National Aeronautics and Space Administration

Ames

Discovery · Innovations · Solutions

NASA Ames Research Center

Presente en la

Feria Aeroespacial México 2015

Base Aérea Militar No. 1, en Santa Lucía, México

Andres Martinez
Small Spacecraft Technology Program (SSTP), Director
SPHERES Program, Director

NASA Ames Research Center
Moffet Field, CA

April 23rd, 2015

National Advisory Committee for Aeronautics *Laboratories*

NACA

Joseph S. Ames

Ames

Dryden

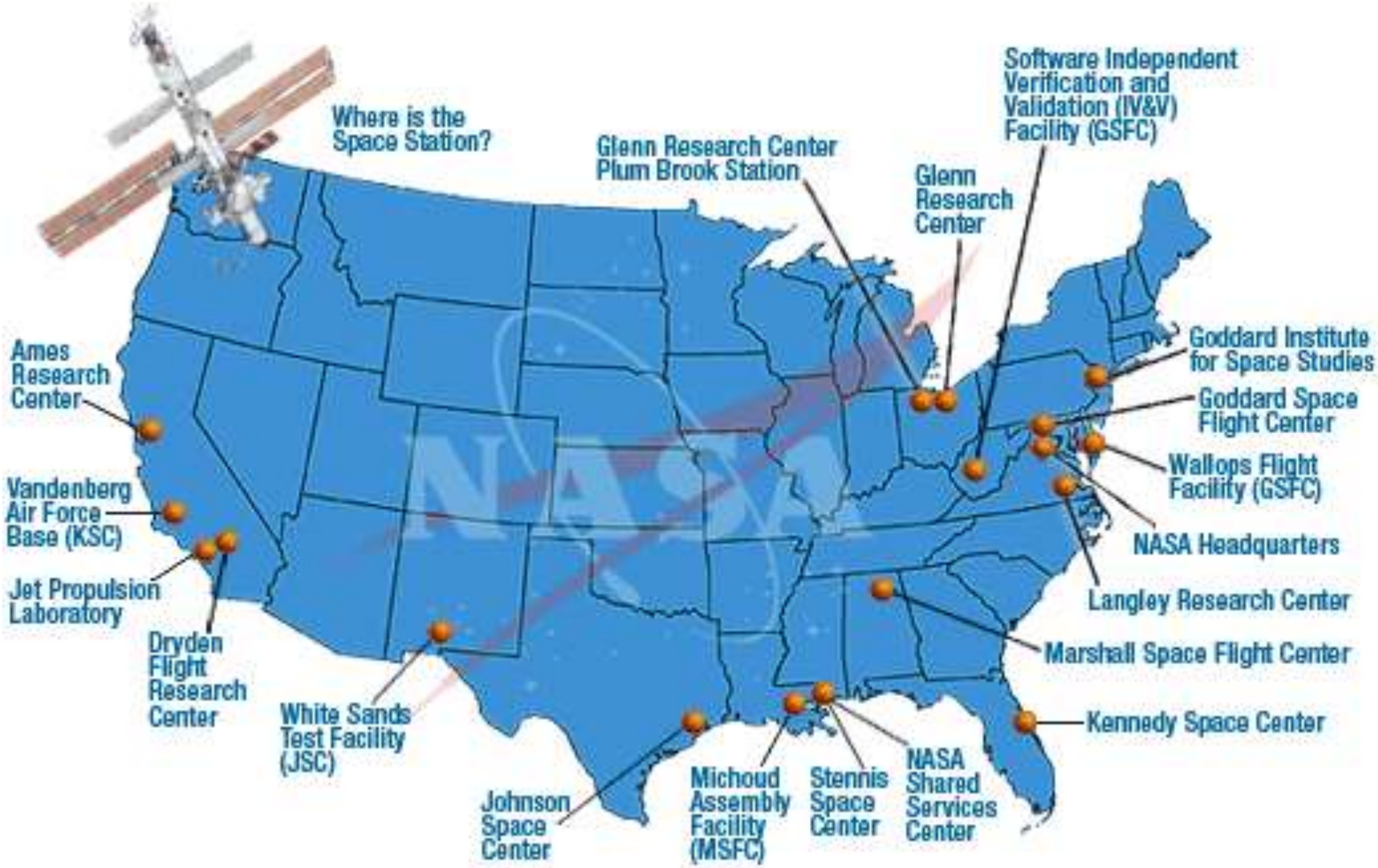
NASA

Langley

Lewis

1915 1939 1940 1946 1958

NASA Now


Where is the Space Station?
Glenn Research Center Plum Brook Station
Software Independent Verification and Validation (IV&V) Facility (GSFC)
Glenn Research Center
Ames Research Center
Goddard Institute for Space Studies
Goddard Space Flight Center
Vandenberg Air Force Base (KSC)
Wallops Flight Facility (GSFC)
NASA Headquarters
Jet Propulsion Laboratory
Langley Research Center
Dryden Flight Research Center
Marshall Space Flight Center
White Sands Test Facility (JSC)
Kennedy Space Center
NASA Shared Services Center
Johnson Space Center
Michoud Assembly Facility (MSFC)
Stennis Space Center
NASA

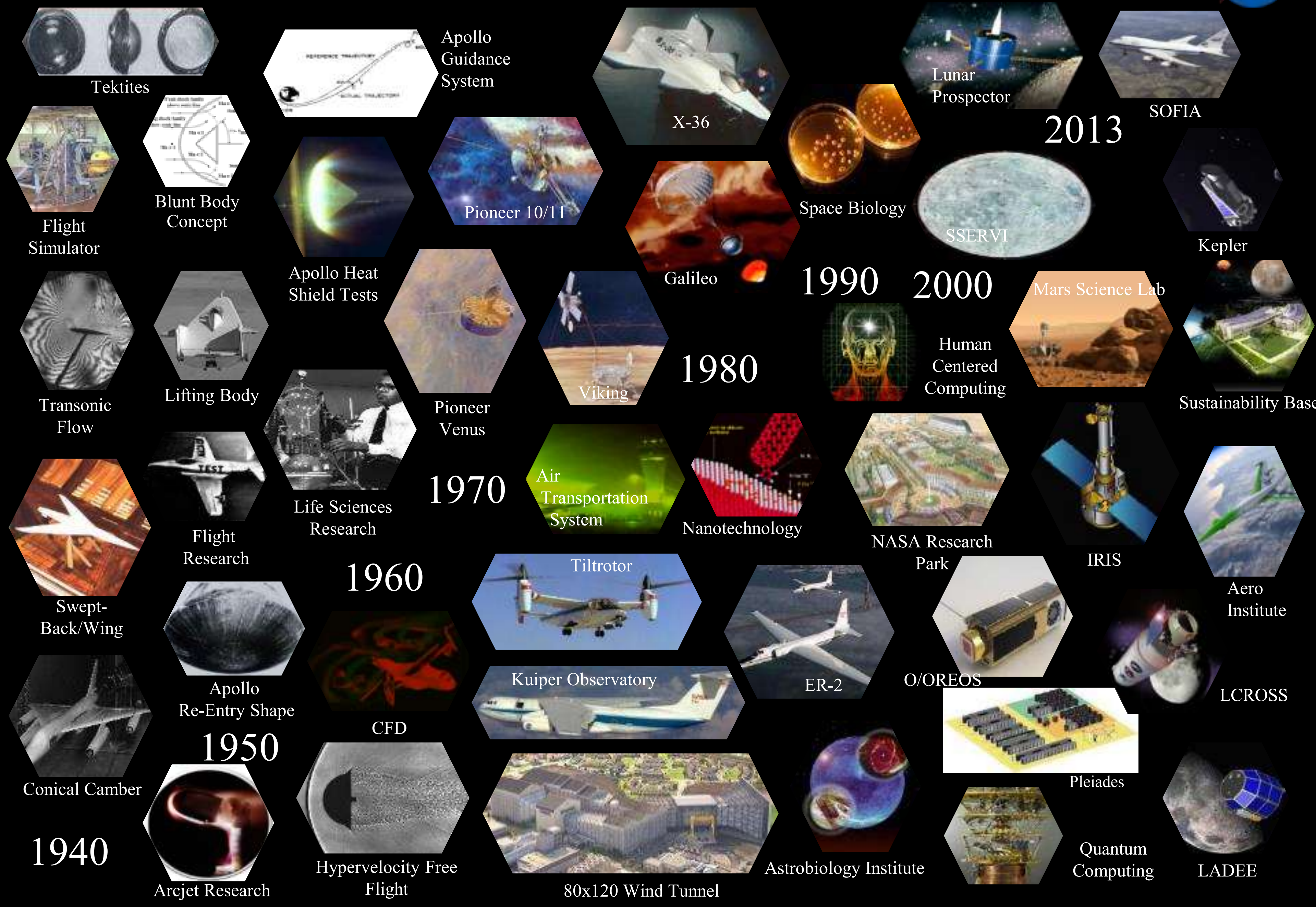
Ames Today

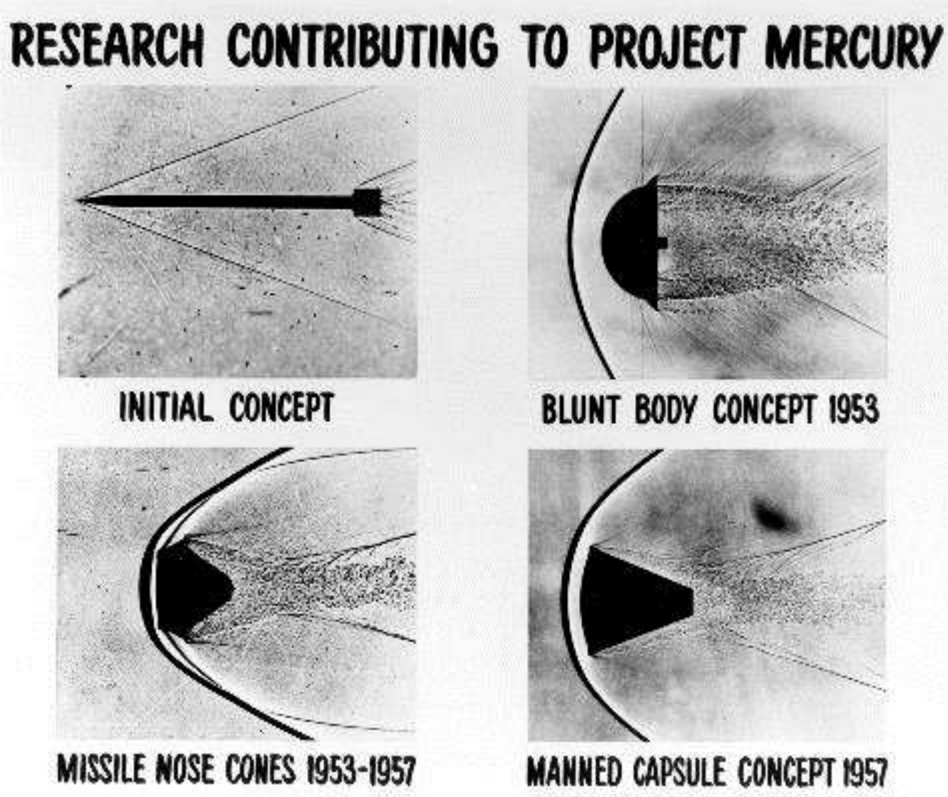
- 2480 employees*
- ≈900M + annual revenue (including reimbursable)

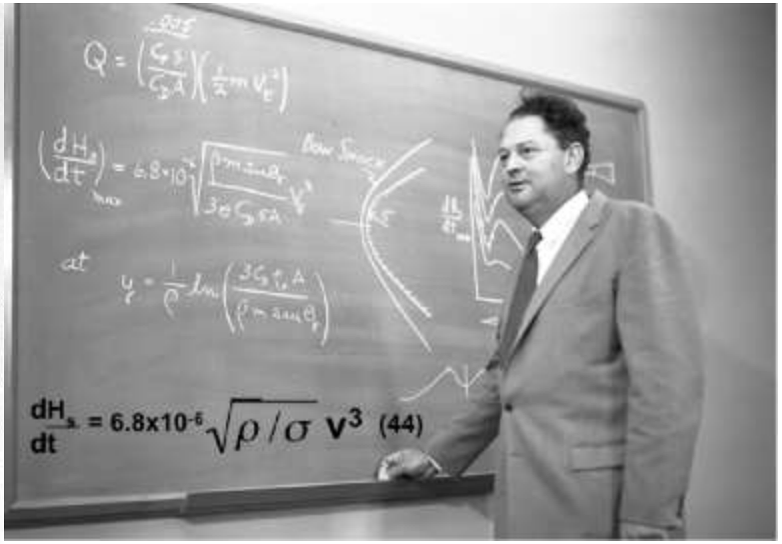
*in addition, 900 students, summer 2014

- Science
  - Space, Earth, Biological Sciences
  - Astrobiology, Lunar Science
- Exploration Systems
  - Exploration Technology Development
  - Entry System Technology
  - Supercomputing
- Projects and Missions
- Aeronautics & Aviation
  - NextGen Airspace Systems
  - Fundamental Aeronautics
  - Aviation Safety
  - Green Aviation
- Affordable Small Satellites
- Innovation, Education, & Entrepreneurial Collaborations
  - NASA Research Park

Seven Decades of Innovation



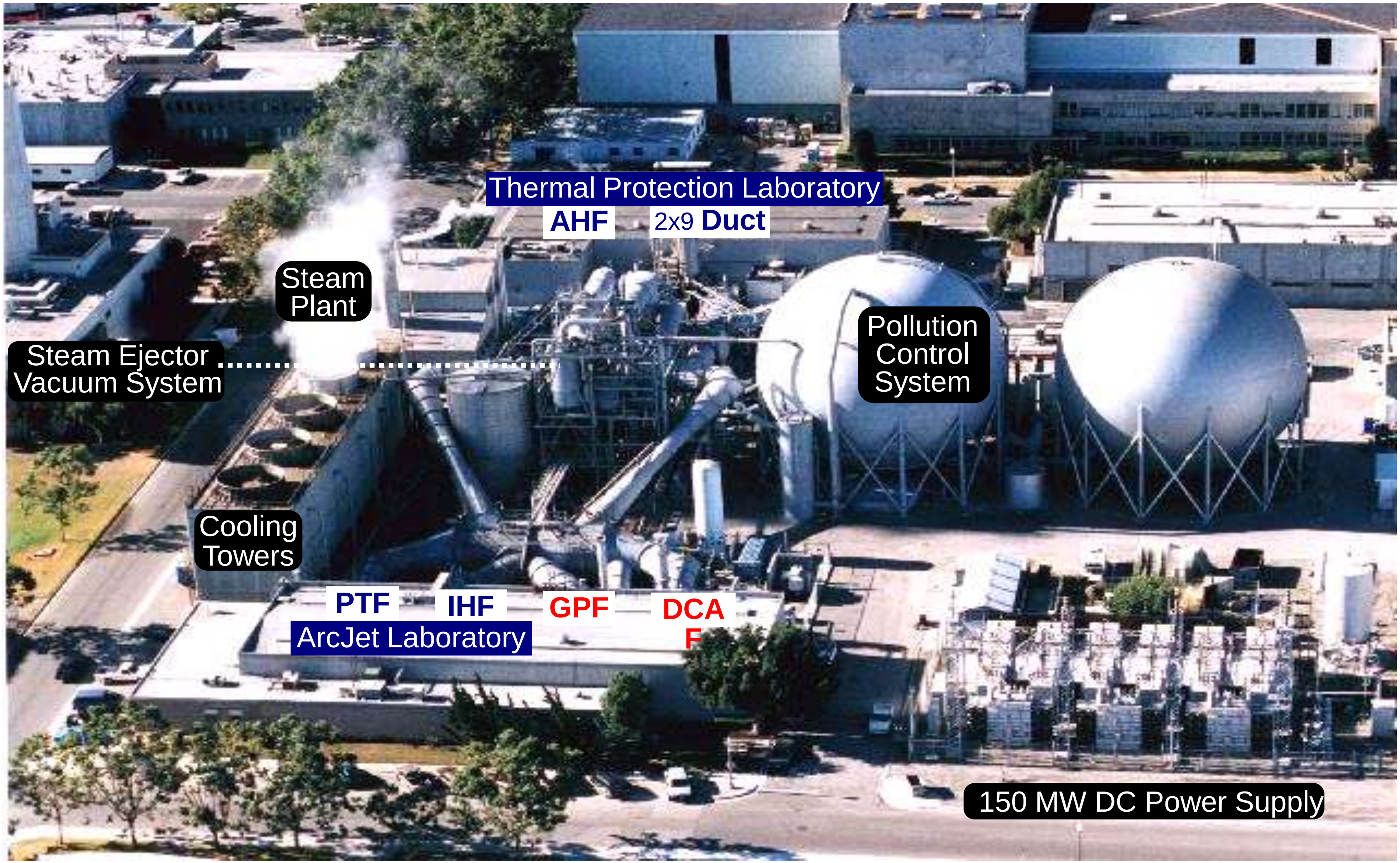




H. Julian Allen – “Blunt Body” concept of re-entry aerodynamics which permitted successful recovery of orbiting spacecraft.

Dean Chapman - Pioneer in Aerothermodynamics

Al Seiff - Planetary Entry Probe Innovator



KEY

2 x 9 Duct - Turbulent Flow Facility
AHF - Aerodynamic Heating Facility
IHF - Interactive Heating Facility
PTF - Panel Test Facility
GPF - Giant Planet Facility
DCAF - Direct Connect Aerodynamic Facility

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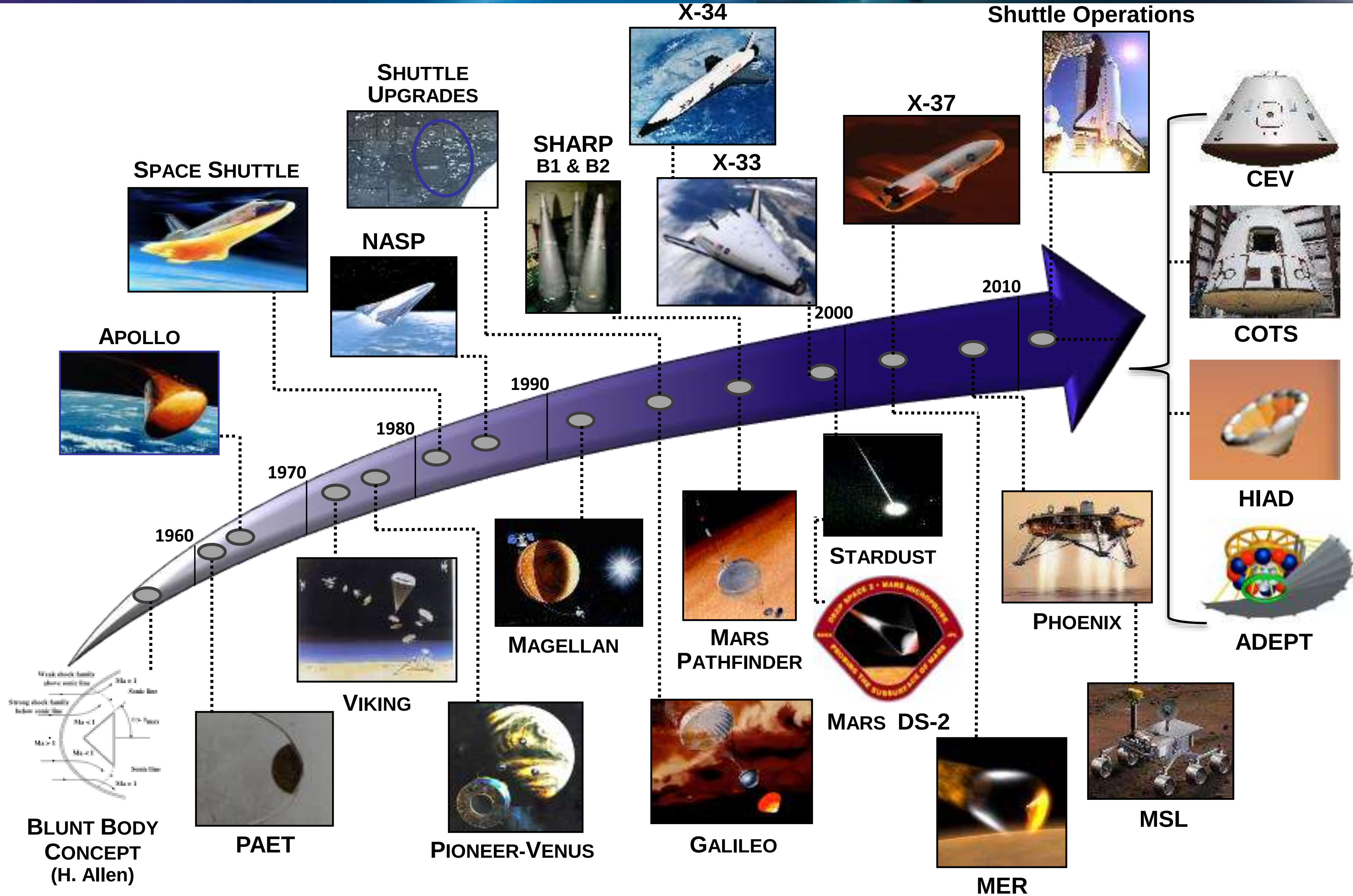


National Full-Scale Aerodynamics Complex

The 80- by 120-foot is an open circuit tunnel. Air is drawn from the huge 360-foot wide, 130-foot high air intake, passes through the 120-foot wide, 80-foot high test section and then is expelled to the atmosphere. The maximum airspeed through the test section is 115 mph. Power is derived from six 40-foot diameter fan blades, each motor rated at 23,500 hp.

