Vermont Tech's Successful CubeSat Launch

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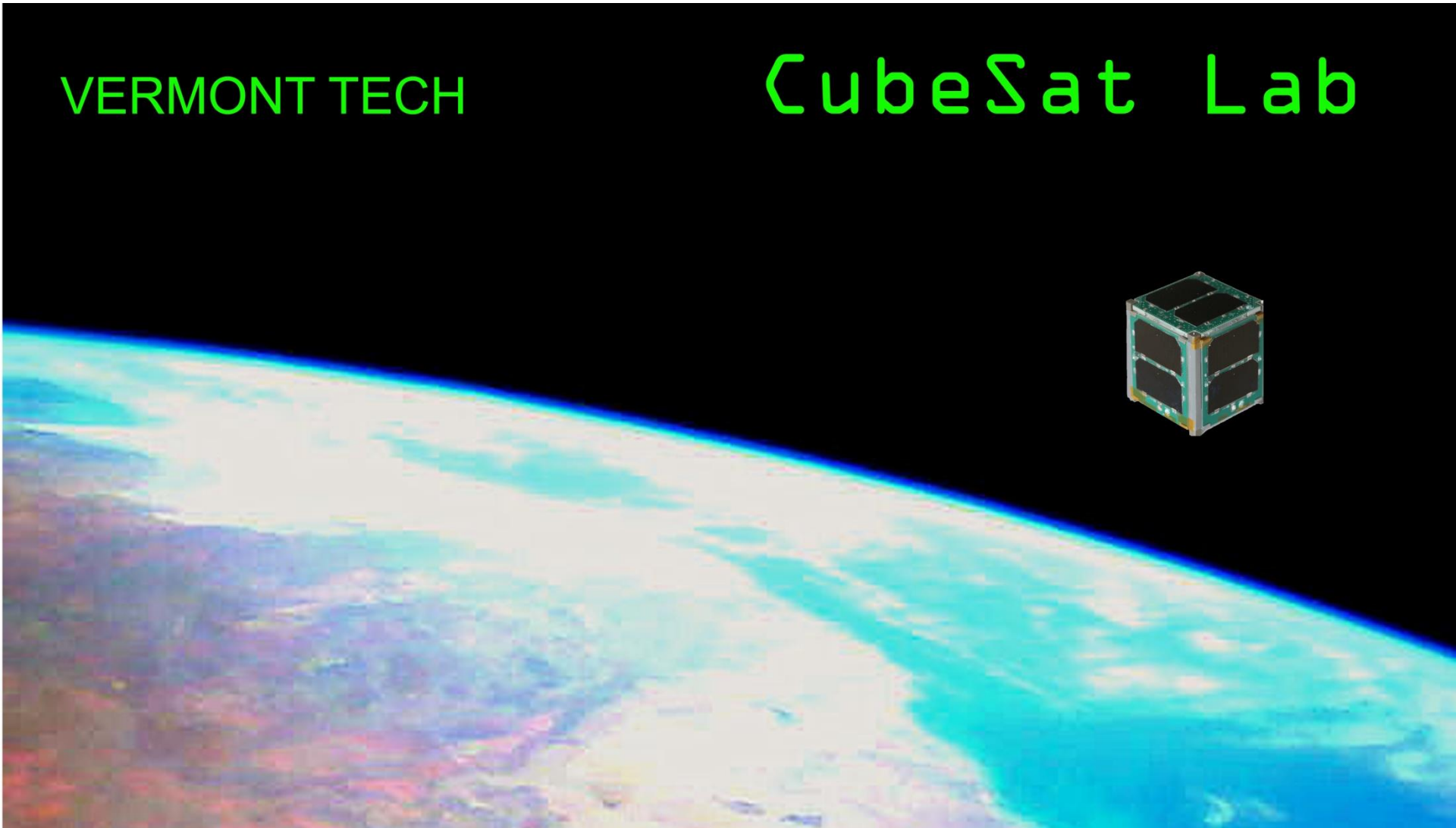


NASA ELaNa IV Launch

VERMONT TECH

- NASA's 2010 CubeSat Launch Initiative (ELaNa)
- Our project was in the first group selected for launch
- Our single-unit CubeSat was launched as part of NASA's ELaNa IV on an Air Force ORS-3 Minotaur 1 flight November 19, 2013 to a 500 km altitude, 40.5^{o} inclination orbit and will remain in orbit about 3 years
- Bill McGrath, Vermont Tech Grad and LED Dynamics CEO downloaded our photos and data

