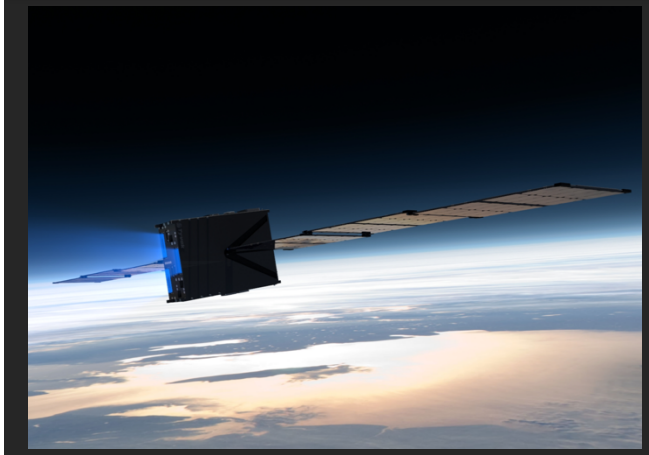
National Aeronautics and
Space Administration

SMALL SATELLITE CONFERENCE 2017
NASA TOWN HALL

August 7, 2017

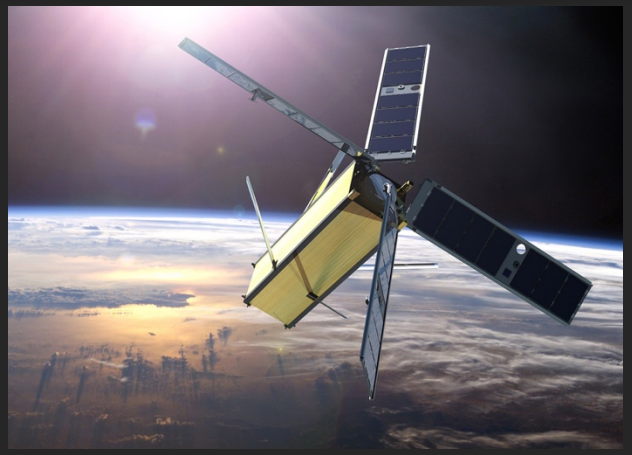
www.nasa.gov

NASA Small Spacecraft Activities



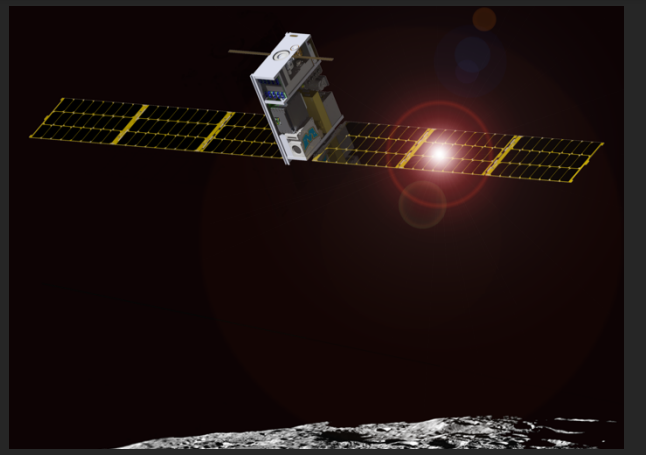
Space Technology

Developing and demonstrating new small spacecraft technologies and capabilities for NASA's missions in science, exploration and space operations.



Science

Conducting scientific investigations and developing precursor instrument technologies for future science measurements. Providing opportunities for secondary payloads in mission opportunities.



Exploration

Sponsoring missions beyond low-Earth orbit to address key strategic knowledge gaps for exploration. Providing access to space (launch opportunities) to the U.S. CubeSat community (academia, government, and non-profits).

NASA Town Hall Agenda

Opening Remarks / Space Technology Mission Directorate
Christopher Baker, Small Spacecraft Technology Program Executive

Small Spacecraft Technology (SST)
Upcoming Missions - Roger Hunter, SST Program Manager
New Initiatives - Elwood Agasid, SST Deputy Program Manager
Smallsat Technology Partnerships - James Cockrell, SST Chief Technologist

Centennial Challenges CubeQuest Challenge
James Cockrell, CubeQuest Challenge Administrator

Small Spacecraft Systems Virtual Institute
Bruce Yost, Small Spacecraft Systems Virtual Institute Director

Science Mission Directorate
Larry Kepko, Senior Program Executive for Suborbital and Special Orbital Research

Earth Science Technology Office InVEST Program Status
Pamela S. Millar, ESTO InVEST Program Manager
Charles D. Norton, ESTO Program Manager Associate

Human Exploration and Operations Mission Directorate / AES
Andres Martinez, Program Executive, Advanced Exploration Systems (AES)

CubeSat Launch Initiative
Garret Skrobot, Mission Manager

Q&A, Feedback and Dialog

Select Overview of Small Spacecraft Activities in Space Technology

Small Spacecraft Technology Program
- Small Spacecraft Technology Development
- Small Spacecraft Capability Demonstration Missions

Flight Opportunities Program
- Suborbital Flight Testing and Capability Development
- Small Launch Vehicle Technology Development

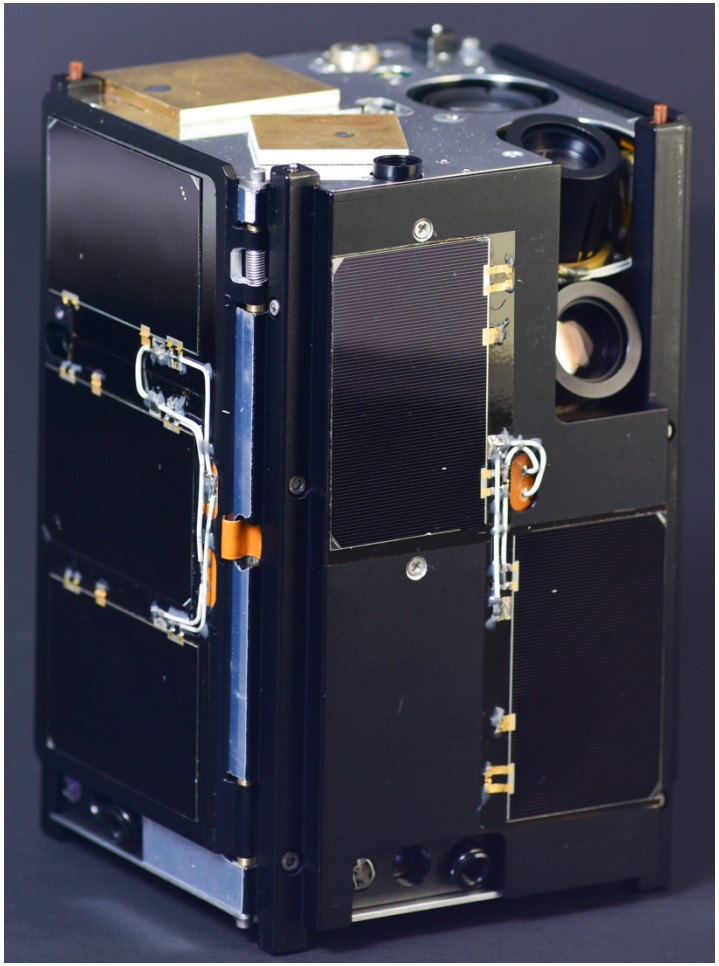
Centennial Challenges
- CubeQuest Challenge

Small Business Innovation Research
- Small Spacecraft Technology Development Subtopics

Small Spacecraft Systems Virtual Institute
- Engagement with the Small Spacecraft Community (Jointly funded by Space Technology and Science)

Other investments in Game Changing Development and Center Innovation Fund programs

Small Spacecraft Technology Program Overview



Small, Affordable, Rapid & Transformative

Goals

Expand the U.S. ability to execute unique missions by rapidly developing and demonstrating capabilities for small spacecraft.

- Enable **new mission architectures** through the use of small spacecraft.
- Expand the reach of small spacecraft to **new destinations**.
- Enable the **augmentation of existing assets and future missions** with supporting small spacecraft.

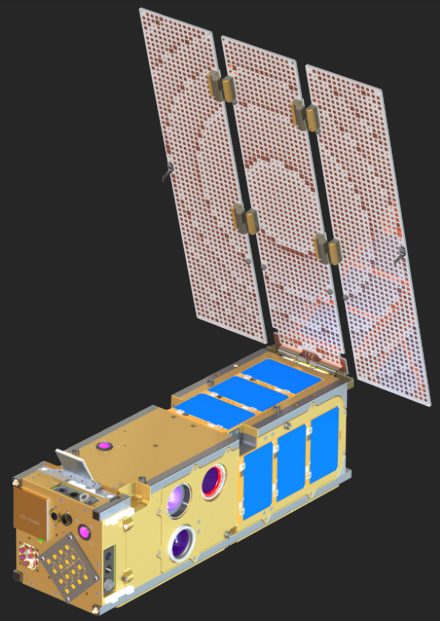
Low-cost platforms provide responsive in-space testing of new capabilities applicable to exploration, science and the commercial space sector. NASA supports and harnesses the rapid pace of innovation in the small spacecraft community through public-private partnerships, the leveraging of advances in industry, and technology transfer that supports new companies and creates new lines of business.

Three flight demonstration missions await launch in early FY 2018 with an additional mission to be delivered for launch in late FY 2018. All four missions blend public investment in new technologies with the capabilities of private industry.

Upcoming Demonstration Missions

Optical Communications and Sensor Demonstration
(OCSD)

Demonstration of small spacecraft proximity operations and high speed optical transmission of data using a miniature laser (200 Mbits/sec).

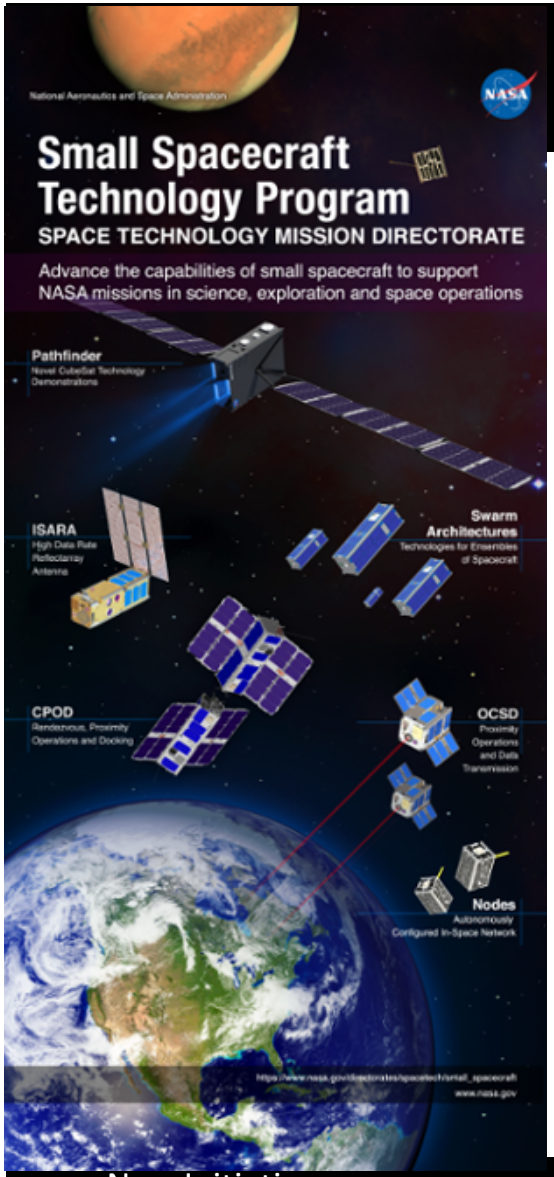


Integrated Solar Array and Reflectarray Antenna
(ISARA)

Demonstration of a Ka-band reflectarray antenna that will provide capability to increase downlink data rates for CubeSats from the existing baseline rate of 9.6 kbps, to over 100 Mbps.

