NASA Space Technology Mission Directorate

Small Spacecraft Technology

Andrew Petro
Program Executive – NASA Headquarters

John Allmen
Program Manager (Acting) – Ames Research Center

Greg Dorais
Program Technologist - Ames Research Center

Smallsat Conference – Logan, UT August 3, 2014

NASA Townhall Meeting
10:00 – 11:30 AM

- **NASA Small Spacecraft Technology Program** (10:00 AM)
  Andrew Petro - STMD
- **Science Opportunities for Smallsats** (10:30 AM)
  David Klumpar - SMD
- **Smallsats and Science Missions Study & Small Launcher Initiative**
  Mike Seablom and Steve Volz – SMD (10:35 AM)
- **New Centennial Challenge for Cubesats** (10:40 AM)
  Eric Eberly - STMD
- **Cubesat Launch Initiative – New Solicitation** (10:45)
  Jason Crusan – HEOMD
- **Overall Q&A and Dialog** (10:50 AM)

Small Spacecraft Technology Program

Small, Affordable, Rapid, & Transformative

Focused Technology Development Projects in:

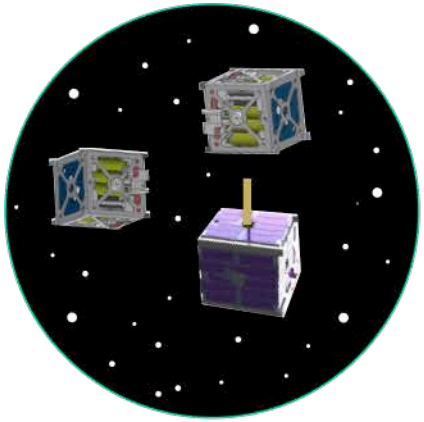
- Communications
- Avionics
- Propulsion
- Power
- Instruments
- Manufacturing
- Small Earth Return Vehicle

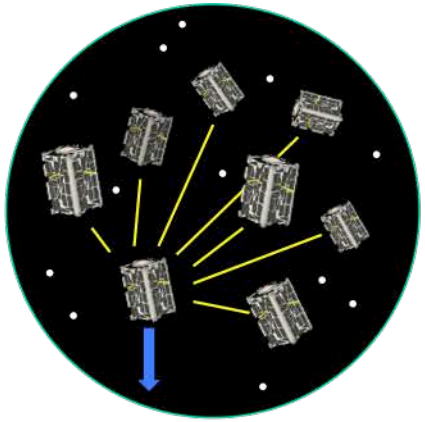
Flight Demonstration Projects in:

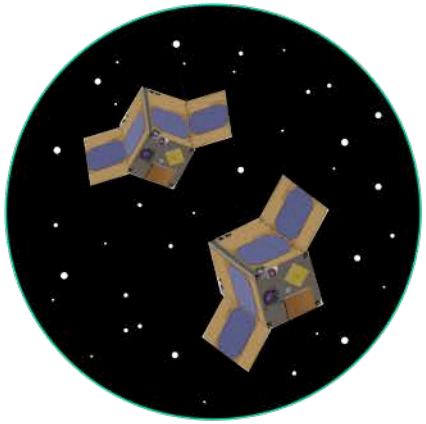
- Radio and Laser Communications
- Formation Flight and Docking
- Low cost satellite buses
- Smallsat swarms for space science missions

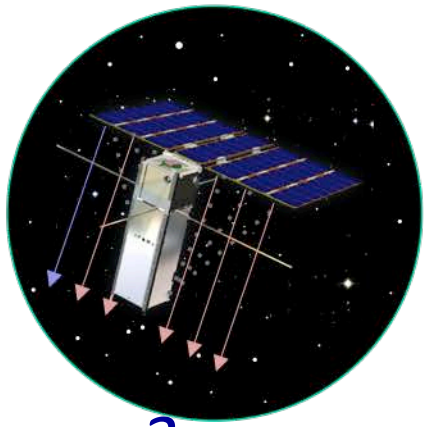
Implemented through:

- Directed NASA projects
- Contracts with private industry
- University-NASA partnerships
- Collaboration with SBIR and other programs



