



**NASA Space Technology Mission Directorate**  
***Small Spacecraft Technology***

**Andrew Petro**  
***Program Executive – NASA Headquarters***

**September 10, 2014**

# Small Spacecraft Technology Program



Small, Affordable, Rapid, & Transformative

## Objectives:

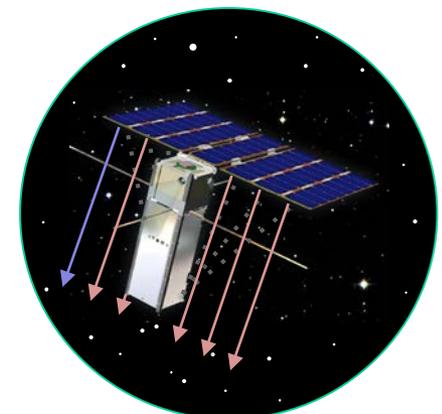
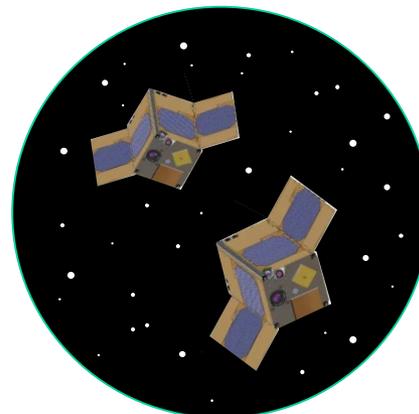
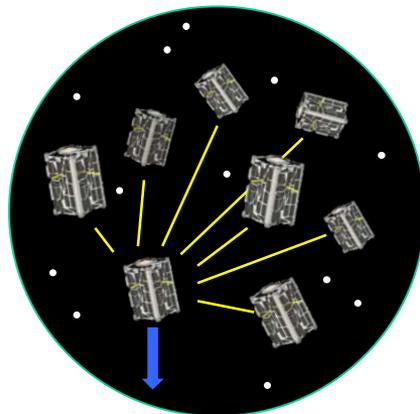
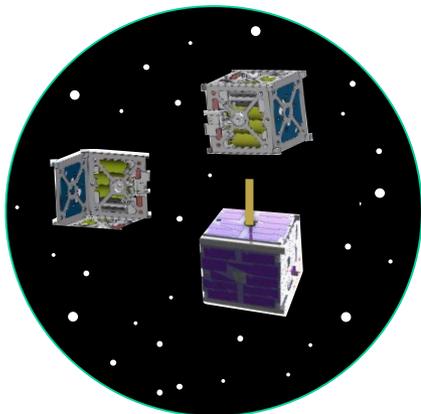
- To develop and demonstrate new small spacecraft technologies and capabilities for NASA's missions in science, exploration and space operations
- To promote the small spacecraft approach as a paradigm shift for NASA and the larger space community.

## Flight Demonstration Projects in:

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

## Implemented through:

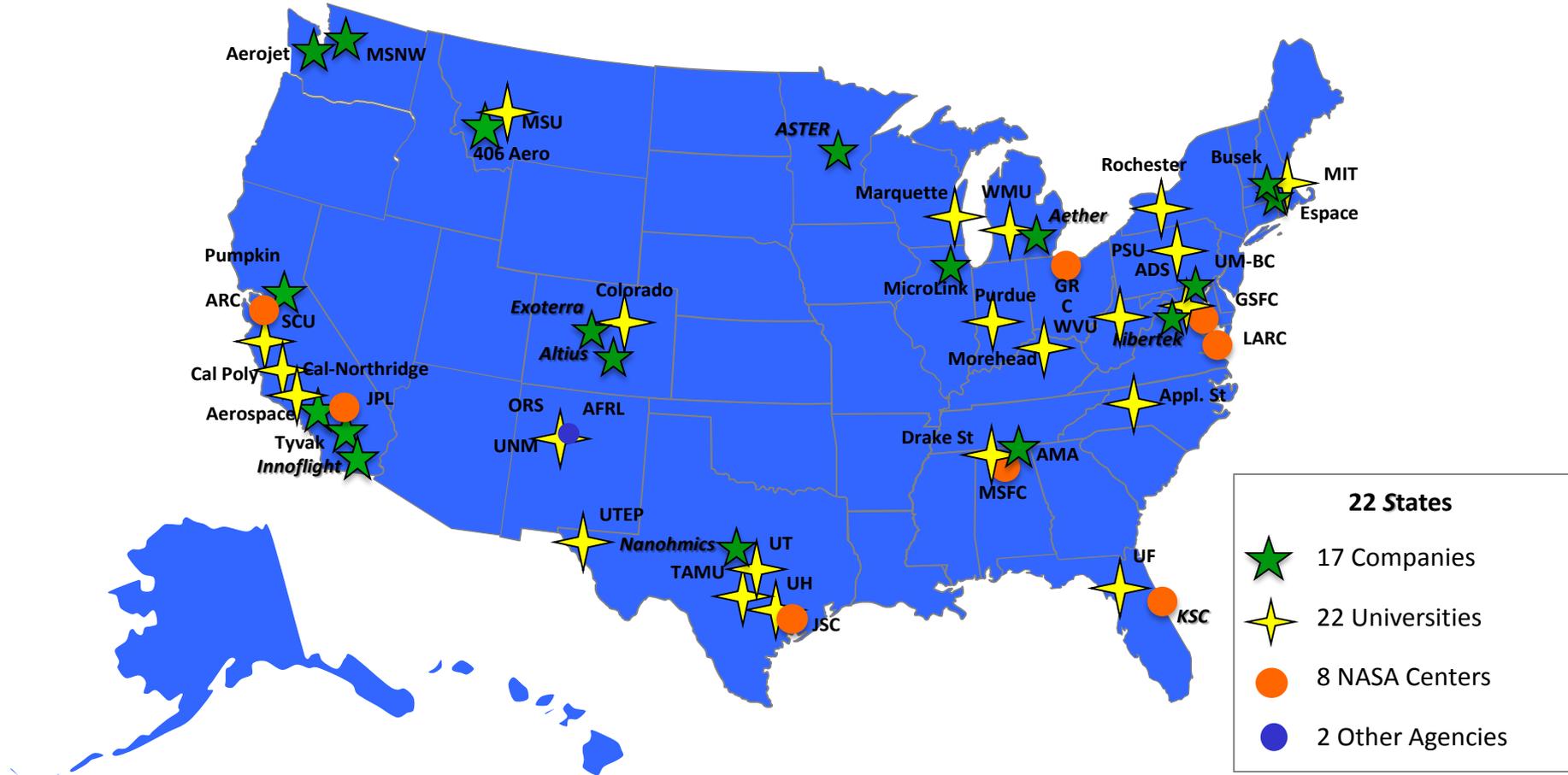
Directed NASA projects  
Contracts with private industry  
University-NASA partnerships  
Collaboration with SBIR and other programs