- Follow our project at http://www.cubesatlab.org

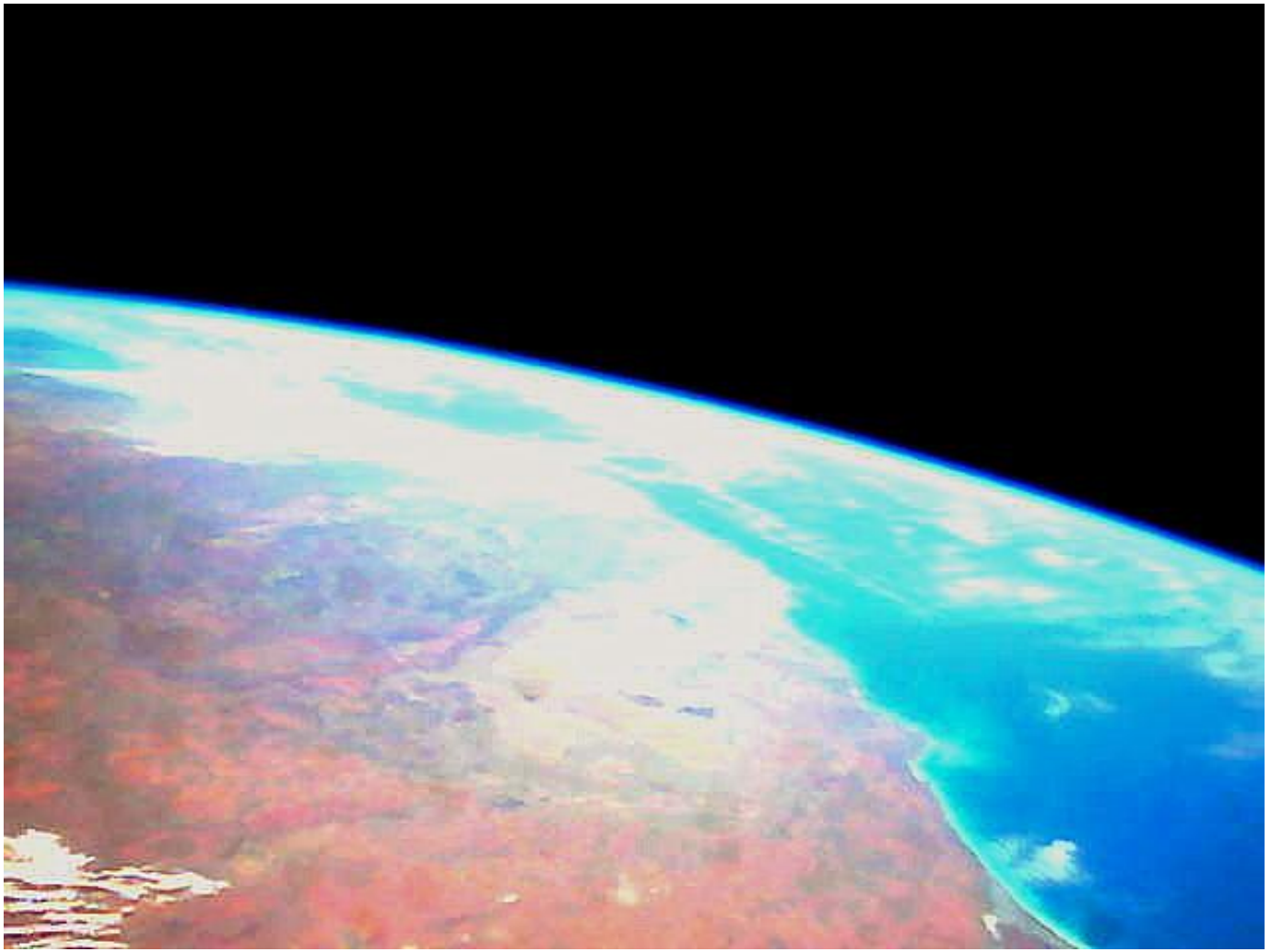
ELaNa IV Results

- 14 University / NASA CubeSats launched
- Only six were heard from at all (2 NASA)
- One lasted one week, one 4 months
- One works partially only in sunlight
- One took five weeks for first contact (NASA)
- Ours, as many Vermonters do, took a 2 ½ month winter vacation

Lessons Learned from ELaNa IV

- Dr. Peter Chapin trained and supervised student programmers & set up the software tool chain.
- Language selection (Ada)
- Static analysis tools (SPARK 2005)
- Repository
- Dan Turner wrote about 80% of 10,000 lines of code

