CubeSat Developers Workshop 2007

Presented By:

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CubeSat History

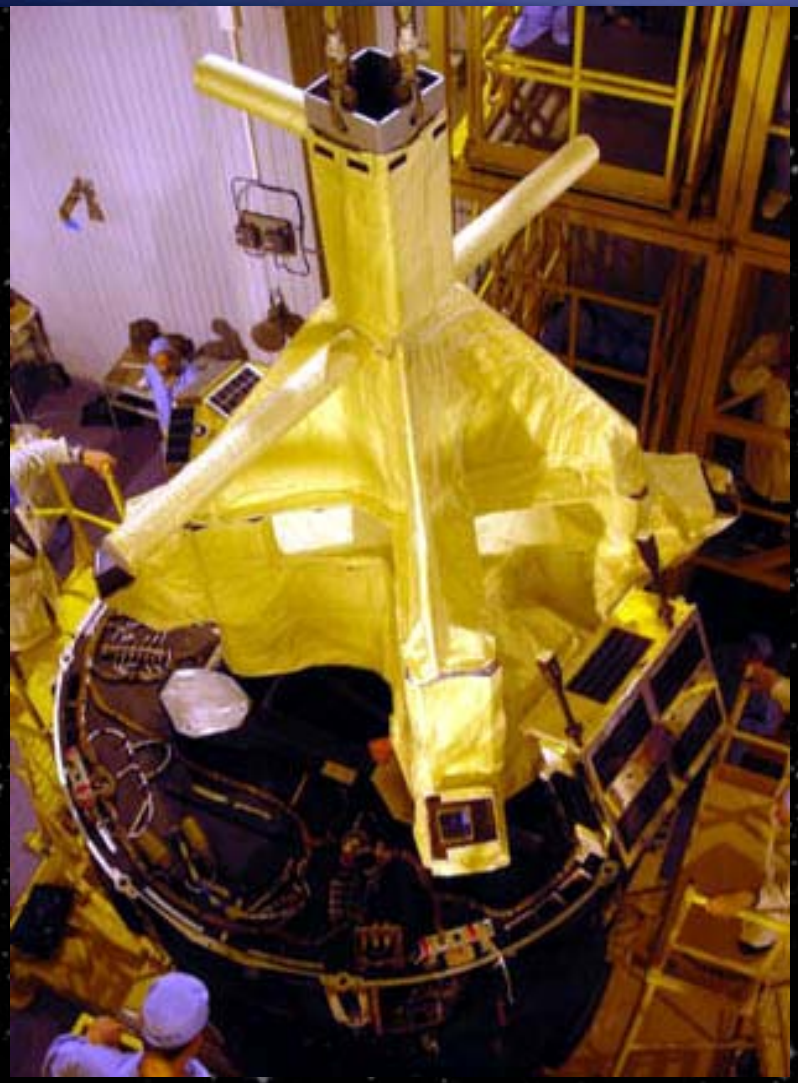
- First conceptualized in 1999 by Stanford and Cal Poly
- Driven by need for student opportunities
- Cal Poly's current role
  - Provide standard interface and system for deploying CubeSats (P-POD)
  - Maintain the CubeSat Standard
  - Coordinate launch opportunities
  - Networking ground stations around the world dedicated to CubeSat operations.

Some Data

- 18 CubeSats in LEO (32 Launched)
  - 6 in non-P-POD launches
    - Toronto
    - ESA (SSETI Express)
    - Japan ■
- Experiments include:
  - Astrobiology (GeneSat)
  - Component Testing (CP-1-3, Boeing, ION, others)
  - Ionospheric Research (QuakeSat)
  - Pico-inspector testing (Aerospace Corp.)

