RockSat-C at Southeastern

Gerard Blanchard

LaSPACE Fall 2021 Council Meeting

SOUTHEASTERN LOUISIANA UNIVERSITY

Overview

- RockSat-C, -X, -XN, RockOn!
- RockSat-C at Southeastern
- Preparing to get involved in RockSat-C
- Value added to the physics program at Southeastern

RockSat-C overview

- RockSat-C is one of a group of sub-orbital space flight programs provided by the Colorado Space Grant Consortium
  - RockSat-C
  - RockSat-X and -XN
  - RockOn!
  - Terrier-Improved Orion sounding rocket
  - Nominal apogee of 72 mi
  - ~2 minutes above Karman line
  - Launch from Wallops Island, VA
    - Except for RockSat-XN

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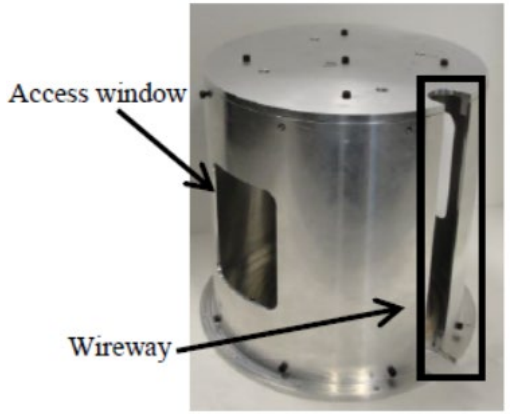
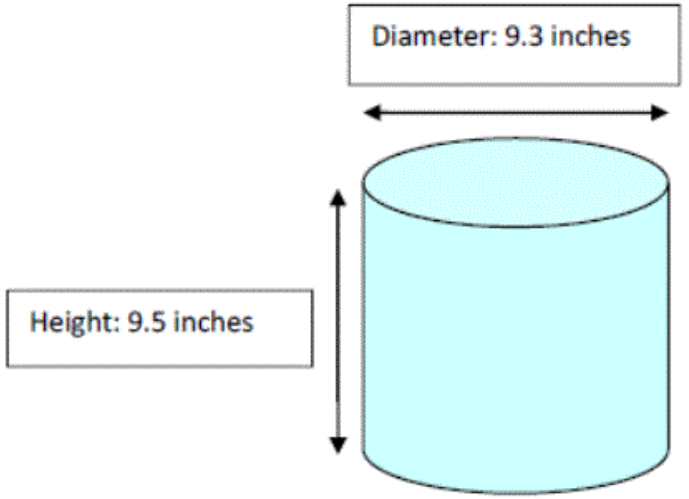
RockSat-C overview (continued)

- The “C” stands for “canister”.
  - The experiment must fit in a standardized canister with interior dimensions of 9.5 inches in height and 9.3 inches in diameter.
    - “Dedicated customers” ($12,000 fee) occupy entire canister.
    - “Share customers” ($7,000 fee) share canister with another experiment.
  - The canister + experiment must weigh (20 ± 0.2) lb.
  - Center of mass must be within 1-inch cube centered on geometric center of the canister.
  - External ports are available.
  - Rocket is spin-stabilized (5 Hz).





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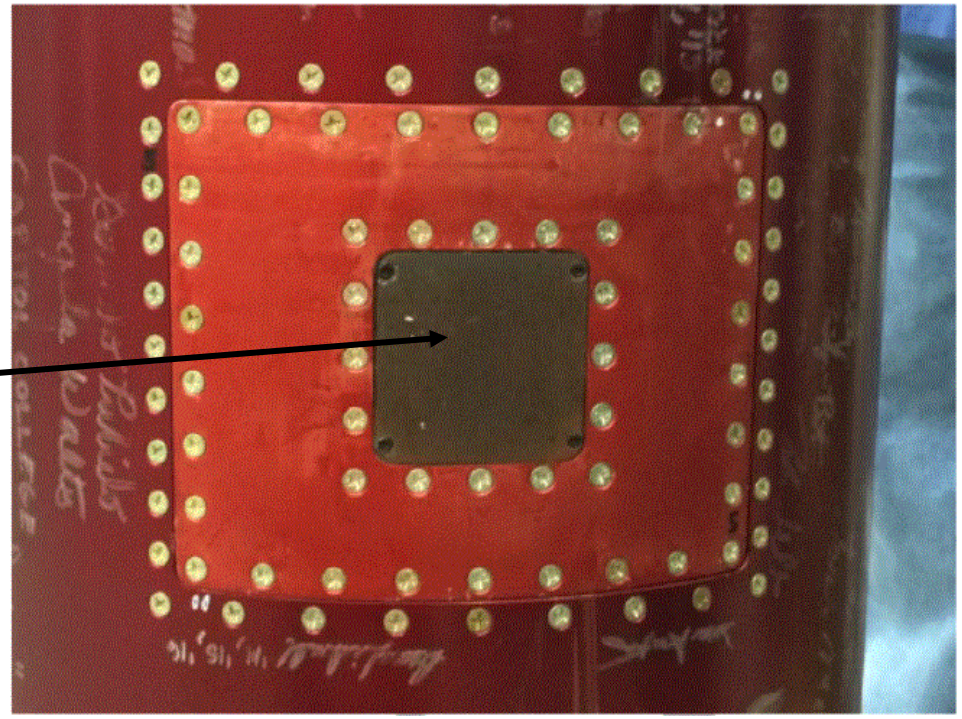
RockSat-C overview (continued)

