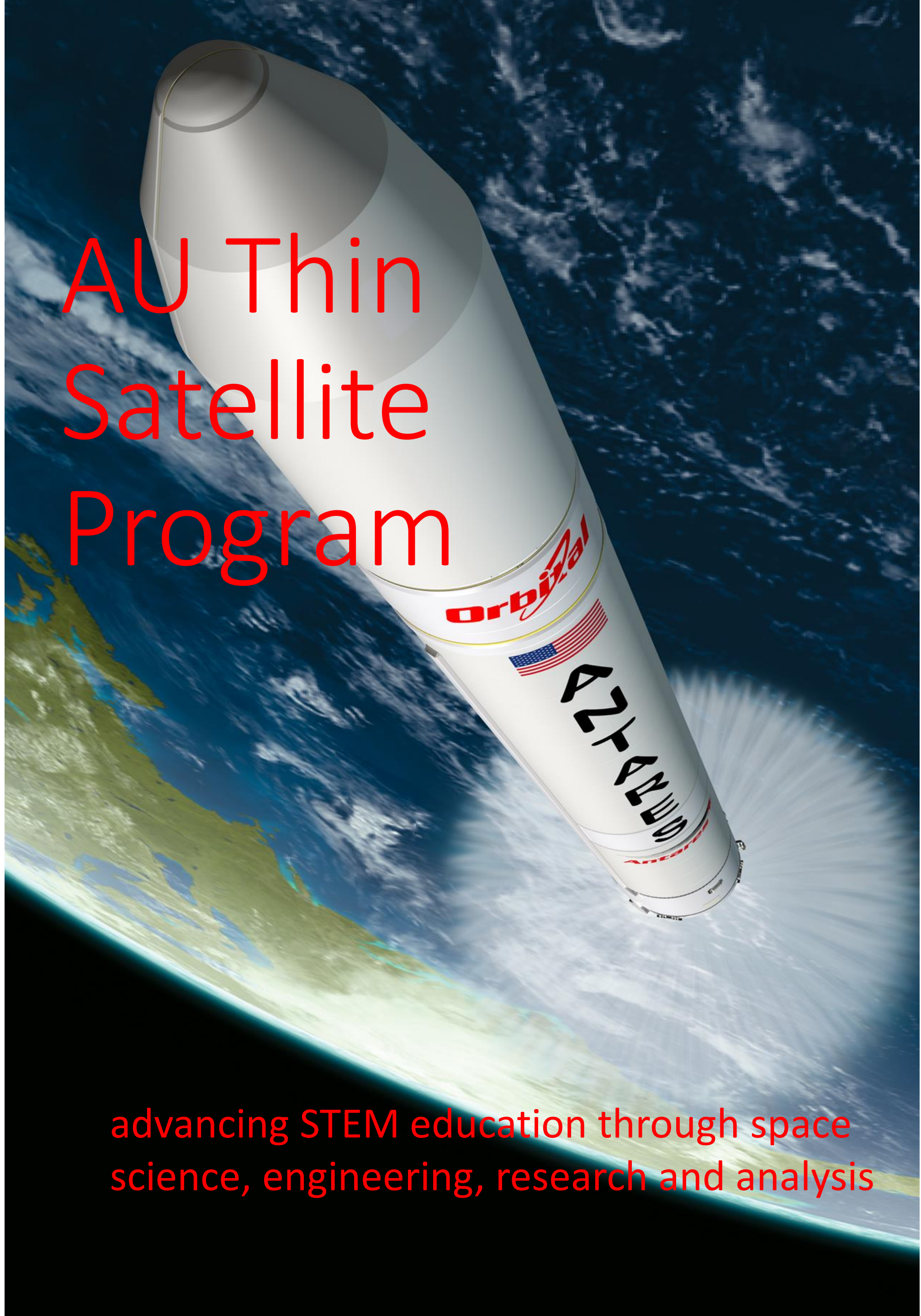
ThinSats, Space Science and STEM Outreach at American University

by
Cyndee Finkel

AMERICAN UNIVERSITY
WASHINGTON, DC

2019 Mid-Atlantic Regional NASA Space Grant Consortia Meeting



Outline

- Overview of the ThinSat project – key players
- Overview of our participation
- Success and Failures
- Future Goals

