



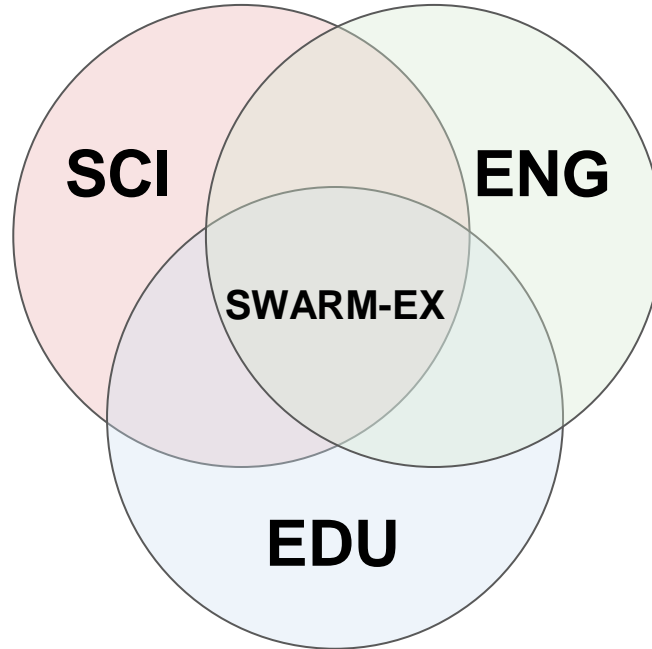
# SWARM-EX Educational Programs in the Development of a Collaborative CubeSat Swarm

Austen Thomas (Presenter), Brodie Wallace, Rohil Agarwal, Regan Mah, Whitney Lohmeyer, Scott Palo, Kristina Lemmer, and Saeed Latif



# Program Goals

- Persistence and correlation in EIA/ETA features
- Changes in EIA/ETA features that occur over timescales of <90 minutes



- Formation flying
- Collision avoidance
- Detach & reconnect
- Propulsion
- UHF crosslink
- CDMA downlink

- Intercollegiate CubeSat Mentoring Program
- CQ Slack channel
- Efforts to track student engagement/progress

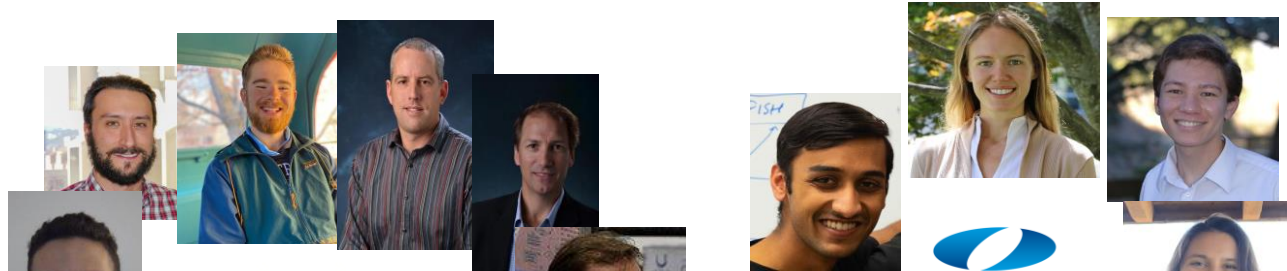




# Multi-University Collaboration

- Six institutions: The University of Southern Alabama (USA), Stanford University (SU), The University of Colorado Boulder (CU), Georgia Tech (GT), Olin College, and Western Michigan University (WMU)
- The SWARM-EX mission provides a unique opportunity for STEM education and allows for cross-institutional mentorship between experienced and new CubeSat programs



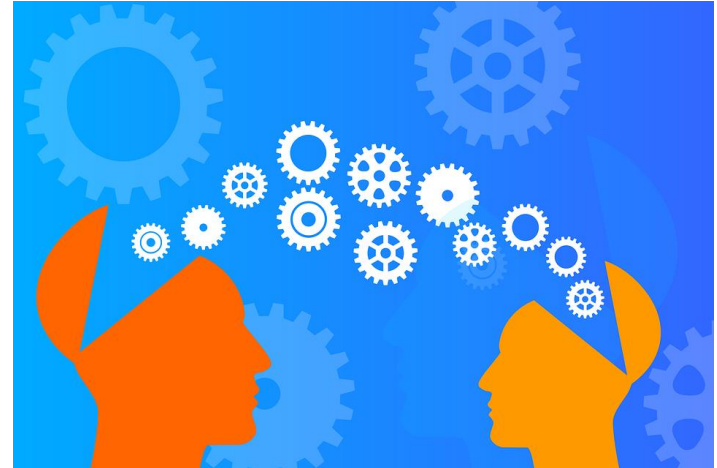


# Our Team



# Current Efforts

- Providing cross-institutional mentoring activities
- Development and implementation of a repository for CubeSat knowledge and expertise
- A survey of student participants
- Seminar Series



[1]



# Cross-Institutional Mentoring

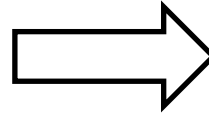
Experienced  
Programs



New  
Programs



Olin College  
of Engineering



# Surveys

- Four Surveys
  - Demographic
  - Entry
  - Annual
  - Exit



[1]





During your participation in SWARM-EX in the last year, which three subsystems were you most involved in?