CubeSat Proximity Operations Demonstration
(CPOD)

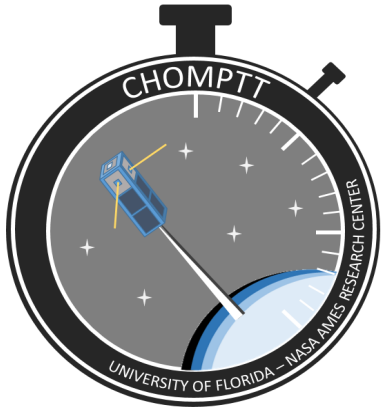
Demonstration of rendezvous, proximity operations and docking using two 3U CubeSats.



New Initiatives

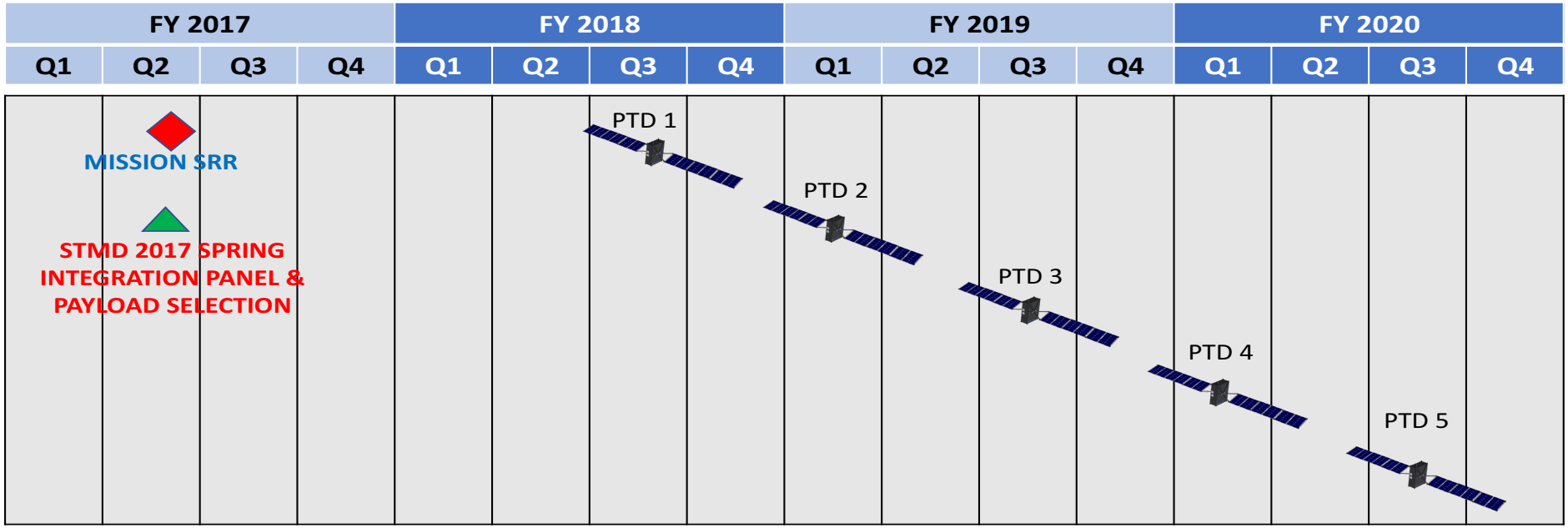
National Aeronautics and Space Administration

"Enabling commercially marketable products to advance the capabilities for small spacecraft to support a wide variety of science, exploration and commercial space missions."



PTD Missions Timeline

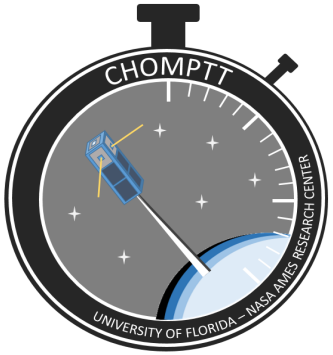
National Aeronautics and Space Administration

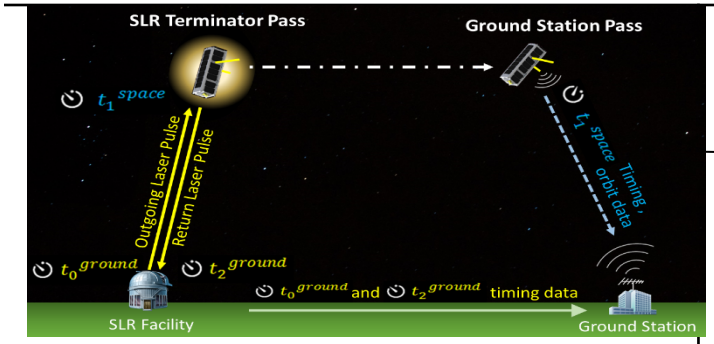


PTD Presentation on Tuesday August 8 Session III

CHOMPTT

PSSL UNIVERSITY of FLORIDA





NASA Sponsors

- HEOMD/AES
- STMD/SSTP

Spacecraft Specifications

- Size/Mass: 3U CubeSat - 4 kg
- Orbit: 500 km, 85° incl.
- Communication: UHF and Optical

Mission Description

CHOMPTT (CubeSat Handling of Multisystem Precision Time Transfer) is a collaboration between the University of Florida and NASA Ames Research Center. The mission will synchronize atomic clocks on a CubeSat with one on the ground to an accuracy of 200 ps by exchanging short laser pulses emitted from the ground, and reflected by a retro-reflector from orbit. The 1U instrument built by the University of Florida comprises a pair of chip-scale atomic clocks, picosecond event timers, and avalanche photo-detectors will be integrated into a NASA ARC 3U CubeSat bus. This technology will enable future optical navigation, satellite networking, and formation flying missions.

Mission Status

The UF flight payload was delivered to NASA ARC in May 2017. Integration and test will conclude in October, 2017 and the spacecraft will be delivered to the launch provider in January, 2018. Launch is tentatively planned for February, 28 2018 on the NASA ELaNa XIX mission, TBC pending successful Rocketlab test flights. The RF ground station at UF and the Satellite Laser Ranging Facility at KSC are currently being updated to accommodate flight operations through fall of 2018.

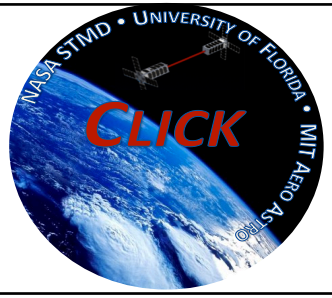
Critical Milestones

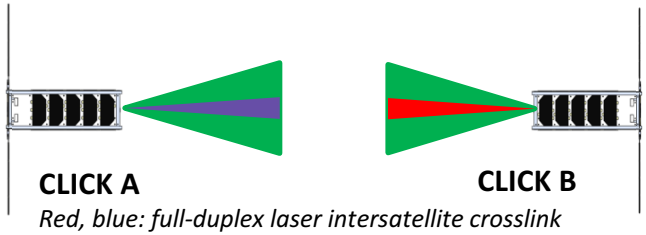
ATP	PDR	CDR	SIR/TRR	FRR	LV Integration	Launch	Mission Ops	Project Close
2/12/2015	3/10/2016	8/12/2016	7/14/2017	11/20/2017	1/15//2018	2/28/2018 TBC	2/28/2018-12/31/2018	2/28/2019

New Initiatives

CUBESAT LASER INTERATELLITE CROSSLINK

National Aeronautics and Space Administration





CLICK A **CLICK B**

Red, blue: full-duplex laser intersatellite crosslink
Green: laser beacon

Spacecraft Specifications

- Mass: 4 kg
- Quantity: Two 3U CubeSats
- Orbit: 400-800 km, 51°or 98° incl.
- Size: 10 cm x 10 cm x 34 cm
- Communication: UHF and Optical

Mission Description

The **C**ubeSat **L**aser **I**ntersatellite **C**rosslin**K** (CLICK) project will demonstrate free space optical (lasercom) crosslinks with precision timing and picosecond pulse width signals (Univ. of Florida), and precision pointing, acquisition, and tracking controls (MIT AeroAstro) in Low Earth Orbit. The cubesat will be operated by NASA, in partnership with the university teams using either a NASA or university ground data system.

CLICK will demonstrate low-cost lasercom for CubeSat based on commercial 1550 nm components, enabling crosslink and downlink capabilities to support upcoming constellation, swarm, and cluster science missions.

Status

Kickoff pending. Payload development leverages previous investments by NASA STMD, STTR, AFRL UNP, and the universities. Bus development by NASA. Payload delivery < 18 months from kickoff.

The full-duplex lasercom crosslink payload will demonstrate > 20 Mbps data rates at spacecraft separations up to at least 500 km. Bus pointing requirement of < 0.5 deg error. Propulsion optional (~10 m/s). Payload requires 12 W orbit average power.

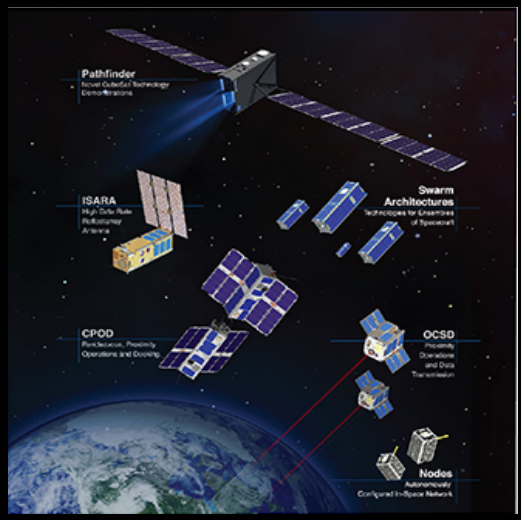
Critical Milestones – CLICK

ATP	SRR	PDR/CDR	SIR/PER	ORR/PSR/FRR	ILC	Launch	Mission Ops	Mission Duration	Project Closure
06/01/17	09/01/17	01/29/18, 06/11/18	10/15/18	04/30/19	05/27/19	TBD	TBD	90 days	TBD

Smallsat Technology Partnerships

STMD SSTP Smallsat Technology Partnerships (STP)

- Development / demonstration of new technologies for small spacecraft
- Open to U.S. colleges / universities in collaboration with NASA Center or JPL (required)
- Subsystem, payload or spacecraft technologies > TRL 3 for ground-based, suborbital or orbital demonstrations



Technology Topic Areas:

- **Instrument Technologies for Small Spacecraft**
- **Technologies that Enable Large Swarms of Small Spacecraft, and**
- **Technologies that Enable Deep Space Small Spacecraft Missions**

Awards:

- ~ 5 awards total
- Maximum 2 years; second year contingent on progress
- Maximum $200,000 each year ($400,000 maximum)
- NASA civil servant / JPL labor up to 0.5 FTE / year
- Up to $25,000 procurement for year 2 NASA expenses

Key Dates:

- Notices of Intent (Mandatory) - August 21, 2017
- Proposals - September 20, 2017
- Selections Announced November 2017 (Target)
- Awards Issued January 2018 (Target)

Solicitation on NSPIRES:

SpaceTech–REDDI–2017 Smallsat Technology Partnerships NNH17ZOA001N-17STP_E1

Cube Quest Challenge

Cube Quest Challenge incentivizes radical advancements in CubeSat capabilities for operations in deep space.
Get your CubeSat to the Moon or well beyond – perform the best – win big prizes!

Final Ground Tournament, GT-4:

Winners announced - **$20k prize and free launch on EM-1** at Small Sat: Deep Space Symposium (June 2017):

- **Cislunar Explorers** - Cornell University (Ithaca, NY)
- **CU-E3** - University of Colorado, Boulder (Boulder, CO)
- **Team Miles** - Fluid & Reason (Tampa, FL)

Next Steps:

- EM-1 launch in 2019
- Lunar Derby and Deep Space Derby

Teams have declared intent to obtain launch other than EM-1 to compete in Lunar and Deep Space Derbies!

