

# Pathfinder Technology Demonstrator

“Demonstrating Advanced Technologies for Advanced Missions”

4S Conference

May 1, 2018

*NASA Space Technology Mission Directorate*

*NASA Small Spacecraft Technology Program*

NASA Ames Research Center | NASA Glenn Research Center





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A revolutionary highly reflective coating could enable spacecraft to get closer to the sun than ever before. Find out more: [go.nasa.gov/2vMJJ35](http://go.nasa.gov/2vMJJ35)

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**Space Technology**

STMD rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships, expanding the boundaries of the aerospace enterprise.

**Tech Demonstration**

NASA's Daniel Herman Champions Solar Electric Propulsion Research

**Technology**

NASA Seeks Innovative Early Stage Technology Proposals

**Video Feature: Space Technology Investments Benefiting Life on Earth**

**Space Travel**

Demonstration Proves Nuclear Fission Can Provide Exploration Power

**NASA Armstrong**

Wi-Fi in Space, Spacecraft Technologies Launched on Blue Origin Rocket

**Earth**

Satellite Imagery Sheds Light on Agricultural Water Use

**Faces of Technology: Carrie Zumwalt**

- ## Programs
- Centennial Challenges
  - Center Innovation Funds
  - Emerging Space
  - Flight Opportunities
  - Game Changing Development (GCD)
  - NASA Innovative Advanced Concepts (NIAC)
  - NASA's iTech Initiative
  - Prizes and Challenges
  - Regional Economic Development
  - The Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR)
  - Small Spacecraft Technology Program
  - Space Technology Research Grants
  - Technology Demonstration Missions (TDM)
  - Technology Transfer



# Small Spacecraft Technology Program (SSTP)

- Program Content
- Precursor Missions
- Demonstration Missions
- Technology Development
- Advanced Concepts
- Program Office, S3VI, CSLI

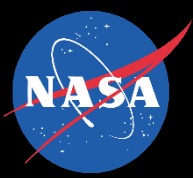
Develop and demonstrate the capabilities that enable small spacecraft to achieve NASA missions in unique and more affordable ways.

- Enable **new mission architectures** for which small spacecraft are uniquely suited.
- Expand the capability of small spacecraft to execute missions at **new destinations** and in challenging new environments.
- Enable the **augmentation of existing assets and future missions** with supporting small spacecraft.

[https://www.nasa.gov/directorates/spacetech/small\\_spacecraft](https://www.nasa.gov/directorates/spacetech/small_spacecraft)



# Pathfinder Technology Demonstrator



## Pathfinder Technology Demonstrator (PTD)

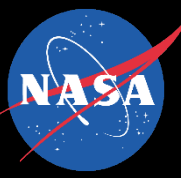
*To demonstrate and characterize novel satellite technologies in Low Earth Orbit*

“Enabling commercially marketable products to advance the capabilities for CubeSats and other small spacecraft to support a wide variety of science, exploration and commercial space missions.”

Request For Proposal was issued and contract awarded for a 6U bus leveraging existing CubeSat industry developments and experience to provide a low-cost, low-risk bus. Contract awarded to Tyvak Nanosatellite Systems.



# PTD Management and Governance



## NASA Management

- HQ: Space Technology Mission Directorate (STMD)
- Program Office: Small Spacecraft Technology Program (SSTP) Level II Office at Ames Research Center
- Mission Management: Ames Research Center
- Payload Management: Glenn Research Center



## Tyvak Management

- Spacecraft Development
- Payload Integration
- Assembly Integration & Test
- Mission Operations



## PTD Governance

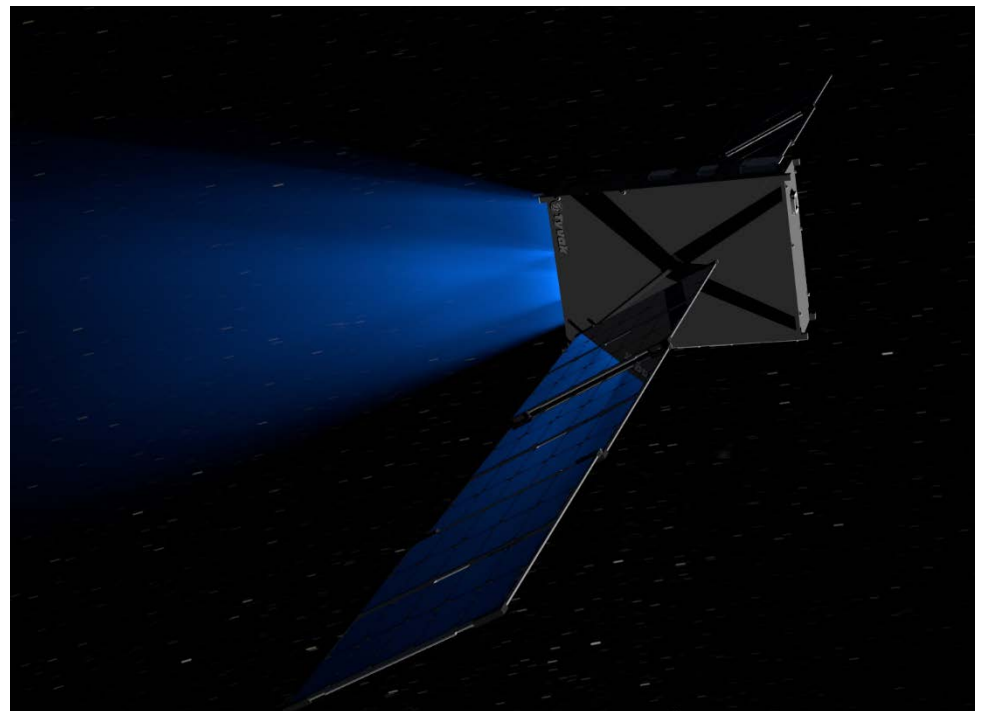
PTD space systems development & demonstration mission utilizes NPR 7120.8 for research & technology development guidance.

