Second Semester of the 2020-2021 LaACES Program

T. Gregory Guzik, Director, Colleen Fava, Assistant Director
Louisiana Space Grant Consortium (LaSPACE)

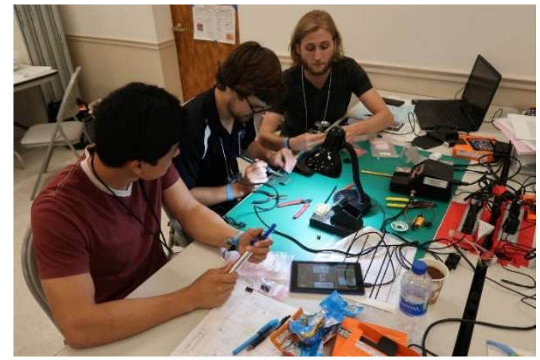
Department of Physics and Astronomy
Louisiana State University
Baton Rouge, LA

Objectives for 2nd Semester

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"

Outline of 2nd 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

Balloon Payload Requirements

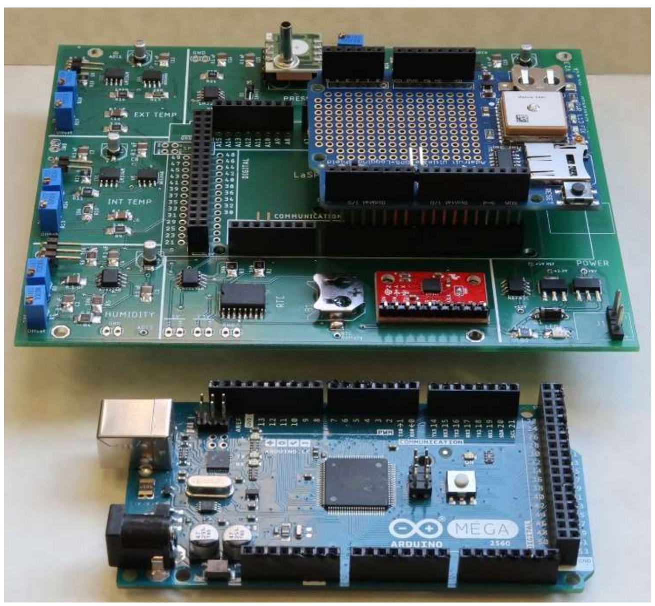
- Limited to about 500 grams weight
- Roughly a polygonal prism with 15 cm to 20 cm long sides
- Mechanical structure constructed from ¾" polystyrene foam
- Vehicle interface is a pair of strings, separated by ~17 cm, that pass through the payload unbroken and secured with spring clips.

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.

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

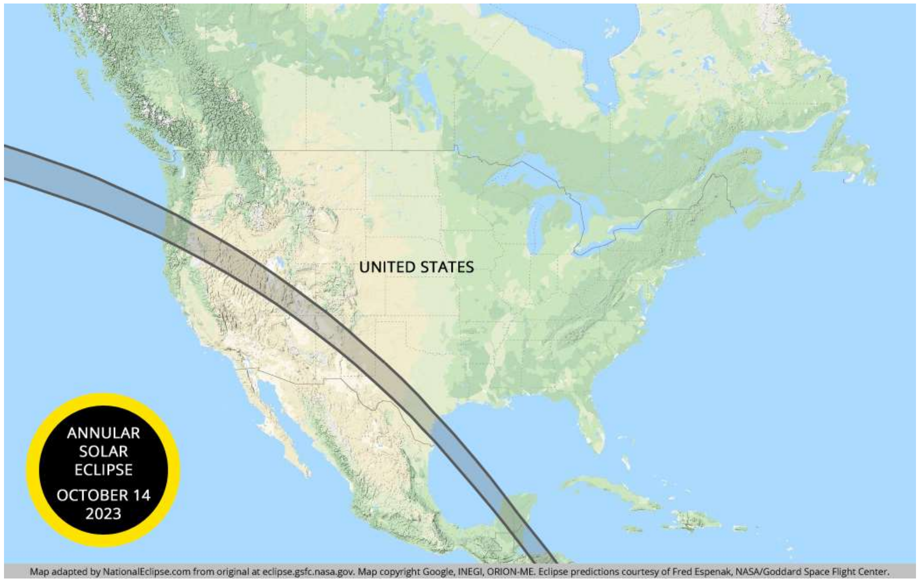
- The prototype area on the Adafruit GPS shield or a separate proto-shield board can be used to interface with other sensors.
- Construction of MegaSat shield is done in parallel with other required activities
- The team will need to include in planning
  - The components that will be part of the payload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