- The external port cover may be modified



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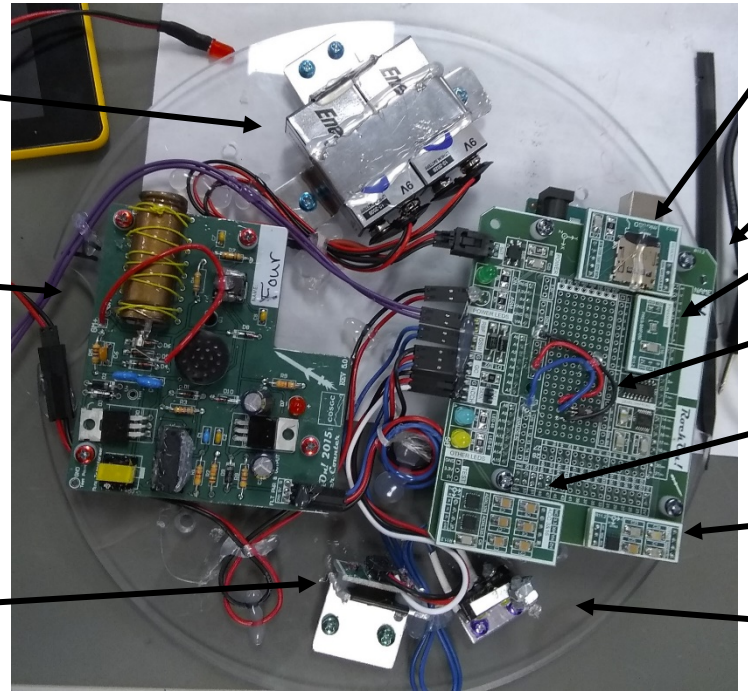
RockSat-X and –XN overview

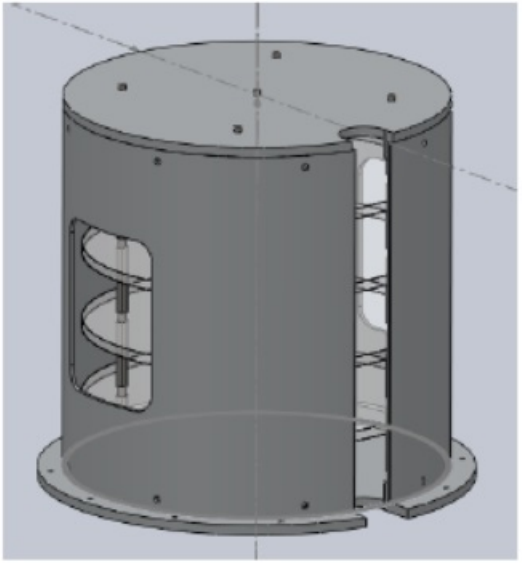
- RockSat-X (eXtreme) is a similar program, with these salient differences:
  - The experiments are not contained in a canister.
  - The rocket skin and nose cone are ejected during flight.
  - The rocket is de-spun after second-stage burnout.
- RockSat-XN (Norway) launches from Andenes, Norway

maps.google.com

RockOn! overview

- RockOn! is an entry-level program that is conducted as a week-long workshop at Wallops Flight Facility in Wallops Island, VA.
- Teams of students and faculty are guided to build a standard payload, which is then launched together with the RockSat-C canisters.





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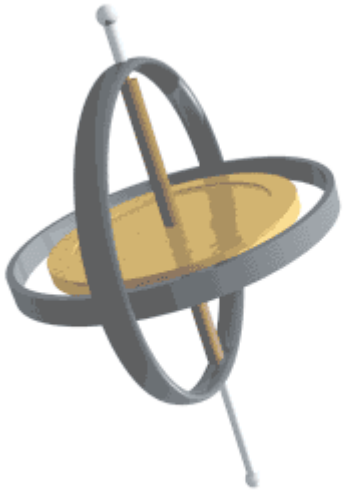
RockSat-C at Southeastern

- Southeastern is participating in RockSat-C this year

- 3 experiments
  - Gyrodynamics of re-entering rocket body
  - Ionospheric electron density using impedance probes
    - Frequency-sweeping
    - Impulse response

Re-entry gyrodynamics

- As the spinning rocket body re-enters the atmosphere, torque from the drag force causes it to precess.