CubeSat History

Eurokot: June 30, 2003



6 CubeSats – 2 Cal Poly P-Pods

SSETI Express: October 27, 2005

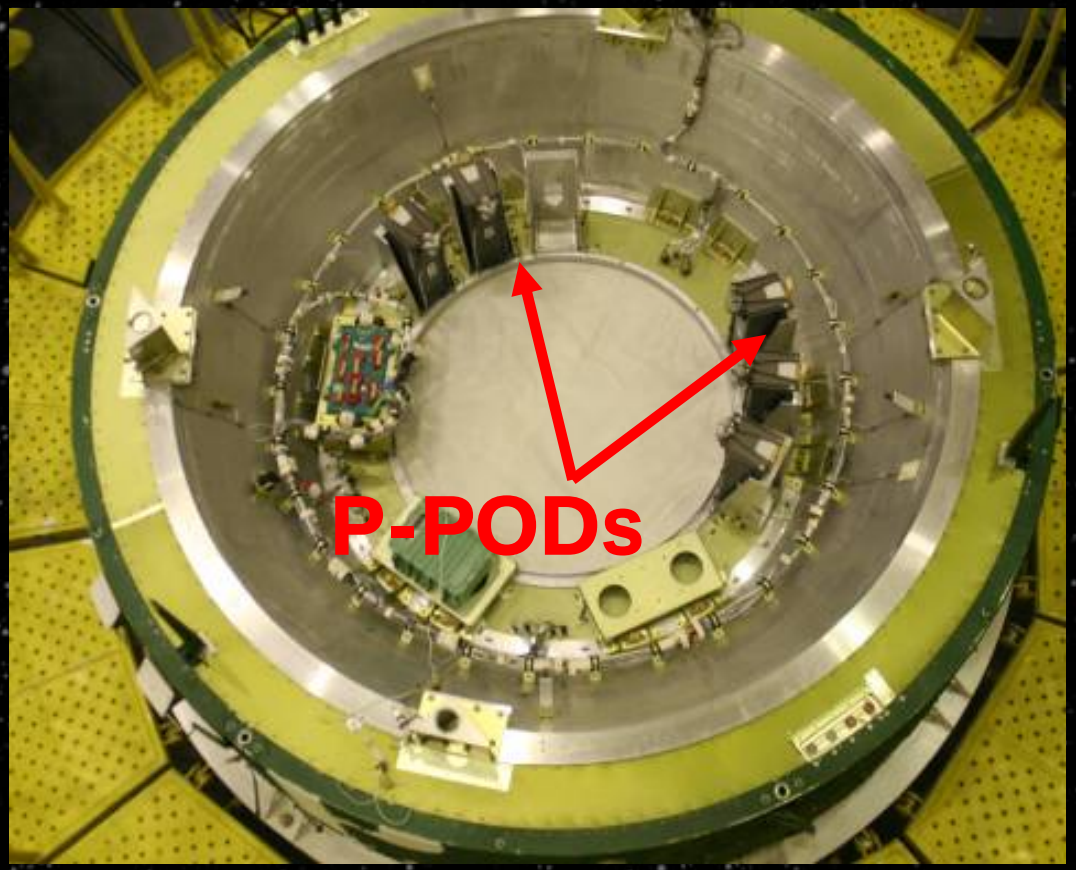
3 CubeSats

CubeSat History

M-V-8:
February 22, 2006

1 CubeSat: CUTE-1.7

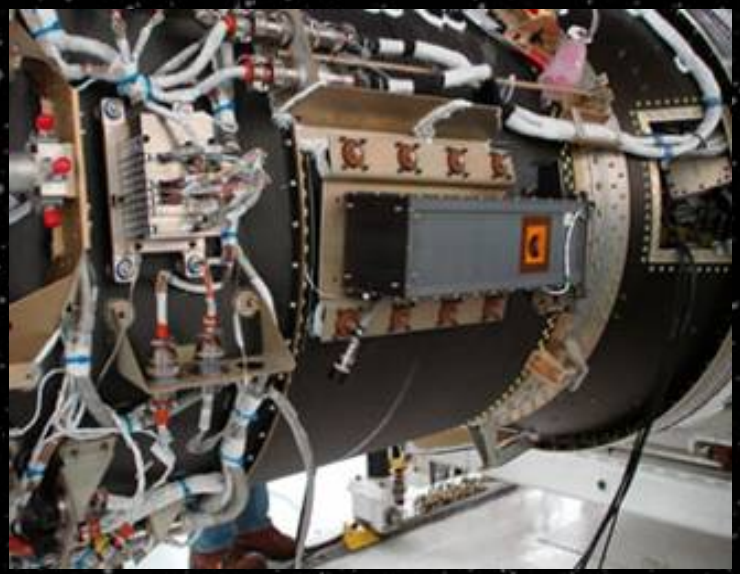
Dnepr 1 (Belka): July 26, 2006
(Launch Failure)



14 CubeSats – 4 P-PODs

Minotaur (TacSat2): Dec 06

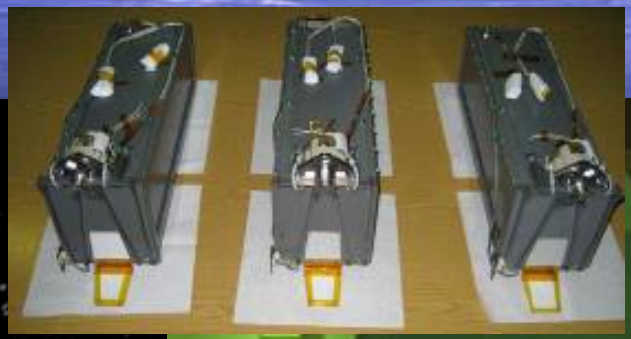
- 1st U.S. Launch of CubeSats

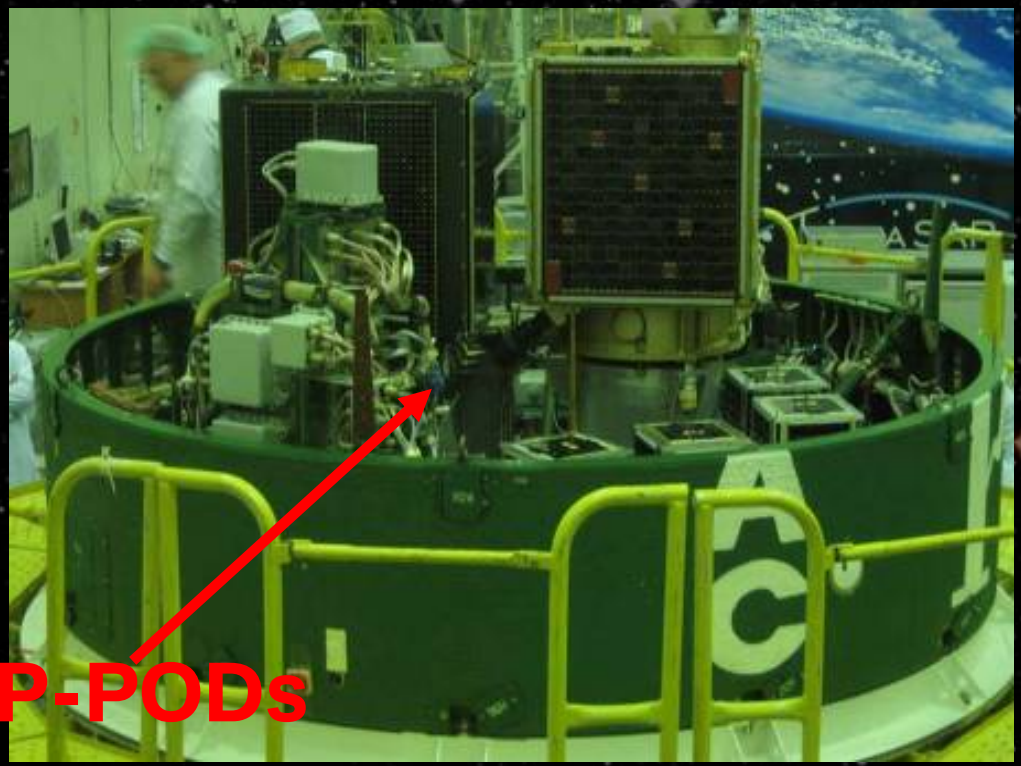


- Payload: GeneSat-1

Dnepr 2 (EgyptSat)

- April 16, 2007
- 7 CubeSats





Boeing's CubeSat TestBed 1 ("CSTB1")

