CUBESAT

Looking Ahead

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CubeSat Developers Workshop

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CubeSat Program Overview

- 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, ridesharing, and responsive deadlines to meet objectives

- Currently 10 CubeSats in orbit

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Basis for the Standard

CubeSats: a practical platform for experimentation in the smallest form factor possible.

- Simple Standard (manageable for universities)

- Standard based on
  - Size of available COTS components (Solar cells, batteries, transceivers, etc.)
  - P-POD dimensions and features
  - Self-imposed safety standards
  - LP environmental and operational requirements

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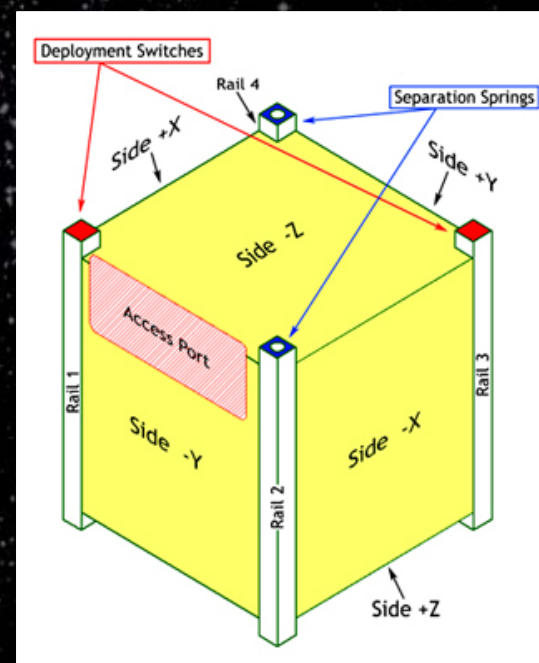
Poly Picosatellite Orbital Deployer
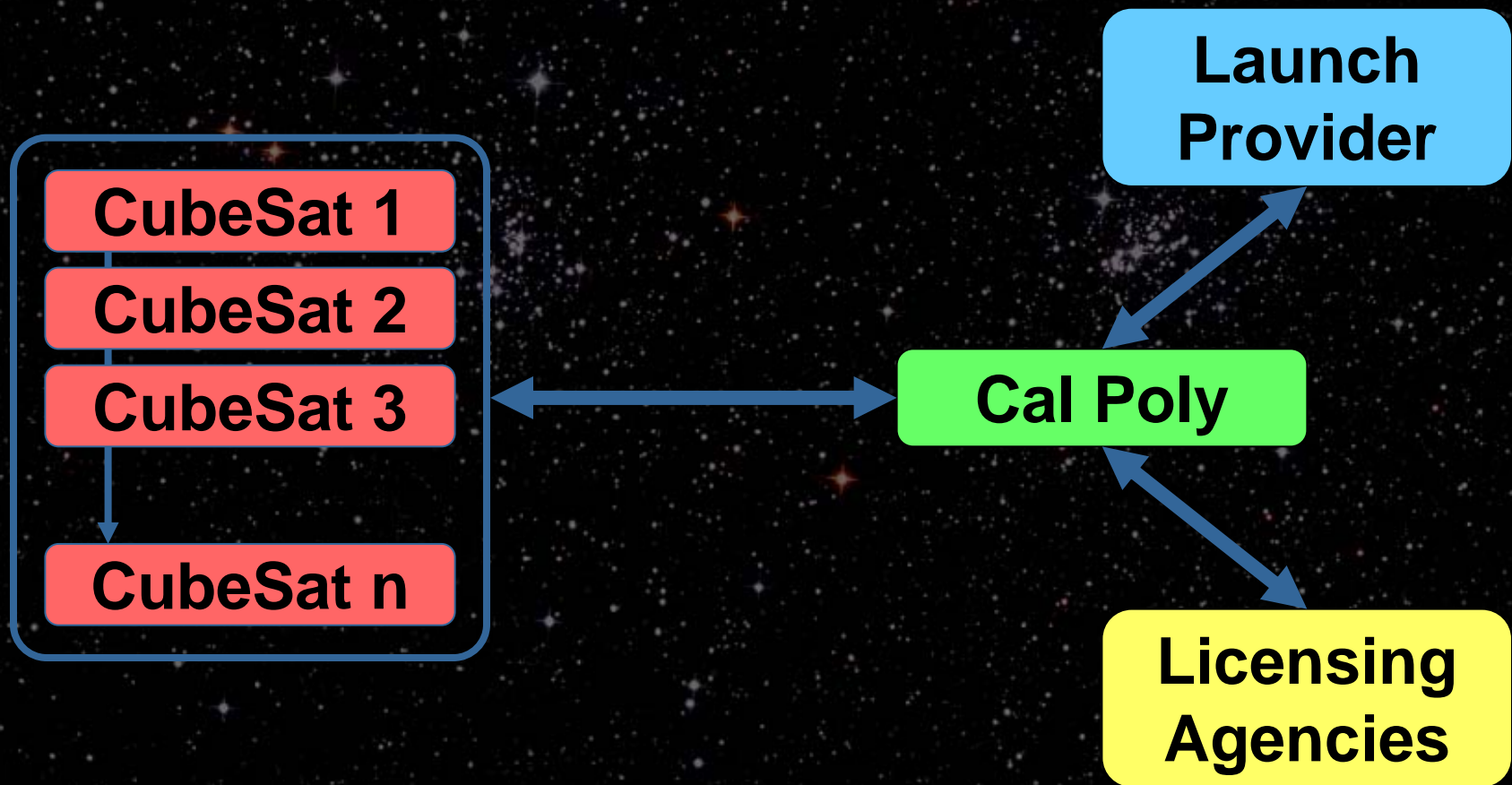
- ## Standard deployment system

