



National Aeronautics and  
Space Administration



# NASA Ames Research Center

October 24, 2014



**Dr. David Korsmeyer**  
**Director of Engineering**  
**NASA Ames Research Center**



# NASA's 10 Centers (13 sites)





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# ***Aerial View of NASA Ames Research Center***







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## ***NACA Laboratories***

**NACA**



Joseph S. Ames

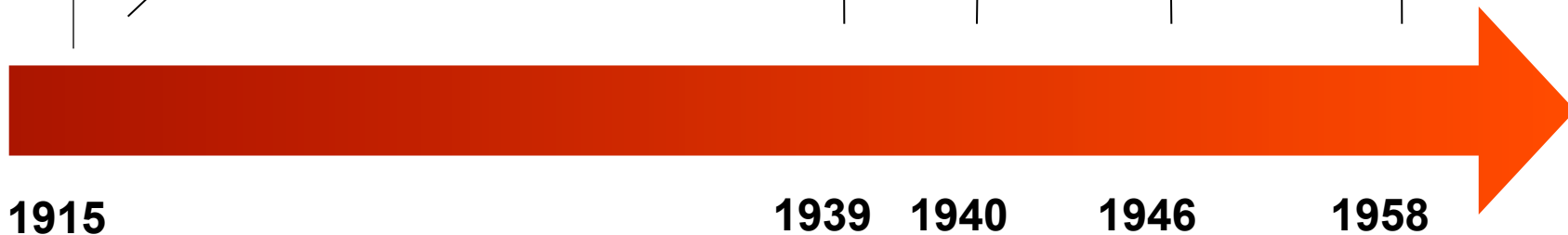
**NASA**

**Ames**

**Dryden**

**Langley**

**Lewis**





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# NASA Research Park

## Innovative Collaboration in Science, Engineering & Education

### 90+ Partners Today

University Associates

Google-North East Section

University of California/UARC-Bldg. 555

M2MI Corporation-Bldg.19

Carnegie Mellon University-Bldg. 23

San Jose State University

-Metropolitan Technology

Center in Bldg. 583C

Foothill-De Anza Community College

United Negro College Fund Special

Programs Corporation-Bldg.19

Space Technology Center

-San Jose State, Stanford, Santa Clara Univ.,

Utah State Univ. /Micro Satellite Classes

Kentucky Science & Technology Corporation-Bldg.19

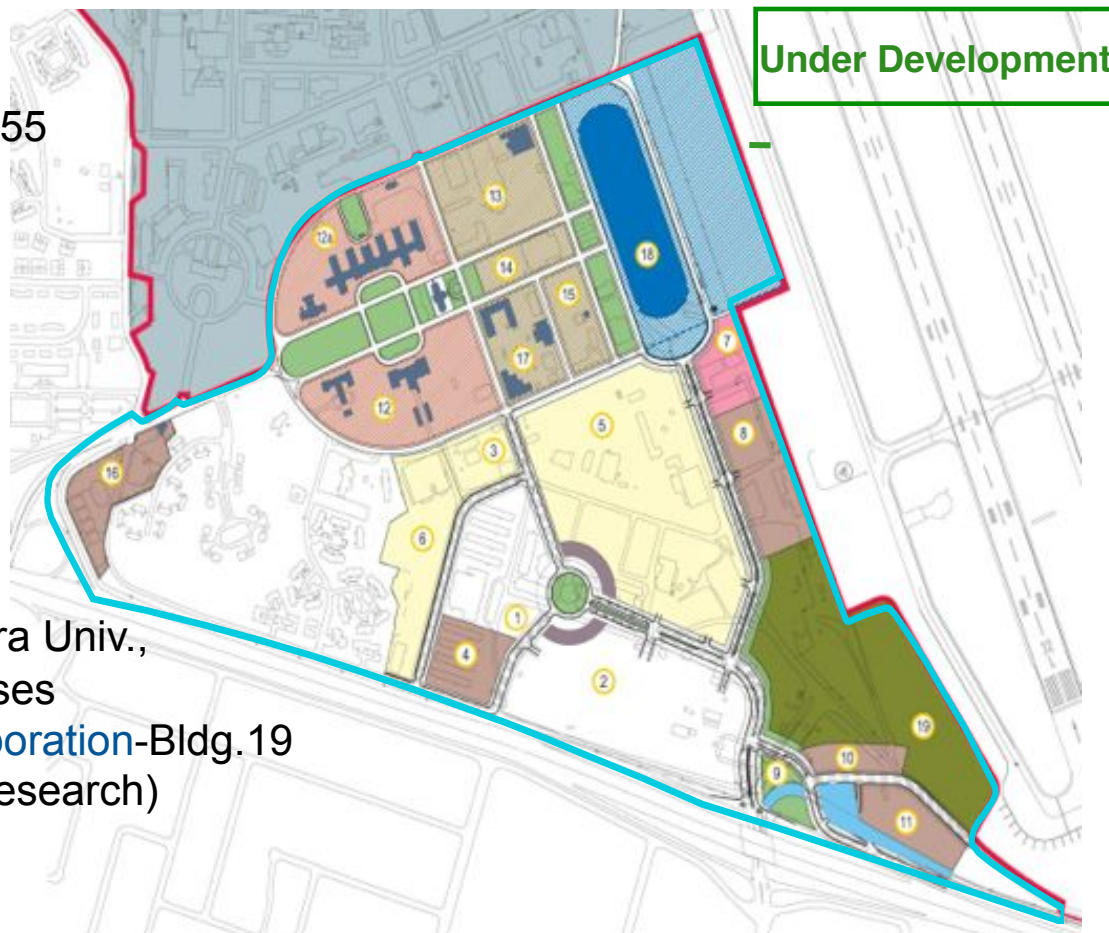
Bloom Energy-Bldg. 543 (Fuel Cell Research)

Industry Partners-Bldg. 566 & 19

UAV Center-Bldg.18

International Space University

Singularity University





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# ***NASA Ames Today***



- **2480 employees\***
- **≈\$900M+ of yearly revenue**  
(including reimbursable)
- \*in addition, 900 students, summer 2014

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





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# Current Active Facilities, 2014 →



**National Full Scale Aerodynamic  
Complex, 80x120 Wind Tunnel**



**Vertical Motion  
Simulator**



**Small Spacecraft  
Development Facility**



**Unitary Plan Wind Tunnel**



**SOFIA**



**Machine Shops**



**Small Satellite Lab**

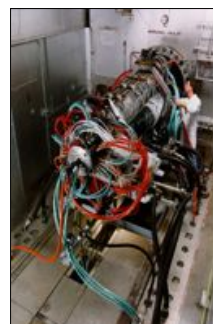


**Pleiades - Columbia  
Super Computer**

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**Ballistic Range**



**Arc Jets**



**MSL - Chem  
Lab**



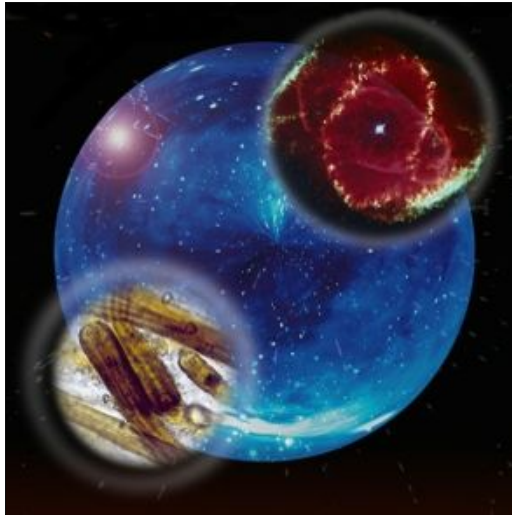
**Air Traffic  
Management  
Lab**



**Virtual Institutes**

## **Virtual Institutes at Ames**

### **Astrobiology Institute**



***Scientific Study of life***

### **Solar System Exploration Research Virtual Institute**



***To advance basic and  
applied lunar and planetary  
science research and to  
advance human exploration  
of the solar system through  
scientific discovery***