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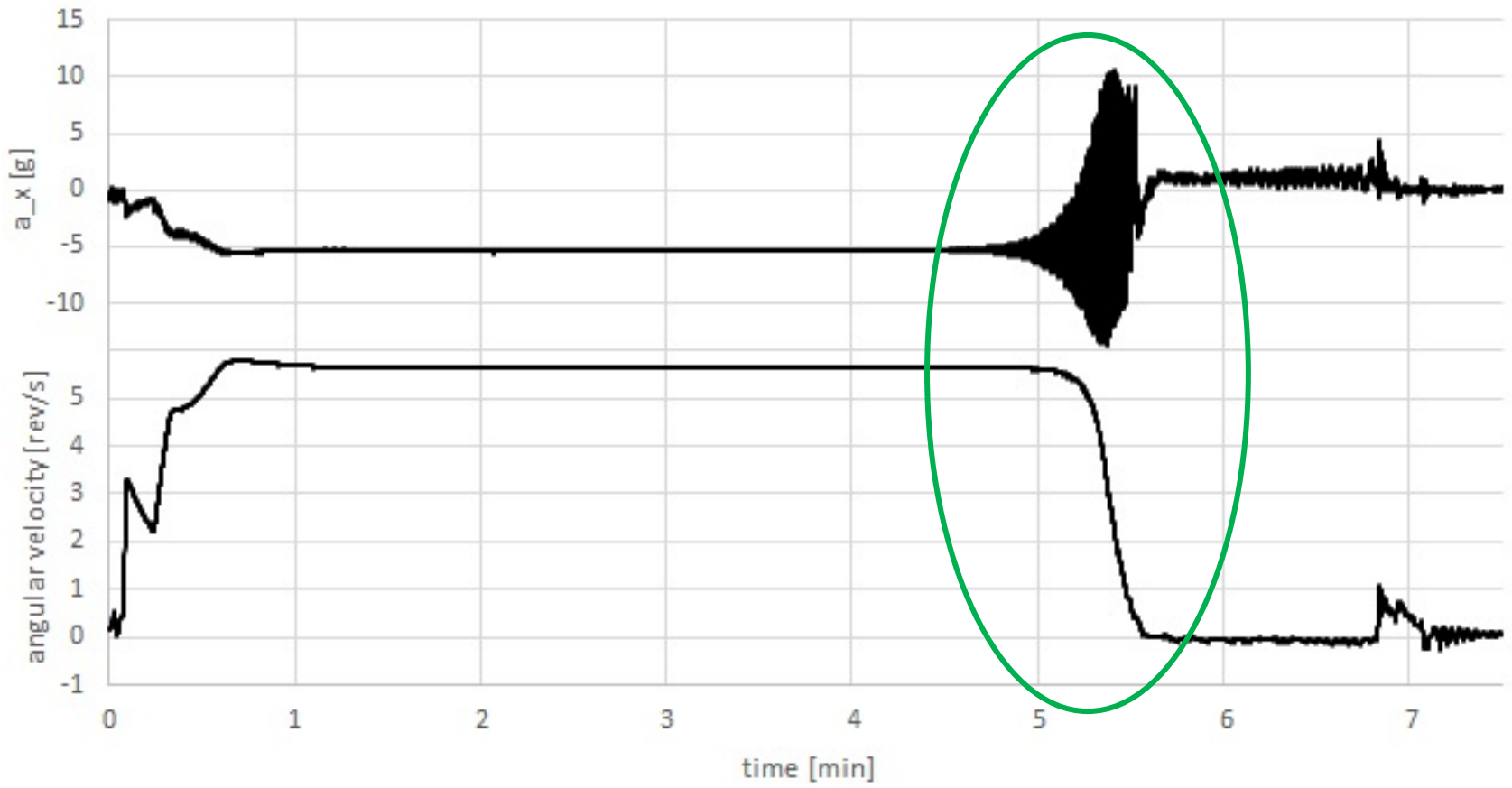
- Gyroscopic precession is covered theoretically in undergraduate physics curriculum, but not in laboratory (at least not at Southeastern).

