• 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° 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
Our first picture of Earth
The North coast of Western Australia near Port Hedland
Brandon - VSGC Awards Dinner - 2014
Vermont Lunar Photos

Clouds over the ocean.
Lessons Learned from ELaNa IV

Brandon - VSGC Awards Dinner - 2014

Western Australia north of Perth
Vermont Lunar Photos

Percival Lakes, Australia

Brandon - VSGC Awards Dinner - 2014
Vermont Lunar Photos

Naunonga, Solomon Islands
Vermont Lunar Photos

Earth Edge

Brandon - VSGC Awards Dinner - 2014
Our ELaNa IV CubeSat

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)

Brandon & Chapin - Ada Europe 2013
Busek Ion Thrusters

BRFIT-1
10 W 0.067 mN

BRFIT-3
80 W 1.6 mN

Brandon - VSGC Awards Dinner - 2014
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

Brandon - VSGC Awards Dinner - 2014
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)