The world's largest wind tunnel. The 80-by 120-foot tunnel is capable of testing aircraft as large as a Boeing 737.

From the dawn of powered flight, military and commercial aircraft have benefitted from NASA Ames Research Center aeronautics research.

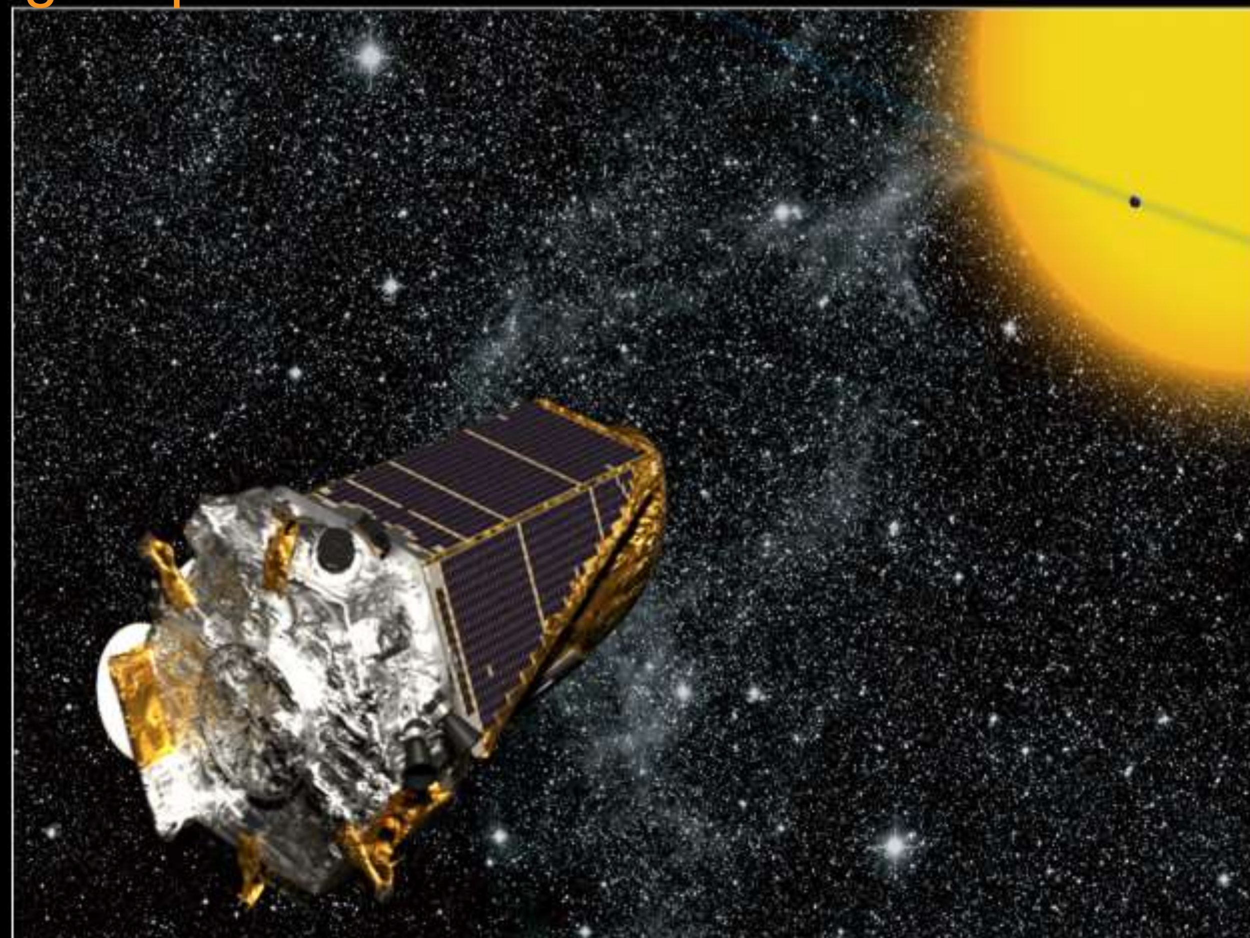
F/A-18 aircraft, first full-scale aircraft to undergo tests in the world's largest wind tunnel.

The model is one-third the size & weight of a full-scale orbiter.

NASA’s Kepler Mission:

Searching for planets around other stars

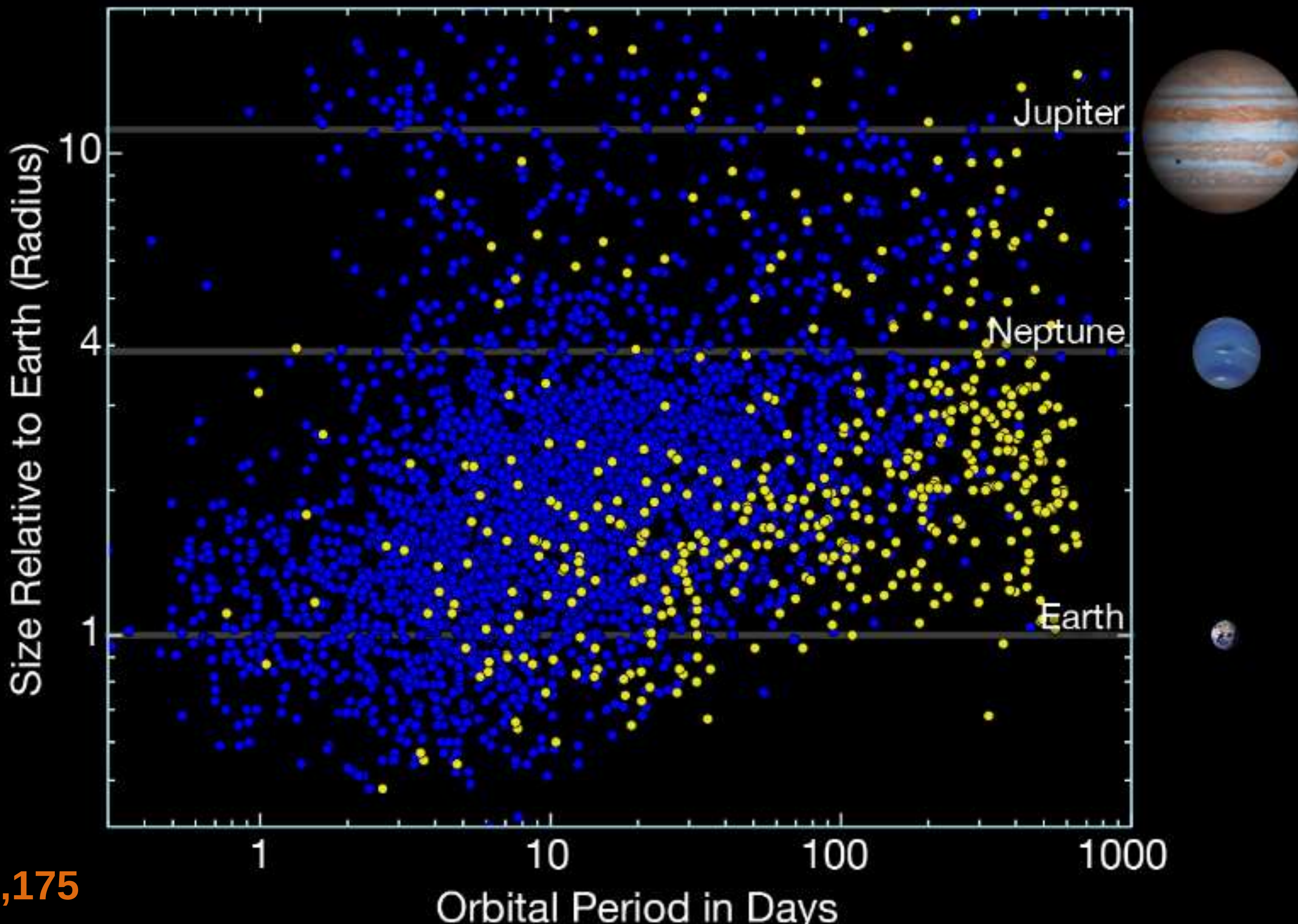
Planets are detected when the orientation of the orbit causes the planet to transit the disk of the star, temporarily blocking out a small portion of the light.



Launched 2009, purpose to determine the frequency and diversity of planets in our Galaxy. Kepler is a survey mission that looked at more than 160,000 stars, simultaneously measuring the brightness of each star every 30 minutes.

4,175 New Planet Candidates

As of January 2015



Total = 4,175

Lunar CRater Observation and Sensing Satellite (LCROSS) Lunar Impactor - 2009

The Lunar Crater Observation and Sensing Satellite was a robotic spacecraft operated by NASA. The mission was conceived as a low-cost means of determining the nature of hydrogen detected at the polar regions of the moon.

Result: Found Water on the Moon, and changed our understanding of Volatiles on the lunar surface.

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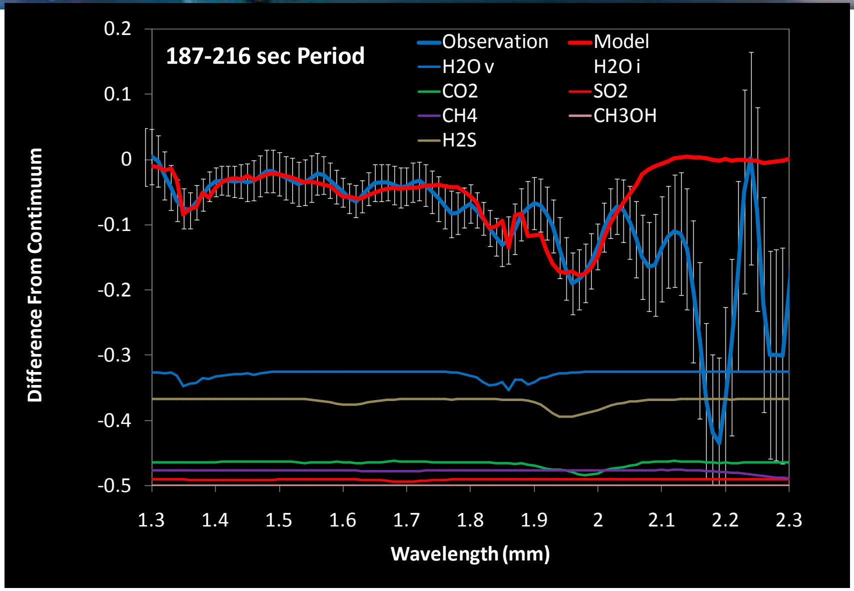
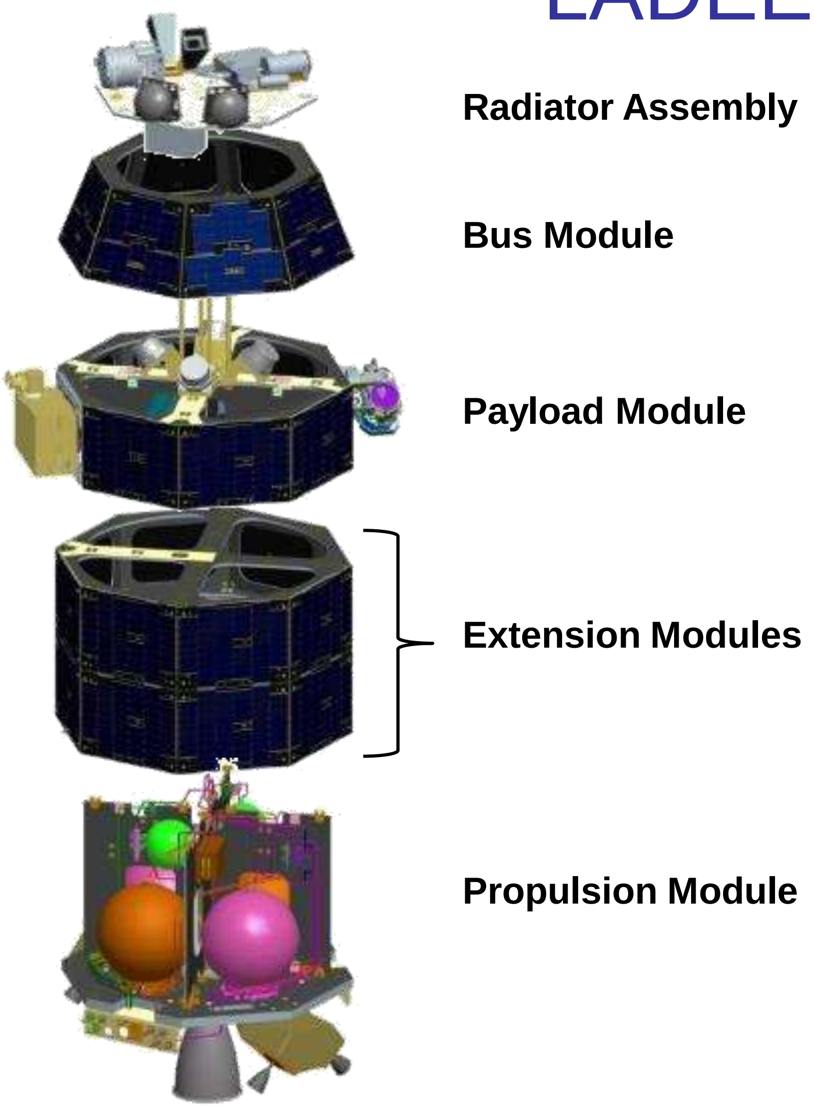


Lunar Atmosphere and Dust Environment Explorer (LADEE) Lunar Orbiter

A robotic mission that orbited the moon and gathered detailed information about the lunar atmosphere, conditions near the surface and environmental influences on lunar dust.

A thorough understanding of these characteristics are now being used to address long-standing unknowns to help scientists understand other planetary bodies as well.

LADEE Lunar Orbiter



Launch: September 2013 - Minotaur V
Launch Site: NASA's Wallops Flight Facility

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Synchronized Position Hold Engage Reorient Experimental Satellites - SPHERES

A Facility of the ISS National Laboratory with three IVA nano-satellites designed and delivered by MIT to research estimation, control, and autonomy algorithms

Installed on ISS in 2006

Managed by NASA Ames since Fall 2010

By working aboard ISS under crew supervision, it provides a risk tolerant Testbed Environment for Distributed Satellite & Free-flying Control Algorithms

- **Formation flight,**
- **Docking,**
- **Close proximity operations**

If anything goes wrong, reset and try again!

The satellites can be reused

✓ **Replenishable consumables**

✓ **Multiple test sessions assigned per year**

Scott Kelly working with SPHERES in the Kibo lab

SPHERES ISS National Lab Facility
- Program Executive: Jason Crusan (HQ)
- Program Manager: Andres Martinez (ARC / R)
- Chief Engineer: Jose Benavides (ARC / TI)
- Operations Lead: Aric Katterhagen (ARC / PX)

If you can't bring the space environment to the laboratory, take the laboratory to space!

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RINGS

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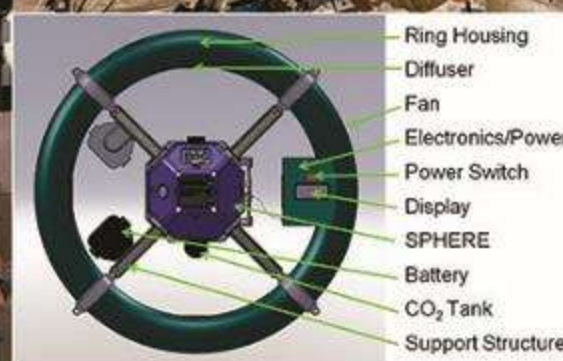

Q. What does it do?

A. RINGS uses two large Electro-Magnets to move around the ISS by attracting and repelling the SPHERES with respect to each other instead of using the built in CO_2 thrusters. Additionally, RINGS are also able to wirelessly transfer power between each other.

Q. Why is it important?

A. Being able to move around without the need of a consumable fuel source is very important for deep space missions. Most spacecraft carry a limited amount of fuel. By using Electro-Magnetic propulsion we no longer have to worry about running out of fuel.

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Halo

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Q. What does it do?

A. Halo will allow for six SPHERES peripherals (add-ons) to be used at the same time and in different configurations. Up to this point, only one item can be used on SPHERES at a time. Halo provides power, data, and a rigid attachment. This allows for multiple attachments, much like a USB hub on your computer.

Q. Why is it important?

A. Sending large things into space can be difficult and expensive. NASA is very interested in spacecraft design that allows for multiple configurations. Rather than putting it together on earth, why not send it up in parts and put it together in space? The future of space exploration is based on collaborative technologies that allow for many smaller vehicles to work together.

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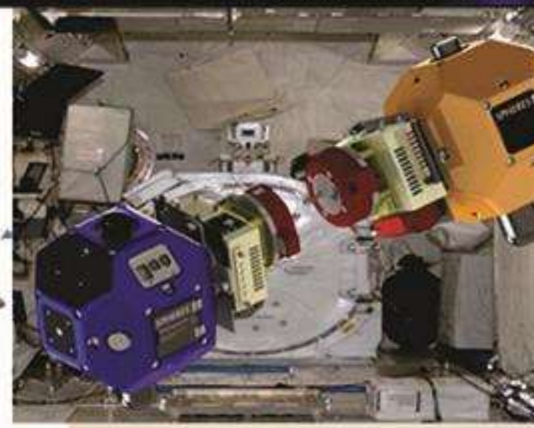

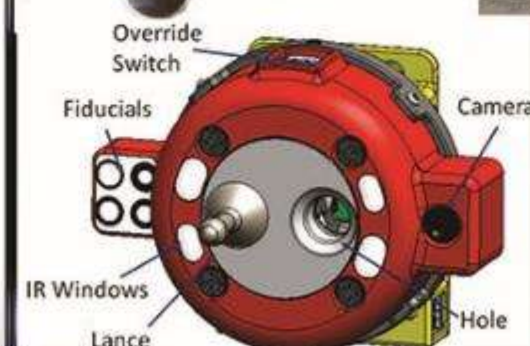

Q. What does it do?

A. The SPHERES Docking Port will allow two SPHERES to rigidly attach to each other autonomously. The lance of on one port goes into the hole on the other side and a mechanism closes to rigidly lock the lance in place.

Q. Why is it important?

A. Currently, docking is still very human dependent and having automated docking systems will make it safer and easier for two spacecraft to be able to attach in space. Once two vehicles join together, the computer has to adapt to the new flight behavior. Research on SPHERES docking allows scientists to write better spacecraft control software.

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SPHERES Slosh

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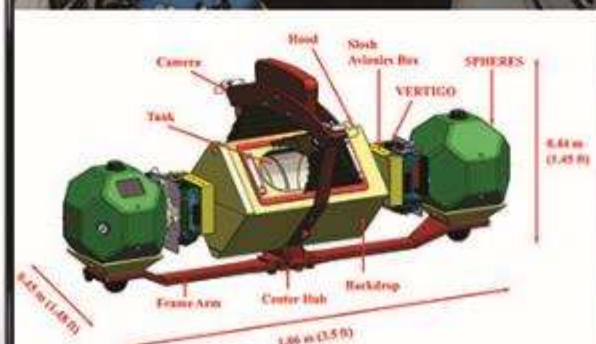

Q. What does it do?

A. Slosh is made up of a clear tank with green colored water used to study fluid movement ("slosh") in microgravity. Slosh uses a combination of movements driven by SPHERES or astronauts to created motion on the tank. The water inside the moving tank is observed by cameras and The data is analyzed on the ground to better understand fluid

Q. Why is it important?

A. As space missions become longer, understanding the dynamics of liquid fuel movement becomes more important. The data collected by the Slosh investigation will serve future NASA's space missions. This will improve slosh predictions by at least 50% increasing our ability to design efficient space vehicles.

