Reliability for Interplanetary CubeSats

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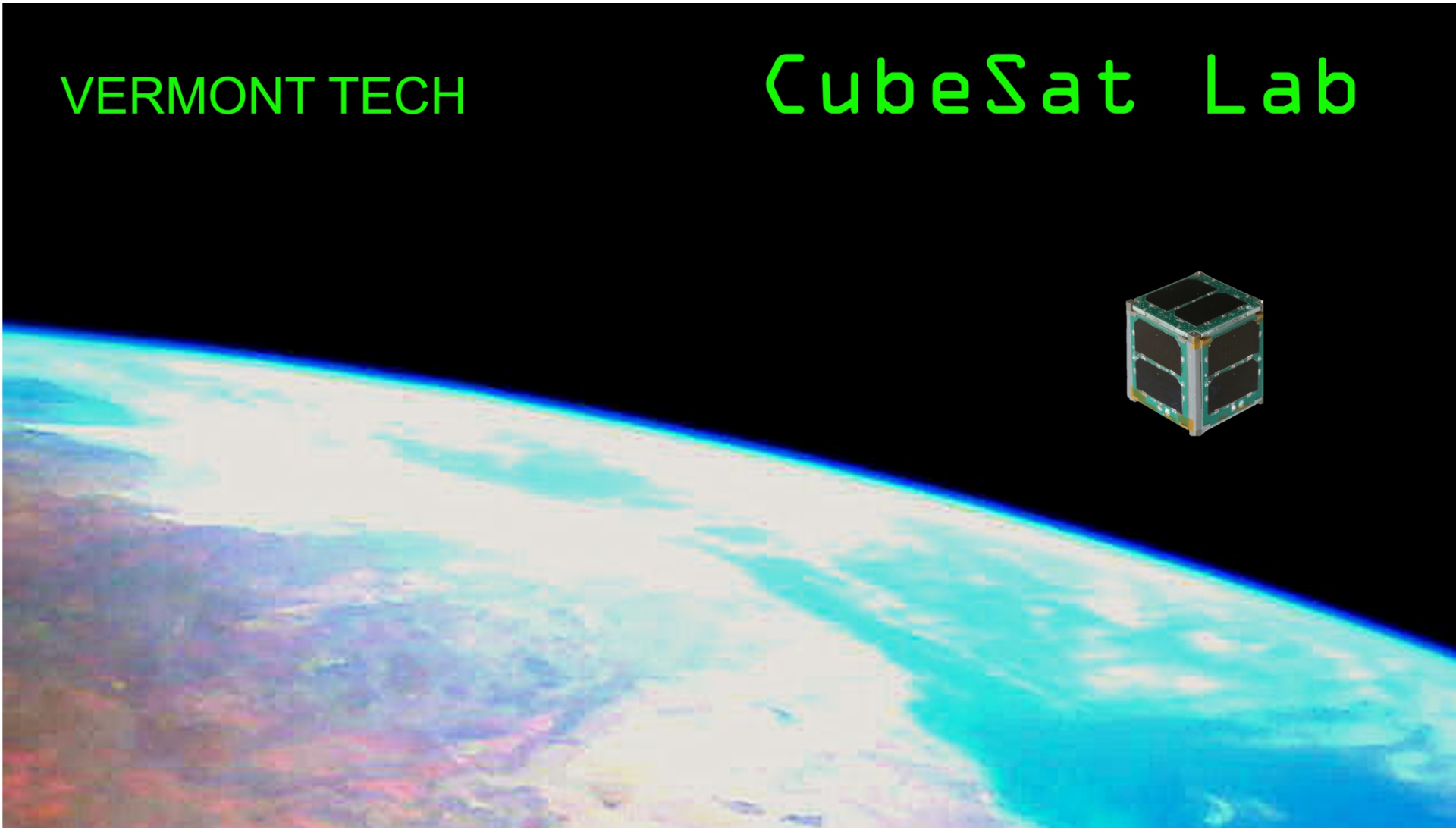