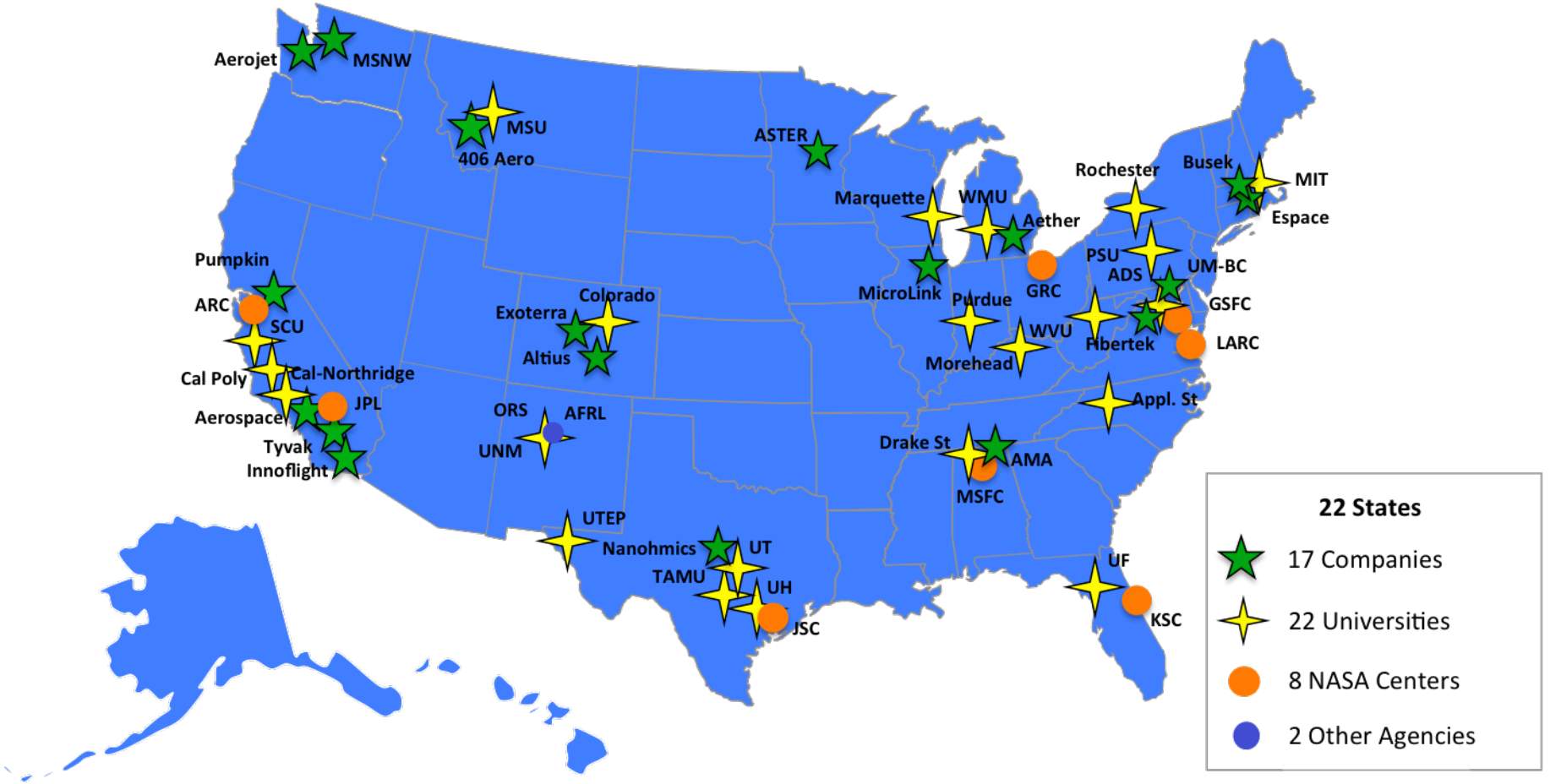






Small Spacecraft Technology Program

Nationwide Participants and Partners



www.nasa.gov/smallsats

Small Spacecraft Technology

Small Spacecraft Technology - State of the Art Report

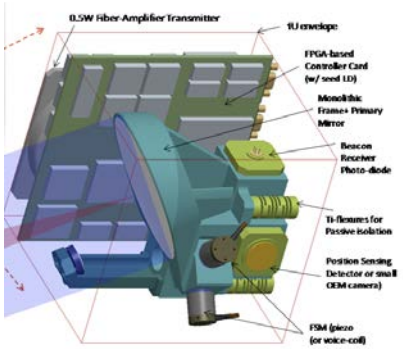
- Compiled for the SST Program by Ames Engineering with inputs from the larger community
- Completed in October 2013
- Annual update intended, broad participation desired
- Link to report on STMD/SSTP website:
  www.nasa.gov/smallsats

SBIR Select Topic – Deep Space Cubesat Technology

- New topic in current solicitation
- Large Phase I proposal response from small businesses

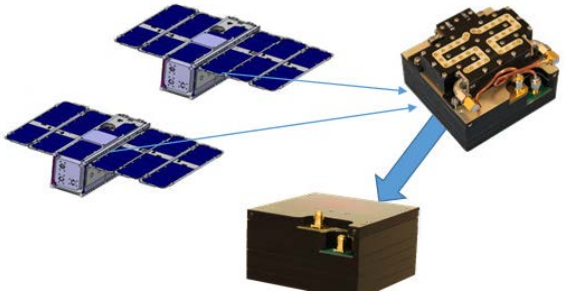
Anticipate future SBIR topics related to Small Spacecraft

SBIR – Deep Space Cubesat Technology
2014 Phase 1 Projects

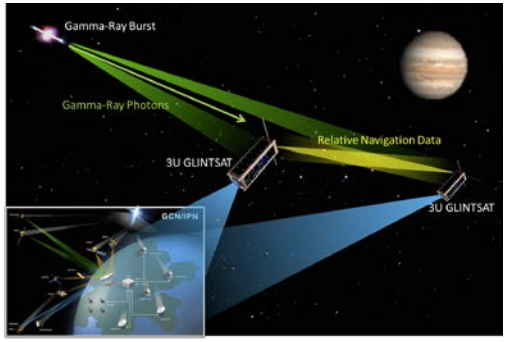


COMMUNICATIONS AND NAVIGATION

1U Cubesat Lasercom Terminal for Deep Space Communication
Fibertek, Inc. - Herndon, VA



Deep Space Cubesat Regenerative Ranging Transponder
Innoflight, Inc. - San Diego, CA

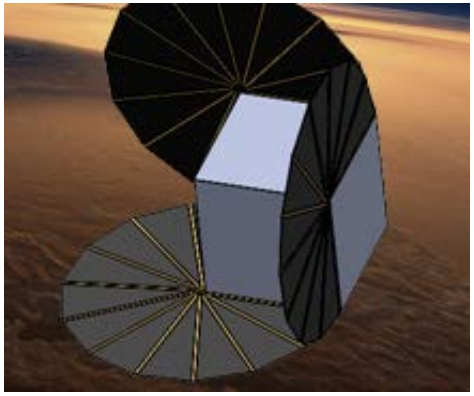


Deep Space Cubesat Gamma-ray Navigation Technology Demonstration
ASTER Labs, Inc. - Shoreview, MN

SBIR – Deep Space Cubesat Technology
2014 Phase 1 Projects

POWER GENERATION

High Power Betavoltaic Technology
MicroLink Devices, Inc. - Niles, IL

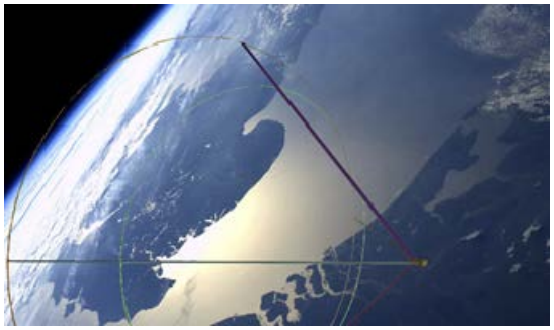


Deployable Solar Energy Generators for Deep Space Cubesats
Nanohmics, Inc. - Austin, TX

