CubeSat Launch Initiative

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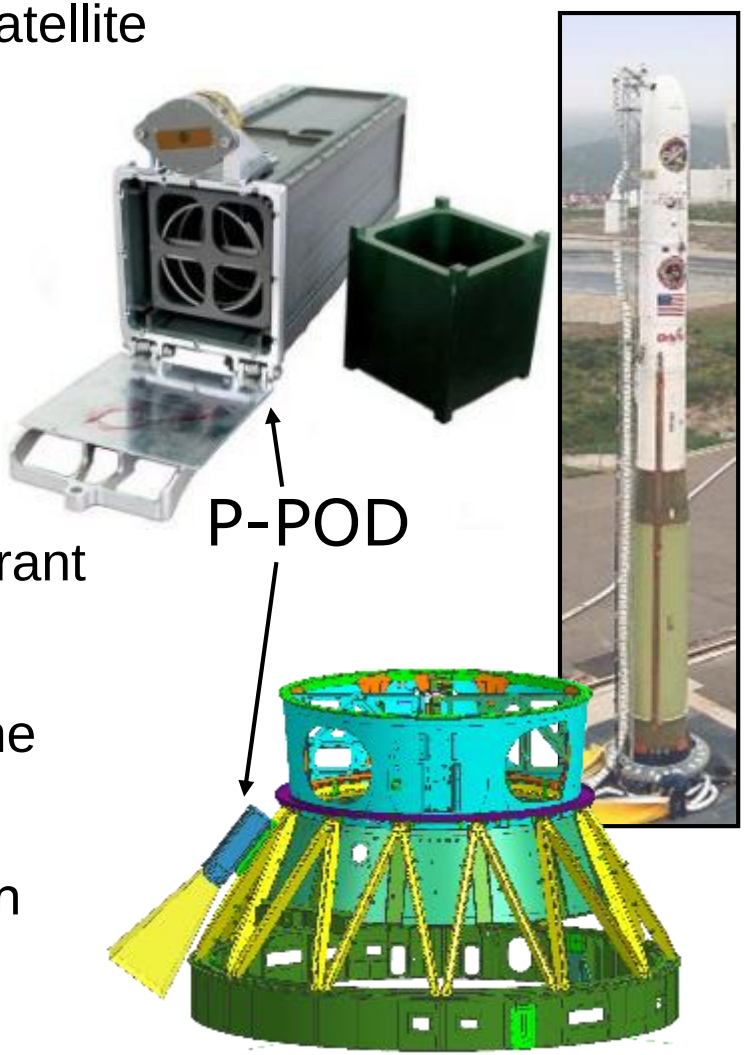
What is a CubeSat?

- A CubeSat is a type of space research nanosatellite
- The base CubeSat dimensions are 10x10x11 centimeters (one "Cube" or "1U"), or approximately four inches
- CubeSats are typically 1U, 2U, 3U, or 6U in volume and typically weigh no more than 1.33 kilogram (about 3 pounds) per 1U Cube
- CubeSats are typically low-cost, high risk-tolerant payloads
- Deployed from standard deployers, such as the “Poly-Picosatellite Orbital Deployer (P-POD)”
- P-POD’s versatile, small profile, tubular design holds three 1U CubeSats or can integrate CubeSats of different lengths (i.e., up to 3U)

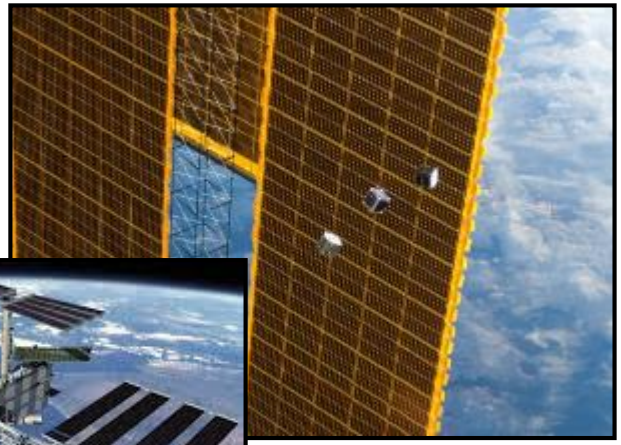


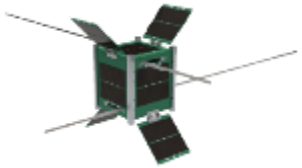
CubeSat Launch Initiative

NASA's CubeSat Launch Initiative (CSLI) provides launch opportunities to educational institutions, non-profit organizations and NASA Centers who build small satellite payloads that fly as auxiliary payloads on previously planned launches or commercial mission or as International Space Station deployments.