NASA ELaNa IV Launch

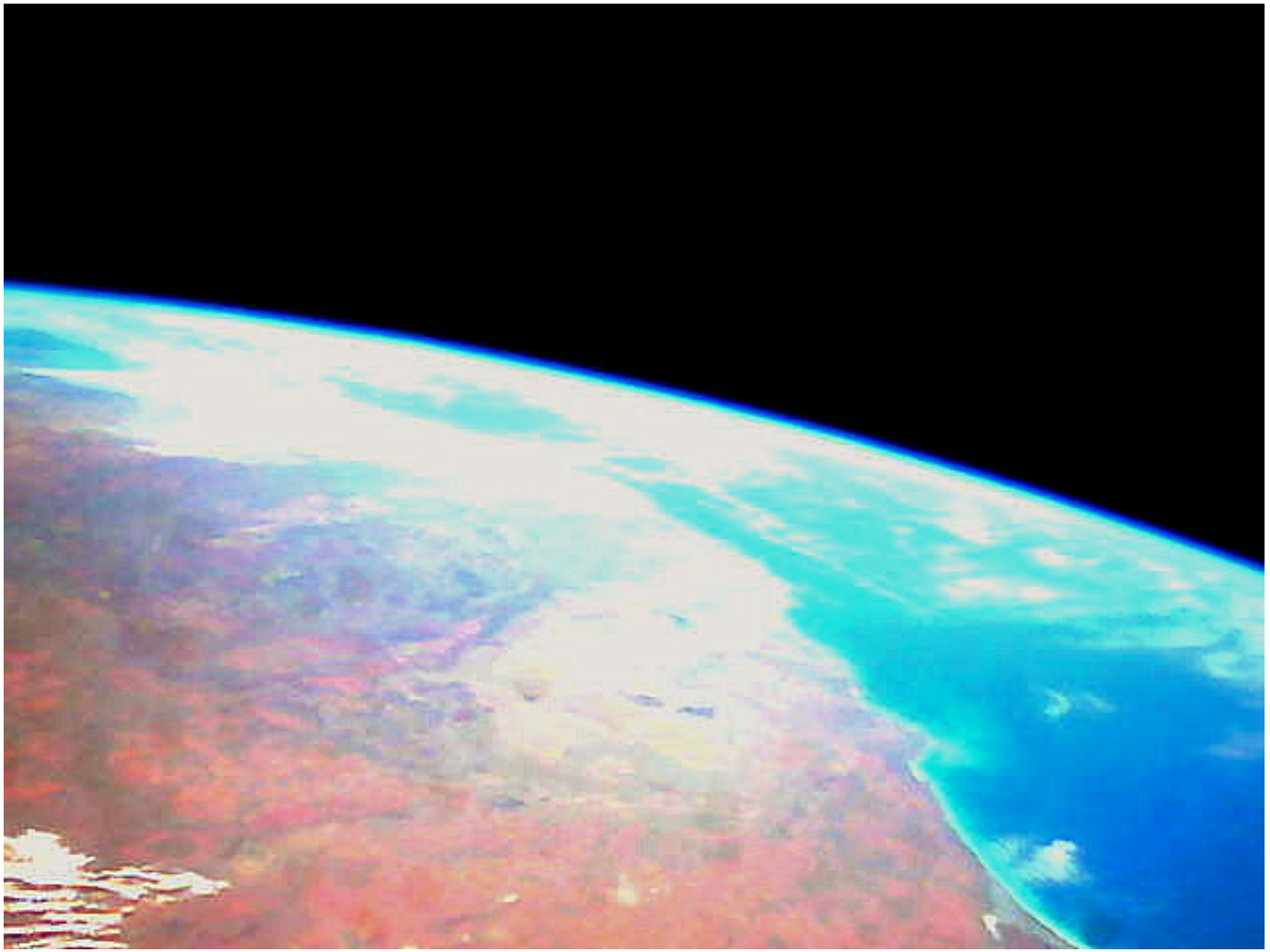
ELaNa IV lessons for interplanetary CubeSats:

- 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
- The Vermont Lunar CubeSat will test the Lunar navigation system in Low Earth Orbit
- Follow our project at www.cubesatlab.org