Note: considering proposed rules change:

- Non-EM-1 teams shall provide notice of intent and required data n.l.t. 90 days prior to CubeSat delivery/integration
  - Greater time for judge's inspections and to publicize teams and their missions

L-to-R: NASA's Associate Administrator of the STMD Steve Jurczyk, Benjamin Fried of team CU-E3, Kyle Doyle of team Cislunar Explorers, Wesley Faler of Team Miles, and NASA's Ames Research Center Director, Eugene Tu

RFI and SPOON Database Activities

Request for Information (RFI) Data Call

- Collecting information regarding the State of the Art for technology, components, and systems relevant to small spacecraft for Earth and interplanetary mission design
- Seeking qualified civil servant and other government experts to serve as reviewers. If interested in volunteering as a SME sign up at the S3VI booth
- https://www.fbo.gov/spg/NASA/ARC/OPDC20220/NNA17S3VI001L/listing.html

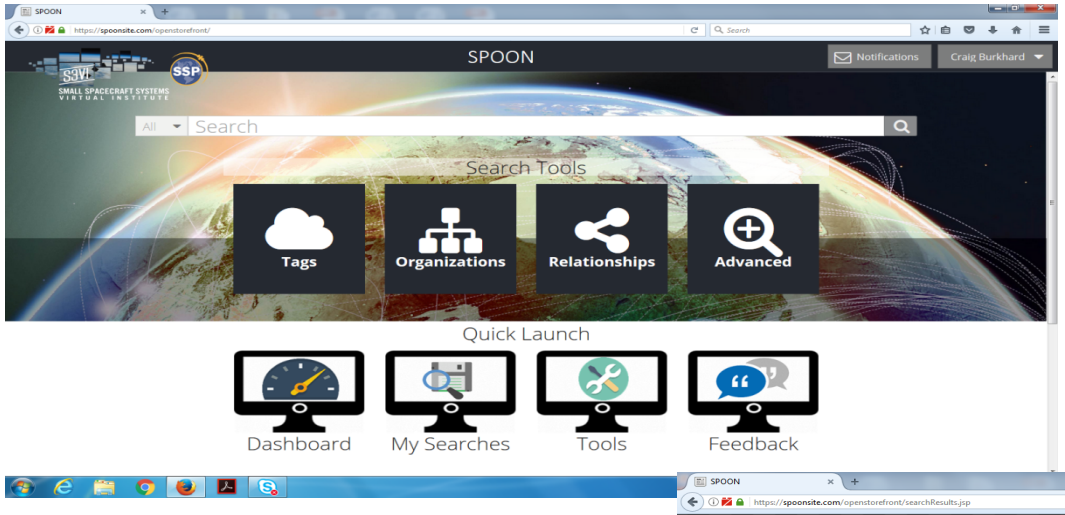
SmallSat Parts On Orbit Now (SPOON)

- This database includes a variety of small satellite components, including payloads, flight processors, antennas, propulsion systems, ground station equipment, star trackers, and more
- SPOON will be the first federated S3VI database
- https://spoonsite.com/

Points of Contact:

- Craig Burkhard (NASA Ames Research Center) craig.d.burkhard@nasa.gov, Phone: 650-604-1170
- Charlene Jacka (AFRL Small Satellite Portfolio) charlene.jacka.1@us.af.mil, Phone: 505-846-1672

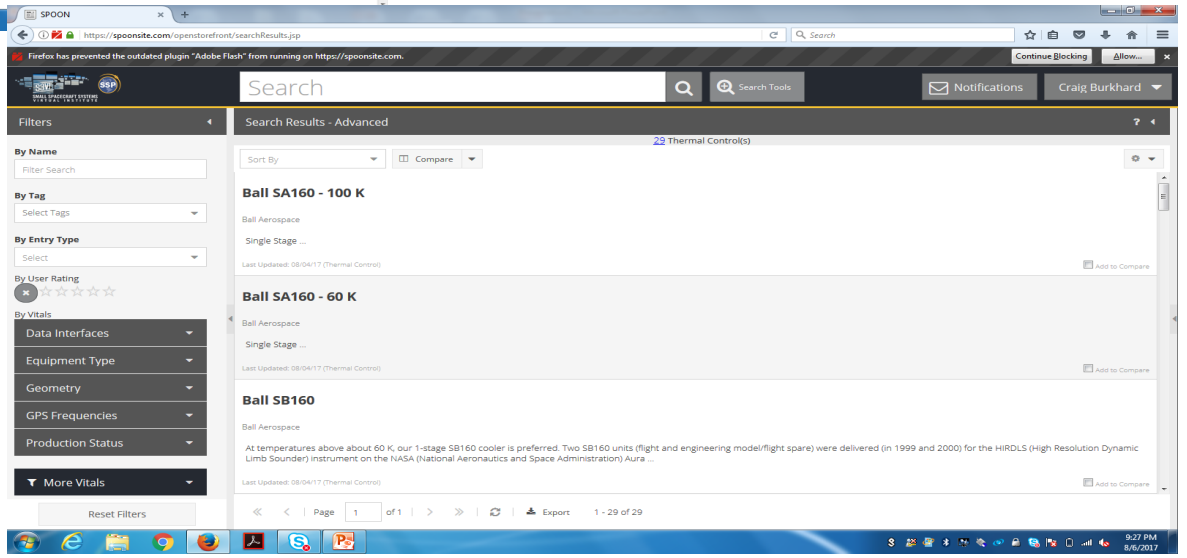
SmallSat Parts On Orbit Now (SPOON)



Search Tool Options By:

- Tag Cloud
- Entry Organization
- Relationships between Entries
- Create Advanced Searches

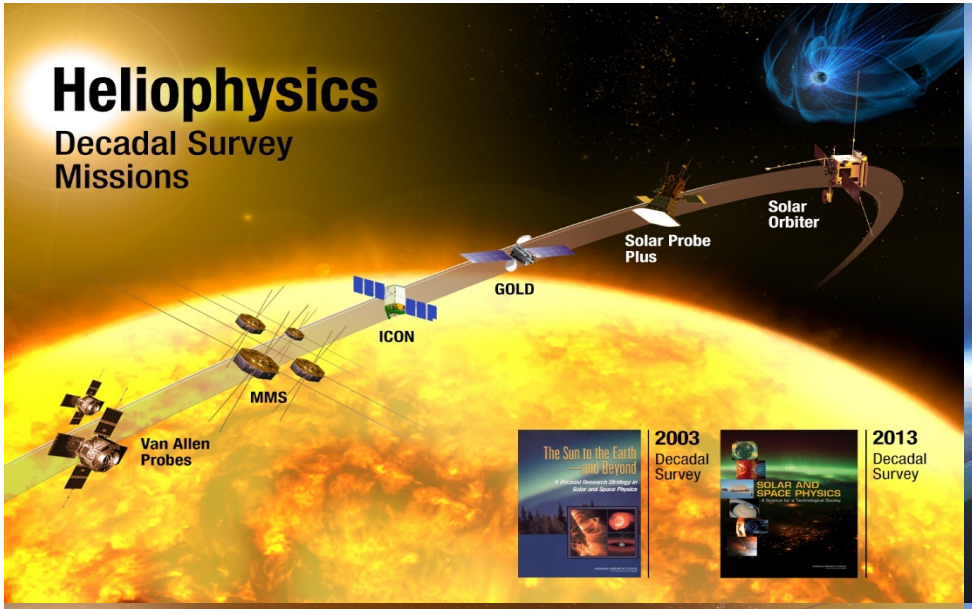
Results for a Tag Cloud Search for "Thermal Control(s)"

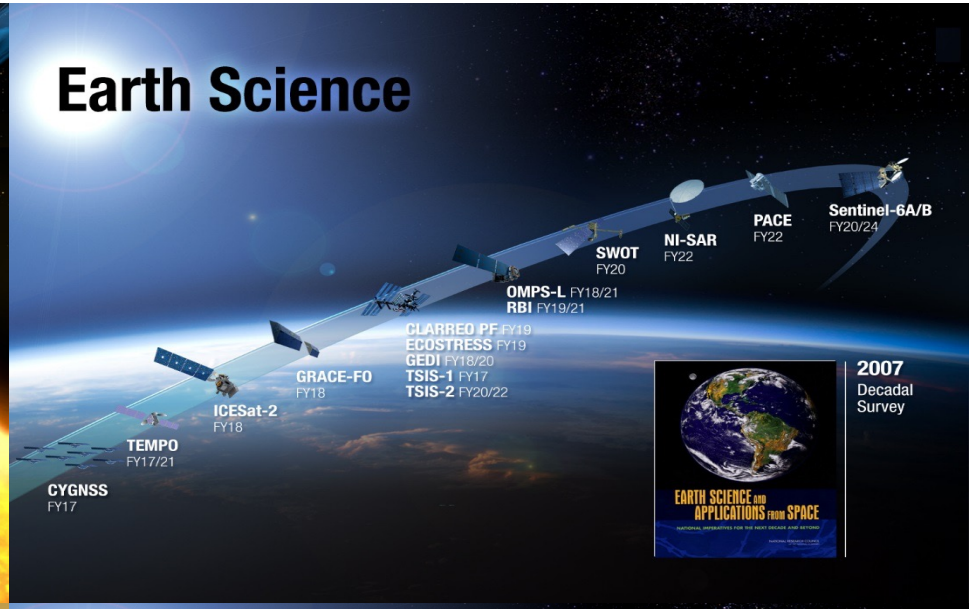


NASA SHORT TALKS

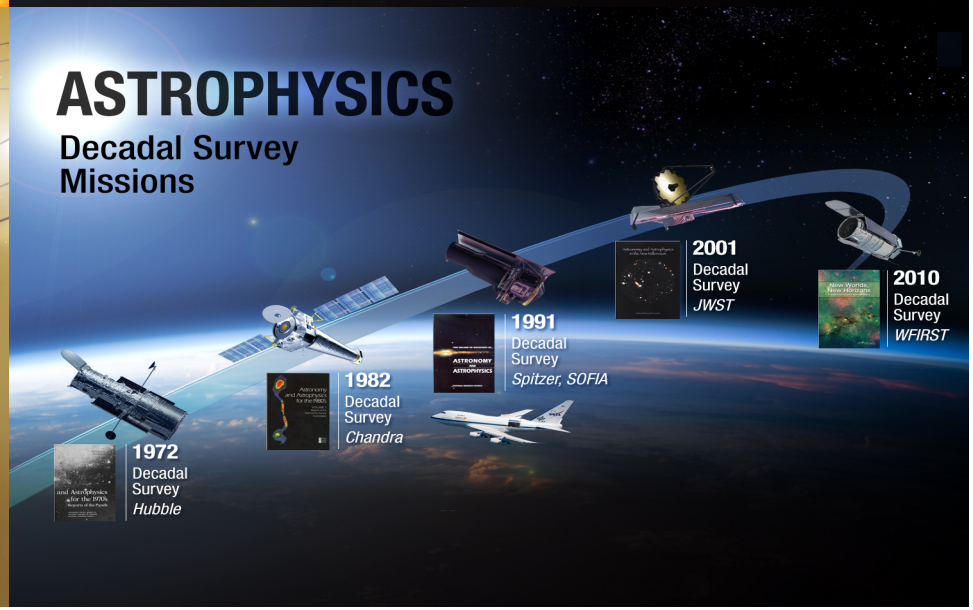
- 3-minute lightning talks on topics including upcoming missions, overviews of technology development efforts, tools and capabilities
- Held on the Fieldhouse Stage during the afternoon breaks
  - **Tuesday, August 8, 4:00 – 4:45PM**
  - **Wednesday, August 9, 3:30-4:15PM**

Please see pages 134 and 135 the conference pocket program for lightning titles and speakers