  - Tubular frame

  - Spring assisted ejection

  - Payload of 3 single CubeSats

- ## P-POD mission objectives

  - Protect LV and primary payload

  - Protect CubeSats from launch environment

  - Safe/reliable deployment

  - Compatibility with many LV

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Cal Poly's Role

- Maintain the CubeSat standard
- Coordinate Launches
- Develop, test, and fly the P-POD

Launch Provider

CubeSat 1

CubeSat 2

CubeSat 3

CubeSat n

Cal Poly

Licensing Agencies

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Operations

- Locating the CubeSat after deployment
- Health status / contingency mode
- Acquisition of signal
- Community support

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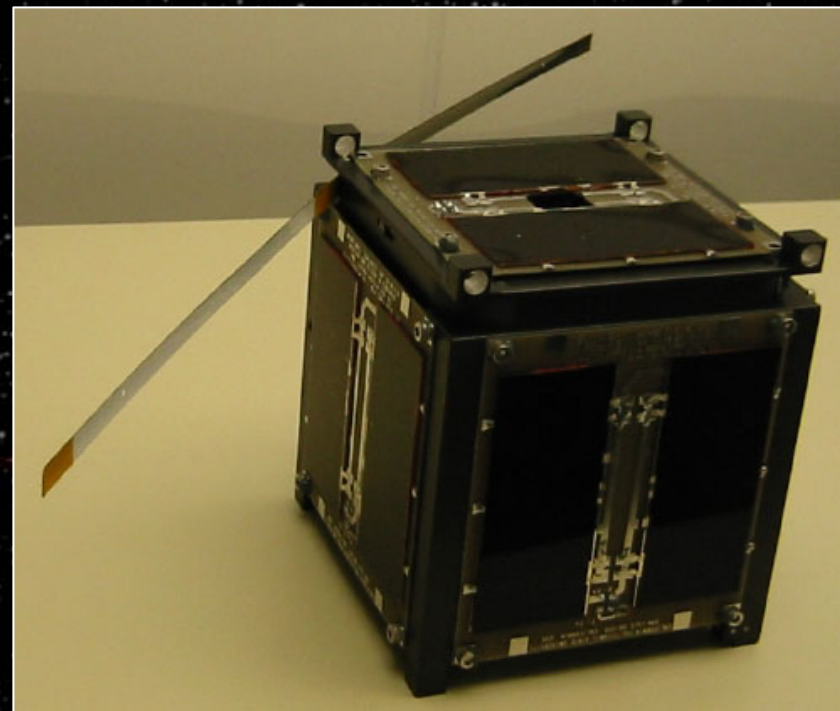
Starting Your Program

