

VANDERBILT



School of Engineering

Small Satellite Program Overview

Dept. of Electrical Engineering and Computer Science
Institute for Space and Defense Electronics
Vanderbilt University
Nashville, TN, USA

Sponsors:

NASA EPSCoR Program
DTRA Basic Research Program
NASA Exploration Space Grant Project
NASA Tennessee Space Grant



Vanderbilt University

Home of the Commodores (and ISDE)



- **Founded in 1873**
- **Private Institution**
- **~11,000 students**
 - **Undergraduate: 6,532**
 - **Graduate/professional: 5,315**
 - **School of Engineering: 1,305**
- **Engineering, Arts & Sciences, Medicine, Nursing, Law, Business, Education, Music, Divinity**
- **2014 Baseball National Champs!**



Vanderbilt University's Space and Defense Electronic Program



University-based radiation effects on electronics research program

Radiation Effects Research (RER) Group

9 faculty with decades of radfx experience
30 graduate students
A few undergraduate interns
Open access
Hundreds of technical publications
Basic research and support of ISDE engineering tasks
Training ground for rad-effects engineers

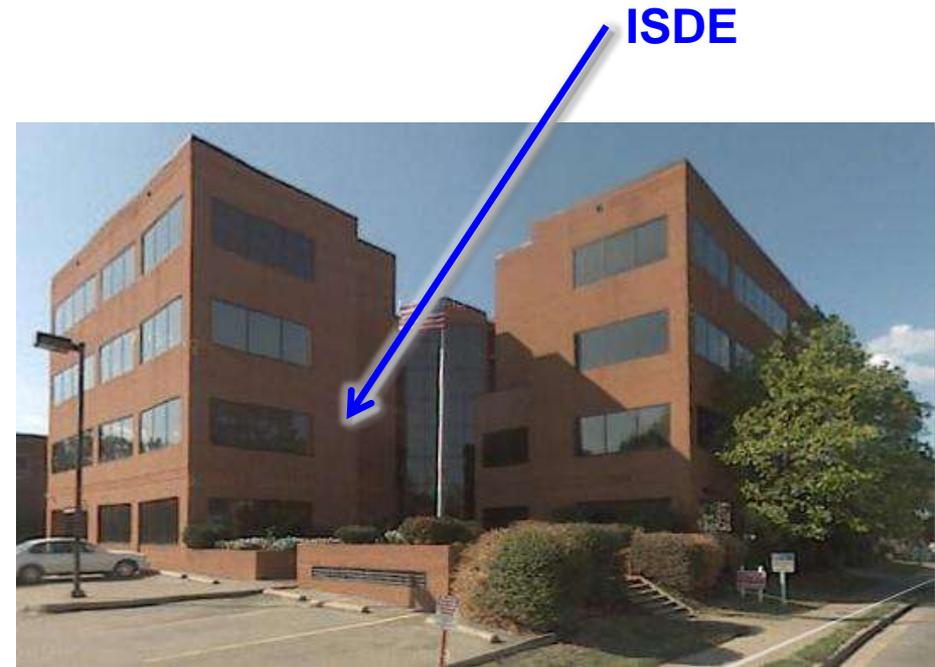
Institute for Space and Defense Electronics (ISDE)

- 14 full time engineers
- 2 support staff
- Limited access, ITAR compliant, IP protection
- Document control, milestone tracking, structured management
- Task driven support of specific radiation effects engineering needs in government and industry, both large and small

Professional, non-profit engineering organization affiliated with the School of Engineering at Vanderbilt University

