LaSPACE Student Flight Trajectory

by Abigail Peck
Mechanical Engineering Student at LSU

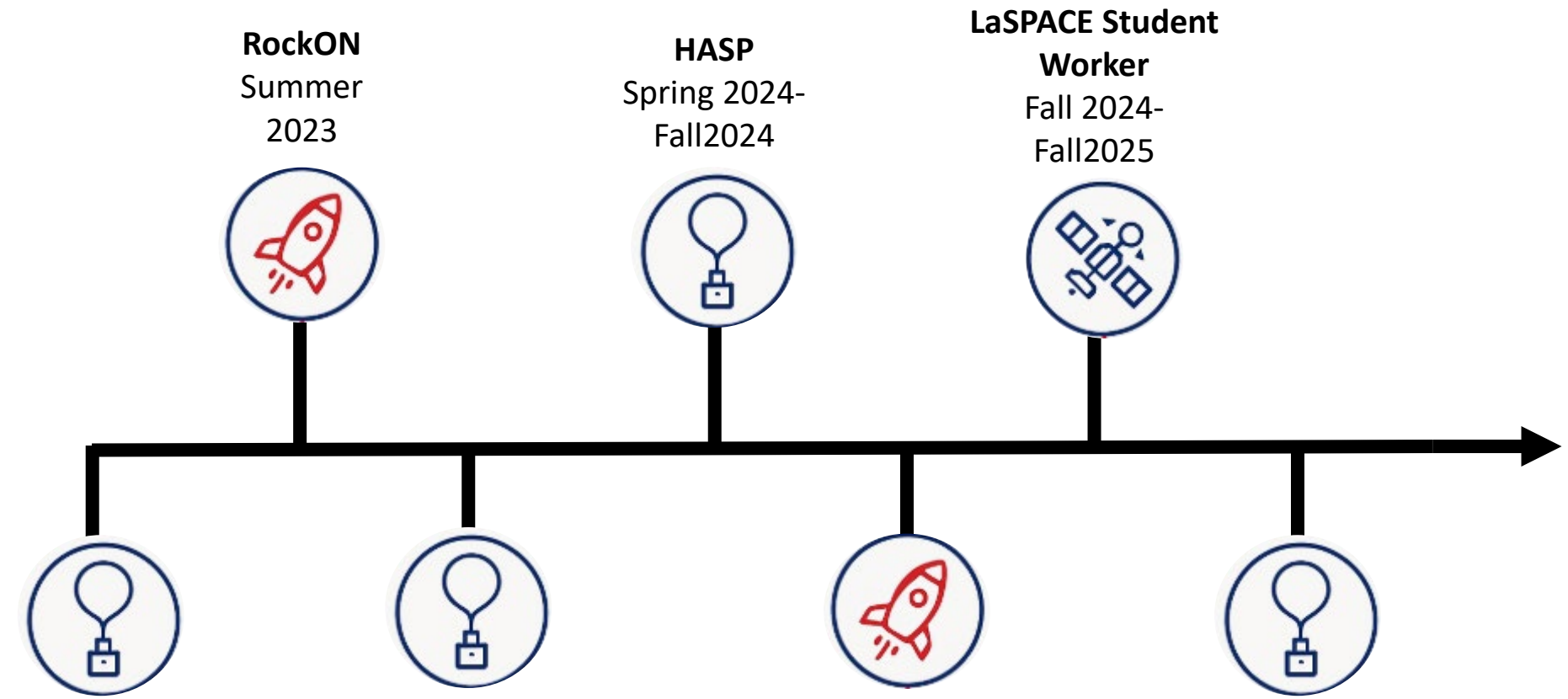
Presented at the 2025 LaSPACE Annual Meeting, LSU

Who am I?

- From Baton Rouge, LA
- I love Star Wars, Disney, art, board games, hands-on projects, my family (and my orange cat, Tater Tot <3)
- Student researcher in EPIC Marvel's Lab Group: Plasma Spray
  Dr. Christopher Marvel
- Grader for ME 1222: ME Design Innovation
  Dr. Genevieve Palardy, Dr. Katherine Pettrey,
  Dr. Andrew Becnel
- Current Secretary for AIAA (American Institute of Aeronautics and Astronautics)
- Past Treasure for SWE (Society of Women Engineers)

Me with my Level 1 certification model rocket.