SBIR – Deep Space Cubesat Technology
2014 Phase 1 Projects

PROPULSION

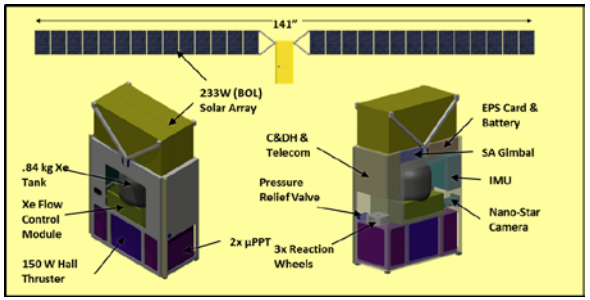
Cubesat Ambipolar Thruster for LEO and Deep Space Missions
Aether Industries, LLC - Ann Arbor, MI



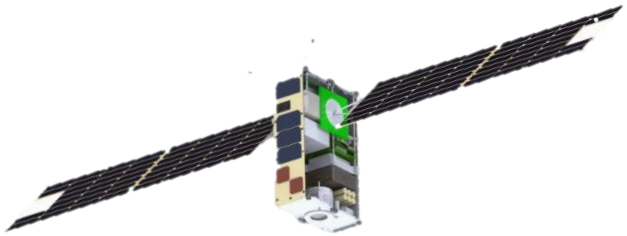
Multi-Purpose Interplanetary Deployable Aerocapture System
Altius Space Machines, Inc. - Louisville, CO

SBIR – Deep Space Cubesat Technology
2014 Phase 1 Projects

DEEP SPACE BUS



Solar Electric Propulsion Cubesat Bus for Deep Space Missions
ExoTerra Resource LLC - Lone Tree, CO



LunarCube for Deep Space Missions
Busek Company Inc. - Natick, MA

Smallsat Technology Partnerships

Cooperative agreements with US colleges and universities to develop and/or demonstrate new technologies and capabilities for small spacecraft in collaboration with NASA.

One to two year projects
Up to $100,000 per year, per university (up to $150,000 if more than one university)
Up to 1.0 FTE in NASA labor per year, per project

13 Projects selected on August 8, 2013
17 universities
7 NASA Center partners

Plan solicitations in two-year cycles
Next solicitation expected in early 2015
for 2016-17 projects

Smallsat Technology Partnerships

2013 Awards

COMMUNICATIONS

High Rate Cubesat X-band/S-band Communication System
University Of Colorado - Goddard Space Flight Center, Marshall Space Flight Center

Space Optical Communications Using Laser Beam Amplification
University Of Rochester - Ames Research Center

Development of Novel Integrated Antennas for Cubesats
University Of Houston - Johnson Space Center

GUIDANCE, NAVIGATION & CONTROL

Smallsat Precision Navigation With Low-Cost MEMS IMU Swarms
West Virginia University & Marquette University - Johnson Space Center

Cubesat Autonomous Rendezvous & Docking Software
University Of Texas - Johnson Space Center

Radiation Tolerant, FPGA-based Smallsat Computer System
Montana State University - Goddard Space Flight Center, Marshall Space Flight Center

An Integrated Precision Attitude Determination and Control System
University Of Florida - Langley Research Center

PROPULSION

Propulsion System and Orbit Maneuver Integration in Cubesats
Western Michigan University - Jet Propulsion Lab

Film-Evaporation MEMS Tunable Array for Picosat Propulsion and Thermal Control
Purdue University - Goddard Space Flight Center

POWER

Smallsat Low Mass, Extreme Low Temperature Energy Storage
California State University - Northridge - Jet Propulsion Lab

SCIENCE INSTRUMENT CAPABILITIES

Compressive Sensing for Advanced Imaging and Navigation
Texas A&M University - Langley Research Center

Mini Fourier-Transform Spectrometer for Cubesat-Based Remote Sensing
Appalachian State University & University of Maryland - Baltimore County - Goddard Space Flight Center

ADVANCED MANUFACTURING

Printing the Complete Cubesat
University Of New Mexico, University of Texas - El Paso, & Drake State Technical College - Glenn Research Center

Technology Development Projects
2013 NRA Awards

SMALL SPACECRAFT PROPULSION

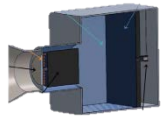
MPS-120 Cubesat High-impulse Adaptable Modular Propulsion System
PI: Christian Carpenter, Aerojet General Corporation, Redmond, WA

Advanced Hybrid Rocket Motor for Cubesats
PI: John DeSain, The Aerospace Corporation, El Segundo, CA
Partner: Pennsylvania State University, University Park, PA

1U Cubesat Green Propulsion System with Post-Launch Pressurization
PI: Michael Tsay, Busek Company. Inc., Natick, MA
Partner: NASA Goddard Space Flight Center

Iodine RF Ion Thruster Development
PI: Kurt Hohman, Busek Company. Inc., Natick, MA

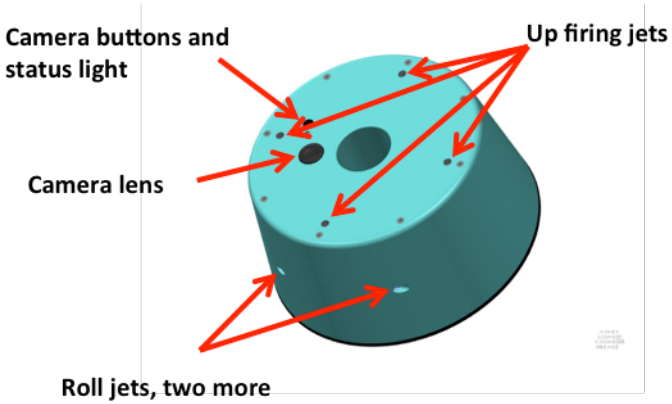
Inductively Coupled Electromagnetic Thruster System Development for Small Spacecraft Propulsion
PI: John Slough, MSNW LLC, Redmond, WA

