Simposium Innovación e Inteligencia Artificial CONALEP 2021

Advanced Exploration Systems (AES) Small Spacecraft Missions

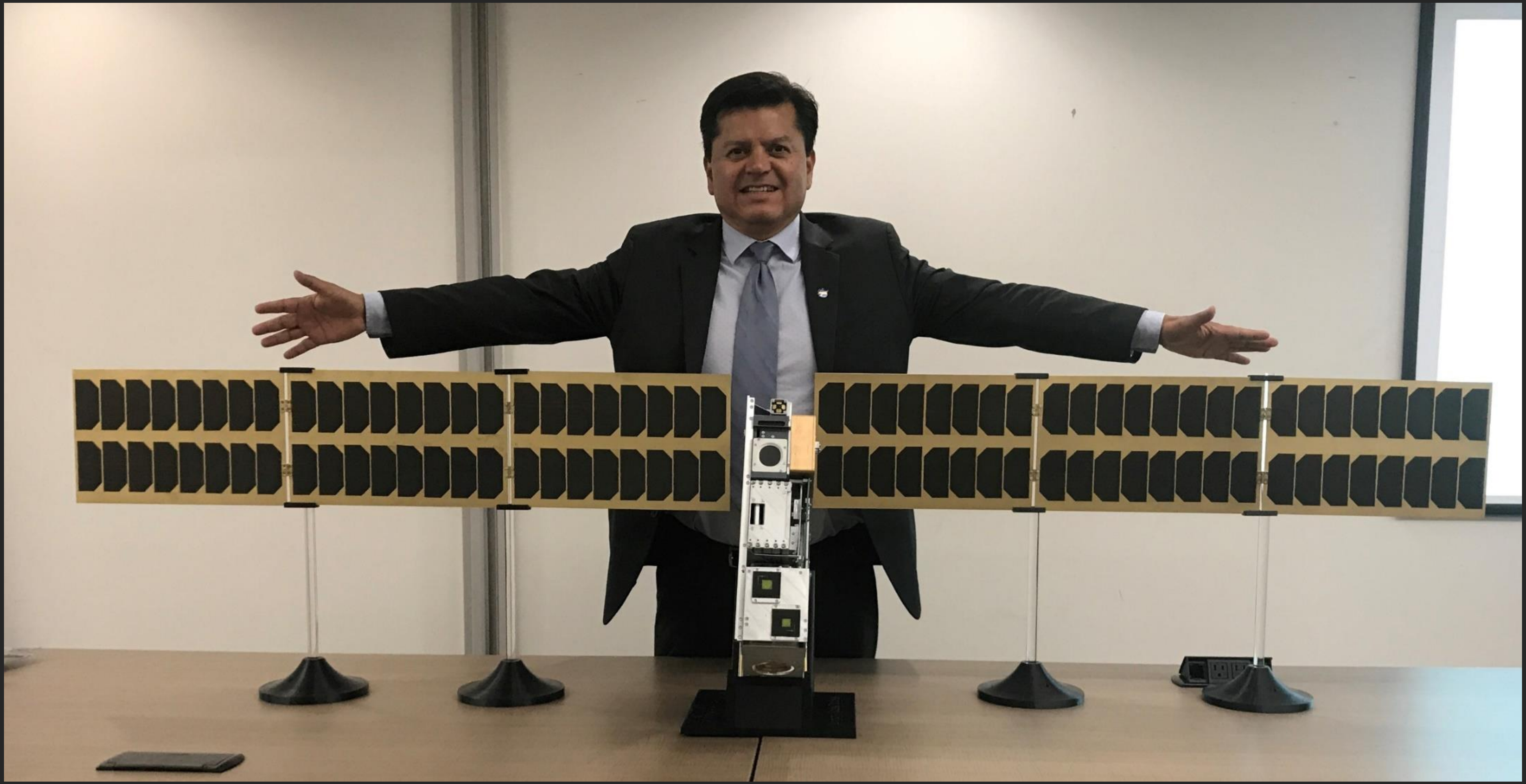
Andres Martinez, Program Executive, Small Spacecrafts

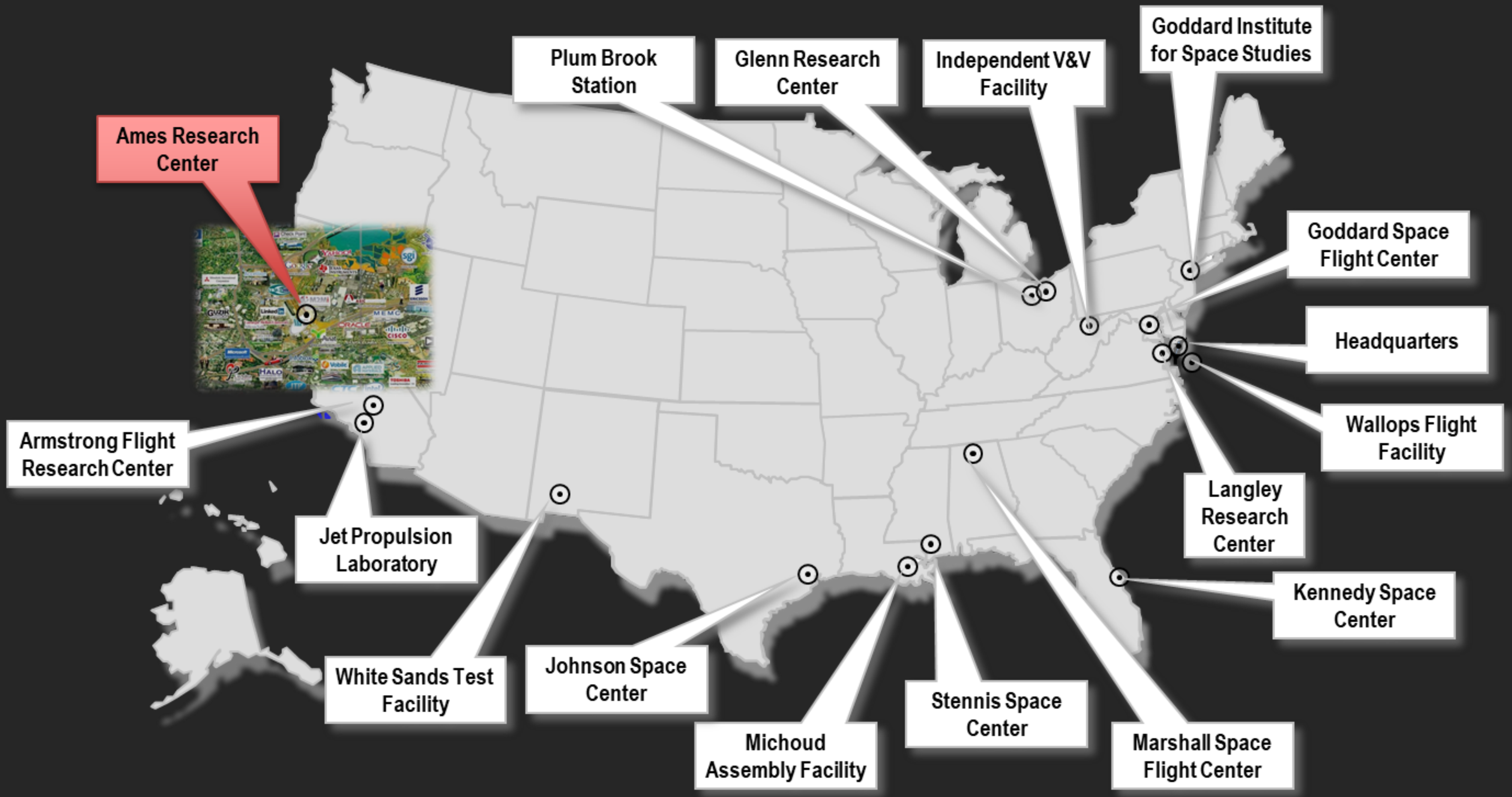
April 29, 2021

Today, I manage missions to Deep Space..!

- **Program Executive, AES, NASA HQ**
- Technical Point of Contact for Latin America, NASA Ames
- Chair, Hispanic Advisory Committee for Employees, NASA Ames

This is one of them… her name is Lunar IceCube!





Ames Research Center
Plum Brook Station
Glenn Research Center
Independent V&V Facility
Goddard Institute for Space Studies
Goddard Space Flight Center
Headquarters
Wallops Flight Facility
Langley Research Center
Kennedy Space Center
Armstrong Flight Research Center
Jet Propulsion Laboratory
White Sands Test Facility
Johnson Space Center
Michoud Assembly Facility
Stennis Space Center
Marshall Space Flight Center

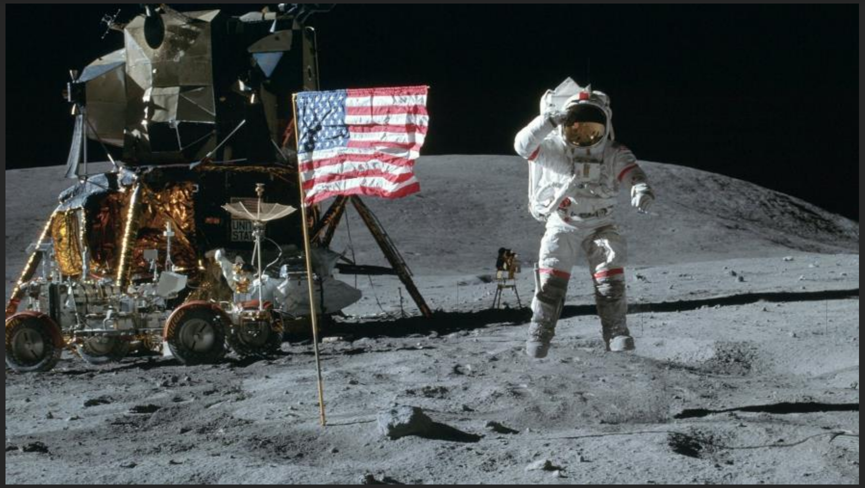
We’re going to the Moon to learn to live on other planets and for the benefit of all humanity.

With the Artemis lunar exploration program, NASA will put the first woman and first person of color on the lunar surface and build a sustainable presence there and in lunar orbit.

NASA Human Exploration Programs

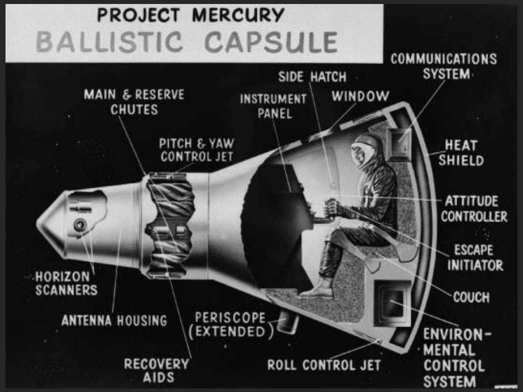
Project Mercury
1958 - 1963

Project Gemini
1965 - 1966



Apollo Program
1961 - 1975

Space Shuttle Program
1981 - 2011



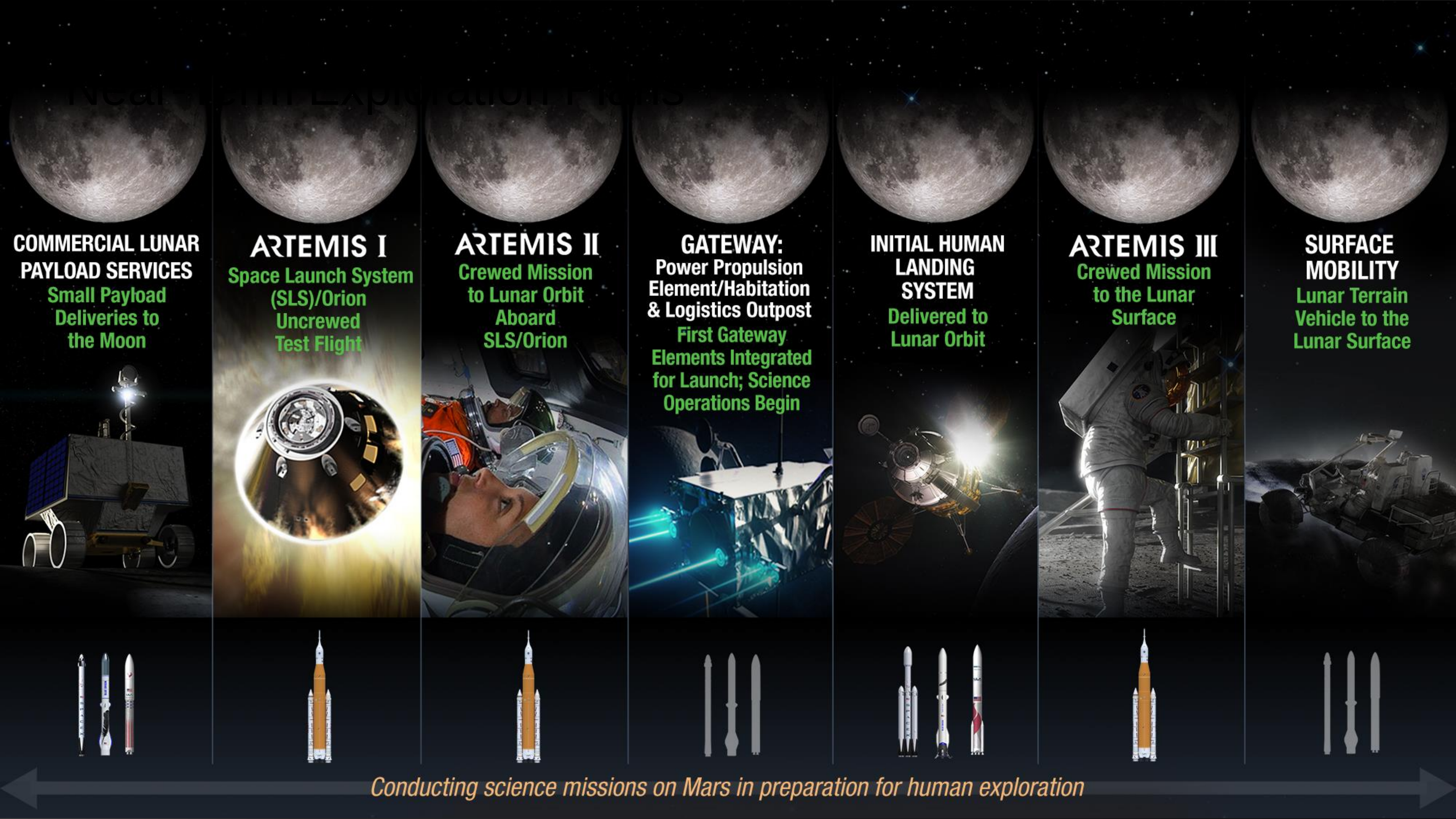
Project Mercury
1958 – 1963
6 Crewed Missions