### **NASA Aeronautics Research Institute**



***Creating new tools and technologies for  
reducing air traffic congestion and  
environmental impacts, improving safety,  
and designing aircraft***





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# NASA Ames: 75 Yrs of Innovation

Flight Simulator

Tektites

Pioneer

X-36

Human Centered Computing

NASA Lunar Science Institute

2010

CubeSats

LADEE

Blunt Body Concept

Transonic Flow

Life Sciences Research

Pioneer Venus

Galileo

1990

Lunar Prospector

LCROSS

Lifting Body

Viking

Air Transportation System

Astrobiology

NASA Research Park

1980

Kepler

Swept-Back/Wing

Flight Research

Pioneer Venus

Tiltrotor

Kuiper Observatory

ER-2

1970

Nanotechnology

SOFIA

1960

CFD

Hypervelocity Free Flight

80x120 Wind Tunnel

1950

Arcjet Research

One of the World's Fastest Operational Supercomputers

1940

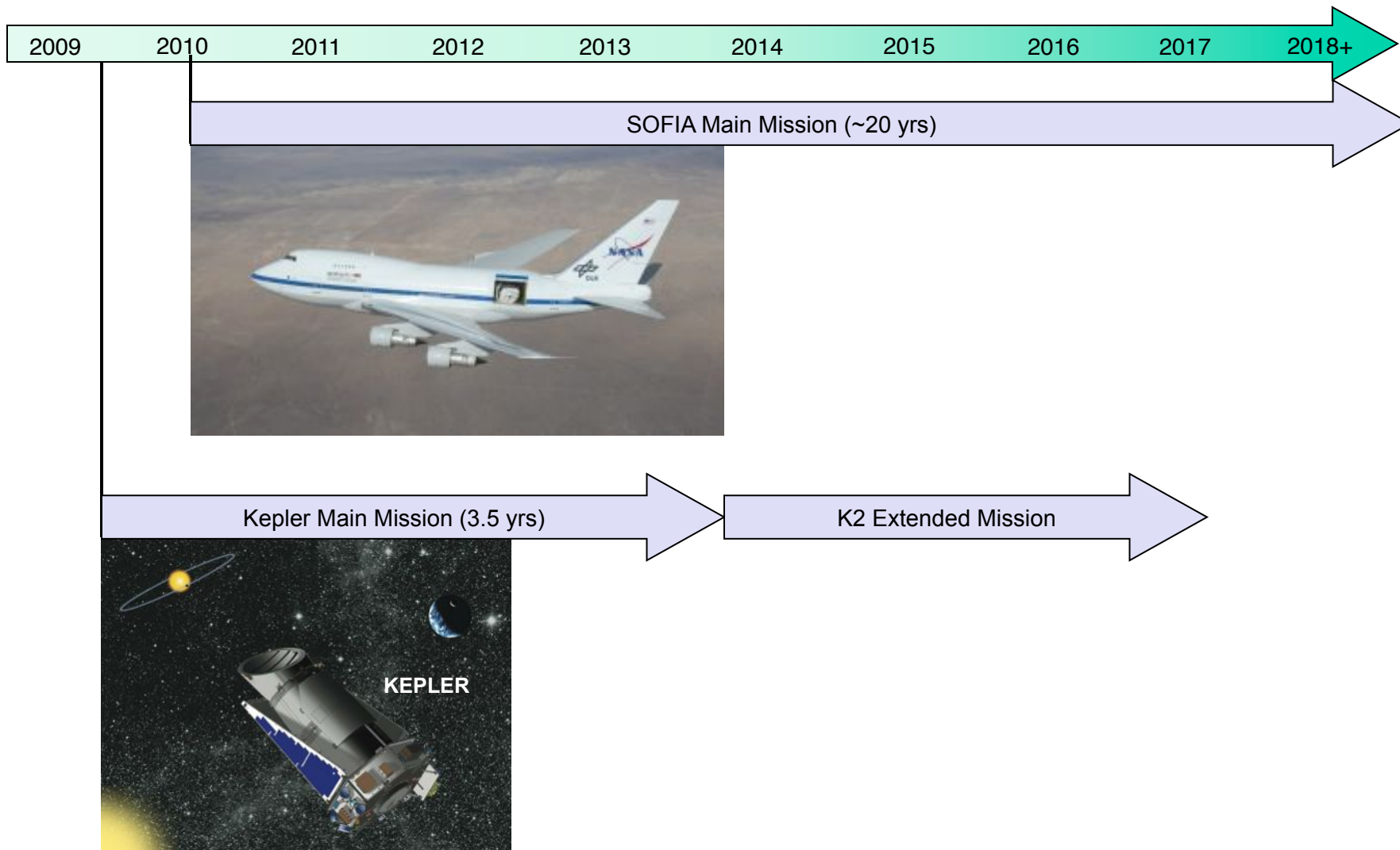
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# Large Astronomy Missions







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# NASA's Kepler Mission

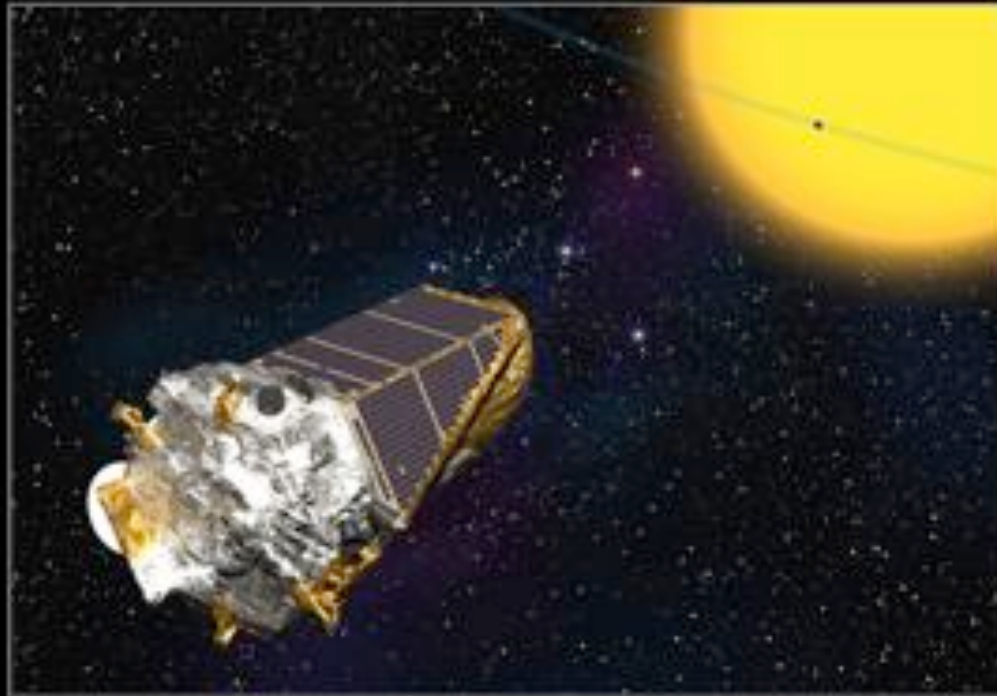
- Determine the frequency of Earth-size and larger planets in the habitable zone of sun-like stars
- Determine the size and orbital period distributions of planets

**Launched:**  
**March 7, 2009**

**Observed 145,000  
Stars**

**977 Confirmed  
Planets Found**

**3277 Candidate  
planets to be  
confirmed**







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# Stratospheric Observatory for Infrared Astronomy (SOFIA)