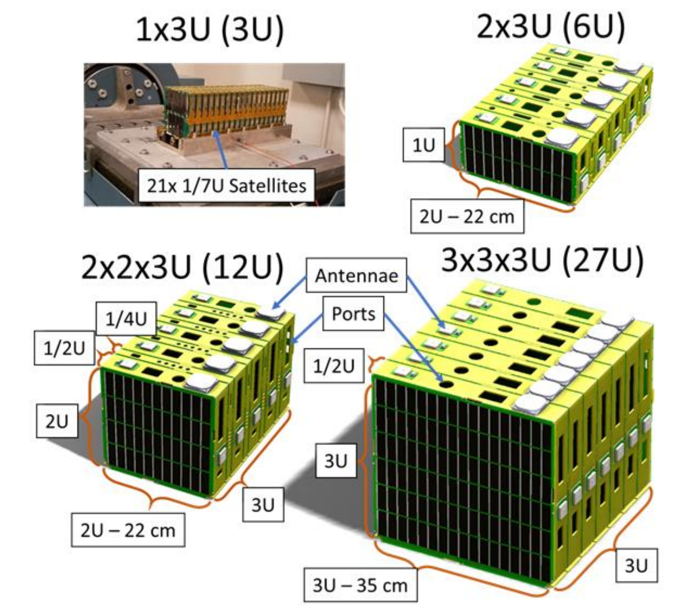
ThinSat Education Program

Twiggs, R., Zucherman, A., Bujold, E., Counts, N., Colman, C., Garcia, J., ... & Orvis, M. (2018). The ThinSat Program: Flight Opportunities for Education, Research and Industry. In *32nd Annual AIAA/USU Conference on Small Satellites. URL: https://digitalcommons. usu. edu/cgi/viewcontent. cgi*.

Program Goals

Decrease	decrease the spacecraft development cycle time
Reduce	reduce the complexity and increase reliability
Provide	provide regular launch opportunities, thereby increasing space access
Engage	engage students earlier in their education (4th to 12th grade)
Reduce	reduce the burden of paperwork and licensing requirements
Mitigate	mitigate the threat of space debris with short orbital life
Reduce	reduce the overall cost of spacecraft development and access to space
Create	create a precursor program to CubeSat program
Create	create a smaller spacecraft platform for valuable space research.

ThinSats



https://www.nearspacelaunch.com/products/thinsat

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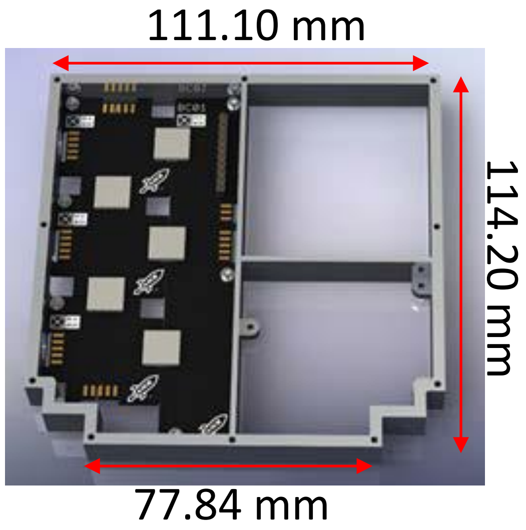
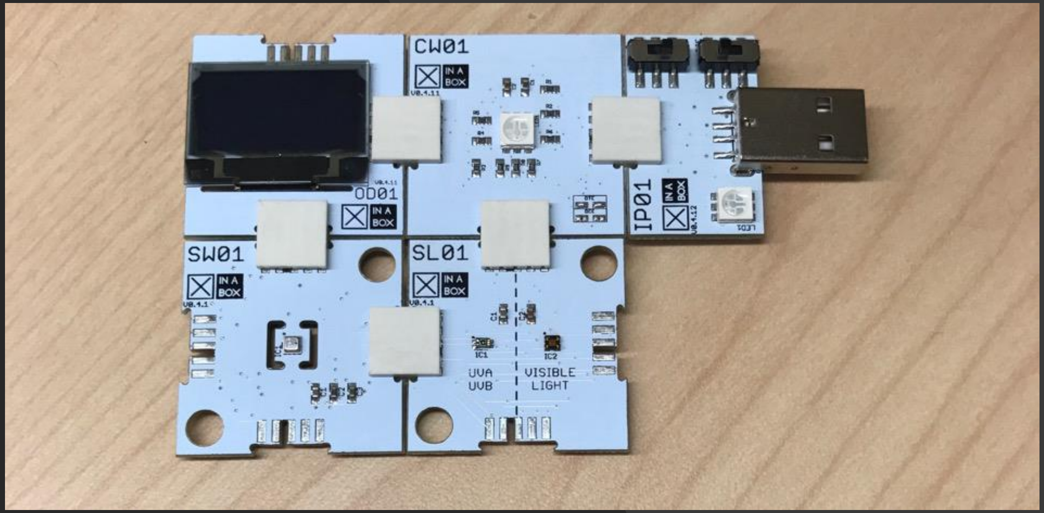