Timeline


RockON
Summer 2023
HASP
Spring 2024-Fall2024
LaSPACE Student Worker
Fall 2024-Fall2025
LaACES
Fall 2022-Spring 2023
LaACES: Solar Eclipse
Fall 2023-Spring 2024
RockSat-C
Fall 2024-Fall2025
LaACES: Student Instructor
Fall 2025-Present

LaACES

(Louisiana Aerospace Catalyst Experience for Students)

Program Overview:

- A hands-on scientific ballooning program by LaSPACE.
- Conducted over two semesters:
  - Fall Semester- technical skill development needed for LaACES experiment in a classroom setting
  - Spring Semester- building and flying a payload/scientific experiment on a sounding balloon

Inflation of the Flight 70 balloon in May 2023

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LaACES: UVA Radiation Payload

(Fall 2022-Spring 2023)

Mission Goal:

To observe how accurately we can measure the payload's orientation to measure UVA radiation in the troposphere and stratosphere.

My Role: Electrical Lead

- Soldered a pre-made PCB (Megasat)
- Prototyped IMU and UVA sensor

My Team:

- Members: John Holley, Angelina Liemkeo, Caroline Davis, and Abigail Peck
- Advisor: Aaron Ryan
- Mentors: Dr. Gregory T. Guzik, Doug Granger, Colleen Fava

Right: Soldering the MegaSat together.
Left: Powering ON the payload on the flightline.

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LaACES: UVA Radiation Payload

(Fall 2022-Spring 2023)

Outcomes and Lessons:

- Gained experience in basic electronics, sensor calibration, real-time programming, and mechanical design.
- Learned how to test and troubleshoot flight hardware under real balloon flight conditions.
- Developed strong technical documentation and communication skills.

- Sometimes recovery is rough and the project isn't entirely successful.

Recovery, payloads stuck in a tree

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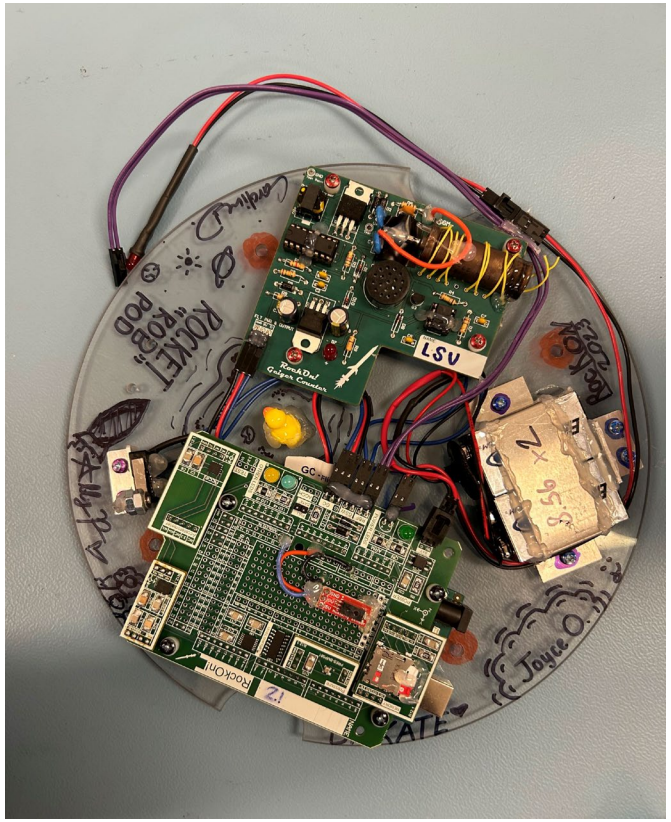
RockON!



Decorated Rock On! payload pre-launch.