Modified Boeing 747 with a 2.5 meter diameter German (DLR) infrared telescope



Joint project with NASA Ames, NASA Armstrong, and DLR

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NASA Ames KIMM Presentation

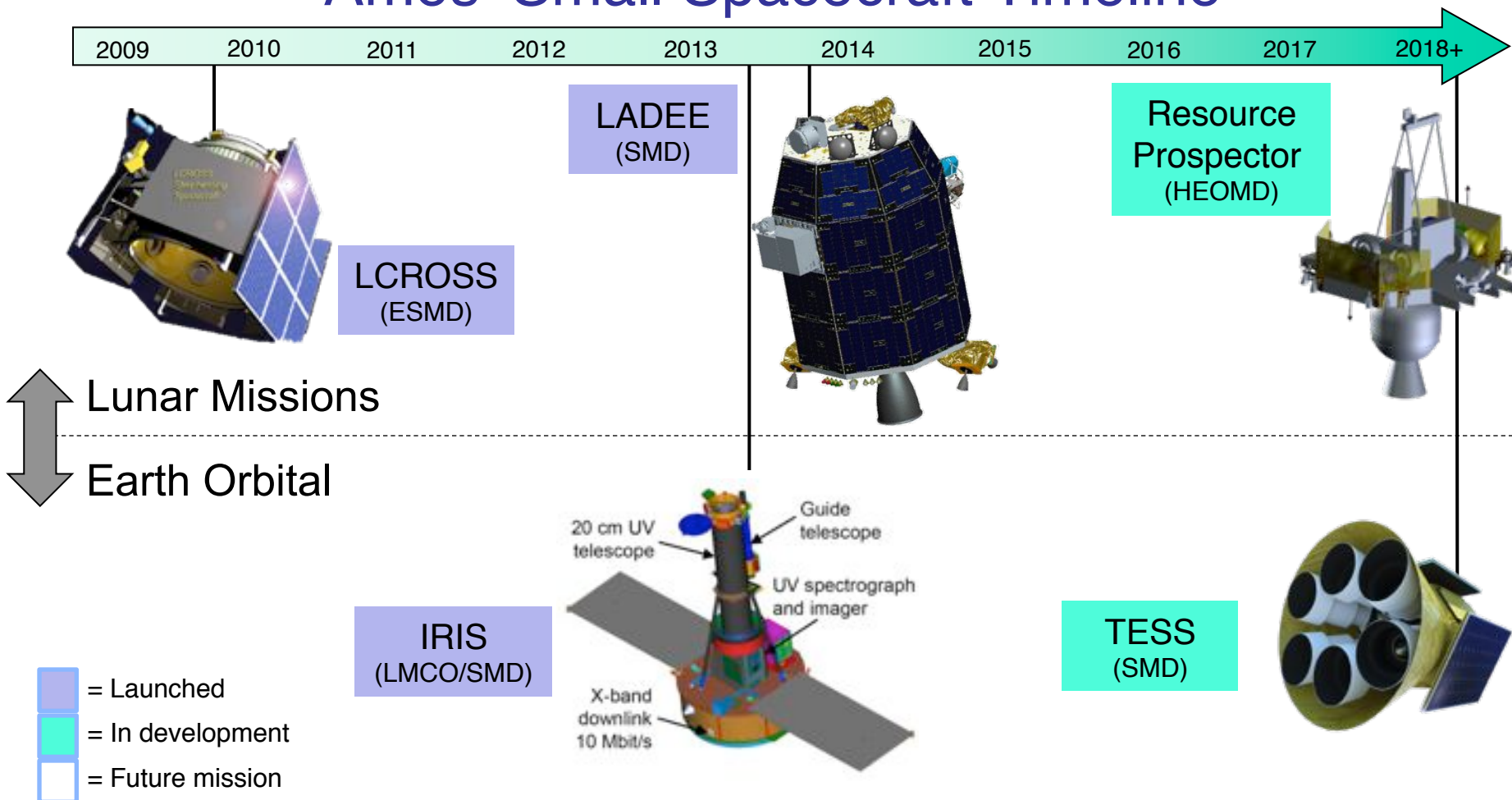
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## Ames' Small Spacecraft Timeline



NASA Ames develops capable, cost efficient (< \$250M) Small Satellites

# LCROSS Lunar Impactor - 2009

**Risk Position:** Class D, Secondary Payload to LRO

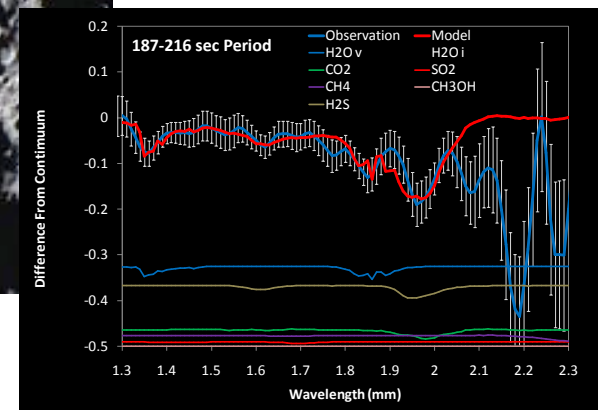
**Cost-Capped:** \$79M cost cap (including margin)

**LV Mass-limited:** 1000kg (*including adaptor*)

**Schedule-Constrained:** 30-month development (Phases A-D)

LAUNCHED ON-TIME AND ON BUDGET

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







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## IRIS:

### Interface Region Imaging Spectrograph

**Mission Type:** SMEX, Heliophysics, \$105M cap,  
GSFC Program Office, Launched in 2013

#### Ames Roles/Responsibilities:

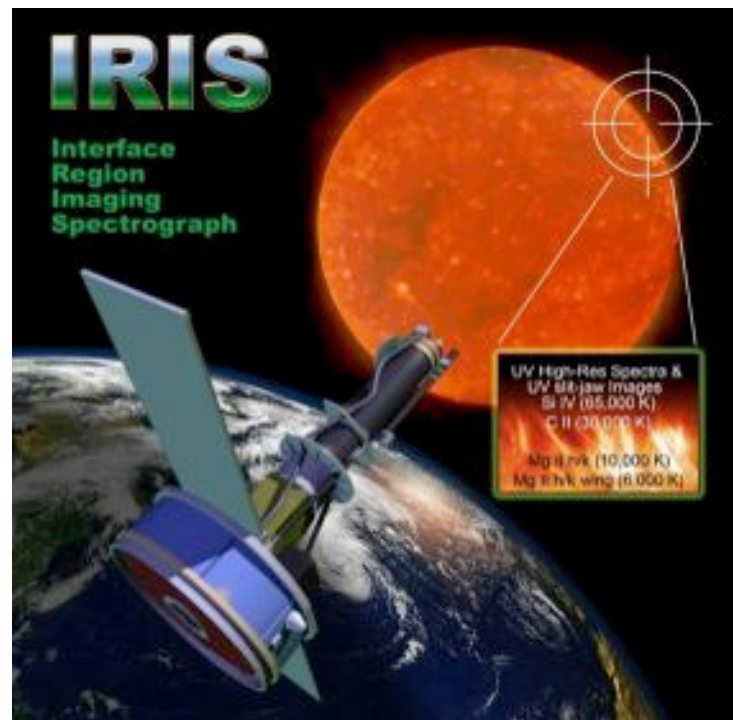
Assistant Project Manager, Science Co-I  
Systems Engineering, EPO Support  
Main role: Spacecraft Mission Operations

#### SCIENCE OBJECTIVES

- Which types of non-thermal energy dominate in the chromosphere and beyond?
- How does the chromosphere regulate mass and energy supply to the corona and heliosphere?
- How do magnetic flux and matter within it rise through the solar atmosphere and what role does flux emergence play in flares and mass ejections?

