Pathfinder Technology Demonstrator

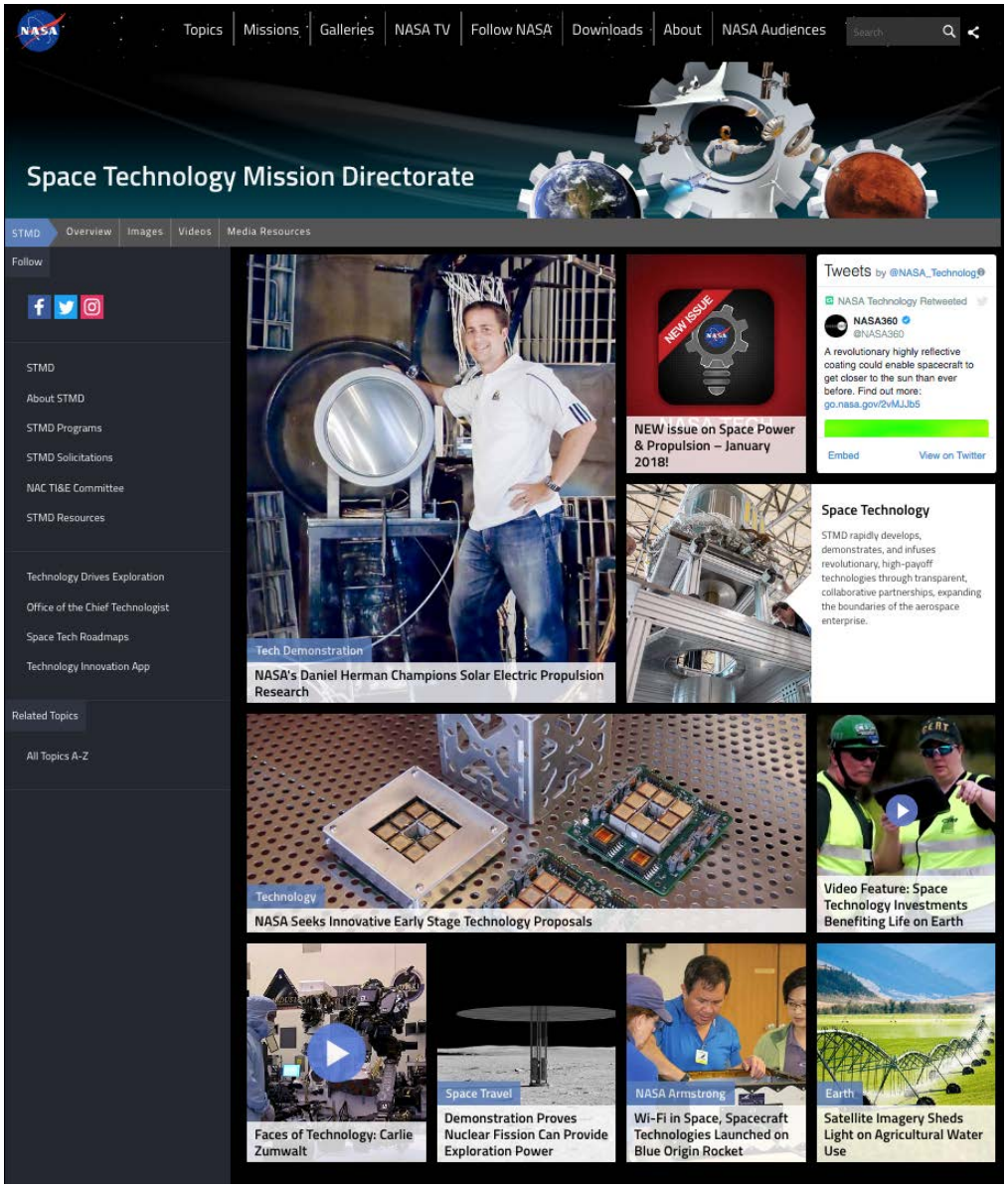
"Demonstrating Advanced Technologies for Advanced Missions"

4S Conference

May 1, 2018

NASA Space Technology Mission Directorate
NASA Small Spacecraft Technology Program
NASA Ames Research Center | NASA Glenn Research Center