## NASA Research and Technology Program and Project Management Requirements

- 7120.8 supports development and demonstration of enabling technologies that will be infused in future NASA missions.

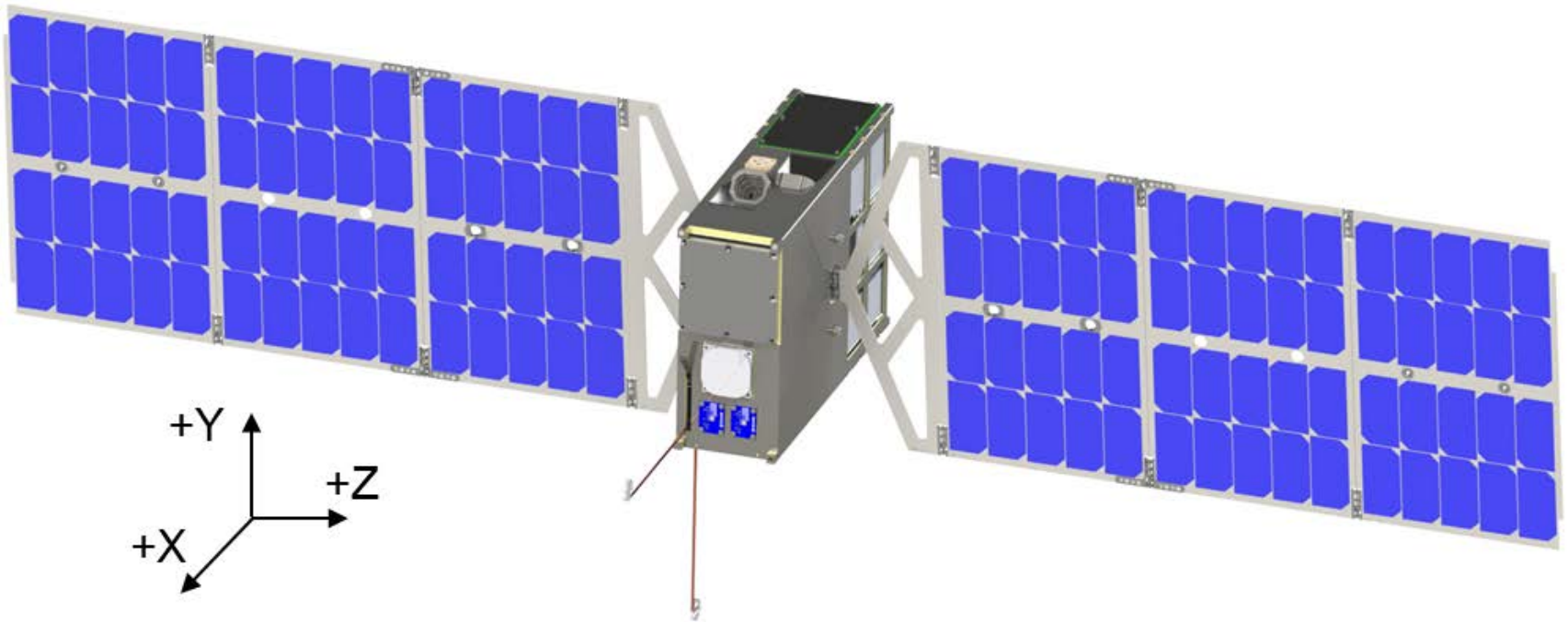
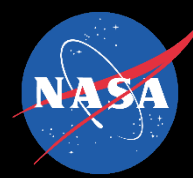
# PTD Level 1 Requirement

| Req#      | Requirement  | Rationale  |
|-----------|--|--|
| L1-PTD-01 | The purpose of the Pathfinder Technology Demonstrator (PTD) mission is to demonstrate novel satellite technologies in Low Earth Orbit (LEO). | The primary purpose of these flight demonstrations is to raise the Technical Readiness Level (TRL) from 5 to 7 of a variety of payloads provided to the project that meet the Pathfinder Technology Demonstrator system interface specification. |





# PTD BUS DESCRIPTION



## Overview

- Tyvak selected to provide PTD bus and I&T services
- Options for up to 5 missions included
  - Common bus design
- PTD-1 will test propulsion system
- GlobalStar demo included