# Small Spacecraft Technology Program



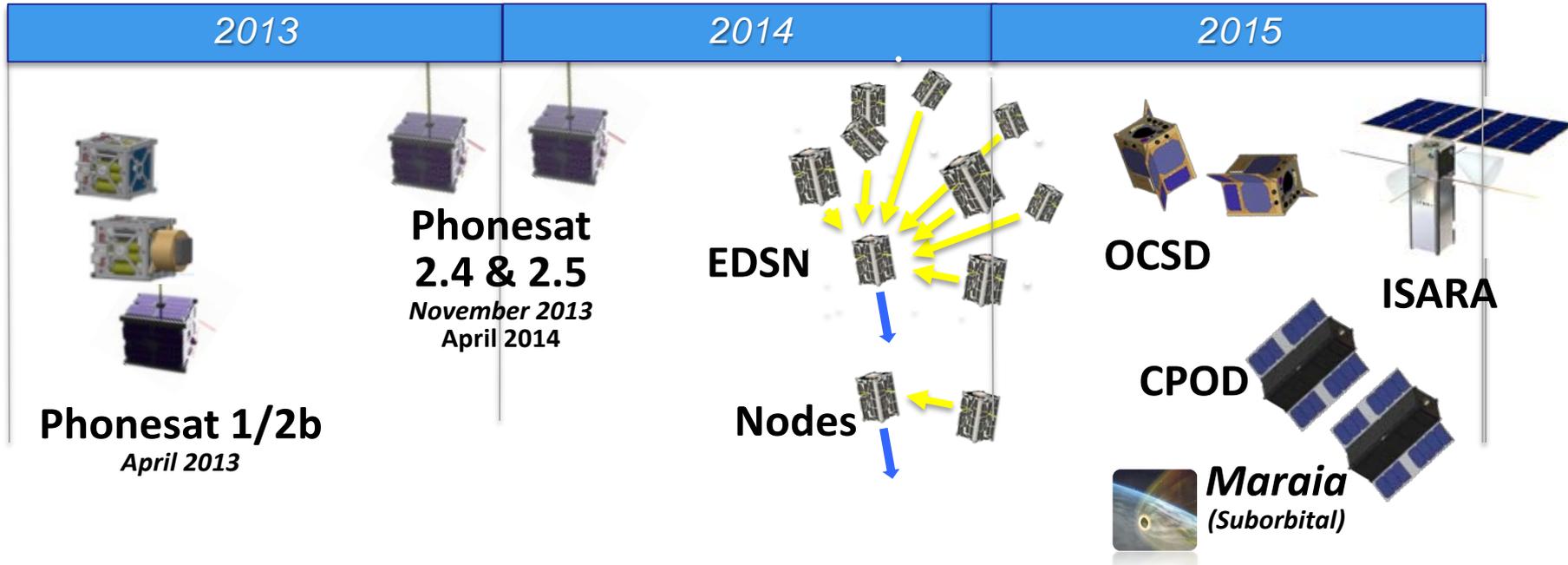
## Nationwide Participants and Partners



[www.nasa.gov/smallsats](http://www.nasa.gov/smallsats)