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Q. What does it do?

A. What if your smart phone really was smart? Scientists here at Ames took a smart phone and used it to control a SPHERES. Using the phone's camera, the team was able to send a live feed from the International Space Station (ISS) to Earth where it could be controlled by the robotics group in real time.

Q. Why is it important?

A. The robotics group here at Ames is investigating the interaction between humans and robots. Scientists test different methods to find an efficient way for humans to control robots. The lessons learned could help us control robots on a distant planet one day.

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Q. What does it do?

A. What if your phone could make a 3D map of the room that you are standing in? The robotics group attached a Google Project Tango Phone to SPHERES so that it could map the inside of the International Space Station and then navigate its way through.

Q. Why is it important?

A. The ability for a robot to map its surroundings is useful when exploring unknown environments. With new sensors, robots are able to sense their surroundings and safely navigate around obstacles. With this capability, robots can be programmed to help astronauts perform non-critical repetitive tasks.

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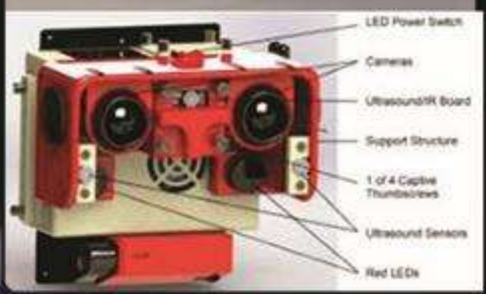

Q. What does it do?

A. Vertigo uses two cameras to visualize the world just like a human does with two eyes. This is called stereoscopic vision. Because of our slightly displaced views, our eyes can sense distance. VERTIGO uses cameras to identify a specific pattern that is printed onto stickers allowing it to spot and track other SPHERES.

Q. Why is it important?

A. If we are to have small robots helping us in space and building things, they will need the same ability to understand their surroundings as humans do. Sensors and software allow the robot to better understand and interpret the world. This allows the robot to take actions such as movement and pathways.

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Zero Robotics

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Q. What is this?

A. Zero Robotics is an annual international competition where both High School and Middle School students compete by programming SPHERES. The top teams have their codes run on SPHERES aboard the International Space Station (ISS). Finalist go to MIT and NASA Centers to see the finals broadcast live from station.

Q. Why is it important?

A. Science Engineering Technology and Mathematics (STEM) outreach is very important, and this competition gives students an introduction to STEM by allowing them to work in teams, programming and problem solving. Experience gained from this program paves the way for our future Scientists, Engineers, and Mathematicians.

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Flight Lab

International Space Station

Engineering Evaluation Lab (EEL)

Granite Lab

Mission Operations Center

Micro Gravity Test Facility (MGTF) Lab:
Cradle/Gimbal and Robotic ARM

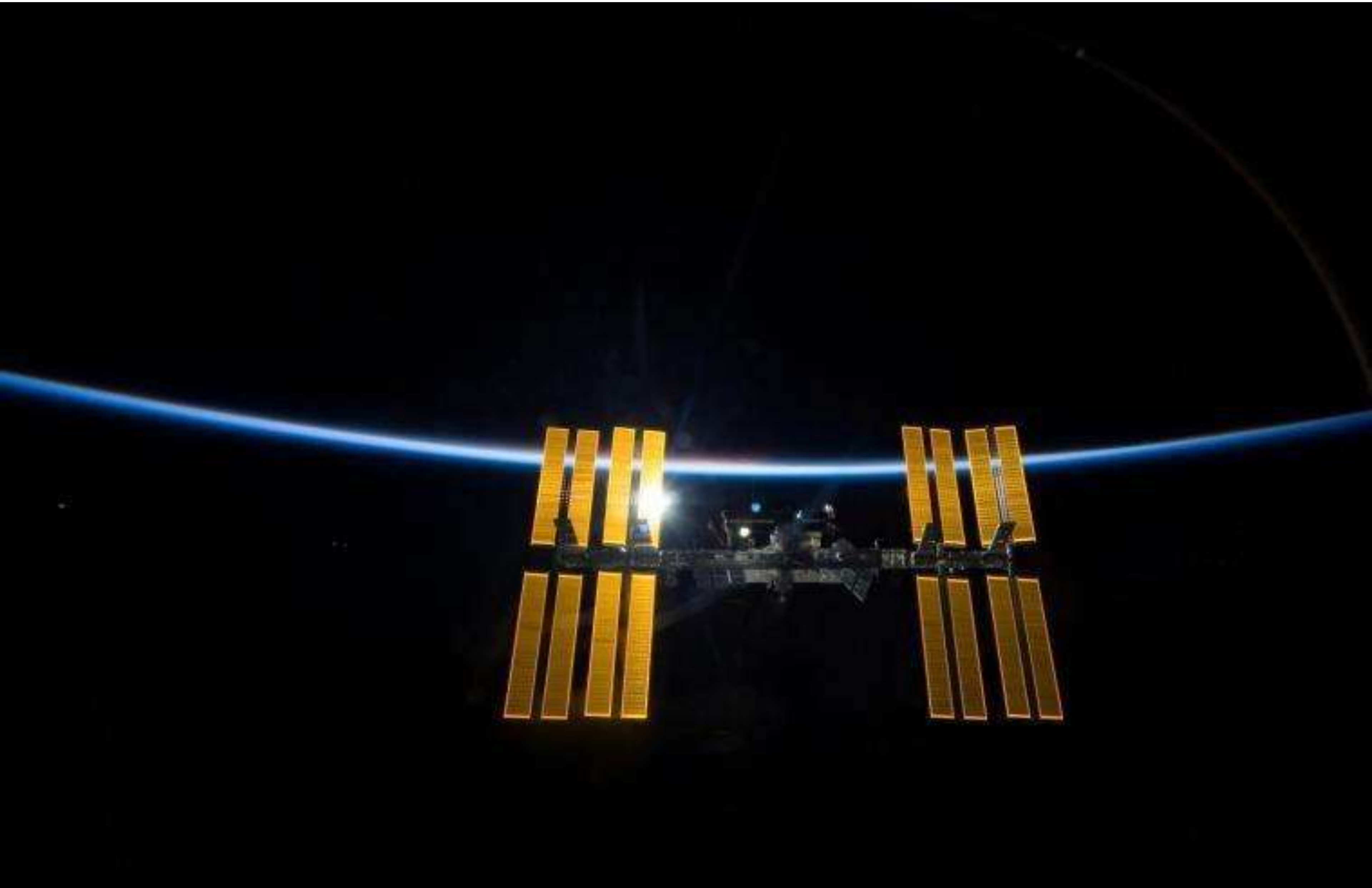
Guest Scientist Program (GSP)

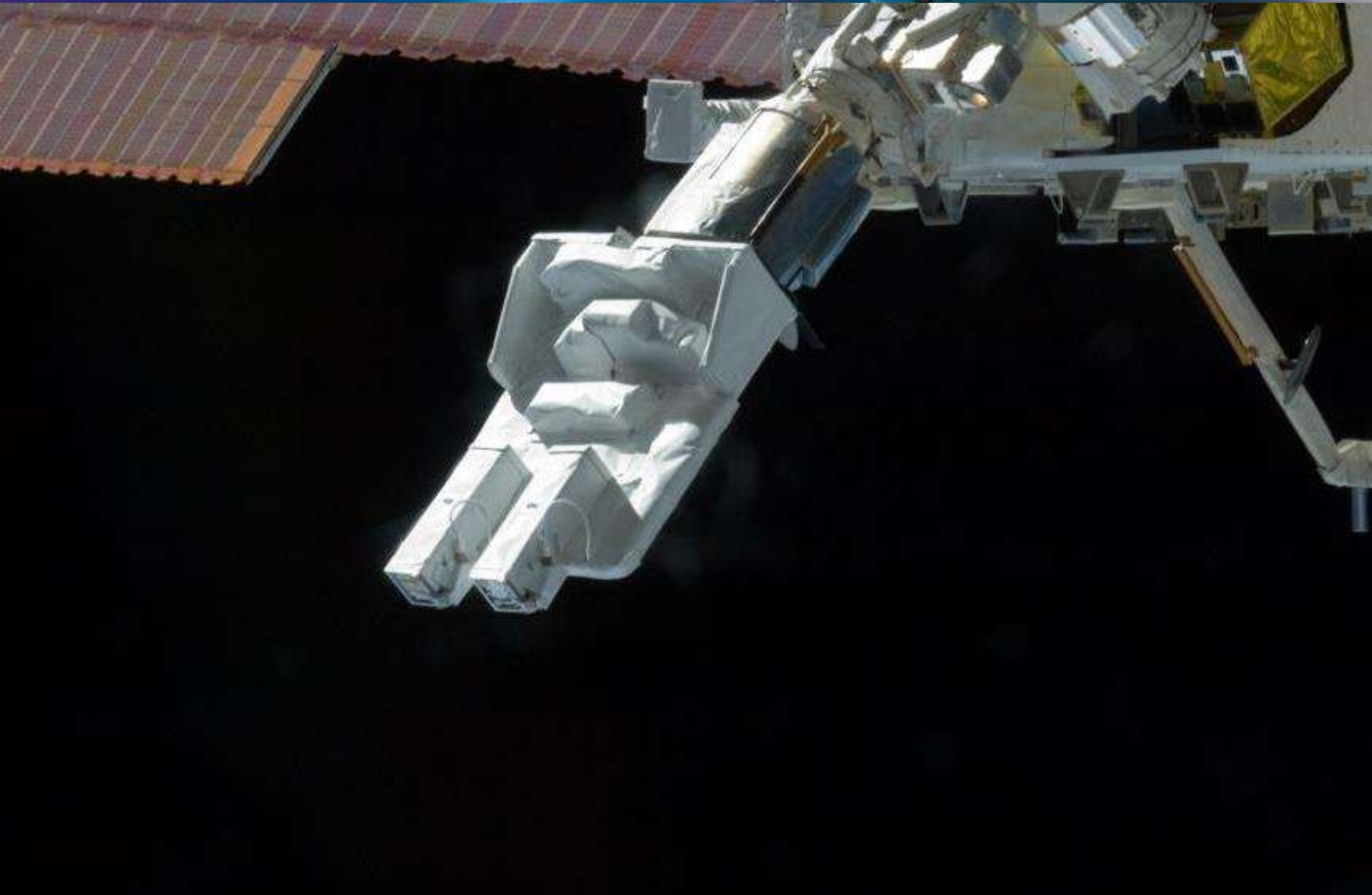
Technical Aspects

1. **Download GSP from Sourceforge, including simulator**
2. **Dev and Test your software on the simulator**
3. **Test in Ames SPHERES Lab**
4. **Deliver Software and planning products to SPHERES Operations**
5. **Conduct test session aboard ISS**

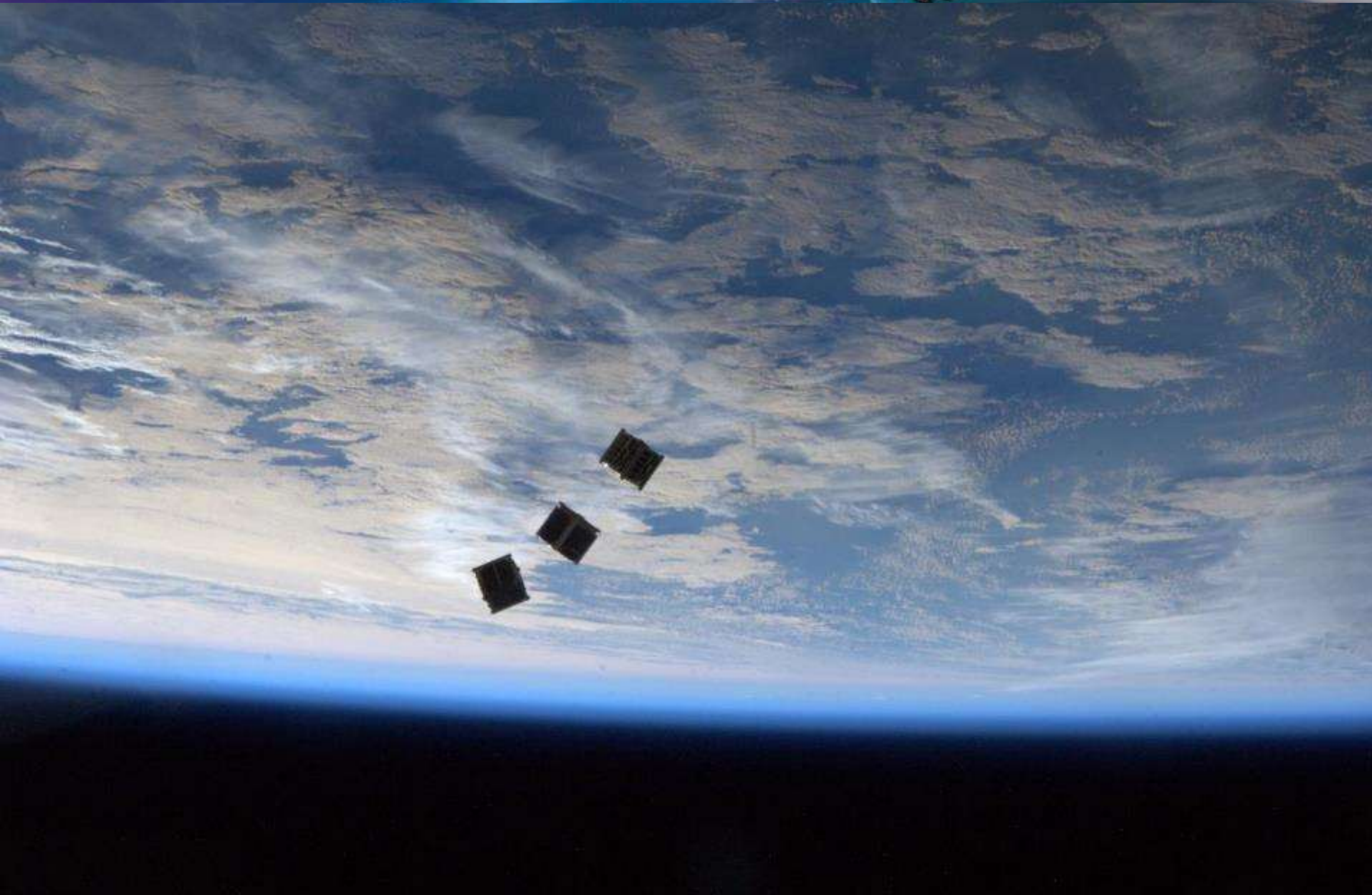
Operational Planning Aspects

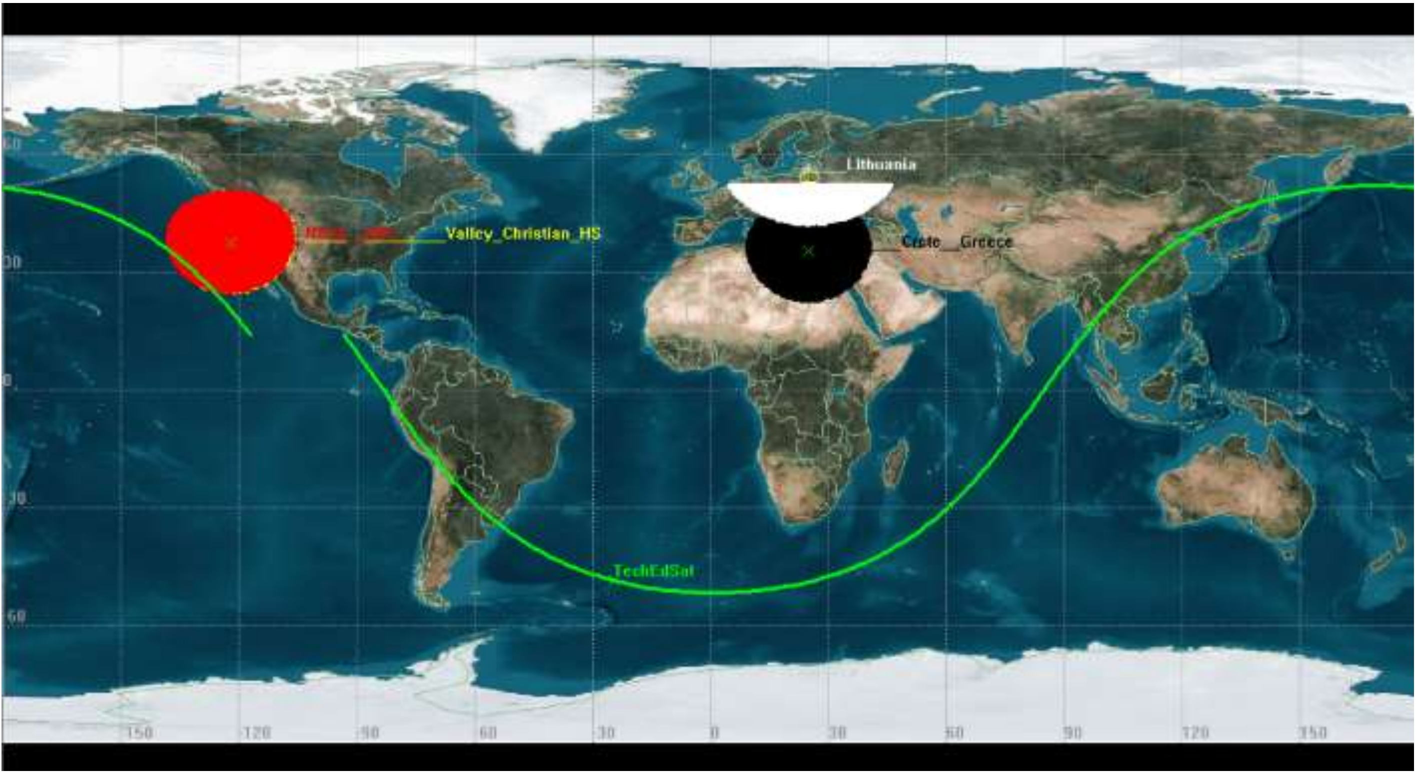
1. **Deliver proposed investigation – one pager**
2. **SPHERES initiates request to schedule ISS Test Session**
3. **Generate all planning items required by ISS (e.g. Test Plan,)**