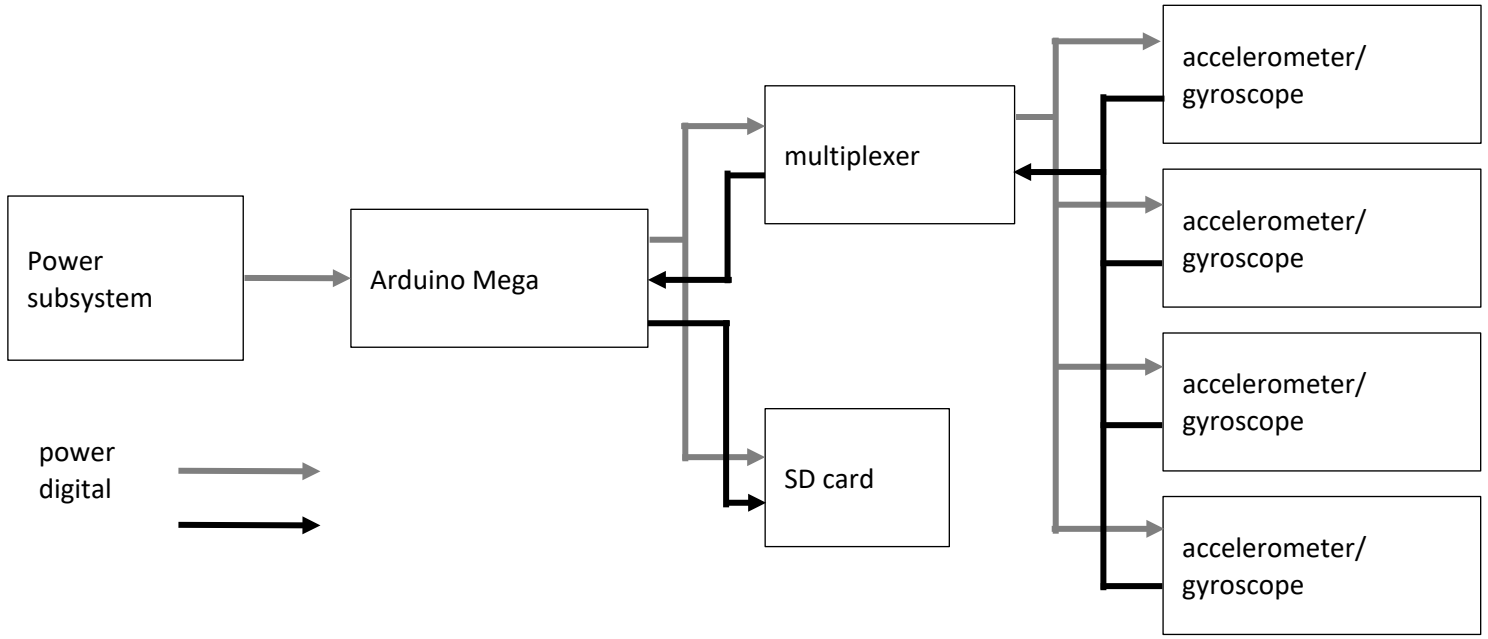
Re-entry gyrodynamics (continued)

- We observed this in RockOn! data



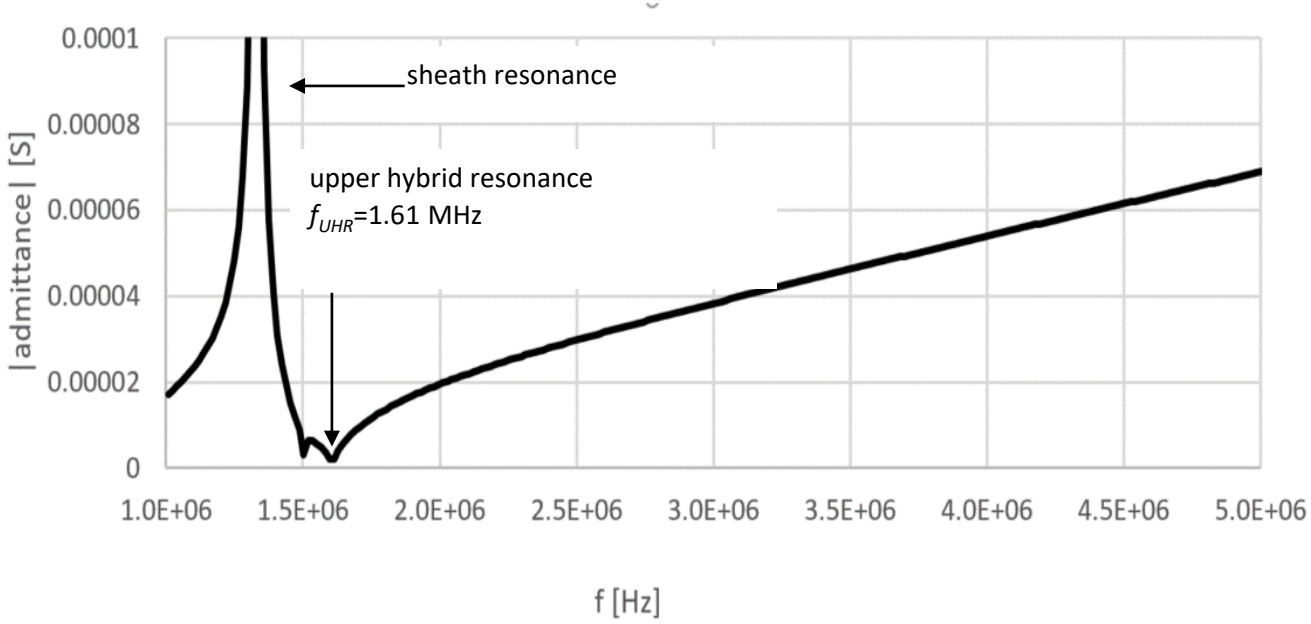
Re-entry gyrodynamics (continued)

- Goal of this experiment is to calculate Euler angles of rotation versus time.
  - Better calibration of accelerometers and gyroscopes.
  - 4 sets of accelerometers and gyroscopes to reduce measurement error.



