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

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

---

**CSTB1 Solar Panel Power**

**CSTB1 Temperatures**

**CSTB1 Temperature**
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 of Cal Poly Cubesat 65 seconds after ejection.

Aerocube-2 Temperature Data (First 12 hrs)
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

Launch Opportunity

Launch Opportunity

Launch Opportunity

Launch Opportunity

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer

Spacecraft Developer
Flexible Secondary Launches

- Launch Opportunity
- Launch Opportunity
- Launch Opportunity
- Launch Opportunity

P-POD (Standardized)

- Spacecraft Developer
- Spacecraft Developer
- Spacecraft Developer
- Spacecraft Developer
- Spacecraft Developer
- Spacecraft Developer
- Spacecraft Developer
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

Vibration

To Integration

Thermalvac

Clean Room
RESULTS

From Design 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…