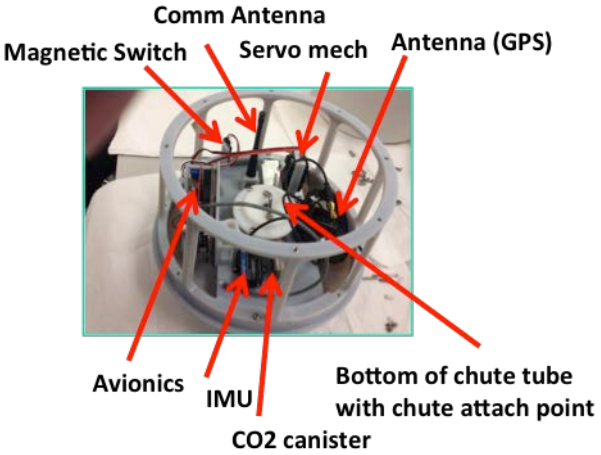


Technology Development Projects
2013 NRA Awards

SMALL EARTH RETURN VEHICLES

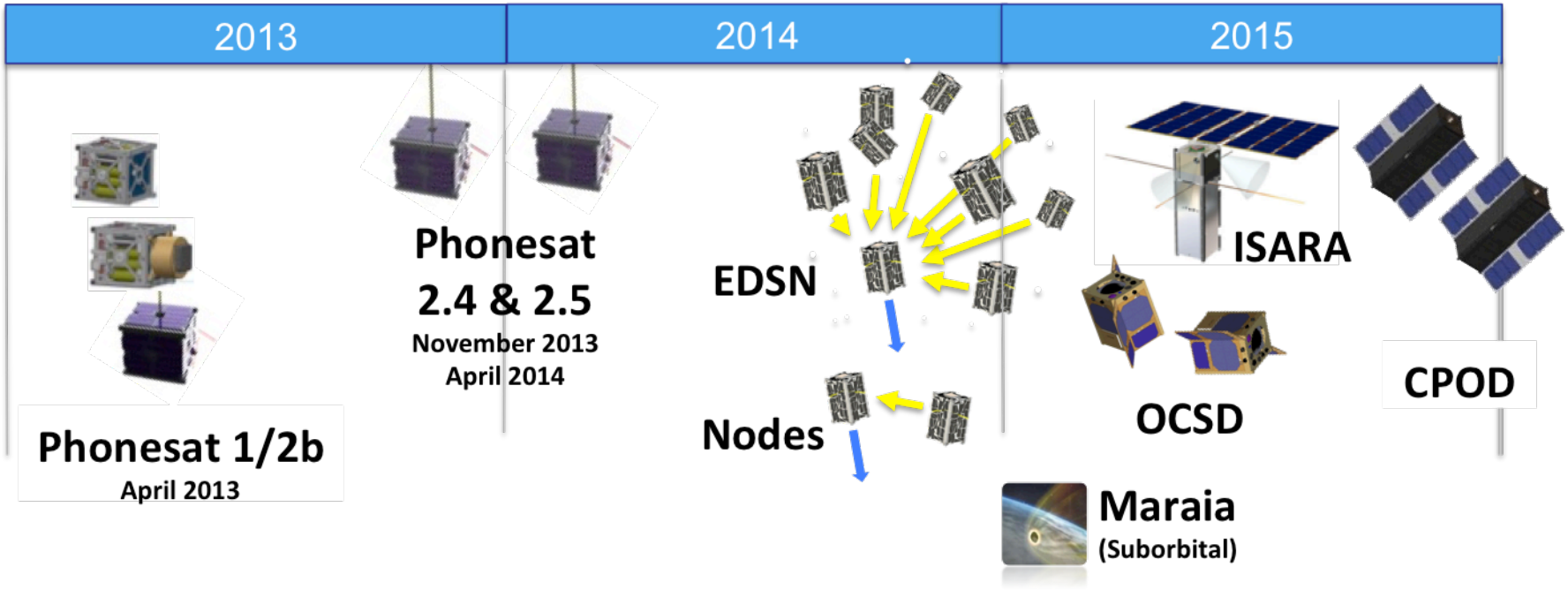
Technology Development for the Maraia Earth Return Capsule
PI: Alan Strahan, NASA Johnson Space Center
Partners: NASA KSC, Up Aerospace