Program Overview:

- NASA Wallops Flight Facility (WFF) hands-on workshop
- Build a rocket payload from scratch in 5 days — launch on a sounding rocket on day 6
- Learn PCB assembly, wiring, & sensor calibration
- Practice data collection + analysis on a sounding rocket

My Role:

- Assembled & soldered rocket flight-certified payload
- Assisted with integration

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RockON!

(Summer 2023)

Right: ULL and LSU Team on flight pad.
Left: LSU Team with RockON! Payload.

My Team:

- Joyce Oluwaseun, Caroline Davis, and Abigail Peck
- Faculty Advisor: Dr. Katherine Pettrey

Outcomes and Lessons:

- Learned how to share one task between multiple people
- Learned about rocket and balloon flight similarities and differences

- Flight postponed due to weather in June 2023, launched August 2023

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LaACES: Solar Eclipse Project

(Fall 2023-Spring 2024)

Mission Goal:

To measure the UV spectrum that is emitted from the corona of the Sun during a total solar eclipse compared to the same measurement before, during, and after totality.

My Role: Mechanical Lead

- Designed, constructed, and system test payload box
- Design and 3D printed a UVA, UVB, UVC, and Broadband photodiode holder
- Weight Management coordinator (500-gram max with electronics)

My Team:

- Members: Beau Johnson, Joyce Oluwaseun, John Holley, Angelina Liemkeo, Caroline Davis, and Abigail Peck
- Advisor: Aaron Ryan
- Mentors: Dr. Gregory T. Guzik, Doug Granger, Colleen Fava

Payload Box and Photodiode holder on scale

LaACES → RockON! → **LaACES: Solar Eclipse** → HASP → RockSat-C → LaSPACE Student Worker → LaACES Student Instructor

LaACES: Solar Eclipse Project

(Fall 2023-Spring 2024)

Outcomes and Lessons:

- Learned how to apply Mechanical design and 3D printing principals to project.
- Learned how to improve and advance payload from a previous project.
- Learned about introducing new people to an established project.

- Flight postponed due to weather (again) in April 2024, launched June 2024.

Right: LaACES eclipse project team.
Left: LaACES 71 balloon launch in June 2024

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HASP

(High Altitude Student Platform)

Program Overview:

- Joint program between LaSPACE & NASA Balloon Program Office
- Flies advanced student payloads to ~110,000 ft for 15–20 hrs on a space test platform
- Annual integration at CSBF Palestine, Texas and launch from CSBF New Mexico
- Payloads meet real NASA flight standards for design & integration

Inflation of HASP Balloon, CSBF New Mexico September 2024

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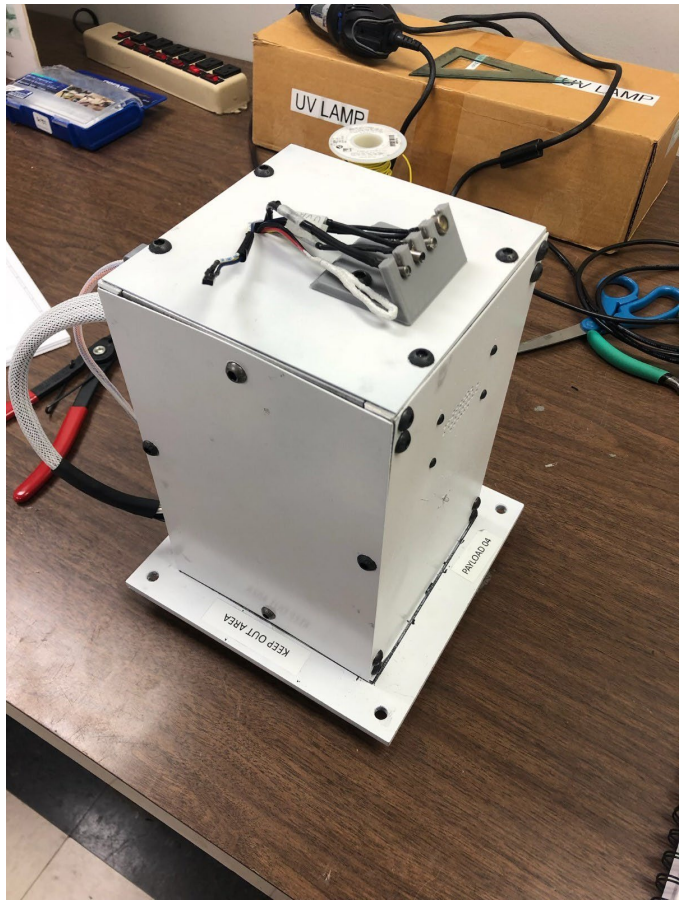
HASP