Project Gemini
1965 – 1966
10 Crewed Missions

Apollo Program
1961 – 1975
6 Missions to the Moon
12 Walked on Moon

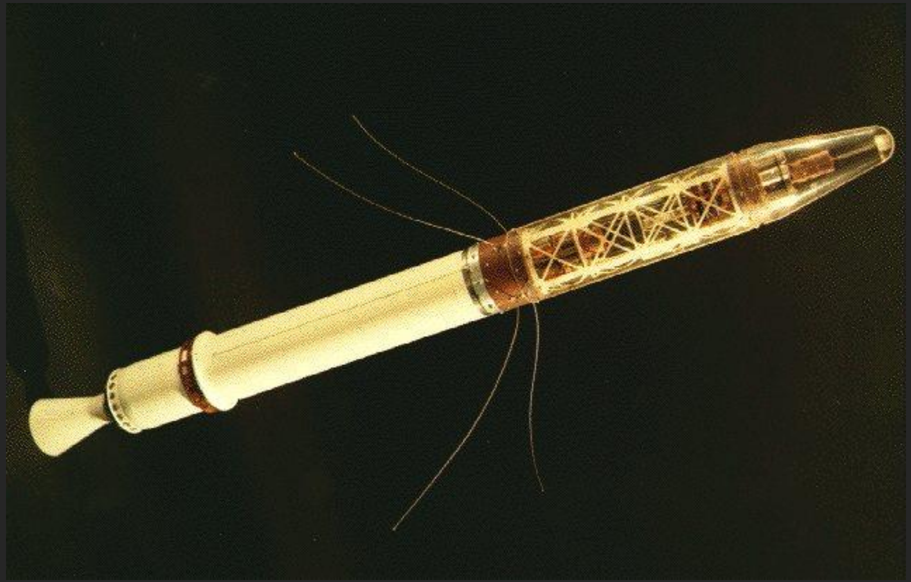
Space Shuttle Program
1981 – 2011
135 Missions
355 individual fliers (306 men and 49 women flew)
848 total crew

The Artemis Generation


Near-Term Exploration Plans
COMMERCIAL LUNAR PAYLOAD SERVICES
Small Payload Deliveries to the Moon
ARTEMIS I
Space Launch System (SLS)/Orion Uncrewed Test Flight
ARTEMIS II
Crewed Mission to Lunar Orbit Aboard SLS/Orion
GATEWAY:
Power Propulsion Element/Habitation & Logistics Outpost
First Gateway Elements Integrated for Launch; Science Operations Begin
INITIAL HUMAN LANDING SYSTEM
Delivered to Lunar Orbit
ARTEMIS III
Crewed Mission to the Lunar Surface
SURFACE MOBILITY
Lunar Terrain Vehicle to the Lunar Surface
Conducting science missions on Mars in preparation for human exploration

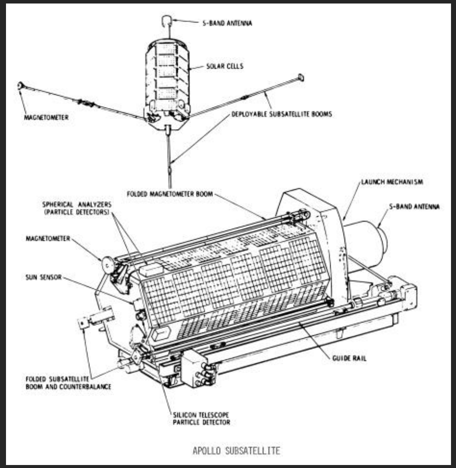
First artificial satellites in space

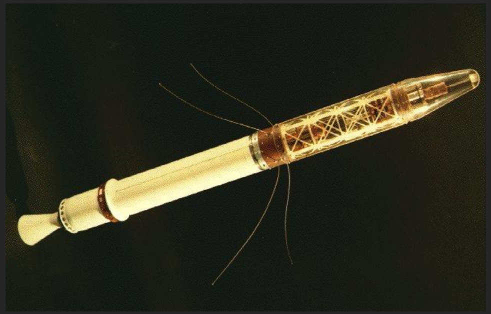
Sputnik (satellite in English) **– OCT 1957**
Russia
(83.6Kg, 58 cm)



Explorer1 – FEB 1958
USA
(13.97Kg, 205.1 cm, 15.2 cm)

Sputnik – OCT 1957
(83.6Kg, 58 cm)





Explorer1 – FEB 1958
(13.97Kg, 205.1 cm, 15.2 cm)

Deployment of small spacecraft during the Apollo 15 and Apollo 16 missions as the command module left lunar orbit. The Particles and Fields Subsatellite (PFS) series, built by TRW, was designed to study the plasma, particle, and magnetic field environment of the Moon as well as to map the lunar gravity field.

These units were the first small spacecraft released into space from a containerized deployment system.

Mission Description:

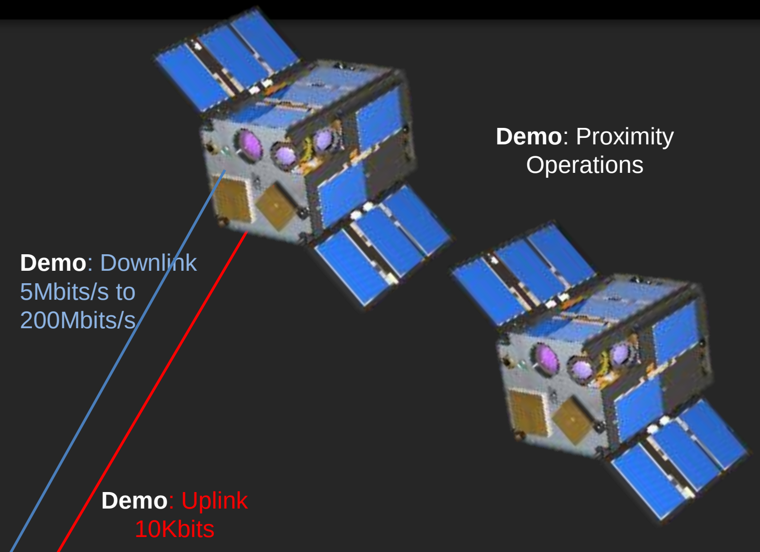
Aerospace Corporation delivered the Optical Communications and Sensor Demonstration (OCSD) and demonstrated small spacecraft proximity operations and high-speed optical transmission of data using a laser (200 Mbits/sec).

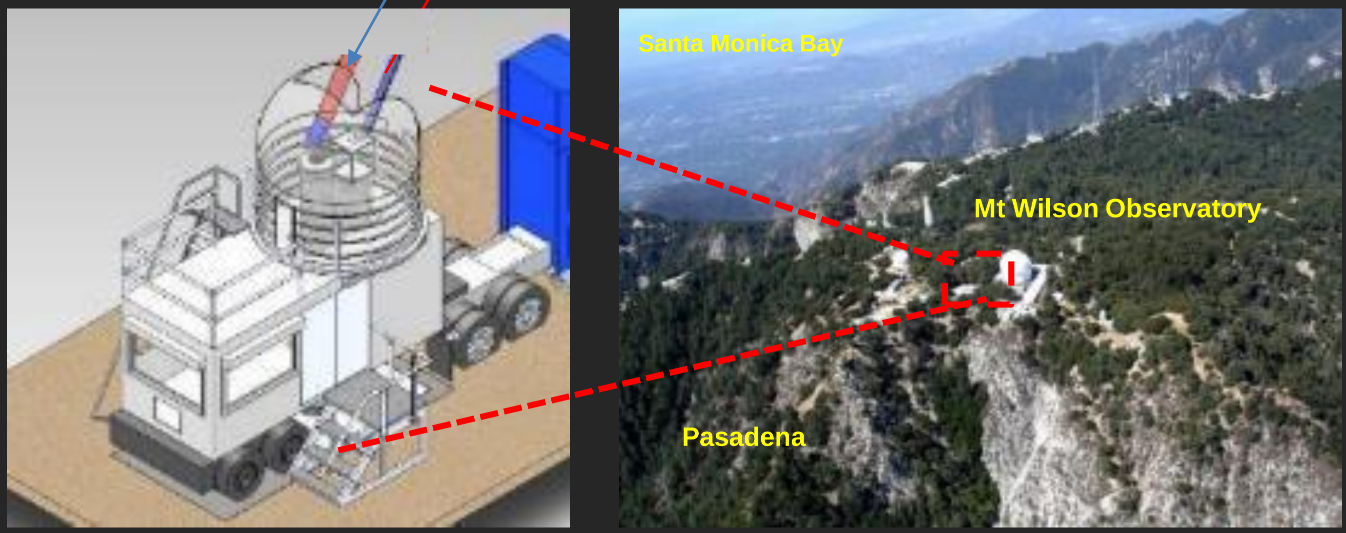
Spacecraft pointing accuracy of 0.1° or better was achieved. Aerospace leveraged much of the spacecraft's design from previous versions of the AeroCube (AC4 though AC6, the NASA SSTP version is AC7).

OCSD included two flight demonstrations: a single satellite in the first demonstration and two satellites in the second demonstration.

Spacecraft Specifications:

- **Mass**: 2.18 kg (wet)
- **Quantity**: Three 1.5U CubeSats
- **Missions**: Two
- **Orbit**: 450 km x 720 km @ 98.7 incl.
- **Size**: 10cm x 10cm x 17cm
- **Communication**: RF (UHF) & Optical: 1064nm Laser
- **Launched**: Falcon 9, DEC 2016, ORB/Cygnus NOV 2017





CubeSat Proximity Operations Demonstration (CPOD)

Mission Description:

Tyvak delivered CPOD, its mission is to demonstrate rendezvous, proximity operations and docking (RPOD) using two 3U CubeSats.

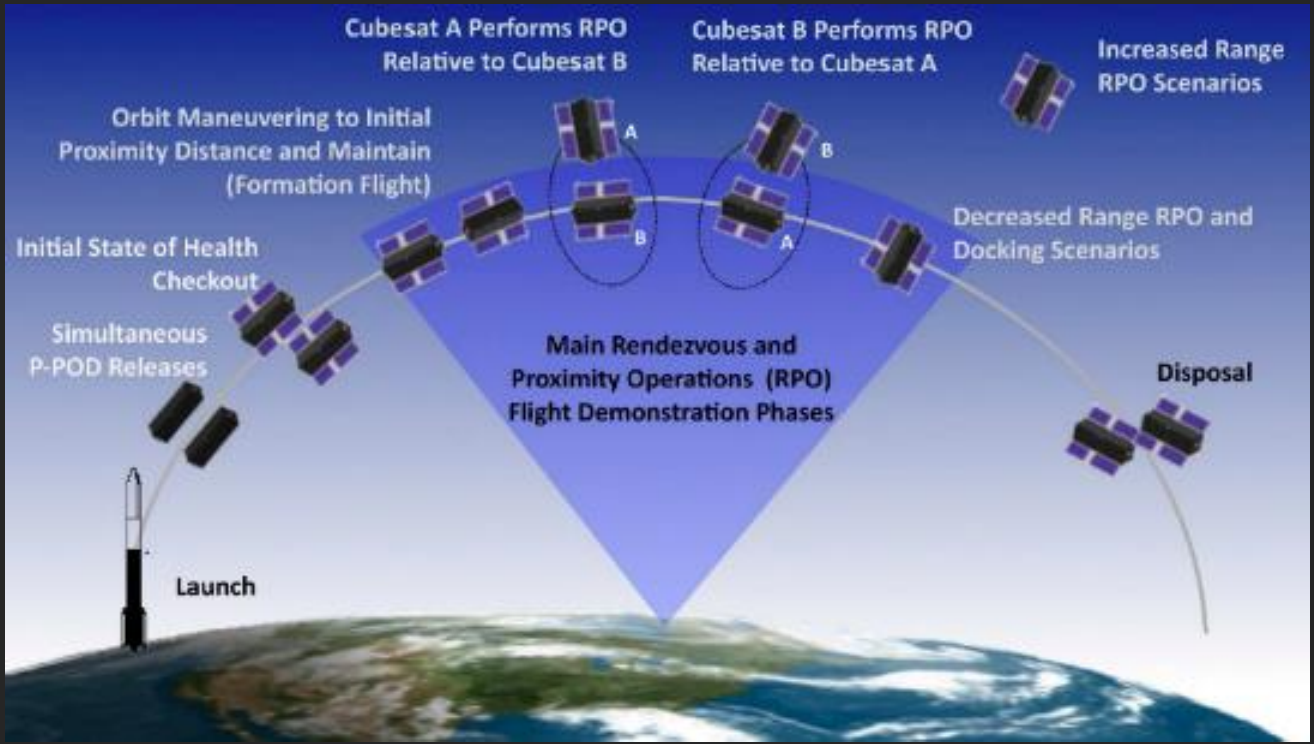
The ability of the two spacecraft to remain at determined points relative to each other (called relative station-keeping) will be demonstrated, as well as precision circumnavigation and docking.

Docking will employ the use of a novel universal docking device, imaging sensors, and a multi-thruster cold gas propulsion system.

Using on-board navigation systems, one CubeSat will perform a series of circumnavigation maneuvers relative to the second CubeSat in order to validate and characterize the new miniature sensors.

Spacecraft Specifications:

- **Mass**: 6 Kg
- **Quantity**: Two 3U cubesats
- **Orbit**: 500km sun-sync; 97 degrees
- **Size**: 10cm x 10cm x 30cm
- **Communication**: UHF; S-band; Inter Satellite Link
- **Launch**: TBD



CPOD Concept of Operations

Mission Description

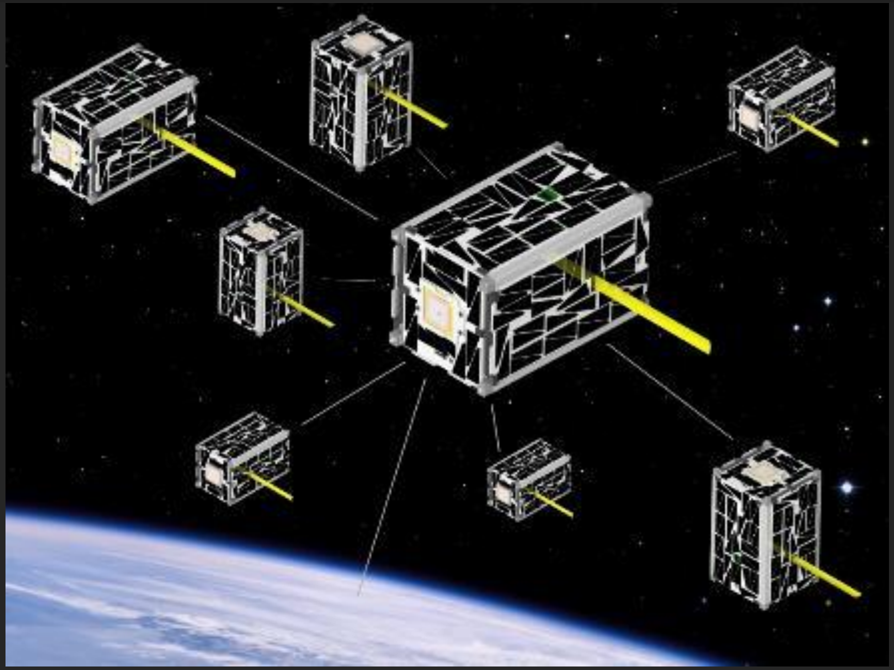
NASA Ames Research Center delivered Edison Demonstration of Smallsat Networks (EDSN), a mission to launch and deploy a swarm of 8 cubesats into a loose formation approximately 500 km above Earth.