Up Aerospace Launch Facility at Spaceport America, New Mexico

Small Spacecraft Technology Program
Projects: 2013-2015



Smallsat Technology Partnerships
13 projects with NASA-University collaboration

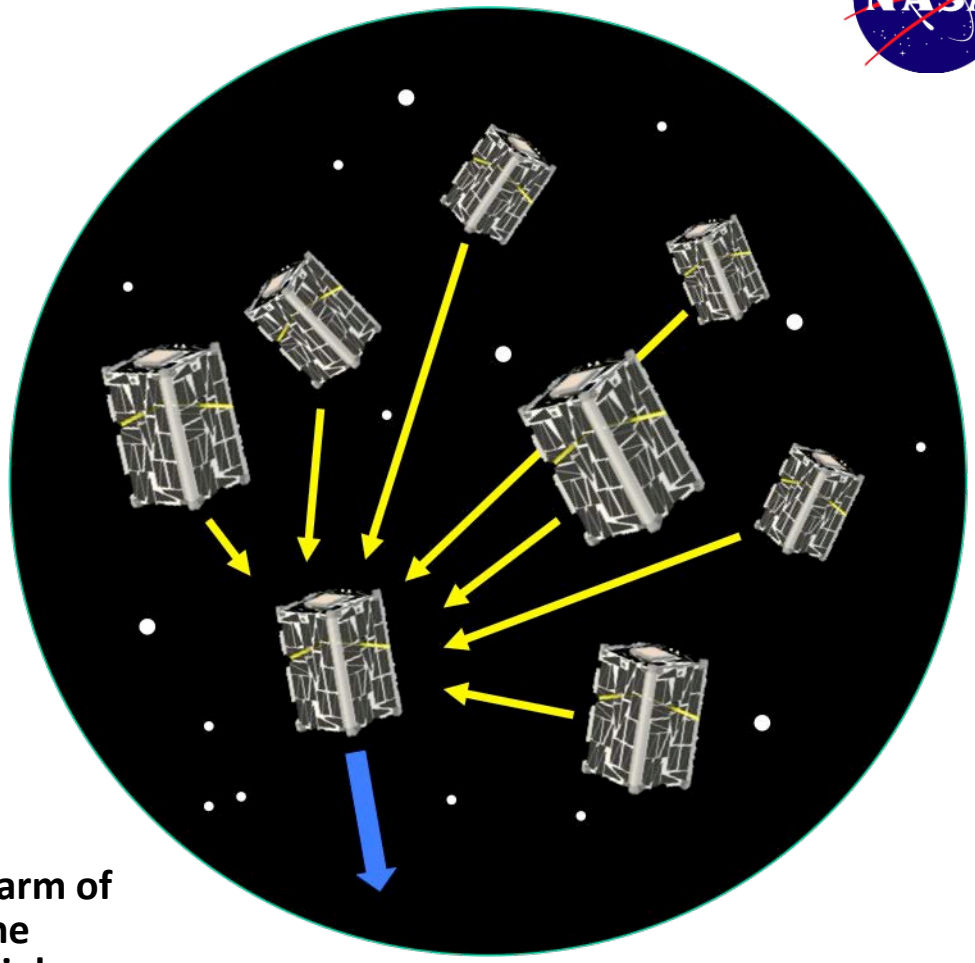
5 Propulsion Technology Projects

SBIR - Deep Space Cubesats

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

EDSN

Edison Demonstration of Smallsat Networks



Ames Engineering Directorate, with support from MSFC

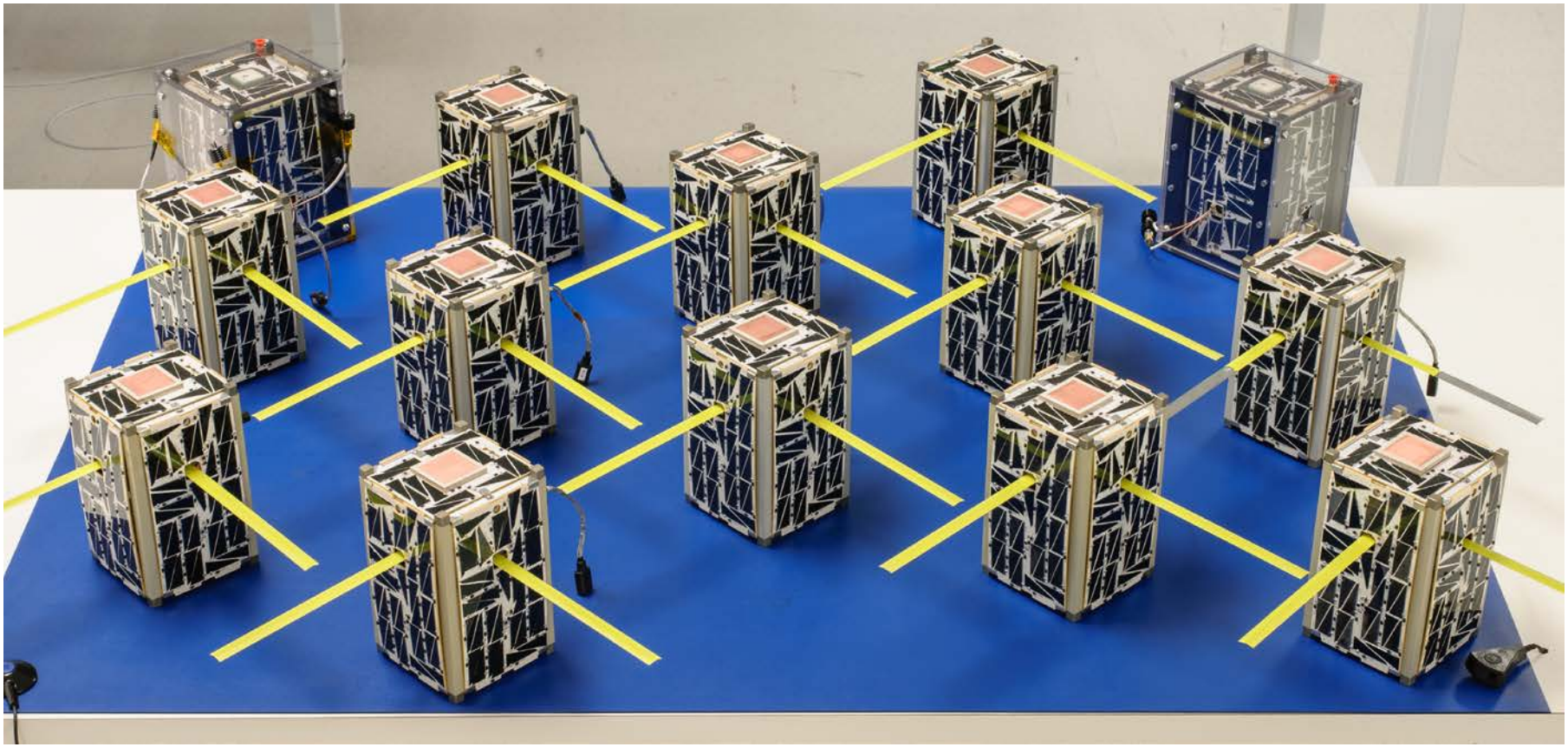
Partners:

Montana State University – Payload
Santa Clara University – Ground Station

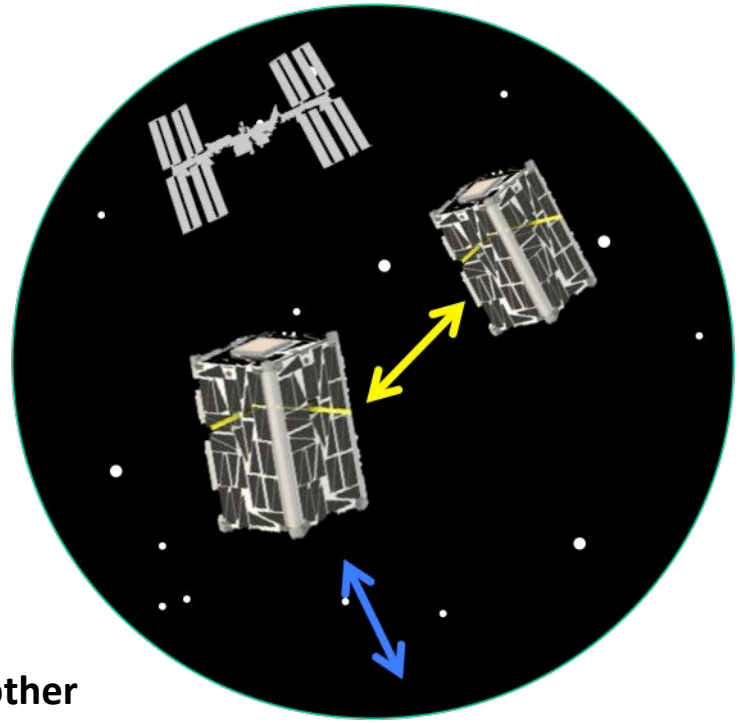
Objective: The EDSN Mission will launch a swarm of 8 low-cost small satellites and demonstrate the operation of an intra-swarm communication link and multi-point sensing measurement.