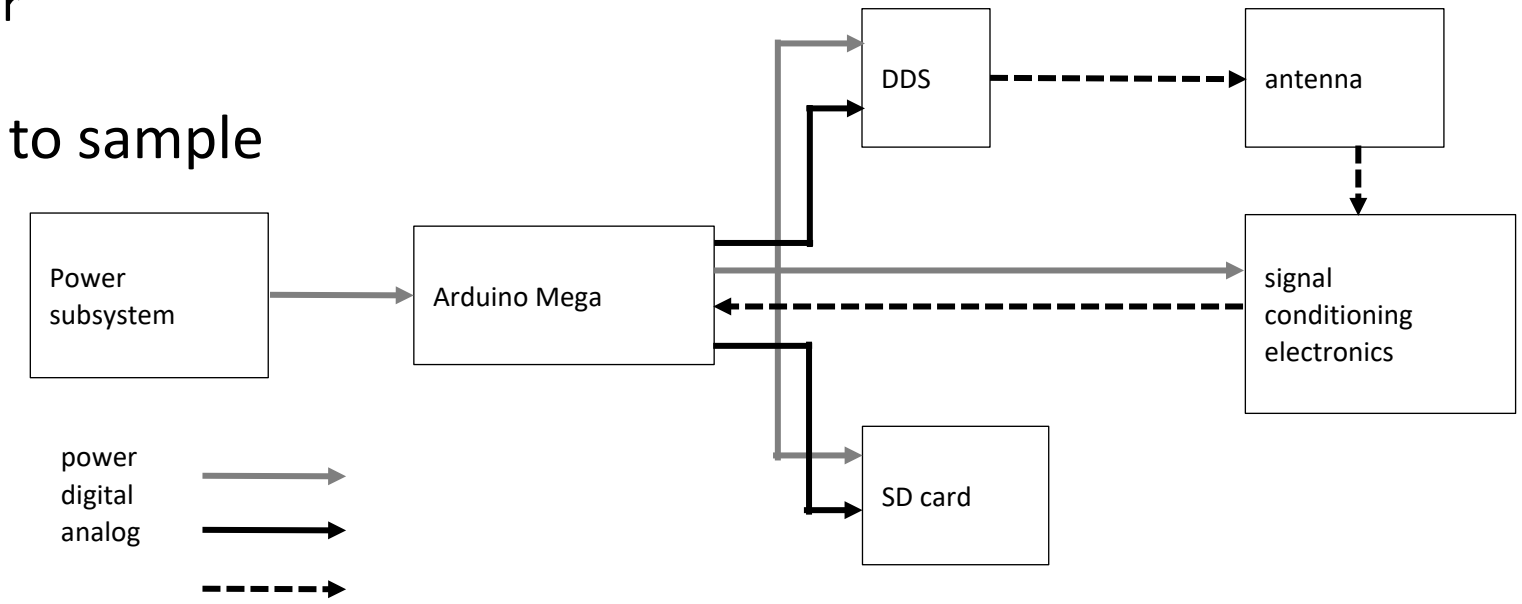
Impedance probe experiments

- The impedance probe technique to measure plasma electron density is based on measuring the upper hybrid resonance frequency.
  - $f_{UHR}^2 = \left(\frac{e^2 N_e}{2\pi m_e \epsilon_0}\right) + \left(\frac{eB}{2\pi m_e}\right)^2$
  - $N_{e\,[\mathrm{m}^{-3}]} = 0.012(f_{UHR\,[\mathrm{Hz}]}^2 - 1.78 \times 10^{12})$
- Plasma waves driven at upper hybrid frequency don't propagate, so the antenna impedance → ∞, and the admittance (1/impedance) → 0.
- We have 2 techniques to measure admittance spectrum.