The cubesats swarm would have collected multipoint satellite data and transmitted the data to the ground through one cubesat.

This capability was to enable a wide array of low cost missions to perform scientific, commercial, and academic research.

Spacecraft Specifications:

- **Mass:** 1.73 kg each
- **Quantity:** Eight 1.5U cubesats
- **Orbit**: 430 km x 505 km @ 94.8°incl.
- **Size**: 10cm x 10cm x 17cm
- **Communication**: UHF / S-Band
- **Launched**: Super Strypi, NOV 2015



EDSN mission lost with Super Strypi failure (ORS-4) on November 3, 2015.

Mission Description:

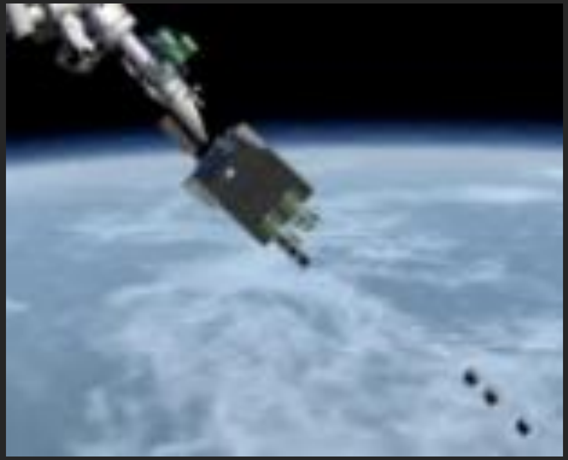
NASA Ames Research Center delivered Nodes, a mission launched and deployed two 1.5U CubeSats from ISS into low-Earth orbit.

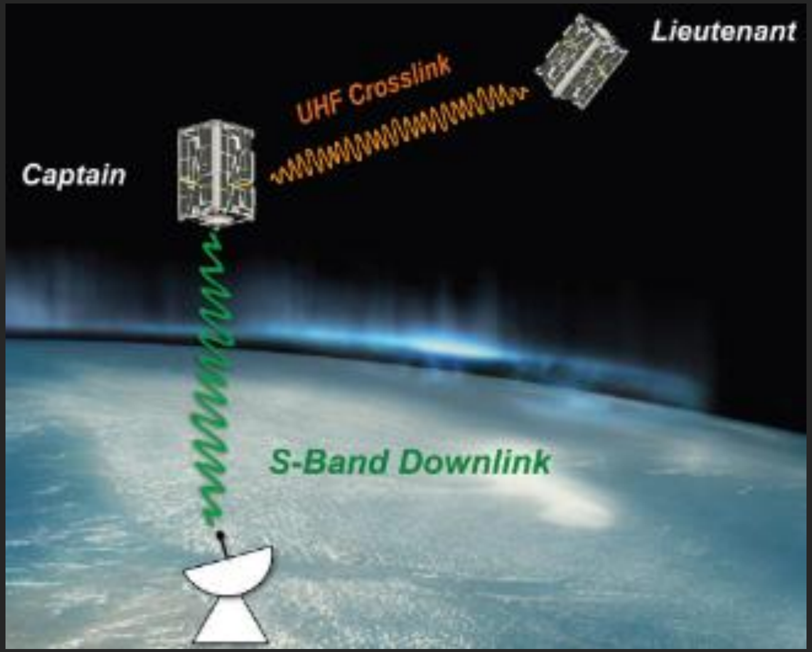
Nodes explored issues associated with the command and control of multi-spacecraft swarms by:

1) relaying ground commands through one satellite to the second satellite,
2) collecting and relaying science data from each satellite to the ground station, and
3) autonomously determining which of the two satellites is best suited to control the space network and relay data to the ground. This capability will enable a wide array of low cost missions to perform scientific, commercial, and academic research.

Spacecraft Specifications:

- **Mass**: 1.73 kg each
- **Quantity**: two 1.5U cubesats
- **Orbit**: 400 km x 400 km @ 51.6 incl.
- **Size**: 10cm x 10cm x 17cm
- **Communication**: UHF / S-Band
- **Launched**: ISS CRS - Orbital 4





Mission Description:

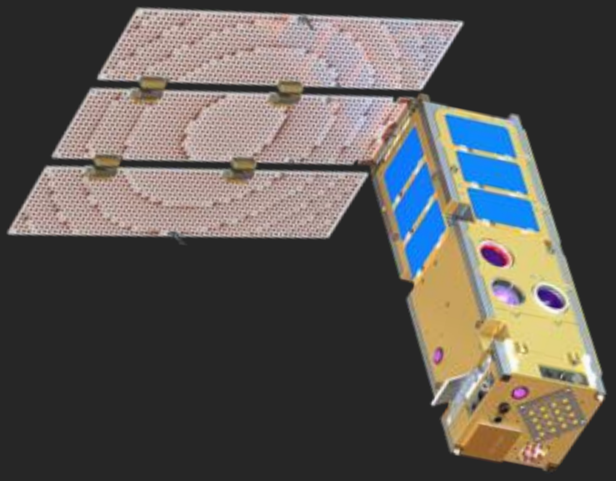
NASA Jet Propulsion Laboratory (JPL) delivered ISARA, a mission demonstration of a Ka-band reflectarray antenna that provides the capability to increase downlink data rates for CubeSats from the existing baseline rate of 9.6 kbps, to over 100 Mbps.

For a modest increase in mass, volume, and cost, this technology is paving the way for data return on high value science missions that utilize distributed CubeSats and small satellites.

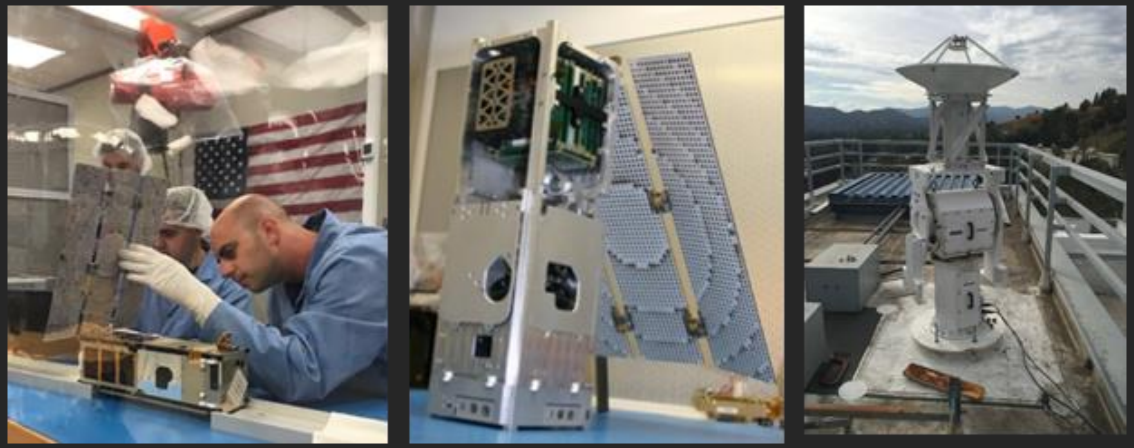
On-orbit, the antenna transmitted a signal which was received by a ground station located at the JPL.

Spacecraft Specifications:

- **Mass**: 4kg
- **Quantity**: One 3U cubesat
- **Orbit**: 450 km x 720 km, 98.7°incl.
- **Size**: 10cm x 10cm x 34cm
- **Communication**: Reflectarray Antenna and ultra-high frequency (UHF) telemetry antenna
- **Launched**: ORB/Cygnus NOV 2017



ISARA Reflectarray



ISARA and Ka-band Ground station at JPL – Pasadena, CA

SporeSat

Mission Description

NASA Ames Research Centered, in collaboration with Purdue University, Texas A&M University, and Santa Clara University delivered SporeSat.

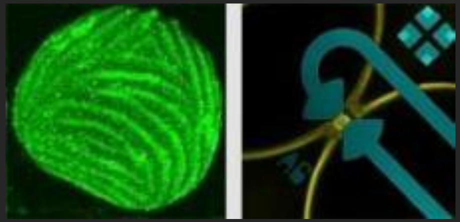
SporeSat was a fundamental space biology science mission in support of human exploration to investigate biophysical mechanisms of plant gravity sensing using a “lab-on-a-chip” experimental approach.

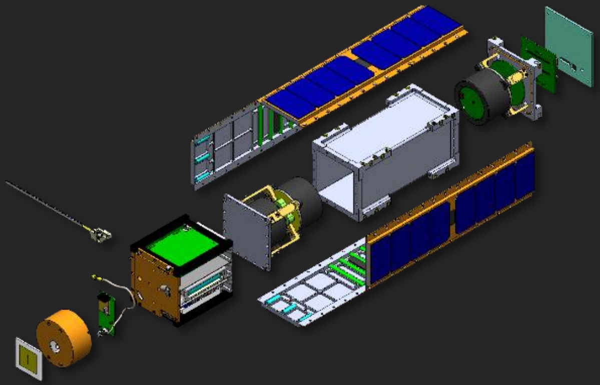
The unicellular germinating *Ceratopteris richardii* fern spore was studied in outer space.

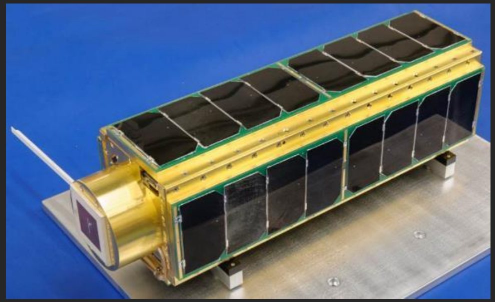
SporeSat was to determine gravity thresholds for calcium ion (Ca^{2+}) channel activation in wild-fern spores.

Spacecraft Specifications:

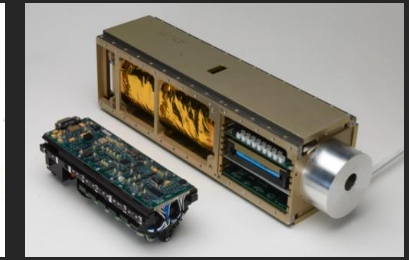
- **Mass**: 5.2kg
- **Quantity**: One 3U cubesat
- **Orbit**: 350 km x 350 km @ 51.6 incl.
- **Size**: 10 x 10 x 30 cm
- **Communication**: UHF, and S band
- **Launched**: SpaceX-3 (April 2014)