Satellite bus based on Phonesat heritage.

EDSN Spacecraft
8 Flight Units, 2 Spares, 4 Engineering Development Units



Nodes



Companion mission to EDSN, using the same satellite design with additional new software capabilities

Led by: NASA Ames Research Center
Partners: Montana State University
Santa Clara University

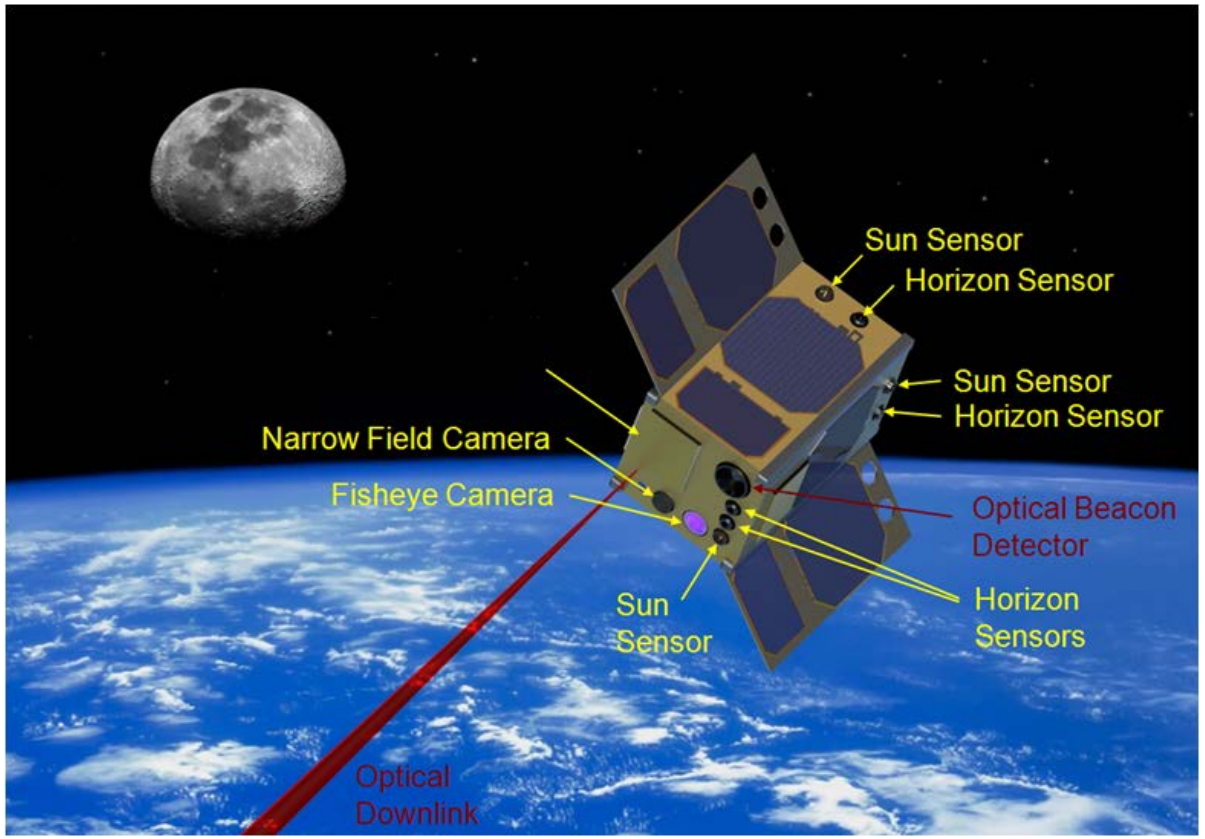
Objective:

- **Each 1.5U cubesat can collect and relay data to the other**
- **Downlink role is negotiated between the satellites**
- **Two-way communication for commands and updates from the ground**
- **Deployed into orbit from ISS**

OCSD Optical Communication and Sensor Demonstration

The Aerospace Corporation

Objective: Demonstrate ranging, optical downlink, cold gas propulsion, and cross-track motion sensing technologies on a cubesat proximity operations mission with two 1.5 U cubesats.



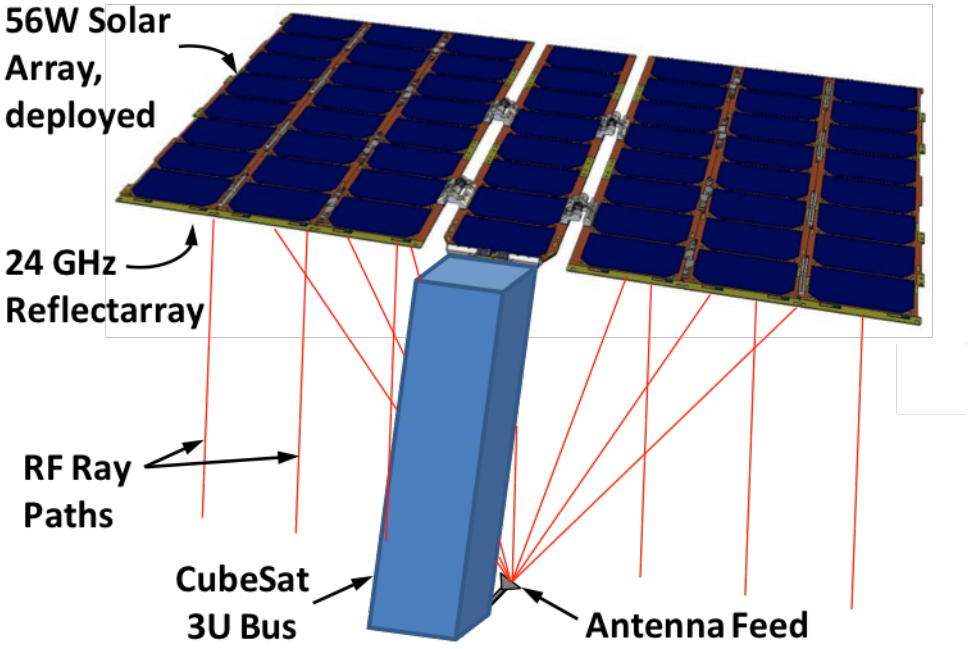
ISARA

Integrated Solar Array and Reflectarray Antenna

Jet Propulsion Laboratory

Partners:
Aerospace Corporation
- Cubesat bus and operations
Pumpkin, Inc. - Solar Panel

Objective: ISARA will demonstrate a high gain antenna (HGA) integrated into a commercially available solar array that enables 100 Mbps Ka-band cubesat communications capability at very low cost and minimal payload mass and volume impact.