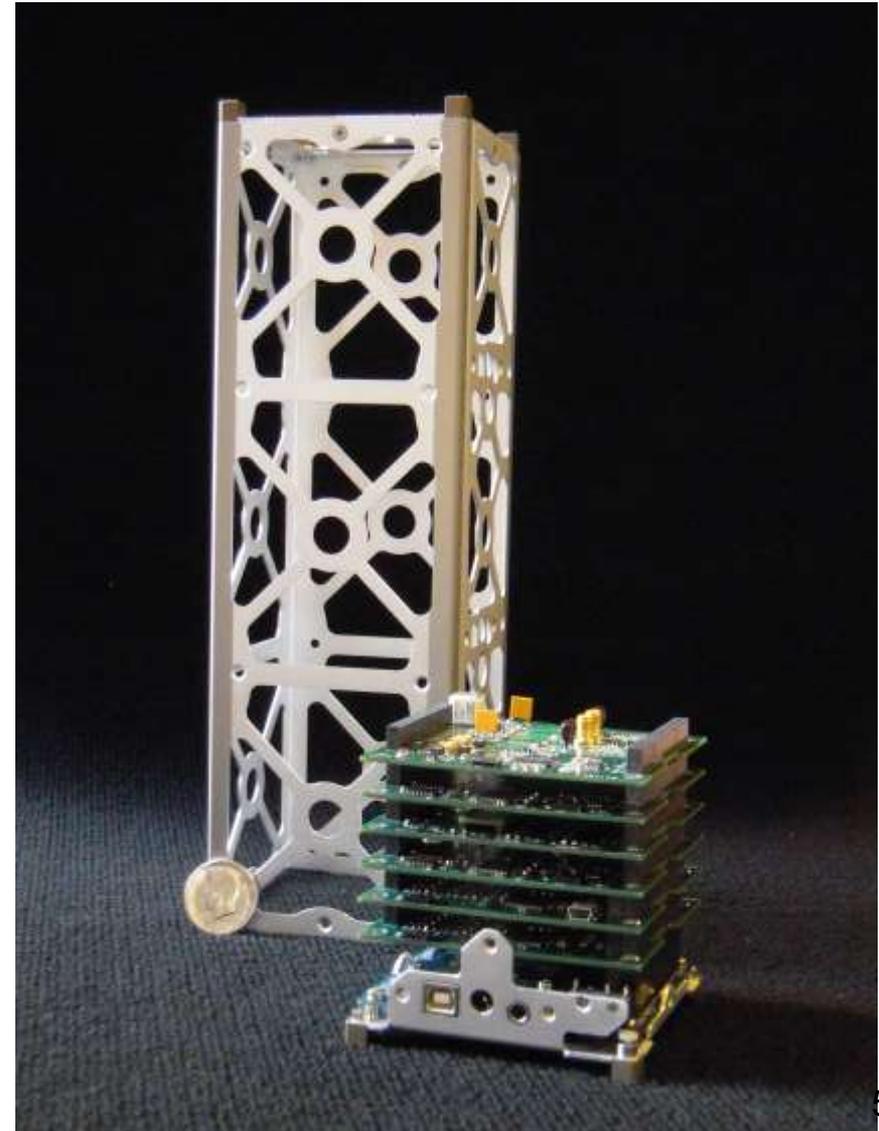


- Academic/professional research organization established by the School of Engineering of Vanderbilt University in 2003 to meet customer microelectronics reliability needs through physical circuit modeling, analysis, and design
- Personnel:
 - 14 Research Scientists & Engineers
 - 9 Faculty (EECS)
 - 2 Admin Staff
 - 30+ Graduate students
- ITAR compliant
- Contains small spacecraft design, development and assembly laboratory



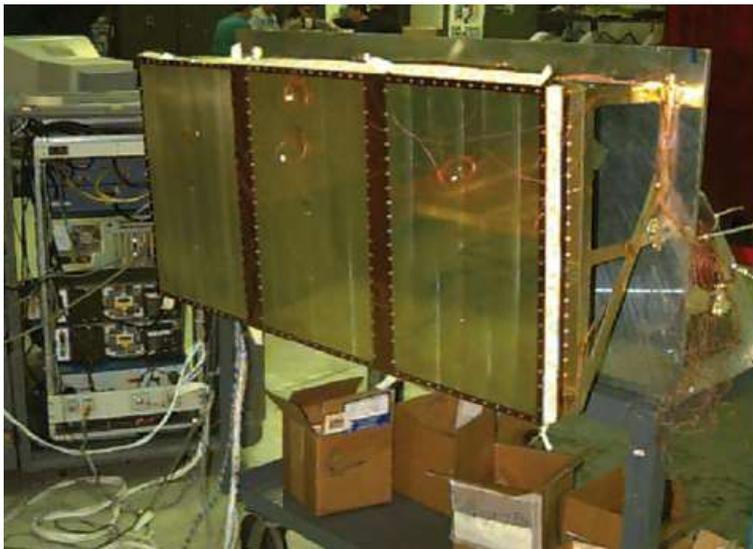
EPSCoR Satellite Program Overview

- **Goals:**
 - Provide a low cost on-orbit system to improve our understanding of the impact of space radiation environments on satellite components and systems
 - Educate students
- Two payloads delivered for S/C integration, one more slated for Fall 2015