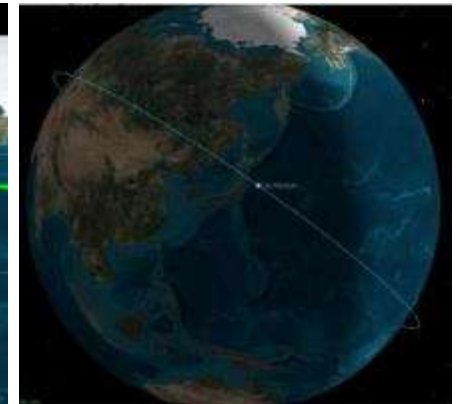




Actual photo of TechEdSat-1 deployed from ISS, Oct 4 2012







Ground Station Location	# Contacts Per Day	Contact Duration, minutes (mean)
NASA ARC	4 to 5	4.96
Valley Christian HS	4 to 5	4.99
Crete, Greece	4 to 5	4.99
Lithuania	4 to 5	5.40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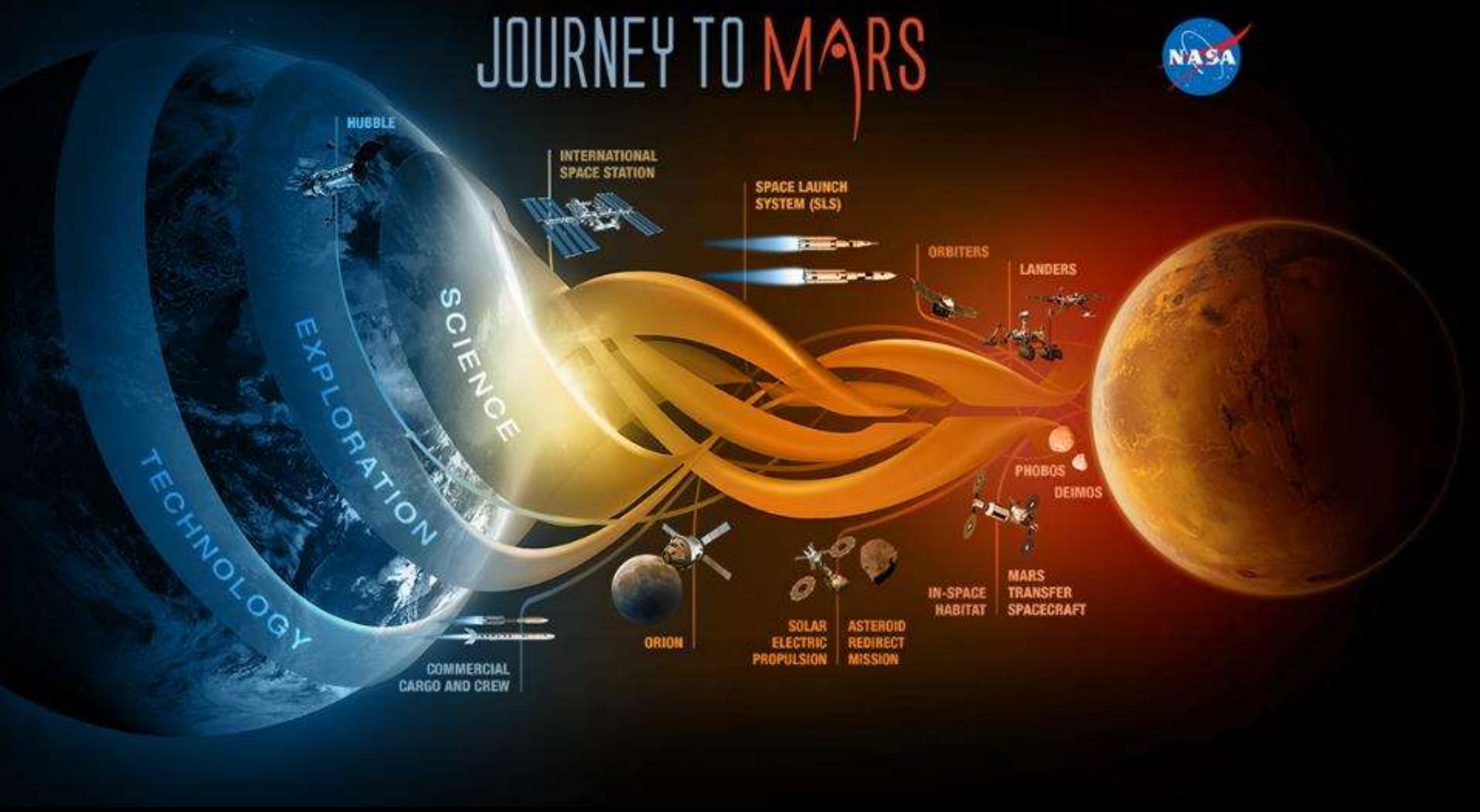
Valley Christian High School


JOURNEY TO MARS
NASA
HUBBLE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM (SLS)
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
PHOBOS
DEIMOS
MARS TRANSFER SPACECRAFT
IN-SPACE HABITAT
ASTEROID REDIRECT MISSION
SOLAR ELECTRIC PROPULSION
ORION
COMMERCIAL CARGO AND CREW


NASA
NASA
NASA'S JOURNEY TO MARS

National Aeronautics and Space Administration

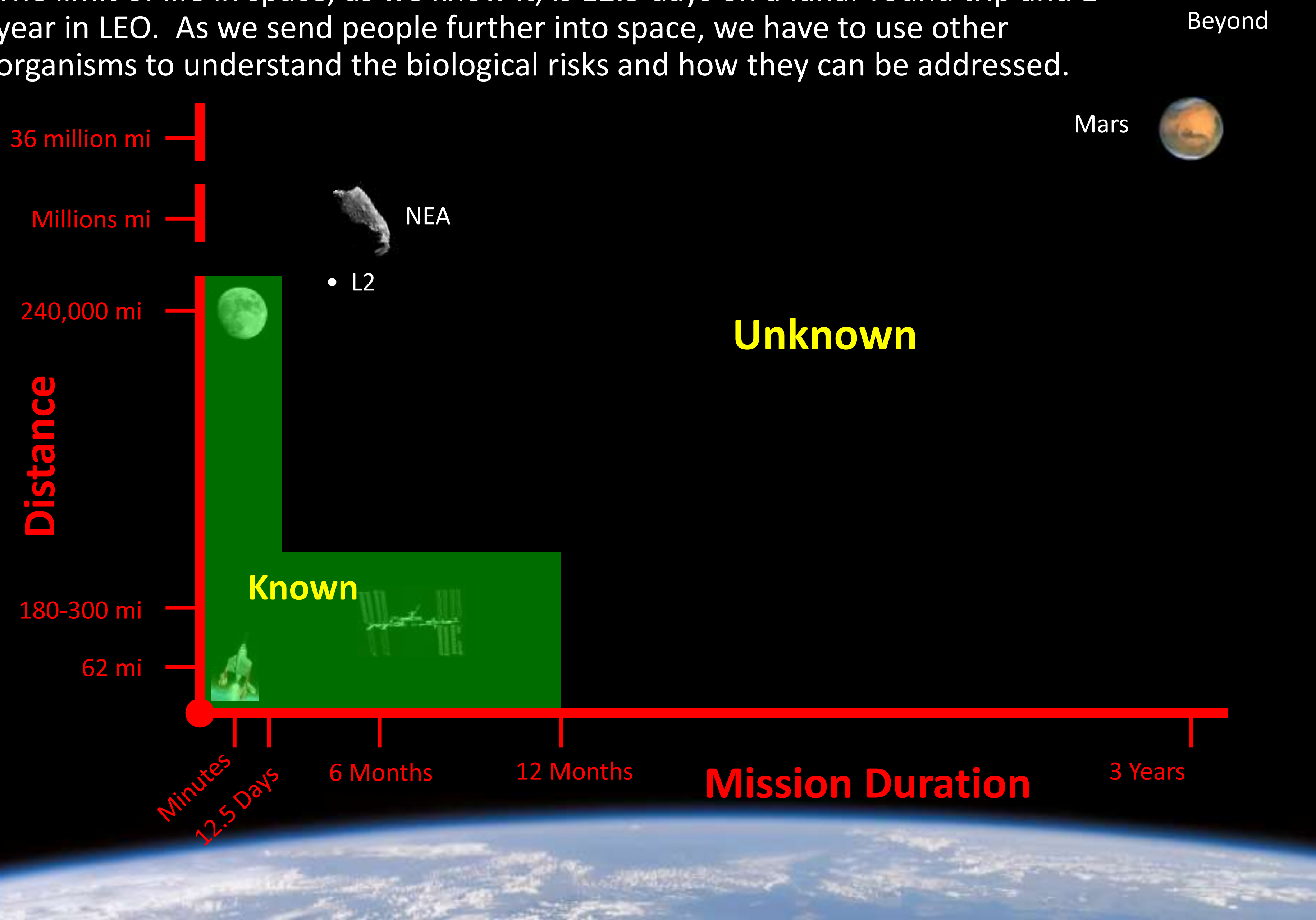
SPORESAT

Andres Martinez
Project Manager
NASA Ames Research Center

September 16, 2014

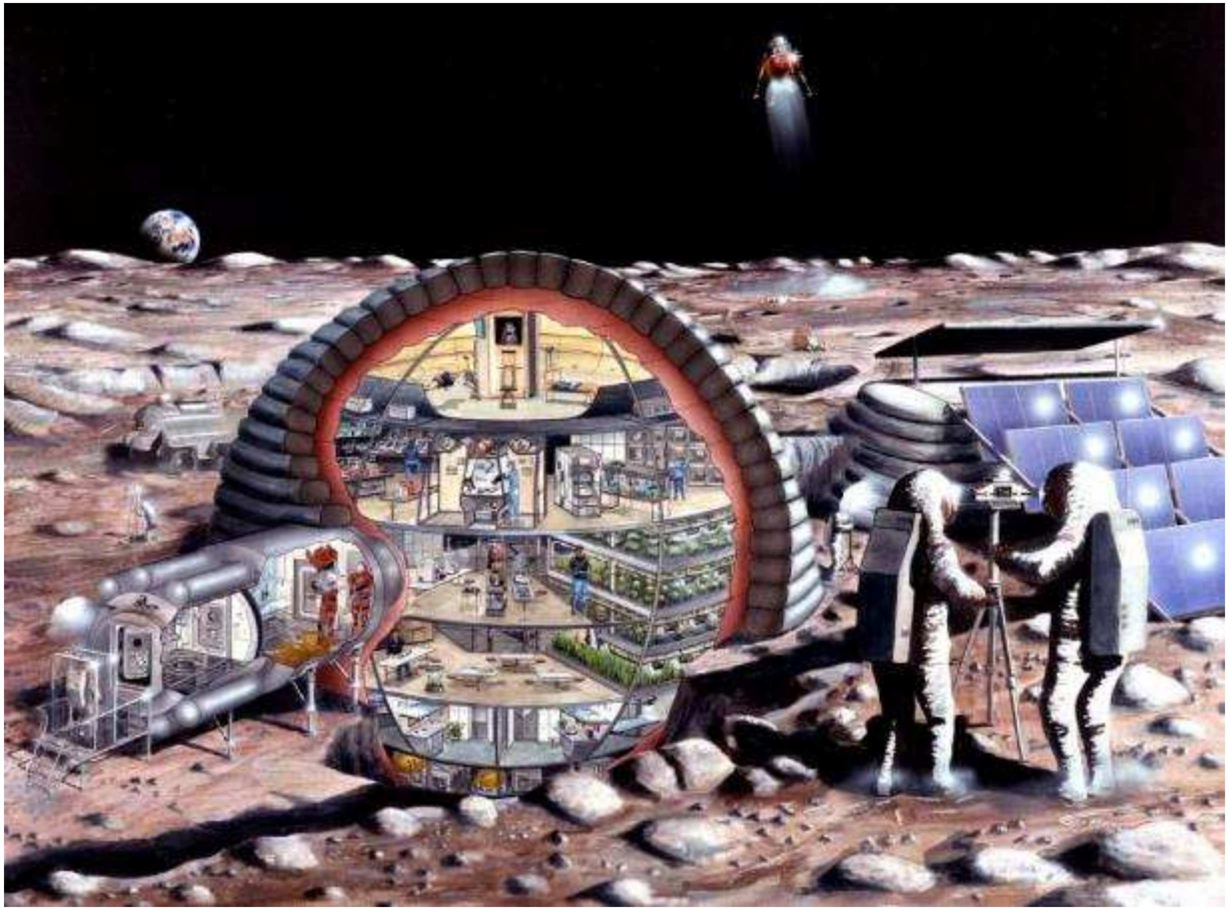
Why Study Space Biology?

The limit of life in space, as we know it, is 12.5 days on a lunar round trip and 1 year in LEO. As we send people further into space, we have to use other organisms to understand the biological risks and how they can be addressed.



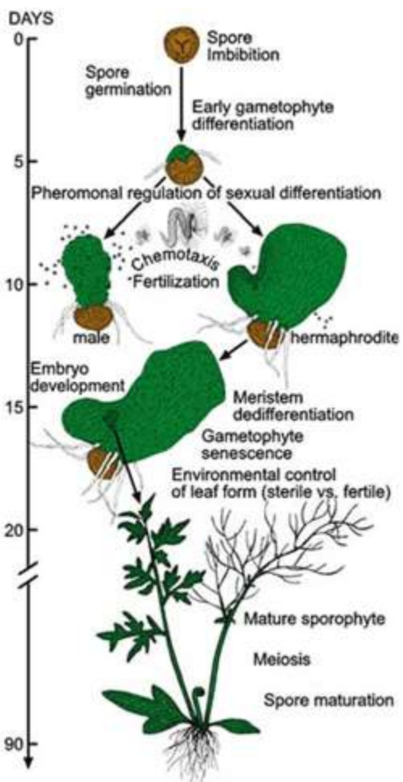
Motivation

If humans are going to live in space or on the moon, we need to understand the basic biological effects of lower gravity—not only on our own bodies, but on plants that may be used for food or to help clean the air or water in a life support system.



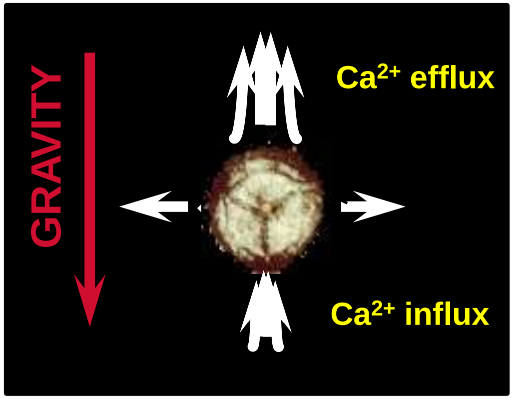
Background

Biologists have studied for decades, through hypothesis and experiments, how certain plants and their spores sense and respond to gravity.



Spores of the fern *Ceratopteris richardii* are among the most studied.

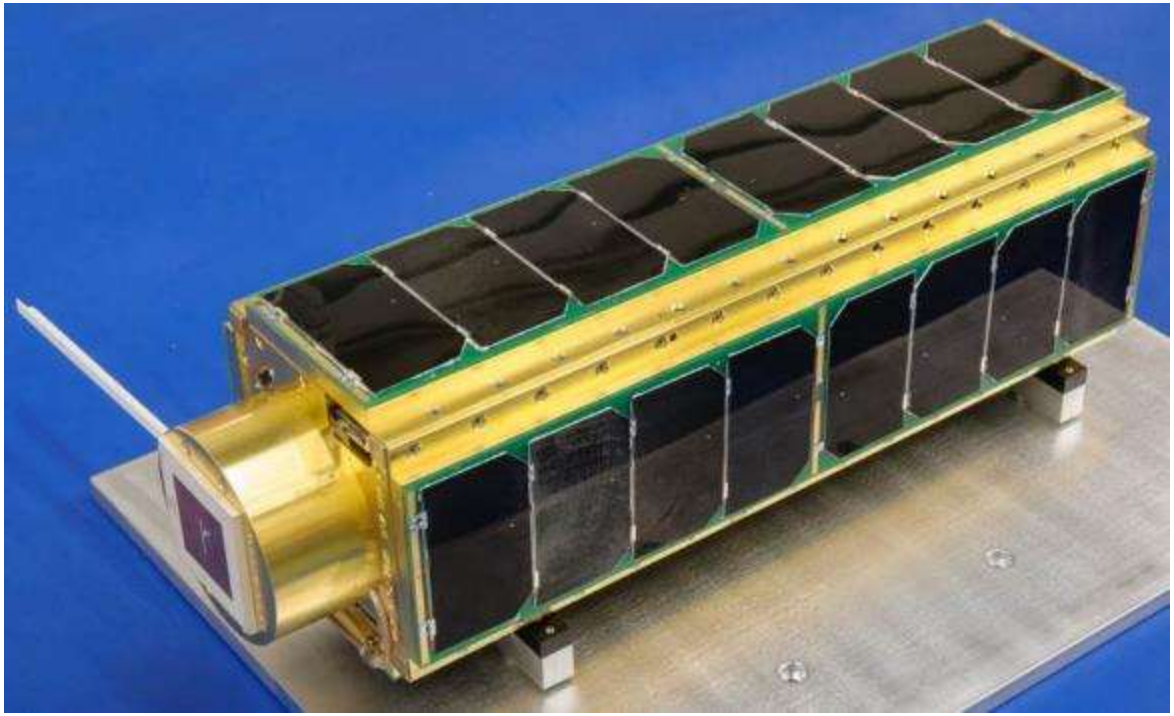
But they have not yet been studied in the microgravity environment of outer space, nor across a range of gravity levels lower than Earth's -- like gravity fields equivalent to the Moon or Mars.



One spore of the fern *Ceratopteris richardii.*
It's 2 – 3x the diameter of a human hair.

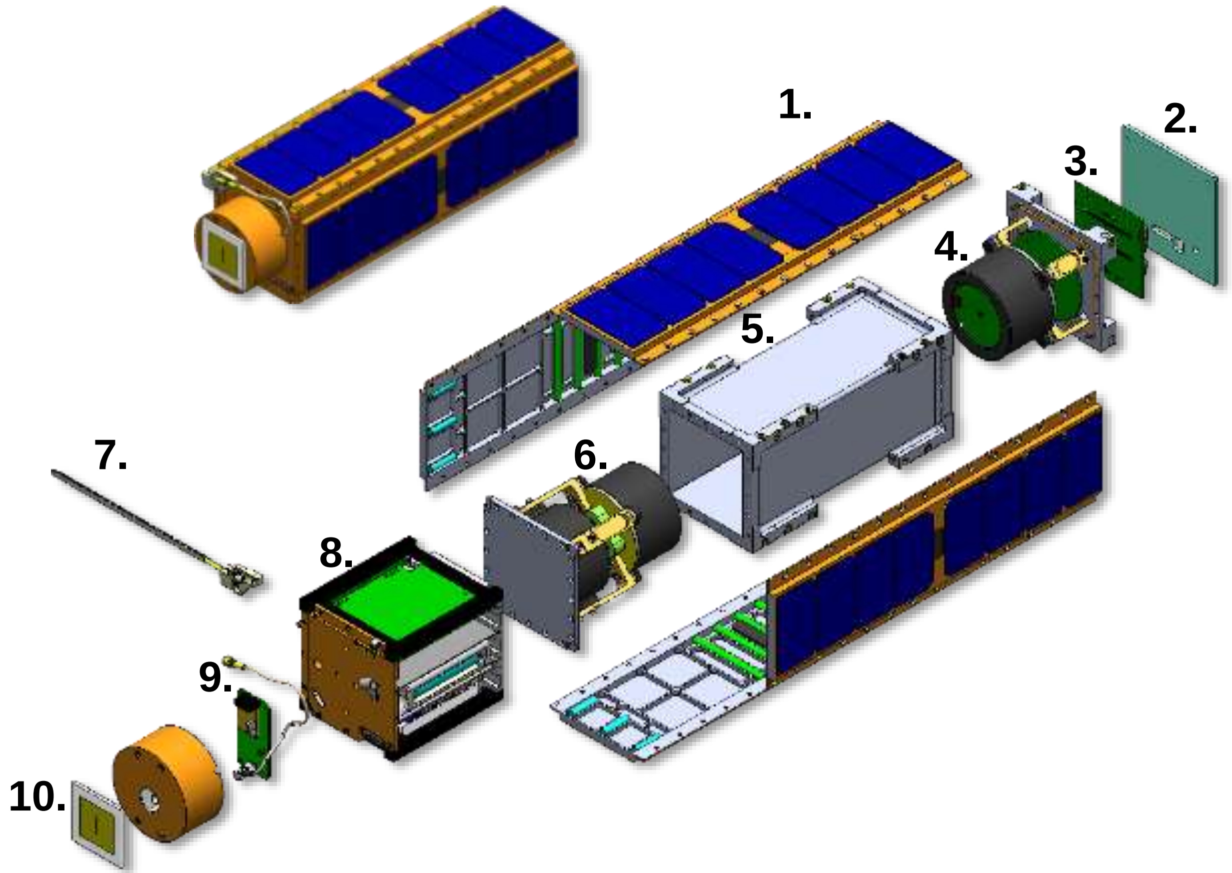
3U Spacecraft Overview

Ames standard 3U design leveraging heritage spacecraft components from PharmaSat, O/OREOS, and GeneSat missions.