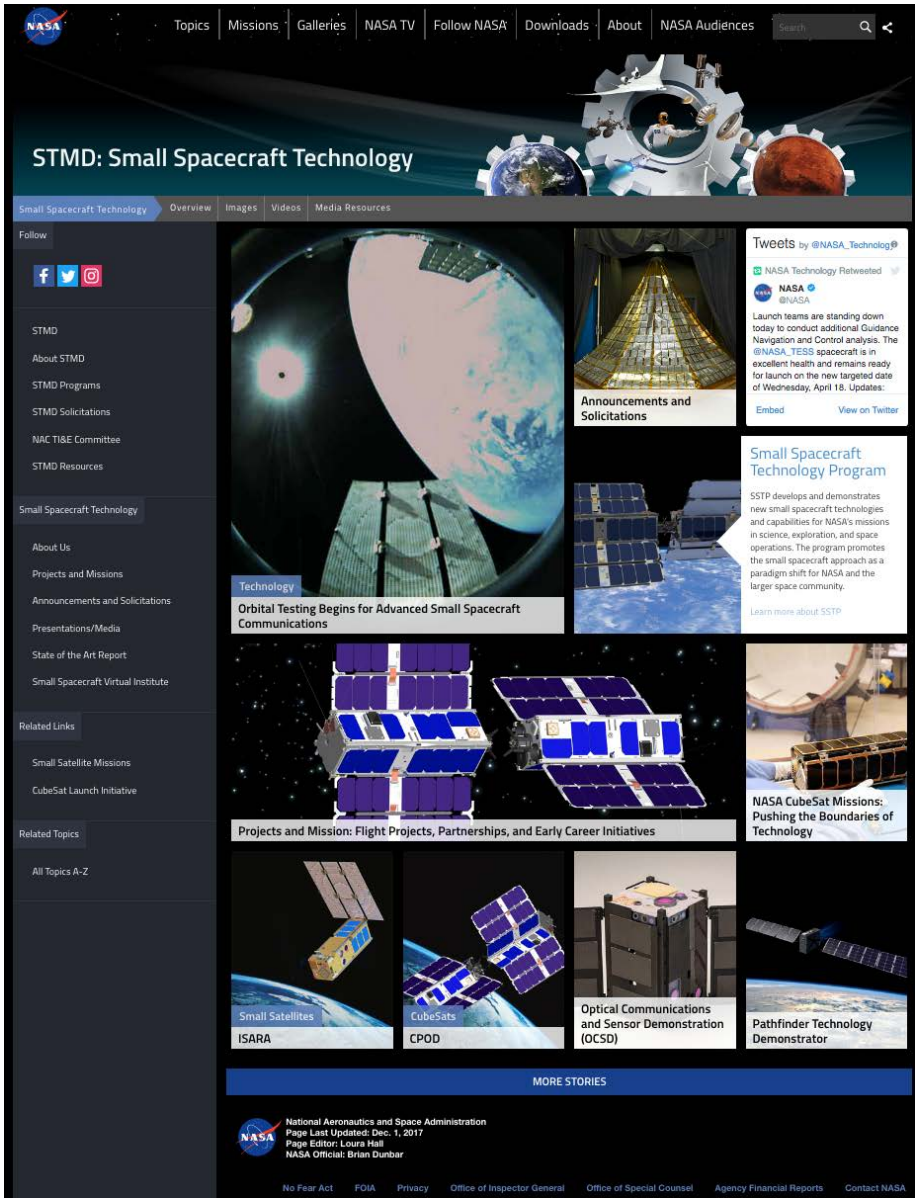
Space Technology Mission Directorate
STMD