# IRIS

Interface  
Region  
Imaging  
Spectrograph



“A SMall EXplorer mission to understand  
how the solar atmosphere is energized”

<http://iris.lmsal.com/>

#### Leads

Principal Investigator (LMSAL)

Science Lead (LMSAL)

Project Manager (LMSAL)

Assistant Project Manager (ARC)

Alan Title

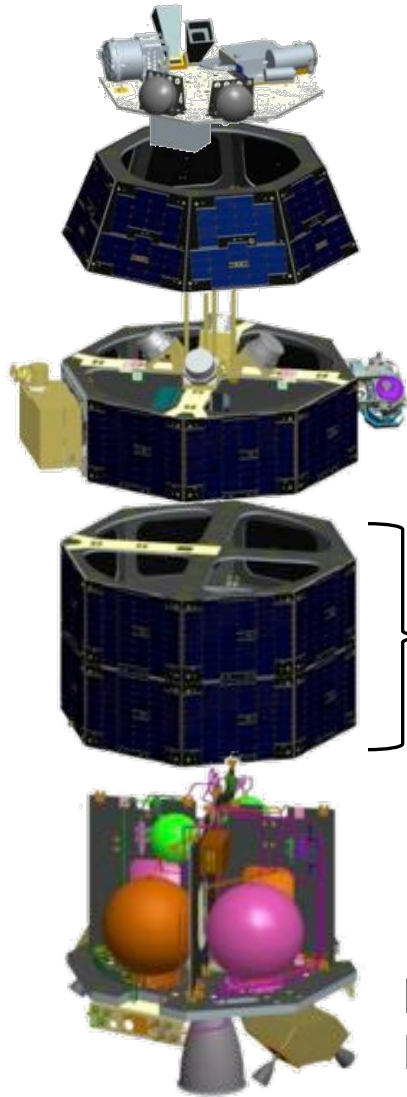
James Lemen

Gary Kushner

John Marmie



# LADEE Lunar Orbiter Design



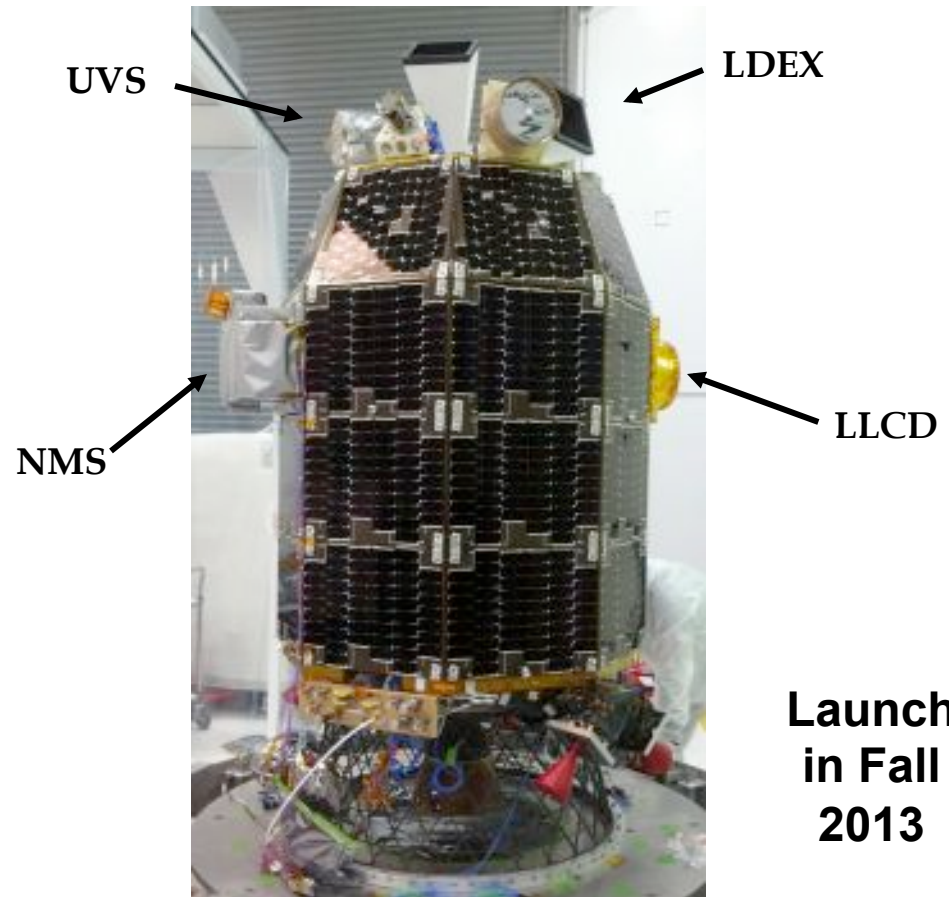
**Radiator Assembly**

**Bus Module**

**Payload Module**

**Extension Modules**

**Propulsion Module**



**Launch  
in Fall  
2013**

Lunar Atmosphere and Dust Environment Explorer (LADEE) is a NASA SMD mission based on the Common Bus Spacecraft Design. (\$250M, Class C mission, Minotaur V, MSFC Program Office)





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Ames

Discovery • Innovations • Solutions



## Objective

- Measure the Lunar Dust
- Examine the Lunar atmosphere

## Key parameters

- Launched Sept 6, 2013
- Impacted on April 18<sup>th</sup>, 2014

## Spacecraft

- Type: Small Orbiter - Category II, Enhanced Class D
- Provider: NASA ARC and NASA GSFC

## Instruments

- Science Instruments: NMS, UVS, and LDEX
- Technology Payload: Lunar Laser Communications Demo

Launch Vehicle: Minotaur V

Launch Site: Wallops Flight Facility

# LADEE : Lunar Atmosphere and Dust Environment Explorer

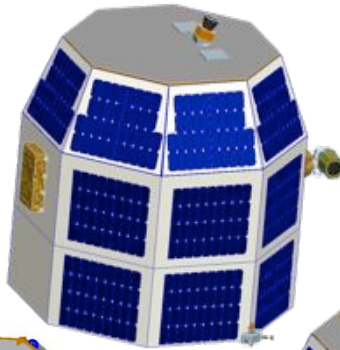






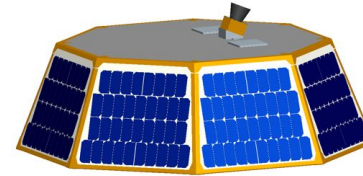
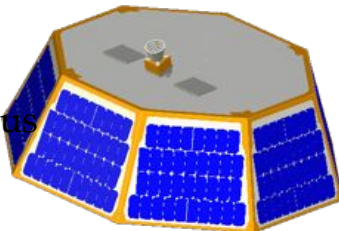
## Ames Common Spacecraft Bus – Modular Approach