Thickness T=12.50 mm
m=280g

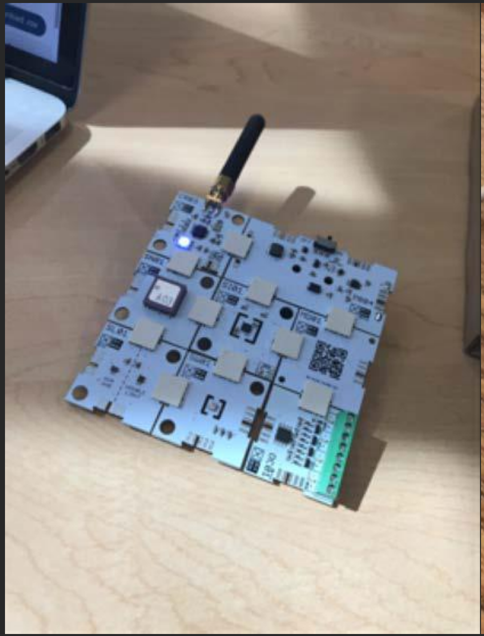
- Each string has at least 1 Mothership (contains GPS, foldout camera)
- Fits in a standard 3U Canisterized Satellite Dispenser (CSD)
- 3U=21 ThinSats
- Grouped into strings in multiples of 3 with ~30 cm in-between.
- Wires or articulating fanfolds (can be solar arrays)

Phase 1: Studying the Troposphere (0-50 km)

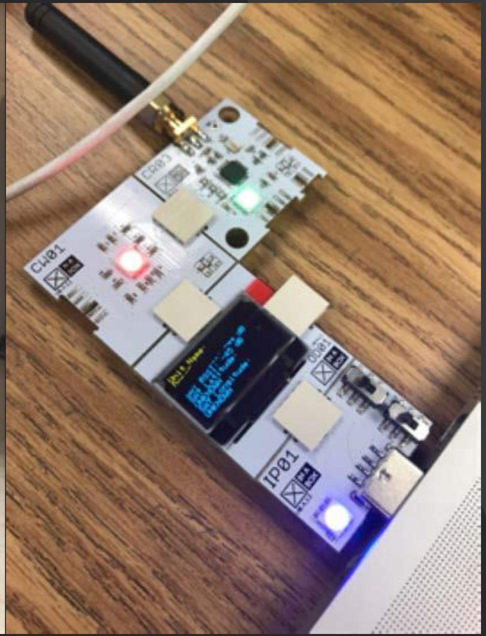
- Introduction to sensors, software, electronics and data methods
- Optional coding
- Low altitude balloon flights/drones