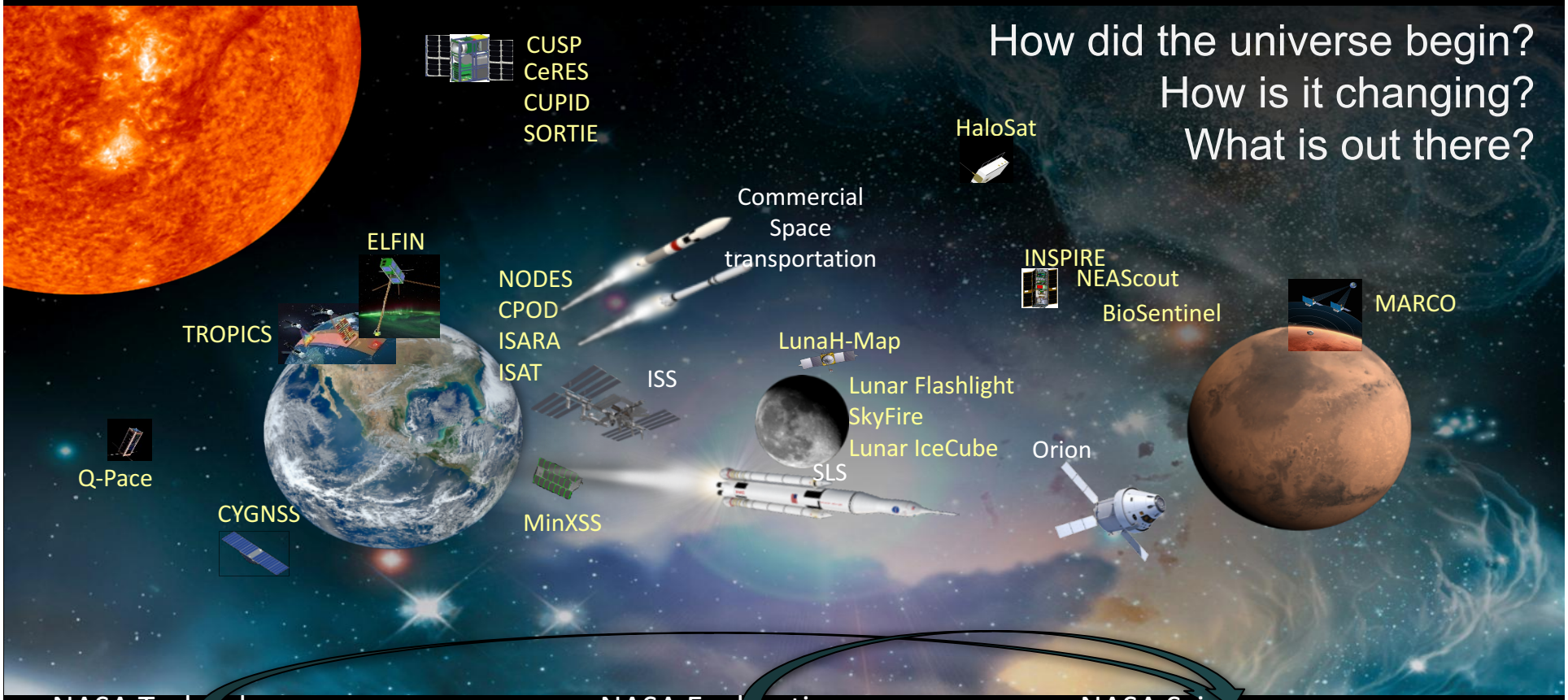

Heliophysics
Decadal Survey
Missions
Van Allen Probes
MMS
ICON
GOLD
Solar Probe Plus
Solar Orbiter
2003
Decadal Survey
2013
Decadal Survey


Earth Science
CYGNSS FY17
TEMPO FY17/21
ICESat-2 FY18
GRACE-FO FY18
CLARREO PF FY19
ECOSTRESS FY19
GEDI FY18/20
TSIS-1 FY17
TSIS-2 FY20/22
OMPS-L FY18/21
RBI FY19/21
SWOT FY20
NI-SAR FY22
PACE FY22
Sentinel-6A/B FY20/24
2007
Decadal Survey


Planetary Science
Decadal Survey
Missions
2003
Decadal Survey
2013
Decadal Survey
Cassini
1997
New Horizons
2006
Juno
2011
MSL
2011
MAVEN
2013
OSIRIS-REx
2016
InSight
2018
Mars Rover 2020
Europa


ASTROPHYSICS
Decadal Survey
Missions
1972
Decadal Survey
Hubble
1982
Decadal Survey
Chandra
1991
Decadal Survey
Spitzer, SOFIA
2001
Decadal Survey
JWST
2010
Decadal Survey
WFIRST

NASA is Enabling the Community's use of SmallSats to Help Answer Humanity's Big Questions



NASA Technology:

SSTP technology investments

- Formation Flight, Propulsion
- Communications, ACS systems

NASA Exploration:

Access to Space, SKGs

- CubeSat Launch Initiative
- SLS/Orion/Commercial

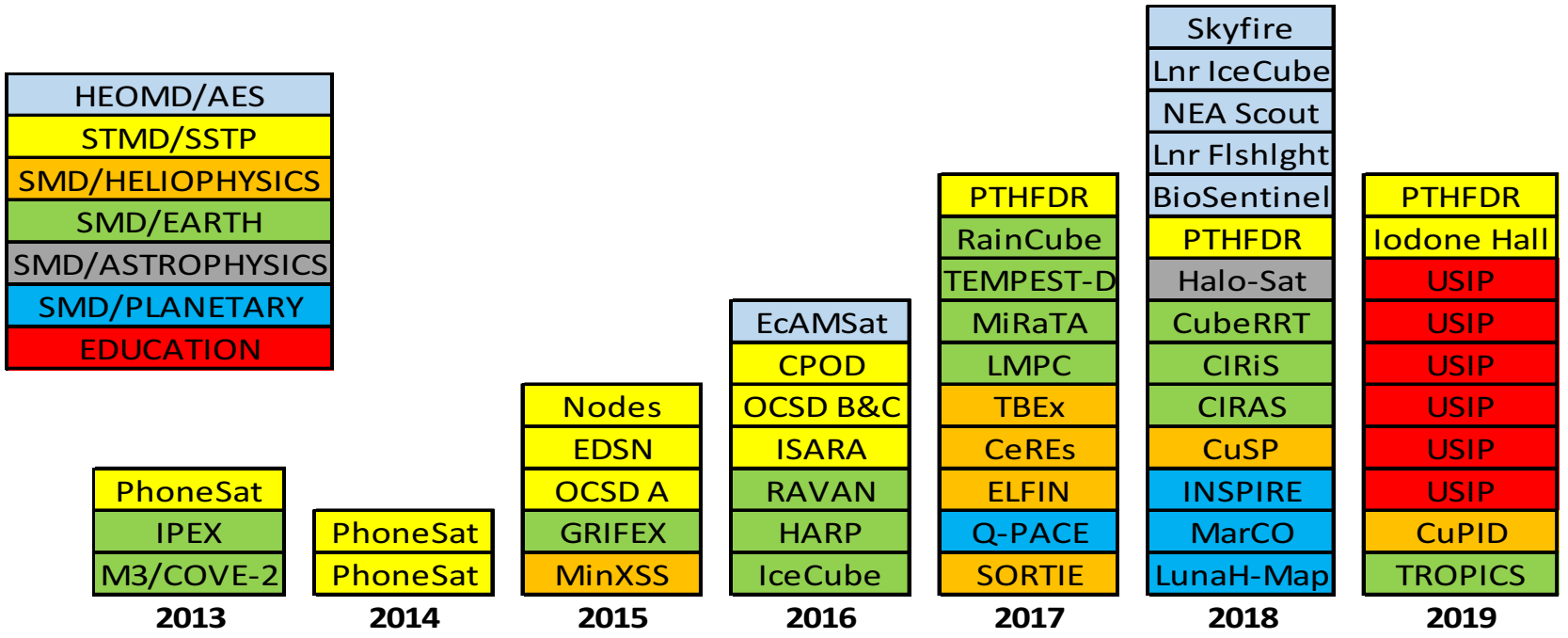
NASA Science:

- SmallSats in all solicitations
- Leveraging STMD technologies
- Augmenting Larger Missions

NASA CubeSats Launch Manifest

NASA has 71 CubeSat missions, comprised of 96 small spacecraft, launched or in development, supporting 27 science, 15 technology, 6 exploration and 23 STEM-related investigations.

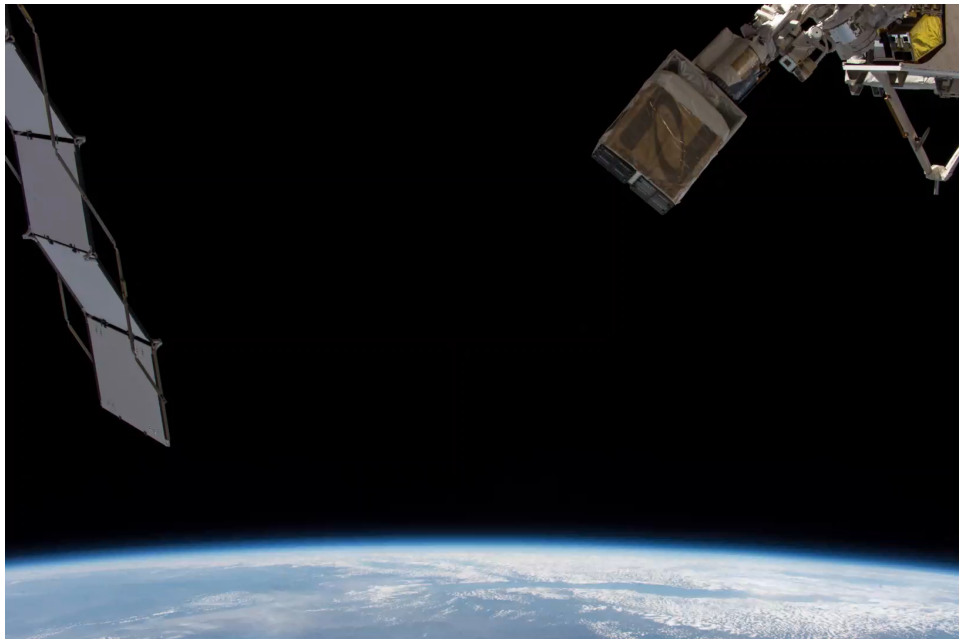
NASA	SMD	STMD	HEOMD	OE
71 missions 96 spacecraft	27 missions 41 spacecraft	15 missions 26 spacecraft	6 missions 6 spacecraft	23 missions 23 spacecraft



SMD's 1st SCIP Science Mission

Heliophysics: MinXSS/3U (PI – Woods/Colorado/LASP)

- The Miniature X-ray Solar Spectrometer (MinXSS) was deployed from ISS in May 16, 2016. ***Threshold Mission successfully completed. MinXSS was selected as the 2016 Mission of the Year at the AIAA SmallSat conference.*** MinXSS is a 3U small satellite with a miniature X-Ray Solar Spectrometer to measure solar soft X-rays (SXRs) to study processes from quiet-Sun to solar flares. Over 40 graduate, and 3 undergraduate students worked on MinXSS.

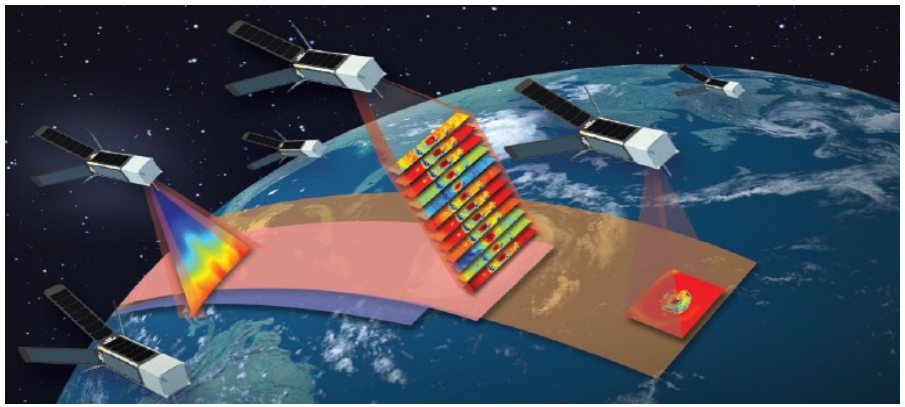


MinXSS – First SMD Cubesat Initiative Panel (SCIP) science mission flown; enabled through the OMB CubeSat funding in FY14.