ELaNa IV Results

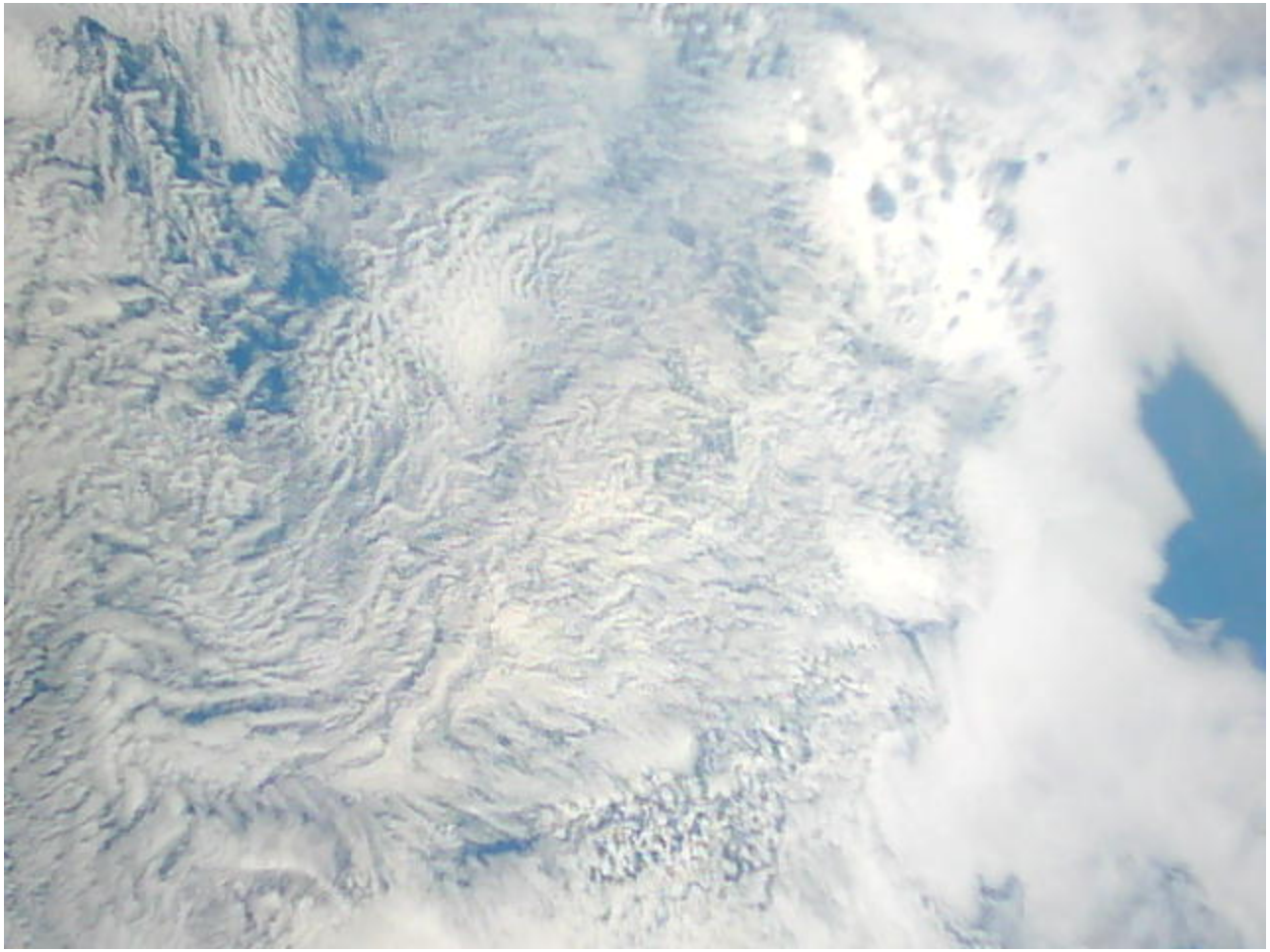
- 12 University CubeSats launched
- Only four were heard from at all
- One worked partially one week
- One lasted four months
- One fried their batteries the first day (definite software error)
- Ours, as many Vermonters do, took a 2 ½ month winter vacation
- Ours has been working 19 months