(Spring 2024- Fall 2024)



HASP payload before launch and integration

Mission Goal:

To observe the changes of ozone in the stratosphere due to photolysis caused by UVA, UVB, and UVC.

My Role: Mechanical Team

- Designed and machined aluminum payload housing
- Worked with electrical team to integrate electrical and mechanical components

My Team:

- Members: Angelina Liemkeo, Abigail Peck, John Holley, Cole Primeaux, Nathaniel Wrobel, Sophie Sprenger, Jared Chaisson, and Caroline Davis
- Advisor: Dr. Katherine Pettrey
- Mentors: Aaron Ryan, Doug Granger, Colleen Fava

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HASP

(Spring 2024- Fall 2024)

LSU 2024 HASP Team at integration at CSBF Palestine TX

Outcomes and Lessons:

- Gained experience with more detailed mechanical design and machining.
- Strengthened team coordination and communication on large projects

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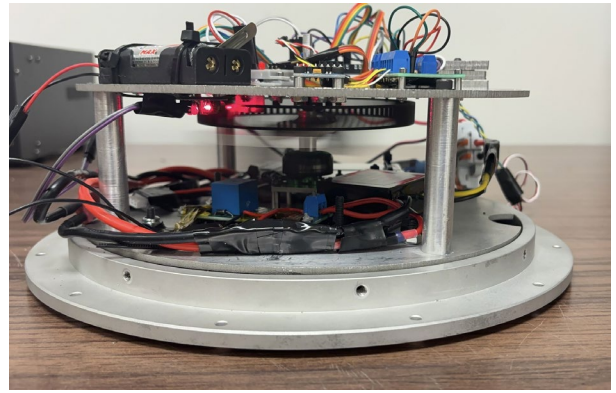
RockSat-C

(Fall 2024- Fall 2025)

Program Overview:

- Advanced NASA sub-orbital rocket program at Wallops Flight Facility (WFF)
- Continuation of RockOn!, focused on student-designed rocket payloads
- Teams design, build, and test experiments for a Terrier-Improved Orion rocket
- Involves NASA-style documentation, design reviews, and integration testing presentations to Wallops officials

First LSU team to participate through LaSPACE funding!



Top: LSU RockSat-C payload during operation
Bottom: Design Review done via ZOOM

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RockSat-C

(Fall 2024- Fall 2025)

Mission Goal:

To produce and measure artificial gravity for a small mass in a micro-gravity environment by applying a centrifugal force from a DC motor.

My Role: Co-Mechanical Lead

- Designed and machined an aluminum frame and rotation arm
- Managed payload integration at WFF
- Assisted with electronics mounting & cable routing

My Team:

- Members: Nathaniel Wrobel, John Kiritsis, Will Patrias, Cole Primeaux, and Abigail Peck
- Advisor: Dr. Katherine Pettrey
- Mentor: Aaron Ryan

LSU 2025 RockSat-C team and payload after passing inspection

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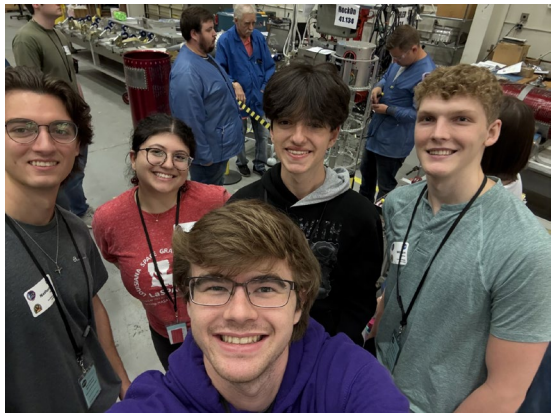
RockSat-C