WeatherSat



FlatSat



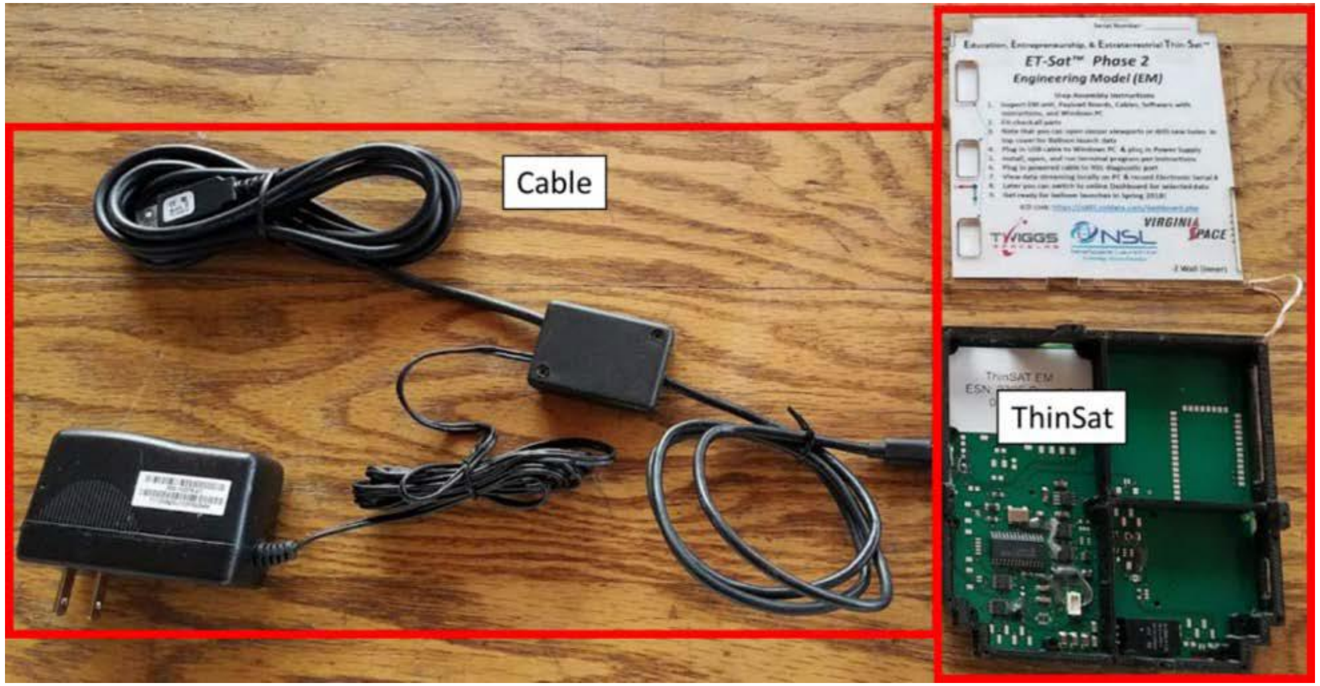
Ground Station

Modular electronics are used for developing and creating projects.

Bjarke Gotfredsen, Judi Sandrock and Daniel Berman (not shown) - founders of XinaBox

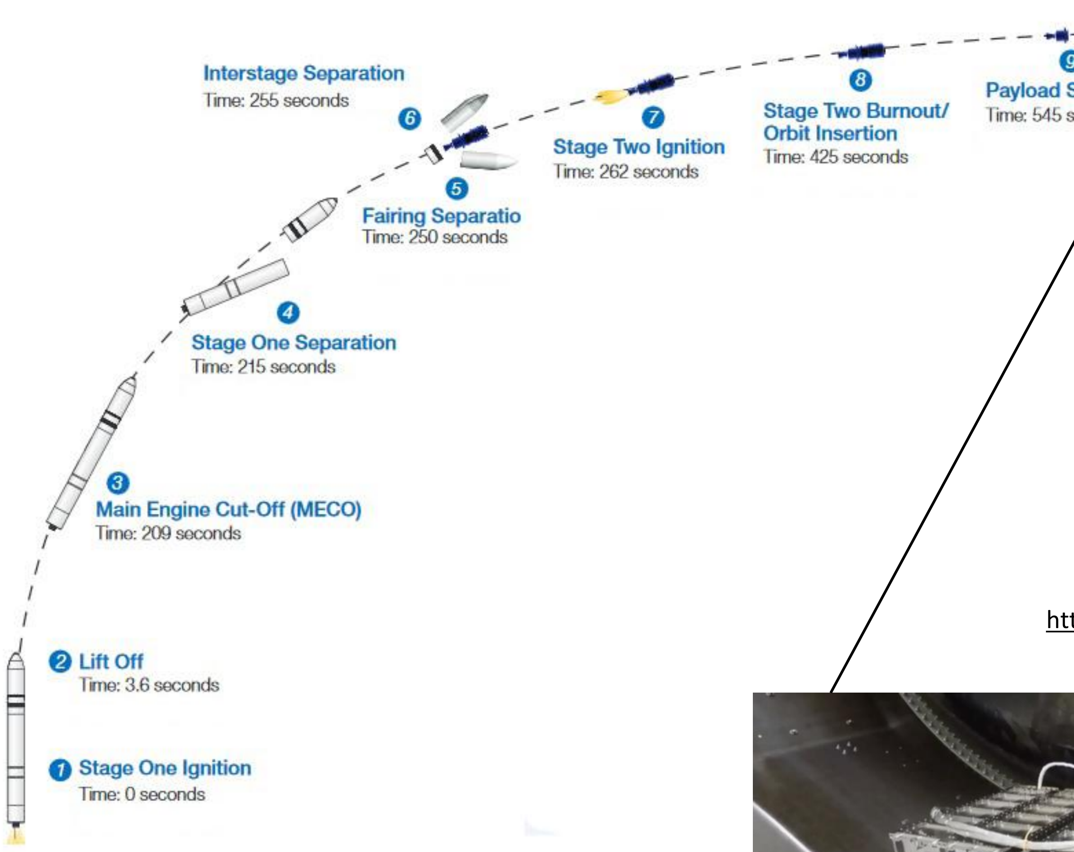
Phase 2: The Mesosphere (50-100 km)

- Students build payload (X-Chips or Custom Payloads) and test in 3D printed EM
- High altitude balloon launch
- 900 MHz radio will be used to communicate sensor data during the flight
- Data will be available for students to download from an online dashboard for data
- processing and analysis

