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

Presentation Summary

- Introductions
- Overview and goals of the Louisiana Aerospace Catalyst Experiences for Students (LaACES)
- The Student Ballooning Course (SBC)
- Project phases and documents produced
- Flight requirements
- The LaACES balloon launch, chase and recovery
- Results from previous LaACES teams

Introductions – LaACES Management

T. Gregory Guzik
LaSPACE Director

Doug Granger
LaSPACE Flight Programs

Colleen Fava
LaSPACE Assistant Director

Dana Browne
LaSPACE
Associate

Aaron Ryan
LaSPACE Flight
Instructor

Jill Juneau
LSU Electronics
Shop Manager

Josh Collins
LSU Electronics
Shop Developer

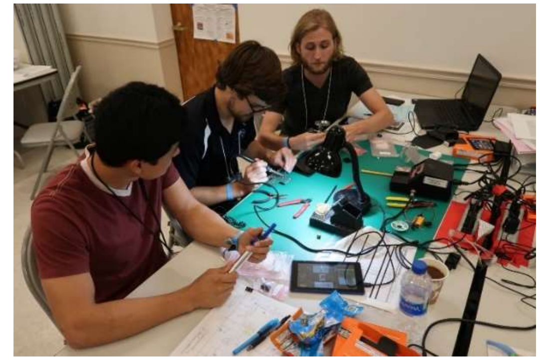
What is LaACES?

- 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 continue towards 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

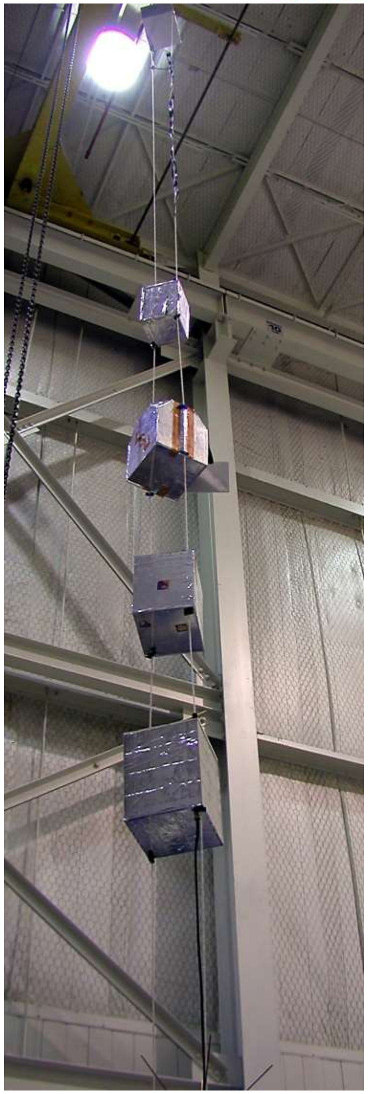
Students communicate their progress through required documents and presentations on a milestone schedule

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 65 flights since 2004
- Major revision of the LaACES electronics, lectures, and activities in 2018, field tested in 2019, and implementing in 2020-2021

LaACES Structure



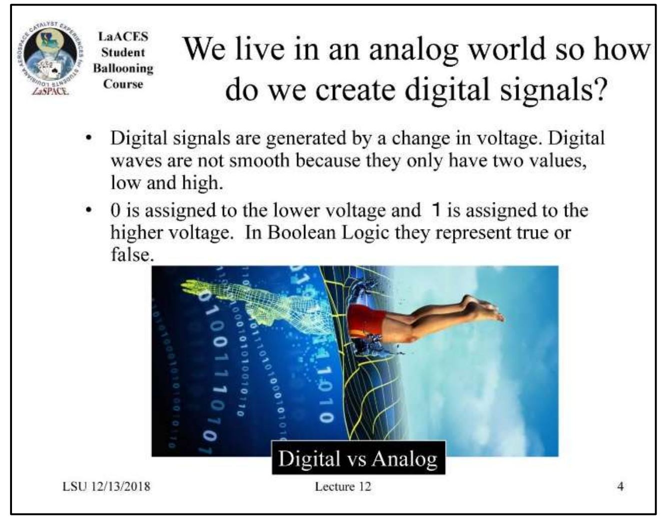
- Involves students from Louisiana institutions
- Students are organized into teams of 3-4
- Fall semester consists of bi-weekly 2 hour "classes"
  - Usually meet Tuesday / Thursday from 6 pm to 8 pm
  - Each week (i.e. two classes) usually consists of 1 hour of lecture and 3 or more hours of activities
  - 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
- Flight operations trip to CSBF in May
- Students expected to devote 10-15 hours per week and will have specific deliverables due on milestone dates