On-Orbit Radiation Effects Experiments

Previous experiments



<http://www.nrl.navy.mil/research/nrl-review/2004/space-research-and-satellite->

• **Expensive and difficult to use or**

RadFxSats Concept



<http://space.webber.edu/harbor/systemScience.shtml>

- **Use quick turn, small spacecraft, e.g. Cubesat, for targeted experiments**
- **Provide a platform to perform basic research on space environment effects**
- **Provide much needed experimental data for radiation effects model validation**
- **Provide a cost effective, short design cycle, and reliable approach to qualify components for spaceflight**
- **Provide a venue to educate graduate, undergraduate, and high school students**

The CubeSat Platform

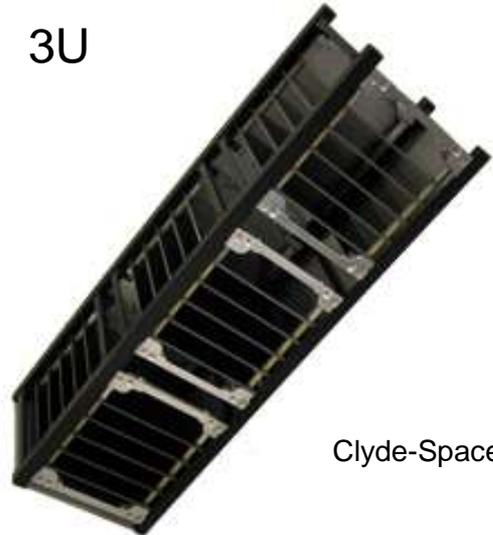
- Specifications developed at Cal-Poly and Stanford
 - www.cubesat.org
- A standard accepted by government, universities, and industry
- Base shape and size (1U: 10 cm cube up to 1 kg)
- Also standards for: 1.5U, 2U, 3U, ...