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

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

Ames Research Center

GRC
GLENN RESEARCH CENTER
at Lewis Field

Tyvak Management

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

Tyvak
A Terran Orbital Corporation

PTD Governance

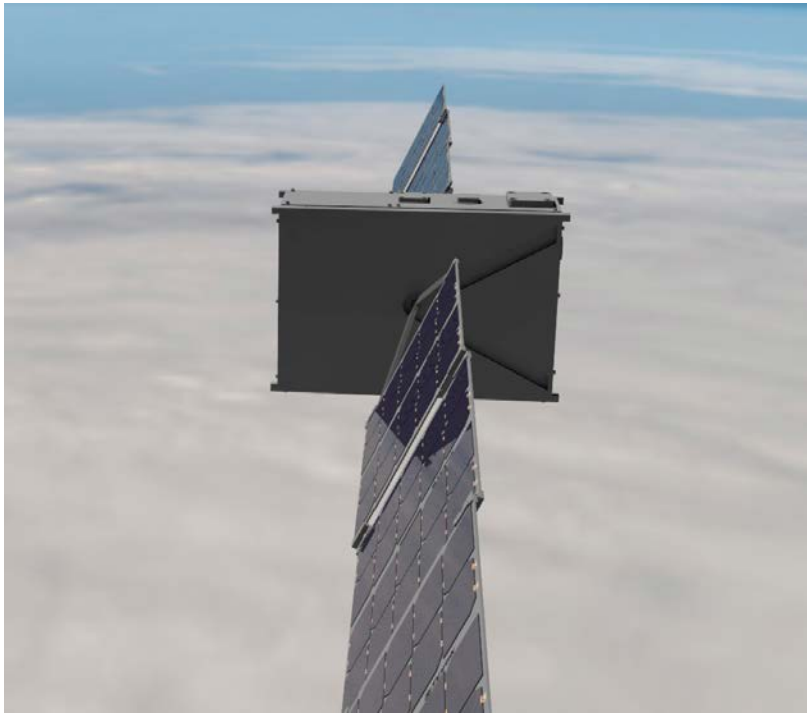
PTD space systems development & demonstration mission utilizes NPR 7120.8 for research & technology development guidance.

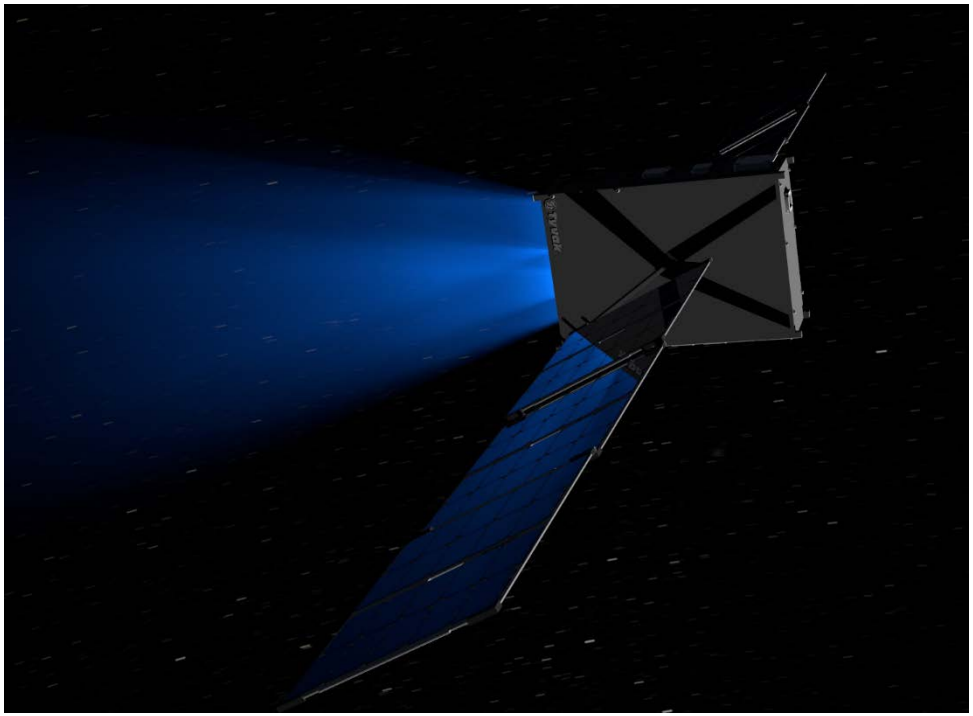
NASA Research and Technology Program and Project Management Requirements