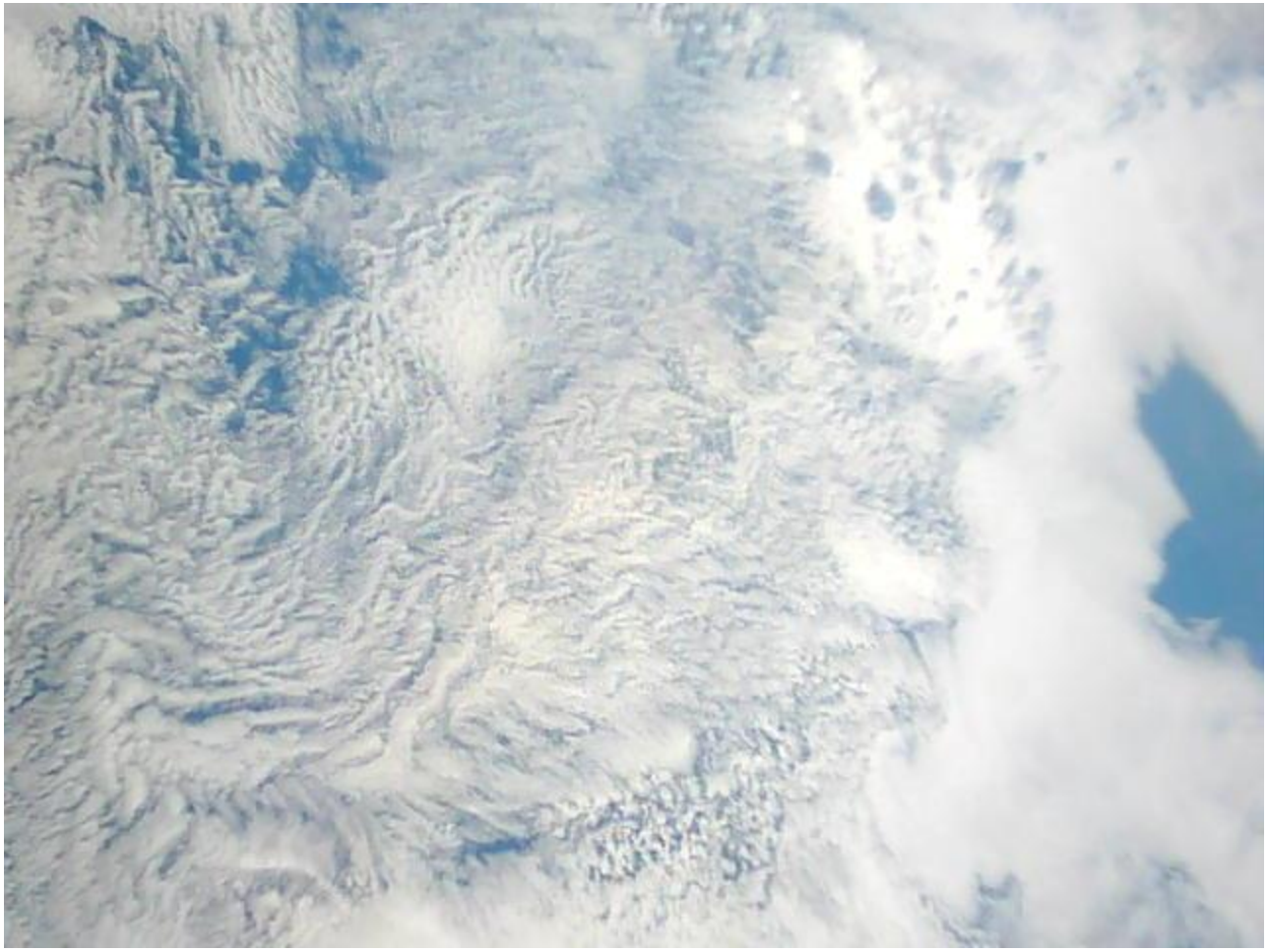
Vermont Lunar Photos



Our first picture of Earth

The North coast of Western Australia near Port Hedland

Vermont Lunar Photos



Clouds over the ocean.

Western Australia north of Perth

