Advanced CubeSat Capabilities

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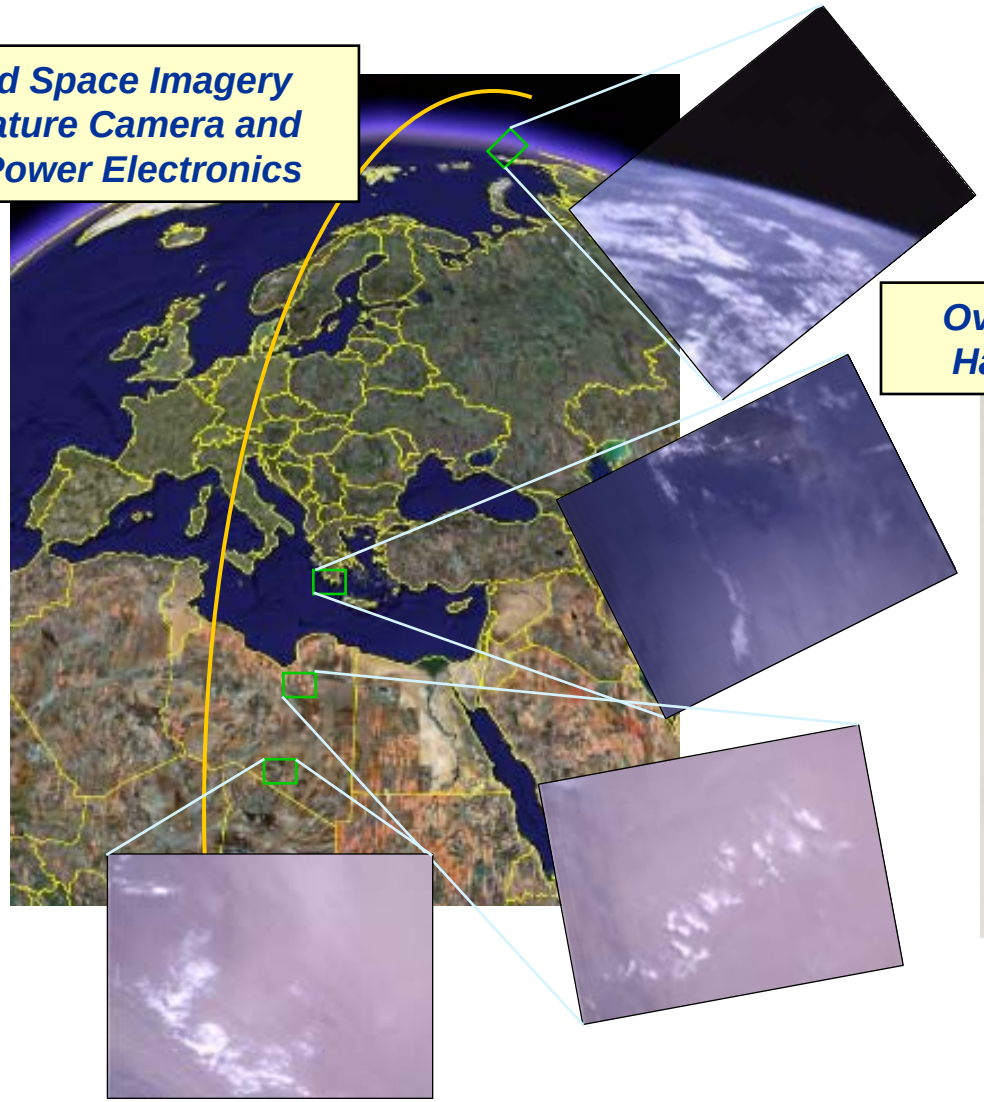
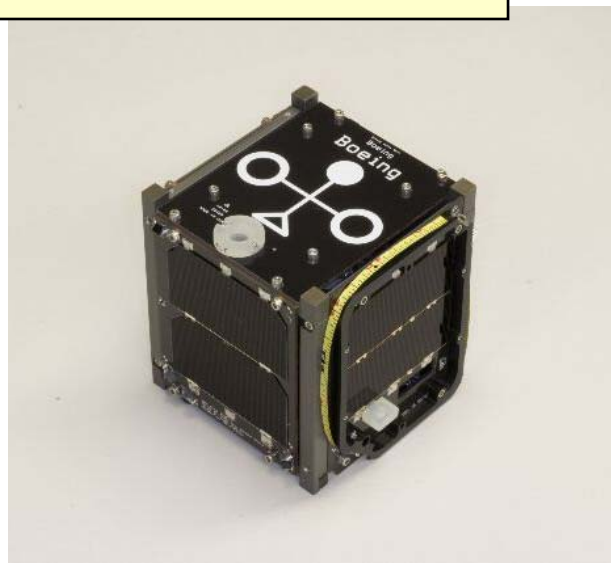
CSTB1 Continues to Operate after 2 Years

- Has Provided a Wealth of Data and Validated Key Technologies

Ground and Space Imagery Using Miniature Camera and Ultra-Low Power Electronics



Over 1,125,000 Data Points Have Been Downloaded !!