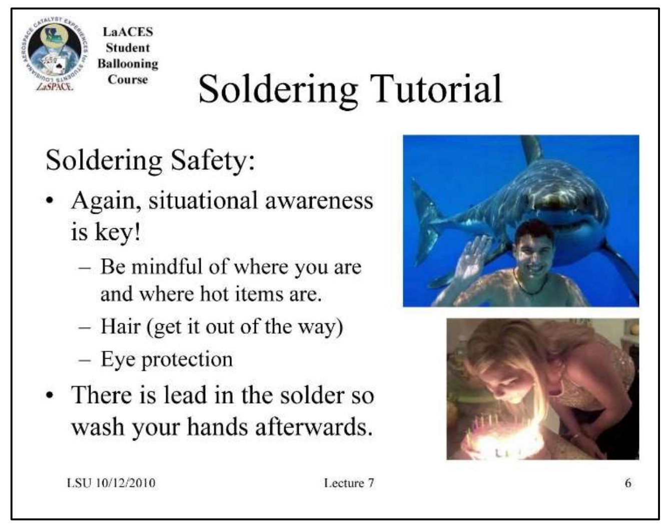
LaACES Conducted by LaSPACE

- As part of our response to the COVID-19 pandemic, LaACES Management will conduct the LaACES sessions remotely
- Sessions will be conducted every Tuesday and Thursday evening from 6 pm to 8 pm via Zoom session
- We are planning to provide each institution with a document camera to accommodate real-time mentoring during activities
- These evening sessions will be recorded but these will be the only times that real-time mentoring will be available
- All LaACES institutions and students will be responsible for all of the material in the LaACES Student Ballooning Course
- The required content in the PDR, CDR, and FRR payload documents makes heavy use of the LaACES SBC material

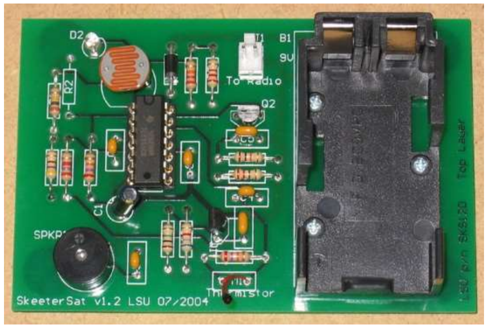
Fall Semester Tasks

- All lectures, activities, and auxiliary material is available for download from the LaACES website
- ~35 PowerPoint presentations covering the primary topics relevant to the program
- ~30 hands-on activities that complement the lectures
- These lectures and activities are organized on the website in the order they should be presented to the students
- Two major projects during fall are the SkeeterSat calibration report and the "Putting it all together" semester capstone project



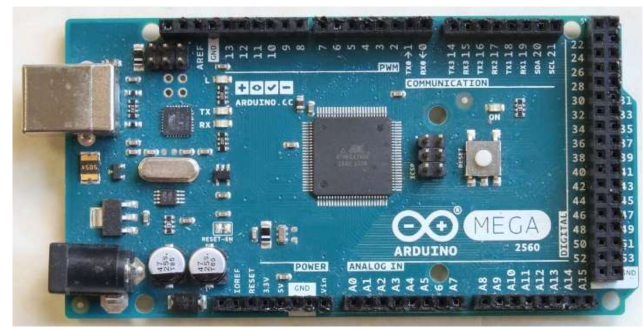


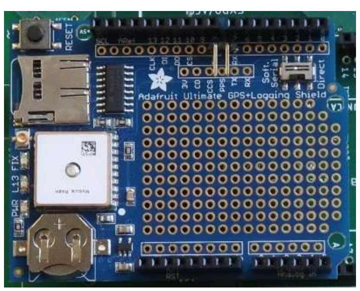
Fall SBC Hardware Components



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

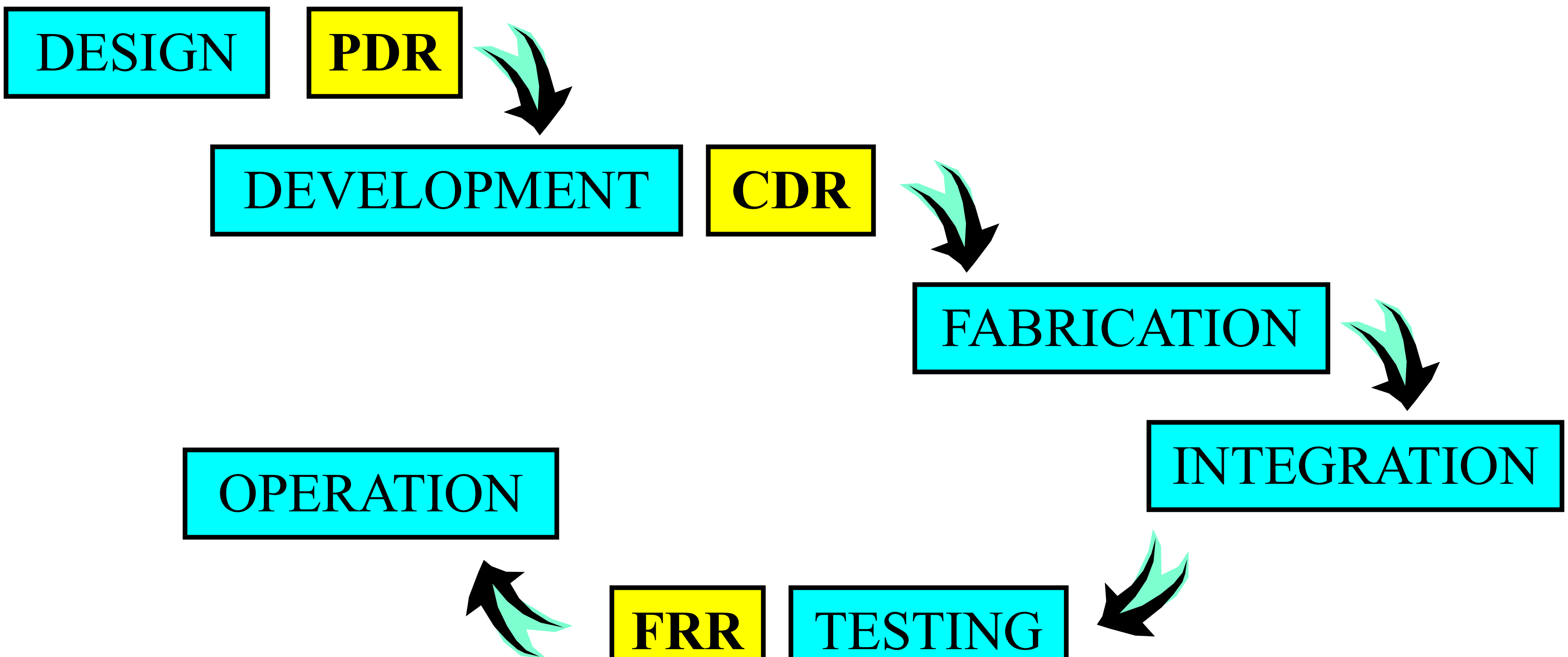
- Guide students toward a realistic payload based upon the MegaSat stack
  - Provide choice of different options
  - Fabrication and use of the MegaSat
- Students must be working in a team during payload development
  - Discuss and guide development of the “Team Contract”
- Project Management Unit:
  - Introduction, 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
  - Preliminary Design Review and Critical Design Review milestones and deliverables
- Thermal Vacuum System Testing at LSU
- Flight Readiness Review milestone and deliverable