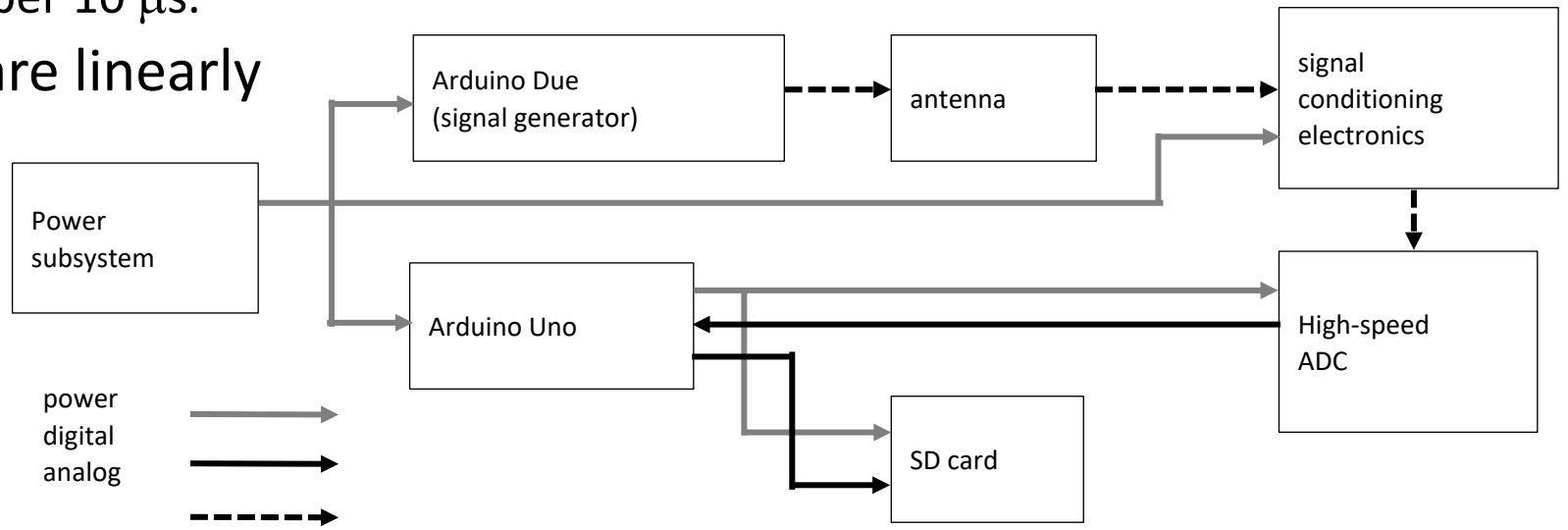
Frequency-sweeping experiment

- The first technique sweeps the antenna frequency from 1 MHz to 5 MHz and measures the antenna current.
  - Simple
  - Slow
    - 1 measurement of N_e per complete sweep
  - Can choose frequencies to sample
    - Logarithmically equally-spaced values of N_e



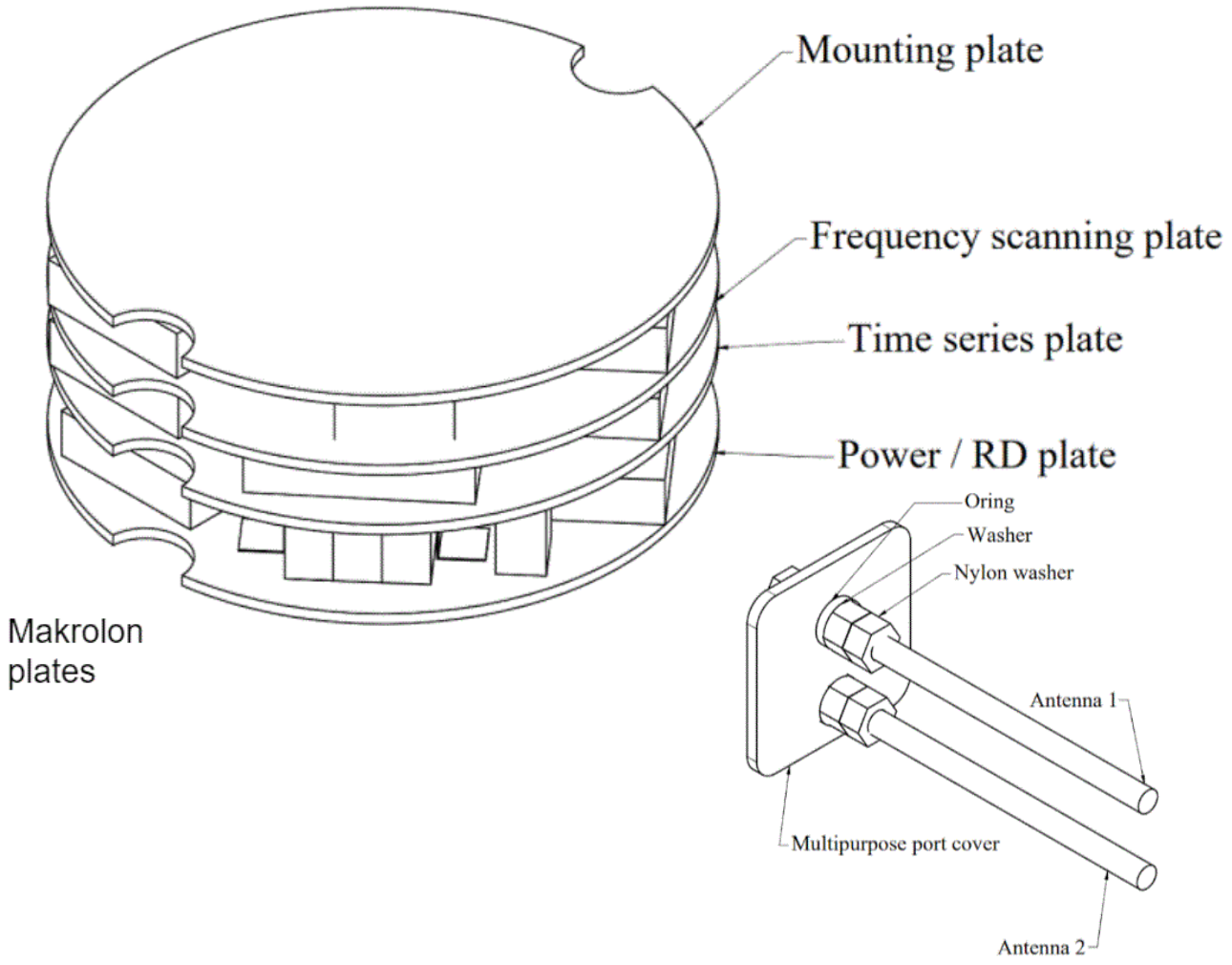
Impulse response experiment

- The second technique sends a 0.4 μs pulse to the antenna every 10 μs and records the antenna current as a function of time. The spectrum is recreated using the Fourier transform.
  - Complex
  - Fast
    - 1 measurement of N_e per 10 μs.
  - Sampled frequencies are linearly spaced
    - Poorer resolution of log(N_e) at lower frequencies