1U



St. Louis University

3U



Clyde-Space

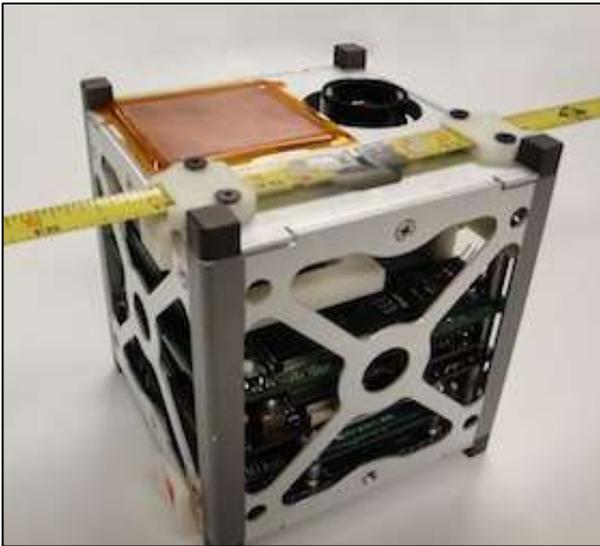


Cal Poly

RadFxSat Concept

- **Vanderbilt provides payload**
- **CubeSat partner provides spacecraft bus**

Example Spacecraft

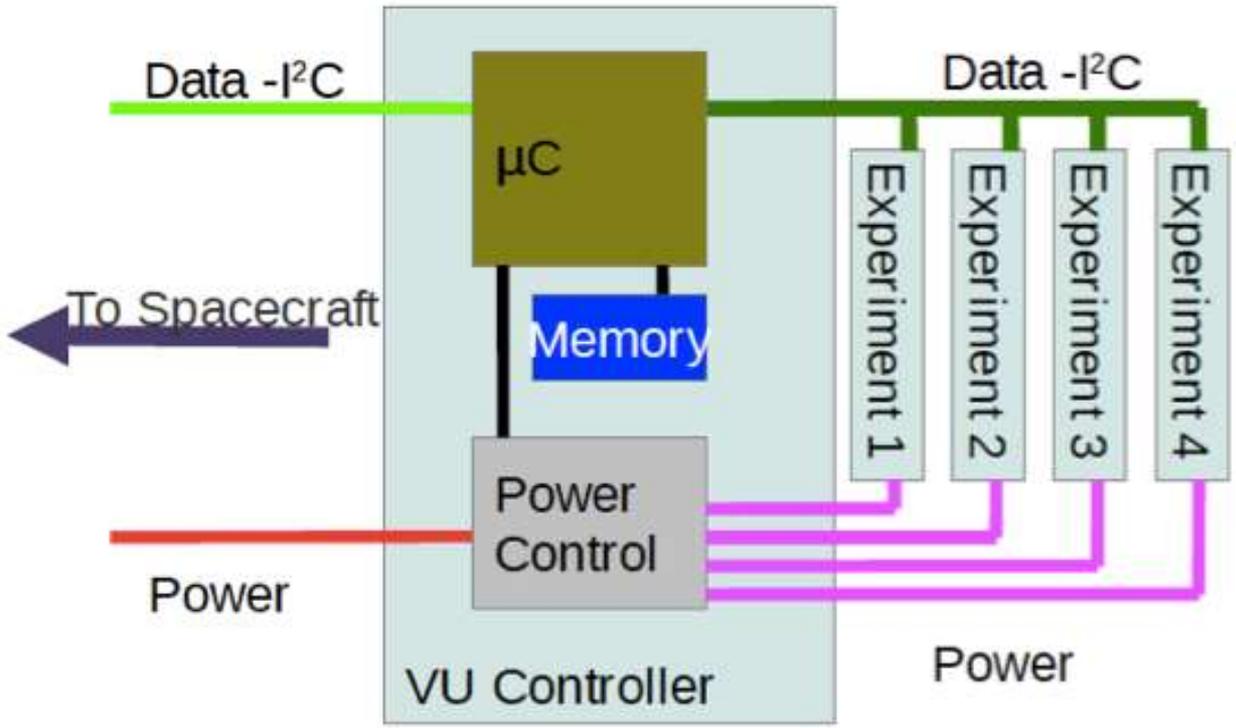


Courtesy of Mike Swartwout

Example Payload



VU Controller



Current Missions

➤ Commodore (Pathfinder)

- Launch summer 2013

➤ Independence (Radfx-1)

- Launch Winter 2014

➤ Vulcan (RadFx-2)

- Launch Spring 2015

➤ TBD (RadFx-3)

- Launch 2016



➤ Independence

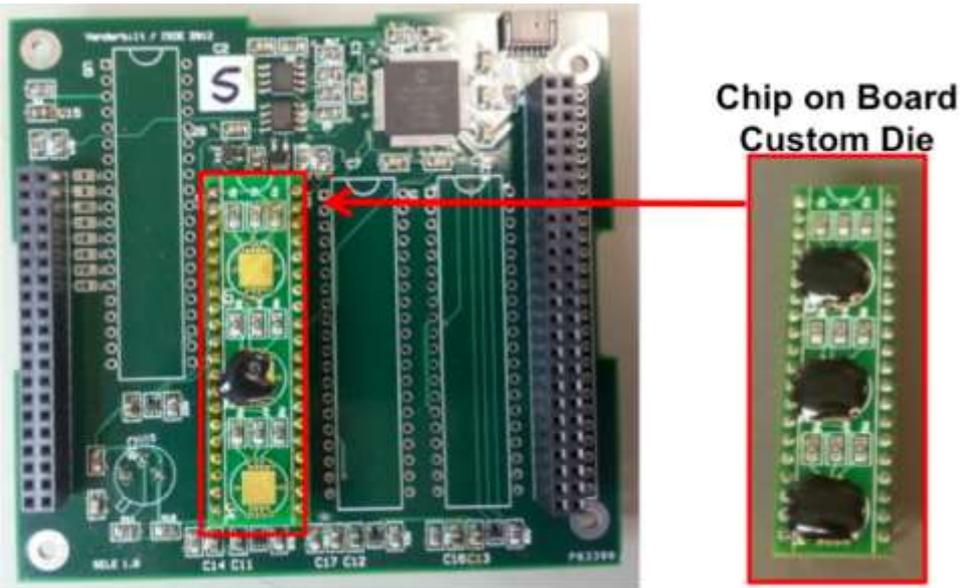
- 2U CubeSat
- 2 Experiments
- CubeSat Partner:
 - St. Louis University (Argus)
 - Payload delivered to SLU
 - Integration is complete
 - In final stages of flight readiness testing.
- ELaNa launch Winter 2014
- ~500 km near polar
- Science partners: DTRA Basic Research, NASA Exploration Space Grant Project, Jazz Semiconductor