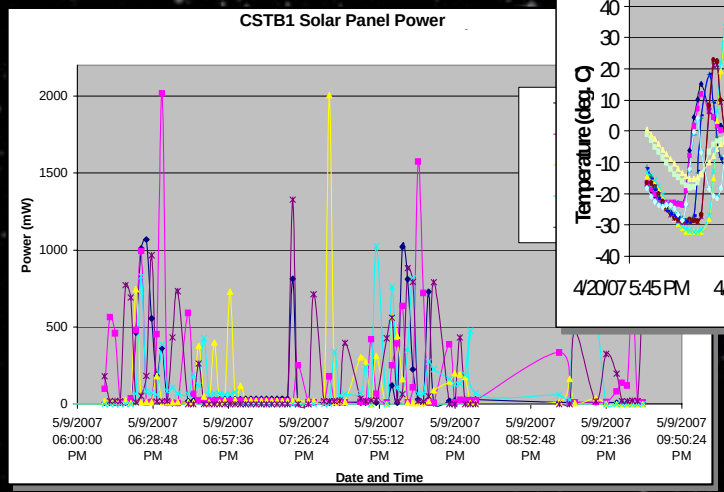
CSTB1 Features

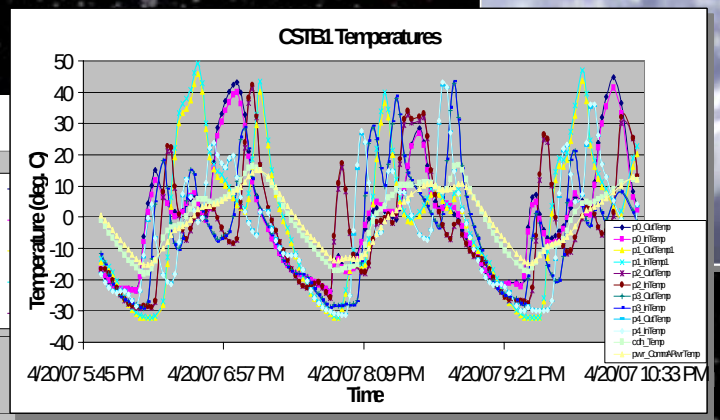
- Ultra-Low Power Imager and MCU for Image Processing
- Coarse Attitude Sensors & Control
- High Capacity Li-ion Batteries
- SOA Triple Junction Solar Cells
- Selected Redundancy for Key Subsystems

Operational Summary

- >100% of Mission Goals Met!!
- More Than 300,000 Data Points and 5.5 MB of Data Downloaded

Photograph taken by CSTB1





CSTB1

STATUS: Launched April 2007, ***FULLY OPERATIONAL !!***

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The Aerospace Corporation

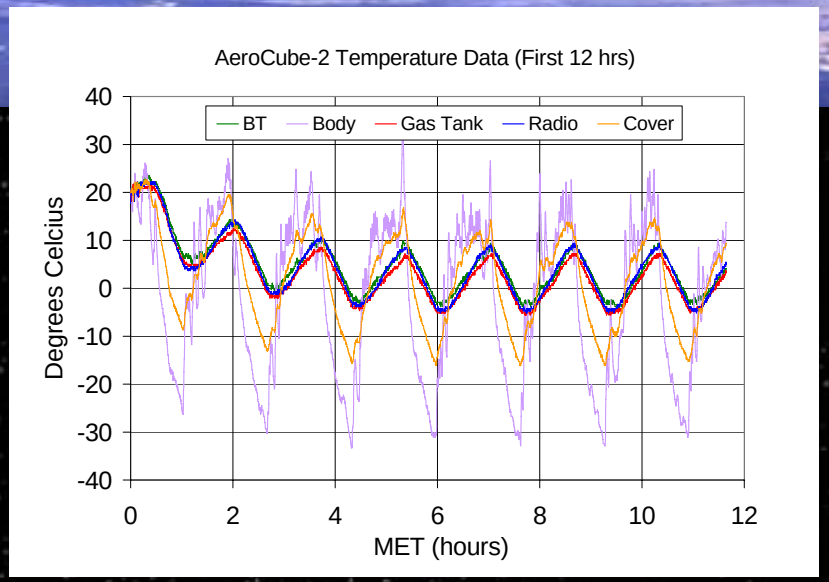
AeroCube-2 April 2007 DNEPR Flight Results

Mission Goals

Demonstrate “Ring Bus” power system
1st Attempt for long duration PICO/Cubesat
Demonstrate 9” pillow balloon for deorbit
Certify local ground station in El Segundo, CA
Photograph earth and other Cubesats

Mission Results

Negative power balance ⇨ mission ended in 24 hrs
Photographed earth and Cal Poly Cubesat
Downlinked SOH data for first 12 hrs
Certified local ground station (good link & tracking)
Did not inflate balloon due to power system failure



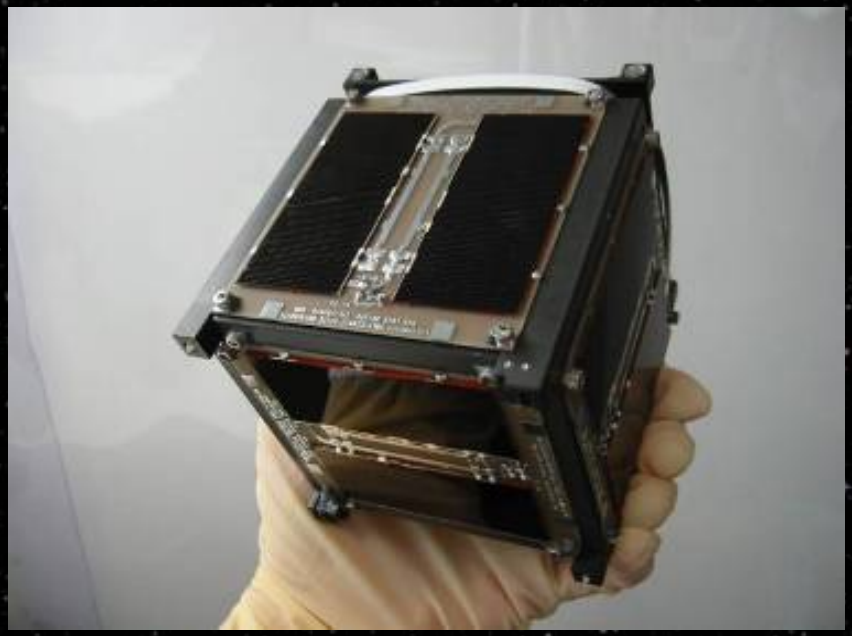
Aerocube-2 photograph of the island of Madagascar from 400 mile orbit altitude and 105 seconds after ejection.

Aerocube-2 photograph Cal Poly Cubesat 65 seconds after ejection

Why Do We Need CubeSats?