Management and Communication

- Management and communication are key components in successful projects
- Communication skill building are embedded in LaACES
  - Laboratory Notebook training and keeping
  - SkeeterSat calibration presentation and document
  - Sensor interface exercise document
  - 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

Project Phases & Major Reviews

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



Flight 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 successfully complete a thermal / vacuum system test in April
3. FRR presentation, usually conducted at CSBF, must be approved by LaACES Management

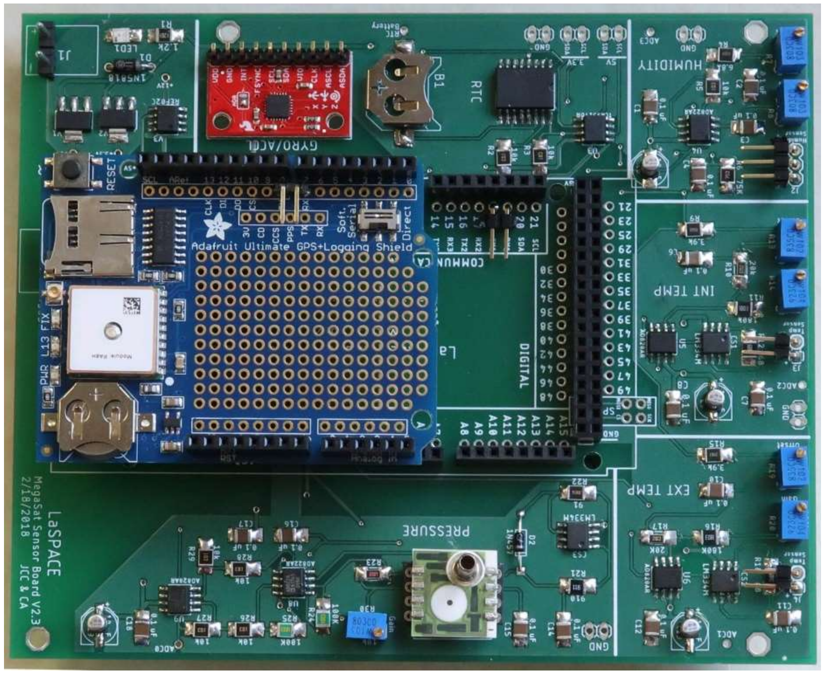
Balloon Payload Requirements

- Limited to about 500 grams weight
- Roughly a polygonal prism with 15 cm to 20 cm long sides
- Mechanical structure constructed from ¾" polystyrene foam
- Vehicle interface is a pair of strings, separated by ~17 cm, that pass through the payload unbroken and secured with spring clips.

Payload mechanical interface

- Need to conduct some kind of science or technology experiment
- Designed, built, tested and shown to be fully "space worthy" by May 2021.
  - Need to successfully complete three major design reviews and T/V system test.
- 48 hours after flight the team will need to have calibrated science results from the flight and present results to an audience of professional scientists and engineers.

Spring SBC Hardware Components



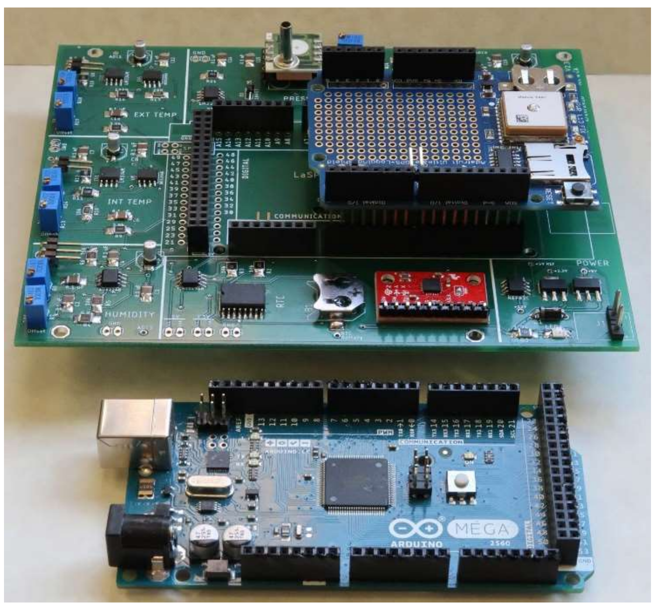
MegaSat Shield is a custom Arduino Mega board that includes two temperature sensors, a pressure sensor, a humidity sensor, a 3-axis accelerometer, a 3-axis gyroscope, and a real time clock. The board interfaces with the Arduino Mega and Adafruit GPS Logger Shield to provide a complete payload solution. Other prototype or custom PCB shields can be easily interfaced to expand the payload capability.