Lessons Learned from ELaNa IV

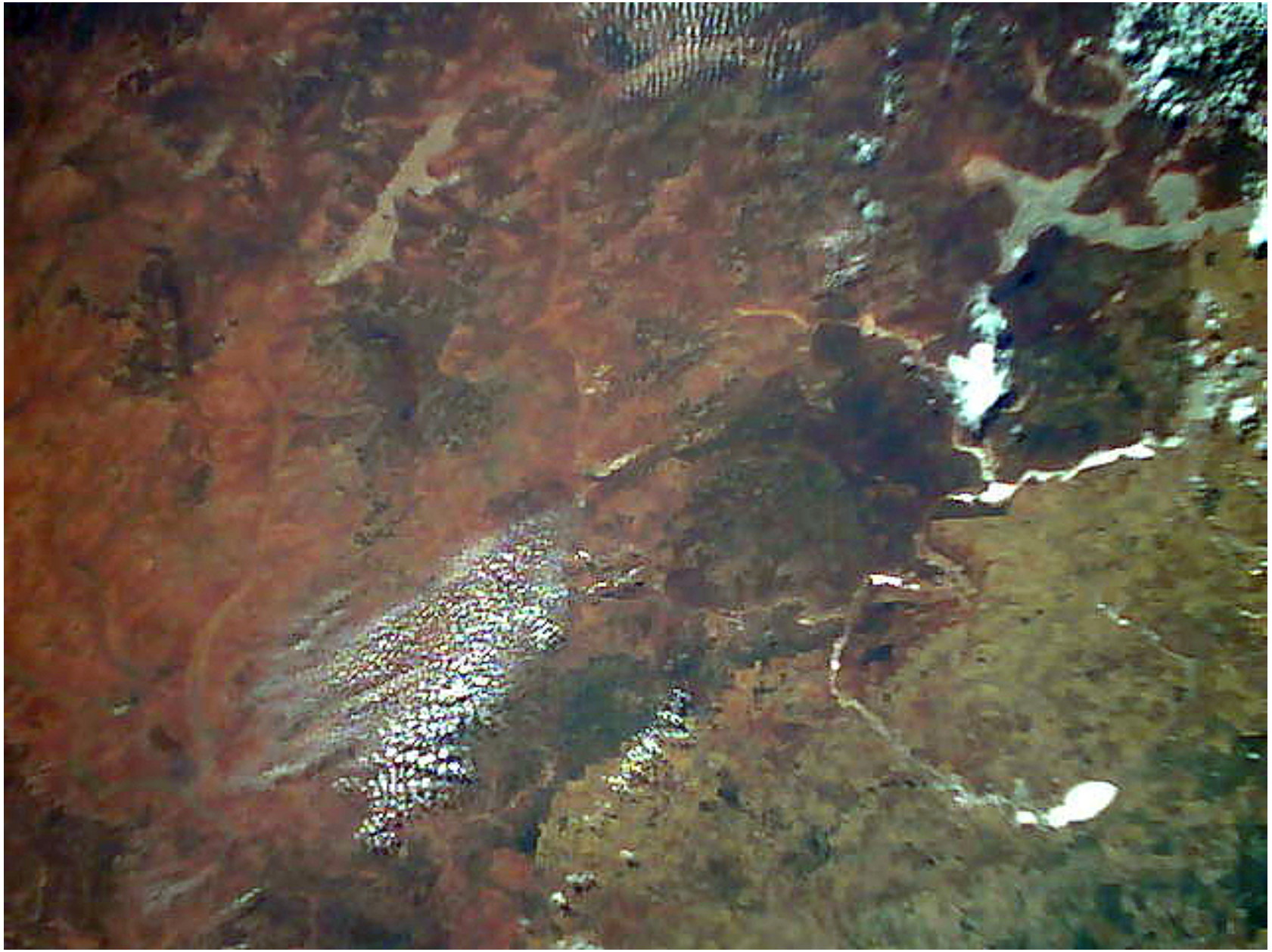


Our first picture of Earth
The North coast of Western Australia near Port Hedland

Lessons Learned from ELaNa IV



Clouds over the ocean.