NASA
DoD
NRO

ISS





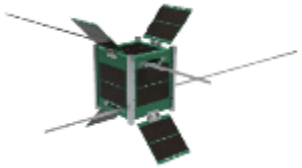
CubeSat Launch Initiative

Objective

- Provide CubeSat Launch Services on Expendable Launch Vehicles and deployments from the International Space Station to U.S. Educational Institutions, Non-profits and NASA Centers.

Aligned to NASA's Strategic Plan

- Strategic Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.
  - *Objective 1.7*: Transform NASA missions and advance the Nation's capabilities by maturing crosscutting innovative space technologies.
- Strategic Goal 2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.
  - *Objective 2.3*: Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.
  - *Objective 2.4*: Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets.



How It Works

NASA Announcement of Opportunity

- NASA solicits proposals through an Announcement of Opportunity (AO)
- Educational Organizations, Non-Profits and NASA Centers submit proposed CubeSat Missions in response to AO

NASA Review

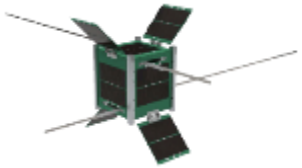
- A NASA Selection Committee made up of members of HEOMD (including the Launch Services Program), Space Technology Mission Directorate, Science Mission Directorate, and Education reviews proposals
- Selection Committee makes final recommendations on CubeSats
- NASA announces selection recommendations

Selectees Develop/Design/Build CubeSat

- Selectee builds satellite
- Selectee raises all funds necessary for satellite construction
- Selectee provides NASA completed satellite for integration for launch

NASA Assigns CubeSats to Manifested Launches

- NASA manifests CubeSat on available flights using excess lift capacity
- Cooperative Research and Development Agreement executed by NASA



Payload Eligibility

Benefit to NASA

Investigation must demonstrate a benefit to NASA by addressing goals and objectives of the NASA Strategic Plan and/or the NASA Education Vision and Goals.

Merit Review

Prior to submission each CubeSat investigation must have passed an intrinsic merit review. In the review, goals and objectives of the proposed investigation must be assessed to determine scientific, educational or technical quality of the investigation.

Feasibility Review

Prior to submission each CubeSat investigation must have passed passed a feasibility review in which the technical implementation, including feasibility, resiliency, risk and probability of success, was assessed.