Miscellaneous Parts includes specialized components & sensors used by some activities including solder practice.

SBC distribution also includes numerous reference documents and specialized software

LaACES MegaSat Core

- 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

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 text 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

Milestone Schedule for LaACES 2020-2021

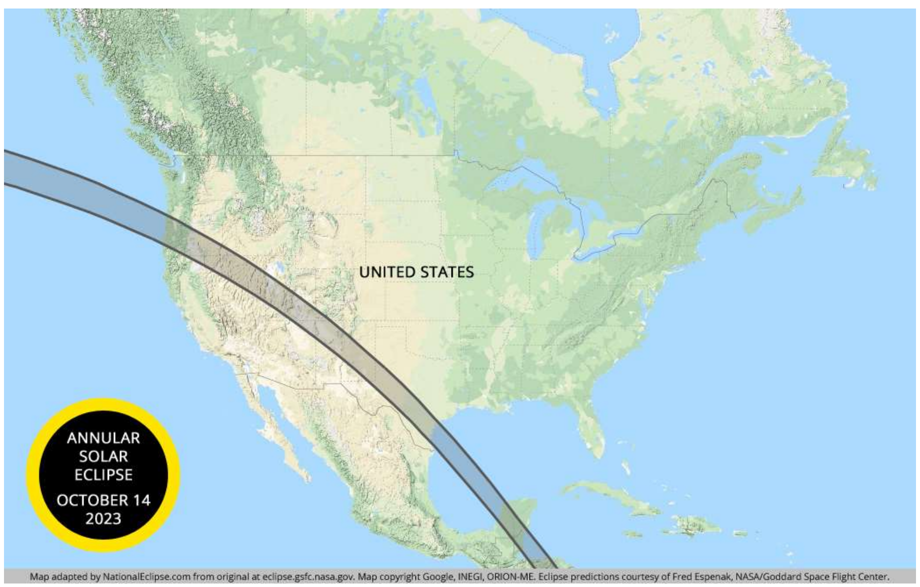
	Institution Deadline	LaACES Deadline
SkeeterSat Report	October 9, 2020	October 16, 2020
Capstone Report	December 16, 2020	December 18, 2020
Team Contract	January 15, 2021	
Pre-PDR	February 1, 2021	
PDR	February 15, 2021	February 15, 2021
Pre-CDR	March 15, 2021	
CDR	March 31, 2021	March 31, 2021
Thermal / Vacuum Test (at LSU)		April 16, 2021
FRR	May 3, 2021	May 3, 2021
LaACES Launch Trip		May 16, 2021 – May 21, 2021
FRR Defense Presentation (at CSBF)		May 17, 2021