Courtesy of SLU

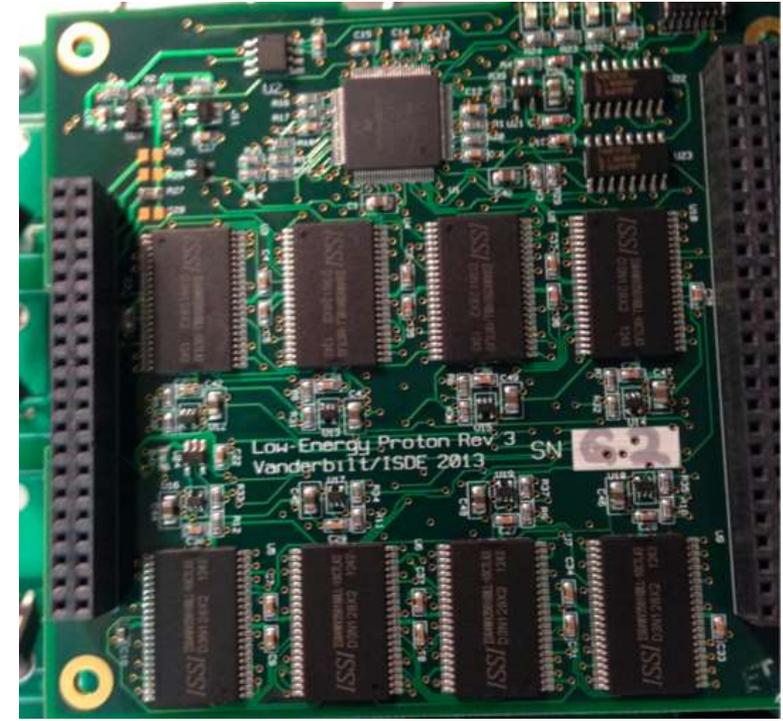
RadFx-1 Experiments

Single Event Latchup



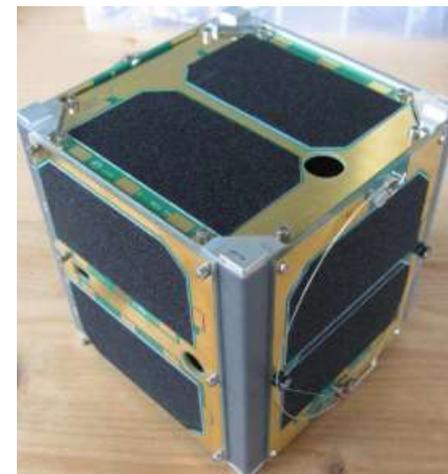
Student Design

Single Event Upset



➤ VUlcAn

- 1U CubeSat
- SEU Experiment
- CubeSat Partner:
 - AMSAT (Fox-1)
 - Flight Unit delivered
 - Early stages of integration
- ELaNa launch Spring 2015
- Science partners: DTRA Basic Research, commercial SRAM



Courtesy of AMSAT

Objectives

- Encourage students to become directly involved in the design and launch of space systems at Vanderbilt University
- Use the framework of satellite systems to introduce electrical engineering design concepts starting at the freshman level
- Expose students to circuit design starting at the freshman and sophomore level
- Reinforce design concepts at increasing levels of complexity as students advance through the curriculum
- Encourage student experimentation outside of standard academic laboratory assignments



- **Vanderbilt's RadFx payloads are expected to deliver information on reliability of commercial electronics**
- **Working on three flight opportunities.**
 - **Delivered two payloads**
 - **Currently developing a third payload**
 - 28 nm SRAM
- **Offers new education opportunity for Vanderbilt grad and undergrad students**