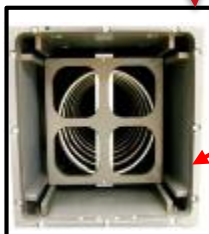
Post Selection

CubeSats are Developed/Designed/Built

CubeSats are placed in dispenser

Dispenser is integrated on the Launch Vehicle

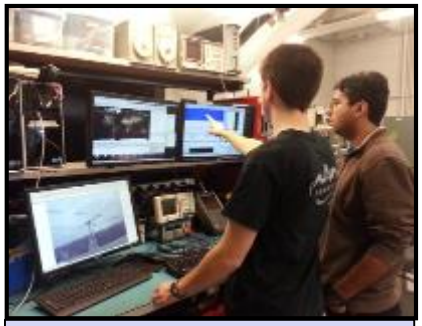
Mission Launches



Deployment spring and pusher plate

Signal Sent to LV, spring-loaded door is open, CubeSats deployed

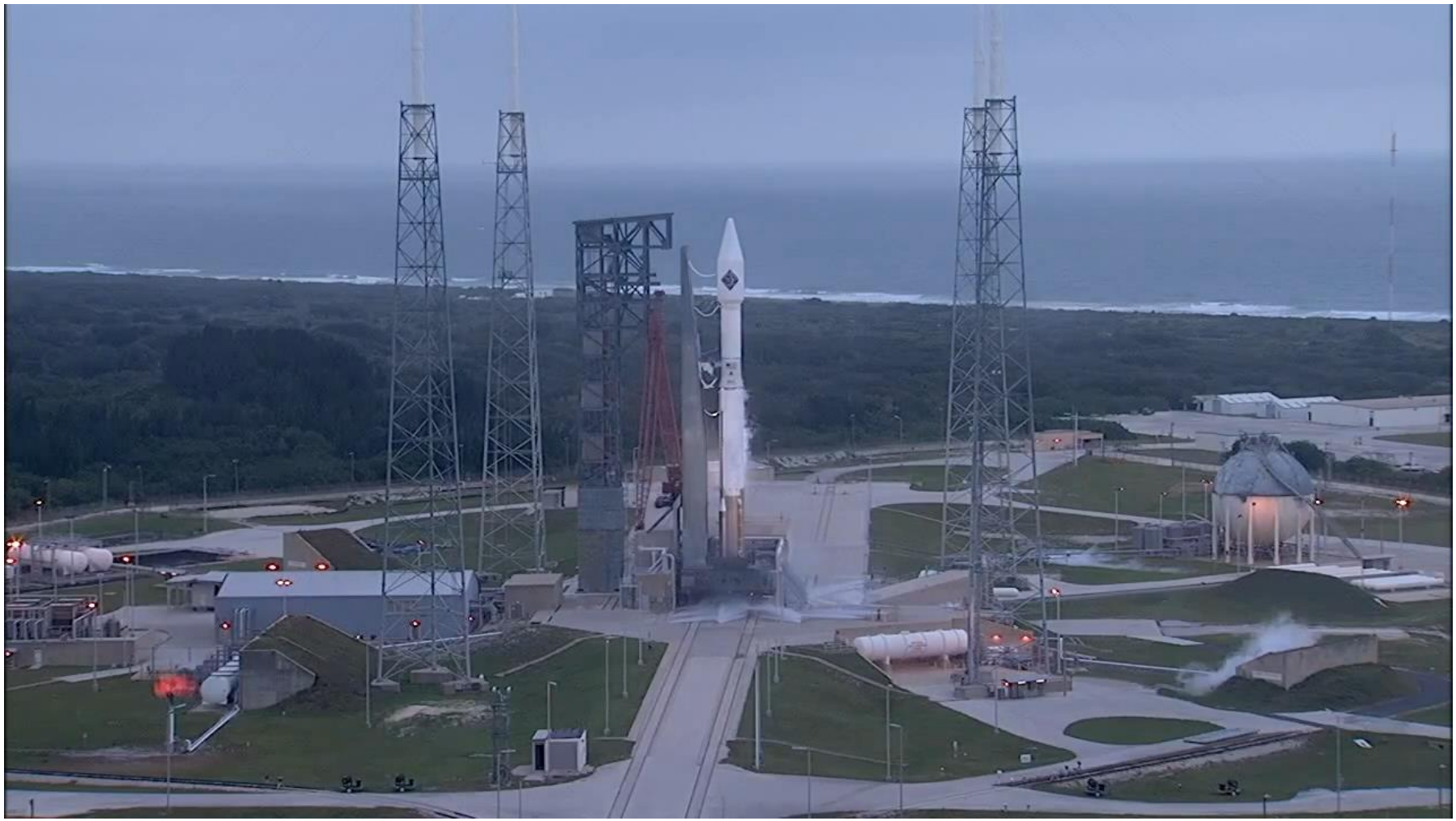
Students or Center track and operate CubeSat from Ground Station



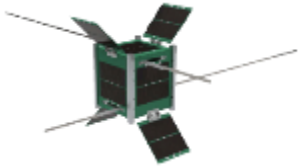
CubeSat burns up on re-entry after completion of mission

Students or Center analyze data, write technical papers, provide results and data to NASA

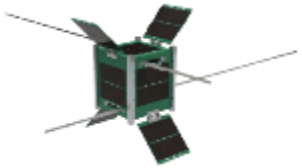
OA-4 Launch



ELV Deployment



ISS Deployment



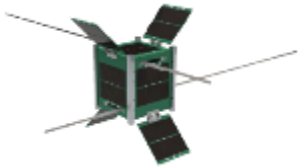
CSLI Benefits

Benefit to Educational Organizations and Non-profits:

- Enables students, teachers and faculty to obtain hands-on flight hardware development experience
- Advances the development of technologies
- Provides mechanism to conduct scientific research in the space environment
- Provides meaningful aerospace and Science, Technology, Engineering and Mathematics (STEM) educational experience

Benefit to NASA:

- Promotes and develops innovative public-private partnerships
- Provides a mechanism for low-cost technology development and scientific research
- Enables the acceleration of flight-qualified technology assisting NASA in raising the Technology Readiness Levels (TRLs)
- Strengthens NASA and the Nation's future STEM workforce



CSLI Implementation Partnerships

Partnerships with other US Government Agencies/Departments

- NASA has established inter-agency agreements with USAF and NRO for CubeSat integration onto non-NASA launches
- NASA assists non-government CubeSat developers in seeking FAA, FCC and NOAA licenses (as necessary)

Partnerships with commercial entities

- NASA has established CubeSat Dispenser Hardware and Integration Services (CSDHISC) IDIQ contract to provide integration hardware and perform integration activities