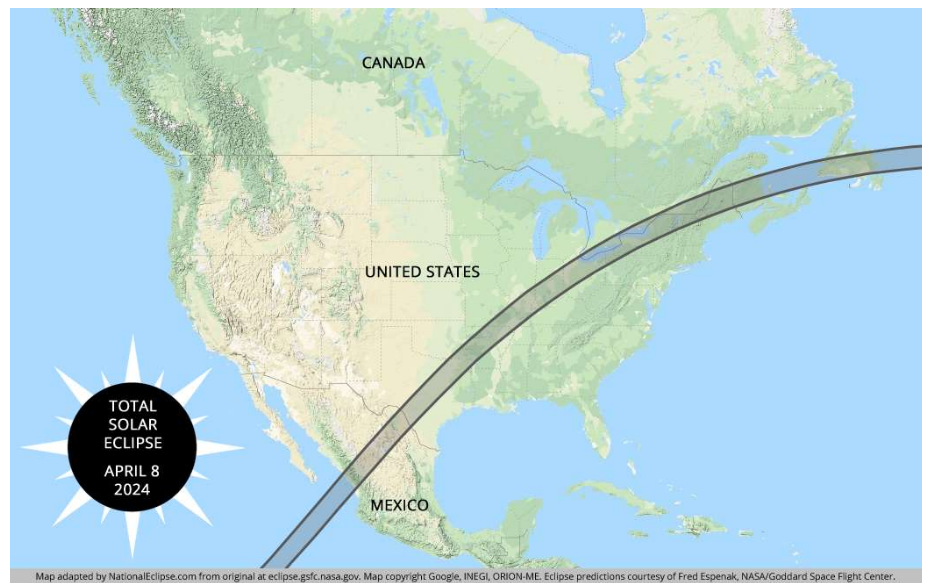
Suggested possible science topics

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

Total Eclipse April 8, 2024

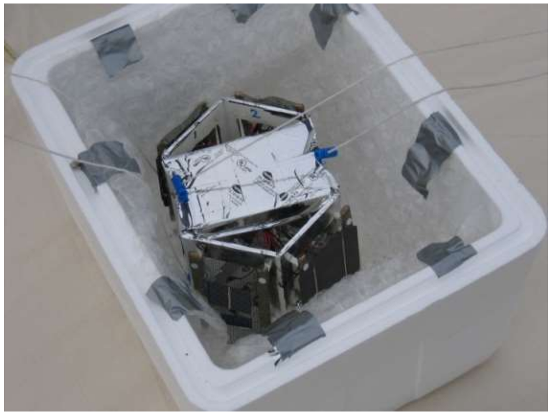
- LaSPACE will be leading a group of student teams during the national balloon flight for the April 8, 2024 total solar eclipse
- Our effort will include a “practice flight” during the October 14, 2023 annular solar eclipse
- As we did for the 2017 solar eclipse, we will hold a competition during LaACES 2022-2023 for “solar eclipse” student payloads





Completed Payloads

ACES09-10: McNeese State University

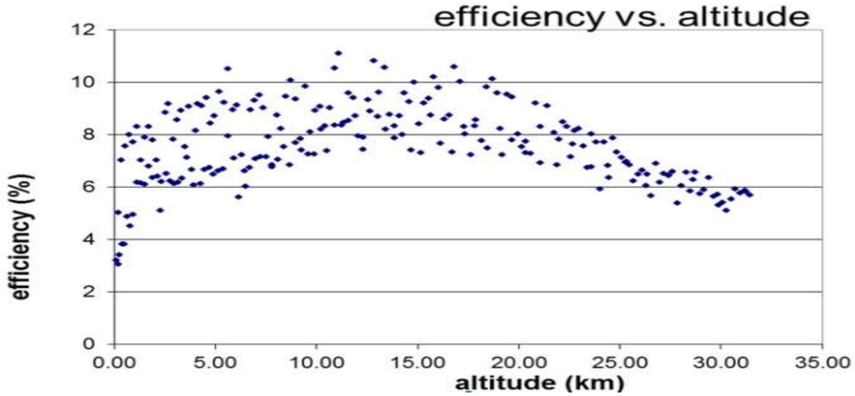


ACES12: University of New Orleans

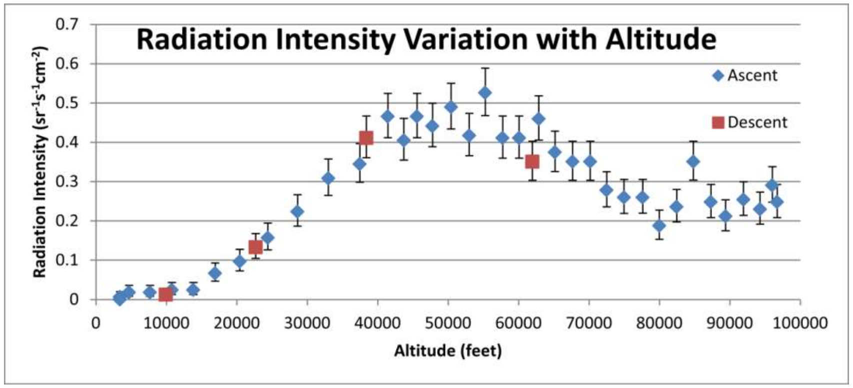
ACES06: Louisiana State University

ACES16: Louisiana State University

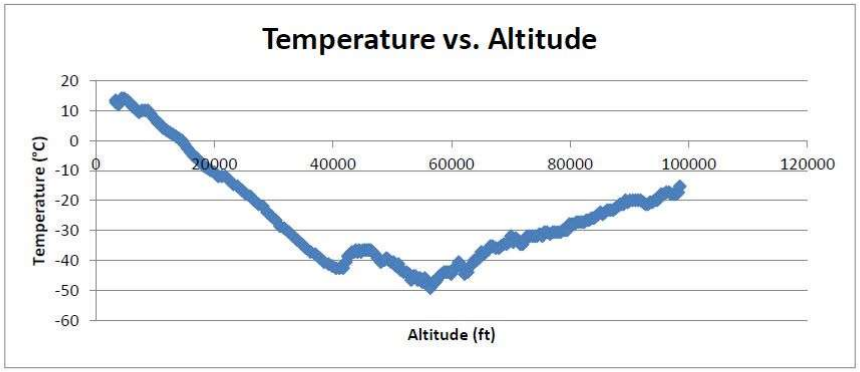
Different Science Topics can be Investigated



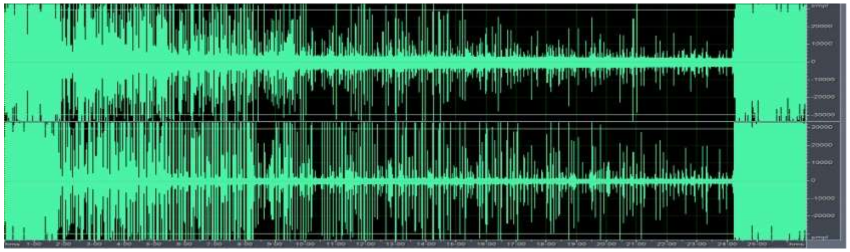
ACES07: Solar Cell Efficiency vs Altitude.