Orbiters

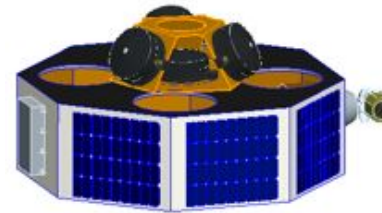


Landers

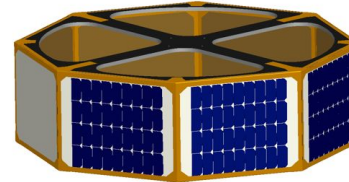
NEO Rendezvous



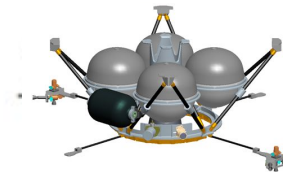
• Bus Module



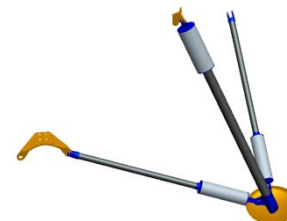
• Payload  
Module



• Extension  
Module



• Propulsion Module



• Legs

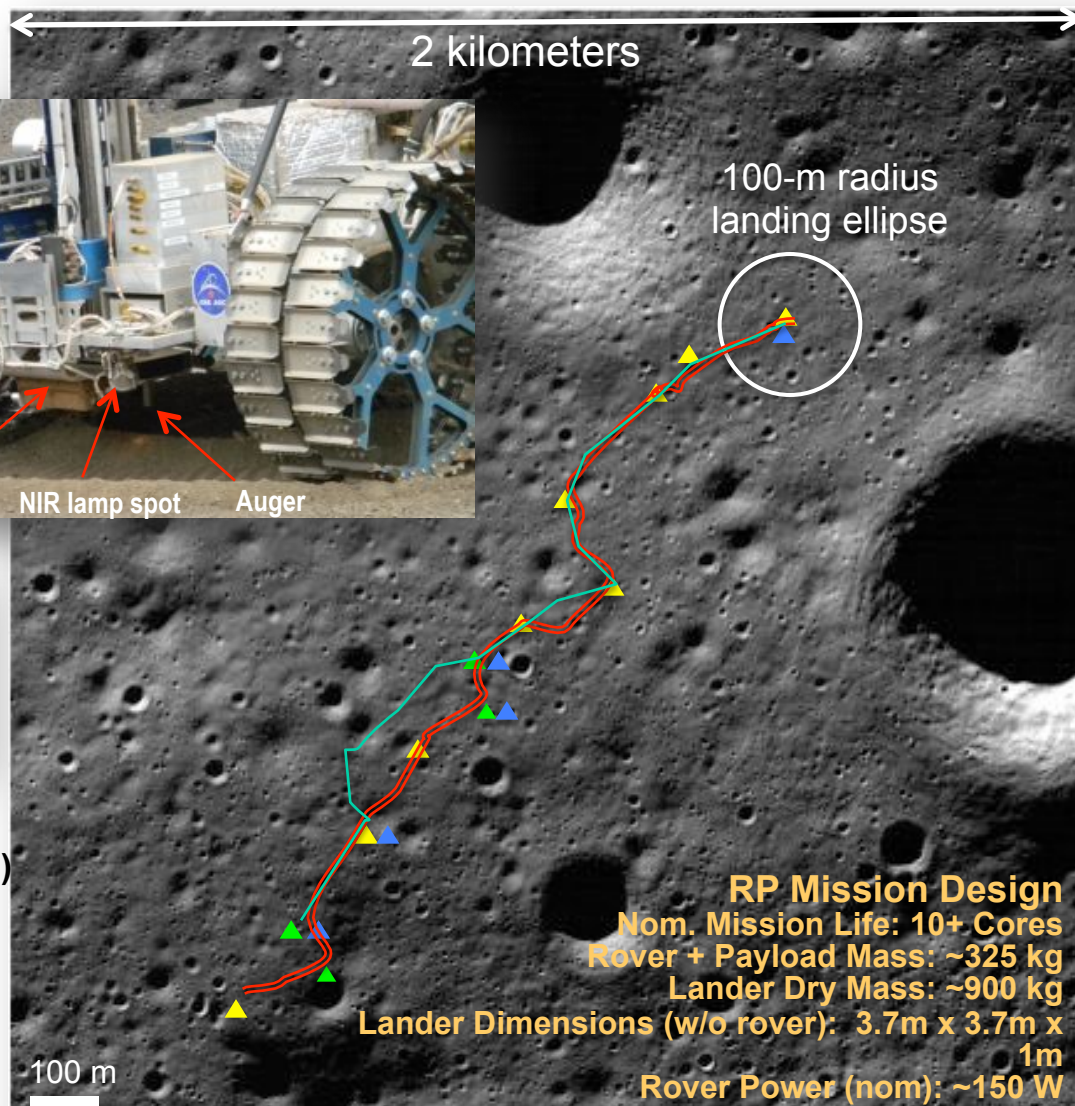
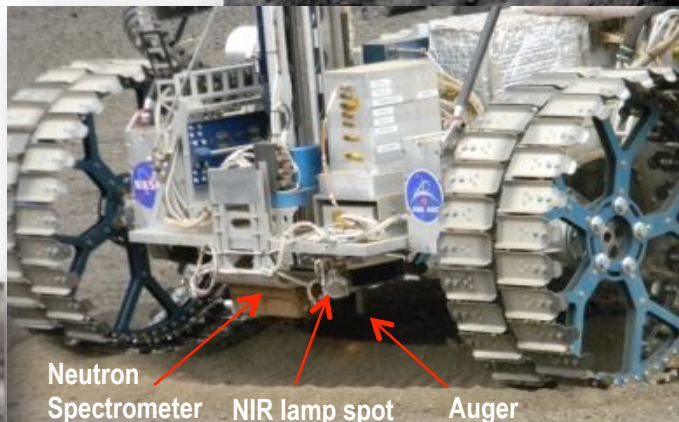
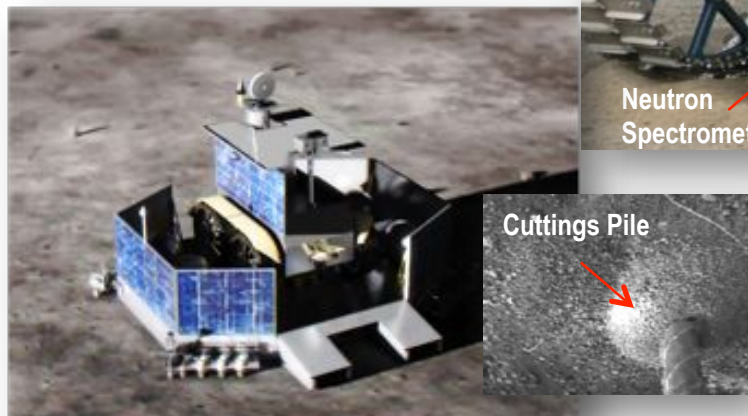
**Multi-Mission Capability enabled by  
Modular Bus Design – Select Modules to  
meet Mission Requirements**



# Resource Prospector (RP) Mission - 2019

## Mission:

- Characterize the constituents and distribution of water/volatiles in lunar polar surface materials
- Demonstrate ISRU oxygen extraction from lunar regolith



## RPM Flight Project Office (NASA-ARC)

- ✓ FY13: Pre-Phase A: MCR (Pre-Formulation)
- FY14-15: Phase A (Formulation)
- FY16: Phase B: SRR, PDR (Prelim Design)
- CY19: RPM launch
- \$250M LCCE Cost Cap, HEOMD
- Class D, Category 3 (<\$250M)
- LV: Falcon 9 v1.1 class

**RP Mission Design**  
 Nom. Mission Life: 10+ Cores  
 Rover + Payload Mass: ~325 kg  
 Lander Dry Mass: ~900 kg  
 Lander Dimensions (w/o rover): 3.7m x 3.7m x 1m  
 Rover Power (nom): ~150 W



# Cubesats (aka Nanosats)

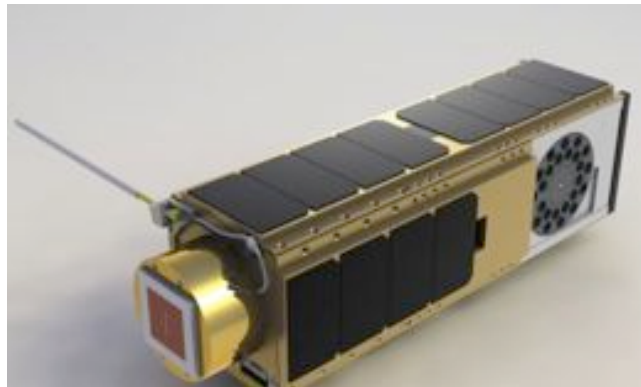
- Started as a University standard for teaching satellite design
  - Cal Poly University and Stanford University
- 10 X 10 X 10cm Cube as a Standard form factor = 1U
- Weighing 1-1.5 kgs for each 1U of volume

