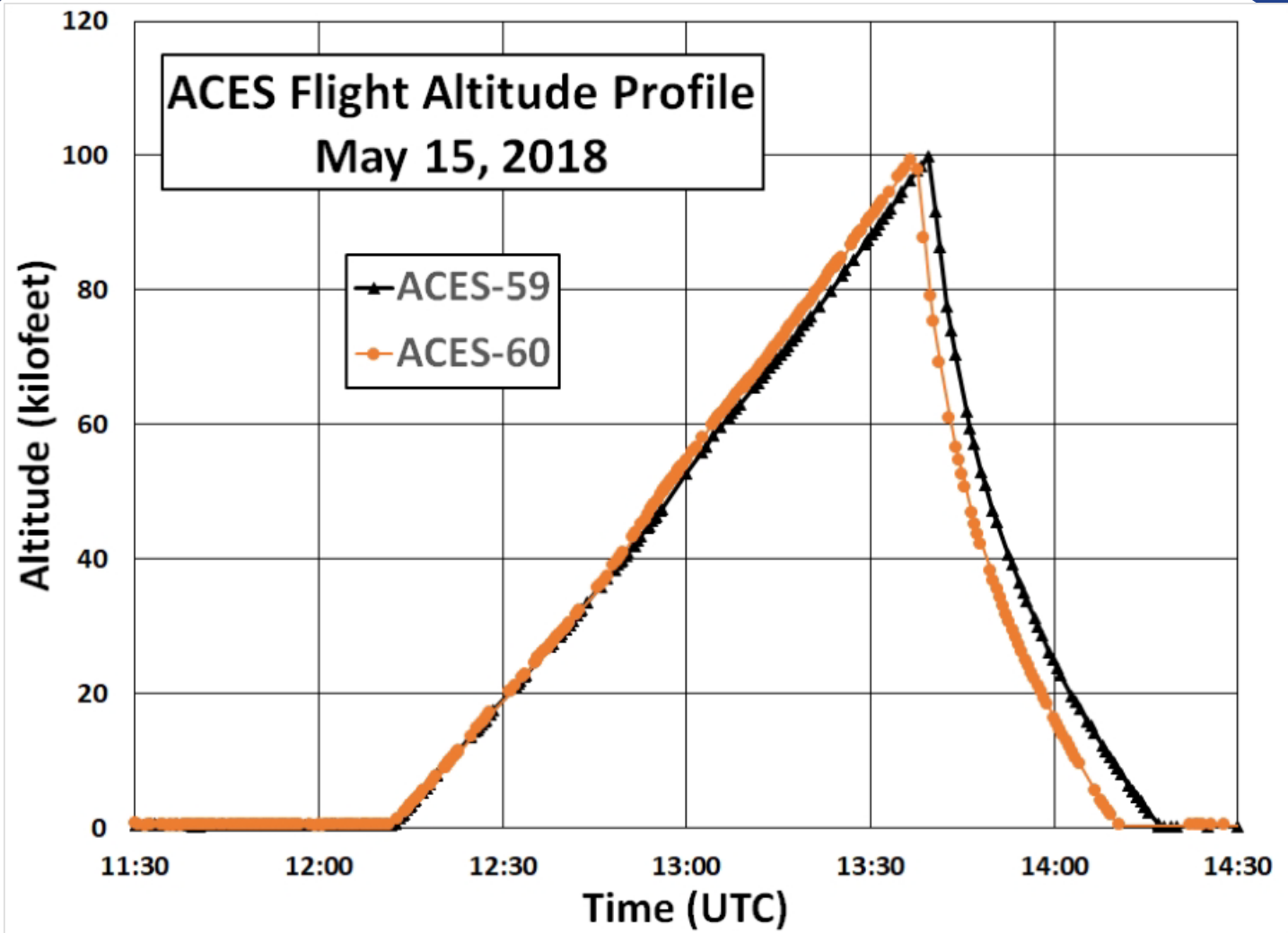


- Vehicles outfitted with Amateur Radio Band radios and tracking computers
- Automatic Position Reporting System (APRS) report position and receives reported positions
- The flight beacon reports the balloon's position
- Laptops track the balloon and chase vehicles
- Chase vehicles stay within line-of-sight of the balloon
- Cut down command is by the primary at preprogrammed altitude