Skills and Experiences

- Team-building
- Project management
- Building to flight standards
- Integration and testing
- Overseeing a complete mission lifecycle

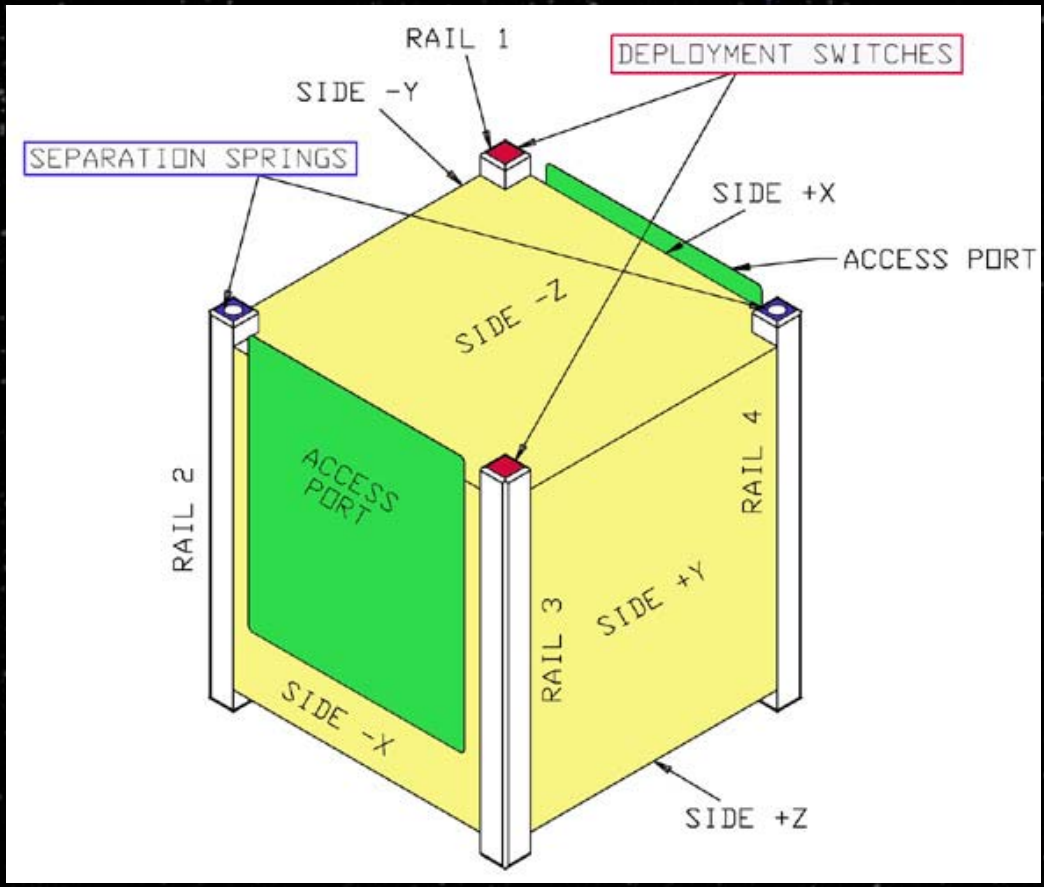


CubeSat Community Purpose

- 80+ universities, private companies, government organizations building picosatellites
- Program designed so that students can participate in entire life cycle of a space mission
- Use concepts of standardization and ridesharing to meet objectives

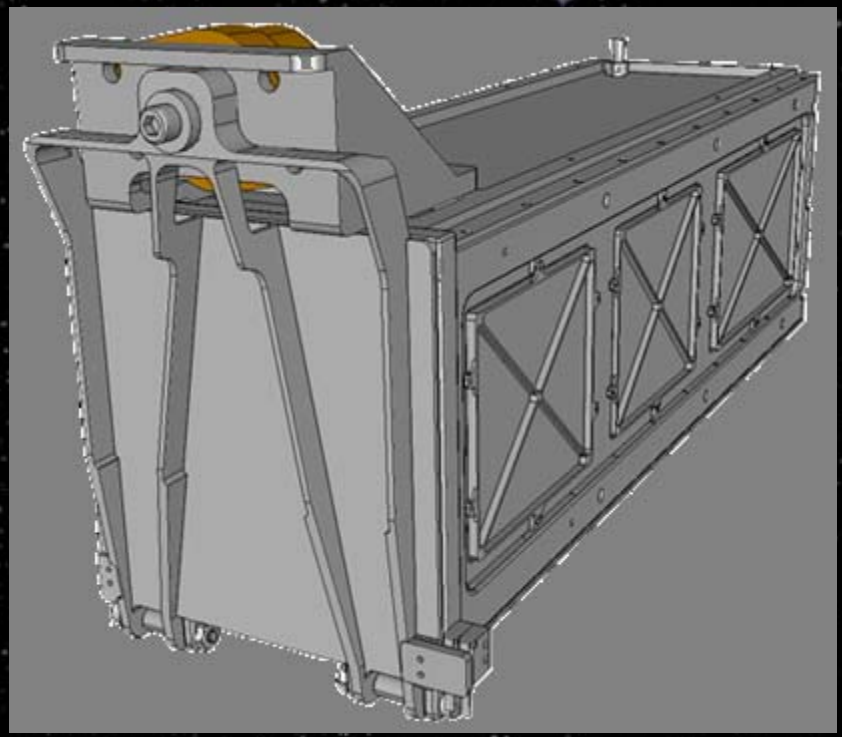
The CubeSat Standard

- Shape and size (10 cm cube)
- Mass (up to 1 kg)
- Interface to P-POD
  - Rails
  - Access ports
- Materials and tolerances
- Operations
  - Deployables
  - Communication
- Different configurations possible



Poly Picosatellite Orbital Deployer

- Standard deployment system
  - Tubular frame
  - Spring assisted ejection
  - Payload of 3 single CubeSats