# 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

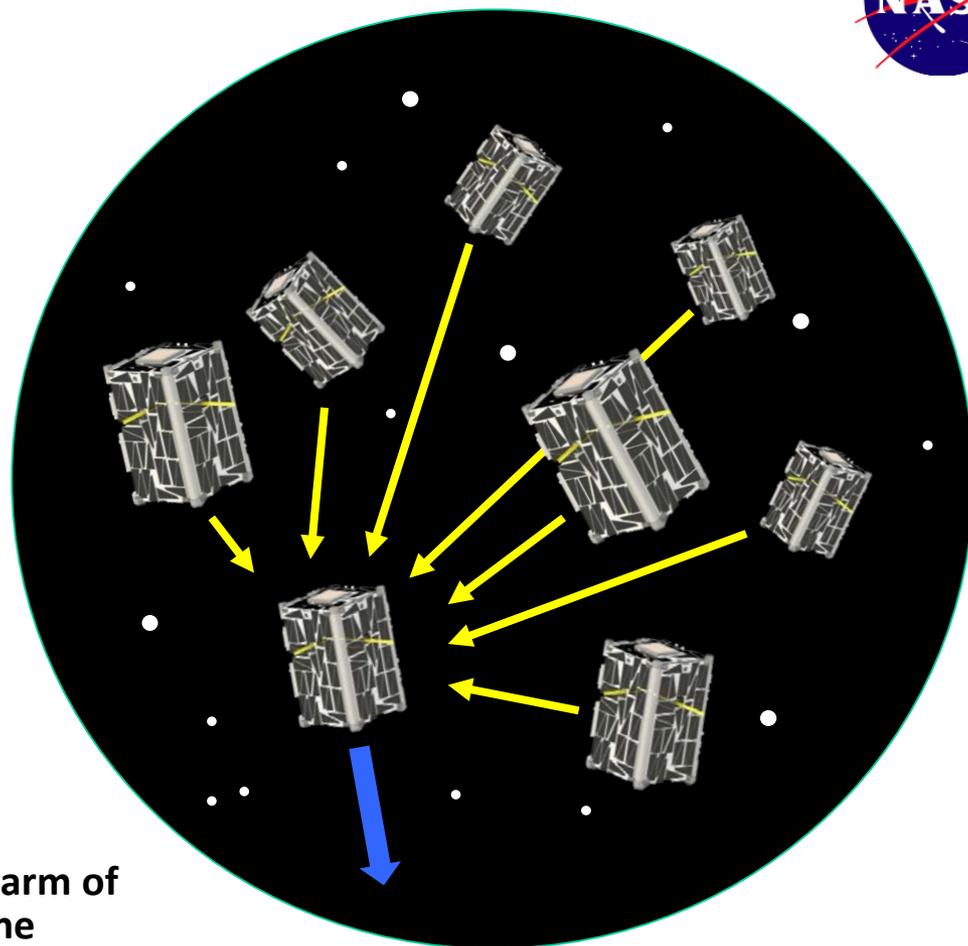
Ames Engineering Directorate,  
with support from MSFC

**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.

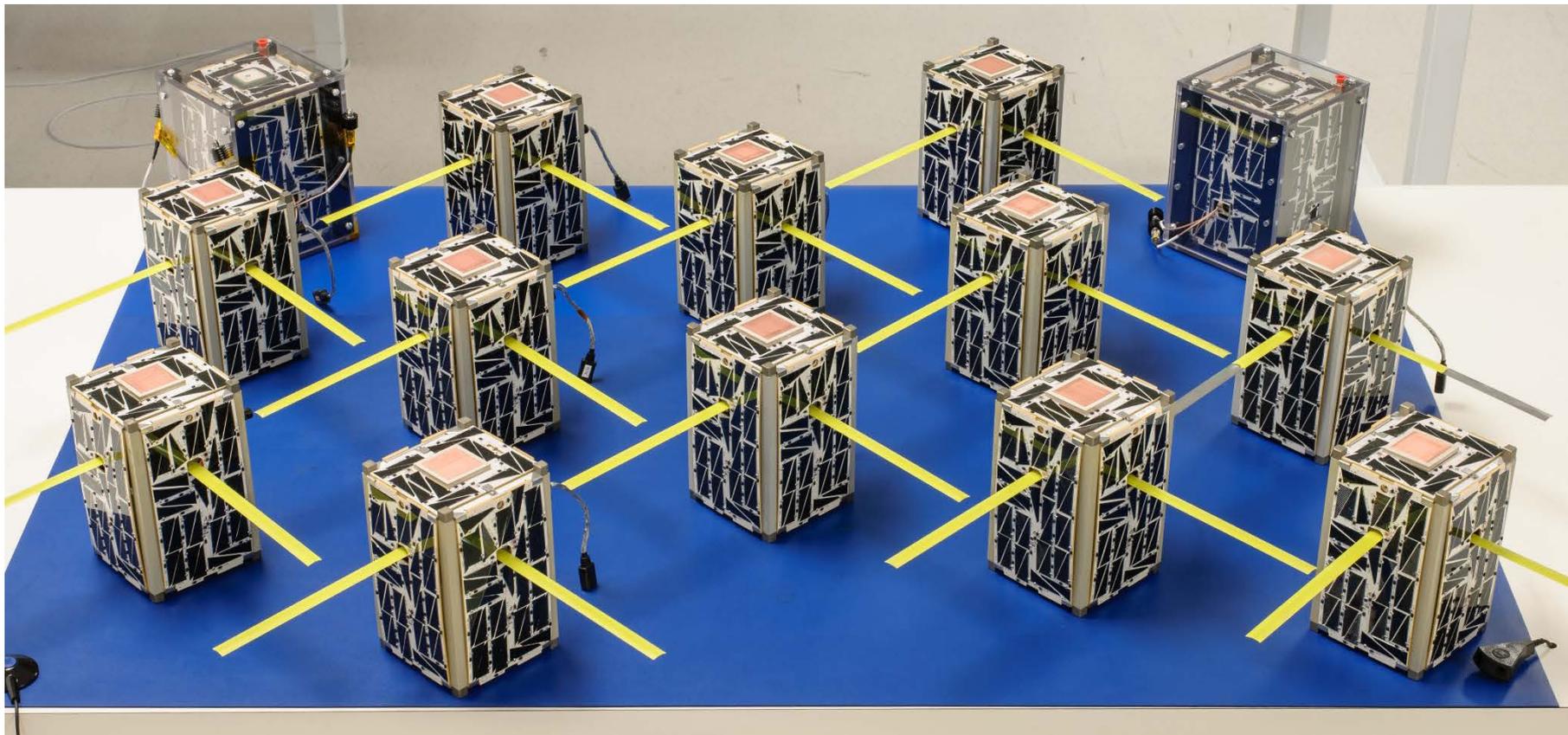
Satellite bus based on Phonesat heritage.