## Common Form Factors

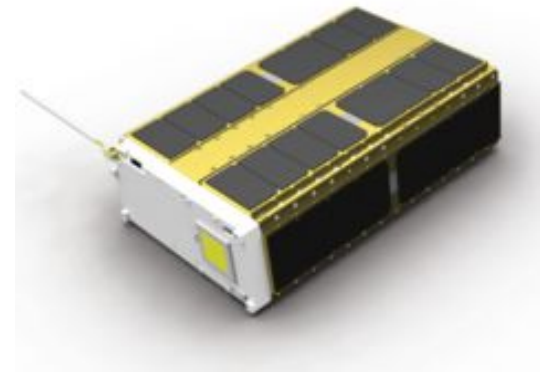
1U



3U



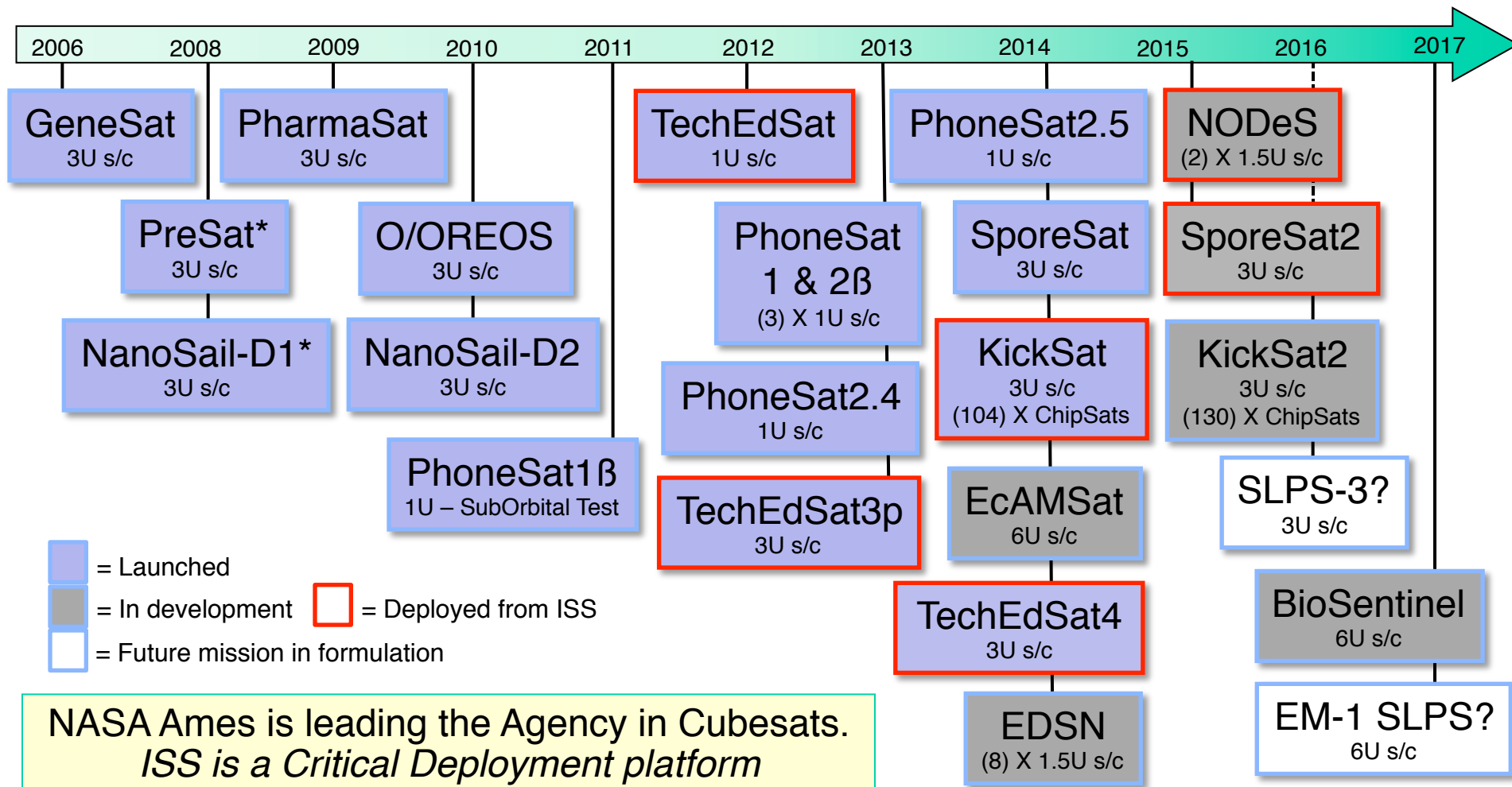
6U







# Ames Nanosat Missions





# Space Biology Nanosats: *Testing Life in Space*

## *Validating and Enhancing ISS biological testing*

### PharmaSat

- 3U Cubesat, launched May 2009, full mission success, 2U Biology payload
- Grew & characterized **yeast (*S. cerevisiae*)**; tracked metabolic activity in 48  $\mu$ wells

### O/OREOS

- 3U Cubesat, launched November 2010, full mission success, 2 payloads
- Demo'd satellite bus & payload instrument functionality > 3.5 years in high-rad 15x ISS

### SporeSat 1 & SporeSat 2 (ISS deployed)

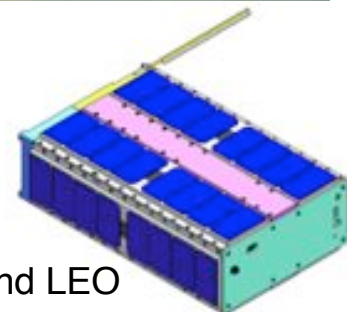
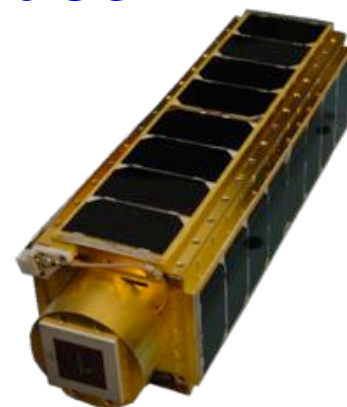
- 3U Cubesat, launched April 2014, 2<sup>nd</sup> spacecraft in Fall 2014
- Demonstrated growth of spores in gel medium, in variable-g

### EcAMSat

- 6U Cubesat, launch ~ Spring 2015, 3U Biology payload
- Demonstrating *e Coli* antimicrobial resistance changes due to radiation and  $\mu$ gravity

### BioSentinel

- 6U Cubesat, launch ~ Fall 2018 on a Lunar mission, 4U Biology payload
- Demonstrate use of simple organisms as “biosentinels” to Inform of risks to humans beyond LEO