	1: Most involved	2: Second most involved	3: Third most involved
Attitude Determination and Control System	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Command and Data Handling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communications	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Electrical Power System	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Guidance Navigation and Controls	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ground Station	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integration and testing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Operations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Propulsion	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science instrument	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Structures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thermal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Education & Public Outreach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What skills have you gained while working on SWARM-EX regarding small satellites? (Check all that apply)

<input type="checkbox"/> SolidWorks, Ansys, or other structural modeling software	<input type="checkbox"/> Altium & Eagle
<input type="checkbox"/> MATLAB, Python, or other coding software	<input type="checkbox"/> Embedded Systems
<input type="checkbox"/> Electronics assembly, such as soldering	<input type="checkbox"/> Electromagnetic Design Software
<input type="checkbox"/> Electronics troubleshooting	<input type="checkbox"/> Engineering Design
<input type="checkbox"/> Thermal Desktop	<input type="checkbox"/> Version Control GIT & SVN
<input type="checkbox"/> How to develop a Requirement Verification Matrix (RVM)	<input type="checkbox"/> Other

# Survey Purpose

- Identify and track students technical capabilities and CubeSat knowledge levels throughout their time working on the SWARM-EX project
- The outcome of surveys is to gain a better understanding of what participants bring and take away from the project

Which of the following most accurately describes your major field of study?

- Aerospace Engineering
- Business
- Civil Engineering
- Computer Engineering
- Computer Science
- Electrical Engineering
- Engineering Physics
- Industrial Operations
- Math
- Mechanical Engineering
- Physics
- Space Science
- Other





# Current CubeSat Resources & The SWARM-EX CubeSat Slack Channel



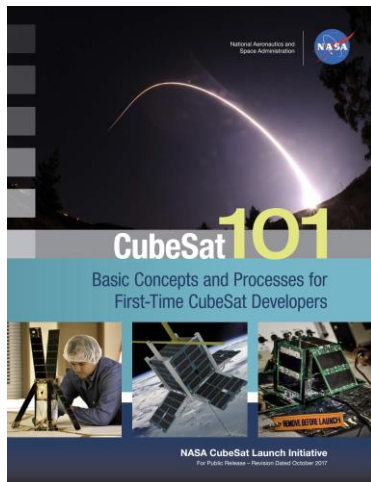
Search small satellite information...

[2019-2020](#)
[2018-2019](#)
[2017-2018](#)
[2016-2017](#)
[2015-2016](#)
[2014-2015](#)
[2013-2014](#)
[2012-2013](#)
[2011-2012](#)

[Small Satellite Conference Proceedings](#)
[CubeSat Developers Workshop Proceedings](#)
[Small Satellite Conference Proceedings](#)

NASA's Small Spacecraft Systems Virtual Institute (SSVI) uses web technologies, databases, and virtual collaboration tools to collect, organize, and disseminate small spacecraft knowledge for the benefit of NASA and the community. SSVI has established the National Search Capability that serves as an entry point to the SmallSat Parts On Order (POO) database and other NASA internal and external databases to allow the public to search multiple databases for small spacecraft parts, technologies and conference proceedings. Currently, SSVI's integrated database consist of the NASA Technology Portfolio System (TPS), the NASA Electronic Parts and Packaging (NEPP) database, SmallSat Conference Proceedings, CubeSat Developers Workshop Proceedings and other Historical Small Satellite Conference Proceedings.

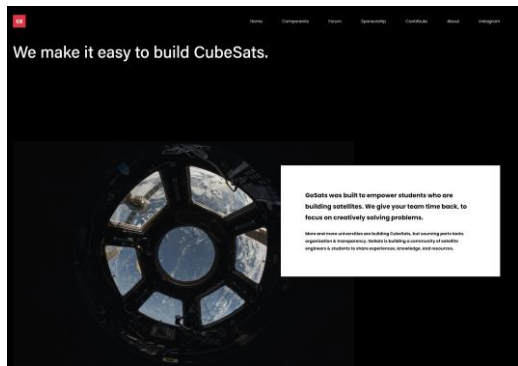
[View more...](#)



[4]



## Launching Cubesat Questions



[3]



# CubeSat Slack Channel

- The CubeSat Questions Slack Channel introduces students and new CubeSat teams to experts and experienced teams
- Subject matter experts from 16+ universities
- Total Members: 98