- Start working on earth stations early!
- Should be operational well before launch
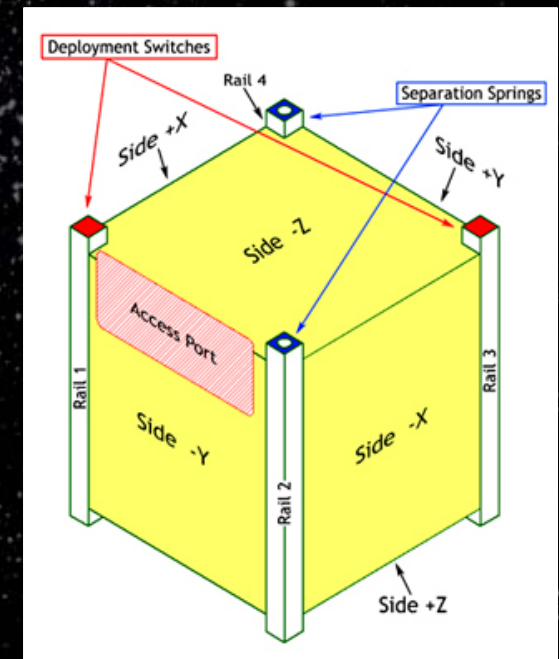- Practice tracking other CubeSats
- Get involved with AMSAT

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CubeSat Construction

- It took us years to build CP1
- 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
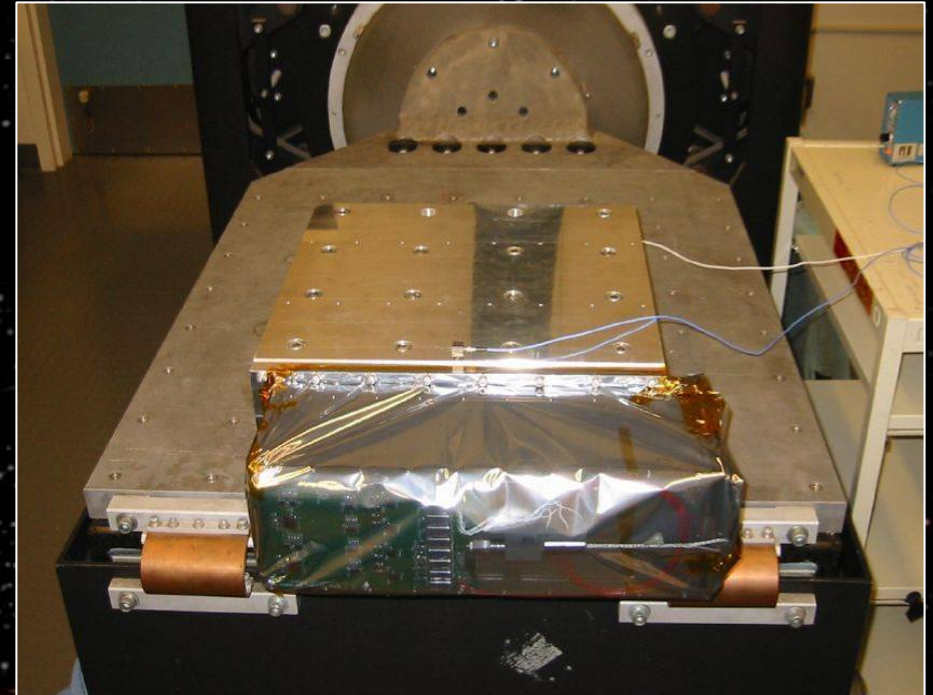
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Vibration Testing