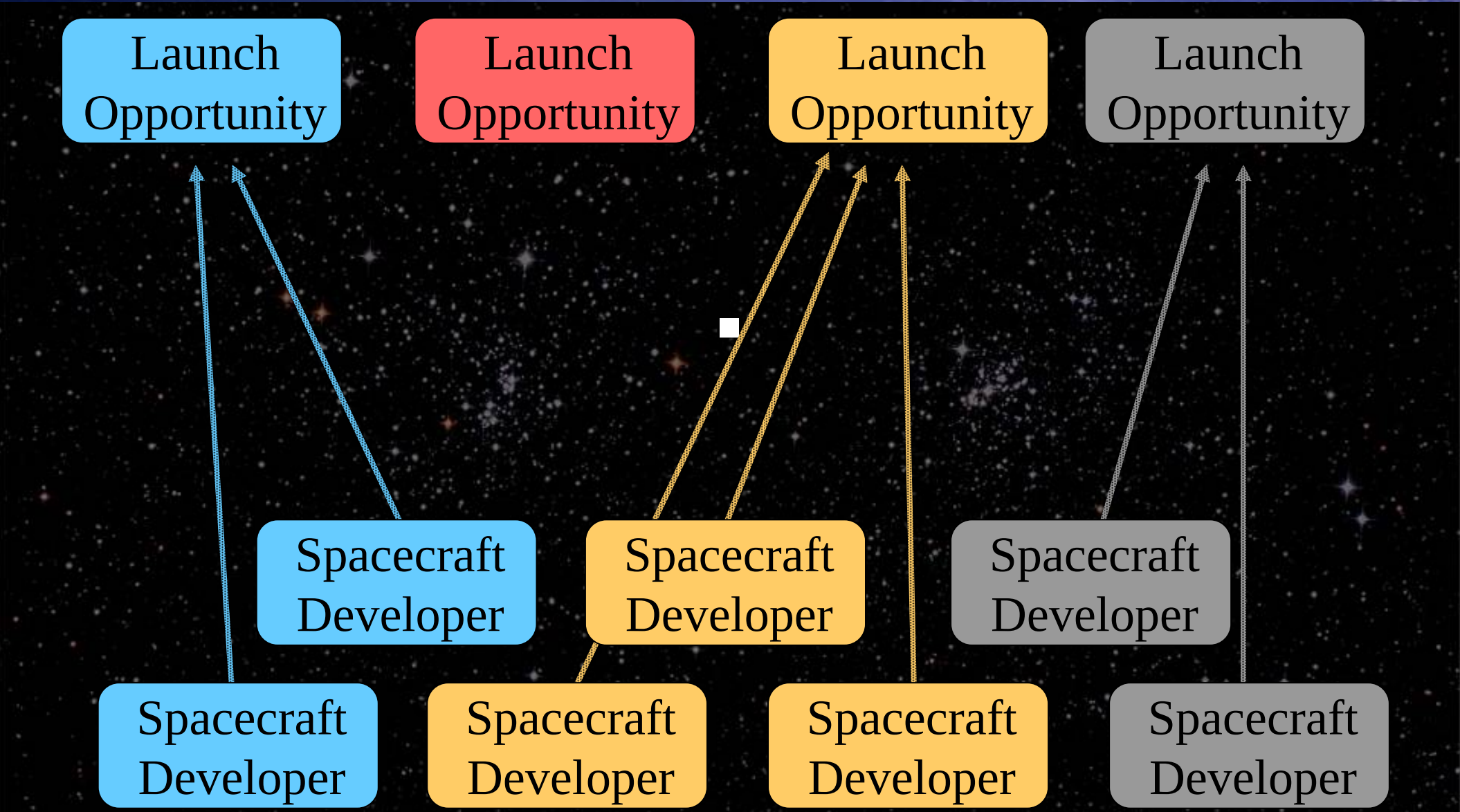


- P-POD mission objectives
  - Protect LV and primary payload
  - Safe/reliable deployment
  - Compatibility with many LV

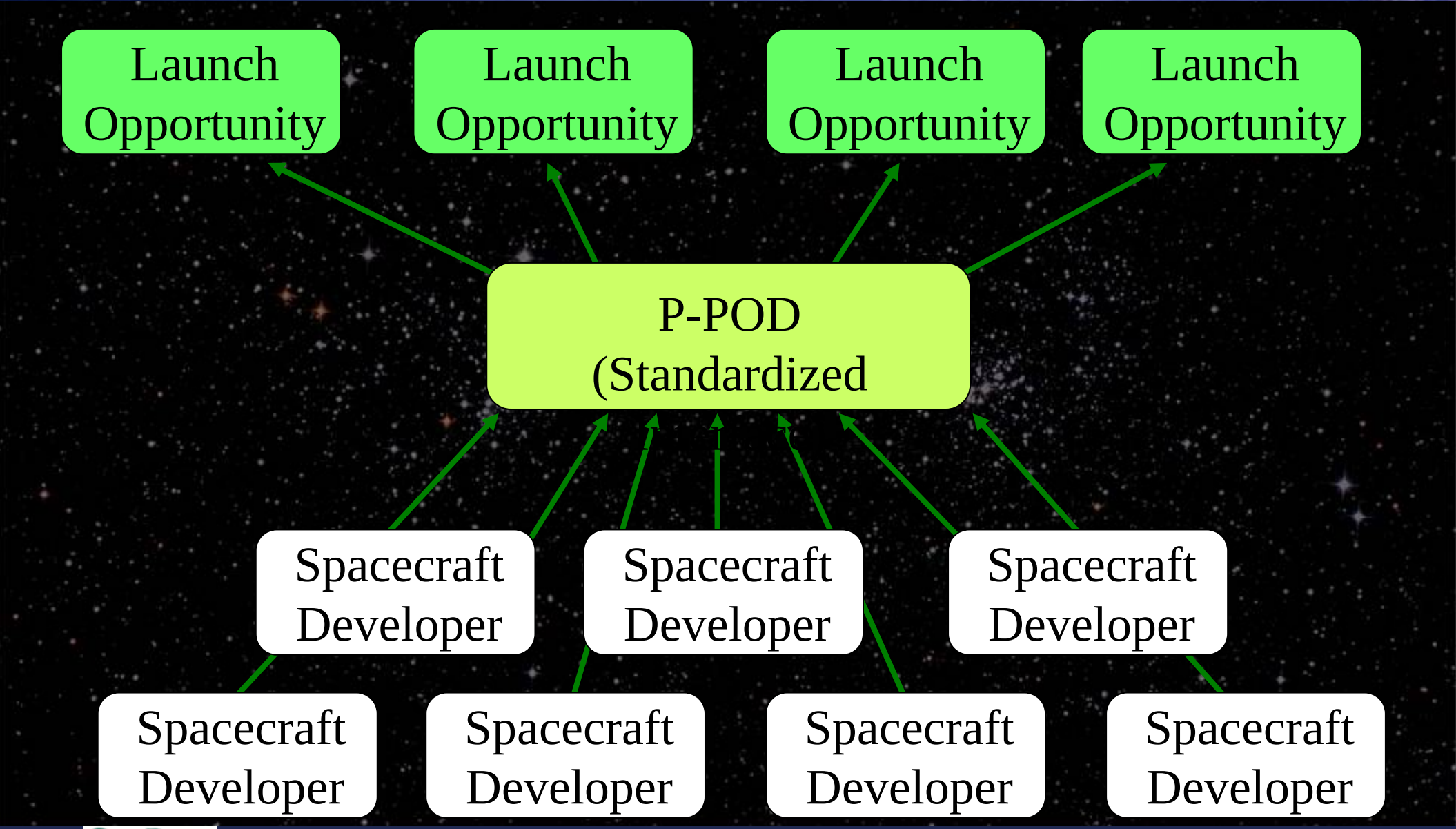
Standard = Flexibility

- Pre-qualified P-POD and LV interfaces
  - Maximize number of compatible missions
  - Reduce integration time
  - Minimize NRE and associated costs
  - Repetition minimizes design, analysis, and testing for subsequent missions
- Possible to transfer spacecraft to a different LV if launch is delayed or canceled
- Spacecraft Development Without Firm Launch
  - Standard Independent of Launch Vehicle
  - Fast Response to Launch Opportunities