7 replies  
7 months ago

My name is Max, and I am with Western Michigan University's satellite team where we are developing a 6U Cubesat. As we have been developing our flight software, some questions have come up. We are looking for information that would apply for a general/conventional LED Cubesat mission. My questions are as follows:

1. When considering GPS telemetry and housekeeping data collection (component voltage/current/temperature reading, battery health data, etc.) while the satellite is in orbit, what is a typical time interval for collect that data? Once every 10 sec., 30 sec., 5 min.? And on the same note, what is a typical time frame for downlinking that data? Once an orbit?, Every chance we get? We understand that every mission will have different downlink and data collection requirements, but is there a general baseline we can build off of?
2. What is typically done by Cubesats directly after leaving the deployer? Is there a switch that triggers activation of the satellite after leaving the deployer? Is there an order of operations that a Cubesat follows for initial system checkouts/detumble/battery charging/downlinking?

7 replies

7 months ago

1. We usually take those readings once every < 10 seconds. I think we've done 1 and 3 seconds before and that's been a comfortable rate. With UHF downlink only, there's usually not enough bandwidth to downlink all of that so we set things up so that we can easily request "decimated" data, e.g., just one sample every 10 minutes. It all stays onboard for months so we can always go back and request higher cadence data if needed.

7 months ago

2. There's usually a period of time required by the launch provider that the CubeSat can't do any deployments or radio transmissions (e.g., 30 minutes). The deployers usually have requirements for where to put the switches in your CubeSat (in a foot or along the rail) that keeps your CubeSat powered off inside and as soon as the switch releases as it exits the deployer, the CubeSat powers on and starts its software timer for deployments and radio transmissions (beacons). Detumble can occur right after deployment I believe, but we usually don't trigger that until the timer completes either. That means its important to make sure your spacecraft is power positive during a tumble in its lowest power consumption mode. The order of operations that we've usually followed is:
  1. deploy - CDH and EPS power up, X minute countdown timer started
  2. timer completes
  3. deploy antennas and begin beacons every ~10 seconds
  4. (optional) 30 seconds later or so autonomously deploy solar panels (alternative option is that this can only be commanded from the ground but we've always opted to do it autonomously)
  5. Aside: Repeat 3-4 every ~60 minutes or so until ground contact is established and a special command sent to disable the repeated deployment attempts
  6. a minute or so later, begin periodic checks of battery voltage to determine if there's enough charge to auto-promote to nominal safe mode, which among other things, powers on ADCS and let it run its detumble algorithm and establishes coarse sun pointing
  7. hopefully ground contact has been established at this point and commissioning can begin

7 months ago

Thank you, this is very helpful!

7 months ago

Others may have different approaches but that's worked for us for a few that have flown already

7 months ago

With regards to the data collection cadence you should consider the rates at which the signals change. For example making a thermal measurement every minute is probably sufficient, but it can be annoying to have to record data at different data rates so you may record temperature every second because that is the sample rate used for current and voltage measurements. Additionally storage is cheap so you can sample fast but only downlink a small subset of data as needed and you would have high rate data available if needed for anomaly troubleshooting.

7 months ago

- Student from Western Michigan University asking questions on GPS telemetry, housekeeping data, and CubeSat deployment
- They received responses from experts with detailed explanations



# CubeSat Knowledge Documents

- Academic Material: Lectures and Webinars
- Frequently Asked Questions Document
- Getting Started Document for CubeSat





# Seminar Series

- The seminar series is a set of lectures covering various topics put on by members of the SWARM-EX project allowing students' to participate in discussions on topics which interests them improving their general knowledge in applied STEM
- Upcoming Topic: In-situ measurements and science instruments & SWARM-EX instrumentation      Presenter: Dr. Marcin Pilinski
- Previous Topics
  - CU-E3 CubeSat Mission      Presenter: Brodie Wallace
  - Academic Journey and Past Research Projects      Presenter: Dr. Scott Palo
  - Application of Engineering Principles to Army/MFO Operations in Egypt      Presenter: Shane Lowe





# Future Work

- Cross-institutional mentoring
- The CQ Slack Channel will continue to be open to additional groups and institutions
- Completing of surveys
- Continuing of seminar series





Questions?





# References

- [1] Lemmer, K. (2020). Education and Public Outreach (EPO). Retrieved from: SWARM-EX Google Drive
- [2] S3VI - Small Spacecraft Systems Virtual Institute (nasa.gov). Small Satellite Information Search. Retrieved from: <https://s3vi.ndc.nasa.gov/>
- [3] Go Sats. (2021). Go Sats. Retrieved from: <https://www.gosats.com/>
- [4] CubeSat Developers (nasa.gov). (2017). CubeSat 101: Basic Concepts and Processes for First-Time CubeSat Developers. Retrieved from: [https://www.nasa.gov/sites/default/files/atoms/files/nasa\\_csl\\_i\\_cubesat\\_101\\_508.pdf](https://www.nasa.gov/sites/default/files/atoms/files/nasa_csl_i_cubesat_101_508.pdf)