Vermont Lunar Photos

Percival Lakes, Australia

Vermont Lunar Photos

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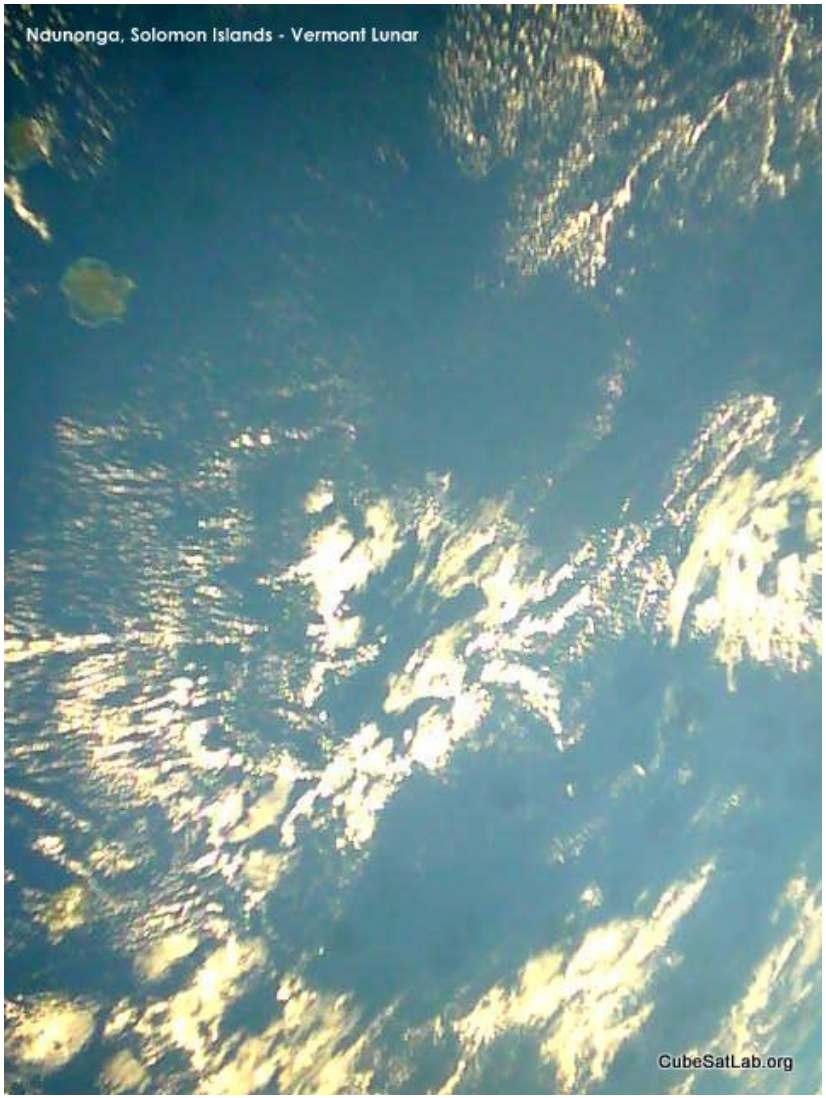
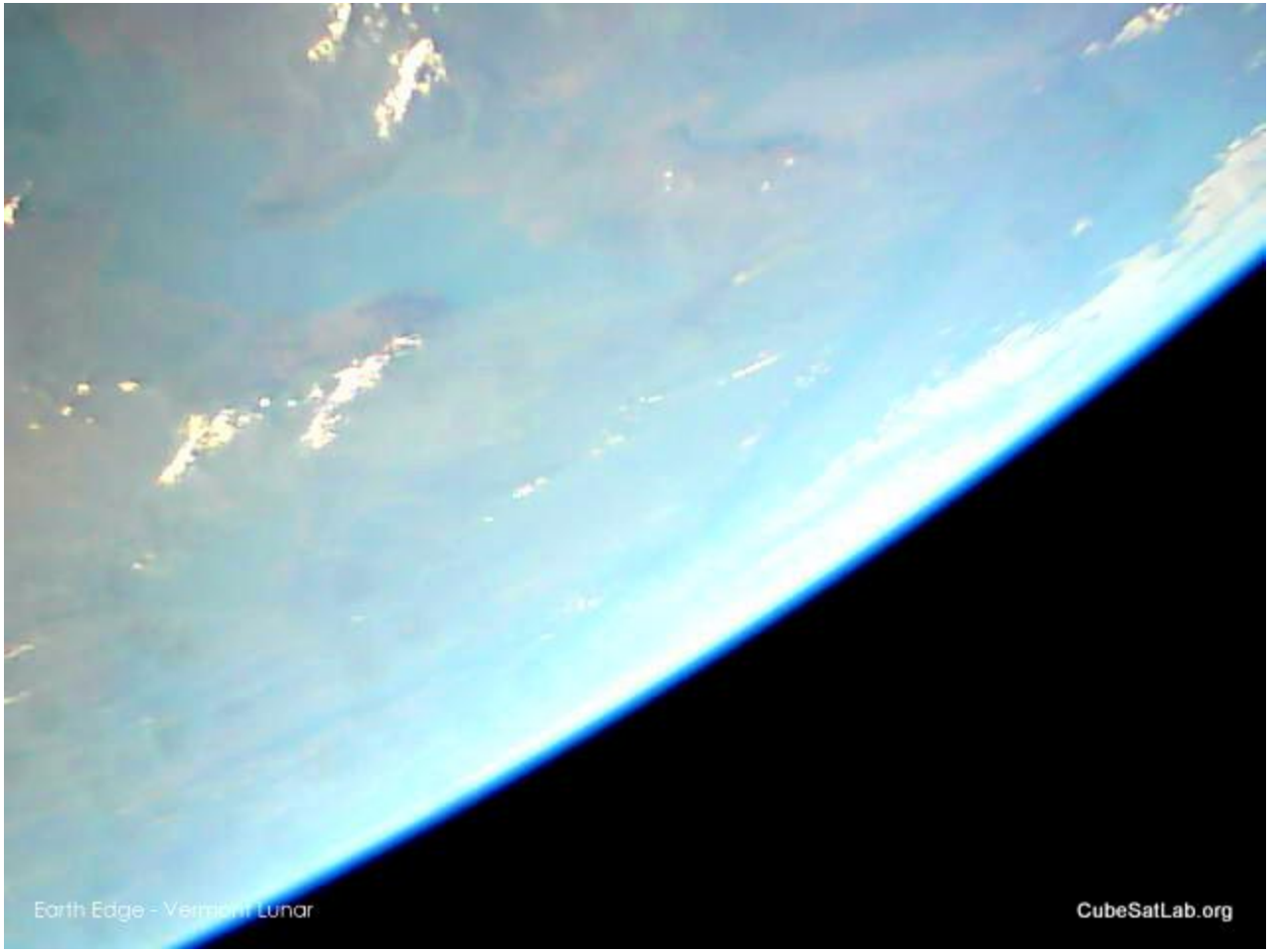