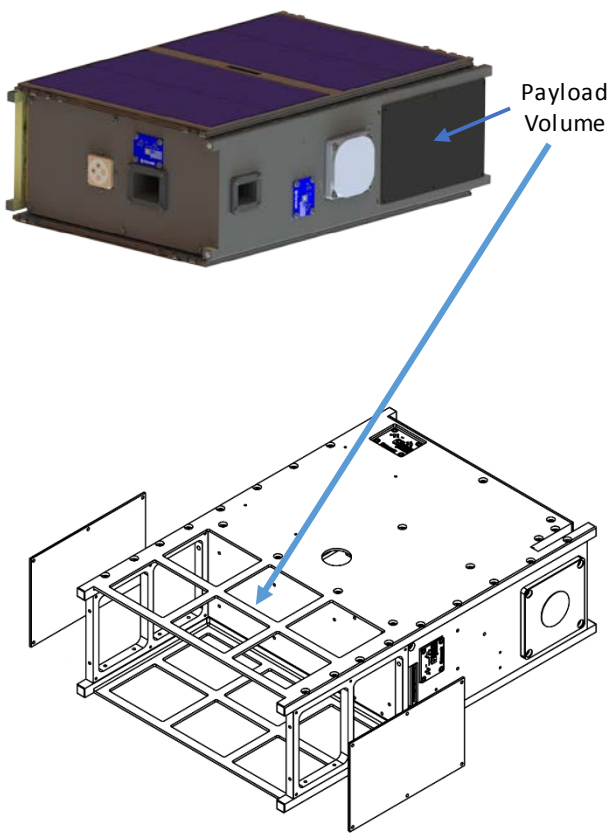
## Implementation

- 6U, 12 kg, 62 W OAP
- Based on existing, flight heritage hardware
- Deployable tracking solar arrays
- UHF/S-band Comms
- PROPCUBE based C&DH

## Status

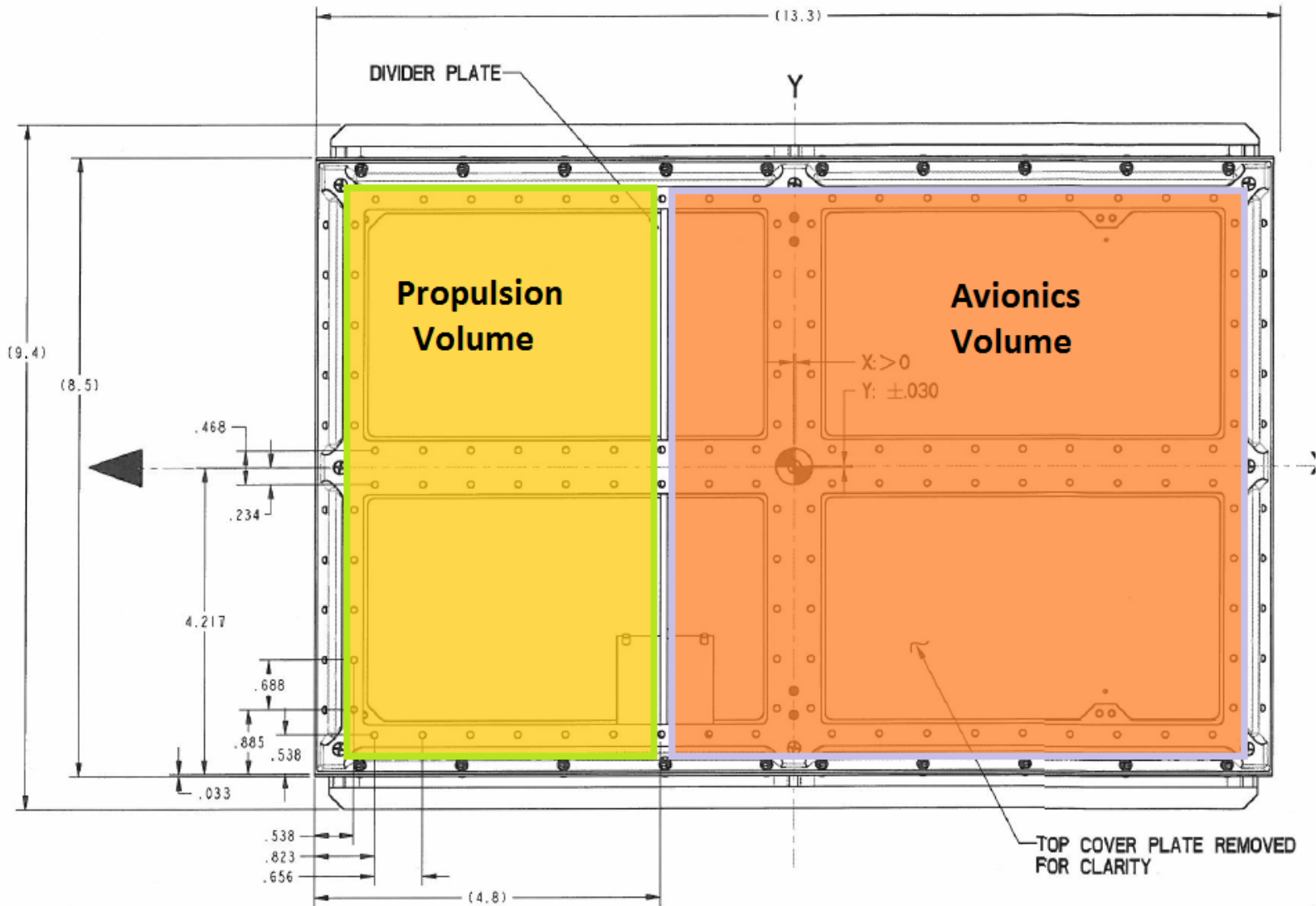
- Jan, 2017: Tyvak Kick-off held
- Feb, 2017: CSLI proposal accepted
  - Likely sun-synch orbit
- Mar, 2017: SRR held
- Qtr 1 2019: Launch of PTD-1
- Mar, 2019: PTD-1 mission complete