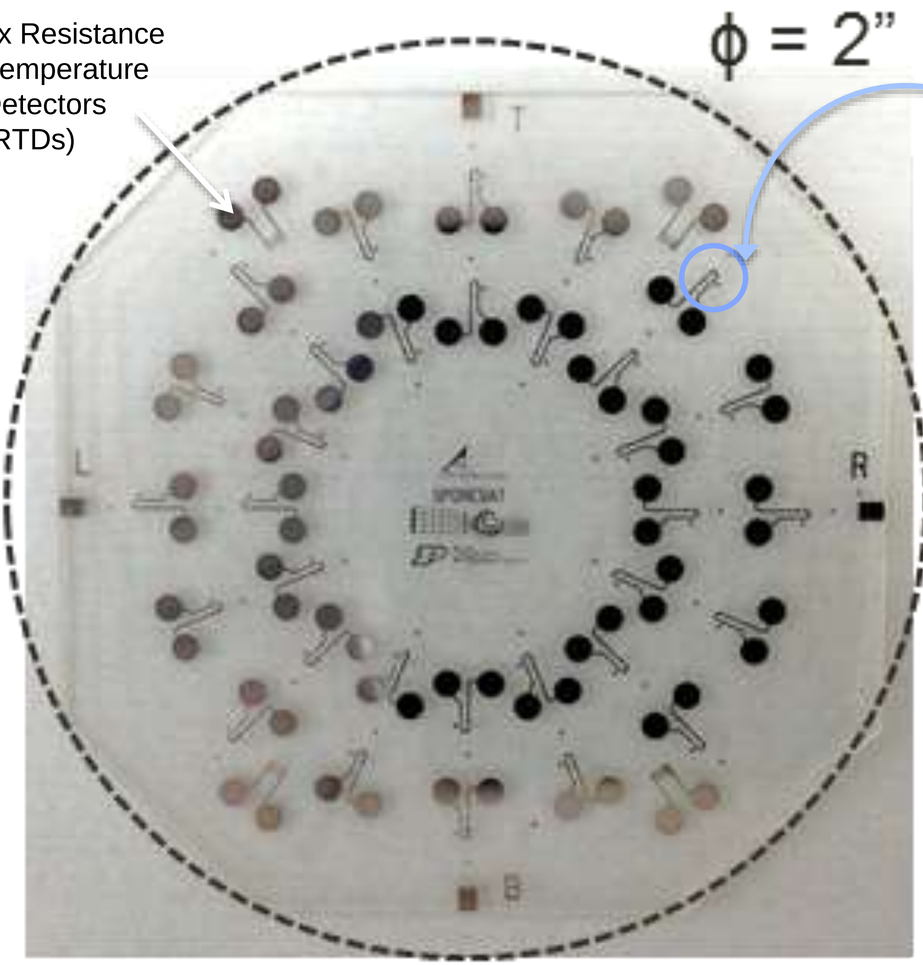
Exploded View Spacecraft

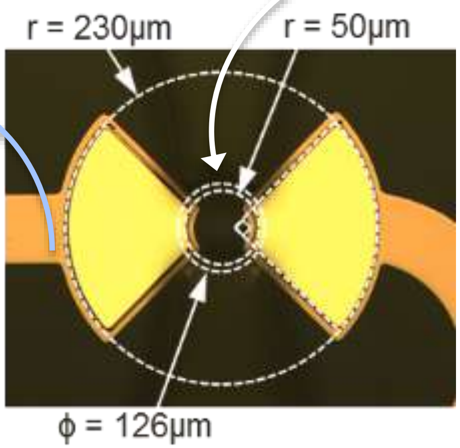
1. Solar Body Panels 4ea.
2. Close Out Panel
3. Bus Interface PCB
4. Front Panel Assembly
5. Hermetic Enclosure
6. Back Panel Assembly
7. Transponder Antenna
8. Avionics Bus
9. Transponder PCB
10. Patch Antenna

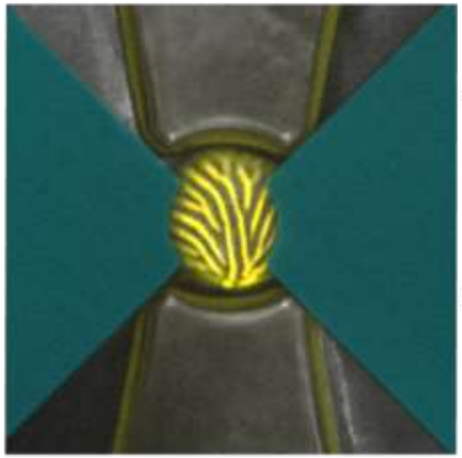


Biology Compact Disc (bioCD)

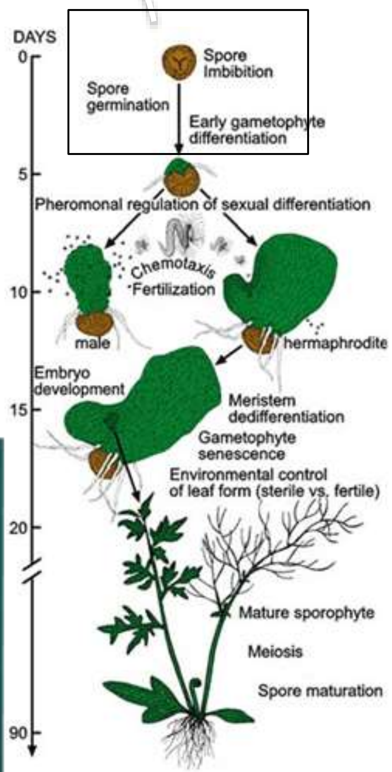
4x Resistance Temperature Detectors (RTDs)





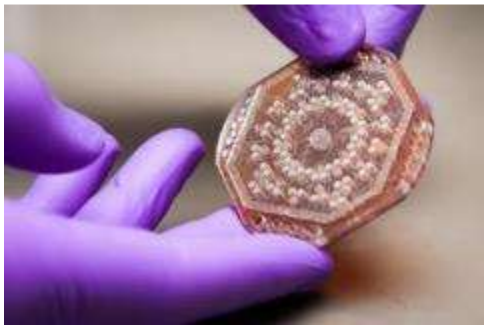
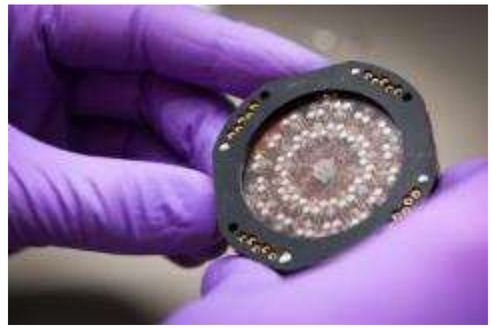
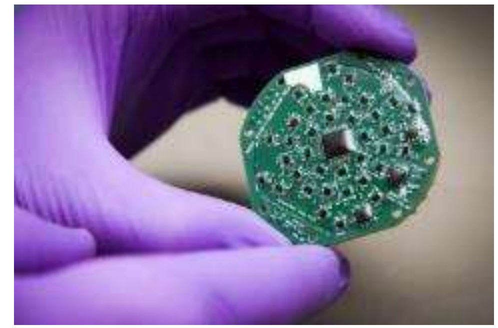
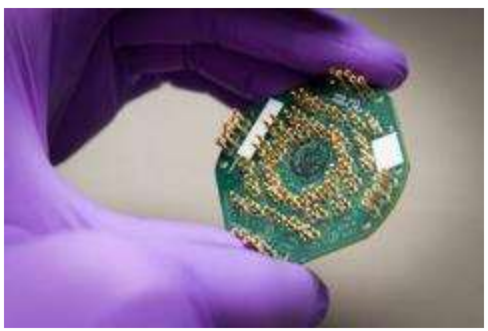
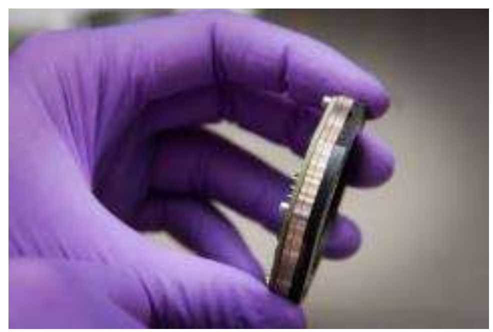
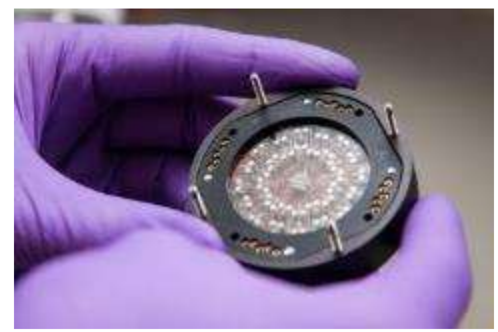


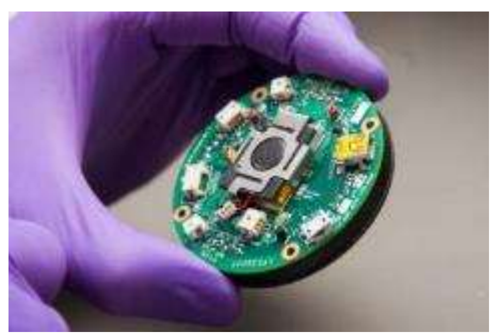
32 pairs of Silver – silver chloride Electrodes with Ca Ion Selective Membrane (ISM)



Wild Fern

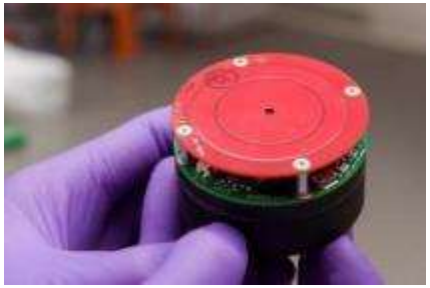
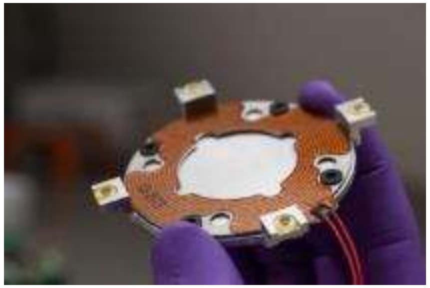
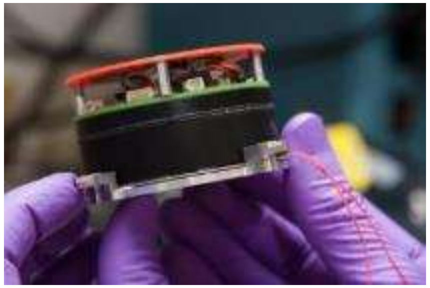
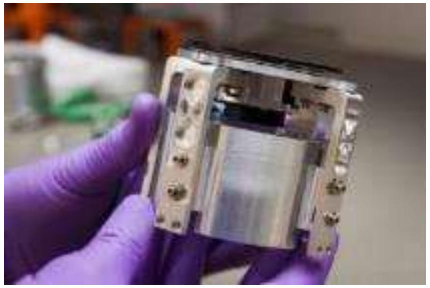
Assembling bioCD Measurement Electronics

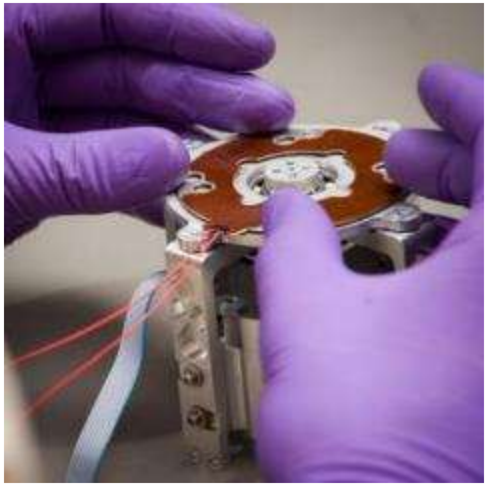







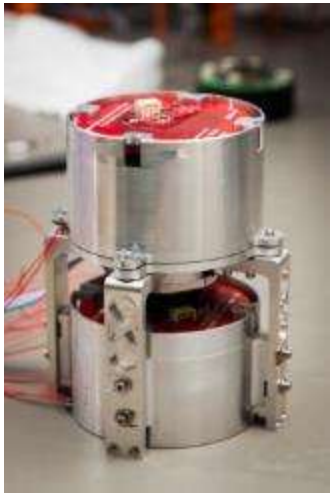



Assembling bioCD Measurement Electronics

Integrating bioCD Rotating Assy. & Motor

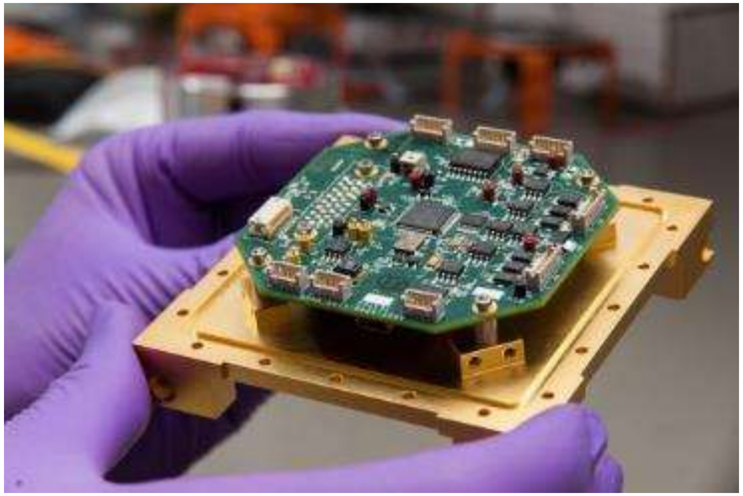
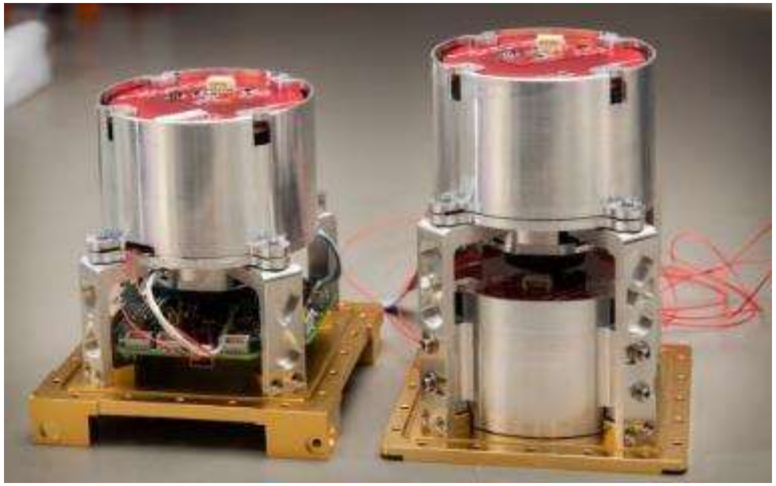