# EDSN Spacecraft

## 8 Flight Units, 2 Spares, 4 Engineering Development Units





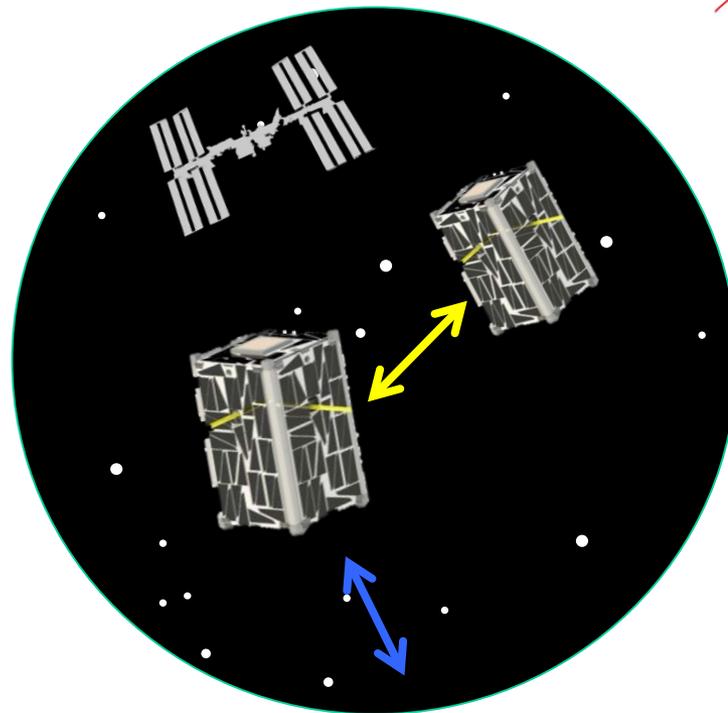
# Nodes

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