Partnerships with commercial entities

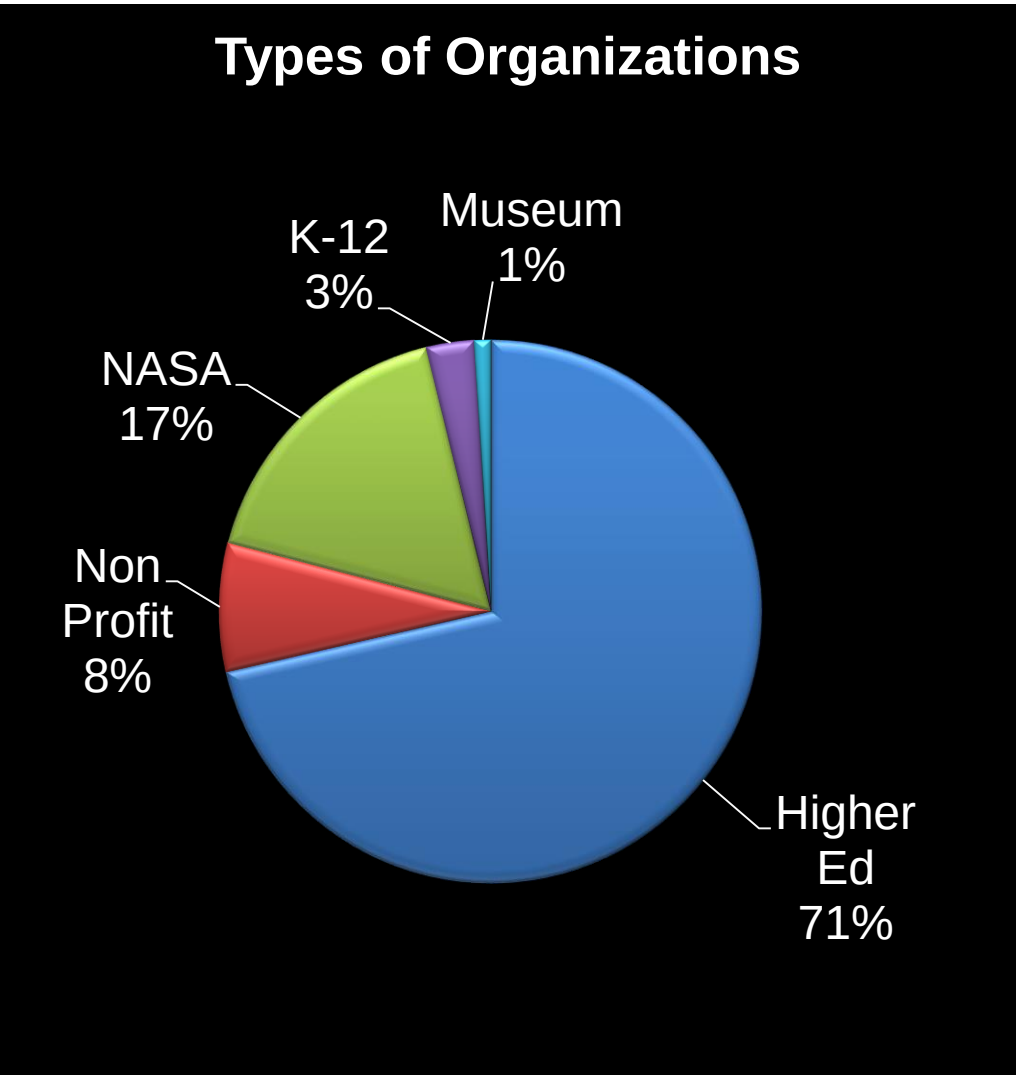
- Public-Private Partnerships – Cooperative Research and Development Agreements with U.S. universities, Non-profits and NASA Centers to provide low-cost technology development and scientific research.
  - 105 projects involving 44 universities, five Non-profits and five NASA Centers

2009–2015 CubeSat

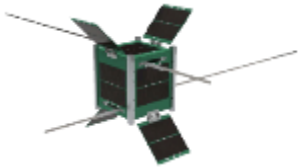
105 Selections – 61 Organizations – 30 States

2015 CSLI Selections

CubeSat Organizations

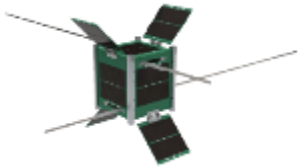


- Eligible Organizations include: Educational and Non-profit Institutions, NASA Centers
- Majority of proposing organizations are universities
- 61 Unique Organizations Selected
- 48% of the universities utilize Space Grant and Experimental Program to Stimulate Competitive Research (EPSCoR) Funding
- 2013 we launched TJ^{3}Sat, the first CubeSat built by and launched for a high school
- 2016 we will launch STMSat-1, the first CubeSat built by and launched for a primary school