(Fall 2024- Fall 2025)

Outcomes and Lessons:

- Learned structural design for rocket payloads and sub-orbital environments
- Learned more about advanced CAD modeling and advanced machining
- Applied previous LaACES & HASP experience to new flight conditions
- Gained insight into NASA launch operations & integration processes for sounding rockets



Top: LSU team after getting successfully integrated
Bottom: Me at launch

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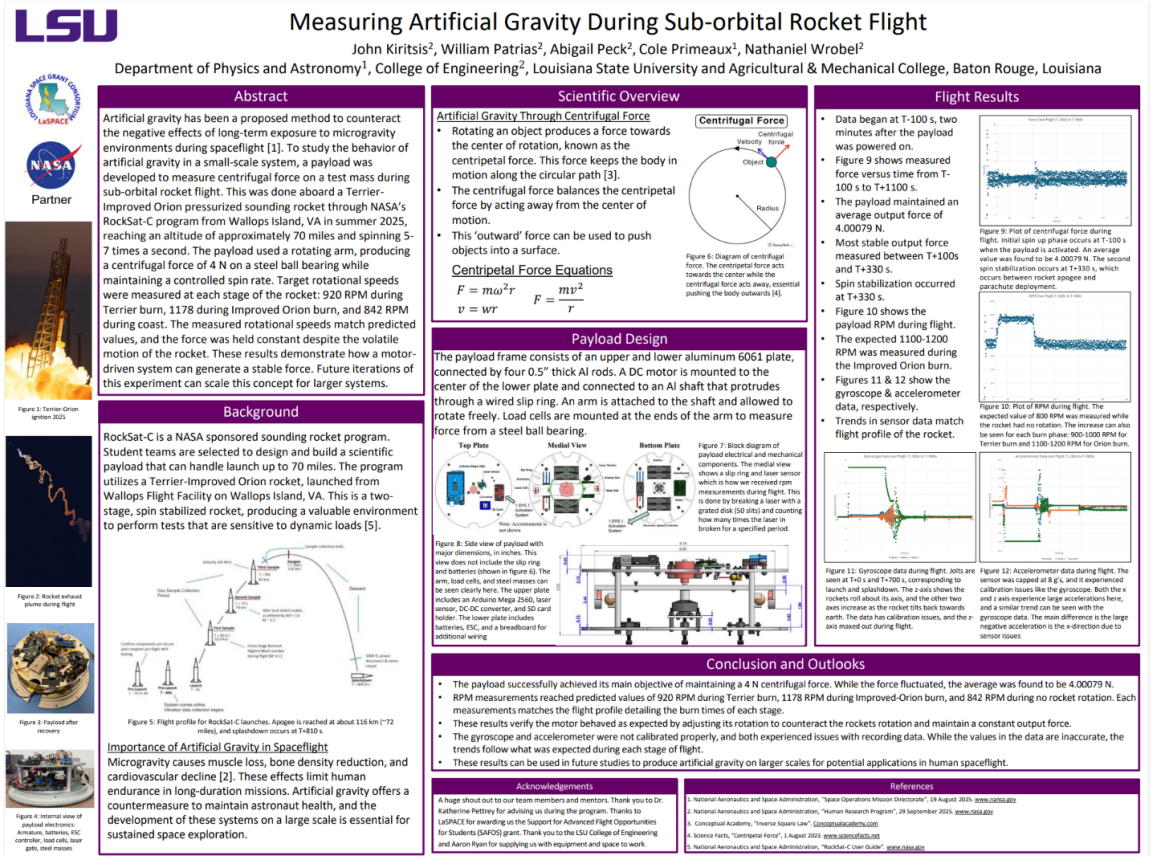
RockSat-C

(Fall 2024- Fall 2025)

If you are curious about this project Nathaniel Wrobel and I will be at Poster #51!