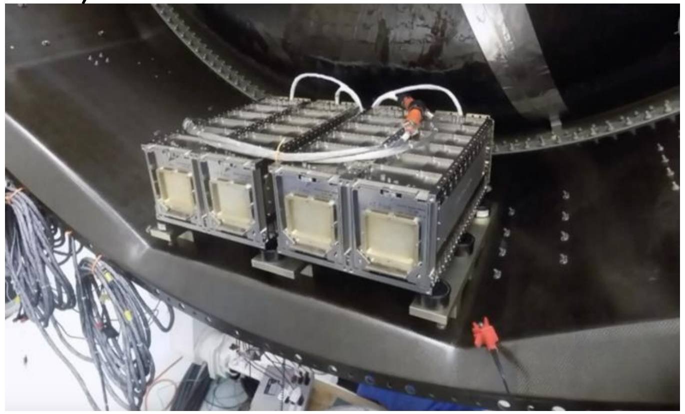


Phase 3: The Extreme Low Earth Orbit (ELEO) 100-300 km

- Students will finalize design/build payloads
- Custom payload: teams will send flight hardware to Twiggs Space Lab for testing/integration
- Standard payload: teams will send defined sensor choices to TSL
- Flight Models are tested and integrated into a CSD by TSL
- Students utilize data from orbit to perform analysis and submit a report