How Do We Measure the Utility of NanoSats?

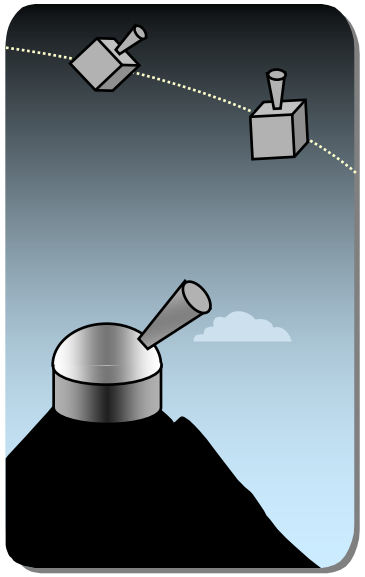
- How Do We Exploit the Strengths of NanoSats?

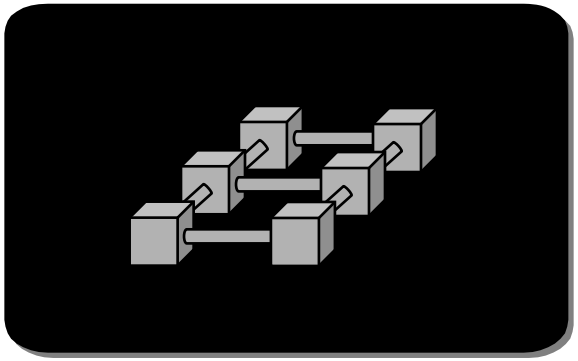
- Utility is Measured the Same Way We Do For Larger Satellites
  - Availability
  - Coverage
  - Resolution

- Key Attributes of NanoSats
  - Cheaper to build and launch
  - Deploy in quantity
  - Small size

Operate in Proximity
- **Resolution**
- **Availability**

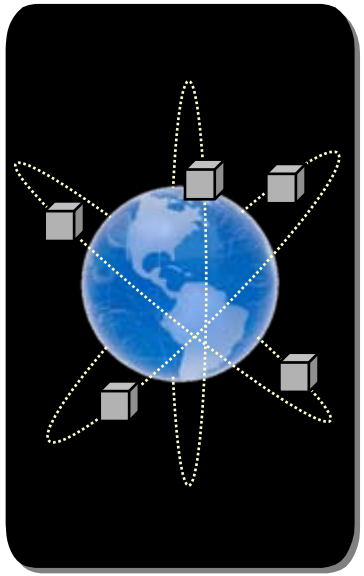
"A 5 inch television looks like a big screen when you are sitting 15 inches away"





Modular, Reconfigurable Vehicle
- **Adaptability**
- **Flexibility**

"Lego-Sats"

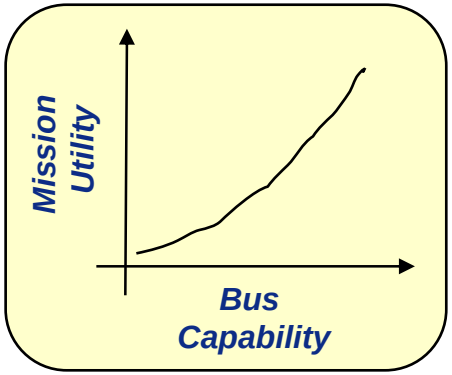


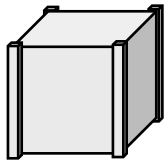
Deploy Constellations of Vehicles
- **Coverage**
- **Availability**

"Timely coarse data can sometimes be more important than high-fidelity, dated data"

Evolution of Nano-Satellites

- Growth in Capability is Inter-Related





Challenge: How to package more capability into CubeSat envelope

Note: Values are Notional

Current CubeSat Performance

- *What Does the Future Hold?*

Subsystem/ Requirement	Parameter	[units]	Current *
C&DH	Performance Storage	[MIPS/W] [GB]	< 500 < 2?
TT&C	Frequency Bandwidth Data Security	[Band] [kbps]	UHF/ ISM/ S-Band < 25? none, ??
ADCNS	Knowledge Control Navigation	[deg] [deg] [m]	> 0.1 > 1.0 > 200
Propulsion	Delta-V Thrusters I_{sp}	[m/s] [#] [s]	< 5 ? 1 - 2? ~ 45
EPS	Storage P/L OAP	[W-hr] [W]	< 50 < 4?
Special Needs	Prox Ops Re-Docking Re-Fueling		No No No
Mission Assurance	Redundancy Reliability	[strings] [%]	0, 1? < 50 ??
Life	Design	[yrs]	< 2