LSU

Measuring Artificial Gravity During Sub-orbital Rocket Flight

John Kiritsis[2], William Patrias[2], Abigail Peck[2], Cole Primeaux[1], Nathaniel Wrobel[2]

Department of Physics and Astronomy[1], College of Engineering[2], Louisiana State University and Agricultural & Mechanical College, Baton Rouge, Louisiana

Partner

Abstract

Artificial gravity has been a proposed method to counteract the negative effects of long-term exposure to microgravity environments during spaceflight [1]. To study the behavior of artificial gravity in a small-scale system, a payload was developed to measure centrifugal force on a test mass during sub-orbital rocket flight. This was done aboard a Terrier-Improved Orion pressurized sounding rocket through NASA's RockSat-C program from Wallops Island, VA in summer 2025, reaching an altitude of approximately 70 miles and spinning 5-7 times a second. The payload used a rotating arm, producing a centrifugal force of 4 N on a steel ball bearing while maintaining a controlled spin rate. Target rotational speeds were measured at each stage of the rocket: 920 RPM during Terrier burn, 1178 during Improved Orion burn, and 842 RPM during coast. The measured rotational speeds match predicted values, and the force was held constant despite the volatile motion of the rocket. These results demonstrate how a motor-driven system can generate a stable force. Future iterations of this experiment can scale this concept for larger systems.

Background

RockSat-C is a NASA sponsored sounding rocket program. Student teams are selected to design and build a scientific payload that can handle launch up to 70 miles. The program utilizes a Terrier-Improved Orion rocket, launched from Wallops Flight Facility on Wallops Island, VA. This is a two-stage, spin stabilized rocket, producing a valuable environment to perform tests that are sensitive to dynamic loads [5].

Figure 5: Flight profile for RockSat-C launches. Apogee is reached at about 116 km (~72 miles), and splashdown occurs at T+810 s.

Importance of Artificial Gravity in Spaceflight

Microgravity causes muscle loss, bone density reduction, and cardiovascular decline [2]. These effects limit human endurance in long-duration missions. Artificial gravity offers a countermeasure to maintain astronaut health, and the development of these systems on a large scale is essential for sustained space exploration.

Scientific Overview

Artificial Gravity Through Centrifugal Force

- Rotating an object produces a force towards the center of rotation, known as the centripetal force. This force keeps the body in motion along the circular path [3].
- The centrifugal force balances the centripetal force by acting away from the center of motion.
- This 'outward' force can be used to push objects into a surface.

Centripetal Force Equations

$$F = m\omega^2 r \qquad F = \frac{mv^2}{r}$$

$$v = wr$$

Figure 6: Diagram of centrifugal force. The centripetal force acts towards the center while the centrifugal force acts away, essential pushing the body outwards [4].

Payload Design

The payload frame consists of an upper and lower aluminum 6061 plate, connected by four 0.5" thick Al rods. A DC motor is mounted to the center of the lower plate and connected to an Al shaft that protrudes through a wired slip ring. An arm is attached to the shaft and allowed to rotate freely. Load cells are mounted at the ends of the arm to measure force from a steel ball bearing.

Figure 7: Block diagram of payload electrical and mechanical components. The medial view shows a slip ring and laser sensor which is how we received rpm measurements during flight. This is done by breaking a laser with a grated disk (50 slits) and counting how many times the laser in broken for a specified period.

Figure 8: Side view of payload with major dimensions, in inches. This view does not include the slip ring and batteries (shown in figure 6). The arm, load cells, and steel masses can be seen clearly here. The upper plate includes an Arduino Mega 2560, laser sensor, DC-DC converter, and SD card holder. The lower plate includes batteries, ESC, and a breadboard for additional wiring

Flight Results

- Data began at T-100 s, two minutes after the payload was powered on.
- Figure 9 shows measured force versus time from T-100 s to T+1100 s.
- The payload maintained an average output force of 4.00079 N.
- Most stable output force measured between T+100s and T+330 s.
- Spin stabilization occurred at T+330 s.
- Figure 10 shows the payload RPM during flight.
- The expected 1100-1200 RPM was measured during the Improved Orion burn.
- Figures 11 & 12 show the gyroscope & accelerometer data, respectively.
- Trends in sensor data match flight profile of the rocket.