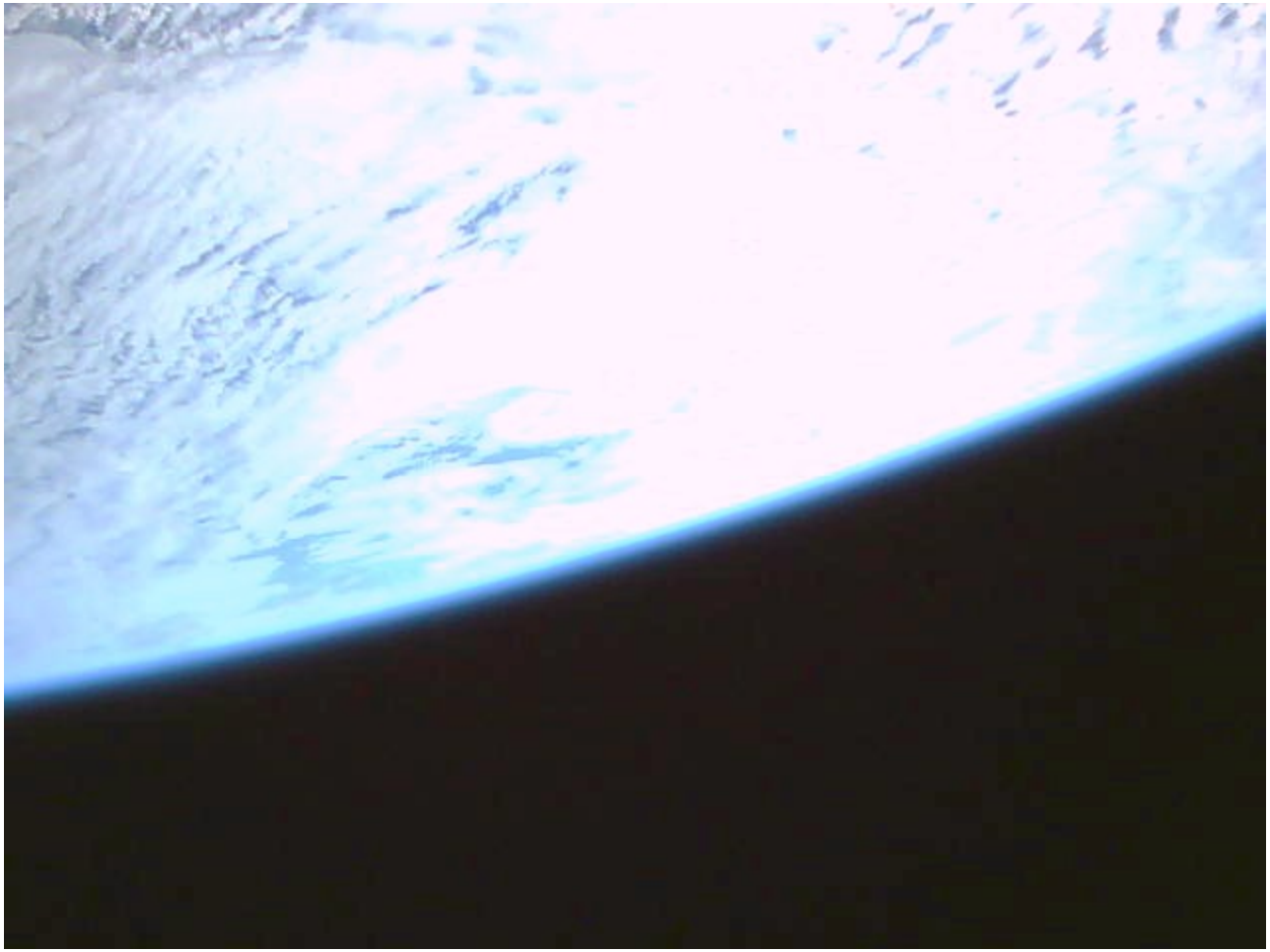


Western Australia north of Perth

