Building a Small Satellite Research Program at the University of Georgia: UGA Payload Development for CubeSats

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IGTF/ASPRS 2017
Cube Satellites

- 1 U defined as 1.33kg and 10 x 10 x 11.35cm
- Can be 1 - 12U’s in one configurations
The CubeSat Revolution

- Cheap
- Relatively easy to launch
- Commercial off the shelf parts

Nano/microsatellite launch history and forecast

Projections based on announced and future plans of developers and programs indicate as many as 3,000 nano/microsatellites will require a launch from 2016 through 2022.

Source: SpaceWorks Enterprises, Inc.
Who we are

• We are all undergraduates
  • Advised by multidisciplinary faculty
  • Started as a student group

• Engineering, Computer Science, Physics, Geography, Graphic Design, Business, Finance & More

• Plus, we love space!
Where We Are Now

• Over 50 students
• ~150 applicants for this semester
• 2 Cube Satellites Under Development
  • Passed 3 reviews with AFRL
  • Passed 2 reviews with NASA
• 12 faculty advisors, mentors, and researchers who are awesome
Our Missions

SPOC

• SPectral Ocean Color Satellite
• ISS orbit
• Measure Coastal, Oceanic, and environmental productivity
• Funded through NASA

MOCI

• Mapping and Ocean Color Imager
• ISS orbit
• Structure from Motion
• Ocean Color
• Funded through AFRL

CGR
Center for Geospatial Research
cgr.uga.edu
Launch
• 2018, 2019, or 2020 Launch - SPOC
  • CSLI class
• ~2021 Launch - MOCI
• ISS resupply

Deployment
• CalPoly PPOD
• NanoRacks
• Kibo Module - JEM Airlock
Typical Mission Timeline

Launch date
CubeSat accompanies the LV into orbit

Recharge + Status Check (1 day)
Recharge battery and full system diagnostic. Perform trial subsystems boot up.

Data downlink (170 days)
Images and telemetry data downlink period, most valuable images first (perspective variety)

Deployment
CubeSat deployment. Establish communication after 45 minutes from launch.

Image Gathering (20 days)
Perform imaging of targeted area. Data set will contain images of the target area from a variety of perspectives, taken over multiple orbits.

Deorbit Phase
CubeSat goes into deorbit mode in preparation for eventual deorbit.
MOCI Mission Overview

Mapping and Ocean Color Imager (MOCI)
MOCI – Structure From Motion

- ARFL Funded project through UNP
- Use Structure from Motion techniques from space based platform
  - Calculate 3-D point clouds on board the satellite
  - Transmit 3-D images back to Earth
  - Optimizes data transmission techniques
- Phase 1 ends in 2018 with final selections determining launch date
MOCl – Success Criteria

- Run on-board SfM using to create 3D point cloud
- Downlink mesh
Tests Using Pluto

• New Horizons Data
• Plan to compare with existing DEMs
• Currently inaccurate, but improvements are in the works
SPOC Sat Mission Overview

Spectral Ocean Color (SPOC) Satellite
SPOC Mission Overview

• Fly multi-spectral imager on CubeSat
• Enhance ecological studies at GCE LTER
  • Vegetation health
  • Chlorophyll-a reflectance of estuarine and coastal waters
  • Phycocyanin reflectance of inland and estuarine waters
  • Colored Dissolved Organic Material reflectance
  • Total Suspended Sediment reflectance

GCE-LTER Eddy Covariance flux tower and a sample Phenocam image

Photo by Wade Sheldon
SPOC Multi-spectral Imaging

• Build in house sensor
  • 420-900 nm
  • 60 bands
  • 8 nm spectral resolution
  • 4 kg
  • 120m spatial resolution

• $200,000
SPOC Multi-spectral Imaging

- Lenses/mirrors
- Single Slit
- Diffraction Grating
- Collimator
- CMOS
Outreach

• Hosting 1-2 high school interns a semester
• Undergraduate-led workshops for middle and high school students
• Creating workshops for underrepresented STEM groups
Outreach

• Produce space news/educational podcasts
• Giving talks to local groups
• Create how to satellite based YouTube videos
If you would like to contribute or learn more about the lab and our missions visit: smallsat.uga.edu

We could always use funds for:

Undergraduate student stipends
Turbo Pump for our vacuum chamber
Helmholtz Cage for ADCS testing
ElectroStatic Discharge tables
Permanent Ground station at UGA
Our Founding

Student Passion + University Research = Success

- Winning first Hackathon for UGA
  - February 2015

- Spacey team begins planning a Cube Satellite
  - June 2015

- UGA Faculty planning to build a satellite payload
  - July 2015

- Spacey Team meets with UGA faculty about CubeSats
  - October 2015

- The SSRL wins funding for first Satellite MOCI
  - December 2015

- Founding of UGA Small Satellite Research Laboratory (SSRL) with 25 students
  - January 2016

- The SSRL wins funding for a second Satellite SPOC
  - April 2016

- The SSRL presents at the Small Satellite Conference
  - August 2016

- The SSRL presents at Dragon Con
  - September 2016

- SSRL moves into completed lab space
  - January 2017

- SPOC mission chosen for launch through NASA CSLI
  - February 2017

- SSRL expands to 50 students
  - March 2017
Who we are
Difficulties at a Non Technical School

• Finding appropriate facilities and expertise in satellite integration
• More expensive to start a program
  • Contributions welcome at www.smallsat.uga.edu
• Missing a strong engineering mentoring component
• Having to rely heavily on independent research
• Getting Departments to work together

Lab space until January 2017
Advantages at a Non Technical School

• Students directly involved in designing/choosing equipment and components

• Entire student team is involved in every aspect of the project including: proposal writing, lab renovations, reviews, and discussions

• “Outside the box” approaches to problem solving and numerous non--STEM majors involved in space based projects

• Easier to attract highly motivated and intelligent students from all majors not just engineering, less intimidating

• Students involved in immersive/experiential learning opportunities that cannot be found else where around campus

• Using gained knowledge to create new courses, provide internships for high school students, and create outreach material
Skills learned - Pre-Launch

- Concept Studies
- Algorithm Development
- Software Development
- Fabrication
- Environmental Testing
- Construction of Ground Station
Skills learned - During Operation

• Command and Control
• Data Gathering
• Research
• Discoveries!
MOCI – Structure from Motion

- Demonstration
- Passive terrain mapping
- Basic everyday cameras
- 3D data products