Figure 9: Plot of centrifugal force during flight. Initial spin up phase occurs at T-100 s when the payload is activated. An average value was found to be 4.00079 N. The second spin stabilization occurs at T+330 s, which occurs between rocket apogee and parachute deployment.

Figure 10: Plot of RPM during flight. The expected value of 800 RPM was measured while the rocket had no rotation. The increase can also be seen for each burn phase: 900-1000 RPM for Terrier burn and 1100-1200 RPM for Orion burn.

Figure 11: Gyroscope data during flight. Jolts are seen at T+0 s and T+700 s, corresponding to launch and splashdown. The z-axis shows the rockets roll about its axis, and the other two axes increase as the rocket tilts back towards earth. The data has calibration issues, and the z-axis maxed out during flight.

Figure 12: Accelerometer data during flight. The sensor was capped at 8 g's, and it experienced calibration issues like the gyroscope. Both the x and z axis experience large accelerations here, and a similar trend can be seen with the gyroscope data. The main difference is the large negative acceleration is the x-direction due to sensor issues

Conclusion and Outlooks

- The payload successfully achieved its main objective of maintaining a 4 N centrifugal force. While the force fluctuated, the average was found to be 4.00079 N.
- RPM measurements reached predicted values of 920 RPM during Terrier burn, 1178 RPM during Improved-Orion burn, and 842 RPM during no rocket rotation. Each measurements matches the flight profile detailing the burn times of each stage.
- These results verify the motor behaved as expected by adjusting its rotation to counteract the rockets rotation and maintain a constant output force.
- The gyroscope and accelerometer were not calibrated properly, and both experienced issues with recording data. While the values in the data are inaccurate, the trends follow what was expected during each stage of flight.
- These results can be used in future studies to produce artificial gravity on larger scales for potential applications in human spaceflight.

Acknowledgements

A huge shout out to our team members and mentors. Thank you to Dr. Katherine Pettrey for advising us during the program. Thanks to LaSPACE for awarding us the Support for Advanced Flight Opportunities for Students (SAFOS) grant. Thank you to the LSU College of Engineering and Aaron Ryan for supplying us with equipment and space to work.

References

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2. National Aeronautics and Space Administration, "Human Research Program", 29 September 2025. www.nasa.gov
3. Conceptual Academy, "Inverse Square Law". Conceptualacademy.com
4. Science Facts, "Centripetal Force", 1 August 2023. www.sciencefacts.net
5. National Aeronautics and Space Administration, "RockSat-C User Guide". www.nasa.gov

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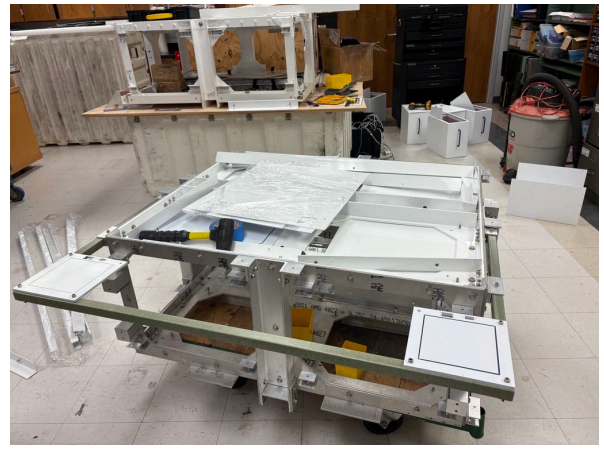
LaSPACE Student Worker

(Fall 2024- Fall 2025)

My Role/Projects:

- LaSPACE 2024 Annual Meeting
  - Photographed event
  - Built and prepared scientific poster boards for student presentations
- Supported outreach events with the MARS Truck, led astronomy & physics demos
- Integrated student payloads and assisted with the LaACES 2025 balloon launch at CSBF Palestine, TX (Posters 16 and 17)
- HASP 2025
  - Made booms and CNC student team plates
  - Helped assemble and test payloads in the CSBF thermal vacuum chamber
- Represented LaSPACE students at the NASA Michoud Assembly Facility in New Orleans