https://en.wikipedia.org/wiki/Cygnus

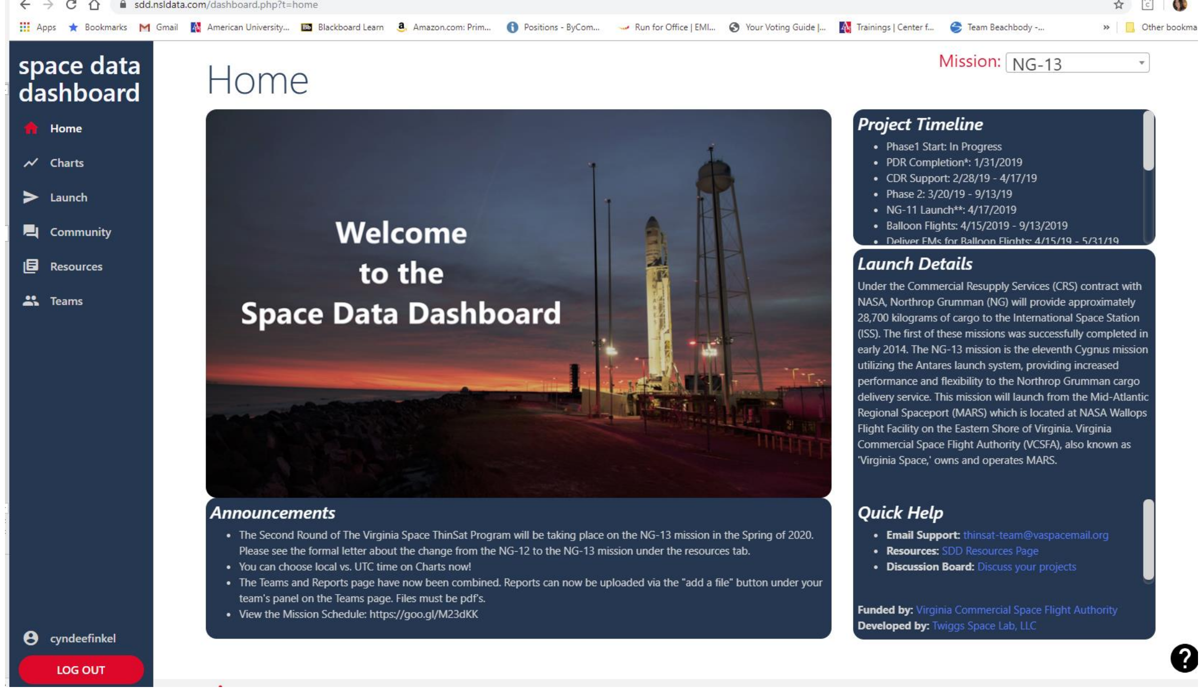


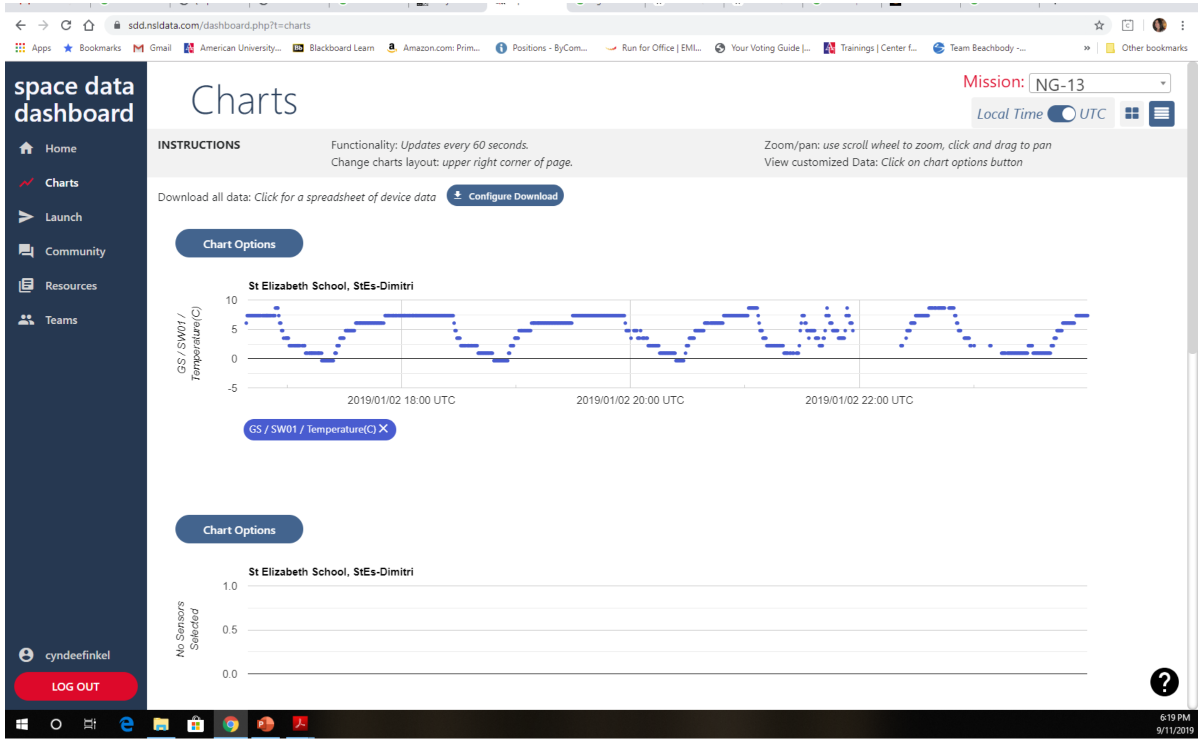
Four 3U containers with ThinSats are transported to orbit on Antares's avionics ring and are deployed between payload separation and solar array deployment. *(Image: NASA TV)*

https://www.flickr.com/photos/nasahqphoto/8670209390/

Space Data Dashboard (SDD)

- One stop shop for student data, program information and support
- Data tracking through all three phases
- Sensor data from all the participating institutions is also available
- Downloadable archive of data





ThinSats at American University


Cyndee Finkel


Fred Bruhweiler


Aaron Grocholski


Phil Johnson


Kristof Aldenderfer


Jessica Uscinski


Derek Hewett


Nathan Harshman


Megan Kemble


Eric Day

XinaBox and Thin Satellite Workshop
May 7, 2018

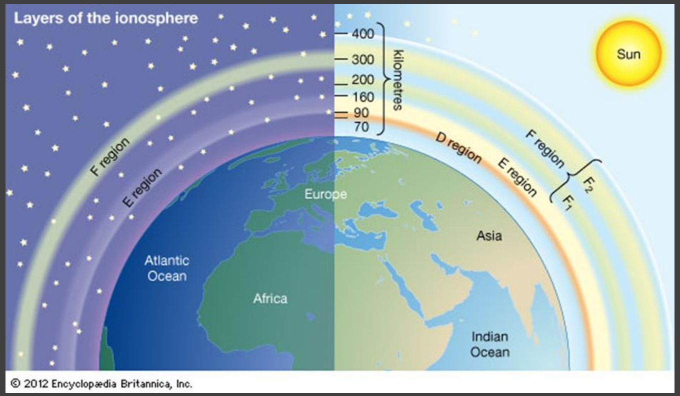
Participants from:
NASA
Long Branch Elementary
Bishop O'Connell
Maryland Women's Heritage Center
H.D. Woodson High School
American University

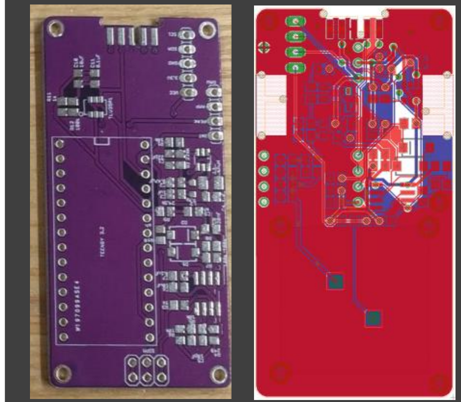
AU Undergrad Team

Project Lead: Jacob Vancampen

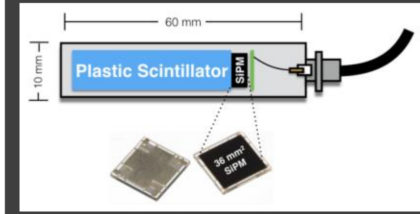
Project: Building an Inexpensive Detector & Measuring Ionizing Radiation from ELEO