Naunonga, Solomon Islands

Vermont Lunar Photos



Earth Edge

Our ELaNa IV CubeSat

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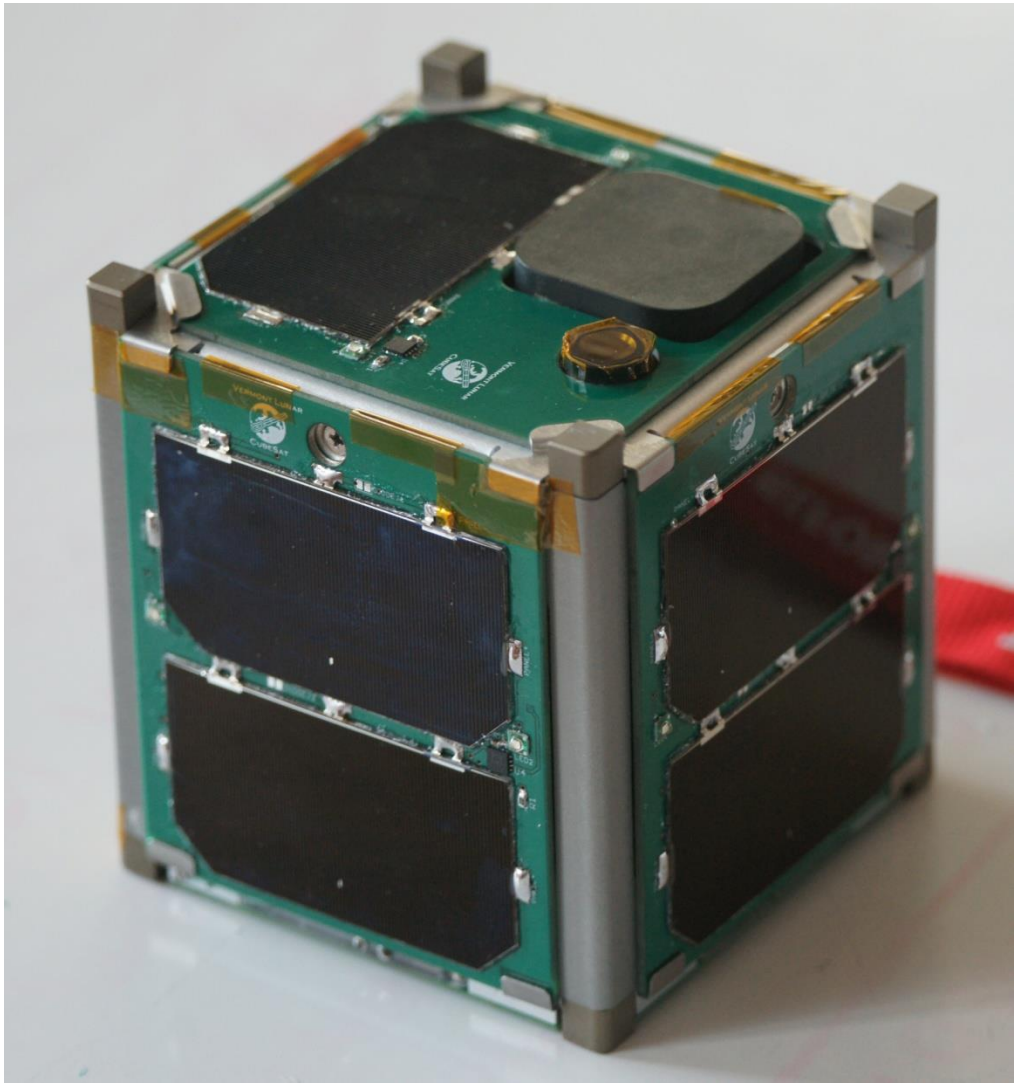
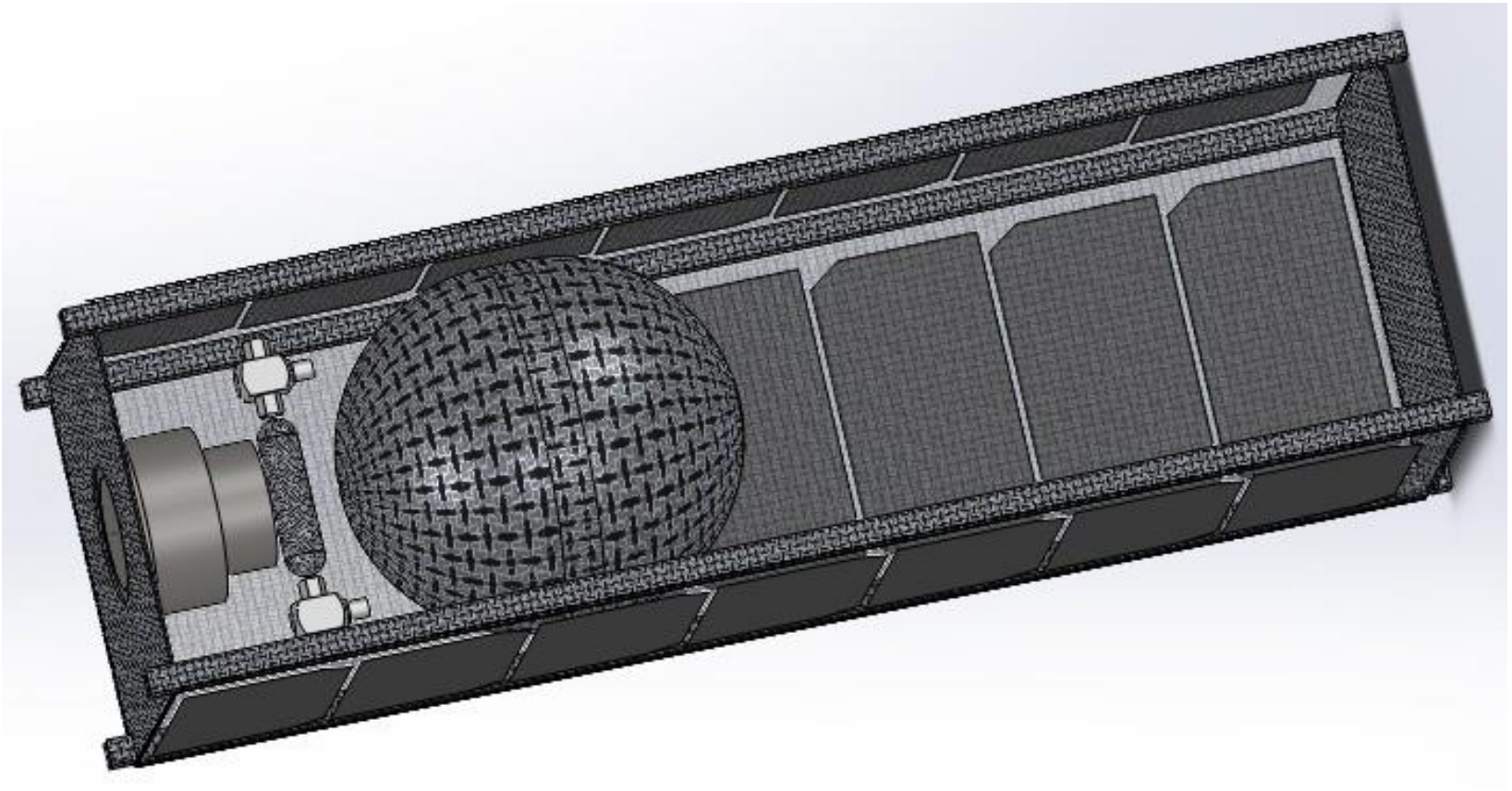


Vermont Lunar CubeSat

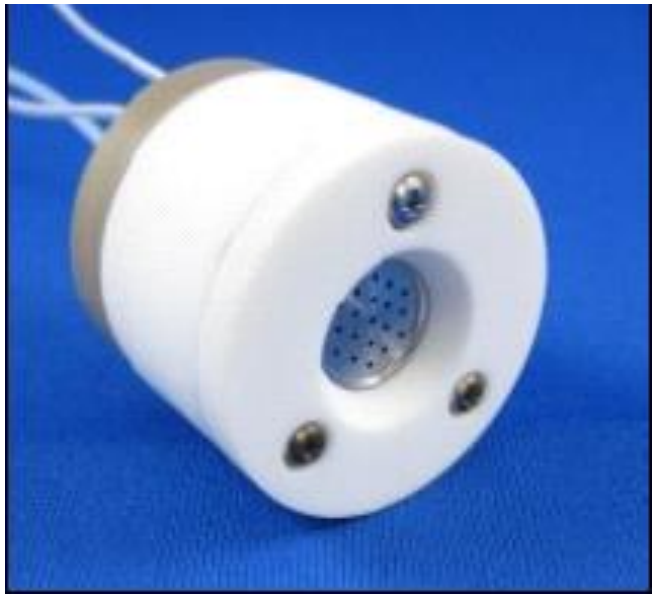
Brandon - VSGC Awards Dinner - 2014

5kg Follow on Ion Drive CubeSat



Triple CubeSat Ion Drive Propulsion system, Lunar or Interplanetary without fold out PV pane (10cm x 10cm x 30cm)l