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

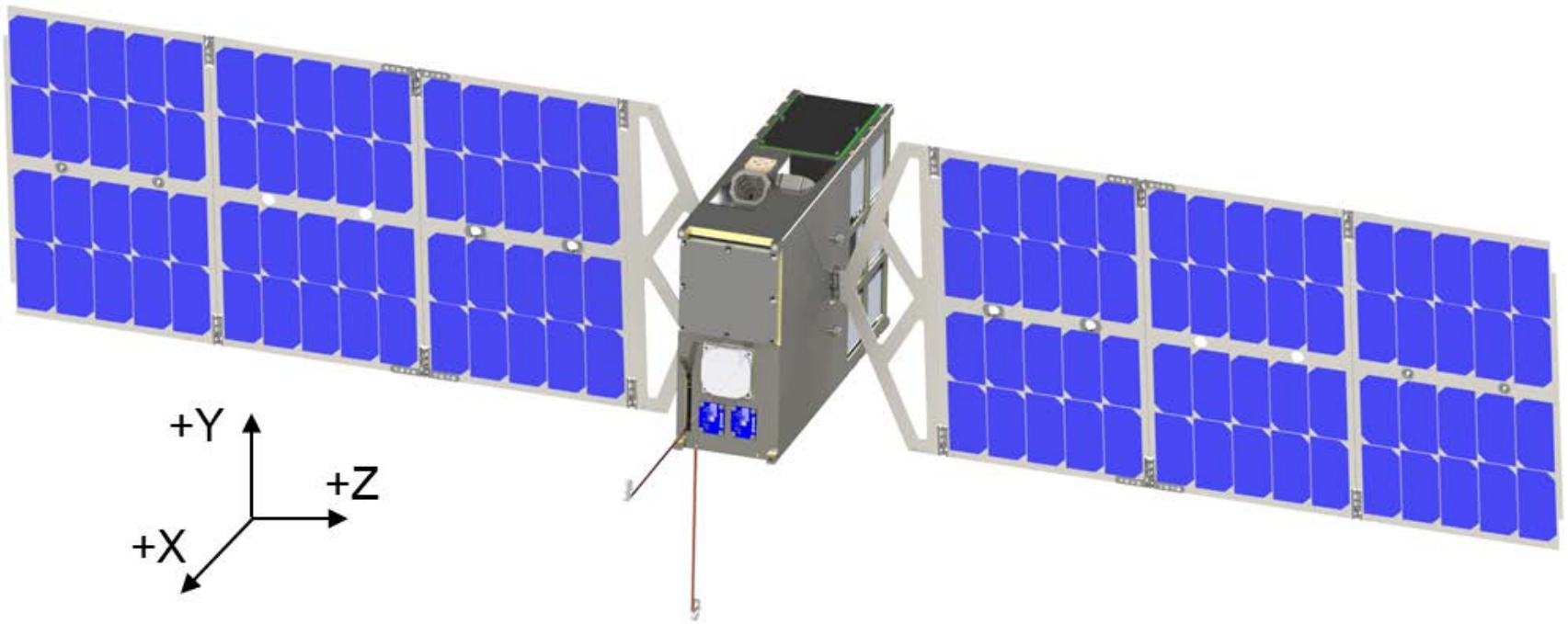
PTD Level 1 Requirement

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



PTD BUS SOLUTION

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

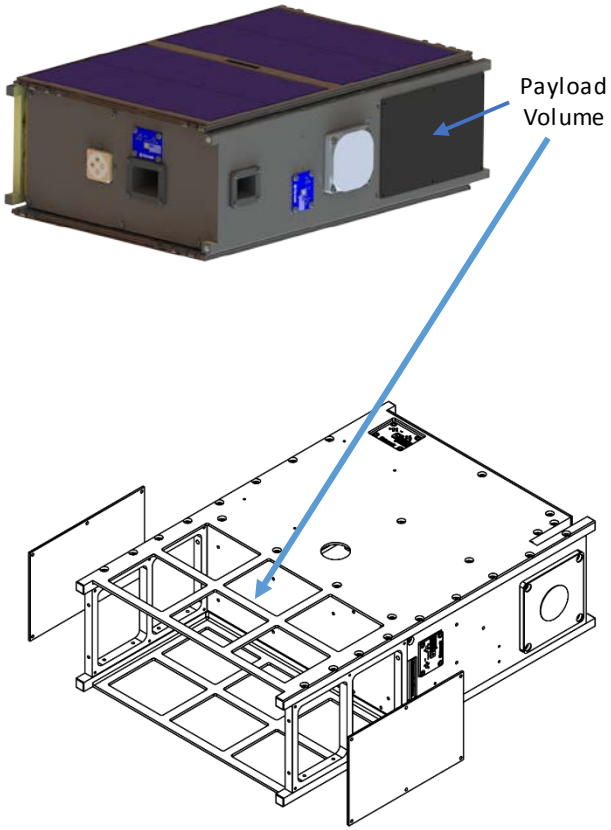
Implementation

- 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