Top: Van de Graff demo
Bottom: HASP 2025 Frame

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LaACES Student Instructor

(Fall 2025-Present)

My Role:

- Mentor for new LSU LaACES student teams
- Lead/help lead weekly labs and lectures on electronics, sensors, and data systems
- Guide teams through payload design, documentation, and testing
- Strengthened leadership, teaching, and communication skills

2025 LSU LaACES presentation to new students

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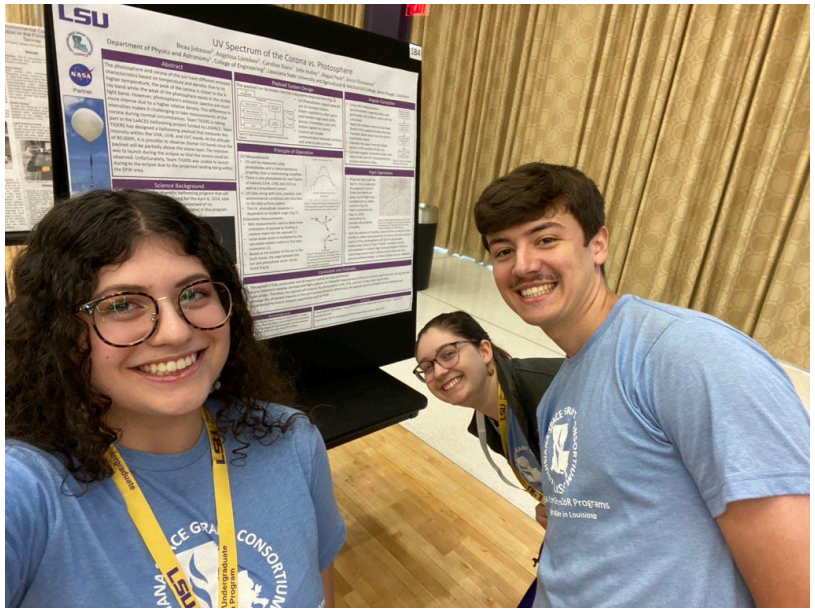
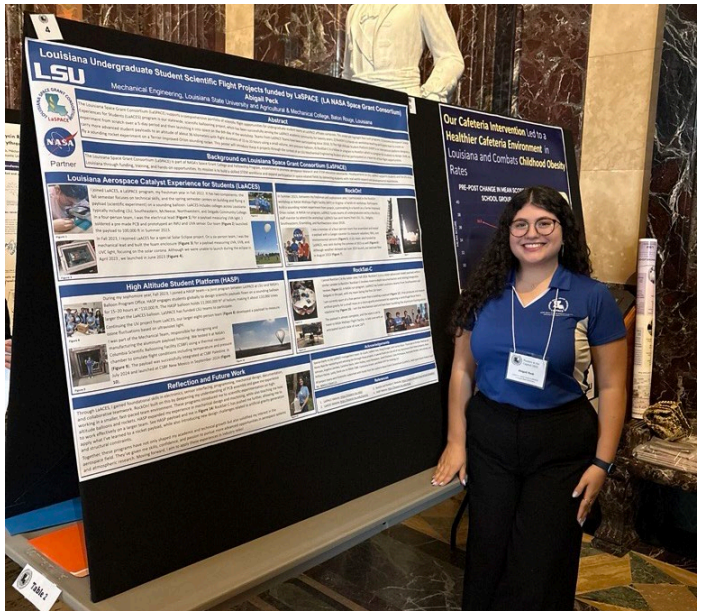
Additional Opportunities from LaSPACE



Discover Day Presentation, April 2024



Posters at the Capitol, June 2025

LaSPACE Student Showcase: Undergraduate Students			
12:40 PM	LaSPACE Student Flight Trajectory *(RockOn!, LaACES, HASP, RockSat-C)*	Abigail Peck	LSU

Speaking at the LaSPACE Annual Meeting, November 2025

Thank you Louisiana Space Grant!

Thank you for investing time and money into me, my projects, and my academic career.

Thank you for your time! Questions!

Connect with me on LinkedIn: Abigail Peck