Lessons Learned from ELaNa IV

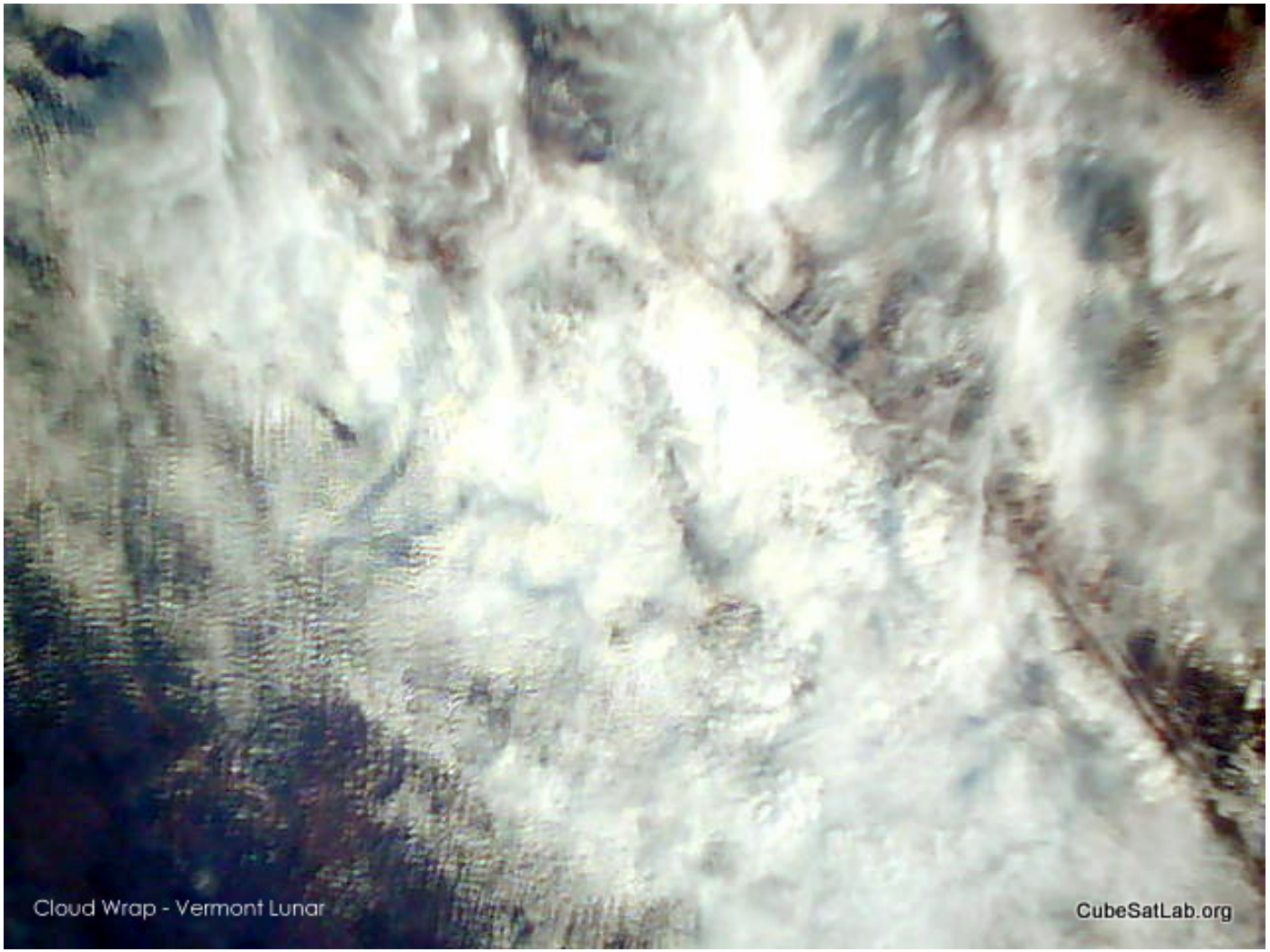
Clouds over the ocean.