CSLI Proposals

	Proposals	Selected	Flown	Manifested	% Launched	% Launch & Manifested
1st Selection	6	4	4		100%	100%
1st Initiative	16	12	11	1	92%	100%
2nd Initiative	25	14	8	2	67%	83%
3rd Initiative	33	26	8	6	32%	56%
4th Initiative	34	24	1	4	5%	26%
5th Initiative	22	16		2	0%	13%
6th Initiative	22	14			0%	0%
	158	110	36	15	34%	48%



CubeSat Focus Areas

Proposed CubeSats must align to NASA's Strategic Plan and, if appropriate, the Education Strategic Coordination Framework.

- 72% conducting Technology Demonstrations
- 53% conducting Scientific Research
- 53% supporting Education

Scientific Research

- Biological Science
- Earth Science
  - » Snow/Ice Coverage
- Near Earth Objects
- Orbital Debris Tracking
- Space Based Astronomy
- Space Weather

Technology Demonstrations

- In-Space Propulsion
- Space Power
- Radiation Testing
- Tether Deployment
- Solar sails
- Material Degradation
- Solar Cells
- Additive Manufacturing

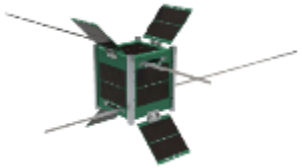
NASA CubeSat Carriers

Atlas V		Delta IV	Delta II	Taurus XL	Athena	Falcon 9		ISS/CRS	Super Styrpi
Common	ABC	Common	2nd Stg Struts Section	Aft End 3rd Stg	Aft End	CRS	Fairing	(e.g., NanoRacks)	Load Path Adapter
Studied	Flown	Studied	Flown	Flown	Studied	Flown	Flown	Flown	Flown





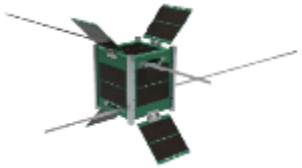


Completed Missions

CubeSat Mission	Primary Mission	Launch Vehicle	Launch Date	Dispensers	CubeSats
ELaNa-I	Glory	Taurus XL	Mar 4, 2011	1	3
ELaNa-II	NROL-39*	Atlas V	Dec 5, 2013	2	5
ELaNa-III	NPP	Delta II	Oct 28, 2011	3	5
ELaNa-IV	ORS-3*	Minotaur	Nov 19, 2013	4	11
ELaNa-V	CRS SpX-3	Falcon 9	Mar 16, 2014	4	5
ELaNa-VI	NROL-36*	Atlas V	Sep 13, 2012	3	4
ELaNa-VIII	ORB-3	Antares	Oct 21, 2014	Nanoracks	1
ELaNa-X	SMAP	Delta II	Jan 30, 2015	3	4
ELaNa-XI	AFSPC-5	Atlas V	May 20, 2015	1	1
ELaNa-XII	NROL-55*	Atlas V	Oct 8, 2015	2	4
ELaNa-VII	ORS-4*	Super Strypi	Oct 29, 2015	2	2
ELaNa-IX	CRS OA-4	Atlas V	Dec. 6, 2015	Nanoracks	4
				Total Launched	49

* Consistent with the National Space Policy of 2010, NASA has agreements with the national security space community to leverage our respective launch capabilities.



Planned Missions

CubeSat Mission	Primary Mission	Launch Vehicle	Launch Date	Dispensers	CubeSats
ELaNa-XIII	FORMOSAT-5	Falcon 9	FY 2016	2	2
ELaNa-XVI	CRS OA-5	Antares II	FY 2016	Nanoracks	1
ELaNa-XV	STP-2	F9 Heavy	FY 2016	2	3
ELaNa-XIV	JPSS-1	Delta II	FY 2017	3	4
ELaNa-XVII	CRS OA-7	Antares II	FY 2017	Nanoracks	6
ELaNa-XIX	VCLS	Rocket Labs	FY 2017	TBD	TBD
ELaNa-XVIII	ICESat-2	Delta II	FY 2018	3	3
ELaNa-XX	VCLS	Virgin Gal.	FY 2018	TBD	TBD
ELaNa-XXI	VCLS	Firefly	FY 2018	TBD	TBD

* Consistent with the National Space Policy of 2010, NASA has agreements with the national security space community to leverage our respective launch capabilities.