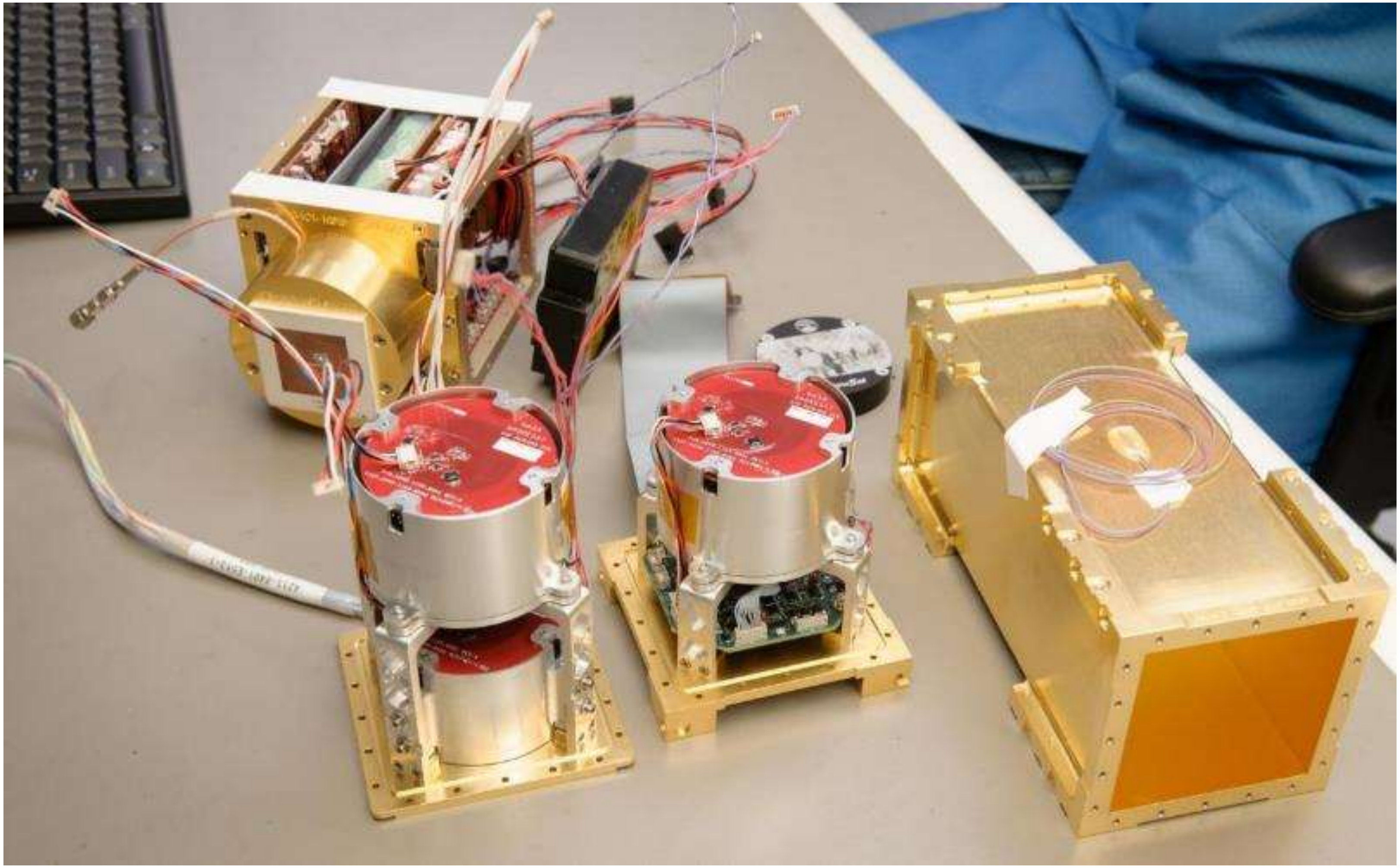


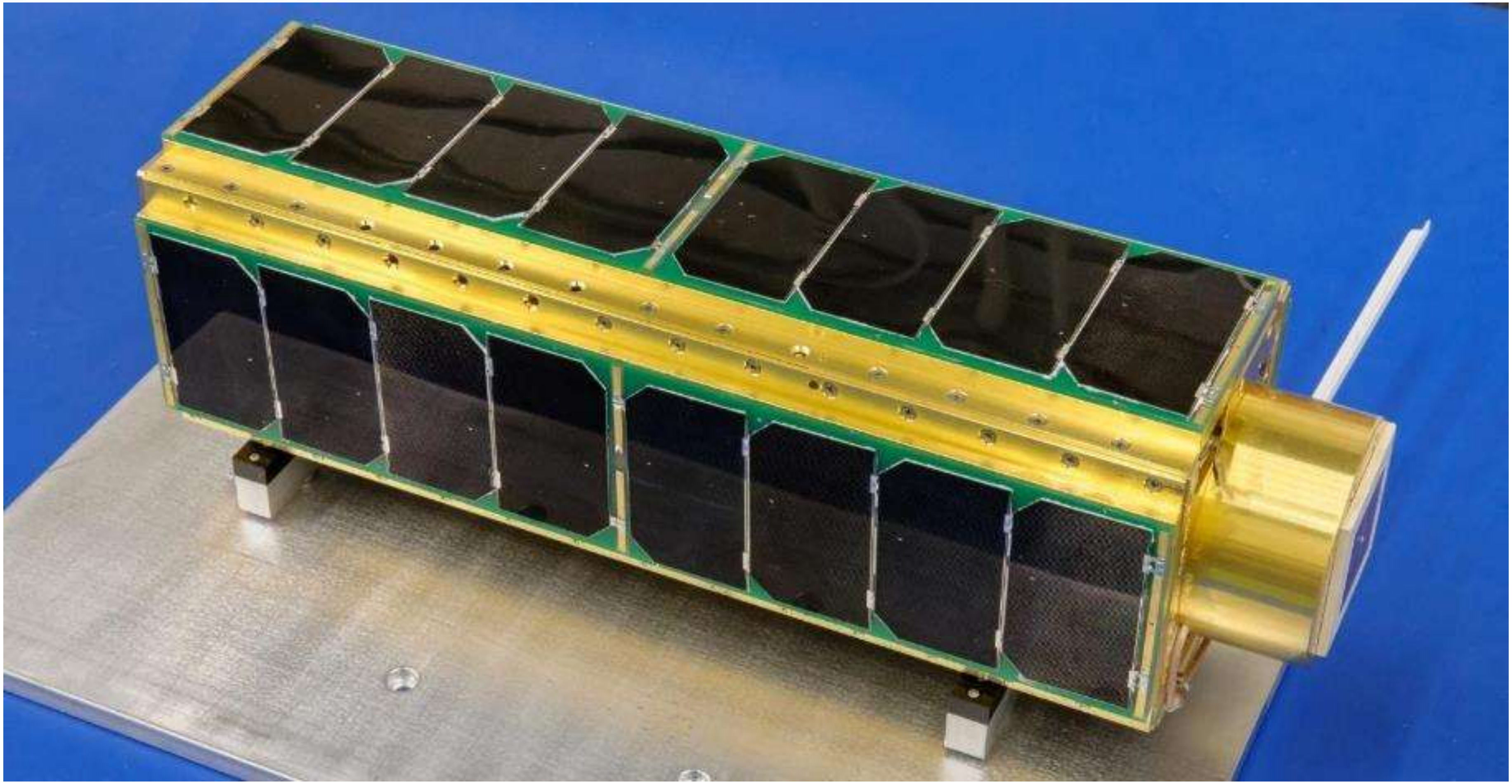
Integrating bioCD/Motor in P/L Vessel




Ready for Integration



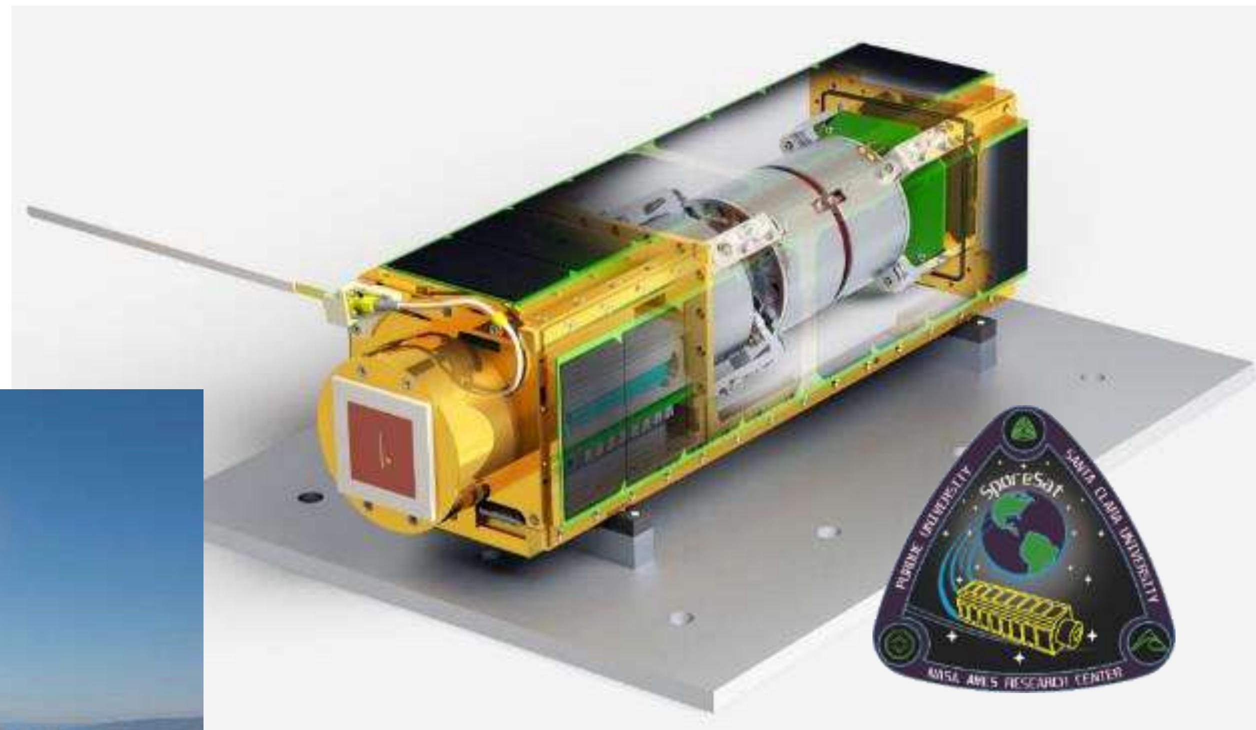


SporeSat-1


NOVEMBER
DECEMBER

Current Status:

Launched at 3:25 pm (EDT) on April 18, 2014 on SpaceX-3 – now in Low Earth Orbit

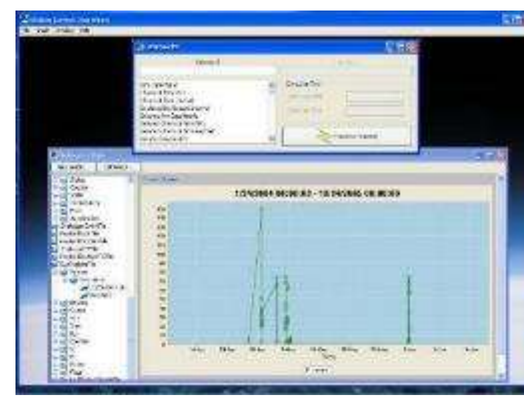


Mission Operations

Two Line Element Set (TLE):

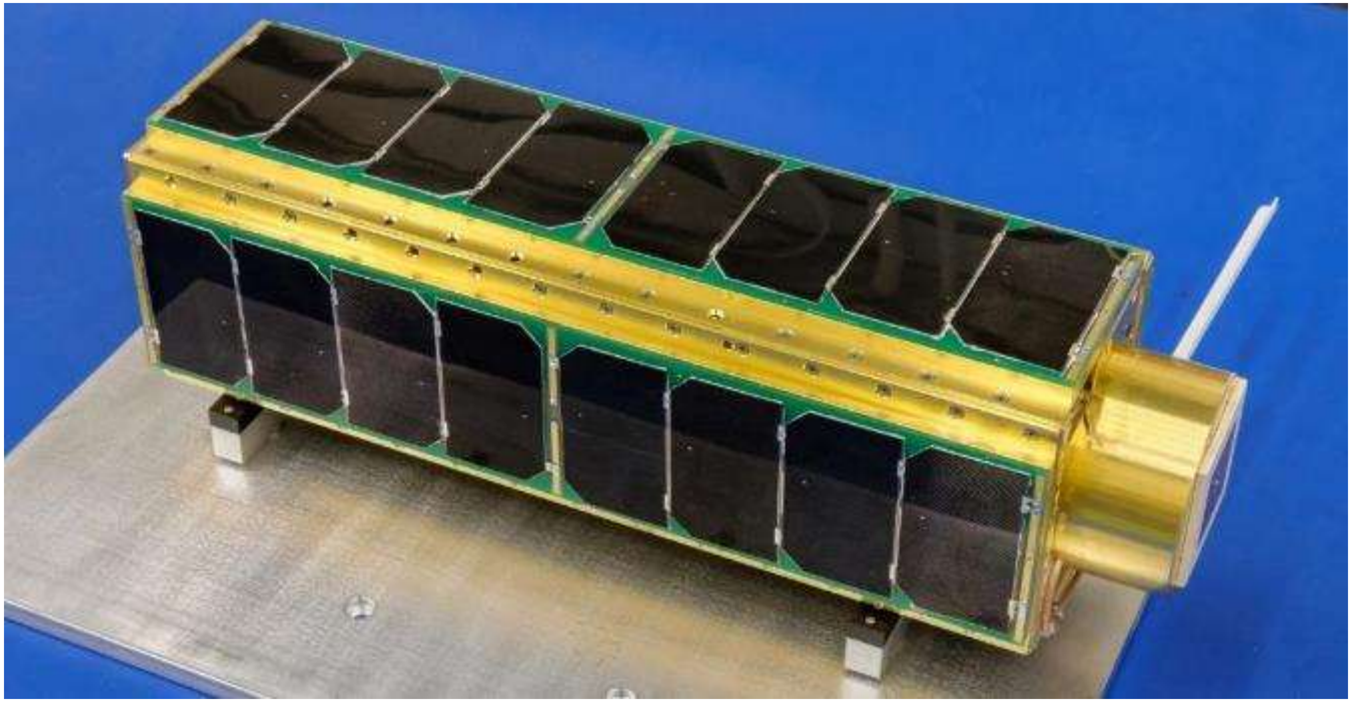
```
1 39681U 14022B   14126.91979341  .00283955  41986-4  76519-3 0   461
2 39681 051.6463 299.0935 0022529 332.3199 027.6507 15.93385135  2889
```

PASS PHASE			
1	Load "Get register file from bus" command Send "Get register file from bus" command Verify "BUS REGISTER FILE INSERTED" into database Log Solar Page Number _____ Derive Last Solar Page Number = Solar Page Number – 1 = _____ and enter this value in Pass Phase Step 5	_____	
2	Load "Get packet from bus" command Send "Get packet from bus" command Verify "BUS H&S FILE INSERTED" into database	_____	
3	Load "Get register file from payload" command Send "Get register file from payload" command Verify "PAYLOAD REGISTER FILE INSERTED" into database Log Accel Page Number _____ Derive Last Accel Page Number = Accel Page Number – 1 = _____ and enter this value in Pass Phase Step 7	_____	



Upcoming Milestones

- Engineering and Science Efforts for Mission 2 underway
- And do it all over again in 2016!



SporeSat-2

National Aeronautics and
Space Administration

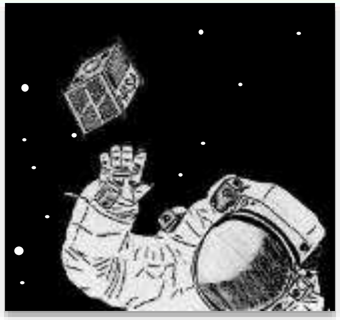
Small Spacecraft Technology Program

Director, Andres Martinez

April 23, 2015

www.nasa.gov/smallsats

Small Spacecraft Technology Program



Program Executive: Andrew Petro (HQ)
Level 2 Program Office at Ames Research Center
Program Manager: Andres Martinez

Goal

1. Promote the small spacecraft approach as a paradigm shift for NASA and the larger space community.

OBJECTIVES

1. Identify and support the development and demonstration of new subsystem technologies to enhance the applicability of small spacecraft to perform future missions; **TRL 3 to 5**
2. Use small spacecraft as platforms for affordably testing and demonstrating technologies and capabilities that might have more general applications in larger-scale spacecraft and systems; and **TRL 5 to 7**
3. Use small spacecraft as platforms for expanding the knowledge, experience and capabilities of individuals and teams within NASA, industry and academia to perform space missions.
4. Support technology transfer from SSTP to SMD, HEOMD, academia, and industry.

Program Relevance, Goals, Objectives, & Customers

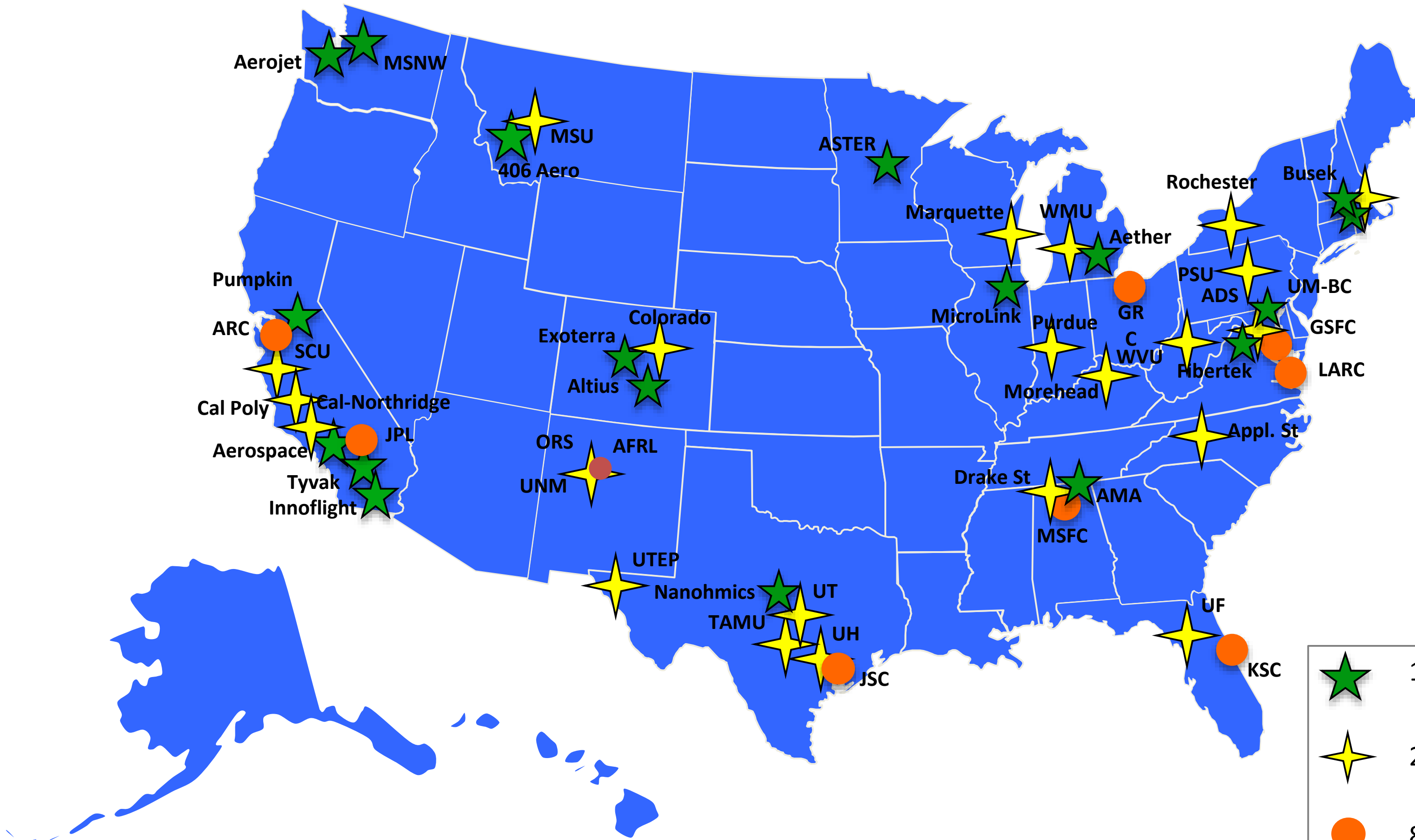
Relevance: *Contributes to 2 of 3 NASA Strategic Goals*

Goals and Objectives: *as related to NASA Strategic Goals*

NASA Strategic Goals	NASA Strategic Objectives	**SST Program Goal:** Promote the small spacecraft approach as a paradigm shift for NASA and the larger space community.	
Goal 1 – Expand frontiers of knowledge, capability, and opportunity in space By empowering the NASA community to...	**Objective 1.7** - Transform NASA missions and advance the nations capabilities by maturing crosscutting and innovative space technologies. Thereby supporting, Objective 1.1, 1.4, 15, and	1.) Identify and support the development and demonstration of new subsystem technologies to enhance the applicability of small spacecraft to perform future missions; **TRL 3 to 5**	2.) Use small spacecraft as platforms for affordably testing and demonstrating technologies and capabilities that might have more general applications in larger-scale spacecraft and systems; and **TRL 5 to 7**
Goal 2 - Advance understanding of Earth and develop technologies to improve the quality of life on our home planet By engaging our workforce and partners to...	Objective 2.3 – Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.	3.) Use small spacecraft as platforms for expanding the knowledge, experience and capabilities of individuals and teams within NASA, industry and academia to perform space missions.	4.) Support technology transfer from SSTP to SMD, HEOMD, academia, and industry.

Customers: *Future NASA missions in NASA Mission Directorates, other USA government agencies, academia, the aerospace industry.*

Small Spacecraft Technology
Nationwide Participants and Partner

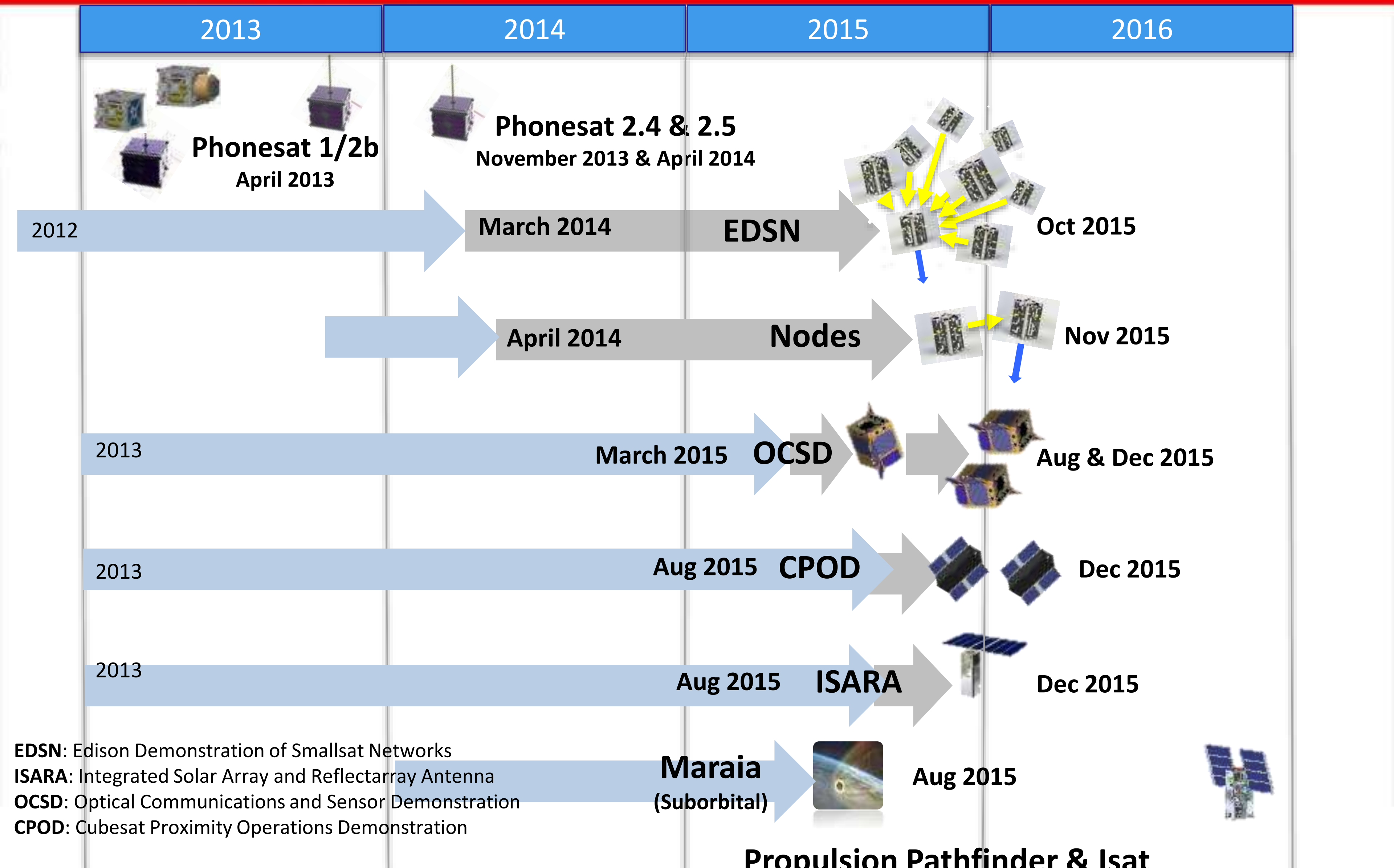


22 States

- 17 Companies
- 22 Universities
- 8 NASA Centers
- 2 Other Agencies

www.nasa.gov/smallsats

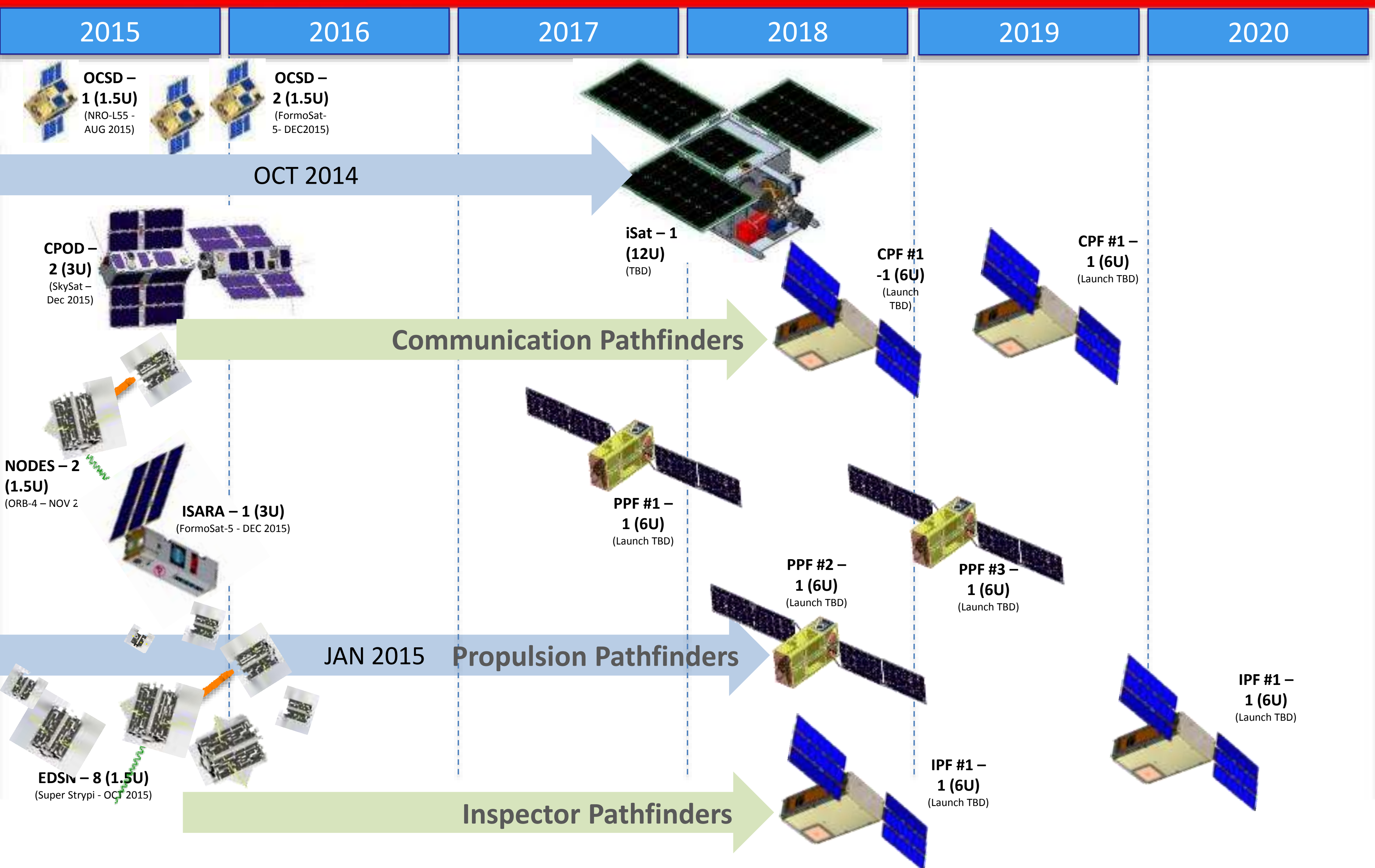
Small Spacecraft Technology Flight Demonstrations