Busek Ion Thrusters



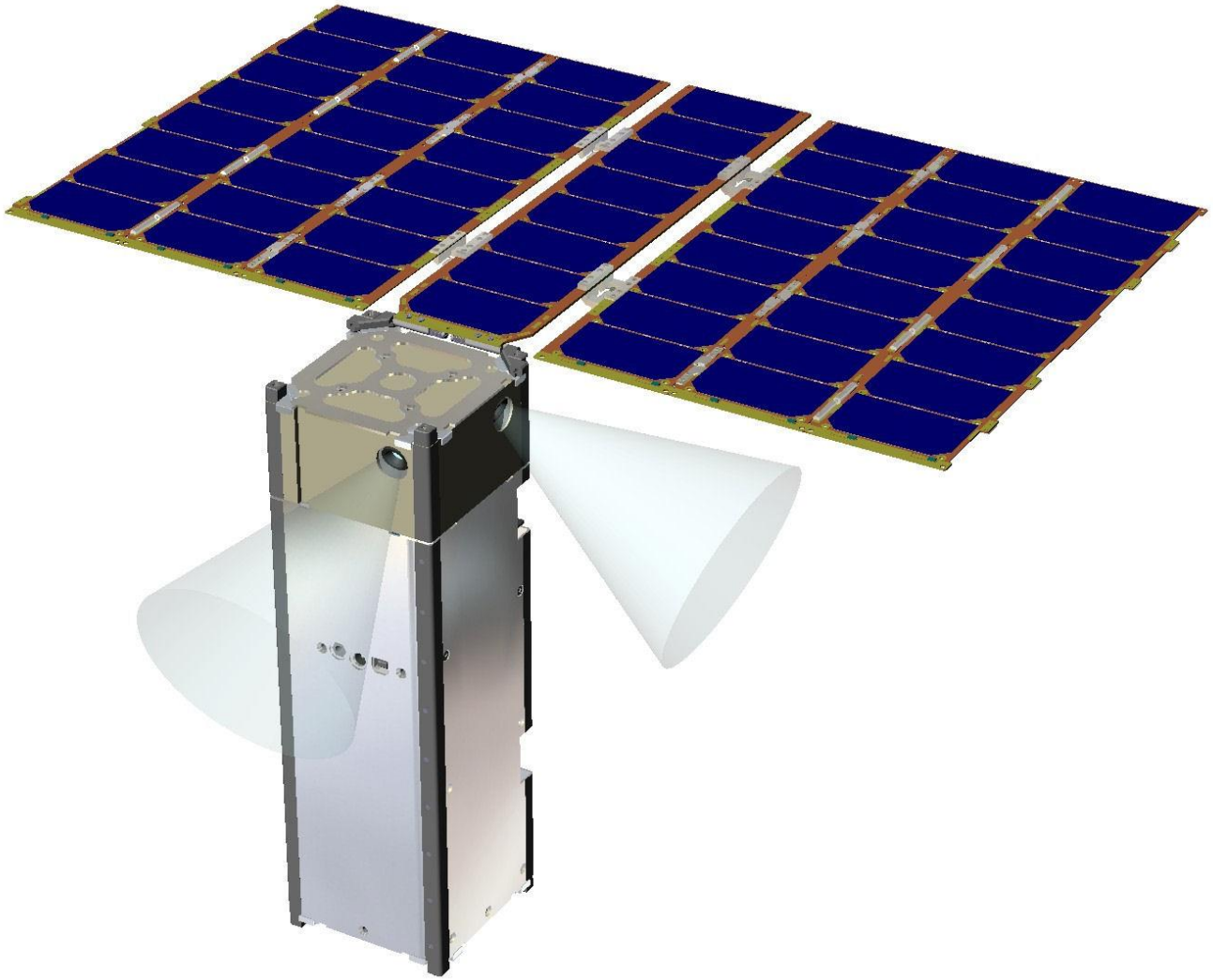
BRFIT-1

10 W 0.067 mN

BRFIT-3

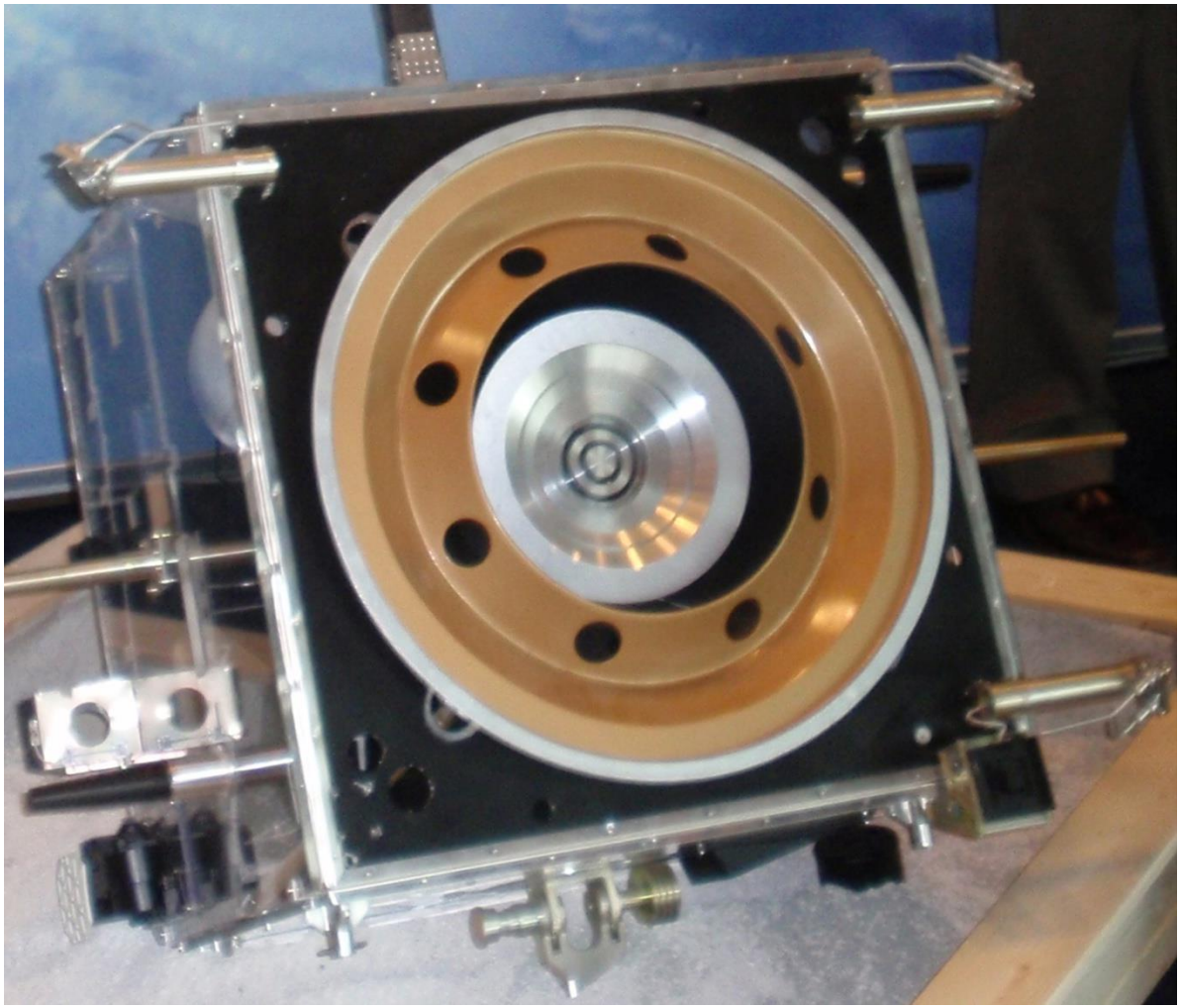
80W 1.6 mN

Follow on Ion Drive CubeSat



Triple CubeSat with CubeSat Kit 56 W fold out PV panel.
Ion drive with 0.5 kg – 0.75 kg Xenon or Iodine.