Current Secondary Launches



Flexible Secondary Launches



Distribution of Costs

- Multiple manifest
  - Distribute costs over many customers
- Multiplexing spacecraft
  - Deploy multiple spacecraft per mechanism
- Repetition
  - Use identical, standard systems not mission specific

Upcoming Launches

- Falcon-1 LV (RazakSat)
  - March 2008
  - 2+ P-PODs
  - Accepting apps

- Minotaur LV (TacSat3)
  - March 2008
  - 2 P-PODs

Upcoming Launches

- Atlas V (multiple)
  - 2009 onward
  - Accepting apps
- Dnepr 3
  - 2009
  - Accepting apps

Other Compatible Launch Vehicles

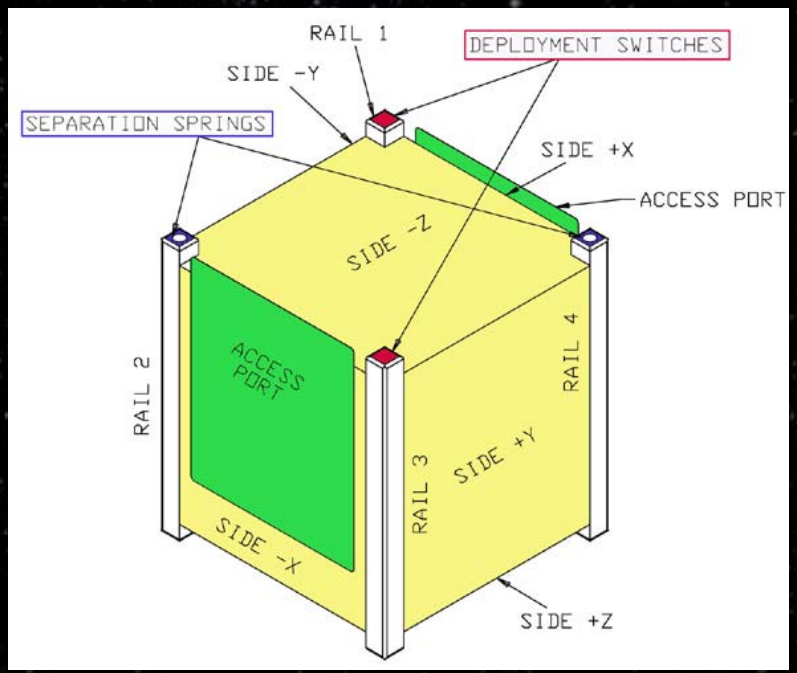
From existing...

...to tested...

...to concepts.

Suggestions: CubeSat Construction

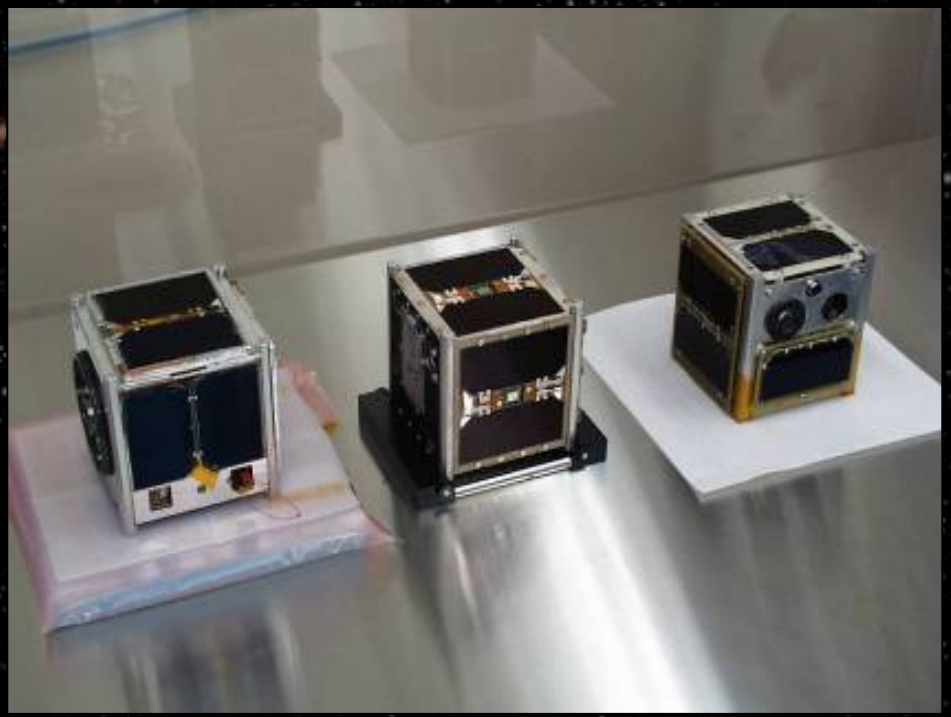
- It took us 2 years to build CP1, 1.5 years for CP2, CP3, 6 months for CP4
- Read the specification carefully



- The "top" of the CubeSat in the spec drawing actually goes in the P-POD first
- Contact us with questions or concerns

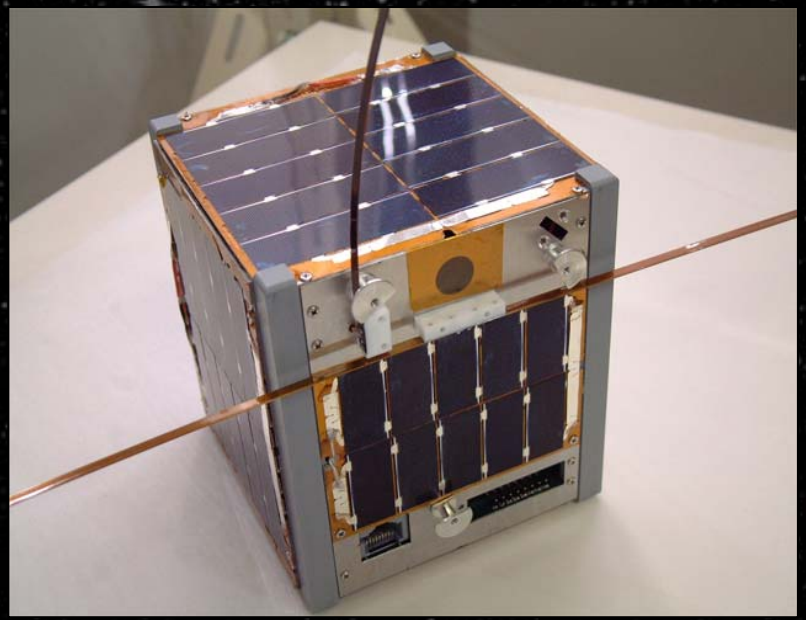
Take Fit Checks Seriously

- Fit checks are important
- Go into fit checks and reviews with highest fidelity hardware possible