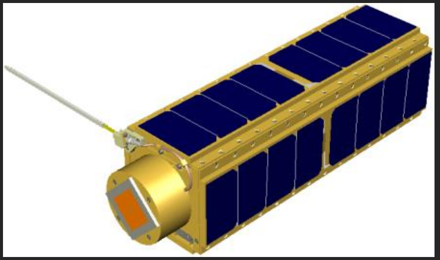




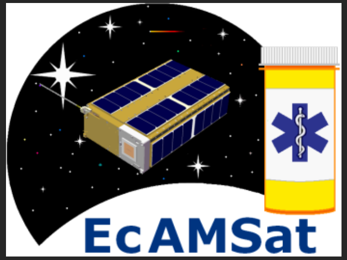

GeneSat-1

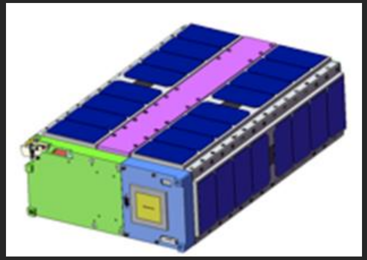



PharmaSat

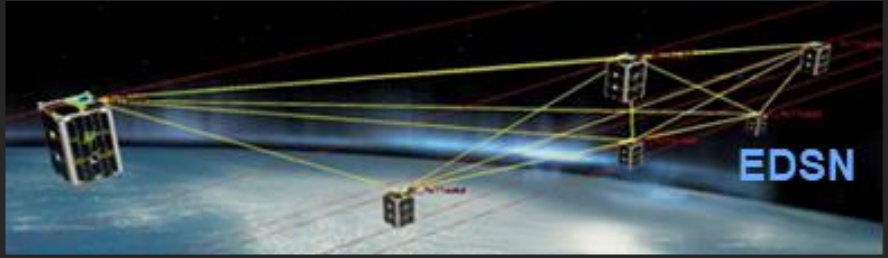



SporeSat

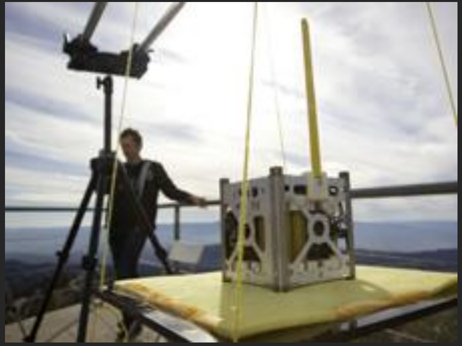

EcAMSat

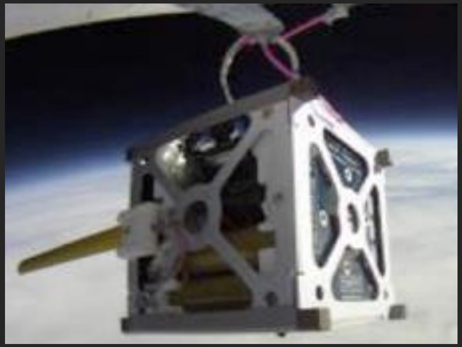


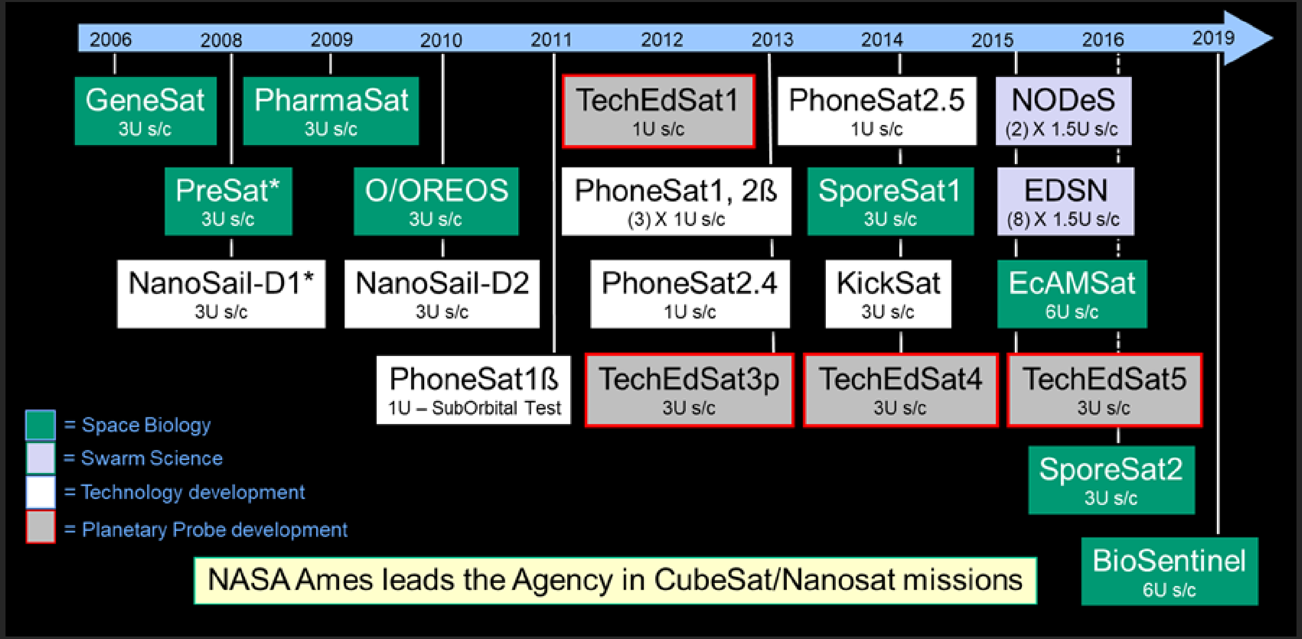

TechEdSat-1

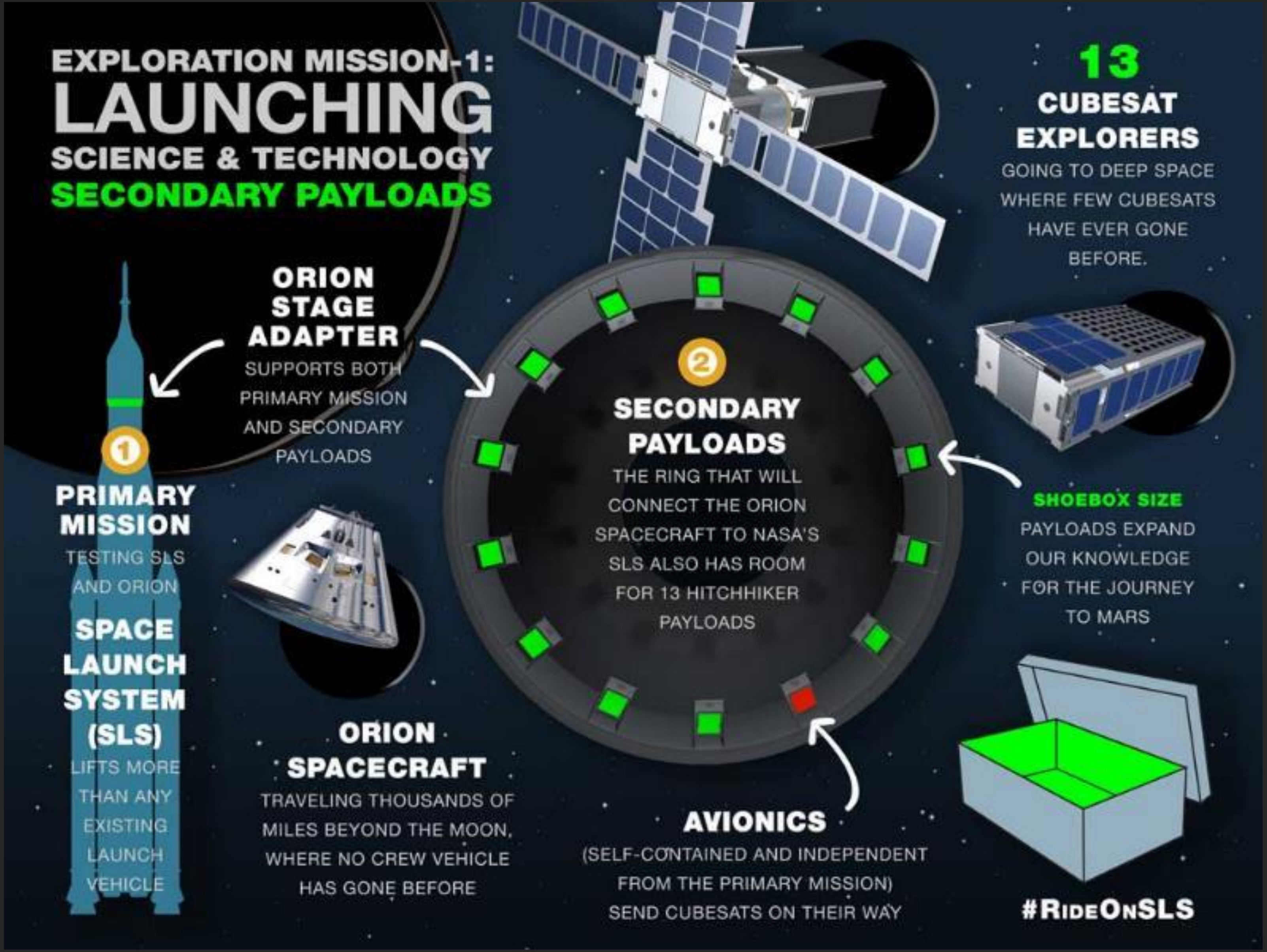

EDSN


BioSentinel

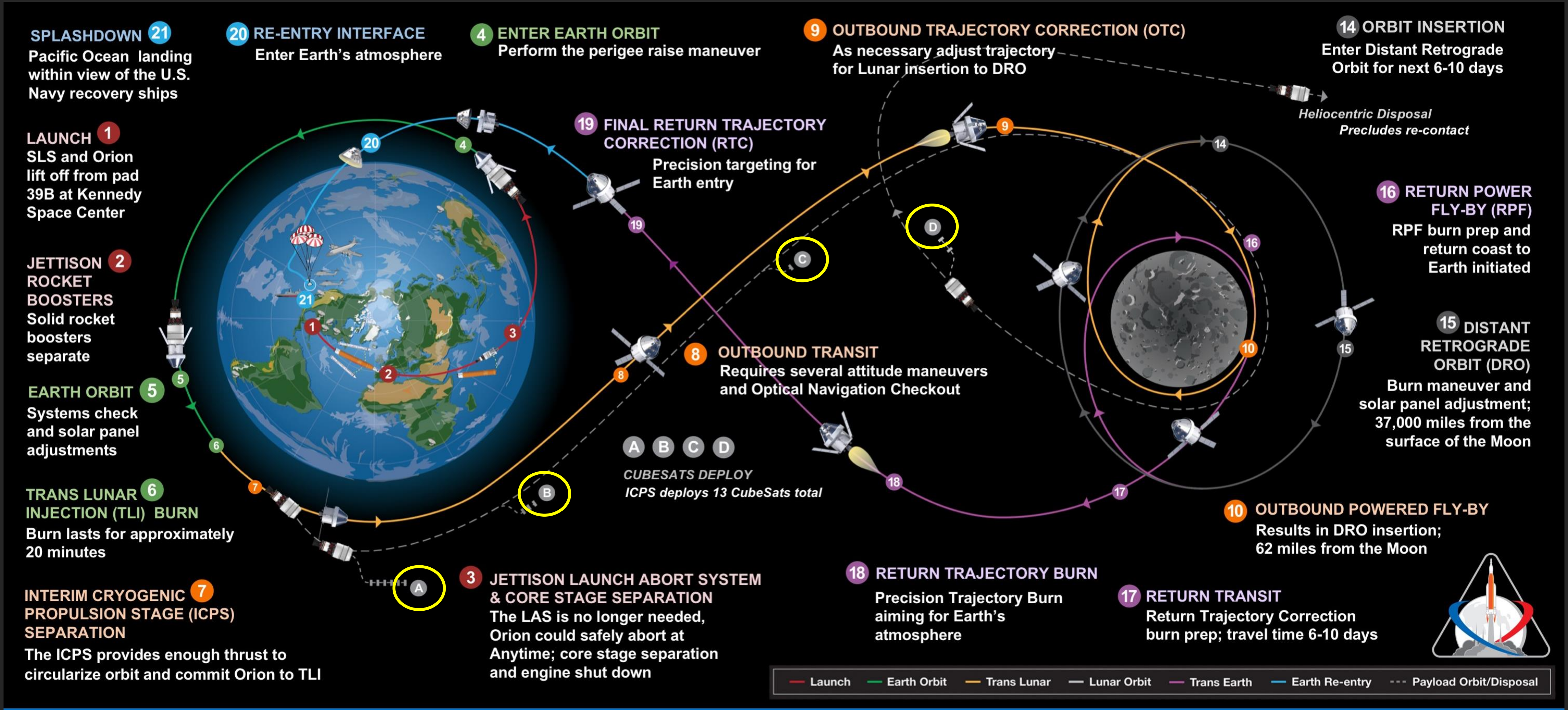





2006
2008
2009
2010
2011
2012
2013
2014
2015
2016
2019
GeneSat 3U s/c
PharmaSat 3U s/c
TechEdSat1 1U s/c
PhoneSat2.5 1U s/c
NODeS (2) X 1.5U s/c
PreSat* 3U s/c
O/OREOS 3U s/c
PhoneSat1, 2ß (3) X 1U s/c
SporeSat1 3U s/c
EDSN (8) X 1.5U s/c
NanoSail-D1* 3U s/c
NanoSail-D2 3U s/c
PhoneSat2.4 1U s/c
KickSat 3U s/c
EcAMSat 6U s/c
PhoneSat1ß 1U – SubOrbital Test
TechEdSat3p 3U s/c
TechEdSat4 3U s/c
TechEdSat5 3U s/c
SporeSat2 3U s/c
BioSentinel 6U s/c
= Space Biology
= Swarm Science
= Technology development
= Planetary Probe development
NASA Ames leads the Agency in CubeSat/Nanosat missions

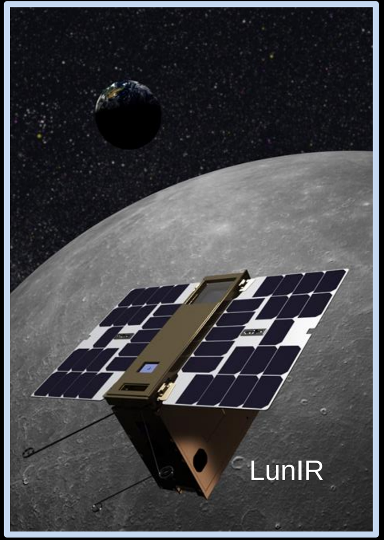

EXPLORATION MISSION-1:
LAUNCHING
SCIENCE & TECHNOLOGY
SECONDARY PAYLOADS
ORION STAGE ADAPTER
SUPPORTS BOTH PRIMARY MISSION AND SECONDARY PAYLOADS
1
PRIMARY MISSION
TESTING SLS AND ORION
SPACE LAUNCH SYSTEM (SLS)
LIFTS MORE THAN ANY EXISTING LAUNCH VEHICLE
ORION SPACECRAFT
TRAVELING THOUSANDS OF MILES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

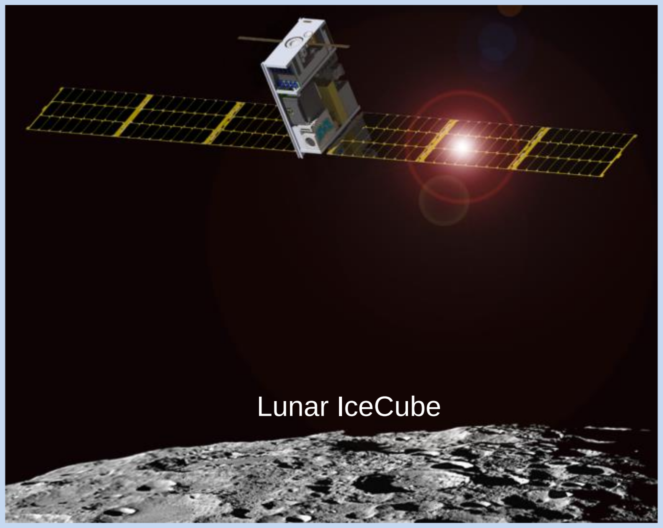
The first uncrewed, integrated flight test of NASA's Orion spacecraft and Space Launch System rocket, launching from a modernized Kennedy spaceport

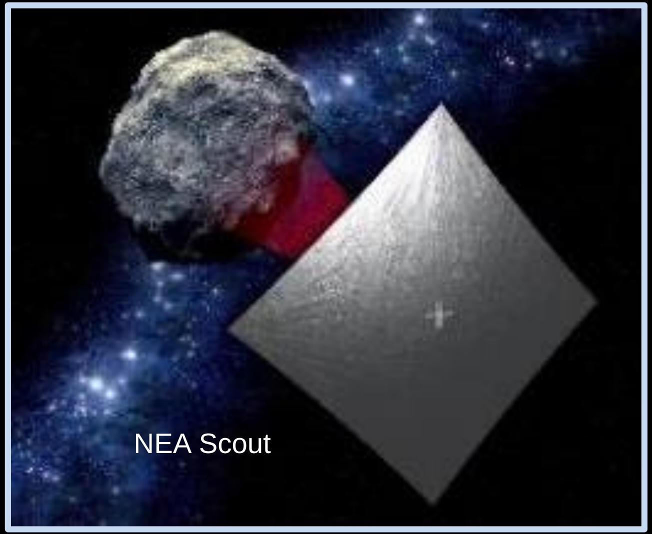


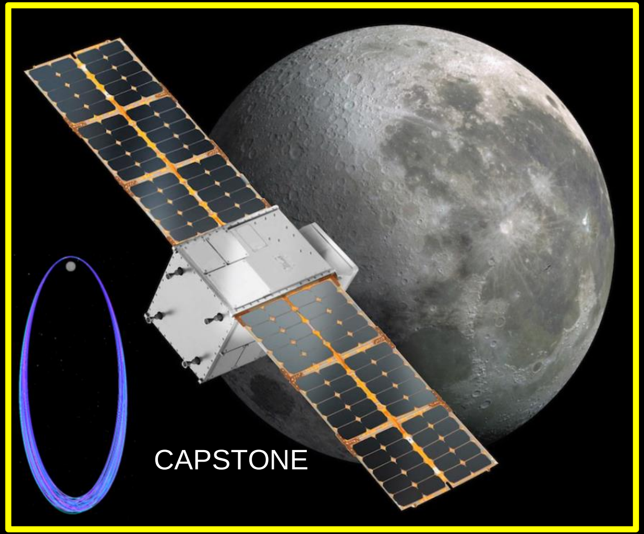
Total distance traveled: 1.3 million miles – Mission duration: 25.5 days – Re-entry speed: 24,500 mph (Mach 32) – 13 CubeSats deployed