| System Characteristics |   |
|------------------------|---|
| Size                   | 6U (10 X 20 X 30 cm)  |
| Mass                   | 12 kg (includes 3kg for payload)  |
| Power                  | 62W OAP, deployable tracking arrays (45W payload allocation, 5W payload survival power) |
| Communications         | UHF/S-band  |
| ADCS                   | 3-Axis Stabilized, high precision   |
| C&DH Heritage          | PROPCUBE  |
| Payload Volume         | 209.5 mm (W) x 96 mm (H) x 125 mm (D) (~ 2.4 U)   |
| Payload Comms          | RS-422 Asynchronous   |

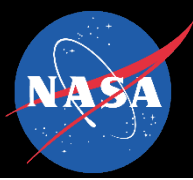
# PTD Geometric View



\*Notional design, TBS after RFP award



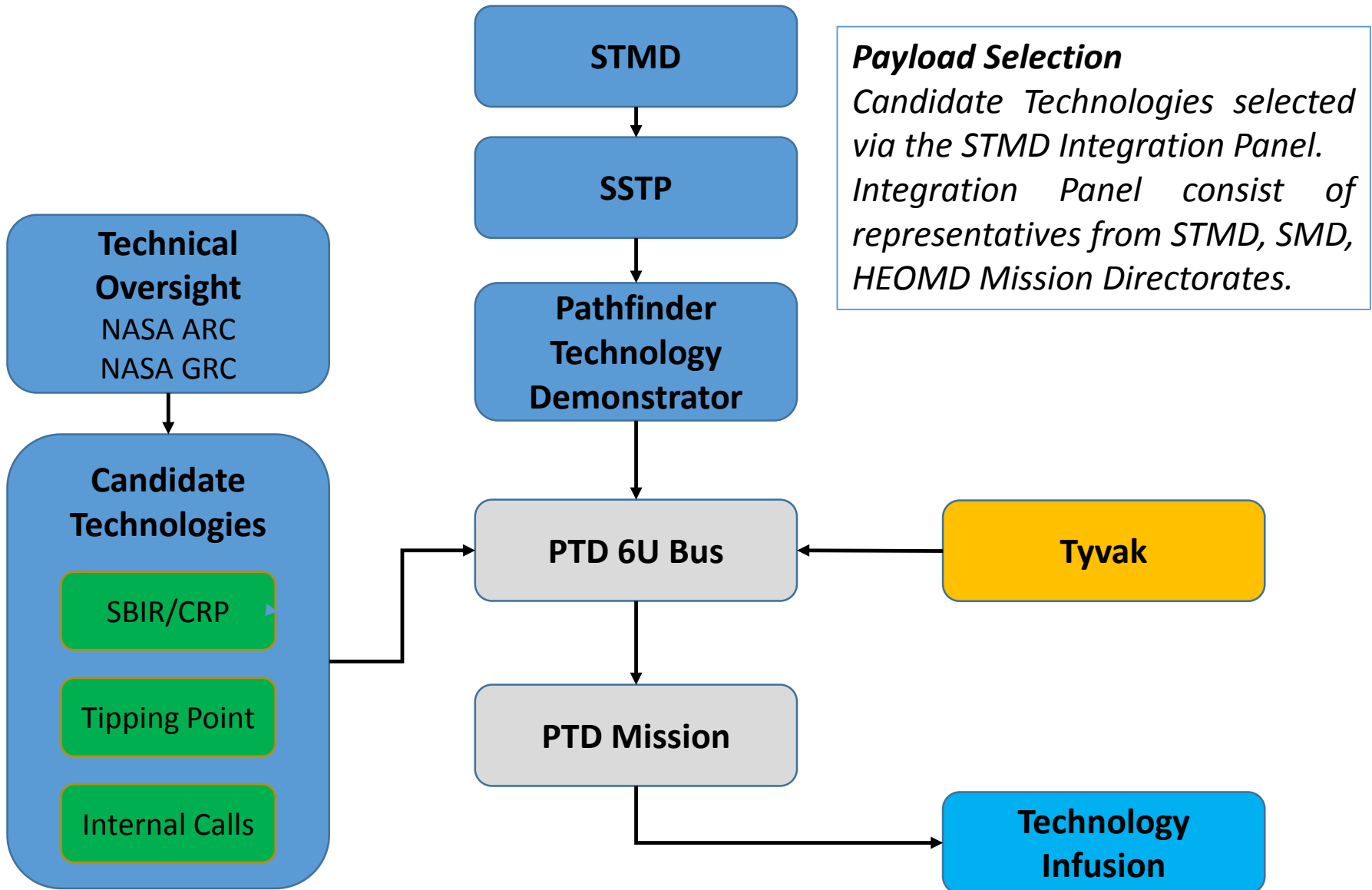
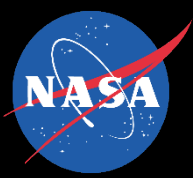
# PTD MISSIONS OVERVIEW