Lessons Learned from ELaNa IV



More clouds.

Photo from June 15, 2015



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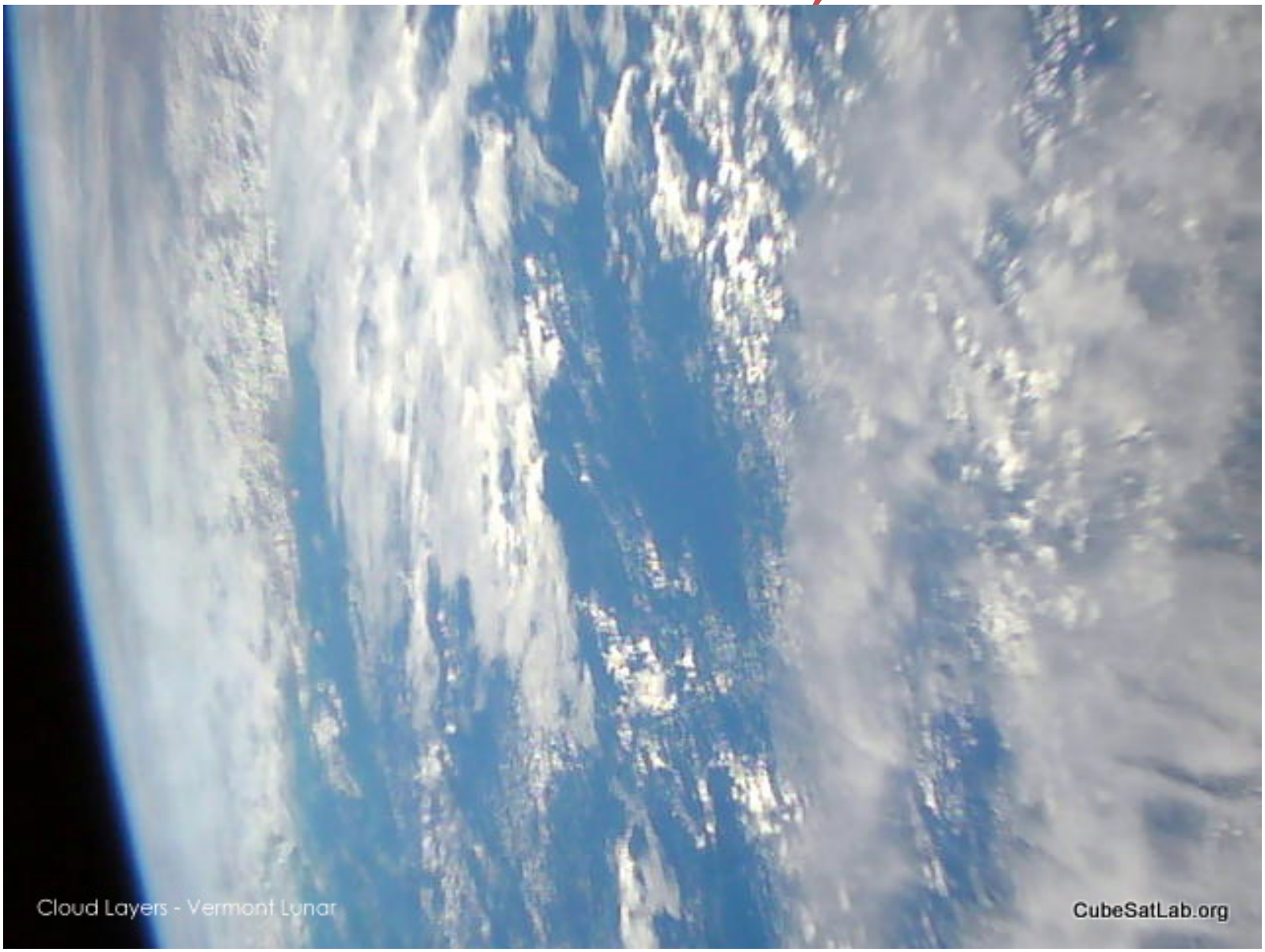
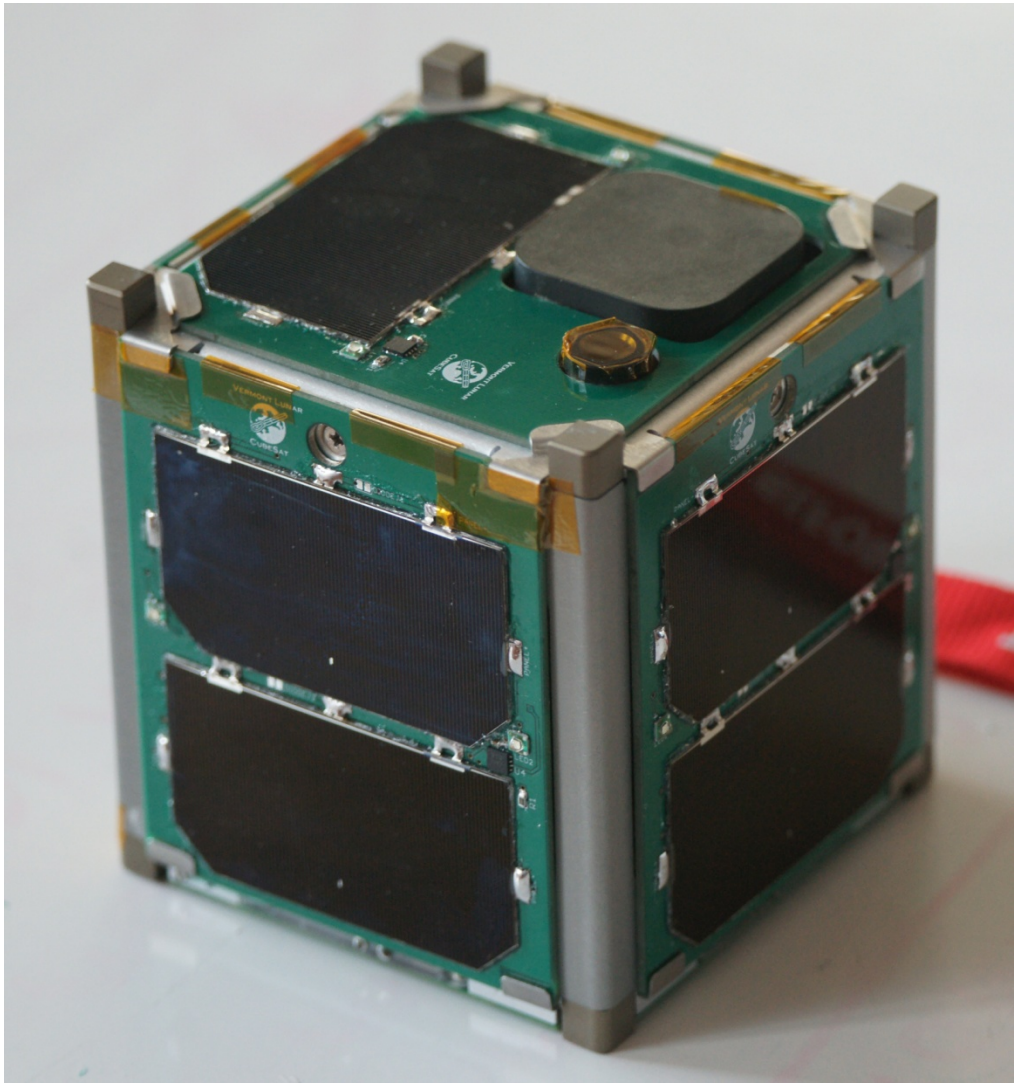