Missions Examples

CSSWE
University of Colorado – Boulder, Co.

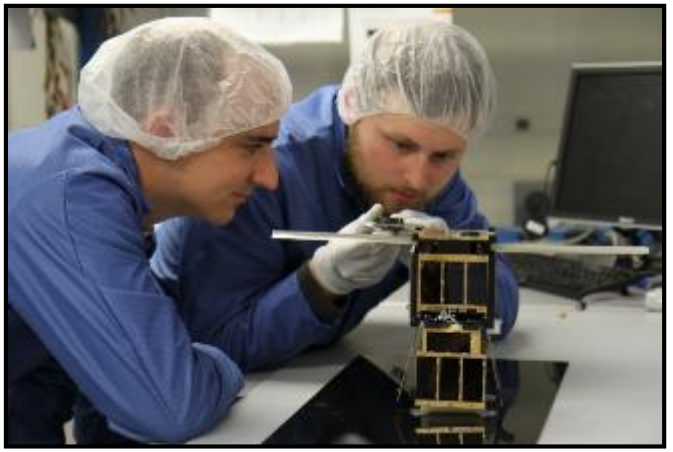
- Measure the directional flux of Solar Energetic Protons (SEPs) and Earth's radiation belt electrons in support of NASA's Radiation Belt Storm Probe Mission
- Space Weather - Heliophysics
- Payload: Relativistic Electrons and Proton Telescope

GOAL: Understand the relationship between SEPs flares and coronal mass ejections

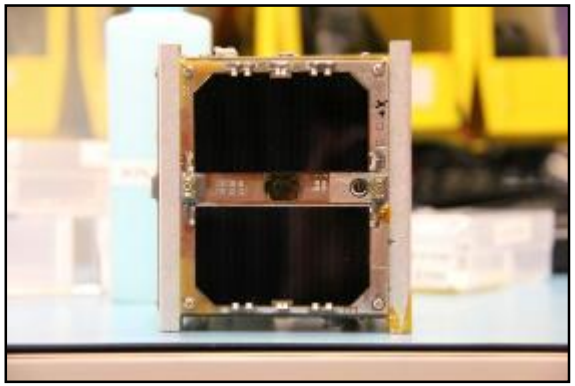
KySat-2
University of Kentucky – Lexington, Ky.
Morehead State University – Morehead, Ky.

- Test components of a novel attitude determination system called a Stellar Gyroscope that uses sequences of digital pictures

GOAL: Determine the three-axis rotation rate of the satellite



Missions Examples



M-Cubed
University of Michigan – Ann Arbor, MI.

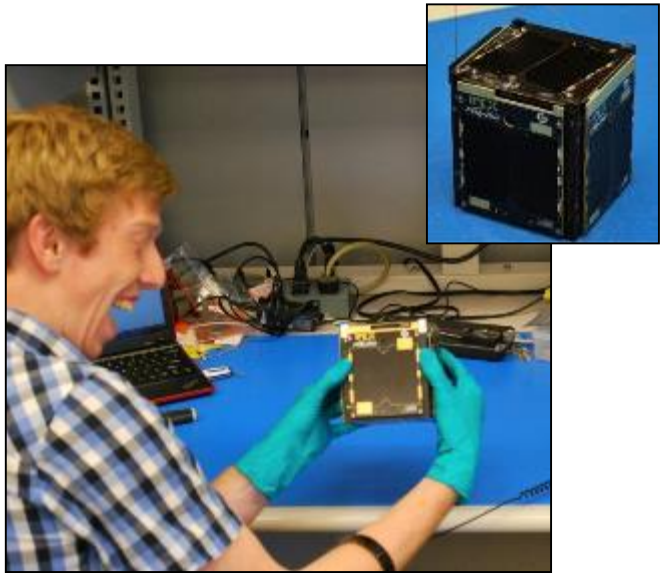
- Obtain mid-resolution imagery of the Earth's surface and carry the JPL/Caltech CubeSat On-board processing Validation Experiment (COVE)

GOAL: COVE will advance technology required for real-time, high data-rate instrument process for future Earth Science