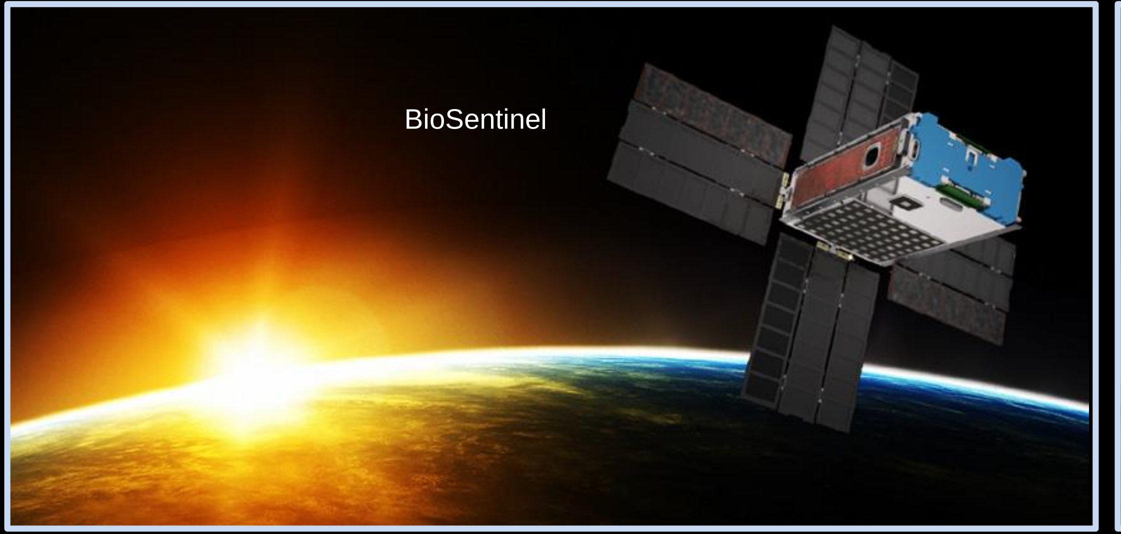
AES SmallSats Supporting Artemis

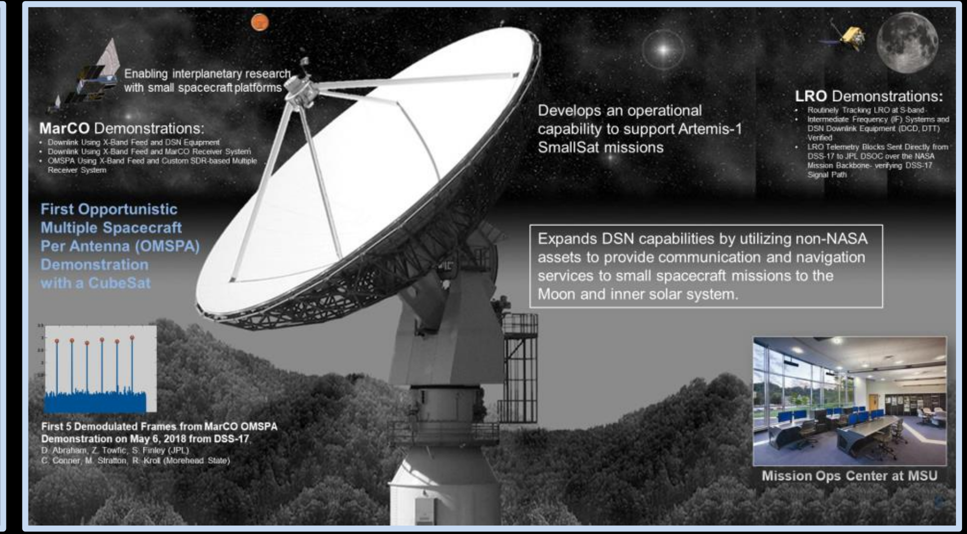












AES SmallSat Missions selected to contribute to key Human Exploration Strategic Knowledge Gaps and to Advance Key Technologies

Why is this project important?

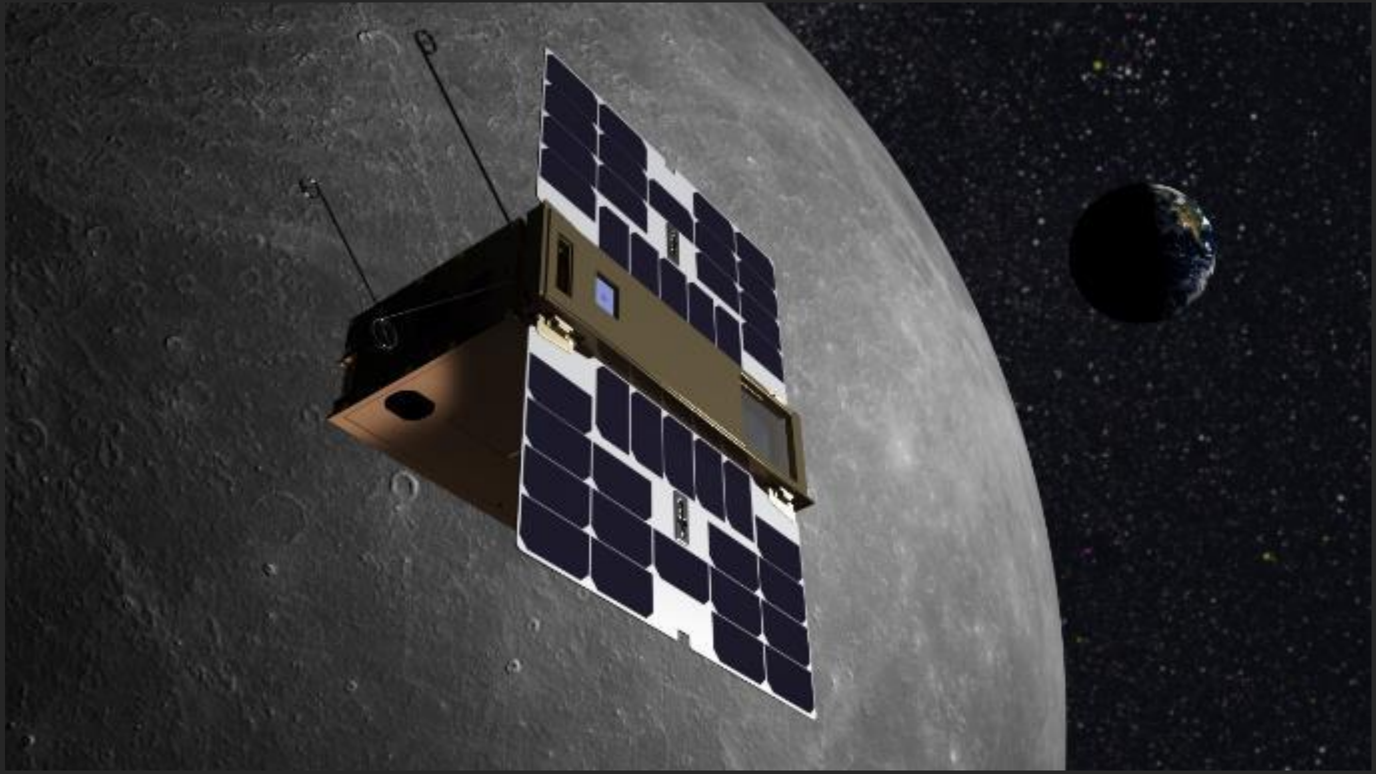
- Capture and downlink MWIR images of lunar surface for analysis toward (7) SKG's
  - ✓ Sensor, optics, control electronics, Cryocooler fit within a 2.4U volume
  - ✓ LM developed micro-cryocooler for Focal Plane Array (FPA) less than 0.5U size

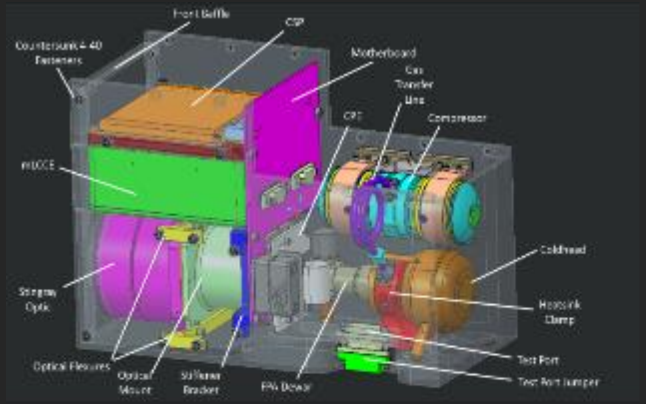
Project Objectives

- Pathfinder small satellite mission hosting a mid-wave Infra-Red (MWIR) sensor. During lunar flyby, LunIR will collect and downlink surface imagery. The MWIR sensor system includes an integrated micro-cryocooler and a high temperature nBn-based 1 Megapixel focal plane.
- LunIR hosts a visible wavelength camera that will be used for on-board navigation processing using the moon
- Data from both will be used for post-processing applicability toward a low Size, Weight and Power (SWaP) common sensor suite for relative navigation.

LOCKHEED MARTIN

Tyvak
A Terran Orbital Corporation





2.4U IR Optical Payload (MWIR, 3.4 to 4 um)

- <2.5 kg, <15 Watts steady-state

1280 x 1024 FPA (nBn) – SBF207

- 12 um pixel pitch; response 1 um to 5 um
- nBn Detector (space qualification 2013-15)

LM micro-cryocooler

- TRL 6 mechanical Unit
- Tactical cryocooler electronics (Iris)

Fixed focus, no shutter

COTS 50mm Focal Length, f/2.3, MWIR Lens

- Optical transmits 76.6%
- FOV = 22.8 degrees

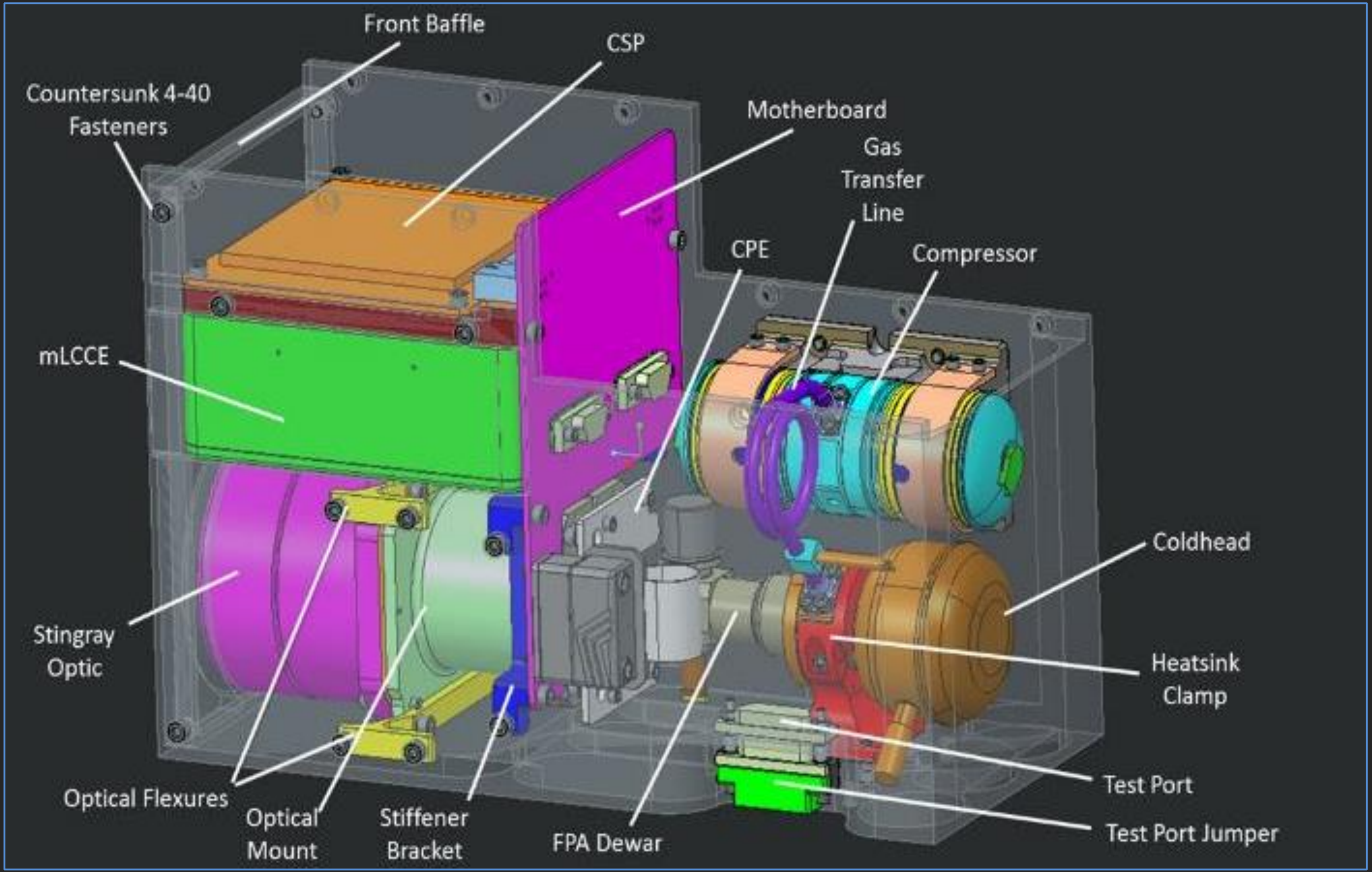
Common Core FSW (NASA/Goddard)