Random Vibration
- 14.1 G_{rms} 20-2000 Hz

Sine Sweep
- 15 G_{rms} 50-2000 Hz
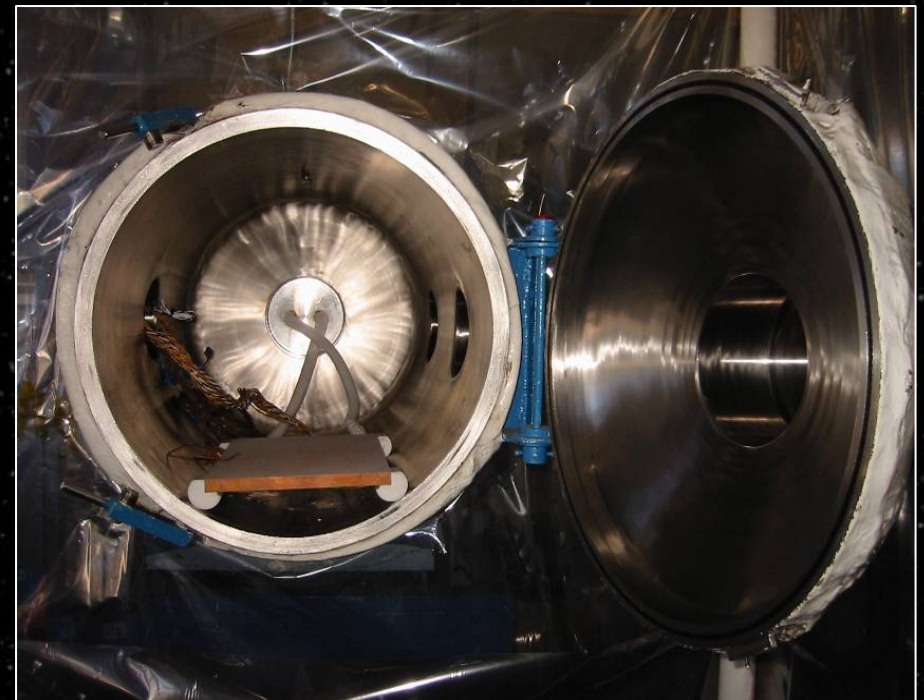
Testing at NASA GEVS worst case scenario

Thermal Vacuum

- Extreme Temperatures (-30 to 70 Celsius)
- 1 hour Soak at Each Extreme
- 2 Cycles

Take Fit Checks Seriously

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

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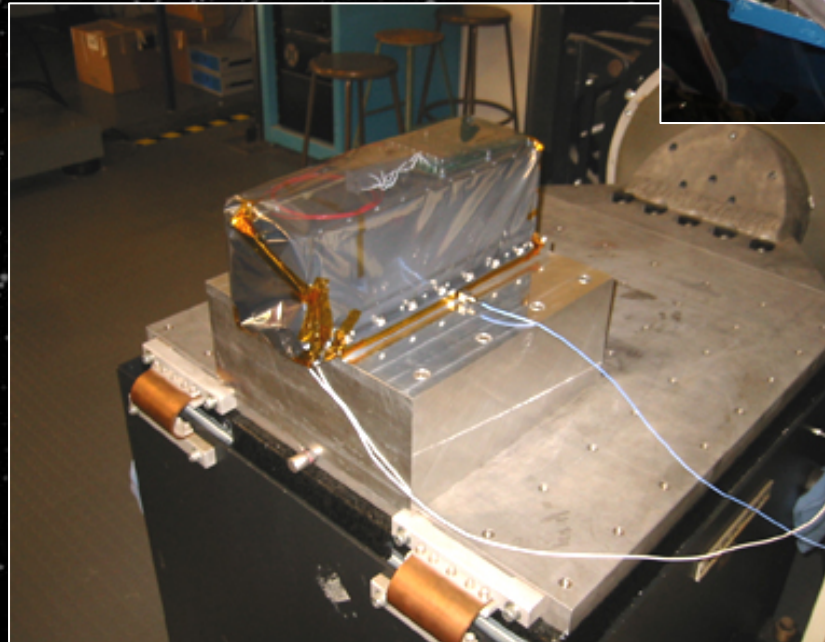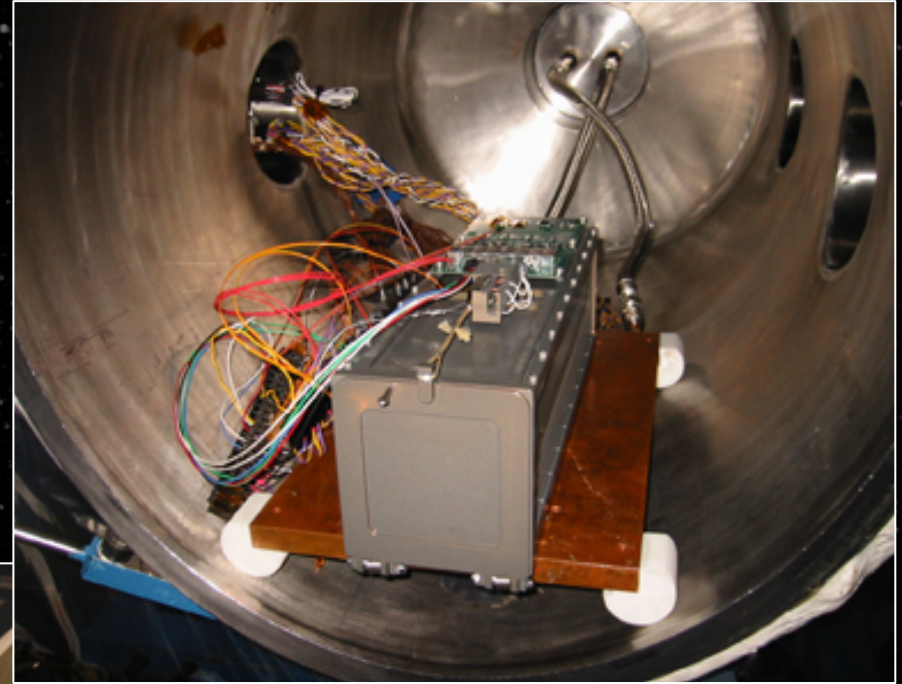
Test Like You Fly, Fly As You Test