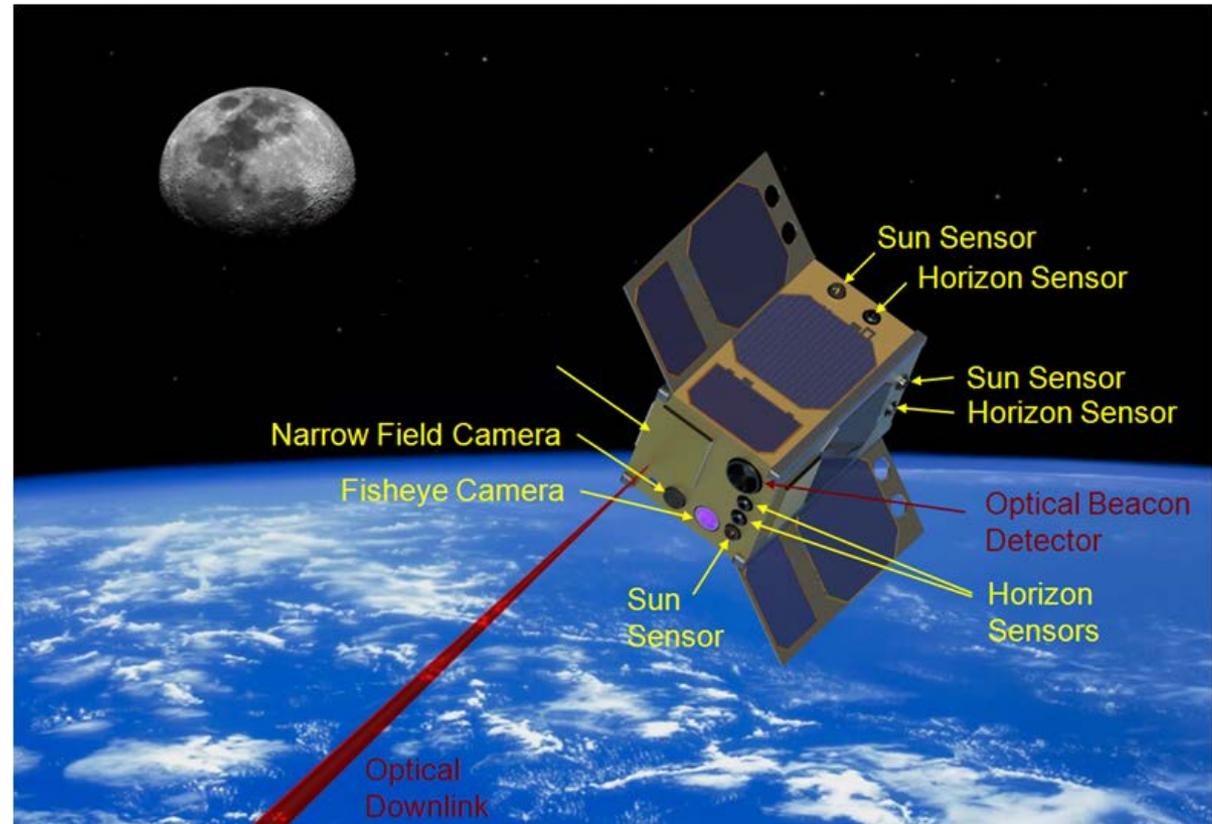


# OCSD Optical Communication and Sensor Demonstration



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

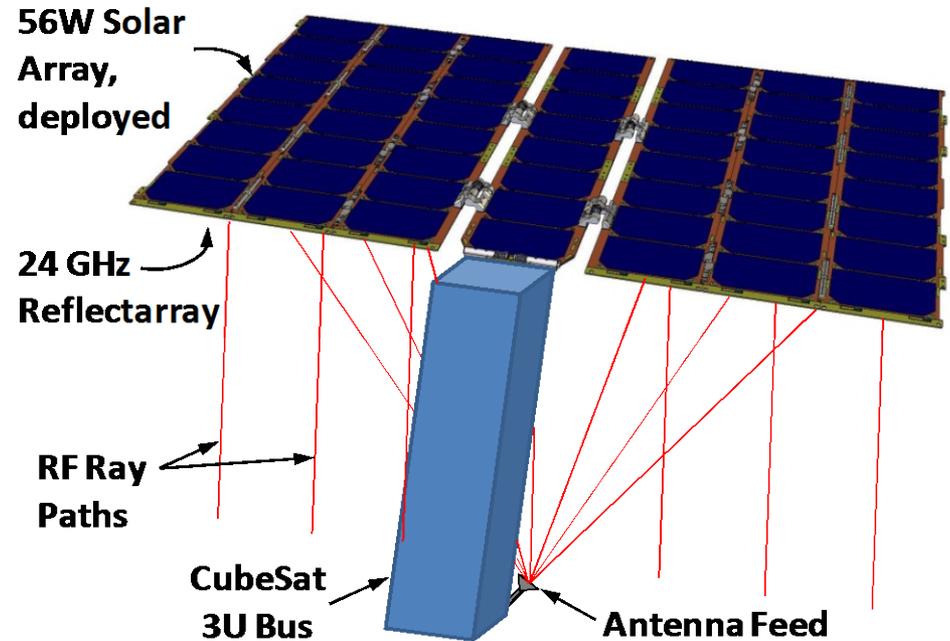
Partners:

