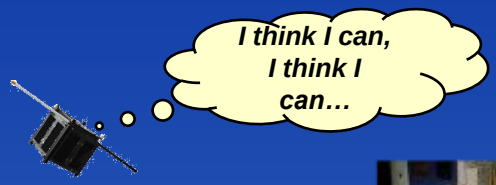


CubeSats- Some Thoughts From an Industry Perspective

Charles S. "Scott" MacGillivray
Manager, Nano-Satellite Programs
Advanced Network & Space Systems

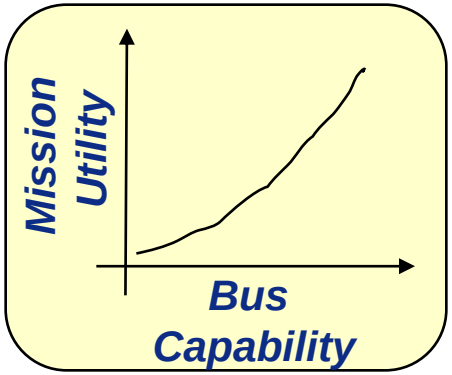
Industry and Academia Have Some Significant Differences

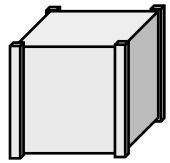
- *Uses of CubeSats Seen Differently*

Industry 	Academia 
Goals / Motivations ▪ **Meet customer's mission requirements within budget and schedule** ▪ **Generate mission data and deliverables** ▪ **Represents a valuable endeavor**	Goals / Motivations ▪ **Learning / training experience for students** ▪ **To have "*University of >enter yours<'s first satellite*"** ▪ **To communicate with the spacecraft, or to take pictures from space** ▪ **General / theoretical research; test new sensor**
Constraints / Negatives ▪ **Contractual obligation of financial, schedule, and performance goals** ▪ **Higher cost of doing work** ▪ **High reliability; it has to work** ▪ **Competitive environment; need to protect intellectual property (IP)**	Constraints / Negatives ▪ **Lack of funds (budgets in $10k-$100k's)** ▪ **'Churn' of students requires significant re-education** ▪ **CubeSat project is secondary to classes** ▪ **Generally, minimal compliance to US State Dept export regulations (exception: Cal Poly)**
Advantages / Positives ▪ **Ability to focus on the project** ▪ **Depth and breadth of experience** ▪ **Rigorous compliance to US State Dept export regulations** ▪ **Deep pockets and *ooh-aah* neat equipment** ▪ **Budgets of $1Ms-$10Ms**	Advantages / Positives ▪ **Inexpensive, motivated labor** ▪ **Flexible performance goals** ▪ **Open and information-sharing environment**