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

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Test Early and Often

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

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Integration

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

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Integration

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

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Integration

- Satellites on Dnepr 1 sat in shipping crate for 1 month (due to launch slip)

- In Baikonur cleanroom, P-PODs were removed and inspected

- Techs performed final inspection and integration onto SHM

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Dnepr 1 Launch

- Dnepr's are converted SS-18 ICBM's used for cluster launches
- Six previous successful launches

- 18 spacecraft on board from 7 countries
- Main payload BelKA

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Dnepr 1 Participants

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Dnepr 1 Launch

- ## Successful Lift-Off

- ## First stage motor shut down in the second minute of flight

- ## Created a crater 70 m long, 25 m deep

- ## Failure analysis currently being performed

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CubeSat Lessons

- Constantly recruit

- Document well

- TEST

- Keep planning ahead

- Get advice

- State department officials are nice... so are customs officers

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Developers Lessons

- The CubeSat tolerances are tight

- Practice building before touching flight hardware

- Think through component usage

- Be flexible in your design

- Build in margin

  - DOCUMENT
  - TEST
  - REPEAT
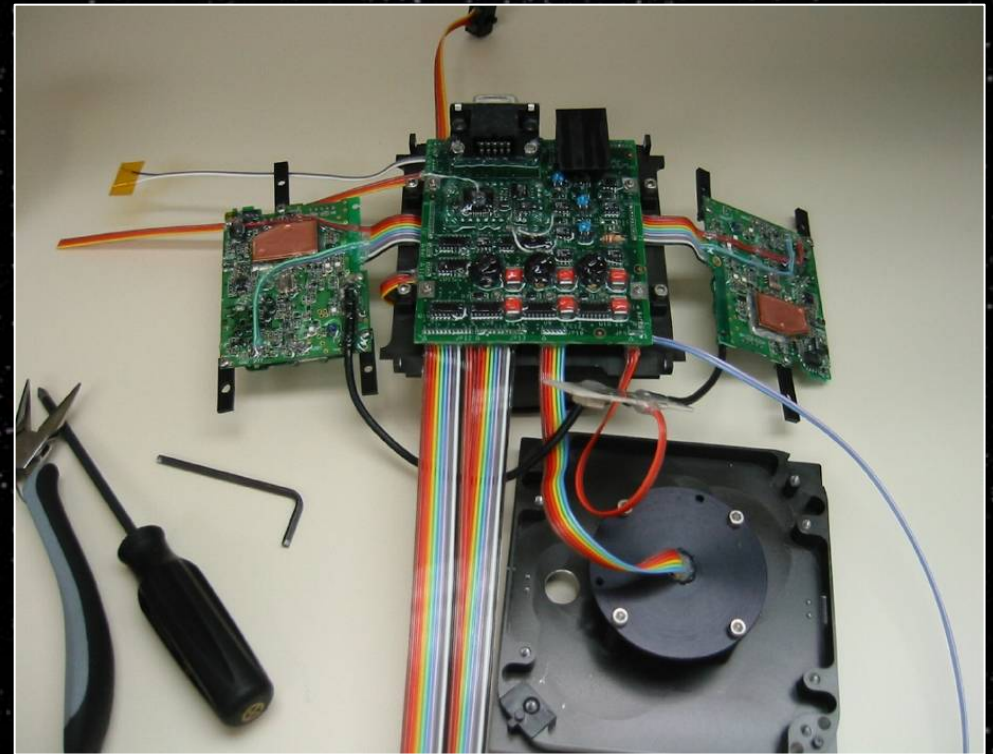
Successes