IPEX
JPL/Cal Poly – Pasadena, Calif

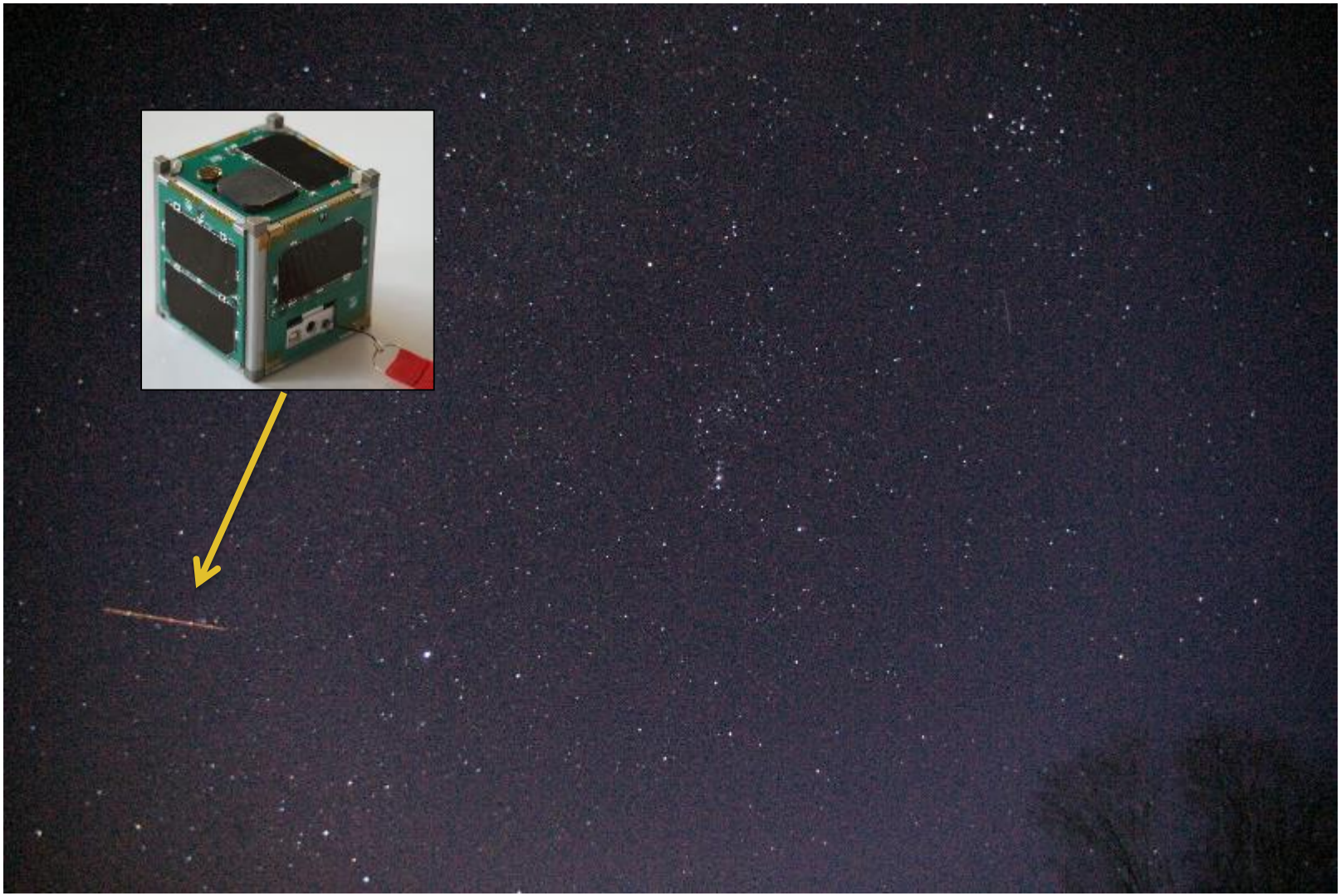
- Demonstrate Intelligent Payload Module (IPM) technologies including autonomous onboard instrument processing, downlink operations, and automated ground operations

GOAL: Validate IPM technologies which is a baseline for the HyspIRI Decadal Survey Mission