Our ELaNa IV CubeSat

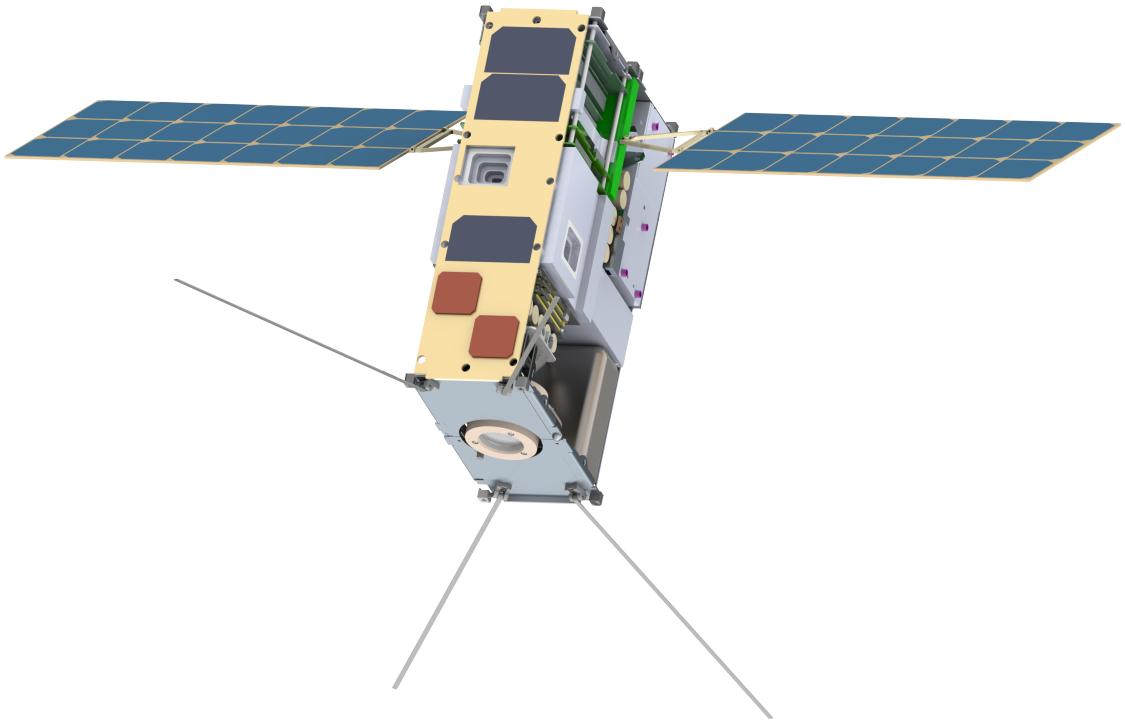
VERMONT TECH



Vermont Lunar CubeSat

Ada Europe 2015

Follow on Ion Drive CubeSat

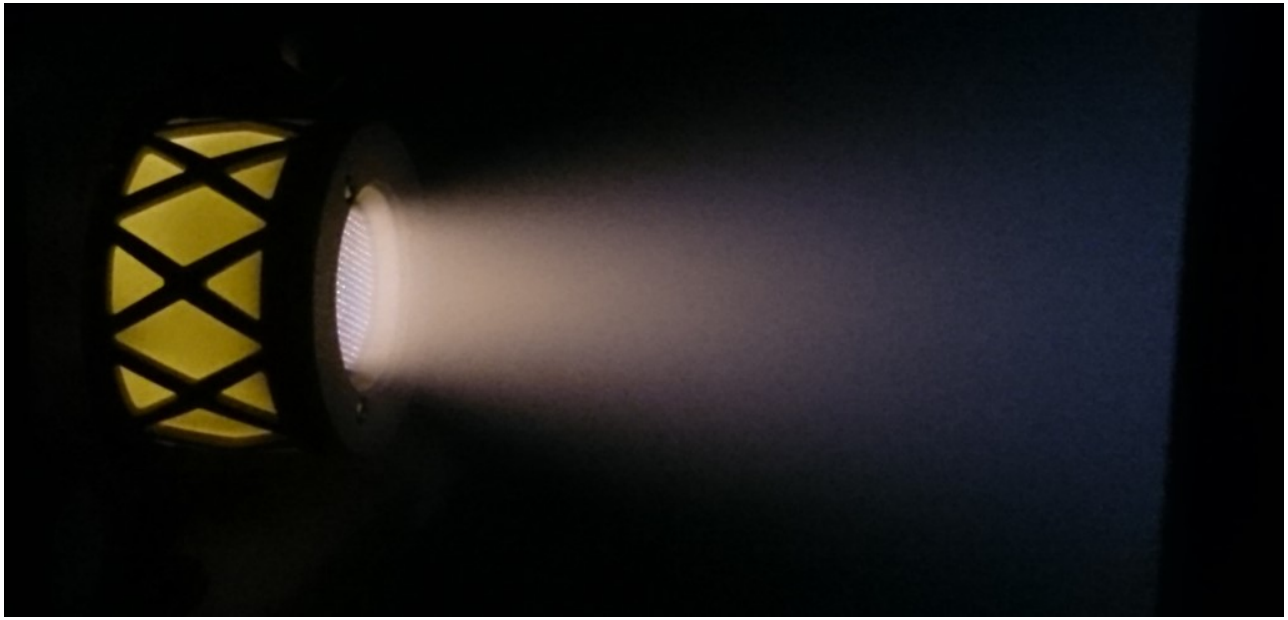


Lunar IceCube 6U CubeSat with 84 W fold out PV panel.
Ion drive with 1.75 kg Iodine. 10cm x 20cm x 30cm, 14kg

Follow on Ion Drive CubeSat

Lunar IceCube orbiting the Moon, looking for Water and other volatiles

BIT-3 Busek Iodine Ion Drive



1.75 kg Iodine, ISP 3,500 seconds 1.4mN thrust, 65W

Busek Ion Thruster

BIT-3

65W 1.4 mN

In operation with iodine

NASA Space Launch System Block 1, EM-1 Flight

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
- Although the CubeSat is limited to 1.3kg, the paperwork might be 13 kg ;)

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
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- Altran Praxis (SPARK)
- SofCheck (AdaMagic)
- Applied Graphics, Inc. (STK)
- LED Dynamics (PV boards)
- Microstrain (IMU)

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