# BioSentinal deep-space Nanospacecraft

## Mission Objectives:

**A freeflyer Nanospacecraft launched as a secondary payload on EM-1**

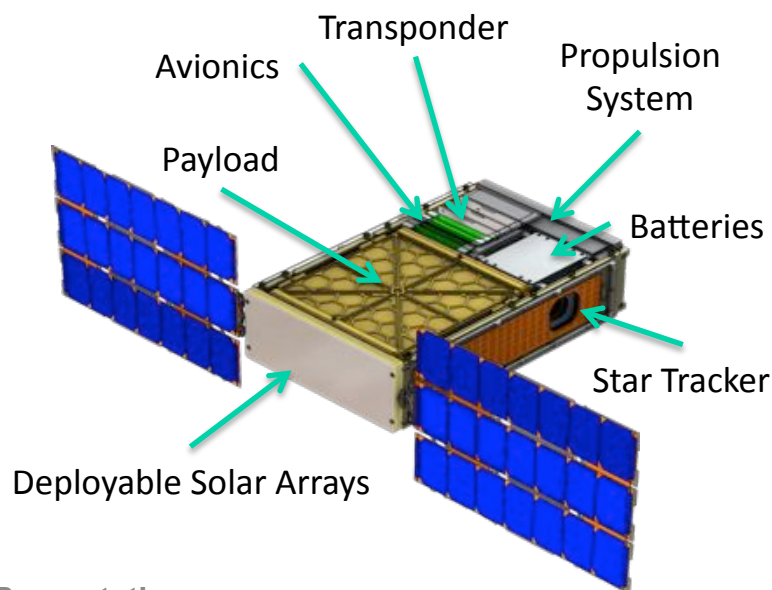
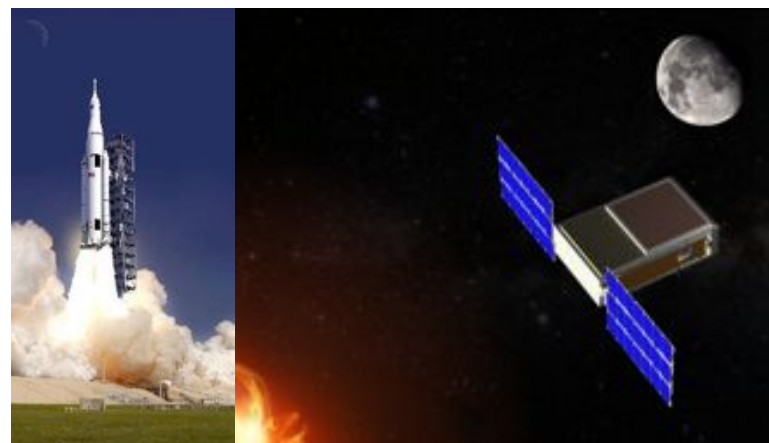
- Range to Earth of 0.73 AU at 18 months
- Far outside the protective shield of Earth's magnetosphere

## Conduct life science studies relevant to human exploration

- 1<sup>st</sup> biological study beyond LEO in over 40 years
- BioSentinel uses DNA double strand break frequencies to calibrate radiation damage in space
- Validate biological radiation damage models in space
- Demonstrate “biosentinel” science concept

## Design payload with sensors for multiple environments

- BioSensor, LET Spectrometer, TID Dosimeter
- Instrument on ISS at similar time to EM-1 launch
- Ground controls in lab and at radiation beam facilities







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# TechEdSats: *Re-Entry Technology Demonstrators*

*ISS Downmass and EDL demonstrators*

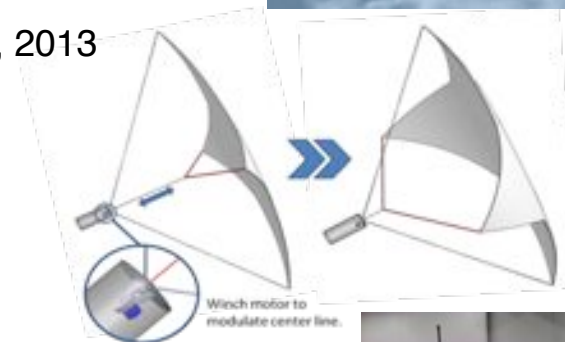
## TechEdSat-1: First U.S. & NASA CubeSat launched from ISS

- 1U Cubesat at 1.2kg, Launched July 21<sup>st</sup> 2012, Deployed from ISS October 4<sup>th</sup> 2012
- Passed out of JAXA's ISS airlock, deployed from JAXA's robotic arm
- Standardized the Process for ISS Cubesat Deployments now used by Nanoracks



## TechEdSat-3p: First 3U Nanosat from ISS

- 3U Nanosat, Launched August 4 2013 (HTV-4), ISS deployed on Nov 19, 2013
- First sub-scale Exo-Brake test; Iridium downlink/uplink test;  
De-Orbit validation burned up during Earth Re-entry



## TechEdSat-4: Deploying from ISS summer 2014

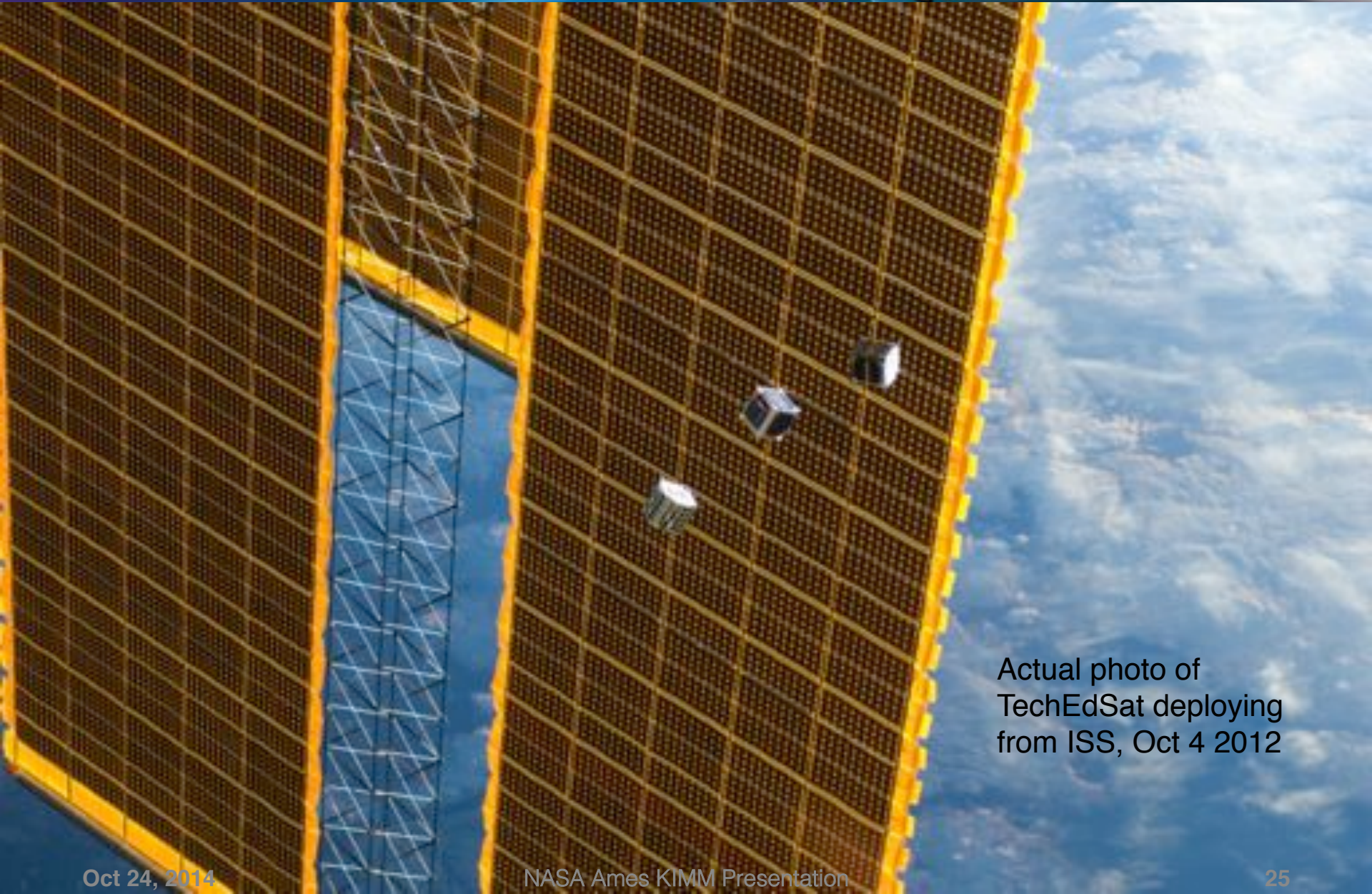
- 3U Nanosat, to be launched ~July 1<sup>st</sup> 2014 on Orbital's Orb2 to ISS
- To be deployed from Nanoracks Cubesat Launch system
- Reflight of TechEdSat-3p Exobrake, updated Iridium & GPS hardware