ACES16: Cosmic Ray Intensity as a function of Altitude



ACES16: Team Space Cadets, Temperature Altitude Profile.

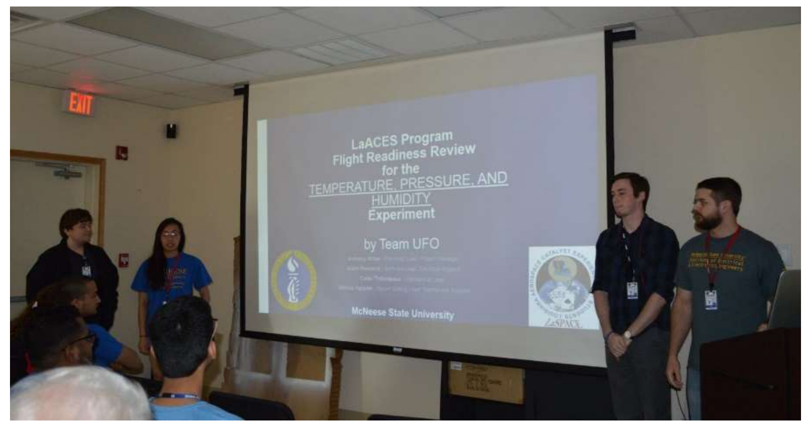


ACES06: Sound Waveform from Tropopause (ascent) back through the Tropopause (descent.)

LaACES Launch Week

- The Columbia Scientific Balloon Facility in Palestine, Texas hosts the LaACES Launch
- Launch date set for the third 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 evening

A Typical Flight String

“Tracker” radio beacon

MSU UFO

Xavier

Primary radio beacon

Iridium beacon

Balloon attach, cut, parachute

Test Arduino Beacon

MSU Tachyos

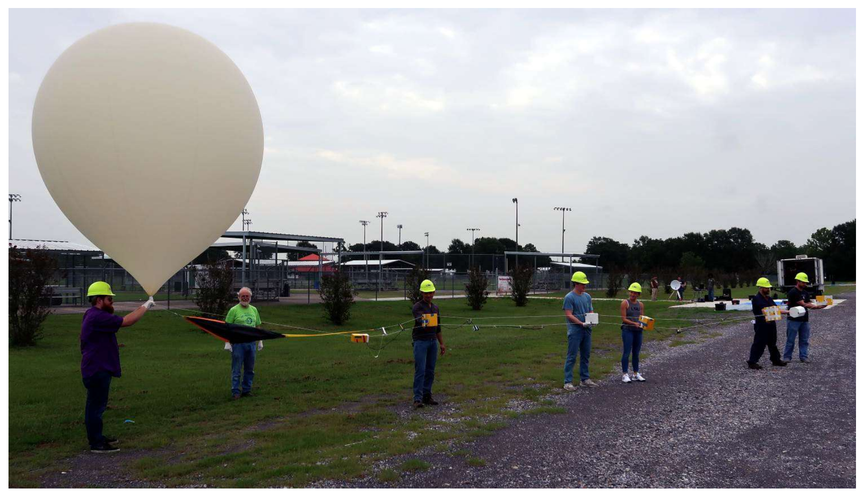
MSU Radio

Video camera

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

Launch Day

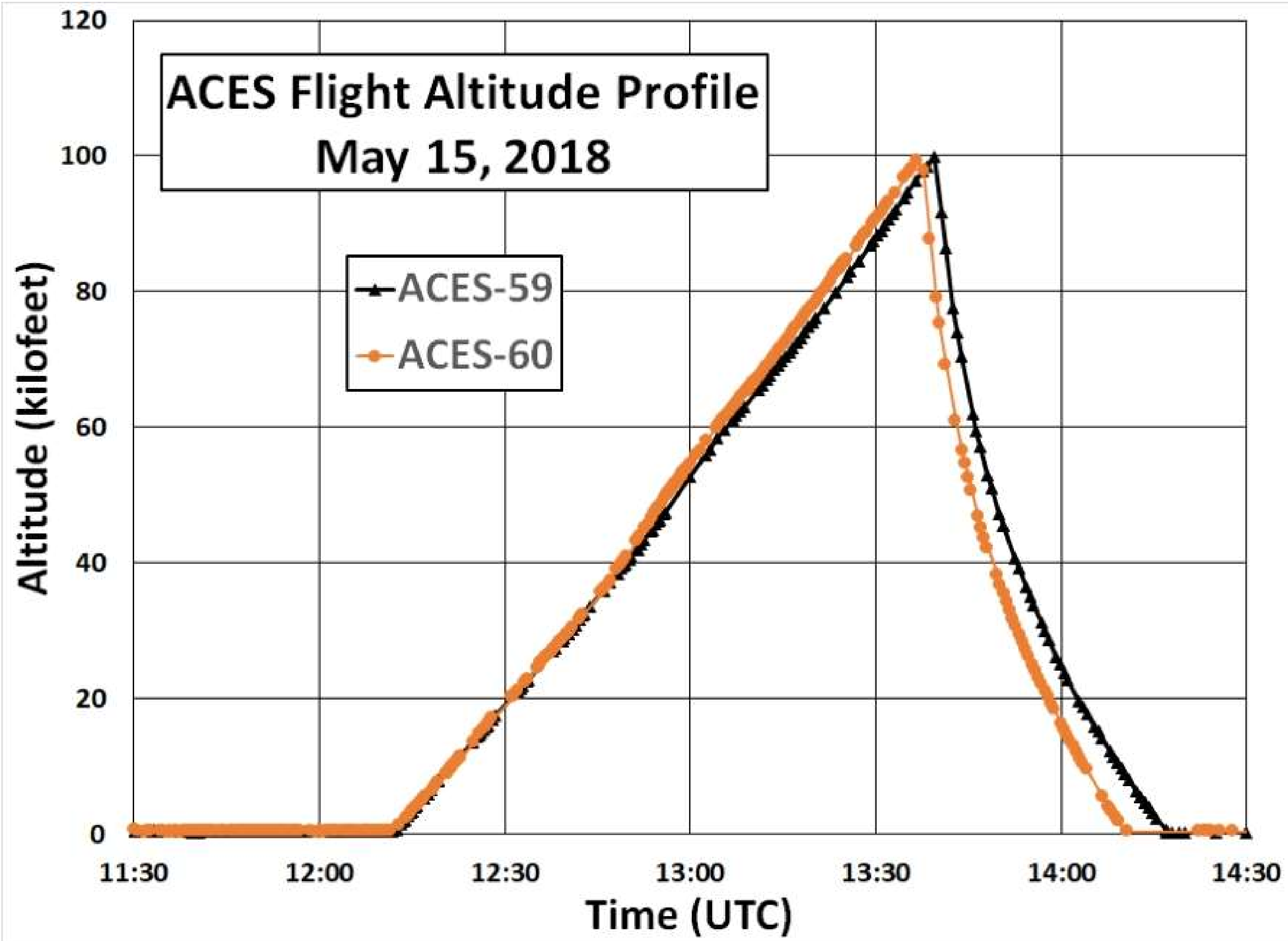
- Begins early Tuesday morning at 5 AM
- Teams make final payload flight preparations
- CSBF crew sets up the helium truck while students walk the flight string to launch pad
- Countdown… Launch!