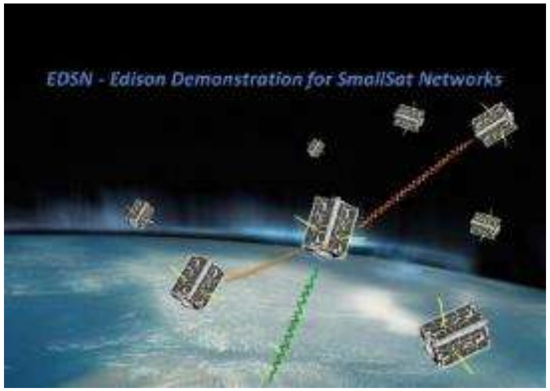
EDSN: Edison Demonstration of Smallsat Networks
ISARA: Integrated Solar Array and Reflectarray Antenna
OCSD: Optical Communications and Sensor Demonstration
CPOD: Cubesat Proximity Operations Demonstration

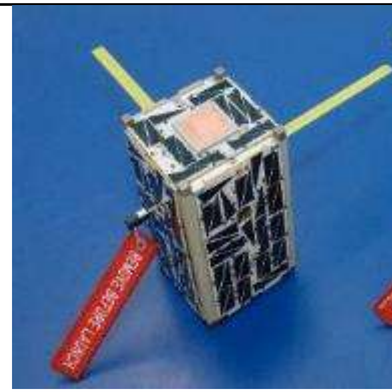
Small Spacecraft Technology Program

Flight Projects: CY 2015-2020



Edison Demonstration of SmallSat Networks (EDSN)





Spacecraft Specifications

- Mass: 1.73 kg each
- Quantity: Eight 1.5U CubeSats
- Orbit: 430 km x 505 km @ 94.8° inclination
- Size: 10cm x 10cm x 17cm
- Communication: UHF / S-Band

Mission Description

NASA's Edison Demonstration of SmallSat Networks (EDSN) mission will launch and deploy a swarm of 8 CubeSats into a loose formation approximately 500 km above Earth. The CubeSats swarm will collect multipoint satellite data and transmit the data to the ground through one CubeSat.
This capability will enable a wide array of low cost missions to perform scientific, commercial, and academic research.

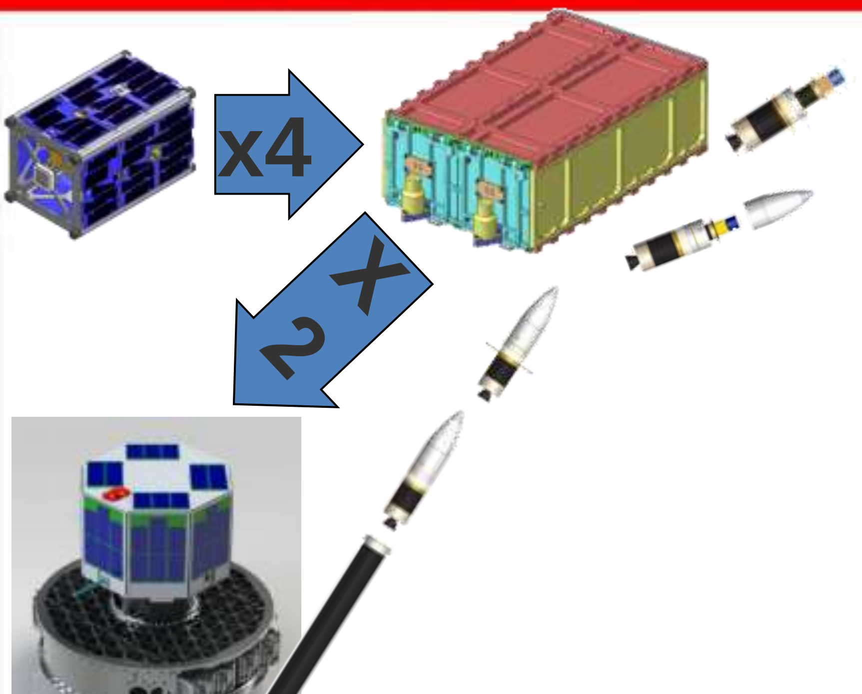
Status

Qualification testing complete and the CoFR has been signed and sent to ORS. The eight flight EDSN units will undergo final verification, system check and Mission Simulation Test prior to shipment to the launch site. EDSN will be launched on the Super Strypi launch vehicle from Barking Sands Pacific Missile Range Facility, Kauai, HI.

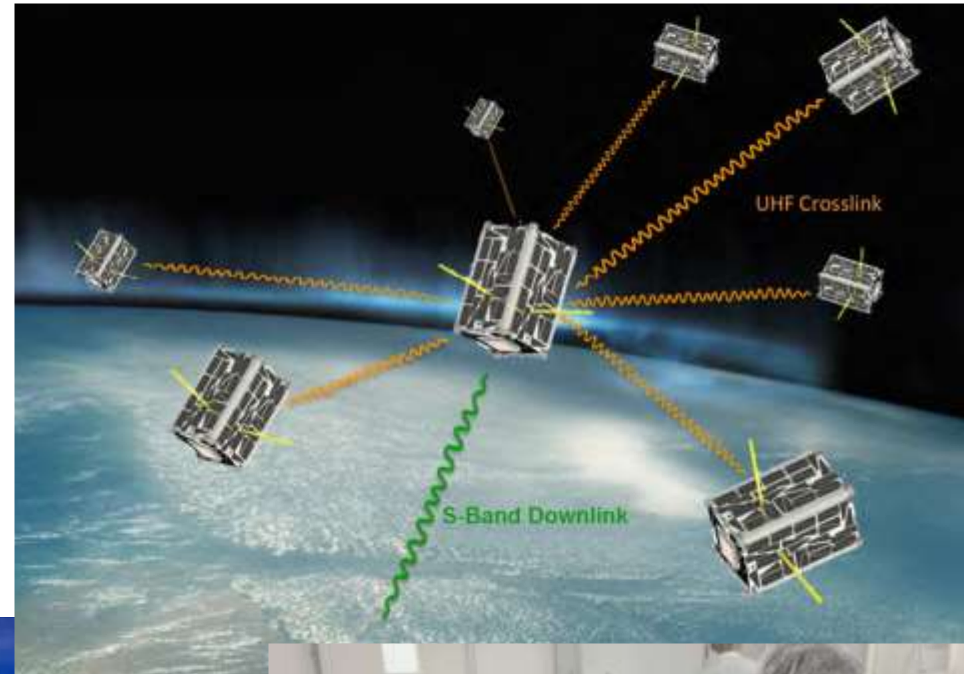
Critical Milestones

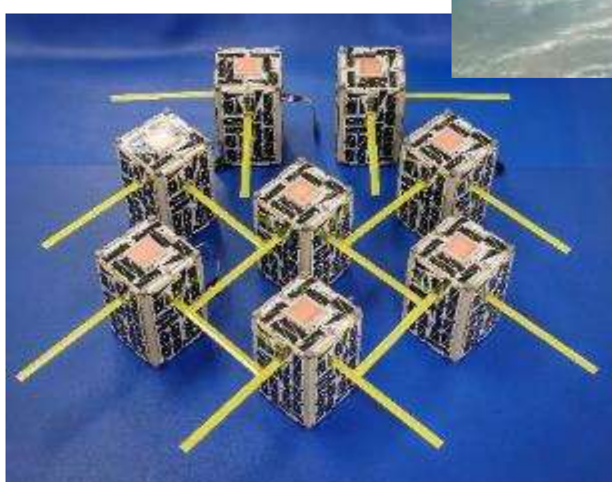
ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
11/18/11	5/28/12	10/10/12	04/02/13	09/20/14	10/22/14	10/29/2015	11/3/15	60 days	2/26/16

Edison Demonstration of SmallSat Networks (EDSN)

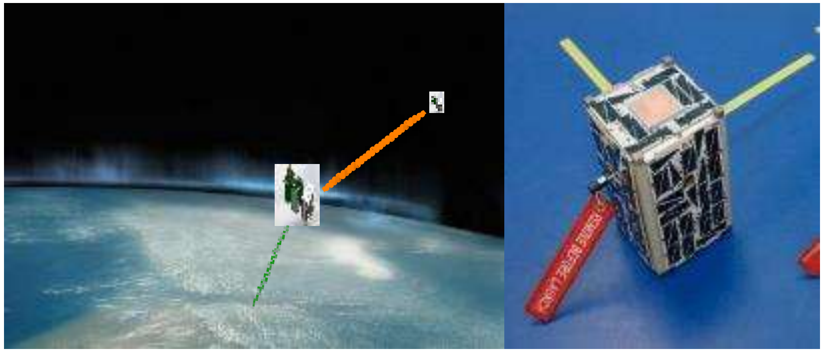


Super-Strypi
OCT 2015





Network & Operations Demonstration Satellite (Nodes)



Spacecraft Specifications

- Mass: 1.73 kg each
- Quantity: Two 1.5U CubeSats
- Orbit: 400 km x 400 km @ 51.6° inclination
- Size: 10cm x 10cm x 17cm
- Communication: UHF / S-Band

Mission Description

NASA's Nodes mission will launch and deploy a two 1.5U CubeSats from ISS into low-Earth orbit. Nodes will explore 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.

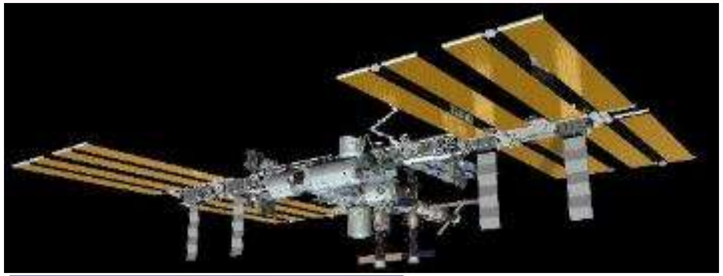
Status

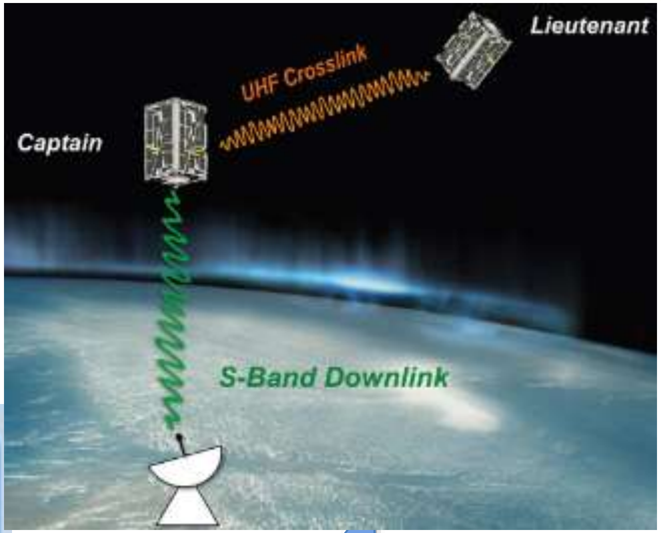
Mission simulations and software check complete. Final verification in progress pending workmanship vibration test to qualify footswitch modification. Spacecraft will be stored until manifested for upmass to ISS. Pre-ship test to be performed prior to shipment to the integration site.

Critical Milestones

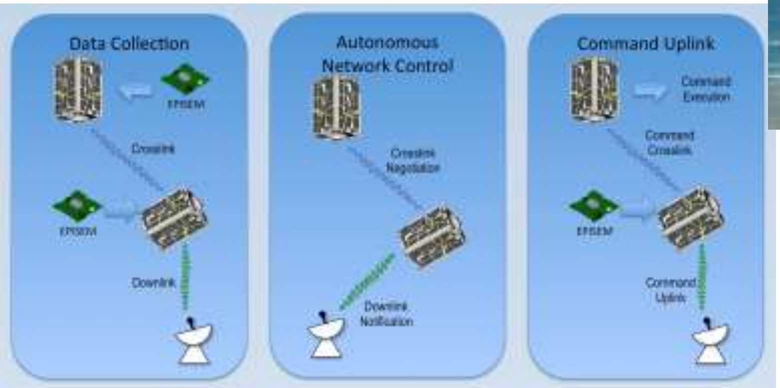
ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
4/1/14	4/5/14	4/21/14	5/23/14	2/22/15	10/1/2015	11/19/15	11/21/15	20	1/28/2016

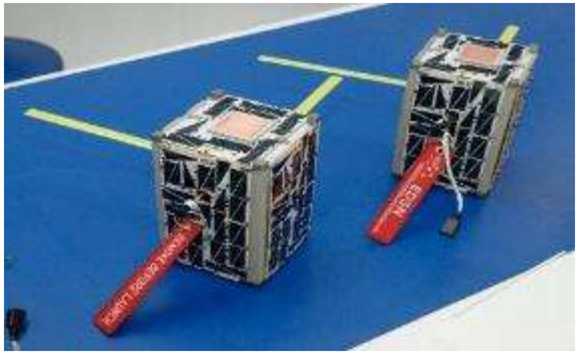
Network & Operations Demonstration Satellite (Nodes)



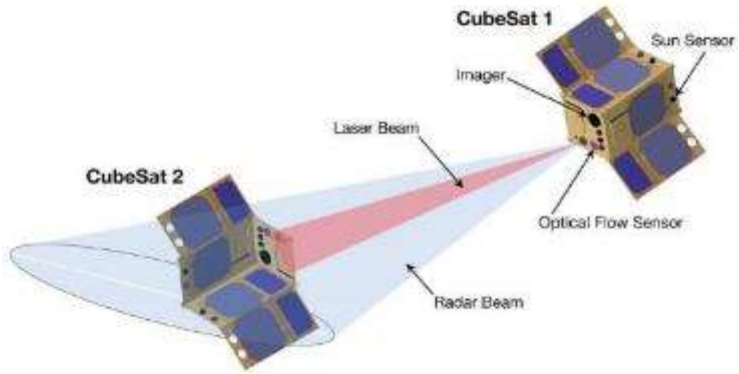


ISS CRS - Orbital 4





Optical Communications and Sensor Demonstration (OCSD)



Spacecraft Specifications

- Mass: 2.18 kg (wet)
- Quantity: Three 1.5U CubeSats
- Orbit: 450 km x 720 km @ 98.7° incl.
- Size: 10cm x 10cm x 17cm
- Communication: RF (UHF) & Optical: 1064nm Laser

Mission Description

Aerospace Corporation is delivering the Optical Communications and Sensor Demonstration (OCSD) will demonstrate small spacecraft proximity operations and high speed optical transmission of data using a laser (200 Mbits/sec). Spacecraft pointing accuracy of 0.1° is planned, Aerospace is leveraging much of the spacecraft design from previous versions of the AeroCube (AC4 though AC6, the NASA SSTP version is AC7). OCSD includes two flight demonstrations: a single satellite in the first demonstration and two satellites in the second demonstration.

Status

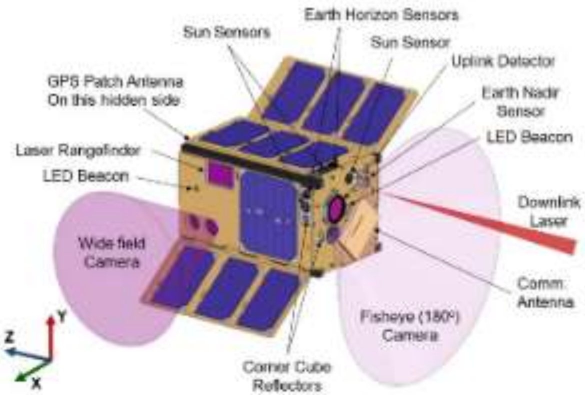
Flight unit for the OCSD-1 demonstration has been delivered to the launch site for the NRO-L55 mission (August 2015). Two flight units for the OCSD-2 demonstration will be integrated and delivered in November 2015 and launched in December 2015.

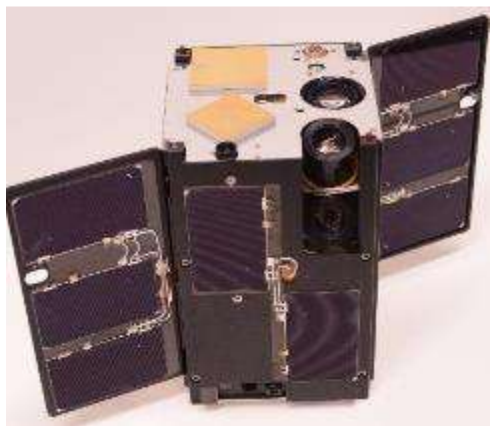
Critical Milestones

ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
9/28/12	3/15/13	9/19/13	3/13/14	3/16/15	3/24/15	8/15/15	9/1/15	90 days	12/1/2015
					11/01/15	12/1/15	12/15/15	90 days	05/01/16

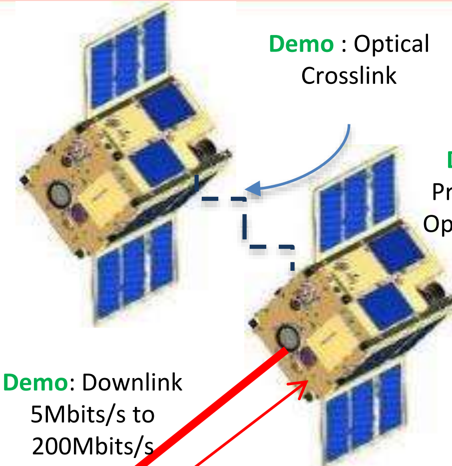
Optical Communications and Sensor Demonstration (OCSD)

Falcon 9 – FormoSat-5 (NET DEC 2015)





Flight Unit #1



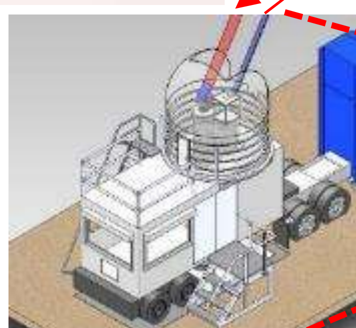
Demo : Optical Crosslink

Demo: Proximity Operations

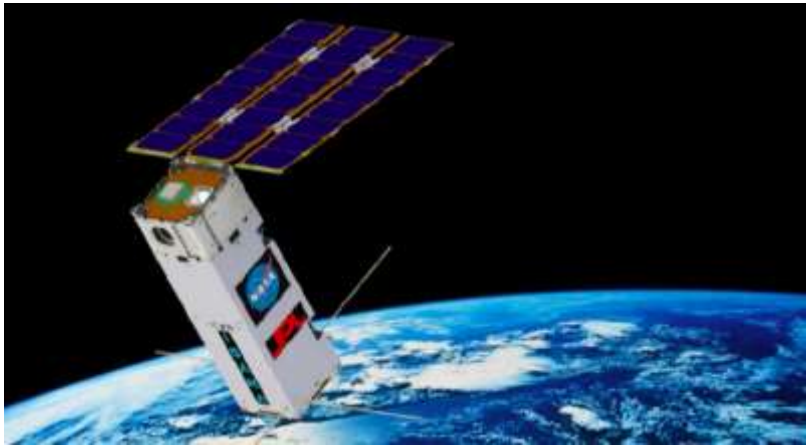
Demo: Downlink 5Mbits/s to 200Mbits/s

OCSD – 2 (1.5U)
(NRO-L55 - AUG 2015)

Demo: Uplink 10Kbits



Integrated Solar Array and Reflectarray Antenna (ISARA)



Spacecraft Specifications

- Mass: 4kg
- Quantity: One 3U CubeSat
- Orbit: 450 km x 720 km, 98.7° inclination
- Size: 10cm x 10cm x 34cm
- Communication: Reflectarray Antenna and ultra-high frequency (UHF) telemetry antenna

Mission Description

ISARA mission will demonstrate a reflectarray antenna that will provide capability to increase downlink data rates for CubeSats from the existing baseline rate of 9.6 kilobits per second (kbps), to over 100 megabits per second (Mbps). For a modest increase in mass, volume, and cost, this technology will pave the way for data return on high value science missions that utilize distributed CubeSats and small satellites. Once on-orbit, the antenna will transmit a signal which will be received by a ground station located at the JPL.