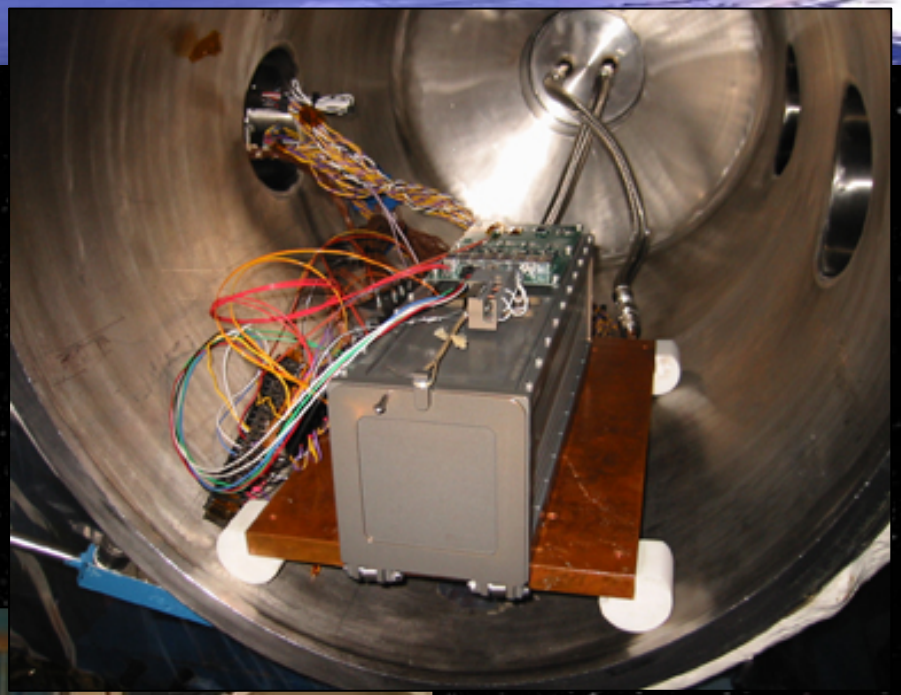
Test Like You Fly, Fly As You Test

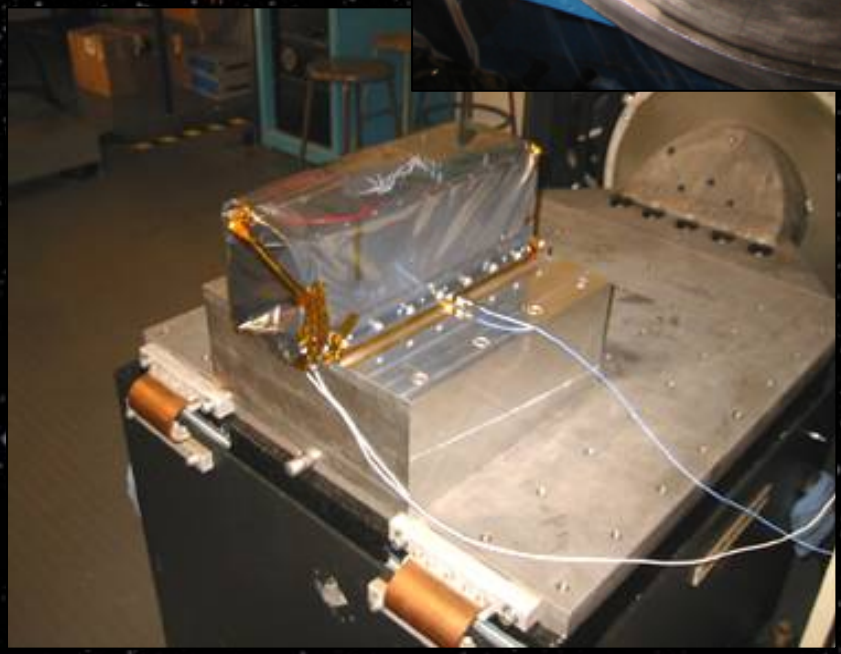
- Do not cut corners during testing
- Test everything exactly as it will fly
- Don’t make last minute changes
- Repeatable Procedures



Test Early and Often

- Test carefully/methodically
- Understand different stages
  - Prototype
  - Qualification
  - Acceptance
- Expect worst case





Integration

- Delivery expected to Cal Poly 2-3 months prior to launch
- Last tests are performed to ensure proper dimensioning and construction

Integration

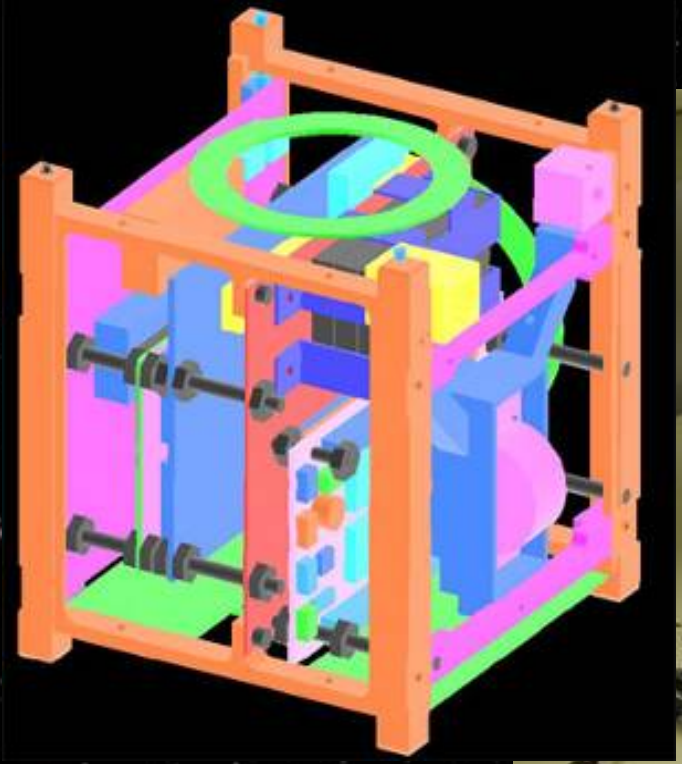
- Satellites are integrated into PPOD, run through acceptance tests
- Last minute battery recharging and diagnostics can be performed
- Shipped to launch site