SMD Enabled Constellation Science

***Tropics*/MIT/LL PI: Blackwell**

A constellation of 12 identical 3U cubesats to provide high-resolution sounding within hurricane eyes – with related precipitation structure evolution, including diurnal cycle.



Each TROPICS CubeSat is a dual-spinning 3U CubeSat with a 12-channel passive microwave spectrometer.

SMD enabled TROPICS instrument precursor technology development through ESTO funding of MiRaTA flight designs.

Tropics – First high-revisit microwave nearly global observations of precipitation – Complements GPM, CYGNSS, and GOES-R missions with high refresh, near all-weather measurements of precipitation

LRD: 2019

Earth Science Technology Office InVEST Program Status / ESTO

Pamela S. Millar
ESTO InVEST Program Manager
NASA Earth Science Technology Office

Charles D. Norton
ESTO Program Manager Associate
Jet Propulsion Laboratory, California Institute of Technology

Jet Propulsion Laboratory
California Institute of Technology

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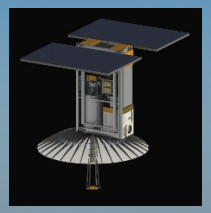
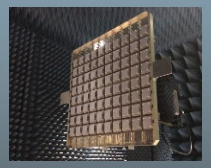
NASA Earth Science Technology Office (ESTO)

ESTO manages, on average, 120 active technology development projects. Most are funded through the primary program lines below. Nearly 700 projects have completed since 1998.

Advanced Technology Initiatives (ATI)



In-Space Validation of Earth Science Technologies (InVEST)
On-orbit technology validation and risk reduction for small instruments and instrument systems that could not otherwise be fully tested on the ground or airborne systems
(average award: $1-1.8M per year over three years)



Advanced Component Technologies (ACT)
Critical components and subsystems for advanced instruments and observing systems
(average award: $300K per year over three years)

Instrument Incubator Program (IIP)
Innovative remote sensing instrument development from concept through breadboard and demonstration
(average award: $1.5M per year over three years)

Advanced Information Systems Technology (AIST)
Provides innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products
(average award: $500K per year over two years)

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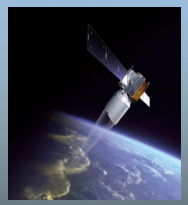
NASA Earth Science Technology Office (ESTO)

ESTO also manages specific sets of technology development and integration projects on behalf of the ESD Research and Flight programs.

Flight

Sustainable Land Imaging-Technology (SLI-T)
New technologies and reduced costs for future land imaging (Landsat) measurements
First solicitation released in FY16 (average award: $3-7M)



Earth Venture Instruments – Technology
Funding from the Flight Program's Earth Systems Science Pathfinder (ESSP) program to further develop promising, highly-rated Earth Venture proposals that require additional technology risk reductions *(average award: $5 - 8M)*

Research and Analysis

Airborne Instrument Technology Transition (AITT)
Provides campaign ready airborne instrumentation to support the objectives of the R&A Program. AITT converts mature instruments into operational suborbital assets that can participate in field experiments, evaluate new satellite instrument concepts, and/or provide calibration and validation of satellite instruments. *(average award: $1M)*

Ocean Biology and Biogeochemistry:
Ocean Color Remote Sensing Vicarious Calibration Instruments
In situ vicarious calibration instrument systems to maintain global climate-quality ocean color remote sensing radiances and reflectances *(average award: $2.3M)*

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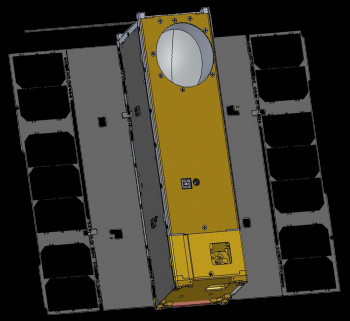
ESTO InVEST 2012 Program

U-Class satellites advancing TRLs for Decadal-Class measurements

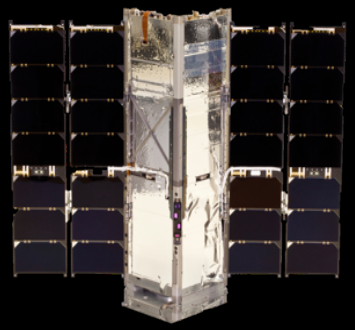
MiRaTA
MIT / MIT-LL



3 Frequency Radiometer and GPSRO

Validation of new microwave radiometer and GPSRO technology for all-weather sounding

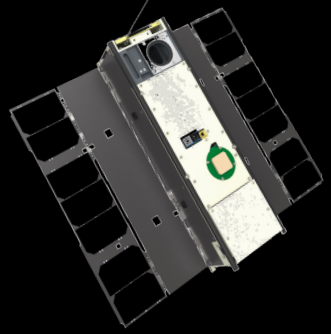
RAVAN
APL



Vertically Aligned Carbon Nanotubes (VACNTs)

Validate VACNTs as radiometer absorbing material and calibration standard for total outgoing radiation

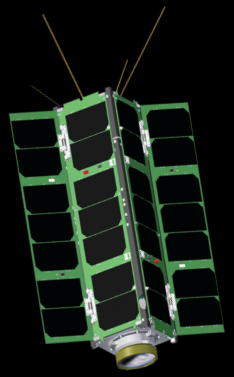
ICECube
GSFC



883 GHz submm-Wave radiometer

Validation of submm radiometer for spaceborne cloud ice remote sensing

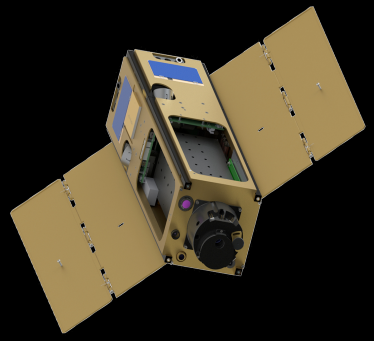
HARP
UMBC



Wide FOV Rainbow Polarimeter

Validation of 2-4 km wide FOV hyperangular polarimeter for cloud & aerosol characterization

LMPC
The Aerospace Corporation



Photon Counting InfraRed Detector

Validation of linear mode single photon detector at 1, 1.5, and 2 microns in space environment

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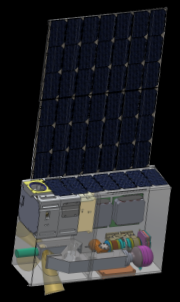
NASA ESTO InVEST 2015 and Venture Tech Programs

U-Class satellites advancing TRLs for Decadal-Class measurements

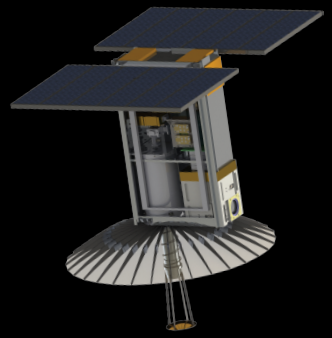
CIRAS
JPL



Infrared Atmospheric Sounder

Demonstrate ability to measure spectrum of upwelling infrared radiation in 4-5 micron spectral region

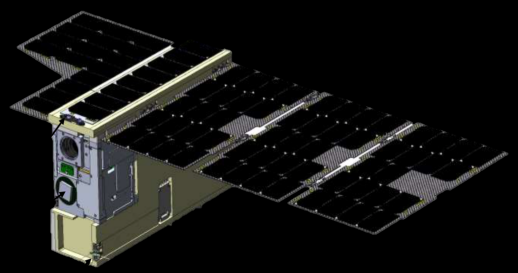
RainCube
JPL



Precipitation Profiling Radar

Validate Ka-band (35.75 GHz) radar payload using new deployable antenna and processing technologies

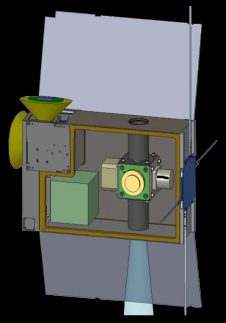
CubeRRT
The Ohio State University



Radiometer Radio Frequency Interference

Demonstrate wideband RFI mitigation technologies vital for future space-based microwave radiometers

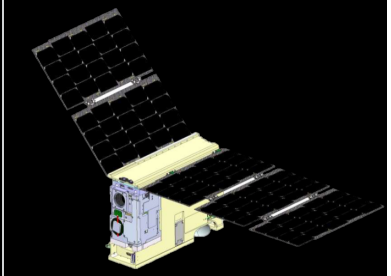
CIRIS
Ball Aerospace



Infrared Radiometer

Validation of an uncooled imaging infrared (7.5-13 um) radiometer for high radiometric performance in LEO

TEMPEST-D
Colorado State University



5 Frequency mm-Wave Radiometer

Technology demonstrator measuring the transition of clouds to precipitation

Venture Tech

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InVEST Launch Status

Project	NET Launch [Deploy] Date	Vehicle	Status	Mission (APIC)
RAVAN	November 11, 2016	Atlas-V (NRO) VAFB	**Launched**	WorldView-4 / Digital Globe
LMPC	TBD	TBD	TBD	TBD
IceCube	April 18, 2017 [May 16, 2017]	Atlas-V (OA-7/ISS) KSC	**Launched**	ELaNa-17 400 km at 51.6 deg. inclination
MiRaTA	October 12, 2017	Delta-II (JPSS-1) VAFB	Manifest	ELaNa-14 440 x 811 km sun-sync
HARP	January 24, 2018	SpaceX-14	Manifest	ELaNa-?? 400 km at 51.6 deg. inclination
CubeRRT	March 14, 2018 [Q2/Q3 2018]	Cygnus/Antares II (OA-9) WFF	Manifest	ELaNa-23 400 km at 51.5 deg. inclination
TEMPEST-D	March 14, 2018 [Q2/Q3 2018]	Cygnus/Antares II (OA-9) WFF	Manifest	ELaNa-23 400 km at 51.5 deg. inclination
RainCube	March 14, 2018 [Q2/Q3 2018]	Cygnus/Antares II (OA-9) WFF	Manifest	ELaNa-23 400 km at 51.5 deg. inclination
CIRiS / CIRAS	Late 2018	TBD	In Work	TBD
CSIM-FD	TBD	TBD	In Work	Commercial