Status

The ISARA payload is in final testing prior to integration with the bus in August 2015. The project is preparing for system-level CDR scheduled for April 15, 2015.

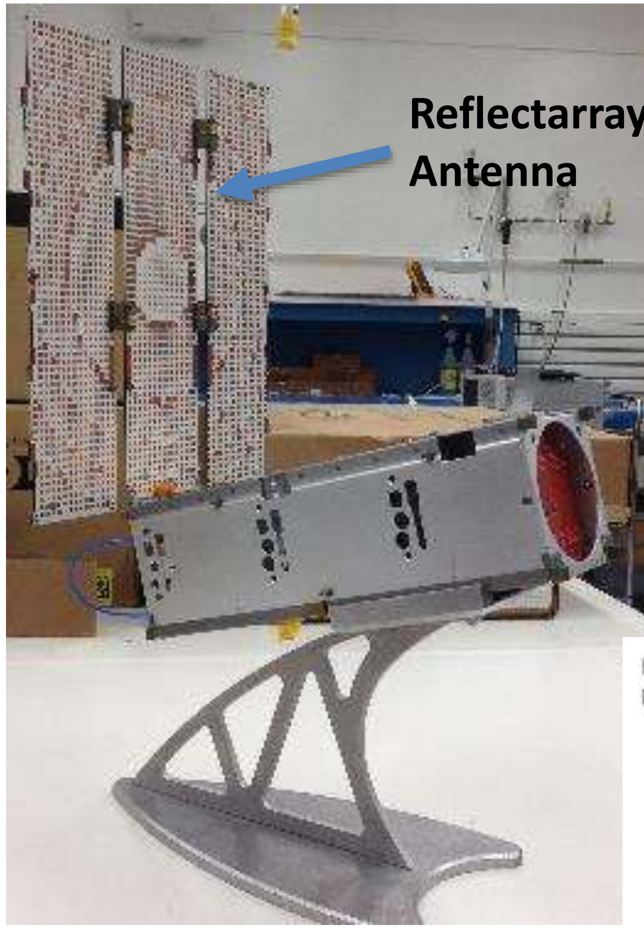
Critical Milestones

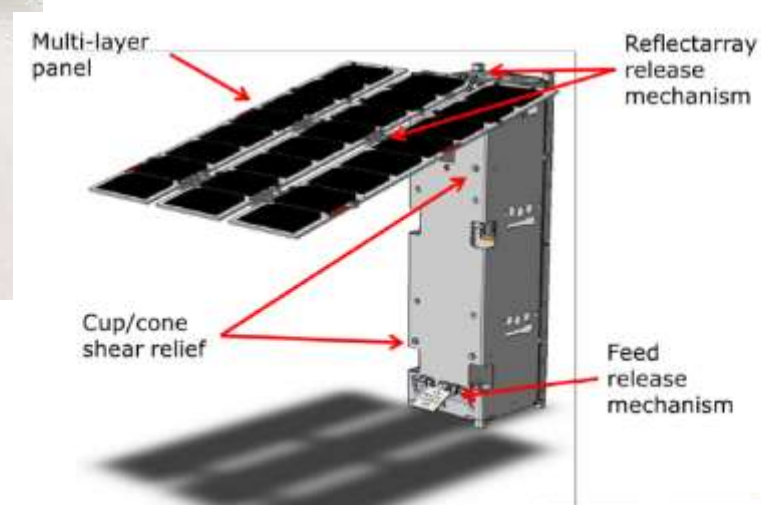
ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
10/01/12	04/11/13	11/12/13	04/15/15	10/23/15	10/23/15	12/01/15	01/02/16	120 Days	5/1/2016

Integrated Solar Array and Reflectarray Antenna (ISARA)

Falcon 9 – FormoSat-5

(NET DEC 2015)





Cubesat Proximity Operations Demonstration (CPOD)

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

Mission Description

CPOD will 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.

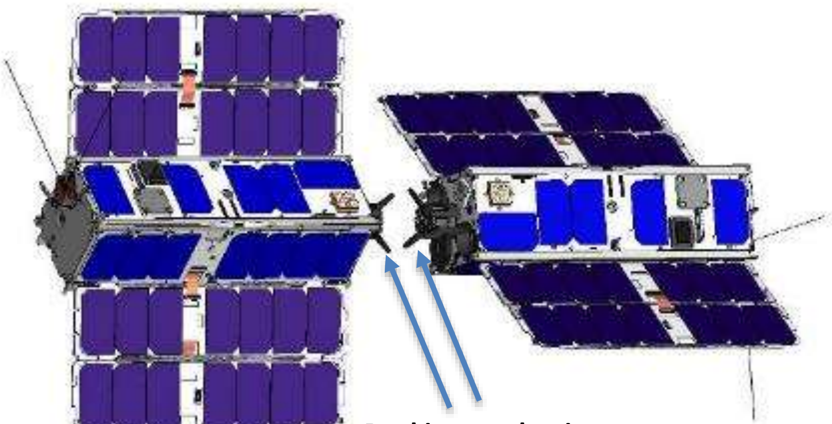
Status

CPOD vehicles are currently in their Integration, Assembly and Testing Phase. Following this effort, the team will commence a set of Hardware In The Loop simulations to refine the operations and further retire mission risks. The launch opportunity is currently scheduled for Q1 2016 on a Minotaur-C (SkySat) from Vandenberg.

Critical Milestones

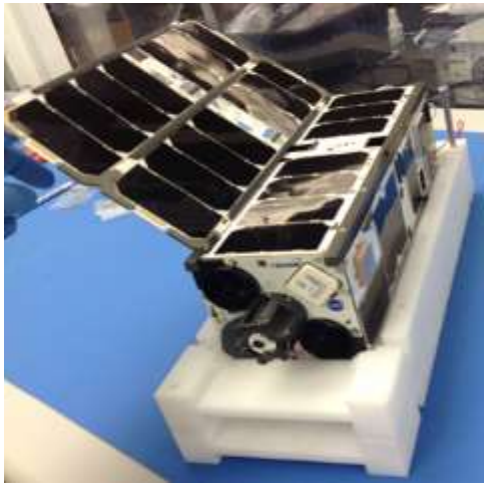
ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
11/01/12	2/19/13	7/19/13	3/6/14	8/31/15	11/20/15	01/1/15	01/15/15	180	5/15/2016

Cubesat Proximity Operations Demonstration (CPOD)

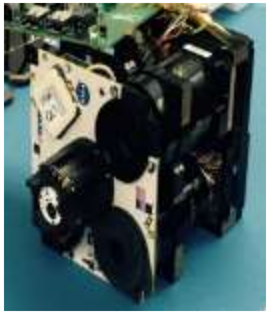


Docking mechanisms

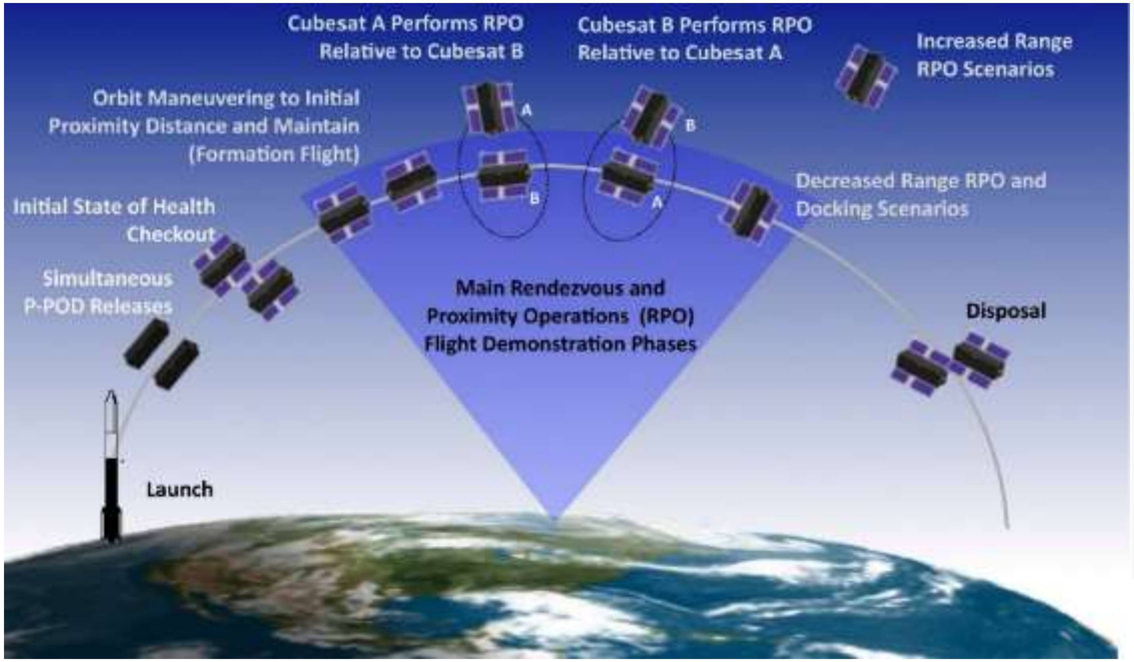
EDU Integration



EDU Integration

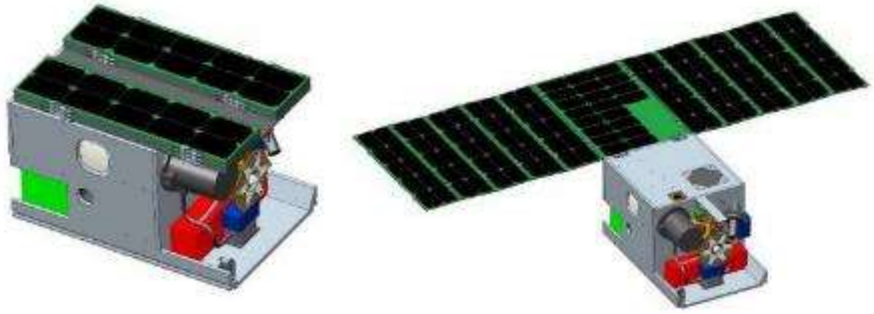


Rendezvous, Proximity Operations and Docking (RPOD) Module



tyvak
NANO-SATELLITE SYSTEMS INC.

Iodine Satellite (iSAT)



Spacecraft Specifications

- Mass: 24kg
- Quantity: One 12U CubeSat
- Orbit: 700km initial orbit (SSO), 98.1880° incl.
- Size: 20cm x 20cm x 30cm
- Communication: S-Band

Mission Description

The iSAT Project is the maturation of iodine Hall technology to enable high ΔV primary propulsion for NanoSats (1-10kg), MicroSats (10-100kg) and MiniSats (100-500kg) with the culmination of a technology flight demonstration. The iSAT project has three major elements: iodine Hall technology development support, the iSAT flight demonstration and future technology risk reduction. In addition to the iodine Hall focus, this project recognizes the market growth potential for SmallSats and the gap in commercially off the shelf (COTS) options for higher capable spacecraft: higher power systems, additional thermal control, higher data rates, improved stability and attitude control, etc.

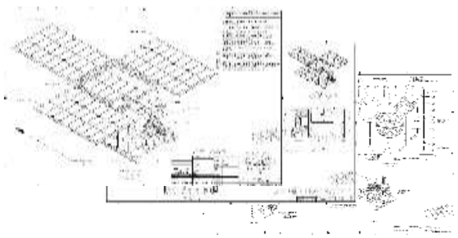
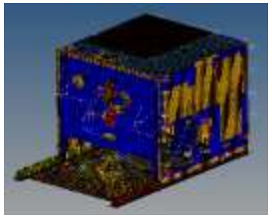
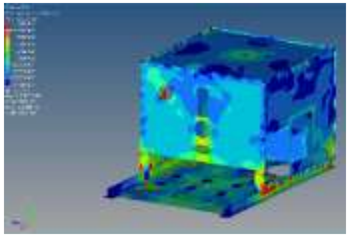
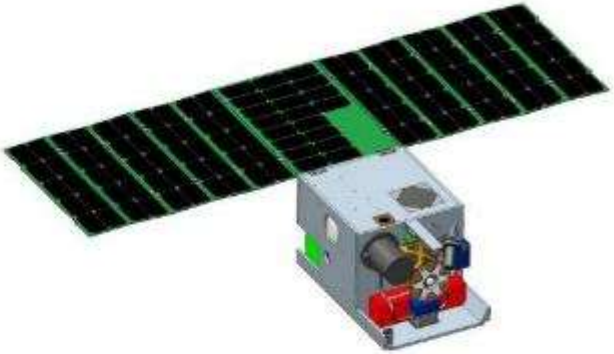
Status

The iSAT project completed it's preliminary design review in December of 2014 and is working towards CDR in the summer of 2015. The current design and analysis cycle is showing positive margins in all areas and development is on plan.

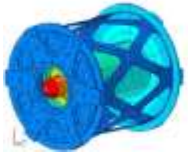
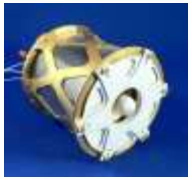
Critical Milestones

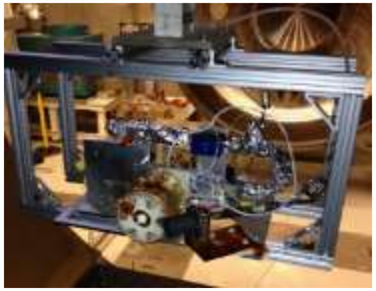
ATP	SRR	PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
7/18/14	7/28/14	12/9/14	TBD	TBD	TBD	05/1/2017	05/15/2017	6 Months	12/15/2017

Iodine Satellite (iSAT)




Propulsion Pathfinder

Spacecraft Specifications

- Mass: 10-12kg
- Quantity: One 6U CubeSat (multiple demonstrations)
- Orbit: 350-800 km, 98° or 51° incl.
- Size: 50 x 9.1 x 13.5 (*inches*)
- Communication: S-Band

Mission Description

The Propulsion Pathfinder Project objective is to perform multiple Earth orbit flight missions with Cubesat-scale spacecraft to demonstrate the operation of, and characterize the performance of, a variety of propulsion technologies suitable for small spacecraft mission applications including precise pointing, proximity operations, targeted deorbit, and small and large orbital maneuvers. The propulsion technologies to be demonstrated include but are not limited to at least one version of miniaturized electrospray propulsion and an RF Ion propulsion system.

Status

The project was recently kicked off and is working towards MCR. Level 1 requirements are signed and Level 2 requirements are underway. System trades are being conducted and programmatics (cost estimates, schedule, and risk) are being defined. Procurement strategies are being defined for the candidate propulsion systems.

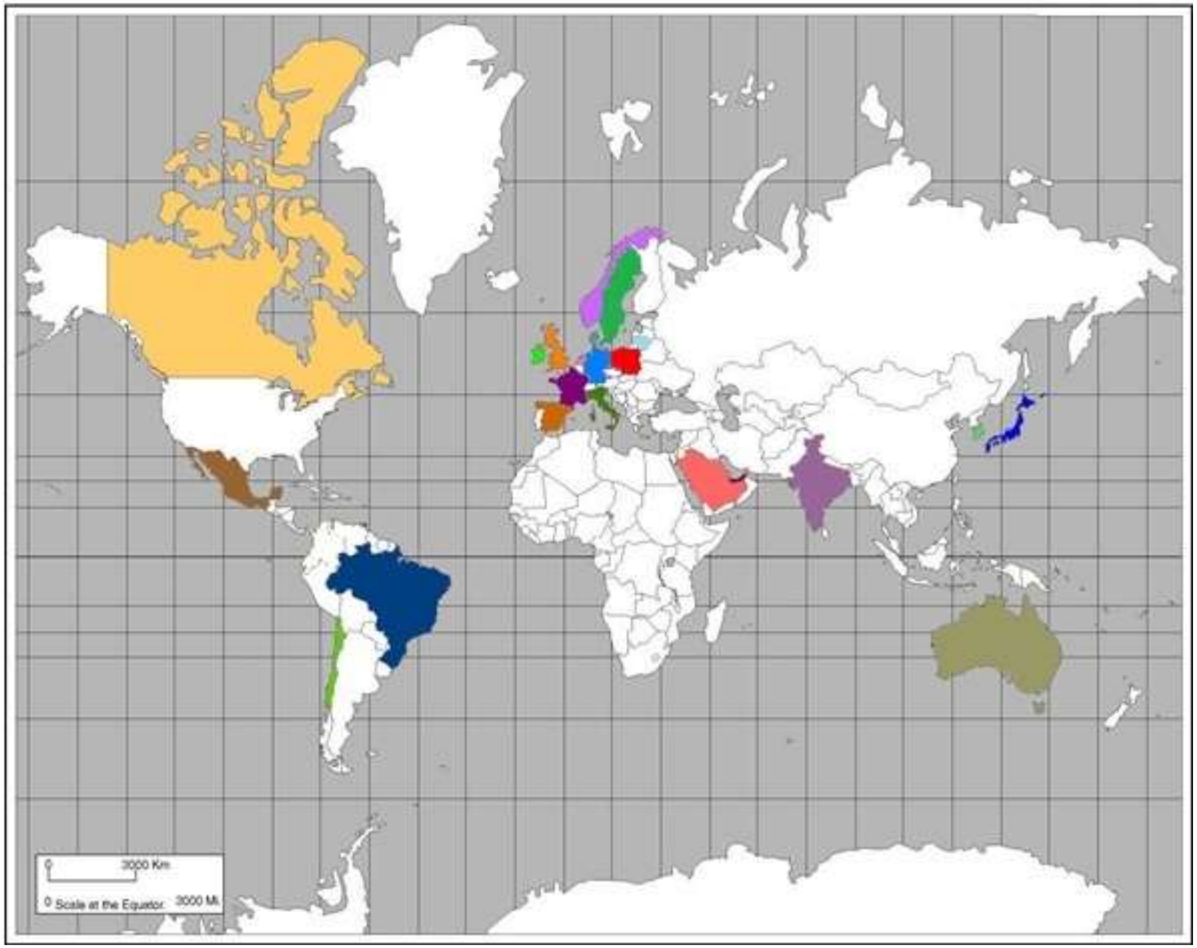
Critical Milestones

ATP	MCR	SRR/PDR	CDR	FHR	FRR/ORR	Launch	Mission Ops	Mission Duration	Project Closure
1/14/15									

International Partnerships

Interns/ Visiting Researchers

1. Australia
2. Brazil
3. Denmark
4. France
5. Japan
6. India
7. Ireland
8. Israel
9. Italy
10. Mexico
11. Norway
12. Poland
13. Spain
14. S. Korea
15. UAE
16. UK



Technical Collaboration

1. Canada
2. Chile
3. France
4. Germany
5. Italy
6. Japan
7. Lithuania
8. **Mexico**
9. Netherlands
10. Norway
11. Saudi Arabia
12. Sweden
13. Spain
14. Trinidad & Tobago
15. UK

QUESTIONS?

http://www.nasa.gov/smallsats

http:// www.nasa.gov/spheres

http://www.nasa.gov/sporesat

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