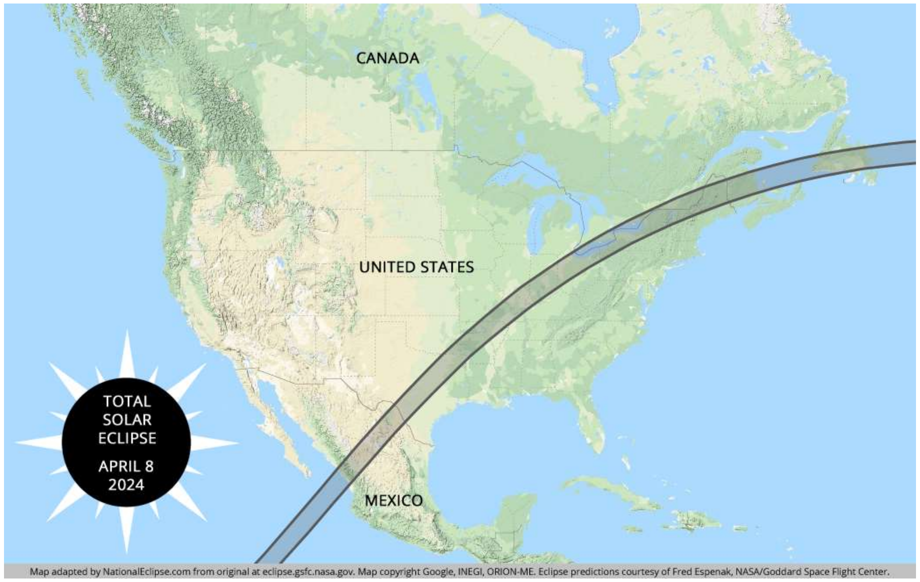
Suggested possible science topics

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





Payload Development Requires Team Cohesion

- The activity for the Project Management unit is to have each team produce their own "Team Contract"
  - Students need to identify and write down their "rules of engagement" for how they will operate as a project team
  - The Team Contract should include items such as meeting schedule, document management, roles, task management, as well as joining and leaving a team
  - The students need to develop this contract on their own without examples or detailed guidance from you
  - Your role is to critique the draft document, get the students to be specific about their operational details, and help them identify "holes"
  - It is likely to take the students 3 to 4 iterations to approach a "final" version
- Examples of previous Team Contracts are available upon request but should NOT be given to the students
- These Team Contracts are not a LaACES deliverable

Payload Development Requires Management

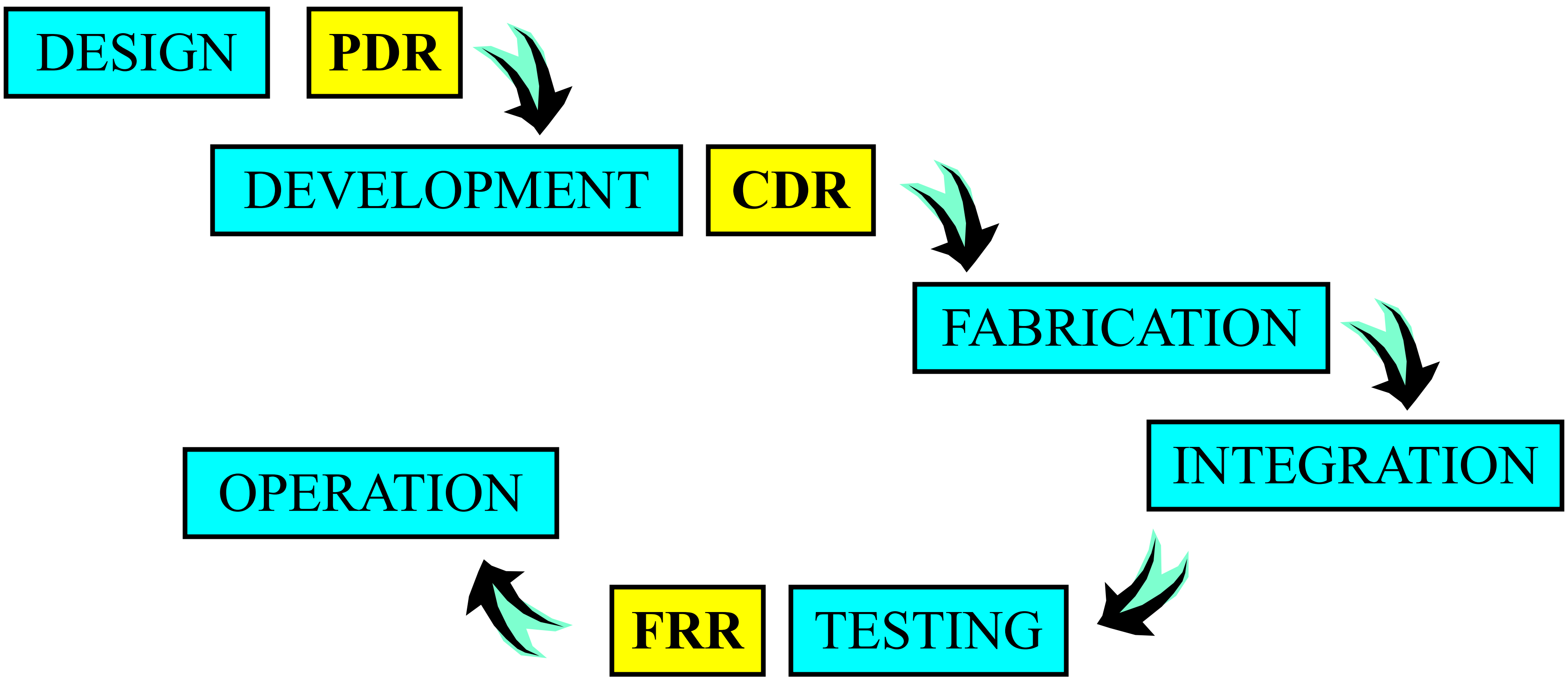
- Project Management lectures and materials are in Part II, Units 21 through 26
  - https://laspace.lsu.edu/laaces/student-balloon-course/
- These lectures and materials include the following:
  - Lecture 21.01: Management, Life Cycle, Documentation
  - Lecture 22.01: Requirements Module - The Basics
  - Lecture 22.02: Requirements Module - Writing Requirements
  - Lecture 22.03: Requirements Module – Change Management
  - Lecture 23.01: System Design
  - Lecture 23.02: Producing a System Design Drawing
  - Lecture 24.01: Defining the Project Tasks, Costs & Schedule
  - Lecture 24.03: The Project Schedule
  - Lecture 24.02: Working with MS Project
  - Lecture 25.01: Basics of Flowcharts
  - Lecture 26.01: Risk and Risk Management