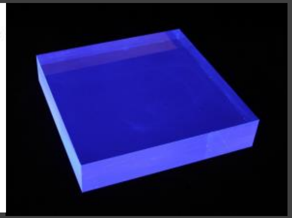
- determine the low-energy electron number density in the ionospheric F-1;
- build a low-cost, open-source SiPM, which measures optical scintillations in special plastic;
- measure count rates and possibly individual energies of electrons, positively charged ions, and, indirectly, neutrons that produce charged particle ionizing secondaries;





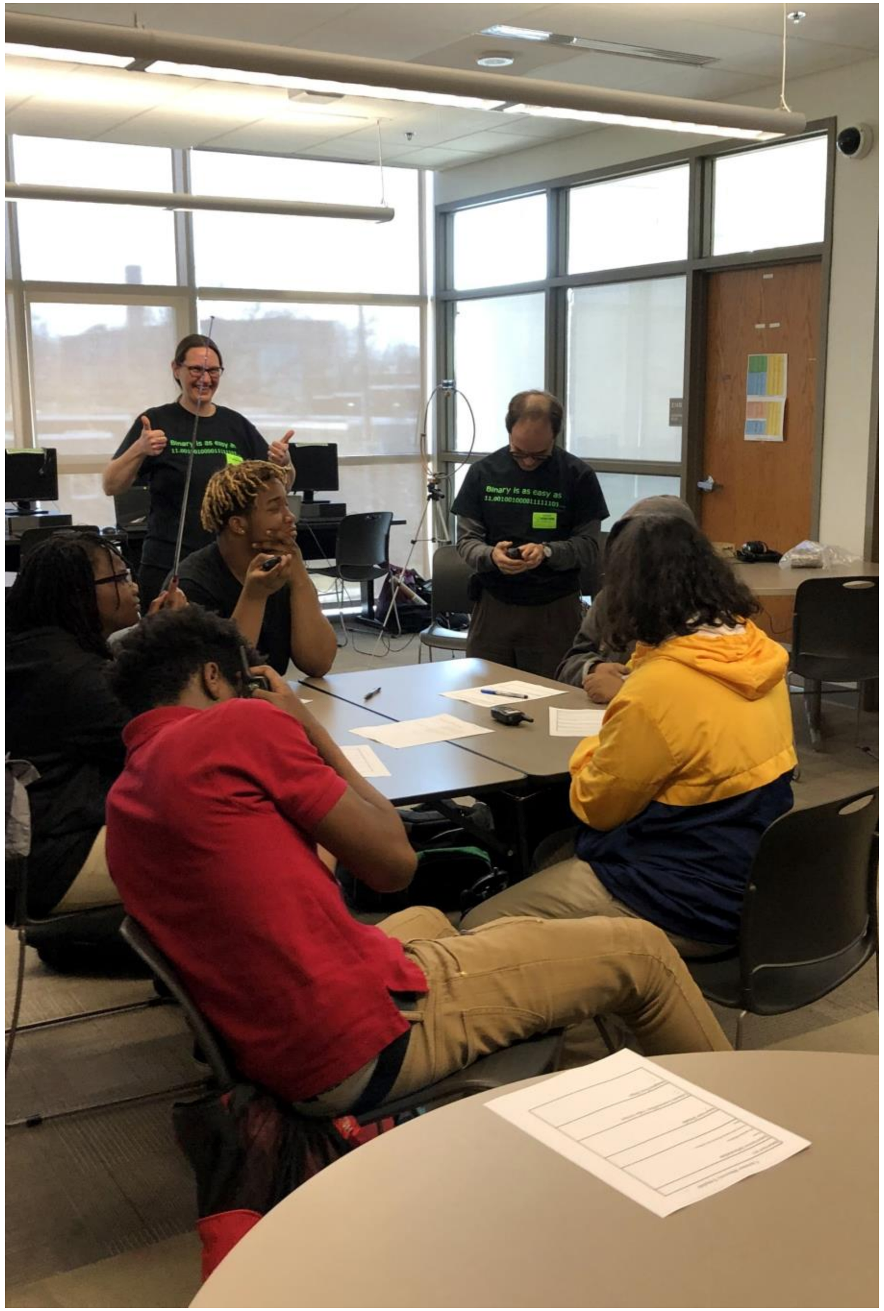
<u>Purple</u>: Version-2 is our most recent board that we have in physical form. <u>Red</u>: The board layout of Version-3 of our prototype depicting what it will look like when fabricated.