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

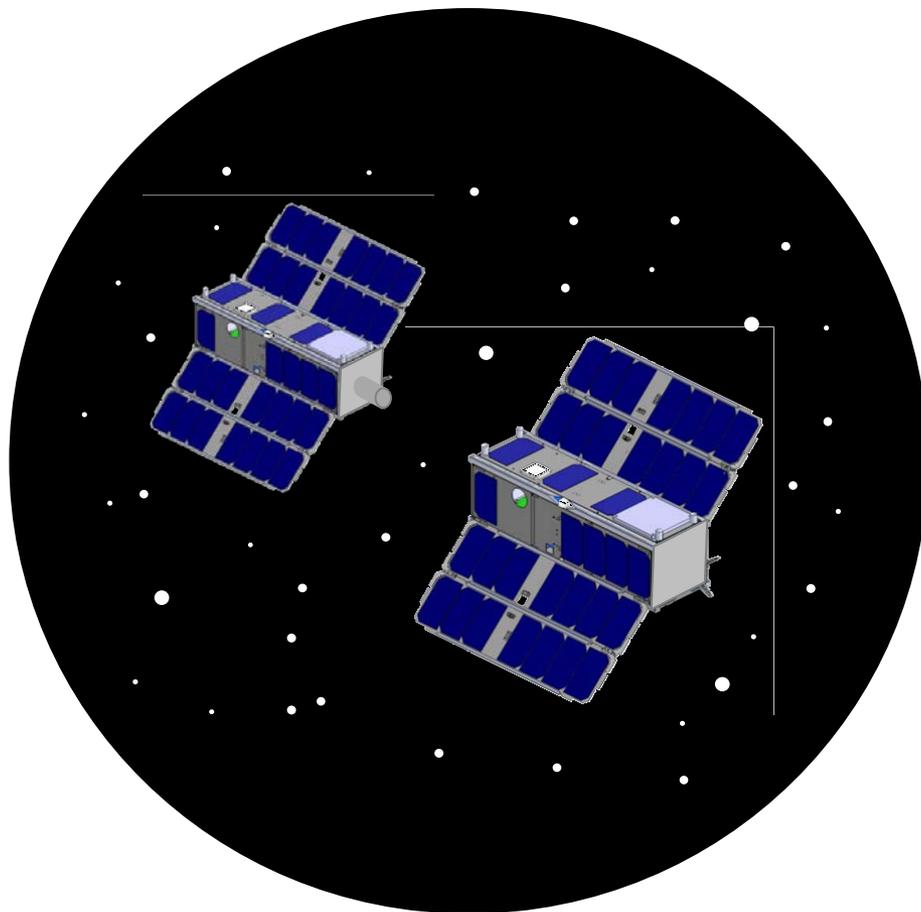
Applied Defense Solutions

Analytical Graphics Inc.

California Polytechnic State University

Government Partner: AFRL

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





# 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*

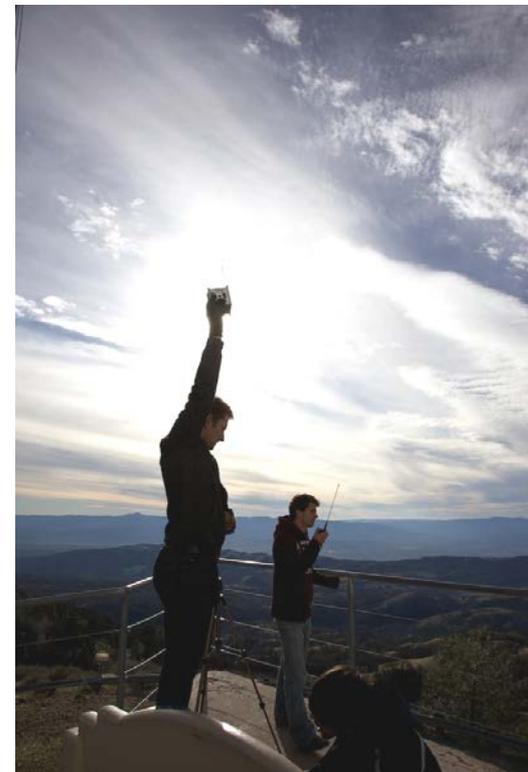
*17 universities*

*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**

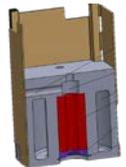
PI: Christian Carpenter, Aerojet General Corporation, Redmond, WA



#### **Advanced Hybrid Rocket Motor for Cubesats**

PI: John DeSain, The Aerospace Corporation, El Segundo, CA

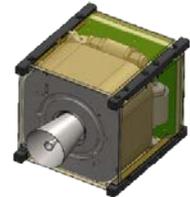
Partner: Pennsylvania State University, University Park, PA



#### **1U Cubesat Green Propulsion System with Post-Launch Pressurization**

PI: Michael Tsay, Busek Company. Inc., Natick, MA

Partner: NASA Goddard Space Flight Center



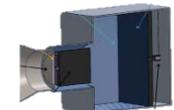
#### **Iodine RF Ion Thruster Development**

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

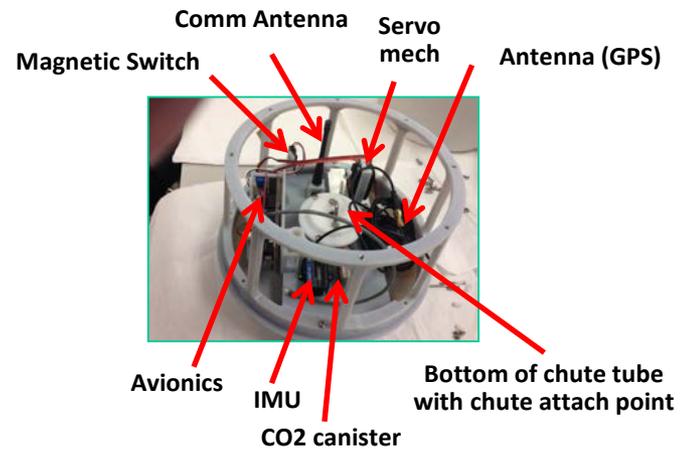
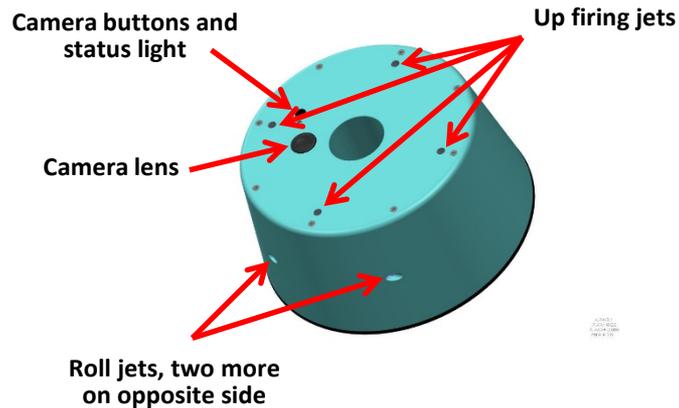