Current Goals

- Increase US launch capability
  - Atlas V, Minotaur, Falcon, others
- Increase number of Developers
- Promote CubeSats as a viable platform for low-cost missions
- Continue to educate students

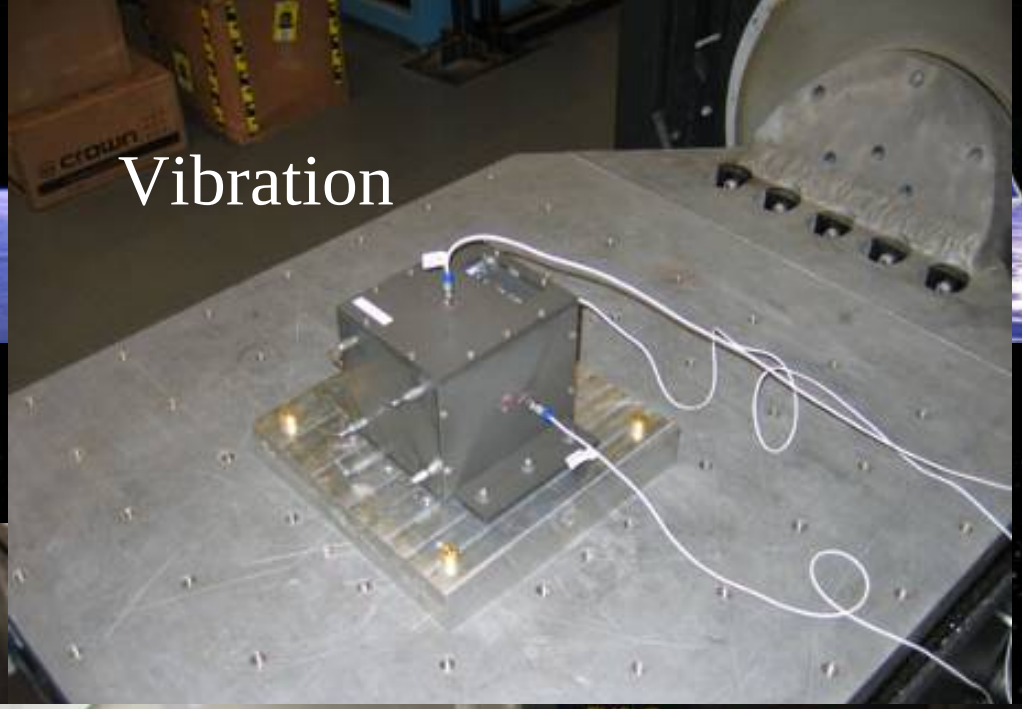
RESULTS

From Design

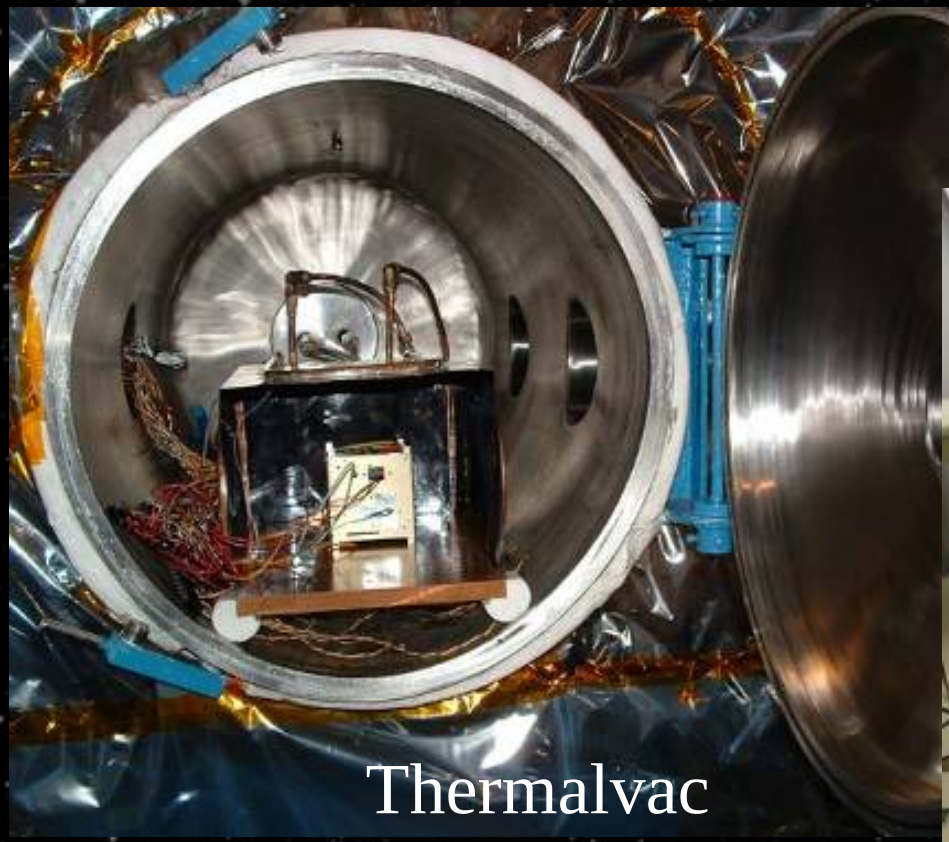


To Spacecraft

RESULTS



To Testing



To Integration

RESULTS

To Launch And Operations

Ground Station

Accomplishments

- Within 8 years
  - 18 CubeSats in LEO (88% successful)
  - Successful coordination & launch of 22 satellites on foreign and US launch vehicles
  - Launching US as well as foreign spacecraft
  - Multiple launch opportunities
  - International earth station networking

CubeSat Lessons

- Start Simple
- Build on Experience
- Constantly recruit
- Document well
- TEST
- Keep planning ahead
- Network
- Be flexible
- Recruit from various fields
- Schools: Find industry partners
- Industry: Find scholastic partners

Questions?

Thank you to all of our Supporters

www.cubesat.org

Additional slides…