** State of the Art (Flown or TRL >7), Based on Open Sources*

Boeing CubeSat Solutions Available

- High Design Maturity and Flight Experience

- Low power Star Tracker for precision attitude knowledge
- Multi-thruster & single-thruster propulsion modules for orbit maneuvering and/or maintenance
- Nano-reaction wheel assembly for precision attitude control
- Complete Attitude Determination, Control & Navigation subsystem
- Flight proven, extensible electrical power collection and distribution subsystem
- Advanced Command & Data Handling subsystem
- High gain S-band antenna

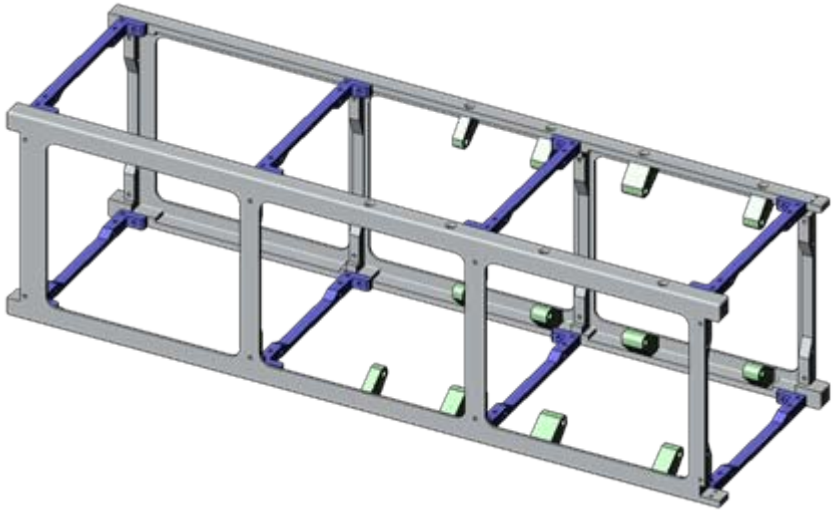
Low Risk and High Performance Subsystems and Components

Tensor™

Boeing CubeSat Structure Design

- The Tensor™ CS Class Structure

- Structural frame has only three different parts
  - The side frame part is the only part that needs to change to support the different CubeSat sizes
  - Cross-members and mounting bracket ears are common to all CS Class structures sizes (1U, 1-1/2U, 2U, and 3U)
  - Mounting bracket “ears” are the only parts that need to be changed to mount other size PCBs and internal components
- Structure does not need to be assembled first, but can be built up as internal components are assembled together
  - Allows easy access to internal components during assembly
- Design of all parts allow low cost manufacturing processes with simple set-ups
- Can be manufactured from high strength aerospace-grade aluminum to provide very low mass structure
  - Aluminum 6061-T6 has yield strength approximately 43% greater than sheet metal aluminum (e.g., 5052-H32)
  - Aluminum 7075-T6 has yield strength approximately 160% greater than sheet metal aluminum



Structure Design Available Now for Your Use

- Jump Start Your Project with a Mature Structure Design

- Royalty-free use for Non-Profit, Not-for-Profit, and Academic organizations
- Similar to “Open Source” approach with Software
- Share any changes & improvements back with CubeSat user community
- Native SolidWorks and STEP CAD Files available
  - Just need to complete and sign End User Agreement

- **Raffle for one 3U CubeSat structure frame set !!**
  - Completed End User Agreement is raffle “ticket”
  - Winners announced during final Workshop session

Contact Information for CAD Files and/or More Information:
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For Government and Industry Participants…

- Follow-On to Successful 2008 Workshop

2009 Government and Industry Nano-Satellite Technology and Mission ("GAINSTAM") Workshop

- **November 4th & 5Th, 2009**
  - ***Wednesday*: Open Forum for all Government and Industry Organizations**
  - ***Thursday*: Closed Forums for Company Proprietary and Classified Presentations**
- **Presentations by Key Members from Government and Industry**
- **Facilitated Discussions on Future Missions and NanoSat Technology Developments**
- **Huntington Beach, CA**

Thank You…

Enjoy the 6th Annual CubeSat Developers Workshop !