Vermont Lunar CubeSat

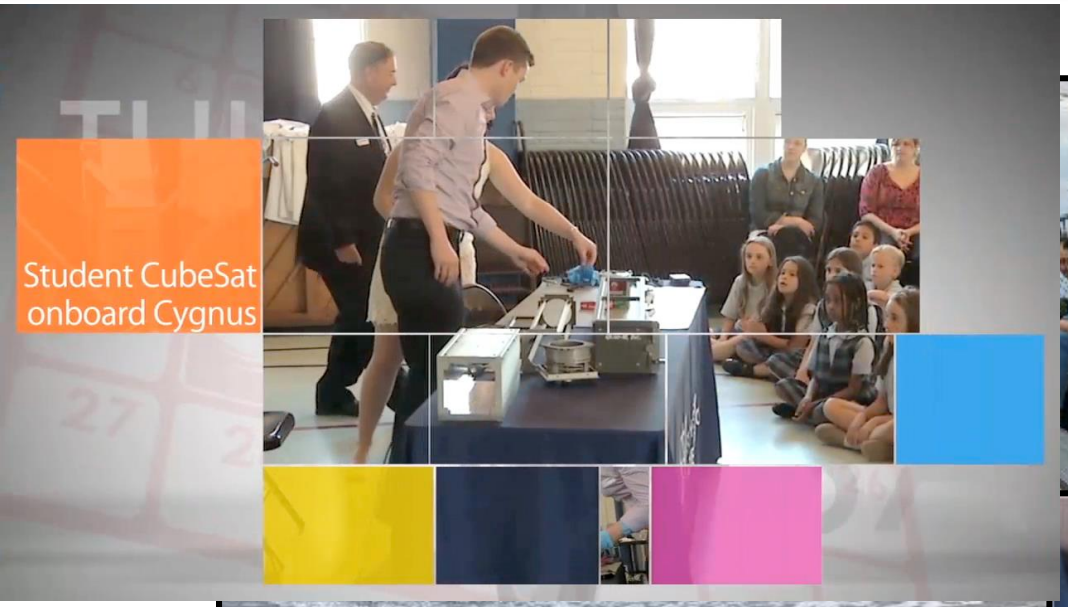
March 6, 2014

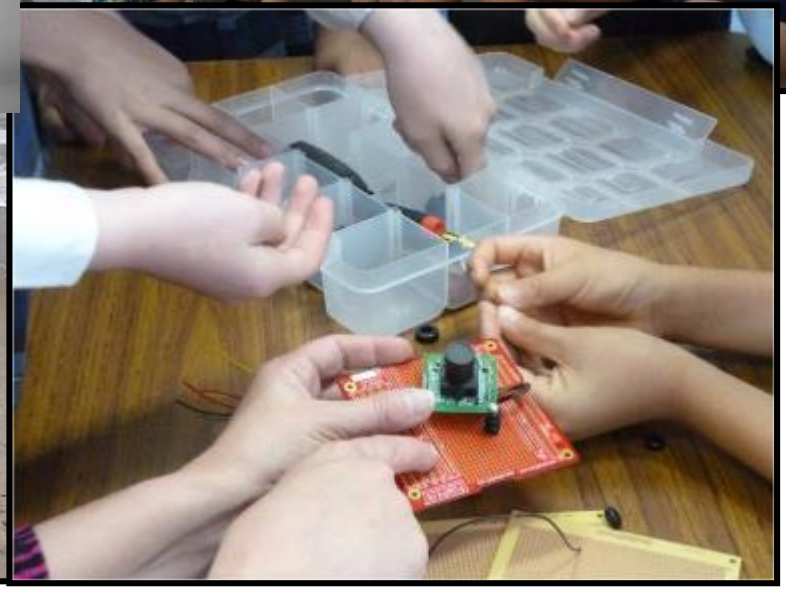


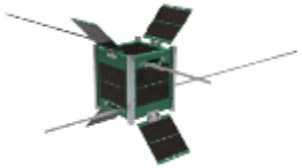
Vermont Lunar CubeSat

Thomas Jefferson High School

St. Thomas More Cathedral School







Feedback

"The ELaNa program has been a game changing event for our research center. It has allowed us to be able to show past performance in the areas of nanosatellite development. This achievement has easily resulted in over $1M in future research projects for the University of New Mexico."

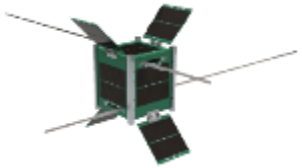
Craig Kief – TrailBlazer
Deputy Director
Configurable Space Microsystems Innovations & Applications Center (COSMIAC)

"Universal, location-independent service is a distinguishing feature of satellite technology. In that spirit, this NASA launch has afforded for our students, here in Louisiana, the same access to this high-technology areas as anyone else anywhere in the nation, and indeed around the world."

George Thomas – CAPE-2
Professor of Electrical and Computer Engineering
University of Louisiana, Lafayette

"The NASA ELaNa program provides an educational experience for the student team that can not otherwise be duplicated in a University setting. Students go from concepts on paper to operating their hardware on-orbit and the lessons learned between those two points is invaluable."

Professor James Lumpp – KYSat-2
Electrical and Computer Engineering, University of Kentucky



Want To Learn More?

http://www.nasa.gov/directorates/heo/home/CubeSats_initiative

http://www.nasa.gov/mission_pages/smallsats/elana/index.html


NASA