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?*

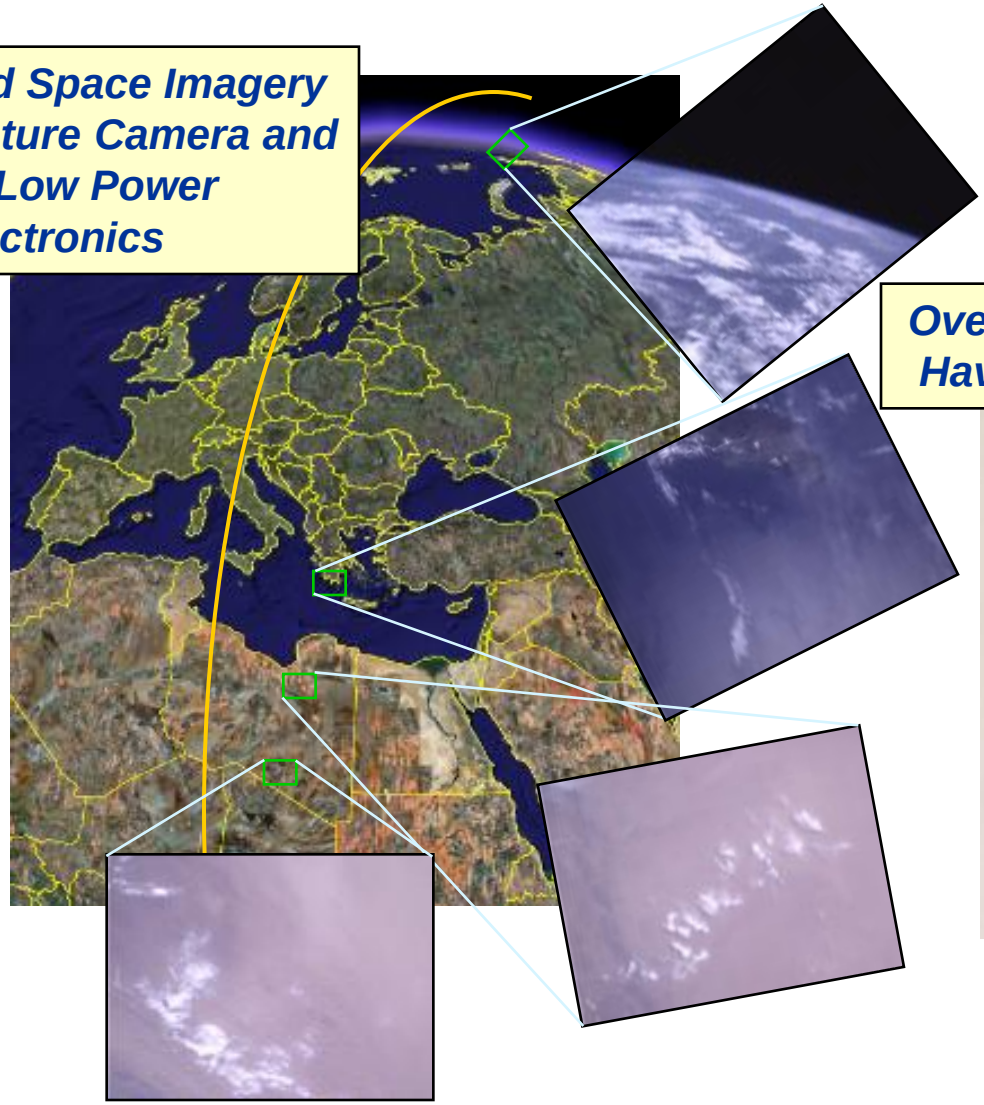
Subsystem/ Requirement	Parameter	[units]	Current *
C&DH	Performance	[MIPS/W]	< 500
	Storage	[GB]	< 2?
TT&C	Frequency	[Band]	UHF/ ISM/ S-Band
	Bandwidth	[kbps]	< 25?
	Data Security		none, ??
ADCNS	Knowledge	[deg]	> 0.1
	Control	[deg]	> 1.0
	Navigation	[m]	> 200
Propulsion	Delta-V	[m/s]	< 5 ?
	Thrusters	[#]	1 - 2?
	I_{sp}	[s]	~ 45
EPS	Storage	[W-hr]	< 50
	P/L OAP	[W]	< 10?
Special Needs	Prox Ops		No
	Re-Docking		No
	Re-Fueling		No
Mission Assurance	Redundancy	[strings]	1, 2?
	Reliability	[%]	> 50 ??
Life	Design	[yrs]	< 1

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

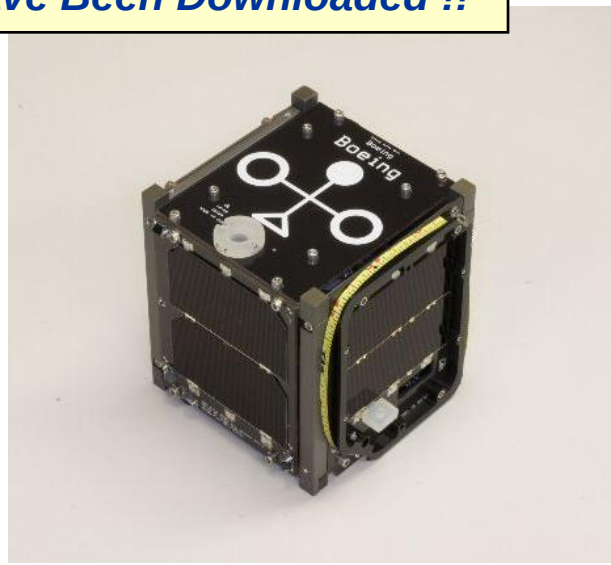
CSTB1 Continues to Operate after 27+ Months

- Has Provided a Wealth of Data and Validated Key Technologies

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



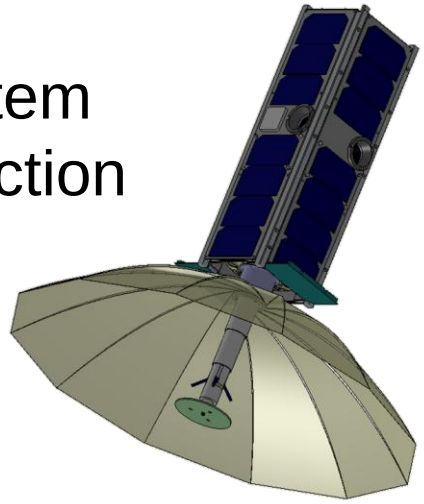
Over 1,125,000 Data Points Have Been Downloaded !!



Boeing CubeSat Solutions Available

- High Design Maturity and Flight Experience

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



Tensor™

For Government and Industry Participants…

- Follow-On to Successful 2008 Workshop

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

Goal: To Address the Unique Needs of Government and Industry for NanoSat & CubeSat Technologies and Missions

- **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**
- **Contact Scott MacGillivray for Information, and to Register**

Thank You…