# PTD Mission Development





# NASA CUBESAT LAUNCH INITIATIVE



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## CubeSat Launch Initiative

CLSI | Overview | Images | Videos | Media Resources

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CubeSat Launch Initiative

- About the CubeSat Launch Initiative
- CubeSat Launch Initiative Selections
- Upcoming ELaNa CubeSat Launches
- Past ELaNa CubeSat Launches
- Announcement of Opportunity
- Resources to Get Started

Related Sites

- CubeSats at NASA
- ELaNa Missions
- Advanced Exploration Systems
- Launching Rockets at NASA

Related Topics

- All Topics A-Z

**Technology**

NASA Announces Ninth Round of Candidates for CubeSat Space Missions

**Space Station**

Failure is an Option: How an Inoperative CubeSat Still Holds STEM Less

**NASA's CubeSat Launch Initiative**

NASA's CubeSat Launch Initiative provides opportunities for small satellite payloads built by universities, high schools and non-profit organizations to fly on upcoming launches. Through innovative technology partnerships NASA provides these CubeSat developers a low-cost pathway to conduct scientific investigations and technology demonstrations in space, thus enabling students, teachers and faculty to obtain hands-on flight hardware development experience.

Each proposed investigation must demonstrate a benefit to NASA by addressing aspects of science, exploration, technology development, education or operations relevant to NASA's strategic goals. This initiative provides NASA a mechanism for low-cost technology development and scientific research to help bridge strategic knowledge gaps and accelerate flight-qualified technology.

**CubeSats**

CubeSats Launch on JPSS-1 Mission

**Technology**

NASA's CubeSat Launch Initiative Broadens Access to Space

**Small Satellites**

NASA ELaNa XVII Mission Launches

**Technology**

NASA Announces Eighth Class of Candidates for Launch of CubeSat Space

**Robotics**

ELaNa IX: Two Universities and a Primary School to Launch CubeSats

**Robotics**

ELaNa VII CubeSat Launch on ORS-4 Mission

**NASA Kennedy**

CubeSat Launchers Expected to Open Research Opportunities for All

**NASA Kennedy**

NASA Awards Venture Class Launch Services Contracts

## CSLI

Provides access to space for small satellites, CubeSats, developed by the NASA Centers and programs, educational institutions and non-profit organizations.

## NASA'S CUBESAT LAUNCH INITIATIVE (CSLI)

**CSLI:**

- PROMOTES innovative public-private technology partnerships
- FACILITATES low-cost technology development
- STRENGTHENS NASA and the Nation's future workforce