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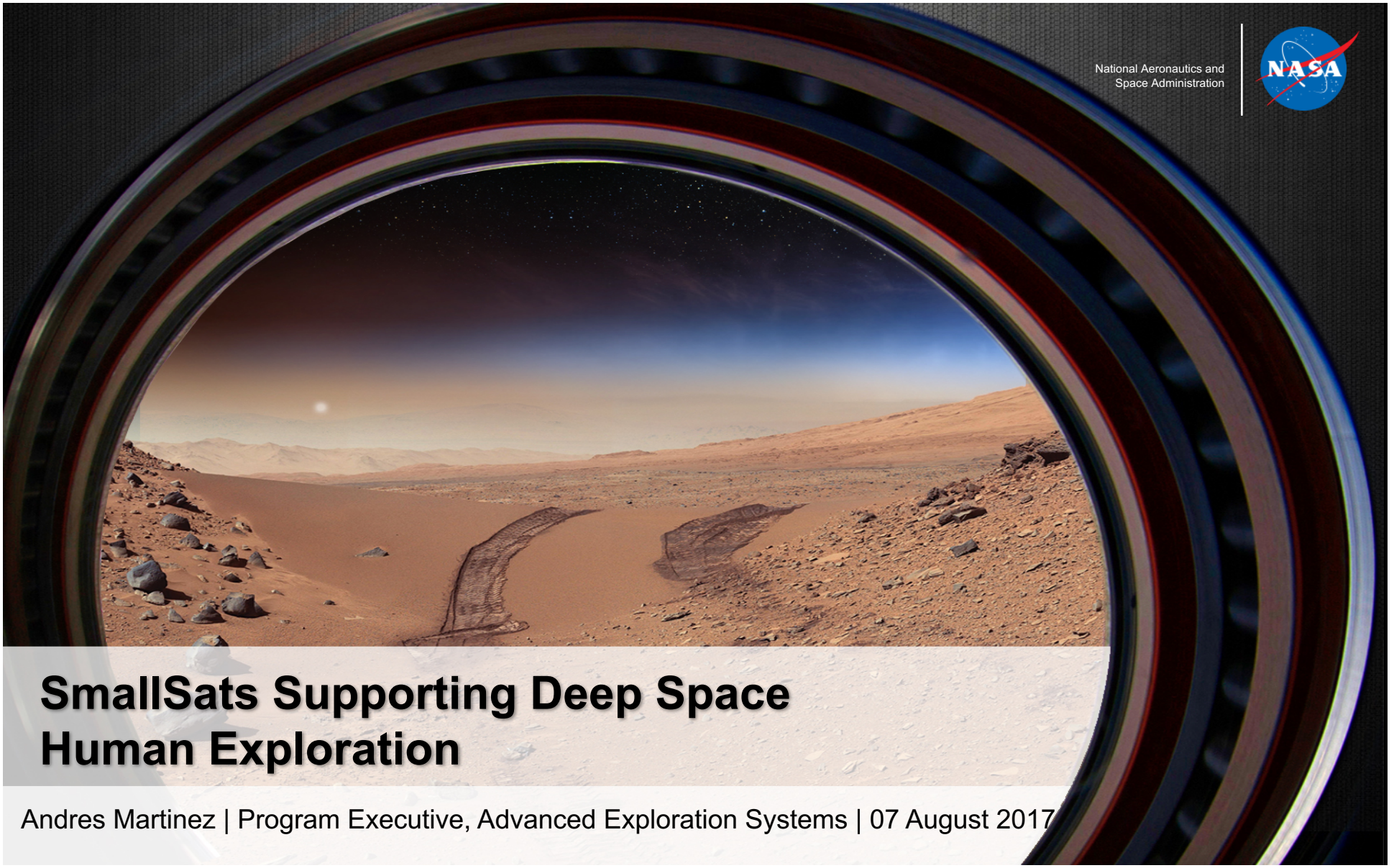
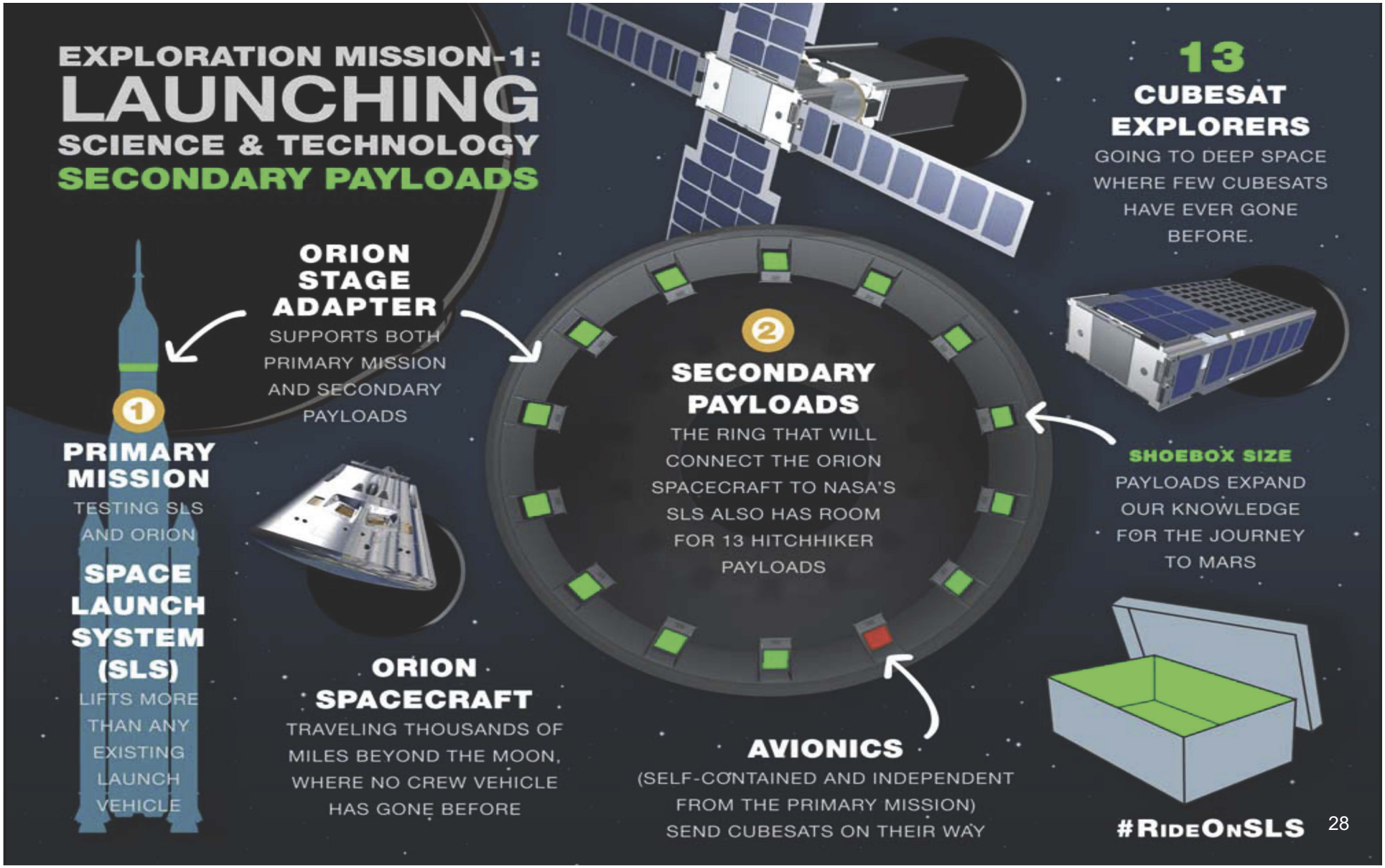
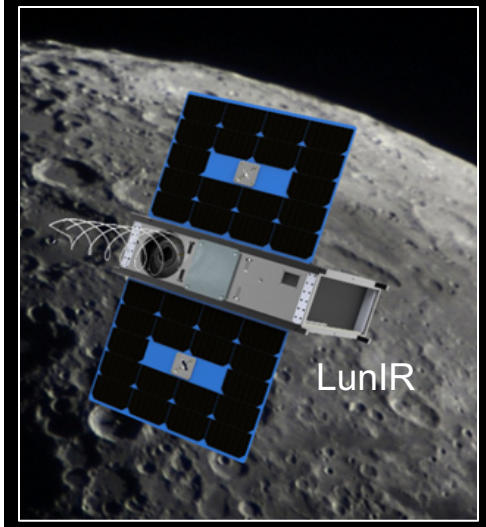


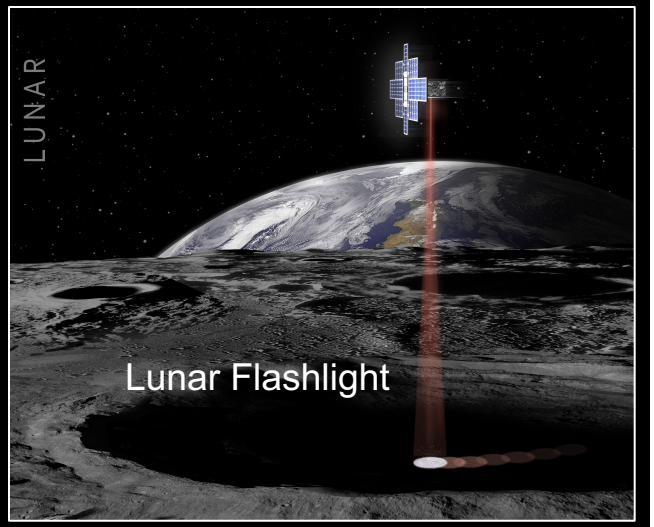
SmallSats Supporting Deep Space Human Exploration

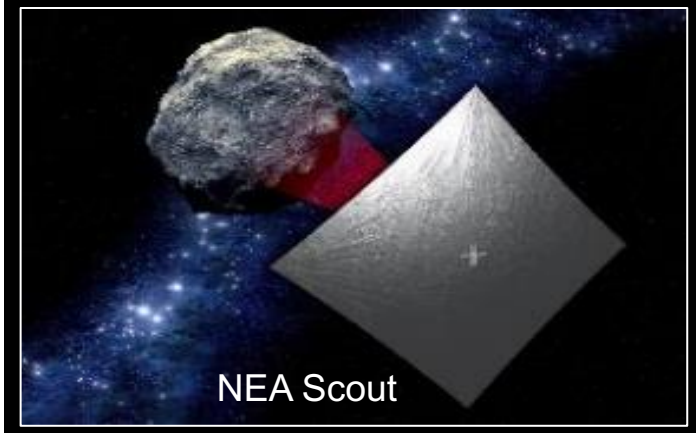
Andres Martinez | Program Executive, Advanced Exploration Systems | 07 August 2017

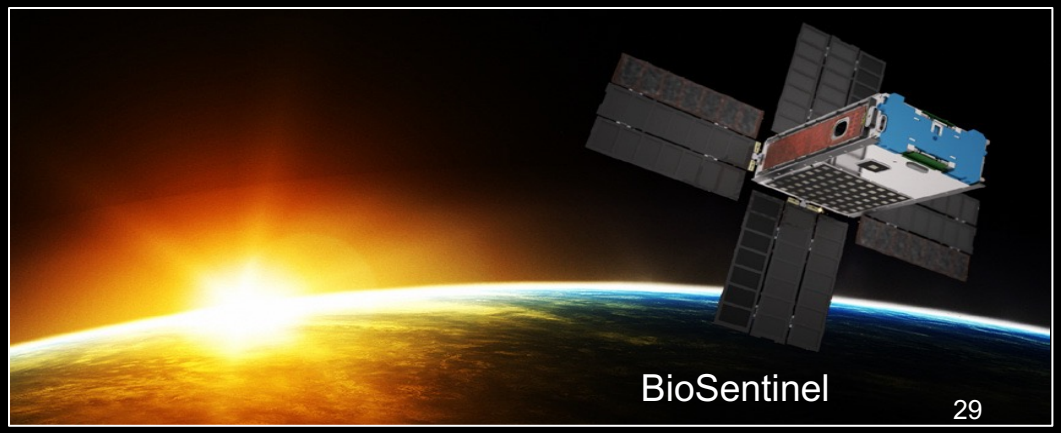

EXPLORATION MISSION-1:
LAUNCHING
SCIENCE & TECHNOLOGY
SECONDARY PAYLOADS
13
CUBESAT EXPLORERS
GOING TO DEEP SPACE WHERE FEW CUBESATS HAVE EVER GONE BEFORE.
ORION STAGE ADAPTER
SUPPORTS BOTH PRIMARY MISSION AND SECONDARY PAYLOADS
1
PRIMARY MISSION
TESTING SLS AND ORION
SPACE LAUNCH SYSTEM (SLS)
LIFTS MORE THAN ANY EXISTING LAUNCH VEHICLE
2
SECONDARY PAYLOADS
THE RING THAT WILL CONNECT THE ORION SPACECRAFT TO NASA'S SLS ALSO HAS ROOM FOR 13 HITCHHIKER PAYLOADS
SHOEBOX SIZE
PAYLOADS EXPAND OUR KNOWLEDGE FOR THE JOURNEY TO MARS
ORION SPACECRAFT
TRAVELING THOUSANDS OF MILES BEYOND THE MOON, WHERE NO CREW VEHICLE HAS GONE BEFORE
AVIONICS
(SELF-CONTAINED AND INDEPENDENT FROM THE PRIMARY MISSION) SEND CUBESATS ON THEIR WAY
#RIDEONSLS