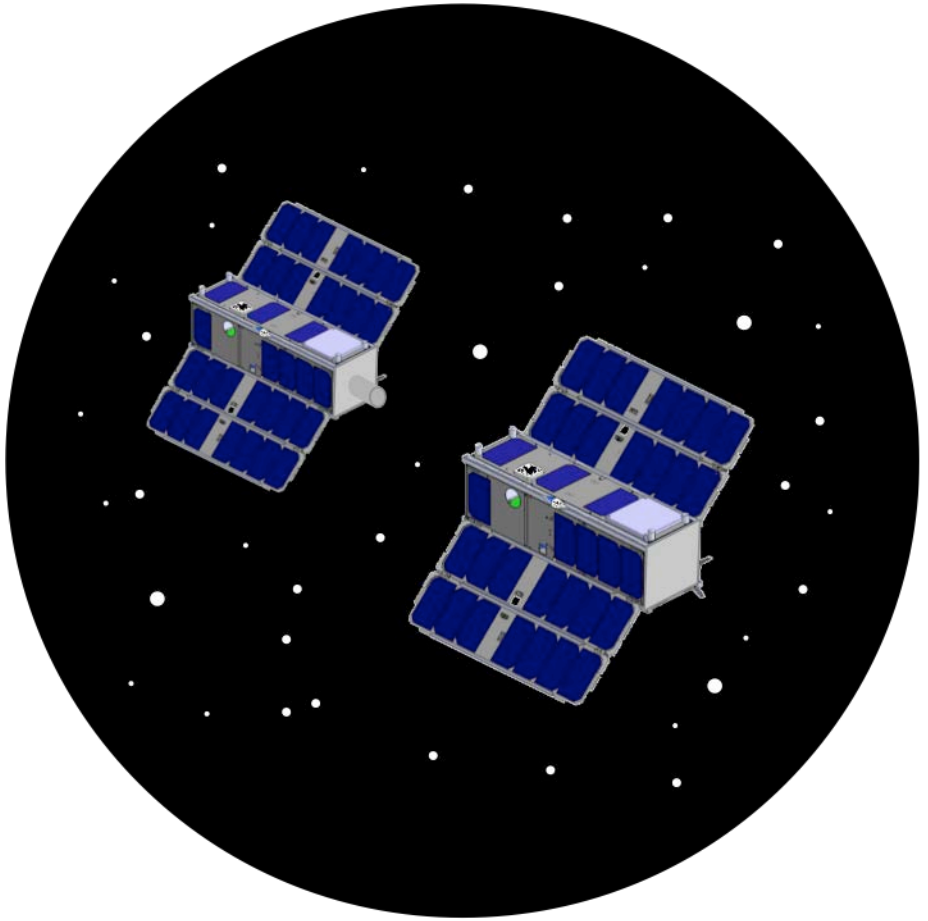
CPOD

Cubesat Proximity Operations Demonstration

Tyvak Nano-Satellite Systems LLC

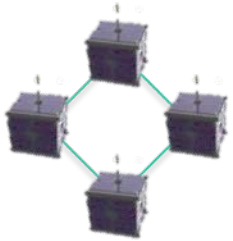
Partners:
406 Aerospace
Applied Defense Solutions
Analytical Graphics Inc.
California Polytechnic State University
Government Partner: AFRL

Objective: Demonstrate close proximity operations and docking of two 3U cubesat spacecraft in LEO.