### SMALL EARTH RETURN VEHICLES

#### Technology Development for the Maraia Earth Return Capsule

PI: Alan Strahan, NASA Johnson Space Center

Partners: NASA KSC, Up Aerospace

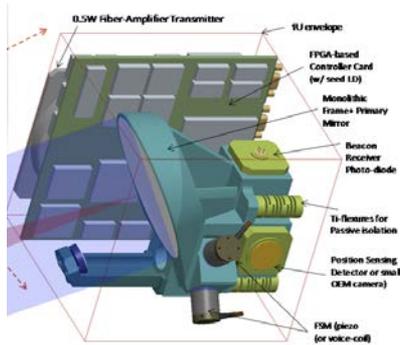


Up Aerospace Launch Facility  
at Spaceport America, New Mexico



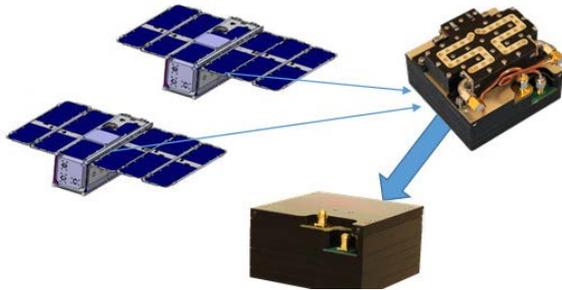
# SBIR – Deep Space Cubesat Technology

## 2014 Phase 1 Projects

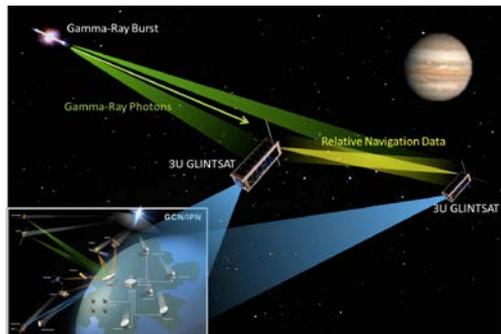


### COMMUNICATIONS AND NAVIGATION

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

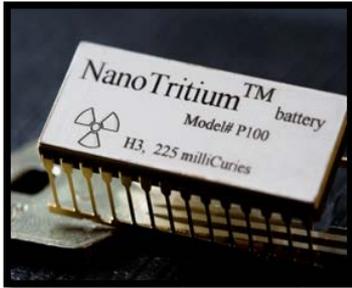


**Deep Space Cubesat Regenerative Ranging Transponder**  
Innoflight, Inc. - San Diego, CA



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

# SBIR – Deep Space Cubesat Technology 2014 Phase 1 Projects



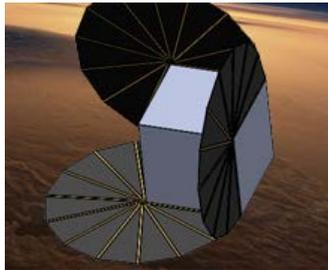
## POWER GENERATION

### High Power Betavoltaic Technology

MicroLink Devices, Inc. - Niles, IL

### Deployable Solar Energy Generators for Deep Space Cubesats

Nanohmics, Inc. - Austin, TX



## PROPULSION

### Multi-Purpose Interplanetary Deployable Aerocapture System

Altius Space Machines, Inc. - Louisville, CO

### Cubesat Ambipolar Thruster for LEO and Deep Space Missions

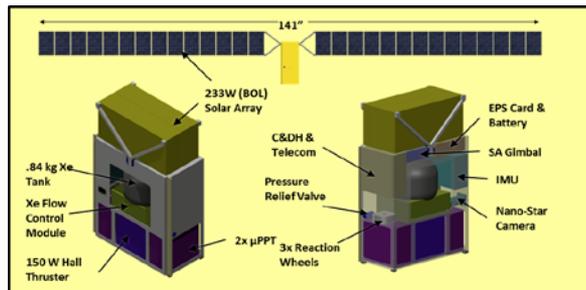
Aether Industries, LLC - Ann Arbor, MI



# SBIR – Deep Space Cubesat Technology 2014 Phase 1 Projects

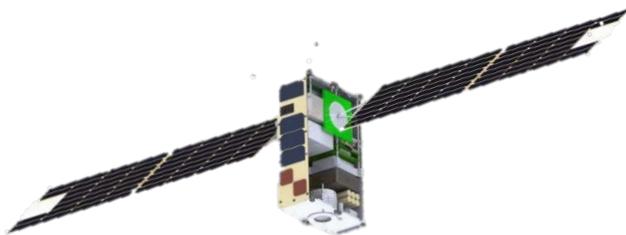


## DEEP SPACE BUS



## 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

# Small Spacecraft Technology



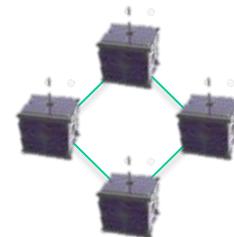
## Small Spacecraft Technology - State of the Art Report