CHREC Space Processor

- Fab by SpaceMicro

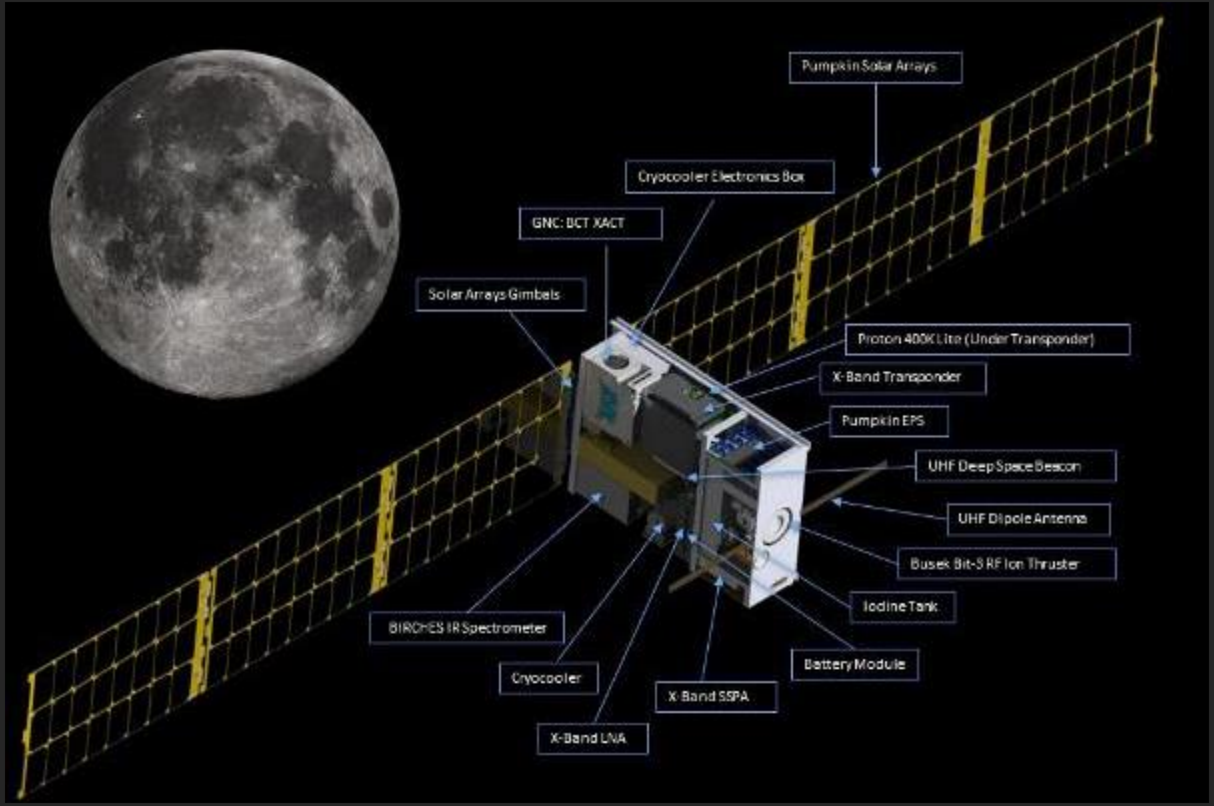
Image Storage: 512 Mbytes, ~100 images (uncompressed)

- Payload data downlinked to bus after each imaging opportunity



Legend:
MWIR – Mid-Wave Infra-Red
CSP – CHREC Space Processor
CHREC – Center for High-performance Reconfigurable Computing
ATC – LM Advanced Technology Center
SBF – LM Santa Barbara Focal plane
mLCCE – micro Low-Cost Cryocooler Electronics
CPE – Close Proximity Electronics

LOCKHEED MARTIN
Tyvak
A Terran Orbital Corporation

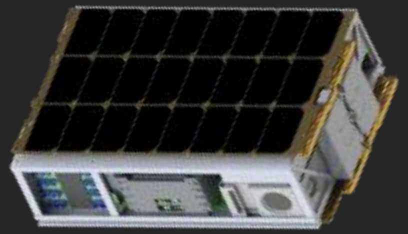


Why is this project important?

- The mission goal is to prospect for water in ice, liquid, and vapor forms and other lunar volatiles from a highly inclined lunar orbit (100 km perilune) using NASA GSFC's BIRCHES infrared (IR) spectrometer: a miniaturized version of the instrument used on OSIRIS REX.
- Potentially lends insight into the location and transport physics of water on the Moon in support of future Human Exploration.

Project Objectives

- Demonstrates enabling technologies for exploration of the Solar System with small satellites, including an innovative RF Ion engine combined with a low energy trajectory to achieve lunar capture. The Busek BIT-3 uses solid-state iodine as the propellant generating significant Δv (1.3 km/s)
- Prospect for water in ice, liquid, and vapor forms and other lunar volatiles from a low-perigee, inclined lunar orbit using NASA GSFC's BIRCHES - IR spectrometer.



NASA Goddard | BUSEK Space Propulsion and Systems | JPL Jet Propulsion Laboratory California Institute of Technology

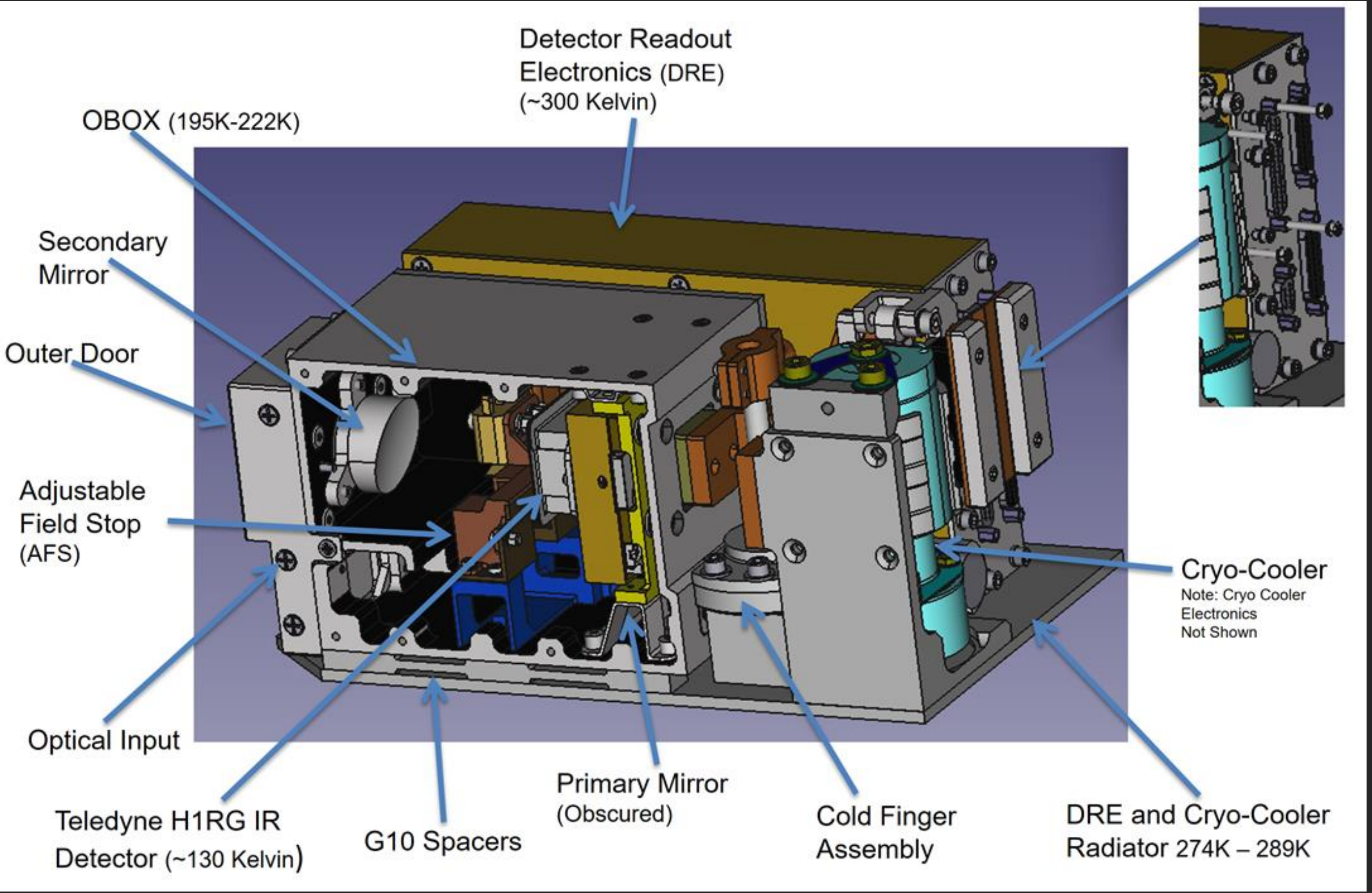
Lunar IceCube - BIRCHES

Description:

- **B**roadband **I**nfra**R**ed **C**ompact **H**igh **R**esolution **E**xploration **S**pectrometer
- BIRCHES Point Spectrometer will determine distribution of volatiles, including forms and components of water, and other volatiles such as NH3, H2S, CO2, CH4, to the extent possible, in lunar regolith as a function of time of day and latitude
- IR measurements associated with volatiles in the 3 micron region at </= 10 nm spectral resolution
- Leverages OSIRIs-REX Heritage - spare

Technology Demonstrations

- **NASA GSFC - BIRCHES** Miniaturized IR Spectrometer - characterize water and other volatiles with high spectral resolution (5 nm) and wavelength range (1 to 4 μm)
- Innovative SmallSat thermal design will maintain detector <115K +/- 1K, optics box <230K +/- 5K, avionics in nominal range



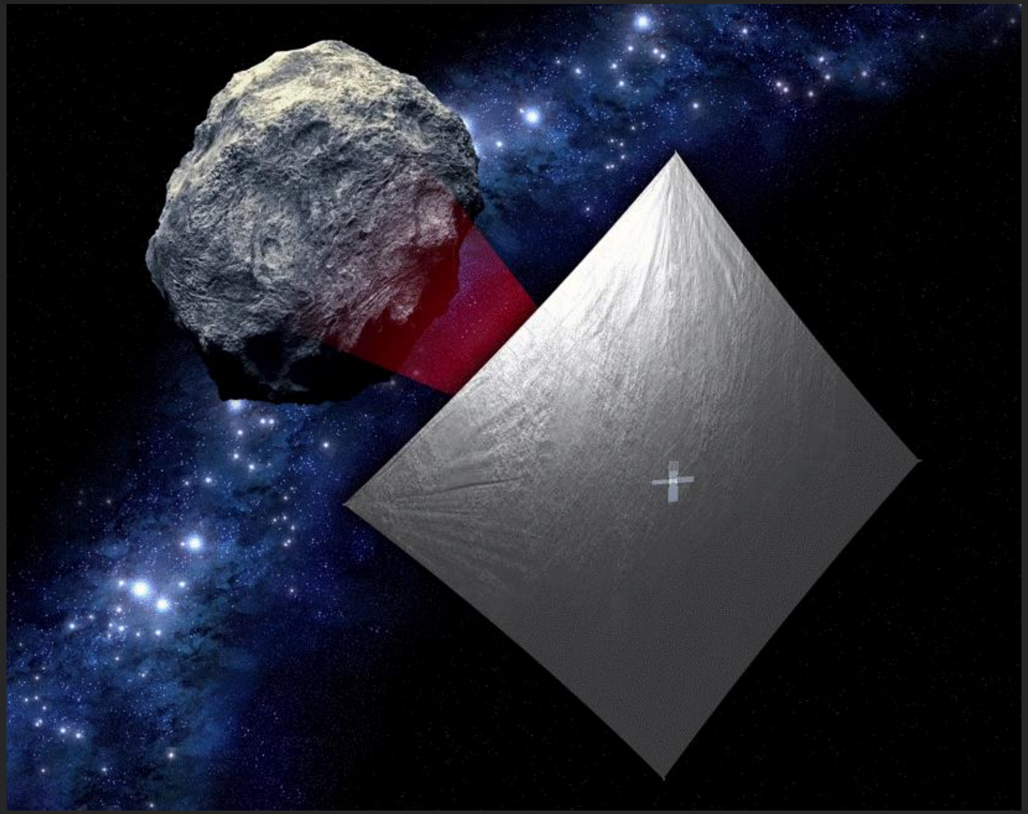
Lunar IceCube instrument: **B**roadband **I**nfra**R**ed **C**ompact **H**igh **R**esolution **E**xploration **S**pectrometer (**BIRCHES**)

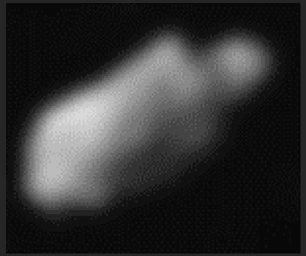
Why is this project important?

- Serves as a robotic reconnaissance mission to fly by and return data from an asteroid representative of near-Earth asteroids that may one day be human destinations.
- Addresses Strategic Knowledge Gaps (SKGs) for future Near Earth Asteroid exploration
- Furthers our scientific understanding of Near Earth Asteroids
- Demonstrates solar sail propulsion for use on future robotic and science exploration and science missions

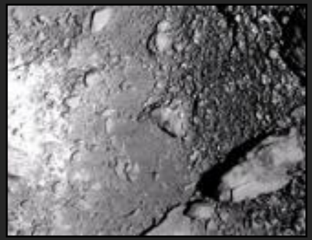
Project Objectives

- Image/characterize a NEA during a slow flyby (e.g. 2019 GF1)
- Design, develop, integrate and operate a spacecraft for the purpose of demonstrating a low cost reconnaissance capability
- Enable asteroids as potential destinations for human exploration
- Characterize a candidate NEA with an imager to address key SKG's





Target Reconnaissance with medium field imaging
Shape, spin, and local environment



Close Proximity Imaging
Local scale morphology, terrain properties, landing site survey

Marshall Space Flight Center
Jet Propulsion Laboratory
California Institute of Technology

BioSentinel

Why is this project important?

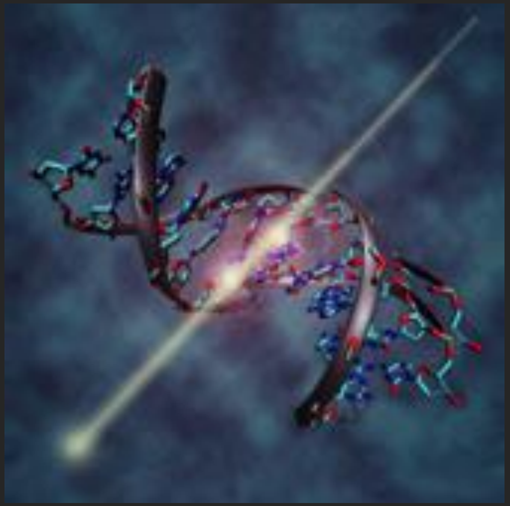
BioSentinel is a deep space mission to detect, measure and correlate the impact of space radiation on living organisms over long durations.

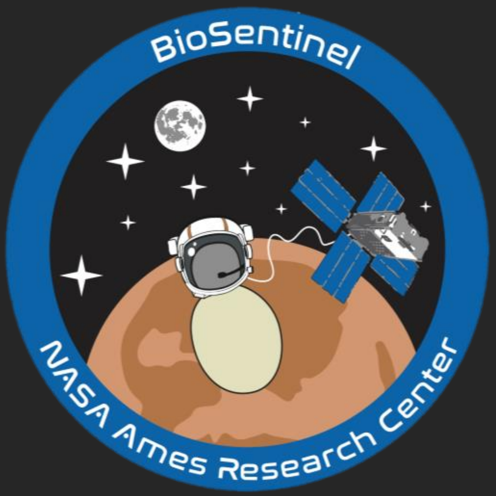
BioSentinel is a free-flyer mission carrying the BioSensor and linear energy transfer (LET) Spectrometer instruments. The BioSensor is a self-contained biology-based radiation sensor using yeast, a simple model organism.

The yeast cells will receive ionizing radiation in desiccated state and in suspension; the BioSensor measures cell growth and metabolic activity.