Deep Space SmallSats, Advanced Exploration Systems, HEOMD, NASA









Deep Space SmallSats, Advanced Exploration Systems, HEOMD, NASA

21m DSN Station

Morehead State University

- Expands DSN capabilities by utilizing non-NASA assets to provide communication and navigation services to small spacecraft missions to the Moon and inner solar system.
- Enabling interplanetary research with small spacecraft platforms
- Develops an operational capability to support EM-1 CubeSat missions

Bridging Key Gaps

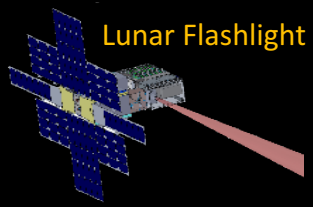
- **Key gaps in technology related to CubeSats for science applications are high bandwidth communications, precision attitude control, propulsion, and the development of miniaturized instrument technology.**

Technology	High Bandwidth Communications	Precision Attitude Control	Propulsion	Miniaturized Instruments
Miniaturized Modular ADCS		✓		
Sphinx Flight Computer				✓
Radiation Sensor Advancement				✓
Integrated Microfluid Advancements				✓
Ion Thruster – RF Ion Engine			✓	
Chemical Green Propulsion			✓	
Deployable & Gimbaled Solar Arrays			✓	
Solar Sail Propulsion			✓	
Iris (v2.1) transponder	✓			✓
Medium Gain Antennae	✓			
High Gain Antennae	✓			
21 m DSN Station	✓			

AES EM-1 Secondary Payloads: Strategic Knowledge Gaps and Key Technologies

BioSentinel

Lunar Flashlight



NEA Scout

LunIR

Lunar IceCube

Technologies Advanced	Strategic Knowledge Gaps Addressed
• Deployable & Gimbaled Solar Arrays • Attitude Determination Control System • Integrated Microfluid Advancements • Radiation Sensor Advancements	**Human health/performance in high-radiation space environments** • Fundamental effects on biological systems of ionizing radiation in space environments
• Sphinx Flight Computer • Iris (v2) transponder • Green Propulsion • Laser Sensors	**Lunar resource potential** • Quantity and distribution of water and other volatiles in lunar cold traps
• Cold Gas Propulsion • Solar Sail technologies	**Human NEA mission target ID -** NEA size, rotation state (rate/pole position) **How to work on & interact with NEA surface -** NEA surface mechanical properties
• Low SWAP • High operating temperature MWIR sensor	**Solar Illumination mapping and determination of Extent, magnitude, age of cold traps**
• RF Ion Propulsion with Solid-state Iodine Propellant • Low energy manifold trajectory • Broadband (1 to 4 um) IR spectrometer	**Determination of: Temporal Variability and Movement Dynamics of Surface-Correlated OH and H2O deposits;** Composition, Form & Distribution of Polar Volatiles

NASA Perspective on CubeSats

- **NASA recognizes the value of CubeSats as platforms for technology demonstration and hands-on training, and sees they offer the potential to address essential science goals.**

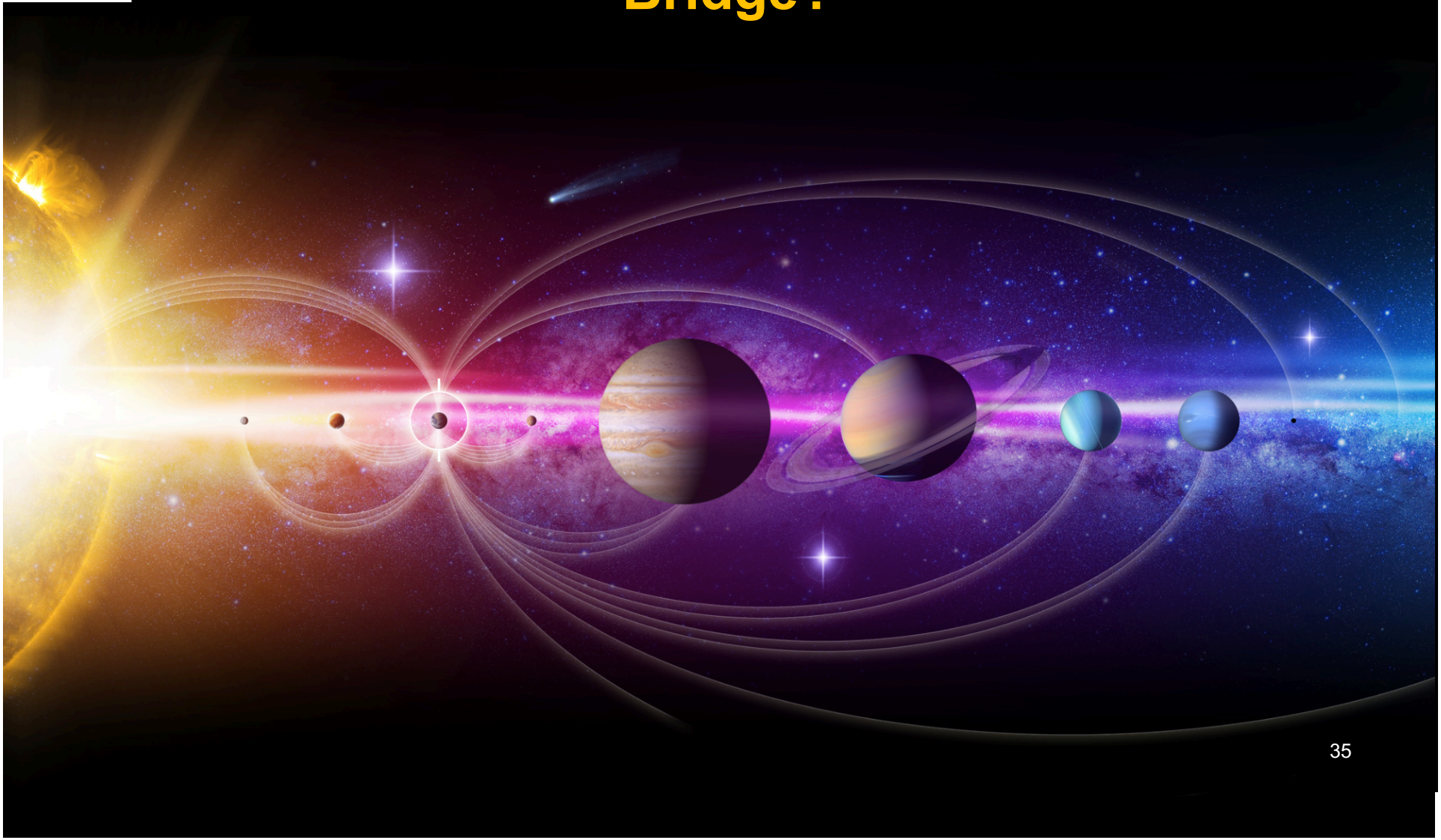
- **CubeSats are scalable platforms, from "suborbital-class" (sub-Class D) to flight project (Class D) platforms, enabling:**
  - Quick access to space for timely science measurements and to "fill the gap" for continuity of measurements between large flight projects.
  - Flight demonstrations to mature technologies for infusion into mission-level programs
  - CubeSats are small enough for the university researcher and fast enough for students to complete all phases of a project during their school career.

- **NASA wants to foster an environment of innovation for CubeSats, and wants insight into what near term investments are needed to ensure science and technology demonstration value from CubeSats as a platform.**

Summary

- CubeSats provide an important proving ground for advancing scientific and technology research while lowering the risk for subsequent flight projects.
- CubeSats can carry out significant science investigations and serve as a technology test bed in the relevant environment at a fraction of the cost of larger orbital flights.
- NASA is fostering a stable customer base for an emerging commercial small spacecraft market by sponsoring of industry and university research and providing reliable access-to-space.
- CubeSat efforts are cultivating the next generation of researchers and technologists.
- CubeSats are travelling farther in the solar system than ever before

What Technology Gap Are You Going to Bridge?



John F. Kennedy Space Center

LAUNCH SERVICES PROGRAM

"CubeSat Launch Initiative" Town Hall Meeting

Garrett Skrobot

ELaNa Mission Manager

Launch Services Program

NASA

Small Sat 2017

John F. Kennedy Space Center

Past Missions

CubeSat Mission	Primary Mission	Launch/Deploy Date	Dispensers	Spacecraft	CubeSats
ELaNa I	Glory	Mar 4, 2011	1	3	3
ELaNa II	NROL-39*	Dec 5, 2013	2	5	4
ELaNa III	NPP	Oct 28, 2011	3	5	5
ELaNa IV	ORS-3*	Nov 19, 2013	4	11	11
ELaNa V	CRS SpX-3	Mar 16, 2014	4	5	5
ELaNa VI	NROL-36*	Sep 13, 2012	3	4	4
ELaNa VIII	ORB-3	Oct 21, 2014	NanoRacks	1	1
ELaNa X	SMAP	Jan 30, 2015	3	4	3
ELaNa XI	AFSPC-5	May 20, 2015	1	1	1
ELaNa XII	NROL-55*	Oct 8, 2015	2	4	4
ELaNa VII	ORS-4*	Oct 29, 2015	2	2	2
ELaNa IX	OA-4	May 16, 2016	NanoRacks	3	3
ELaNa XVII	OA-7	April 18, 2017	NanoRacks	3	3
			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.

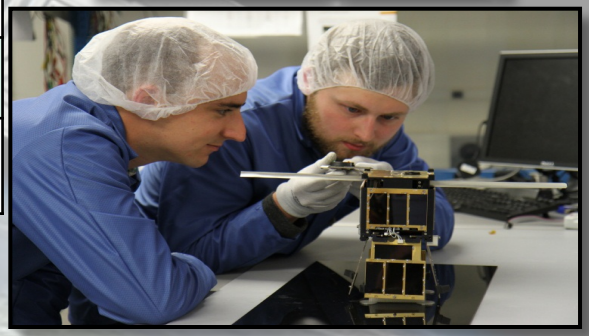
ELaNa Mission Schedule

John F. Kennedy Space Center

LAUNCH SERVICES PROGRAM

CubeSat Mission	Primary Mission	Launch Vehicle	NET Launch Date	Cubes
ELaNa XXII	SpX-12	Falcon 9 FT	August 13, 2017	3
ELaNa XIV	JPSS-1	Delta II	October 12, 2017	5
ELaNa XV	STP-2	Falcon 9 Heavy	April 30, 2018	3
ELaNa XIII	OA-8	Antares	October 11, 2017	2
ELaNa XIX	VCLS	Rocket Lab	November 2017	10
ELaNa XX	VCLS	Virgin Galactic	December 2017	12
ELaNa XXIII	OA-9	Antares	March 14 2018	9
ELaNa XVIII	ICESat- 2	Delta II	September 12, 2018	4