1 m Wide, 367kg ESA SMART-1



82 kg xenon @ 150 atmospheres, 1,200W

Student Participation

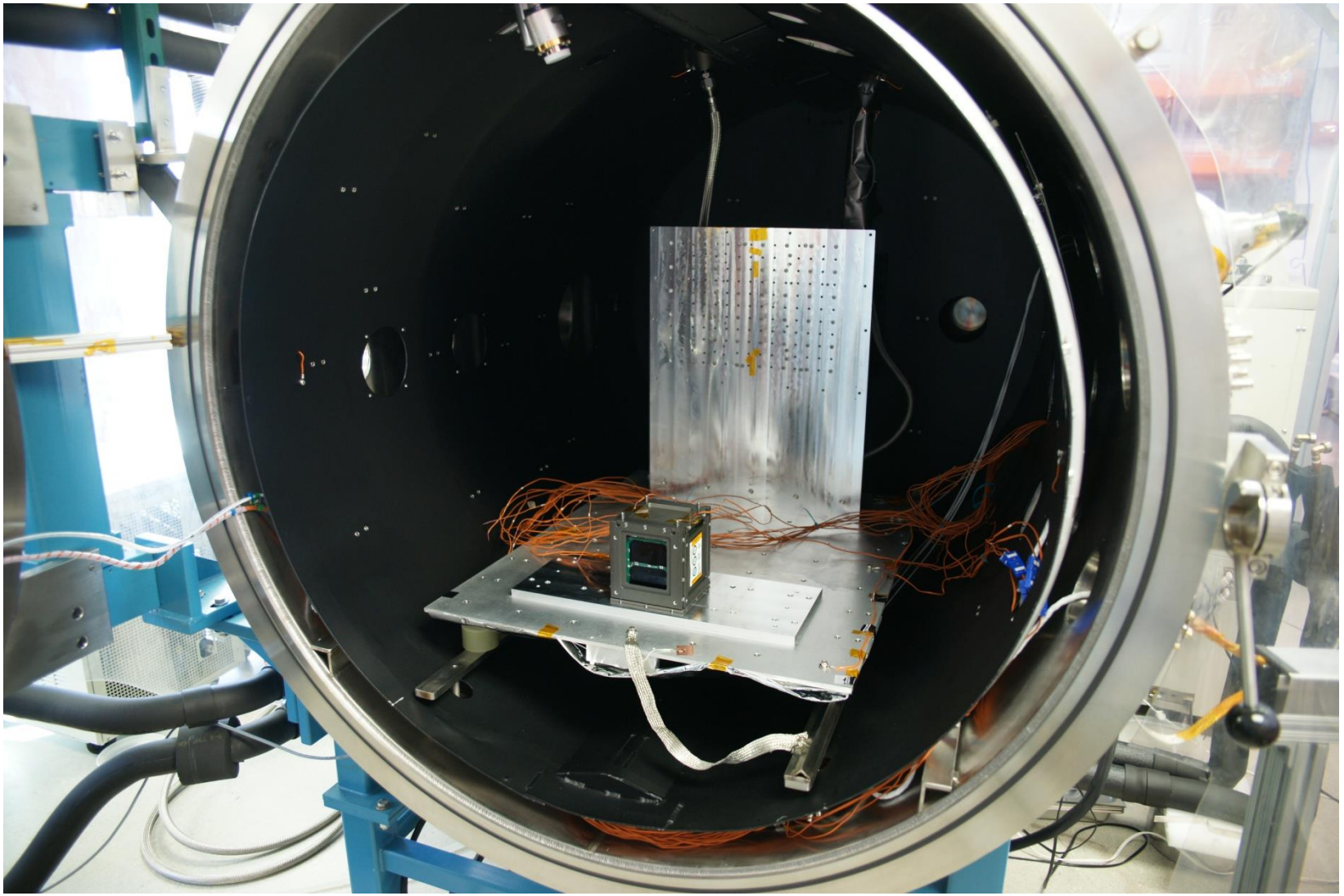
- 2011 (Summer) – 3 students (3)
- 2012 (Fall) – two graduated, one started (2)
- 2013 (Summer & Fall) one started (3) then two left (1)