Project Objectives

- Develop a deep space nanosat capability
- Develop a radiation biosensor useful for other missions
- Define & validate SLS secondary payload interfaces and accommodations for a biological payload





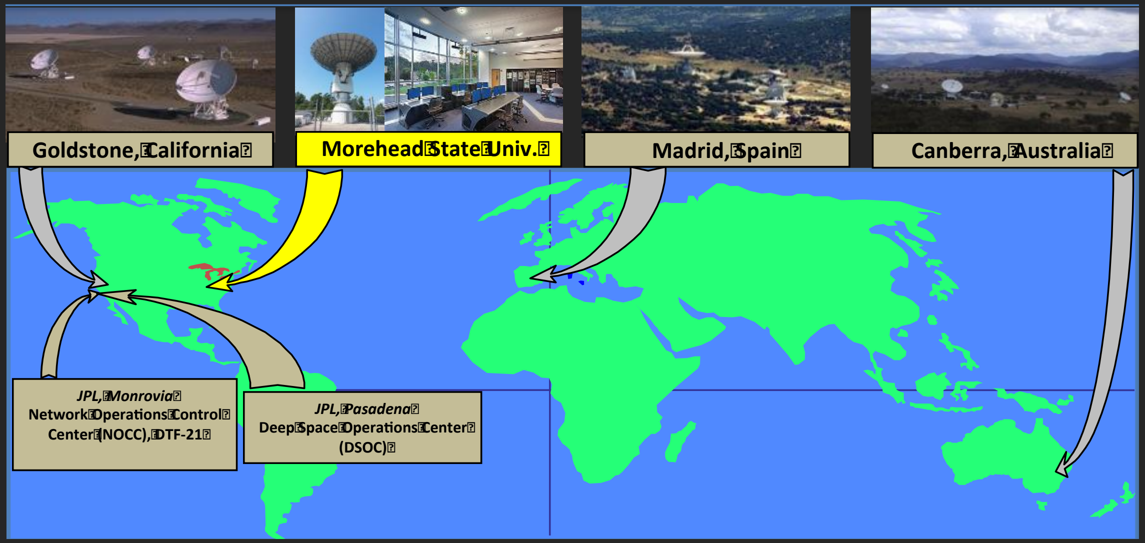
Ames Research Center

Deep Space Network (DSN) - Deep Space Station 17 (DSS-17)

Why is this project important?

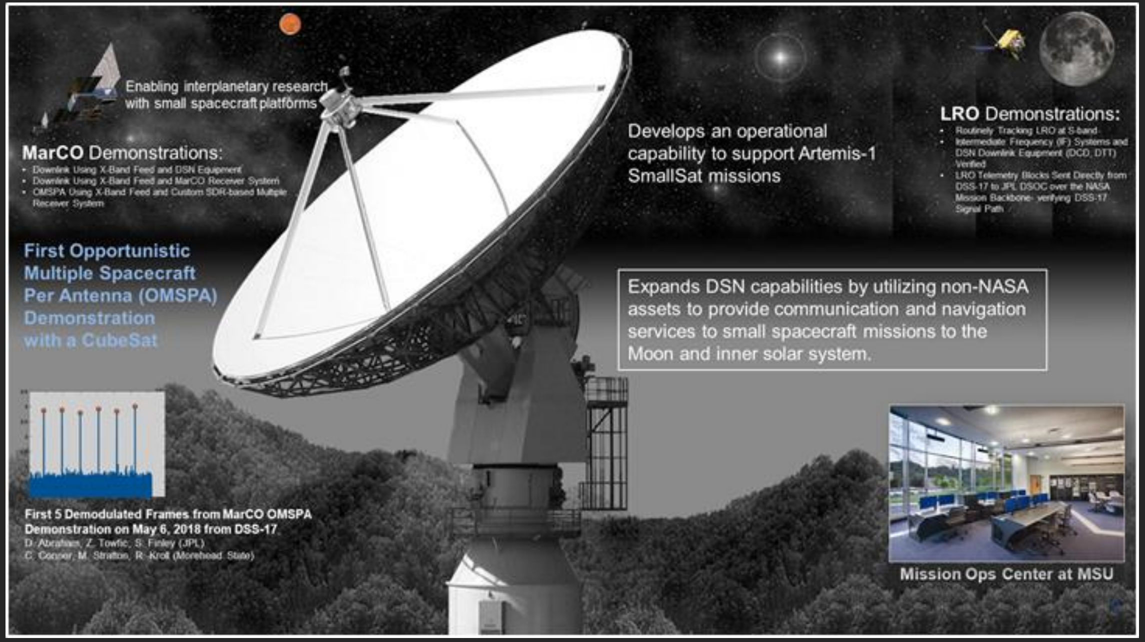
- Serves as a test-case for other non-NASA ground stations to provide auxiliary deep space navigation and tracking support for small spacecraft missions.
- Ground segment support for Artemis, Moon to Mars, and Beyond!
- Provides operational capability to support Artemis 1 CubeSat missions in the 2021 timeframe:

Artemis Missions Supported by DSS-17 at MSU:			
Lunar IceCube	LunIR	CAPSTONE	LunaH Map
BioSentinel	NEA Scout	Lunar Flashlight	CuSP



Project Objectives

- Expand DSN capabilities by utilizing non-NASA assets to provide communication and navigation services to small spacecraft missions to the Moon and inner solar system
- Provide operational capability to support Artemis SmallSat missions
- Enable interplanetary research with small spacecraft platforms



Jet Propulsion Laboratory
California Institute of Technology

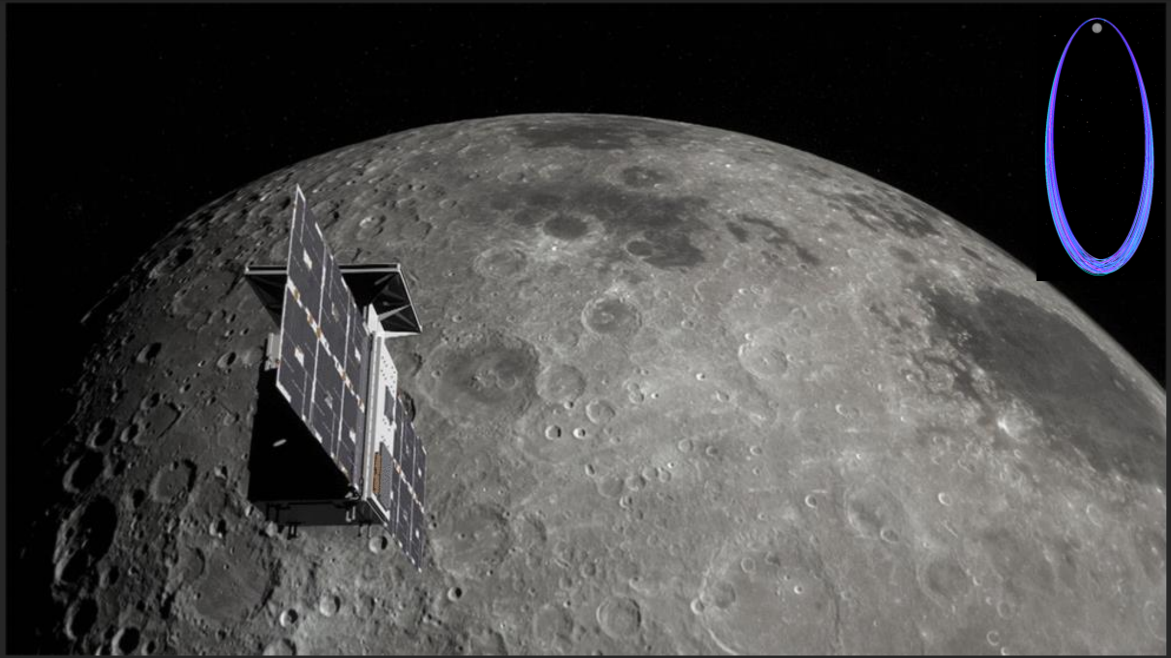
Why is this project important?

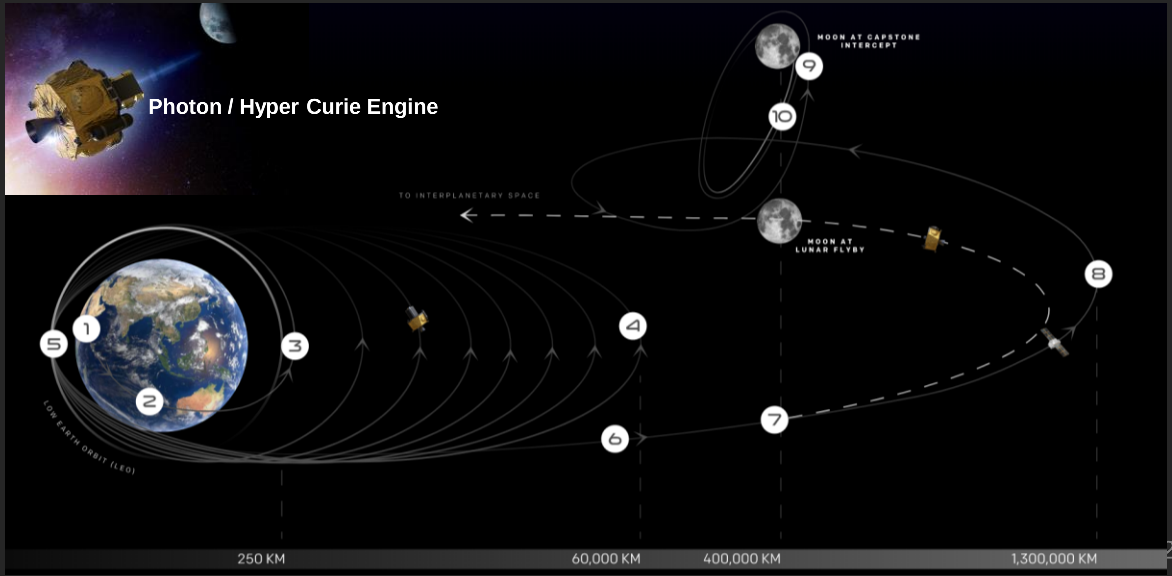
- The Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) is expected to be the first spacecraft to operate in a near rectilinear halo orbit (NRHO) around the Moon. In this unique orbit, the CubeSat will rotate together with the Moon as it orbits Earth and will pass as close as 1,000 miles and as far as 43,500 miles from the lunar surface.
- Following a three-month trip to the Moon, CAPSTONE will enter a near rectilinear halo orbit, which is a highly elliptical orbit over the Moon's poles, to verify its characteristics for future missions and conduct a navigation demonstration with NASA's Lunar Reconnaissance Orbiter.

Project Objectives

- **Verify** the characteristics of a cis-lunar near rectilinear halo orbit NRHO/three-body Earth-Moon Operations for future spacecraft. Demonstrate entering and maintaining this unique orbit.
- **Demonstrate** the Cislunar Autonomous Positioning System's (**CAPS**) ability to generate spacecraft-to-spacecraft navigation services that allow future spacecraft to determine their location relative to the Moon without relying exclusively on tracking from Earth. CAPSTONE spacecraft **communicates** with LRO to **demonstrate** relative measurements and components of autonomous navigation system
- Pathfinder – Document operational experience and lessons learned for insertion into and operation in a lunar NRHO. Mitigate technical risks of NRHO operations and validate navigation and stationkeeping analysis and simulation and directly transfer that experience and lessons to **inform NASA Gateway** planning activities.
- Demonstrate **one way ranging** using chip scale atomic clock (CSAC) integrated with IRIS radio.

Advanced Space | Tyvak A Terran Orbital Corporation | ROCKET LAB | STELLAR EXPLORATION





TechEdSat-1

Mission Description

NASA Ames Research Centered mentored students from San Jose State University. The mission was to demonstrate:

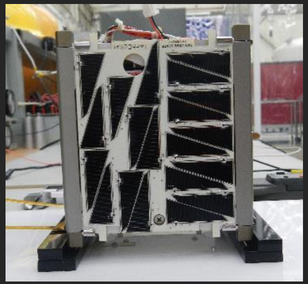
1.) the capabilities of the JAXA J-SSOD aboard the ISS, and be one of the first cubesats to be deployed from the ISS.

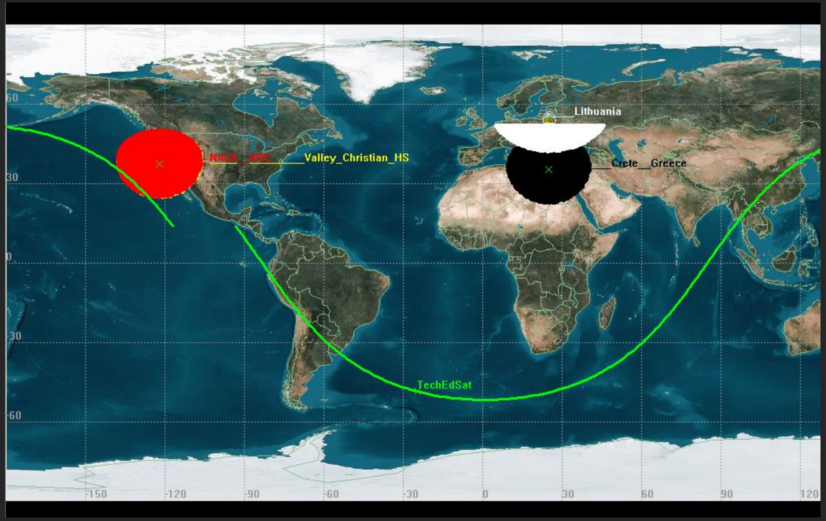
2.) Iridium and OrbComm inter-satellite communication as a method of eliminating the requirement for a physical ground station in small satellite missions.

3.) Ability for engineering students to deliver a flight system to be up-massed to the International Space Station for deployment to space.

Spacecraft Specifications:

- **Mass**: 1.2kg
- **Quantity**: One 1U cubesat
- **Orbit**: 400 km x 400 km @ 51.6 incl.
- **Size**: 10 x 10 x 11 cm
- **Communication**: UHF band
- **Launched**: HTV-4 (JUL 21, 2012



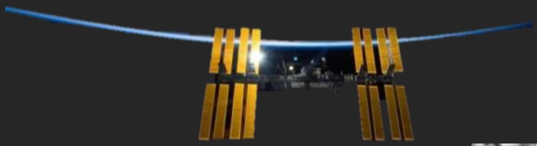


Mission Description

The AztechSat-1 is a 1U CubeSat-class small satellite managed, designed and built by an interdisciplinary team of engineering students and other areas of the Puebla State Autonomous University (UPAEP-Universidad Popular Autónoma del Estado de Puebla – Puebla, Mexico). This primary mission to conduct an inter-satellite communication demonstrations between AztechSat-1 and the Globalstar Constellation.