- CubeSat Accomplishments

  - Successful coordination and launch of 14 satellites

  - Fully functional 1-3 kg satellites at a low cost

  - International earth station networking

  - Changing launch vehicles 5 months before launch

  - Launching US as well as foreign spacecraft

  - Multiple launch opportunities

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Successes

- ## Student Benefits
  - Experience in: designing, testing, budgeting, testing, designing, teamwork, networking, testing...

  - Elementary through University can be involved

  - Thesis/Senior Projects in real-world application

  - Great jobs after school!
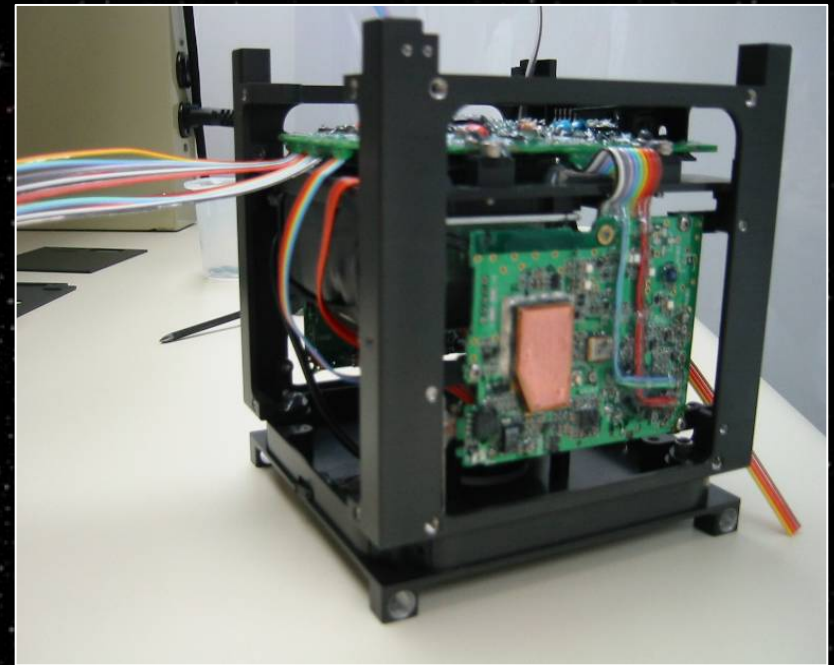
Successes

- Industry Benefits
  - Research is beneficial to all
  - Viable options for multiple purposes
  - Opportunities to sponsor space research
  - Very low cost
  - Experienced grads entering the market
  - Develop US launch opportunities

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Successes

- Scientific Benefits

  - Size of satellites are shrinking

  - Research is more affordable, reduced need for free launches

  - Space on LV for more payloads

  - Technology is allowing more options on CubeSats

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Future Launches

- Dnepr 2 scheduled for Winter 2006
- 7 satellites in 3 PPODs
- Falcon-1 Launch scheduled for 2007
- NLV's being developed

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Final Lesson from Russia

How to toast!

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Questions?

In Memory of Cliff K7RR

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