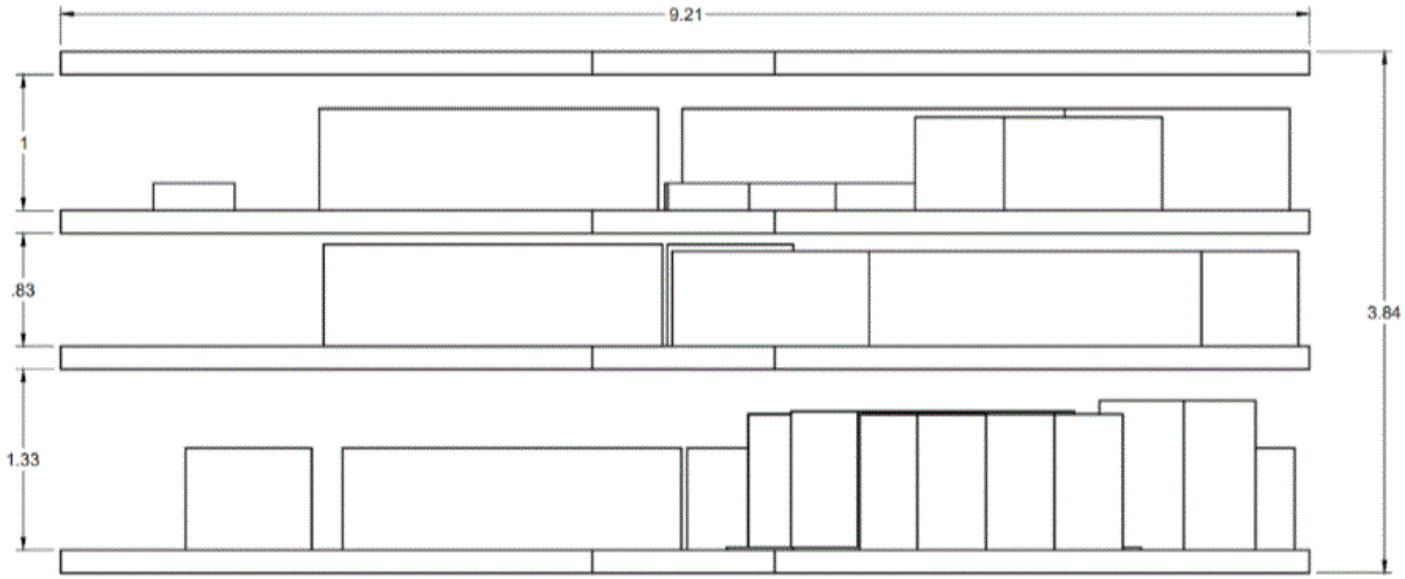
Payload structure

- Payload will mount to top of canister.
- Antennas will mount to multipurpose port.

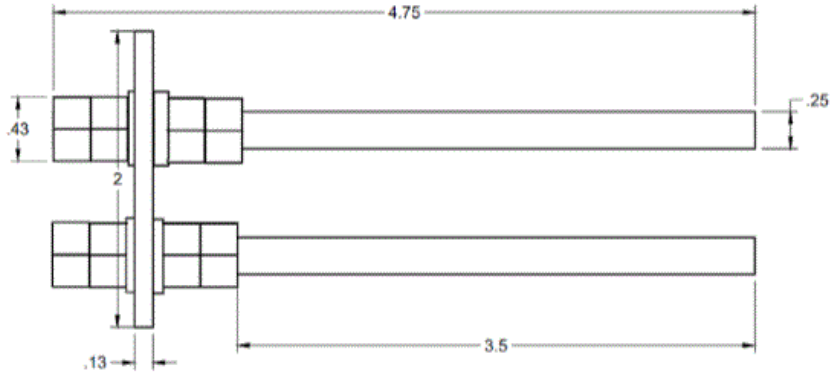


Payload structure (continued)

- We will keep height under 4.25 inches to provide for 1 inch clearance between payloads sharing canister.



Units: inches



Units: inches

RockSat-C schedule

- September
  - Intent-to-fly form due
- October
  - Conceptual Design Review
  - $1,000 payment due
  - Preliminary Design Review
- November
  - Critical Design Review
- January
  - Final downselect: flights awarded
  - Progress update
- February
  - Subsystem Test Review
  - Partial payment due
  - Progress update
- March
  - Integrated Subsystem Test Review
- April
  - Final payment due
  - Canisters sent to customers
  - Progress update
  - Full Mission Simulation Review
- May
  - Progress update
- June
  - Preliminary Check-in Document
  - Flight Readiness Review
  - Travel to Wallops for testing, integration, and flight
- July
  - Preliminary results report
  - Final report

Preparing to get involved in RockSat

- Go to the RockOn! workshop.
- Get involved in LaACES.
  - LaSPACE's student ballooning program.
- Start your SAFOS proposal early.
  - Submit 2 months before period of performance starts.
  - Look for a cash match.
    - Especially if you want a full canister, you will need more money.