- 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](http://www.nasa.gov/smallsats)

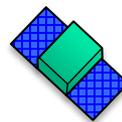


# Possible Future Directions

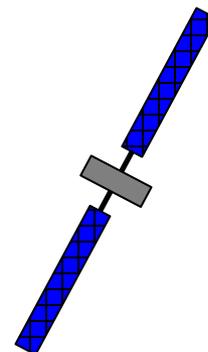
- **Nanosat Science & Communications Constellations**



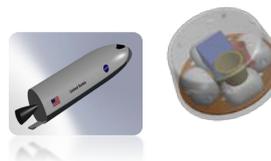
- **Inspector/Explorer Nanobots**



- **Small Solar Electric Propulsion Buses**



- **Small Entry Vehicles and Testbeds**

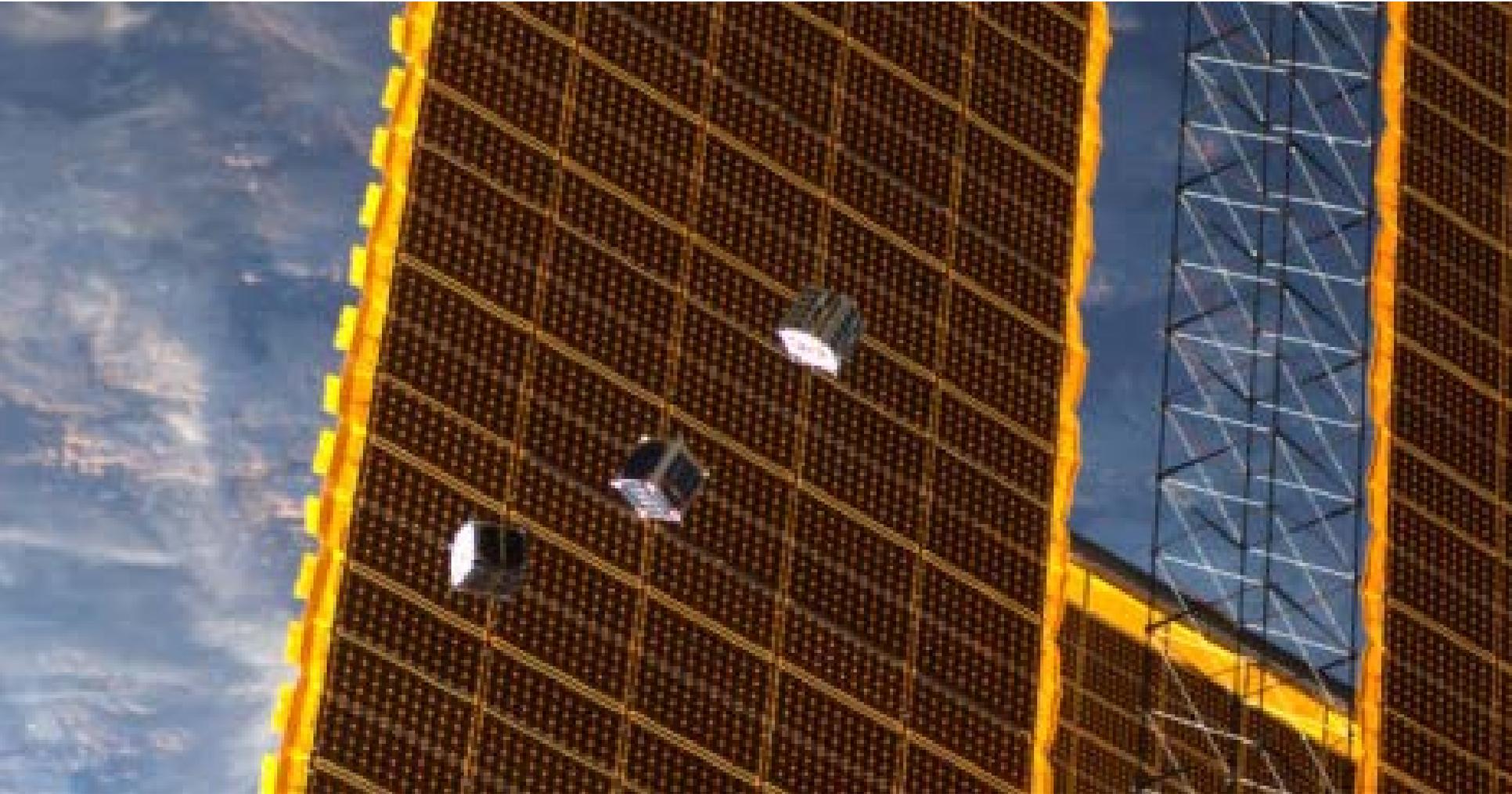


- **Low-Cost Deorbit**

- **Nano-launcher Capability**



# Small Spacecraft Technology



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