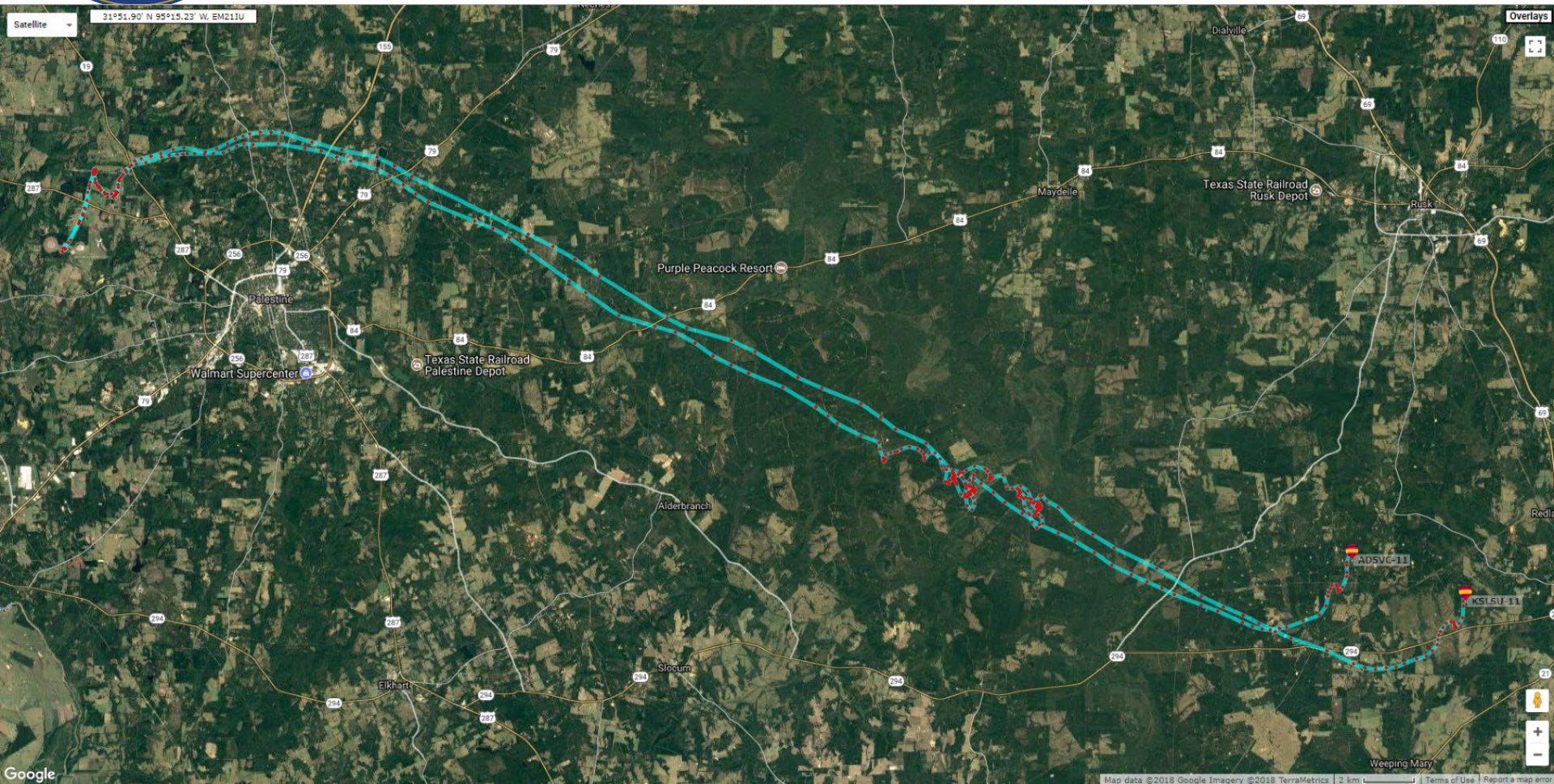


Typical flight profiles





ACES-59 & ACES-60 Flight Paths





Recovery

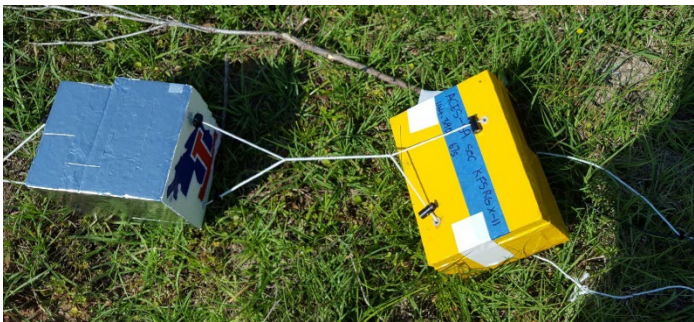


- Payload lands 45 minutes after cut-down command issued
- The tracking team is at the landing site upon landing
- Recoveries range from easy to very difficult
- An assortment of recovery tools is brought to assist





Sometimes recovery is easy





Sometimes not so easy





LaACES is always fun plus you end up learning something