A Silicon photomultiplier (SiPM) is an array of single-photon avalanche diodes (SPADs). When a SPAD is hit with a photon, due to the photoelectric effect, a short but large avalanche current will be produced. The output signal from the SiPM is a small but detectable voltage.

Inspired by Cosmic Watch (MIT), our detector consists of a low-cost Silicon photomultiplier (SiPM) which measures optical scintillations produced by ionizing radiation in the attached scintillator material. Besides accomplishing our scientific mission, we would like to develop a simple detector design that might be regularly flown, with small variations, by others in future ThinSat missions.



H.D. Woodson High School
Feasibility of Magnetic Field Measurements in ELEO

Woodson Project Details

Can we accurately measure the Earth's magnetic field?

The strength and direction of the magnetic field varies with position relative to earth surface. Plus, it has a long term variation and a short-term variation due to solar storms (CMEs) near earth surface at ELEO.

Due to the induced magnetic fields from the S/C , the intrinsic earth's magnetic field can be difficult to measure. Thus, we place the magnetometer, at a distance from the S/C power and communication modules.

Additionally, Students will learn: the importance of calibration, how to obtain a good dataset, how to form hypotheses, determine correlations among datasets

St. Elizabeth's Day School

Project: Probing the Atmospheric Density & Deceleration Profile at Extreme Low Earth Orbit (ELEO)

St. Elizabeth's Project Details

How does the "drag" increase as the ThinSat spirals inward? How does drag vary between night and day-side of earth? What about turbulence at terminator between day and night-time?

These results are important scientifically, in that we can use them to better estimate time for deorbiting satellites. This is extremely important in determining ways to minimize the amount of hazardous debris in earth orbit.

Additionally, Students will learn: the importance of calibration, how to obtain a good dataset, how to form hypotheses, determine correlations among datasets

They also learn general aspects of atmospheric science.To determine deceleration (drag), students must correct for centripetal acceleration, which comes from rotation about axes (tumbling & buffeting).

Date	Lesson	Topic	details	guests
11/13/2018	1	Program Introduction	Intro to program and thin sat • Use preconfigured sensors to show all of the data they can collect • Layers of the atmosphere • Get gmail accounts to setup canvas and dashboard accounts • Demonstration: 3D printed model of a ThinSat	
12/14/2018	2	Sensors and Temperature	• Teach students to connect sensors • Temperature lesson • Individual experiments – bring bags to seal sensors and use ice water, etc for temperature variations • Introduction to Space Data Dashboard	Judy Sandrock and Bjarke Gotfredsen from XinaBox
1/11/2019	3	Pressure	• Pressure lesson • Individual experiments • Demonstration: vacuum chamber with balloon, and xinabox sensors in chamber	
1/25/2019	4	Radiaion	• UV lessons • Demonstrations: IR camera • Experiment: assessing different light bulbs – uses sources in a banker box along with xinabox sensors	AJ Di Grigorio and Jessica Uscinski
2/26/2019	5	Business in Space	• Introduction to creating developing a product	Kathryn Walters Conte (AU)
3/14/2019	6	Communications	• Radios and how they work • Antennas • Ham demos • Gave away 2-way radios to students	Donna Dietz and Michael Robinson
3/28/2019	7	Business in Space	• Product development continued • Group presentations	Kathryn Walters Conte

Wallops Flight Facility Field Trip

- Balloon Program Office Research and Development Lab
- Wallops Range Control Center
- Lunch and Learn (NASA internships)
- Horizontal Integration Facility
- Mid-Atlantic Regional Spaceport (MARS) PAD 0A

A very special thanks to:
Linda A. Sherman
Directorate Education Coordinator
NASA Wallops Flight Facility
Wallops Island

Additional outreach

Othoniel Sinclaire
2018/2019 intern from The Lab School of Washington

Hanan Kadir
2019 Mills Family Fellow recipient

Future: One-off classroom visits in local schools have proven popular with students and teachers.

Teachable Moments

- Functioning workspace environment
- Partnerships between host institutions and K-12 schools
- Predictability of launch schedules
- FAA regulations
- Designated photographer

Future of ThinSat

H.D. Woodson High School	Schedule 4 more visits along with a field trip for a low altitude balloon launch. Student poster presentation at an AU STEM event Prepare students for TA position for ThinSat summer school (pending) Additional meetings will be planned when launch date is finalized.
ThinSat as a summer school	One week sleep-away camp eligible for 18 D.C. public school students Low altitude balloon launch day trip to Airlie
AU Undergrad team	Improve on our open source model Balloon launch training