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Actual photo of  
TechEdSat deploying  
from ISS, Oct 4 2012



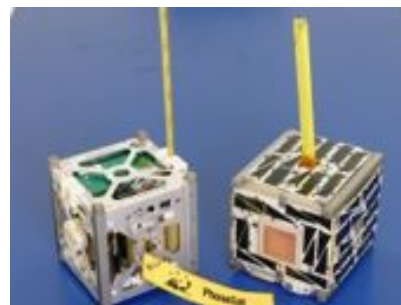


# PhoneSats/EDSNs: *COTS Tech Demonstrators*

(Consumer-grade technology evaluation/validation for NASA use)

## PhoneSat 1: First Phone-based spacecraft

- 2 x 1U Cubesats, Actual Nexus S phones as full Cubesat
- Launched April 21, 2013 on Antares-1. Achieved full functionality

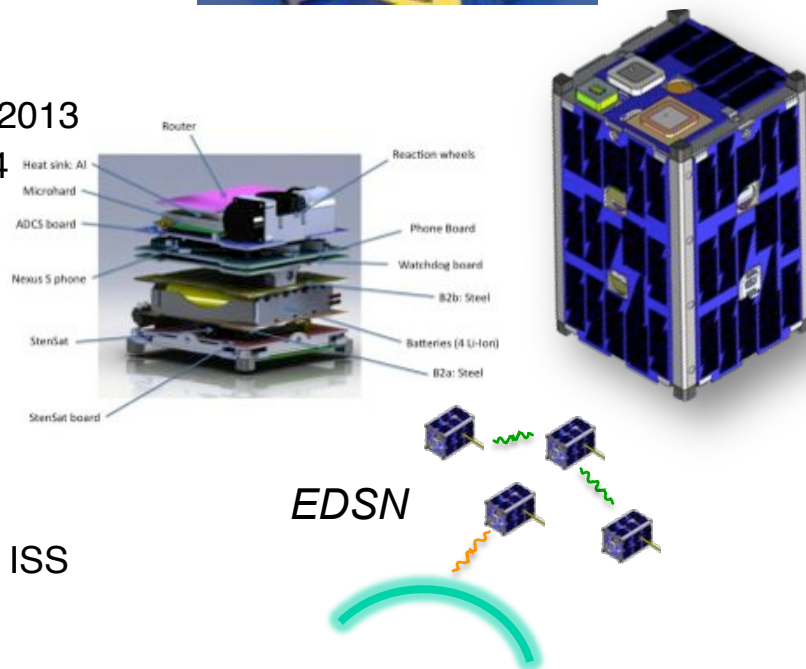


## PhoneSat(s) 2B, 2.4, and 2.5

- 1U Cubesats, avionics derived from Nexus S Phone
- PhoneSat 2B Launched April 21, 2013 on Antares-1
- PhoneSat 2.4 launched on a Minotaur 1 – ELaNa 4 in Nov 2013
- PhoneSat 2.5 launched on SpaceX – ELaNa 5 in April 2014

## **EDSN: First Nanosat Swarm**

- Phonesat as core of 8 x 1.5U Cubesats,
- EDSN Swarm satellites using PhoneSat 2 components

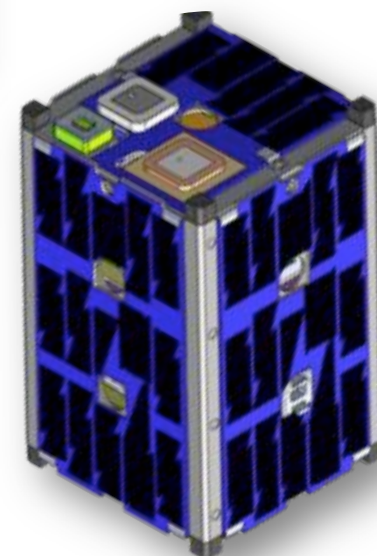
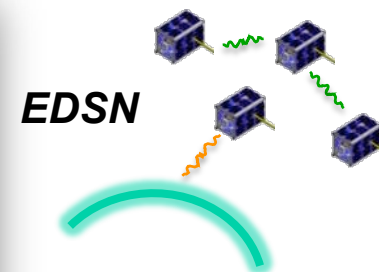
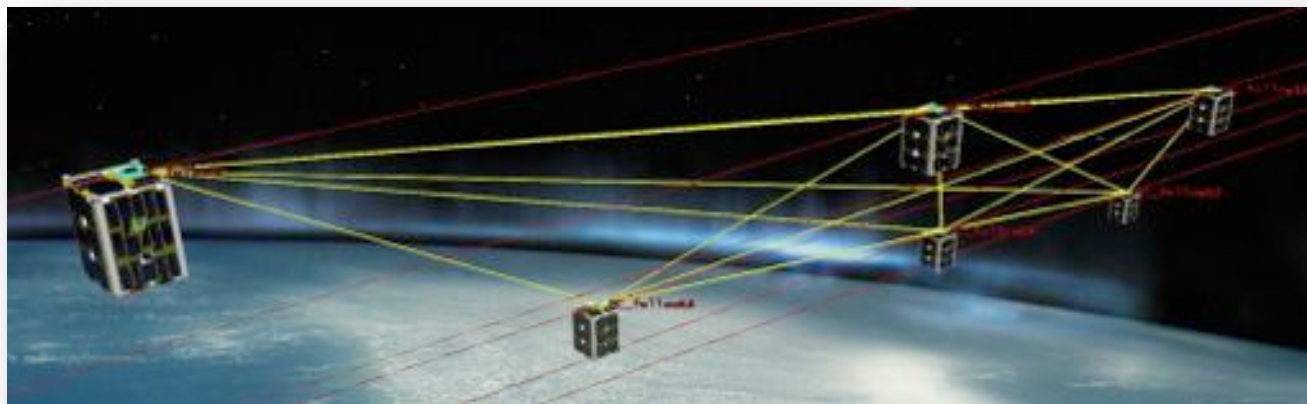


## **NODeS: ISS Nanosat Swarm demonstrator**

- 2 EDSN Nanosats with Advanced Software deploying off of ISS



# EDSN: A Cubesat Swarm



## Small Spacecraft Technology Demonstration:

- **Novel intra-swarm communications**

The first true Swarm in space. Configured to allow spacecraft to talk to each other and share data, while taking geographically dispersed payload measurements  
1 spacecraft talks to Ground for the whole Swarm.

- **Multi-point space physics (radiometers)**

**Early 2015 Launch**

- NASA Ames – PM and S/C bus
- Montana State University – Instrument
- Santa Clara University – Ground Station

EDSN spacecraft is a 8x 1.5U nanosat technology mission from NASA's Space Technology org



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NASA Ames KIMM Presentation

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# 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. S. Korea
13. Sweden
14. Spain
15. Trinidad & Tobago
16. UK

**NASA Ames enjoys partnering with Other countries**





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# Summary

- NASA Ames is one of the oldest NASA Centers
- NASA Ames is one of the most innovative NASA Centers
- NASA Ames partners with International organizations and Space Agencies on Small satellite technologies



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# Questions?