**Educational Launch of Nanosatellites**

**Launch Vehicles**

**Missions**

23 ELaNa  
114 CubeSat

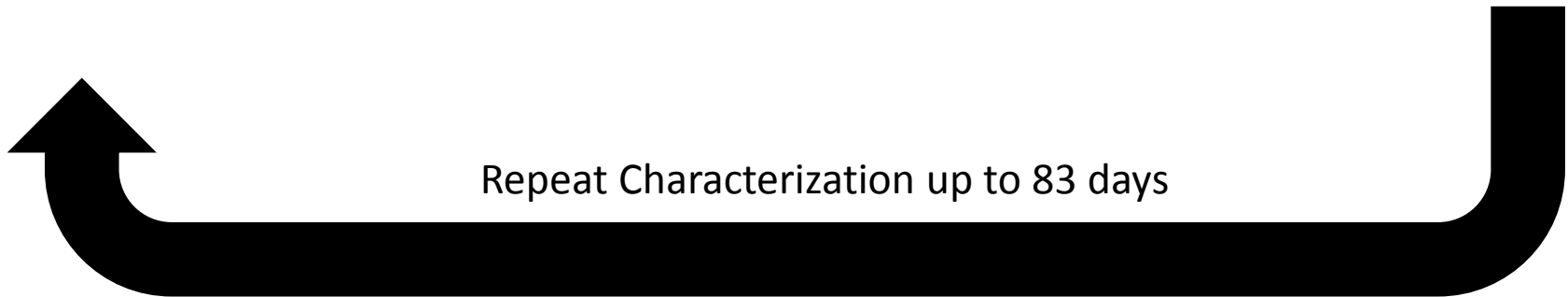
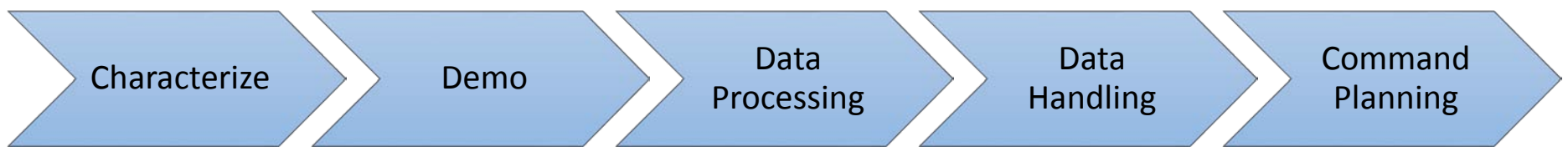
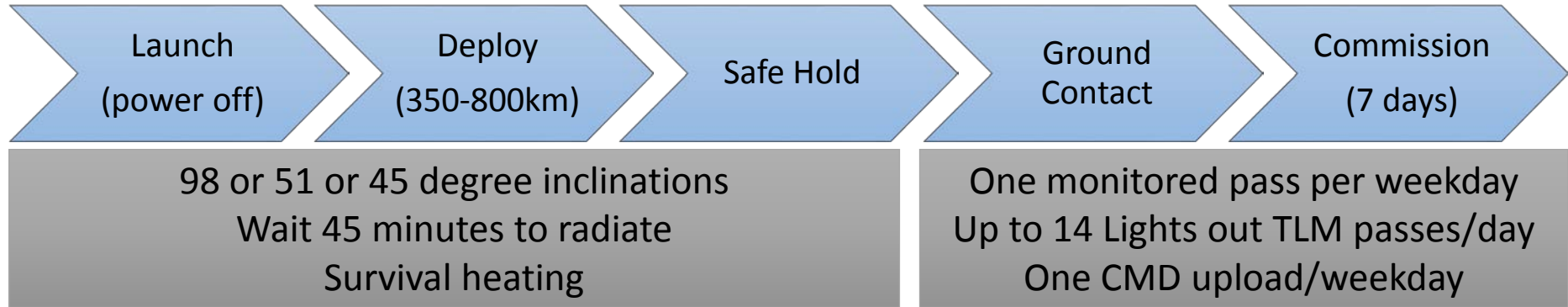
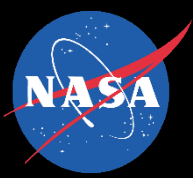
**LAUNCH PROVIDERS**

|                   | NASA | Boeing | Boeing | Boeing | Boeing | Boeing | VENTURE CLASS | BY STATUS |
|-------------------|------|--------|--------|--------|--------|--------|---------------|-----------|
| MANIFESTED        | 3    | 0      | 2      | 0      | 16     | 29     | 50            |           |
| LAUNCHED          | 15   | 13     | 13     | 1      | 16     | 0      | 58            |           |
| TOTAL BY PROVIDER | 18   | 13     | 15     | 1      | 32     | 29     | 108           |           |

[go.nasa.gov/CubeSat\\_initiative](http://go.nasa.gov/CubeSat_initiative)



# PTD-1: Operational Concept



# PTD-1: Operational Concept

## ❖ Spacecraft Checkouts

- Mix of automatic and manual checkouts
- Star tracker alignment verification
- GNC system performance verification
- Solar Array performance verification

## ❖ Payload Checkouts

- Power and verify connectivity
- Enable Payload Self-Tests (if available)



## ❖ Payload Operations

- Slews to fixed orientation in local velocity frame
- Maintains constant orientation
- Enable Collection of payload data
  - GPS data for propulsive payload maneuvers

## ❖ Secondary Mission

- Communicate using Globalstar system



## ❖ Launch

- Spacecraft powered off for launch, contained within deployer
- Uncertainties in orbital insertion expected

## ❖ Deployment from Dispenser

- Spacecraft boots up when physical inhibit switches are released
- Significant body spin rates from deployer springs and Upper state rotation
- UHF antenna and solar array deployment
- ADCS-managed automatic detumble