Total Manifested 47



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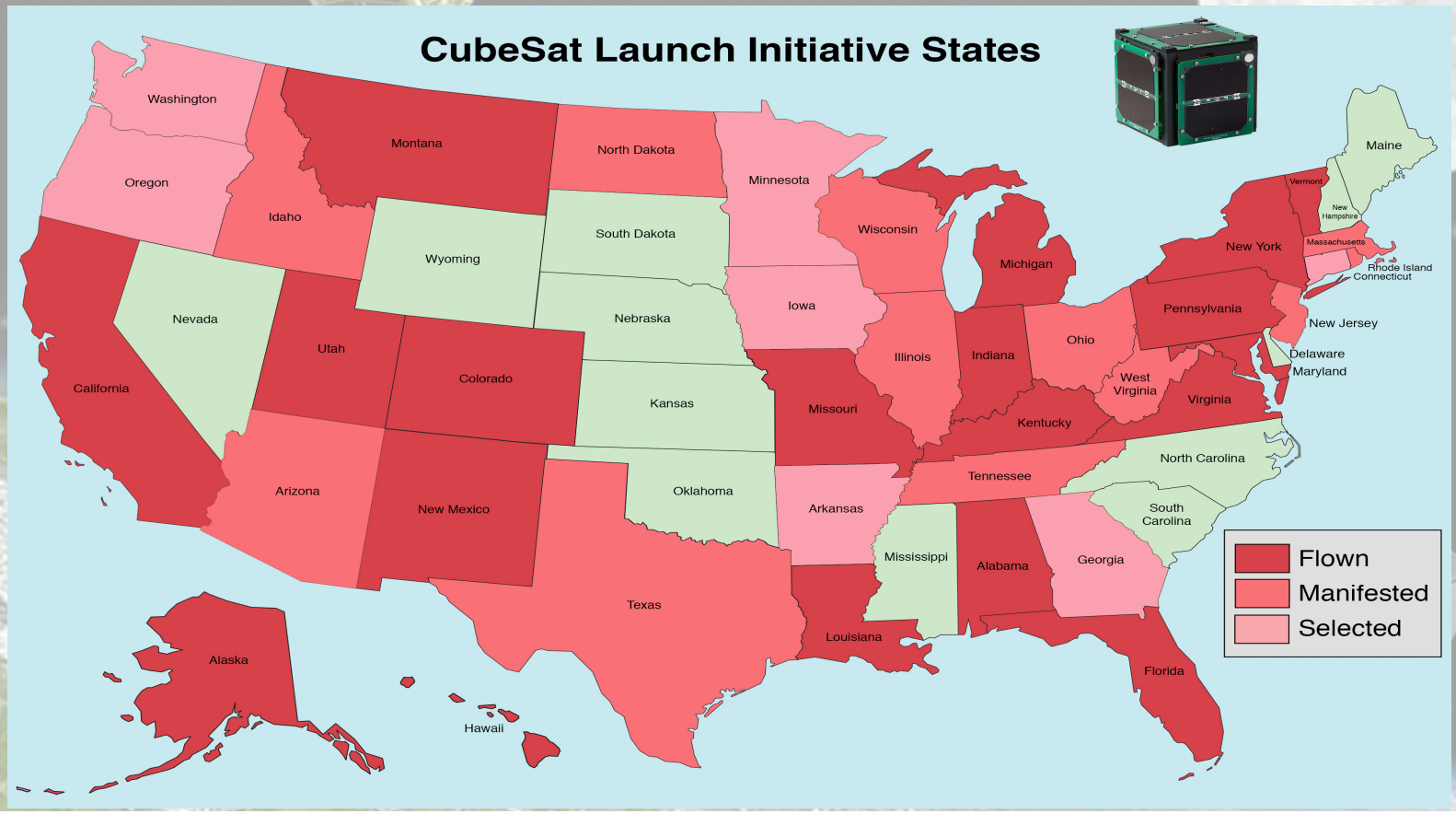
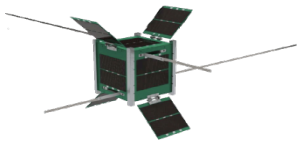
LAUNCH SERVICES PROGRAM

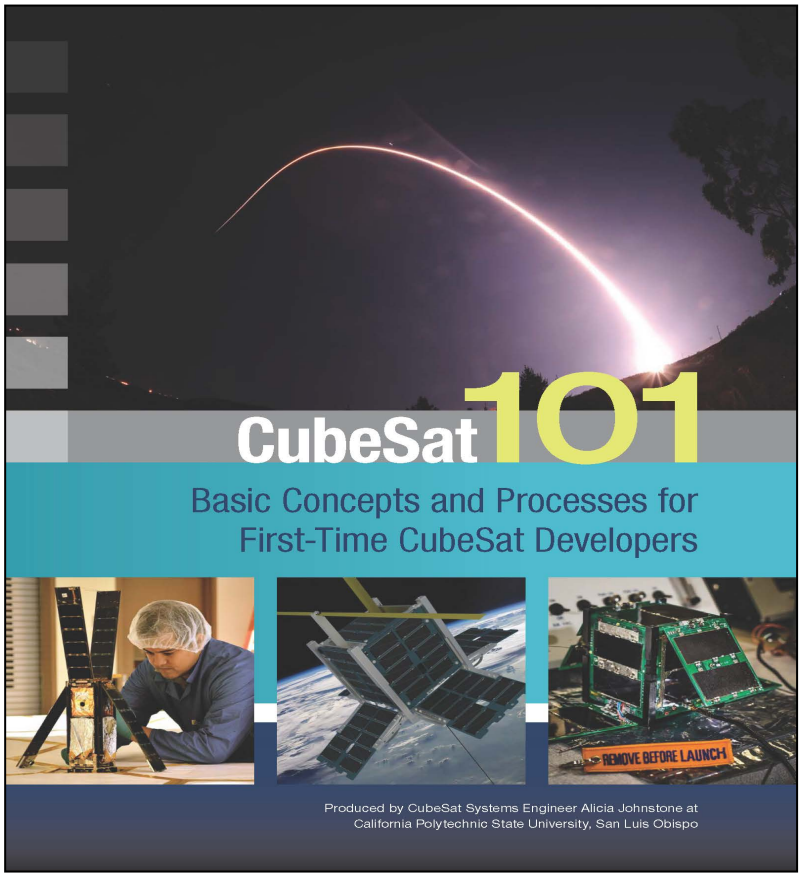
50 CubeSats from 50 States

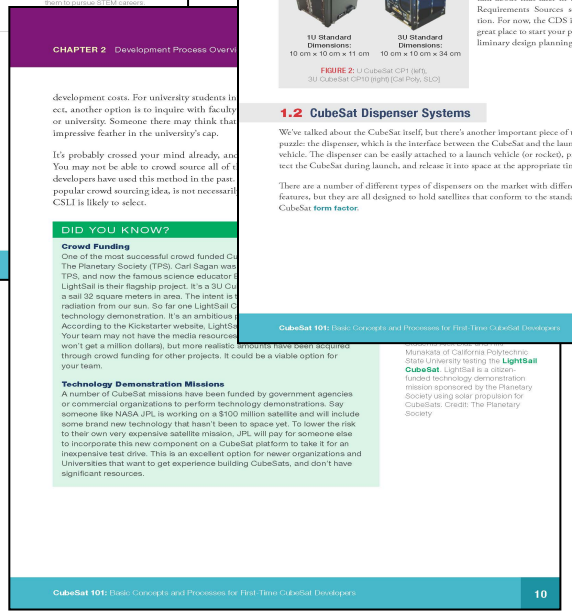
Goal to broaden NASA's CubeSat Launch Initiative to reach all states by targeting the 12 "rookie states" that have had no previous presence in space.

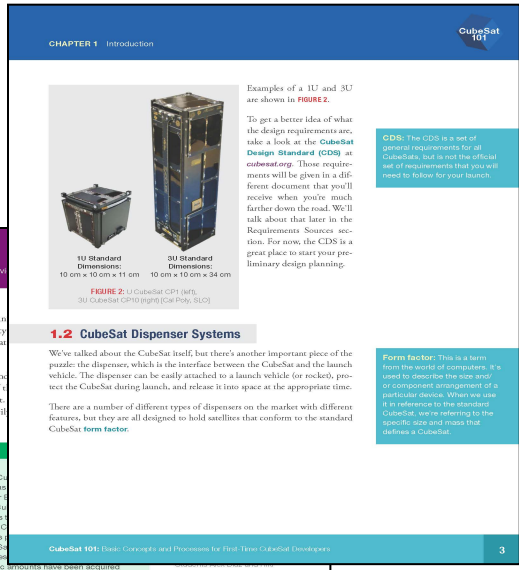




CubeSat 101
Coming Soon







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LAUNCH SERVICES PROGRAM

Announcement of Flight Opportunity

Release Date: August 3, 2017

Response Date: November 21, 2017 @ 4:30 PM EST

Announcement Date: February 16, 2018

https://www.nasa.gov/feature/nasa-s-cubesat-launch-initiative-broadens-access-to-space-for-educators-nonprofits

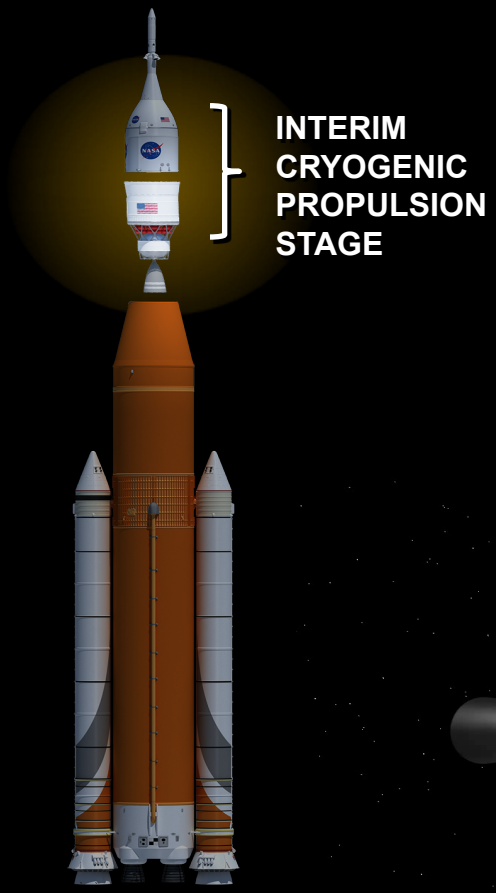
Objective

NASA Human Exploration and Operations Mission Directorate is anticipates making launch opportunities for a limited number of CubeSats on launches or deployed from the ISS currently planned for 2018-2021.

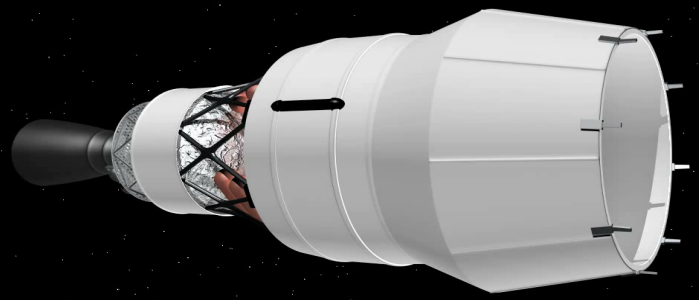
NASA will provide integration and other services as necessary to complete the launch activity.

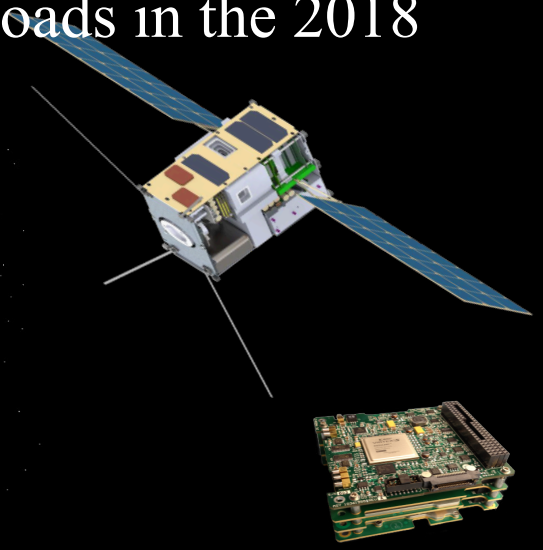
NASA will not transfer any funds to collaborators under Agreements negotiated in response to this Announcement.

Further into Space



At this time, NASA is not offering opportunities for payloads on the Space Launch System (SLS). However, NASA is tentatively planning to issue a CubeSat Launch Initiative call for future SLS secondary payloads in the 2018 timeframe






NASA