RockOn!

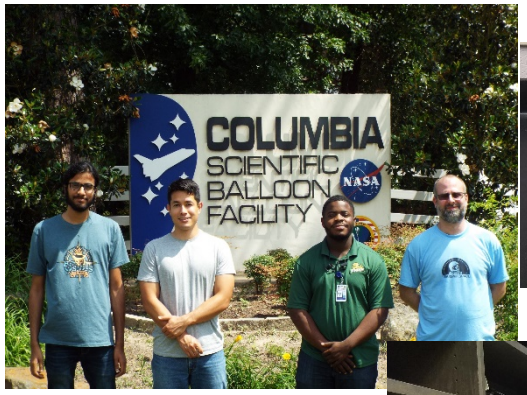
- Victoria Frabbiele and Cydney Hooper attended RockOn! 2019.
  - Victoria gained the skills and confidence needed for RockSat-C.

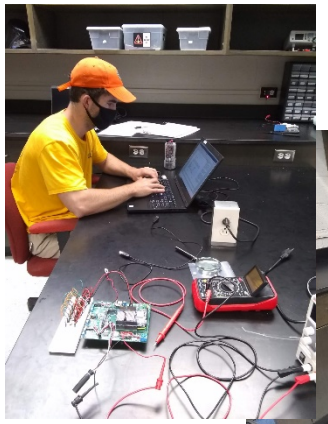
LaACES

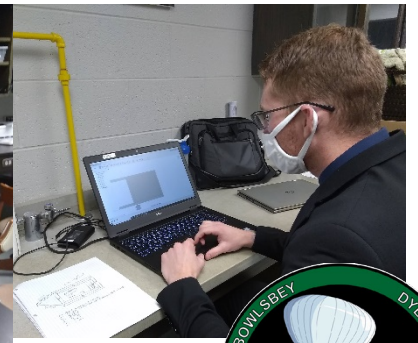
- LaSPACE's LaACES program is similar to RockOn! and RockSat combined, but for a balloon-borne experiment.
  - 1-year project
    - Fall: Balloon course
      - Electronics, soldering, programming, reporting, project management
      - 2 lab reports
    - Spring: Payload development and flight
      - Preliminary Design Review
      - Critical Design Review
      - Flight Readiness Review
      - Flight
        - NASA Columbia Scientific Balloon Facility in Palestine, TX
      - Post-flight presentation
        - Science results and/or failure analysis

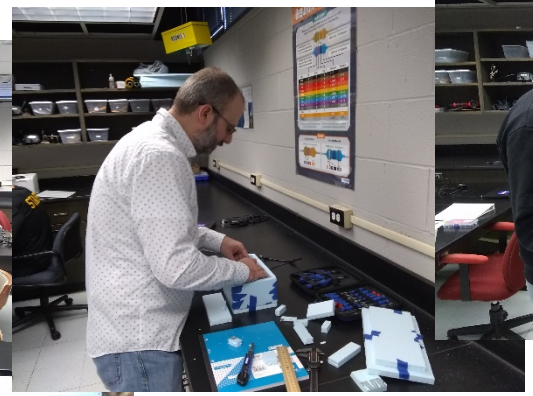
LaACES (continued)

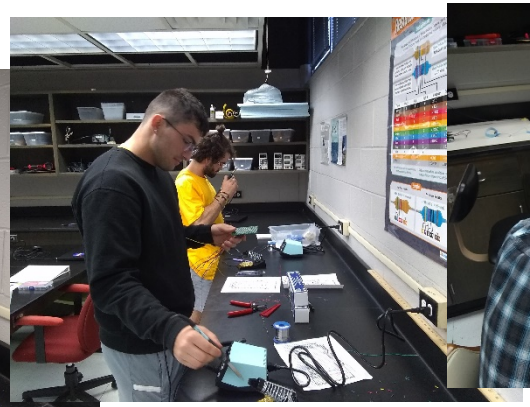
- Southeastern has participated in LaACES each year since 2018-19
  - Valuable skills for RockSat-C
  - Well-equipped laboratory
  - *AJP* article in press











Value added to Southeastern physics program

- The American Physical Society recommends integrating design experiences into the physics curriculum to fulfil a generally-unmet need in physics student career preparation.
  - 30% of physics majors have engineering careers.
    - AAPT statistics
  - Leak et al., *Teaching the Whole Physics Student: Integrating Communication, Context, and Career Preparation into the Physics Curriculum*, 2018.

- Of the 14 physics majors who have graduated since May 2019 or will graduate in Spring 2022, 10 have participated in LaACES or RockSat.

Conclusion and Acknowledgement

- We are excited to be working toward our experiments in space.
- If you want to do RockSat, then LaACES and RockOn! are good programs for getting started.
- Through LaACES and SAFOS, LaSPACE has had a huge impact on the physics program at Southeastern.