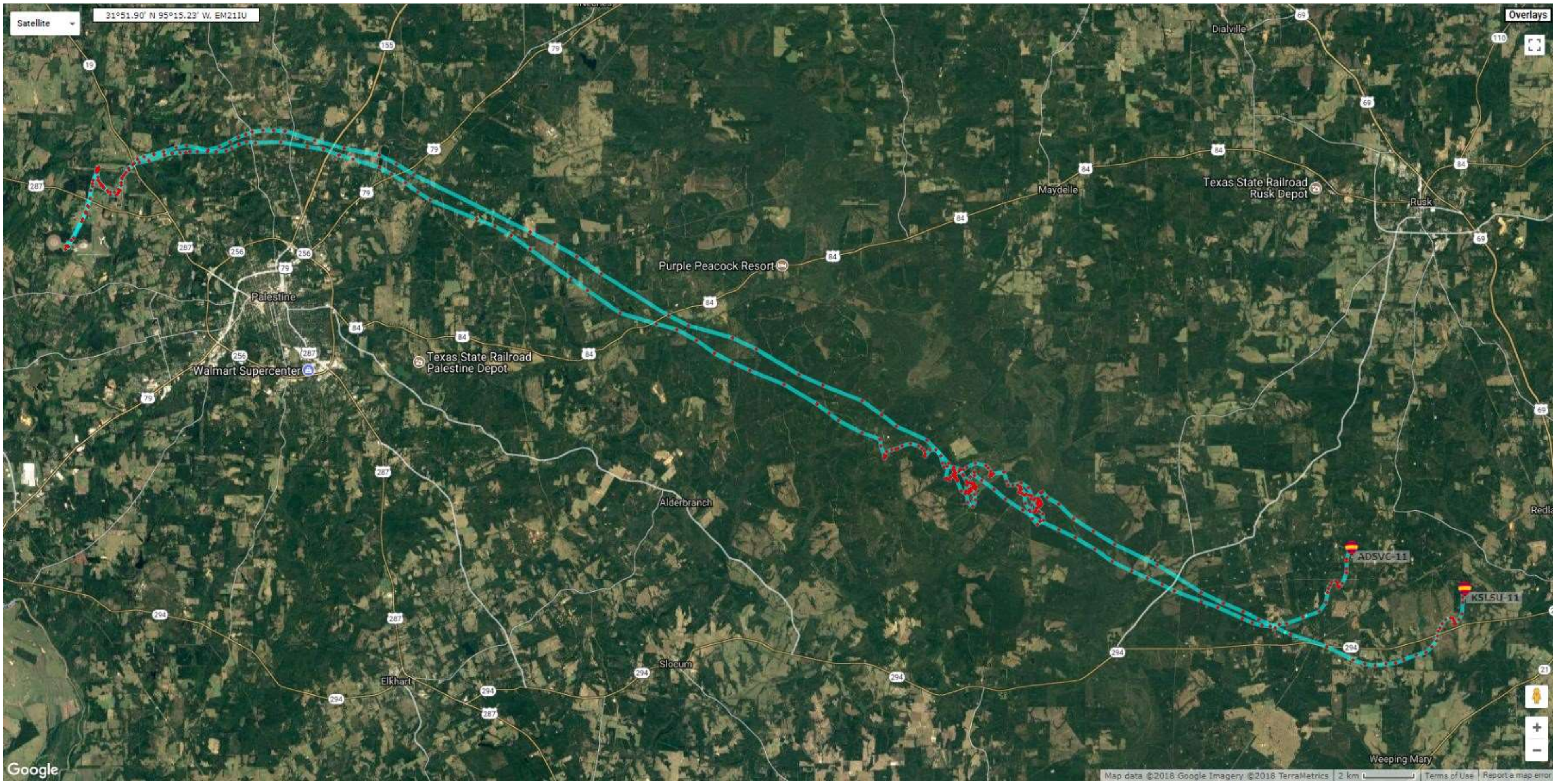
Tracking The Payload

- Vehicles outfitted with VHF transceiver
- 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 issued from the primary chase vehicle