Payload Structure and Design

- Payload design lectures are in Part II, Units 27 through 30
  - https://laspace.lsu.edu/laaces/student-balloon-course/
- Units 27 and 28 are concerned with fabrication, testing, and use of the MegaSat
- Other payload lectures and materials include the following:
  - Lecture 29.01: LaACES Balloon Vehicle and Flight Profile
  - Lecture 29.02: Mechanical Design Guidelines
  - Lecture 29.03: Payload Construction Consideration & Techniques
  - Lecture 29.04: Constructing an ACES cube payload
  - Lecture 29.05: Constructing an ACES octagon payload
  - Activity 29.01: Constructing a Structure with XPS foam
  - Lecture 30.01: Simple Power Systems
  - Lecture 30.02: Batteries and Battery Packs
  - Activity 30.01: Power Systems and Budgets

Well Defined Project Phases

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



The Project Reviews

- There are at least three major reviews during a project
  - Preliminary Design Review (PDR)
  - Critical Design Review (CDR)
  - Flight Readiness Review (FRR)
- You should also include a Pre-PDR and Pre-CDR review at your institution to divide the reviews into more manageable sections
- Each review has a somewhat different objective and emphasis and provides a check on project progress for all stakeholders
- Templates are provided for all review documents. Read carefully all instructions contained within the template!
- Required deliverables to LaACES Management are written documents for the PDR, CDR and FRR
  - These documents must be fully vetted by the institution faculty advisor(s)
- The required documents will be rated as Pass / Fail. A "Fail" on any document means the team will very likely not fly

The Project Reviews Document Templates

- The templates provide a sequence of payload documentation from the initial organization and justification to the final defense of the payload flight worthiness
- Each template ADDs to the previous template so it is important for a student team to fully complete one document before moving on to the next.
  - Pre-Preliminary Design Review (Pre-PDR) template
  - Preliminary Design Review template
  - Pre-Critical Design Review (Pre-CDR) template
  - Critical Design Review (PDR) template
  - Flight Readiness Review (FRR) template
- An example completed FRR document that comes close to being rated as PASS
  - Fly Boys Air Mass Flow Rate FRR
  - NSU DemonSats FRR
  - SELU ROOMIE-2A FRR

Preliminary Design Review (PDR)

- The primary objective for the PDR is to review results from the design phase
- At the end of the PDR, the team should be able to show that they have "thought the problem through"
- The PDR should focus on the following topics:
  - Goals and objectives ← **Pre-PDR**
  - Science background and requirements ← **Pre-PDR**
  - Preliminary System design
  - Concept hardware & software design
  - Tasks, schedule, resource needs, long-lead items ← **Pre-PDR**
  - Preliminary risk assessment & management plan

Critical Design Review (CDR)

- The primary objective of the CDR is to review the results from the development phase
- Determines whether the flight team is ready to begin building their payload
- CDR should emphasize the following topics:
  - Resolving issues identified during the PDR ← **Pre-CDR**
  - Prototyping results and “proven” designs ← **Pre-CDR**
  - Completed system design and defined interfaces ← **Pre-CDR**
  - Finalize tasks, schedule, procedures and costs
  - Updated risk assessment & management plan
  - Preliminary MO & DA plan

Flight Readiness Review (FRR)

- Determine that all issues from CDR have been resolved
- Document Experiment Readiness
  - Documentation of as-built configuration
  - Environmental testing results (e.g. from thermal / vacuum test)
  - Calibrations performed
- Provide quantitative evidence that the payload:
  - Does the payload meets the stated objectives and requirements?
  - Is the payload safe to operate?
  - Are there any impacts to the flight string or other payloads?
  - Will the payload perform properly?
- Required oral FRR presentation during the launch trip
- Identify outstanding issues that must be addressed prior to flight
- The FRR will determine whether the flight team is allowed to attach their payload to the flight vehicle!

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