Software Development Comments

- SPARK caught errors as we refactored the software as we developed greater understanding of the hardware
- SPARK helped the discipline of the software during turnover as some students graduated and were replaced
- Although we did not have a formal development process, without SPARK we probably would not have completed the project with the limited personnel resources and tight time constraint

X and Y axis Vibration Test

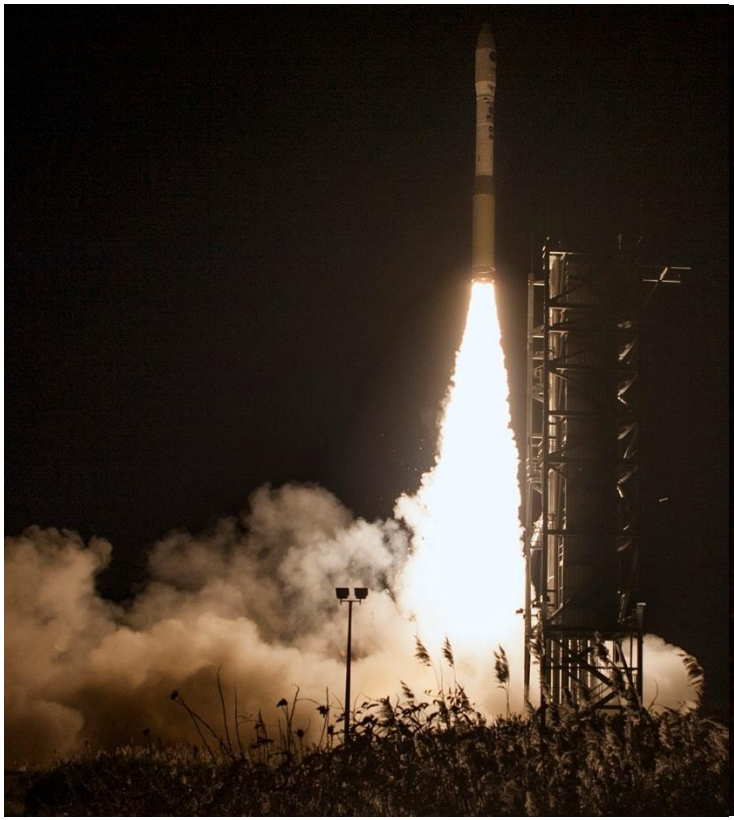
Vacuum Thermal Bakeout

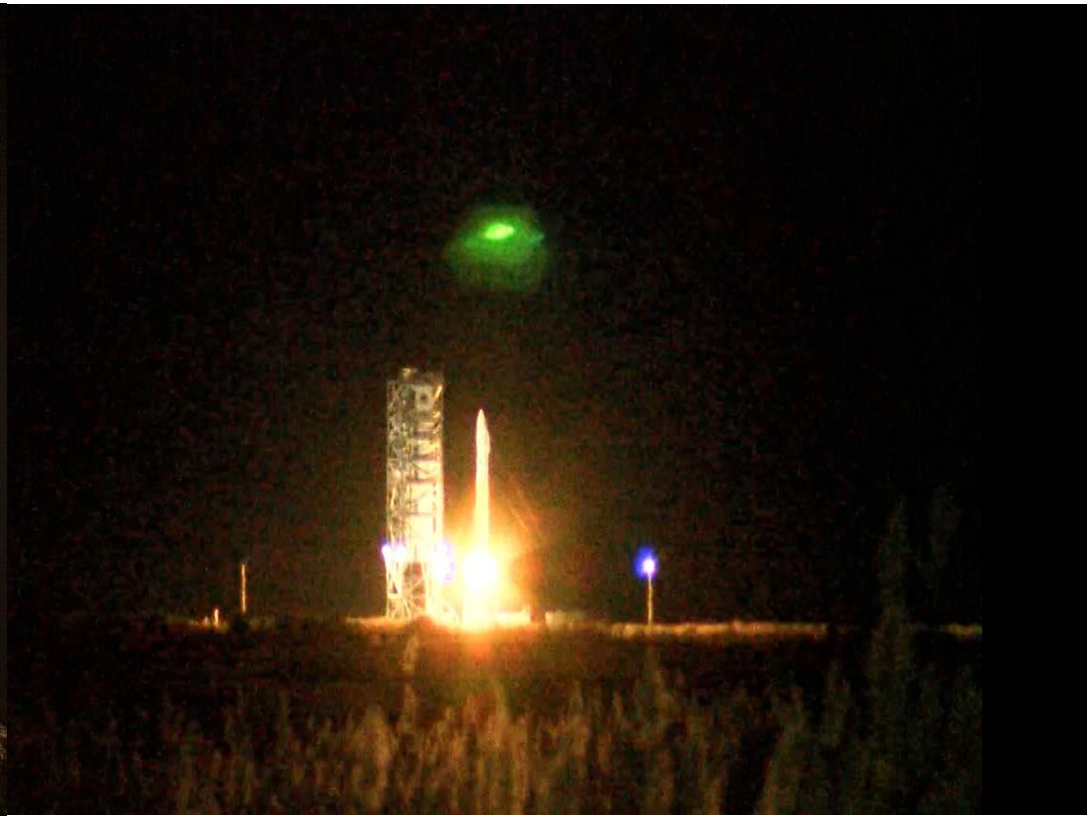


NASA Launch Opportunity

The Integrated Launch Stack for
The Minotaur 1 rocket
Our CubeSat was installed on
September 17, 2013

ELaNa IV Launch Minotaur 1 – Wallops Island November 19, 2013, 8:15 PM





First two stages are Minuteman II first two stages, third and fourth stages are Pegasus second and third stages

Acknowledgements

- NASA Vermont Space Grant Consortium
- NASA
- Vermont Technical College
- AdaCore, Inc. (GNAT Pro)
- Altran Praxis (SPARK)
- SofCheck (AdaMagic)
- Applied Graphics, Inc. (STK)
- LED Dynamics (PV boards)
- Microstrain (IMU)

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