Typical flight profiles



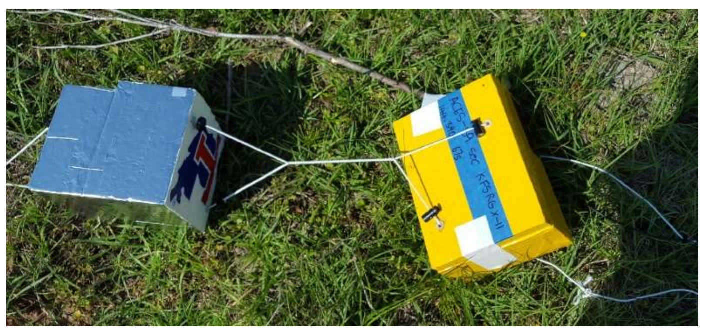
ACES-59 & ACES-60 Flight Paths



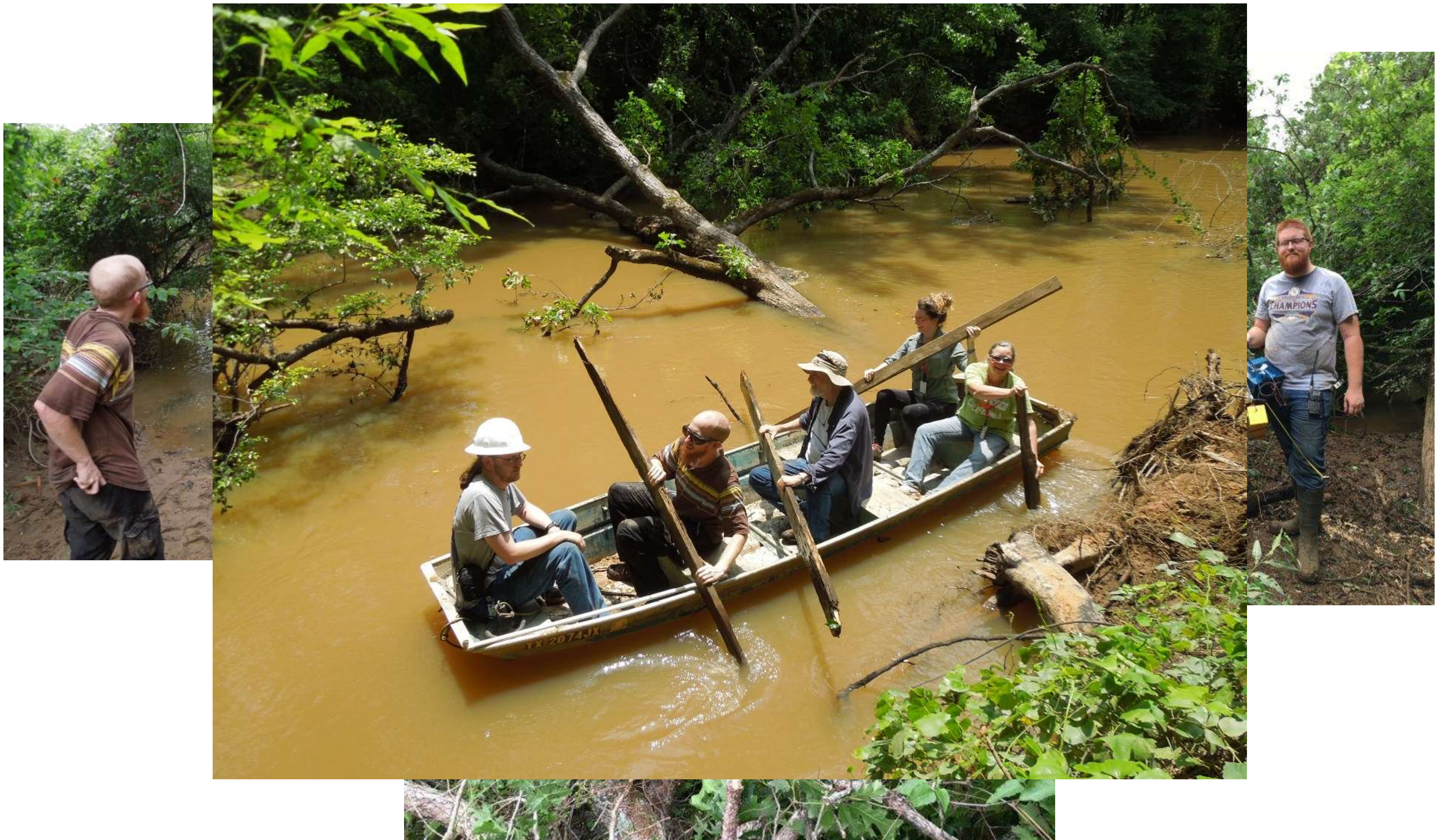
Recovery

- 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