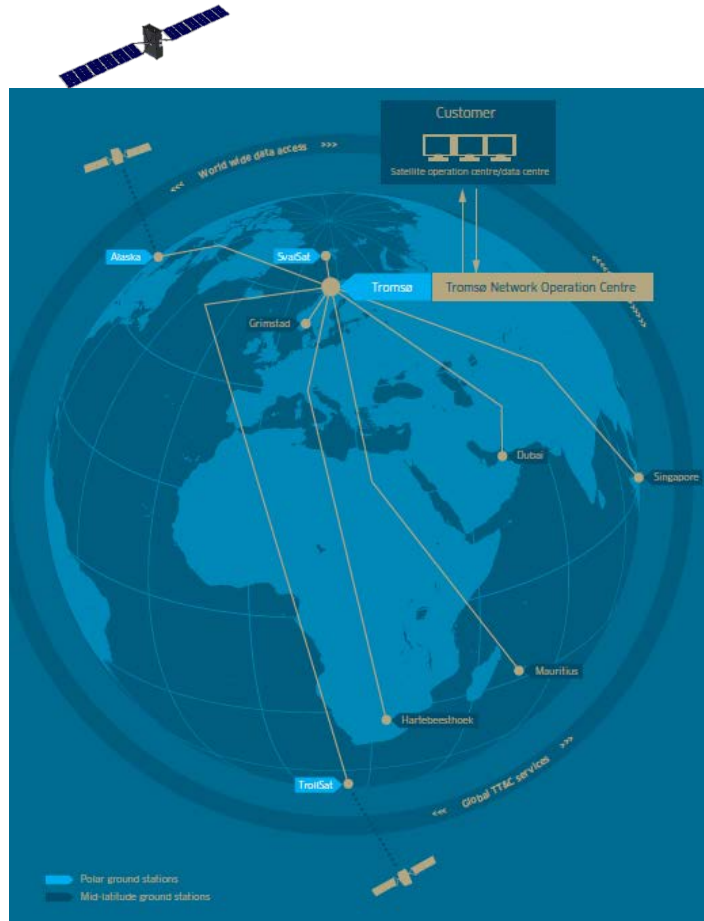
## ❖ Spacecraft Disposal

- Inhibit charging & solar array motion once all operations are completed
  - End of mission fuse
- Consume / Vent all remaining propellant
- Discharge all energy storage devices
- Spacecraft reenters within L-25 years



# Mission Operations & Ground Network

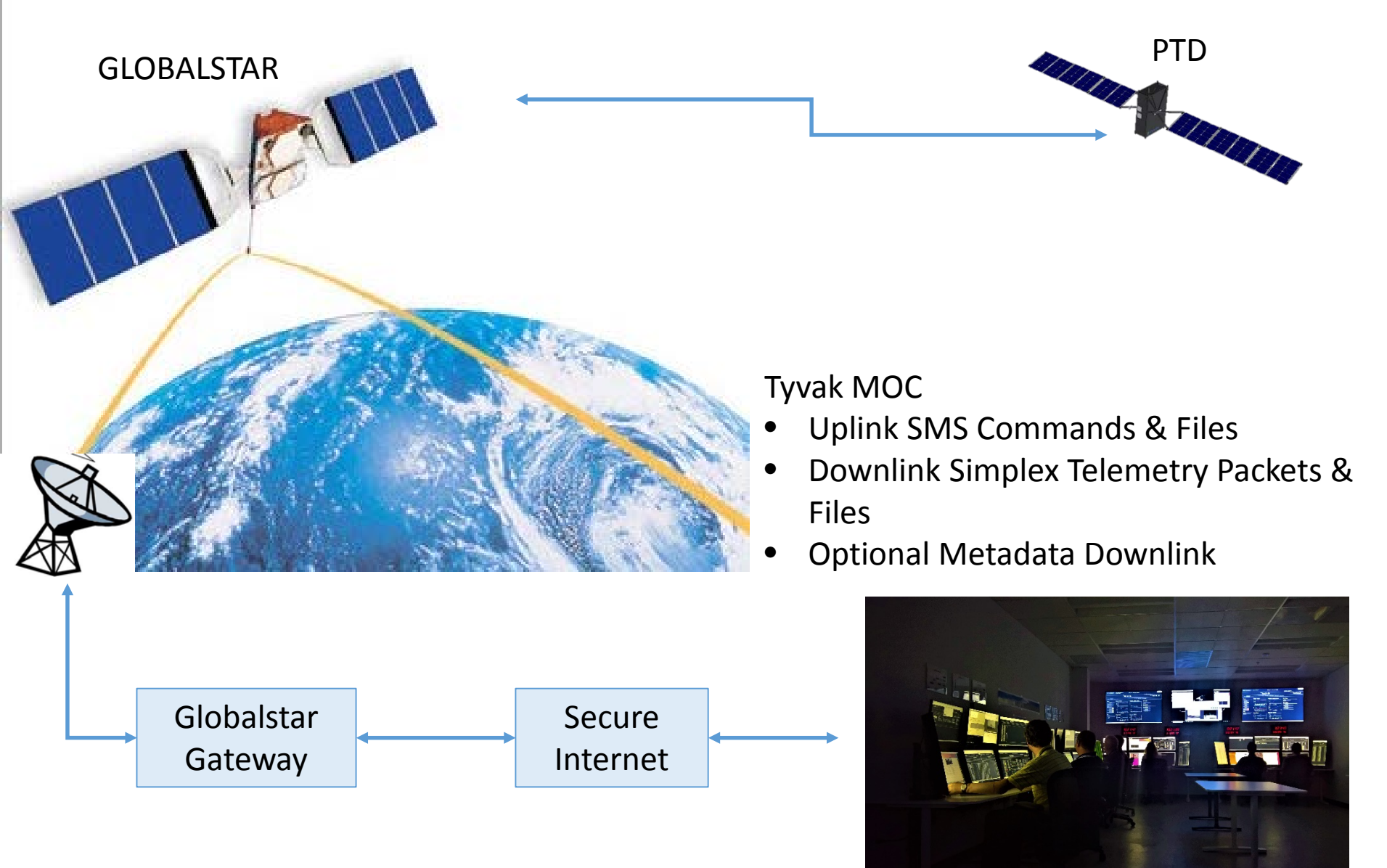
Mission Manager: NASA SST  
Mission Operations Center: Tyvak  
Ground Stations: Tyvak, KSAT  
Communications: UHF/S-Band