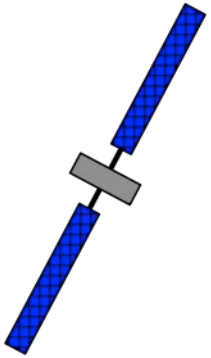
Possible Future Directions

- Nanosat Science & Communications Constellations

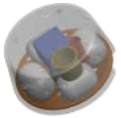


- Inspector/Explorer Nanobots

- Small Solar Electric Propulsion Buses



- Small Entry Vehicles and Testbeds

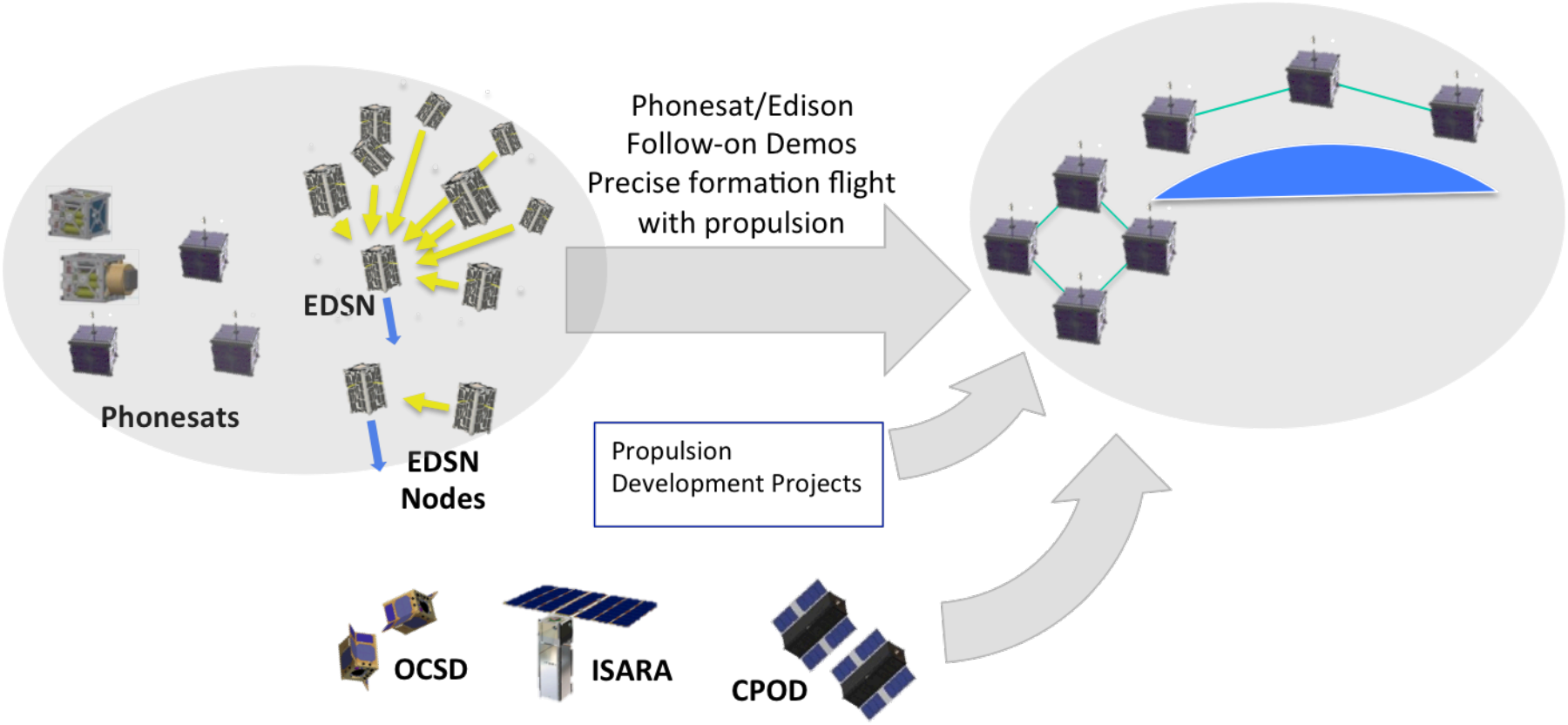


- Low-Cost Deorbit

- Nano-launcher Capability

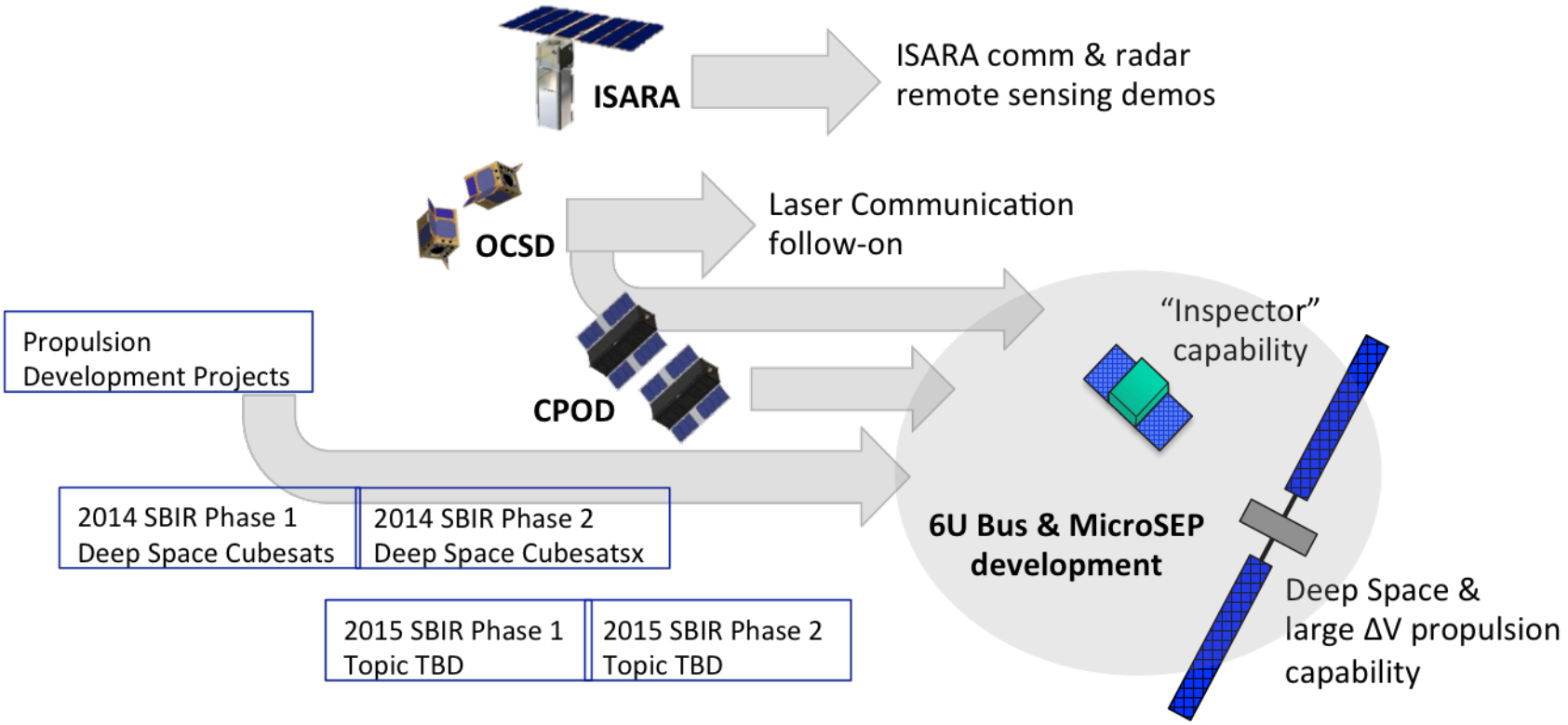
Possible Future Directions

- **Nanosat Science and Communications Constellations**



Possible Future Directions

- **Inspector/Explorer Nanobots**
- **Small Solar Electric Propulsion Buses**



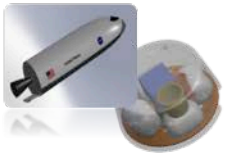
Possible Future Directions

- **Small Entry Vehicles and Testbeds**

Maraia suborbital test

Suborbital and orbital demos

Earth Return Payload & EDL testbed



- **Low-Cost Deorbit**

Drag devices, tethers, and simple propulsion systems

Small Spacecraft Technology

- *Please visit SSTP Exhibit*
- *Talk with SST Program Staff*
- *Visit our website*

www.nasa.gov/smallsats