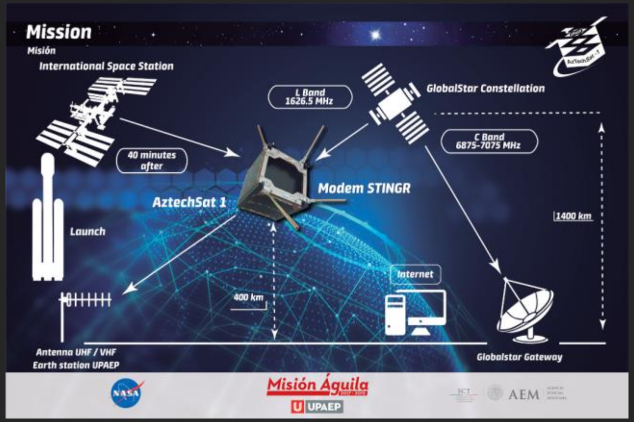
AztechSat-1 is the first spaceflight project of the Aerospace Engineering department at the Universidad Popular Autónoma del Estado de Puebla (UPAEP). This project provides participating students the hands-on experience managing, designing, building satellites, and operating a space mission.

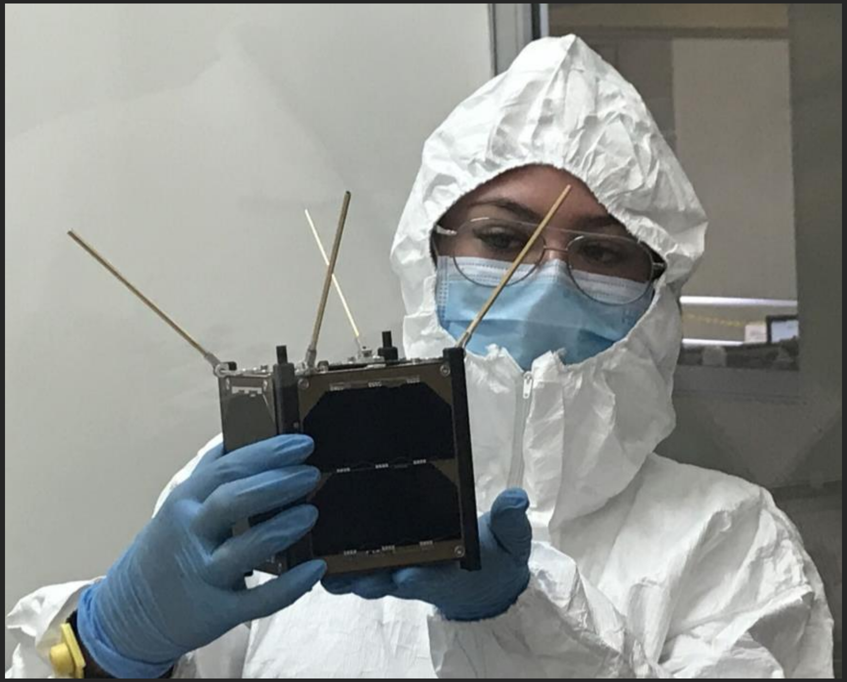
Using inter-satellite communication with the Globalstar Constellation to augment the downloaded data will increase data availability and reduces the requirements for ground stations, thus reducing mission cost. This may potentially increase the amount of data available for the principal investigators.



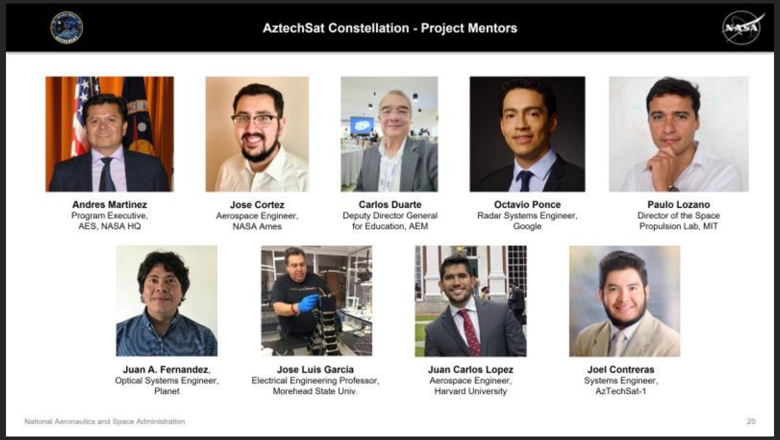
Spacecraft Specifications:

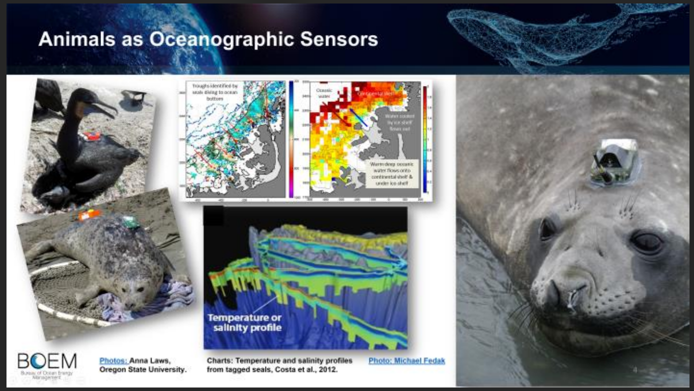
- **Mass**: 0.910 kg
- **Quantity**: One 1U cubesat
- **Orbit**: 400 km x 400 km @ 51.6 incl.
- **Size**: 10 x 10 x 11 cm
- **Communication**: UHF band, Globalstar
- **Launch**: SpaceX-19 (DEC 05, 2019)

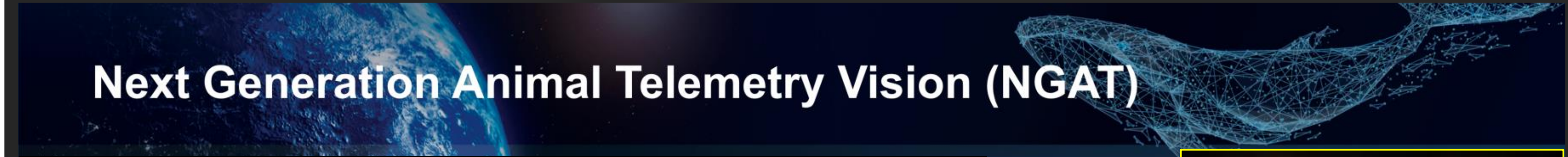


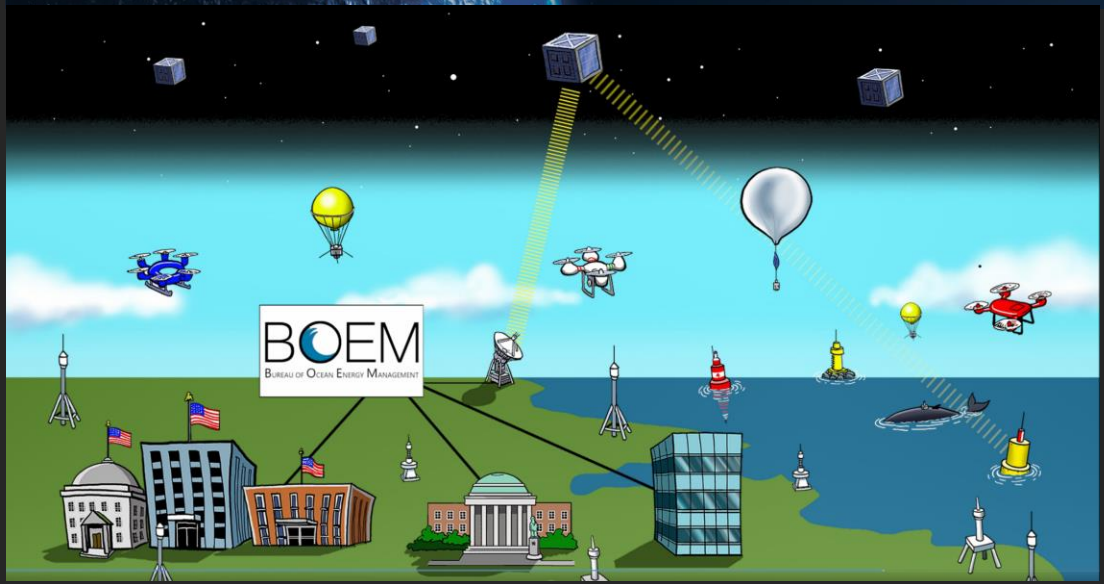


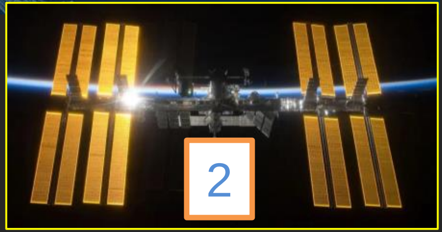
AztechSat Constellation – NASA / AEM Proposed Mission

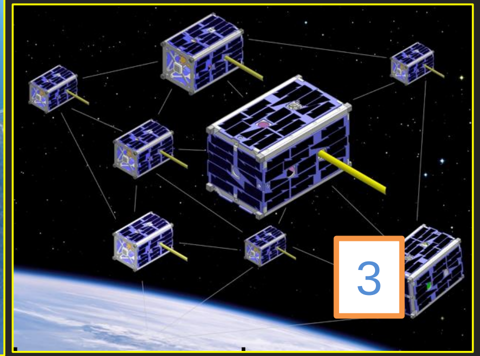


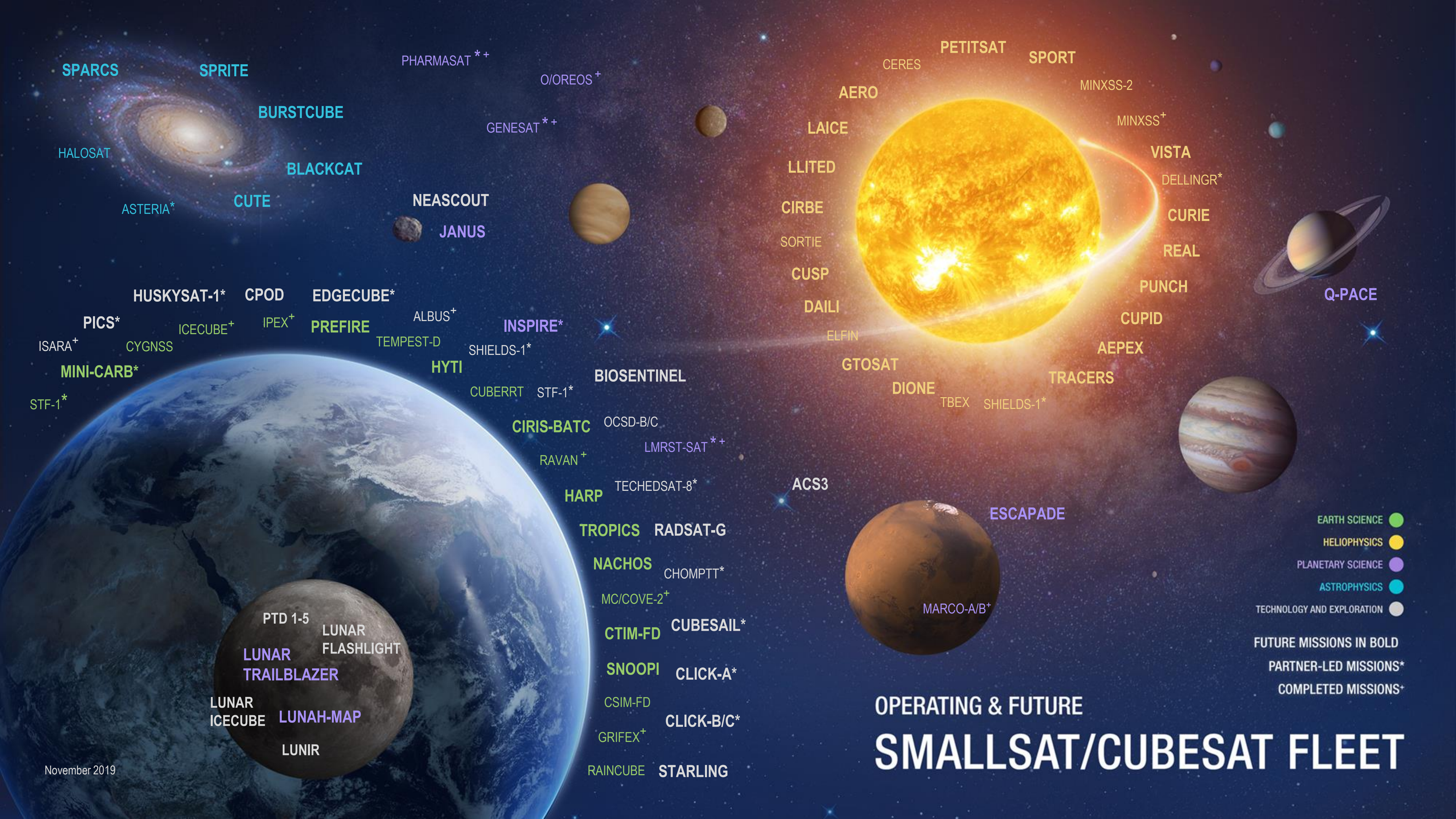











SPARCS
SPRITE
BURSTCUBE
HALOSAT
BLACKCAT
ASTERIA*
CUTE
PHARMASAT *+
O/OREOS+
GENESAT *+
NEASCOUT
JANUS
CERES
PETITSAT
SPORT
AERO
MINXSS-2
LAICE
MINXSS+
VISTA
LLITED
DELLINGR*
CIRBE
CURIE
SORTIE
REAL
CUSP
PUNCH
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ELFIN
AEPEX
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BIOSENTINEL
STF-1*
CUBERRT
STF-1*
CIRIS-BATC
OCSD-B/C
LMRST-SAT *+
RAVAN+
HARP
TECHEDSAT-8*
ACS3
TROPICS
RADSAT-G
ESCAPADE
NACHOS
CHOMPTT*
MC/COVE-2+
MARCO-A/B+
CTIM-FD
CUBESAIL*
SNOOPI
CLICK-A*
CSIM-FD
CLICK-B/C*
GRIFEX+
RAINCUBE
STARLING
PTD 1-5
LUNAR FLASHLIGHT
LUNAR TRAILBLAZER
LUNAR ICECUBE
LUNAH-MAP
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November 2019
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HELIOPHYSICS
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SMALLSAT/CUBESAT FLEET

Small Spacecraft Coordination Group

Formed to advise the SMD, STMD, and HEOMD Associate Administrators on strategy to guide cross-agency initiatives, policies, and programmatic scope

Small Spacecraft Integrated Strategic Plan	SSCG Focus Areas

- Strategy and Implementation
- Safety, Mission Assurance, & Reliability
- Services and Infrastructure
- Launch Accommodation and Rideshare
- Cybersecurity and Enterprise Protection
- Commercial Partnerships & New Space
- International Relationships and Outreach

Small Spacecraft Virtual Institute: https://www.nasa.gov/smallsat-institute

Science
New Observation Methods

Exploration
Strategic Knowledge Gaps

Technology
Spacecraft Subsystems

Thank you!

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