**KSAT Ground Station Network**

**Mission Ops Center Tyvak Inc., Irvine, CA**

# PTD Globalstar Comm Network Evaluation



## Tyvak MOC

- Uplink SMS Commands & Files
- Downlink Simplex Telemetry Packets & Files
- Optional Metadata Downlink



# PTD – 1 PAYLOADS

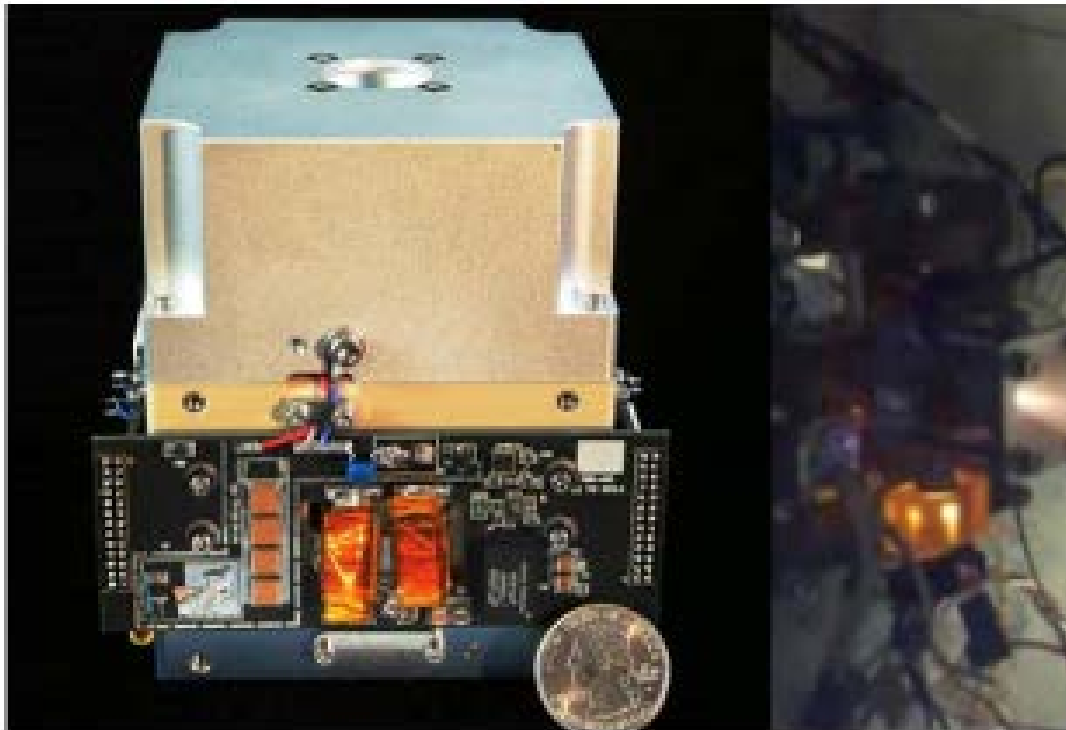
National Aeronautics and  
Space Administration



# PTD 1 TUI HYDROS H<sub>2</sub>O THRUSTER

|                   |                                      |
|-------------------|--------------------------------------|
| <b>Vendor</b>     | <b>Tethers Unlimited, Inc.</b>       |
| <b>email</b>      | <b>www.tethers.com</b>               |
| <b>Phone</b>      | <b>+1 425 486 0100</b>               |
| <b>Technology</b> | <b>Water based propulsion system</b> |

“The HYDROS Propulsion System uses on-orbit electrolysis of water to generate hydrogen and oxygen propellant, which are fed to a simple bipropellant thruster.” \*



| <b>Metric</b>            | <b>Value</b> |
|--------------------------|--------------|
| Configuration            | 2U           |
| Isp                      | >310 s       |
| Average Thrust           | > 1.2 N      |
| Total # of Thrust Events | 1230         |
| Total Impulse Delivered  | > 2151 Ns    |
| Mass                     | 2.6 kg Wet   |
| Power                    | 5W – 25W     |

\*James, K. et al, “HYDROS: High Performance Water-Electrolysis Propulsion for Cubesats & Microsats”, *IEEE Space Conference 2017 (AAS 17-145)*

# PTD-2 BCT Hyper XACT

|                   |  |
|-------------------|--|
| <b>Vendor</b>     | <b>Blue Canyon Technologies</b>  |
| <b>email</b>      | <b><a href="http://bluecanyontech.com/">http://bluecanyontech.com/</a></b> |
| <b>Technology</b> | <b>Attitude Determination and Control</b>                                  |

- *Hyper-XACT is a major upgrade to the current-generation XACT*
- *The result is an evolution to a product designed for missions with **lower risk postures** and **more challenging performance requirements***

## Improvement Goals over standard XACT

Radiation tolerance

Pointing accuracy

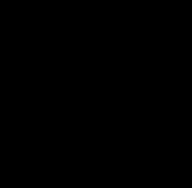
Attitude knowledge

Orbit lifetime





# PTD 1 Mission Demonstration





# PATHFINDER TECHNOLOGY DEMONSTRATOR

National Aeronautics and  
Space Administration