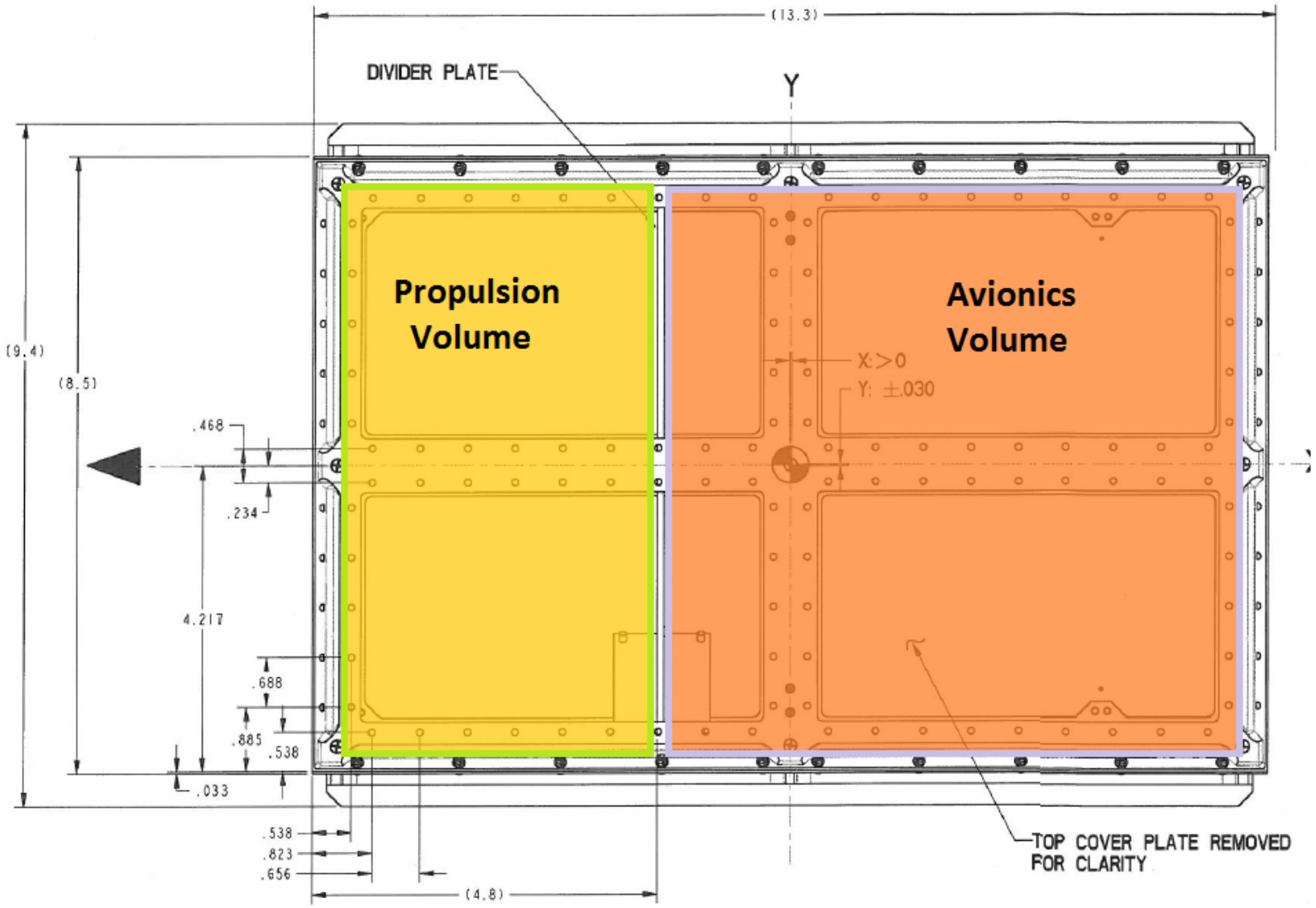
- Jan, 2017: Tyvak Kick-off held
- Feb, 2017: CSLI proposal accepted
  - Likely sun-synch orbit
- Mar, 2017: SRR held
- Qtr 1 2019: Launch of PTD-1
- Mar, 2019: PTD-1 mission complete

Spacecraft Characteristics



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 Asynchronus

PTD Geometric View

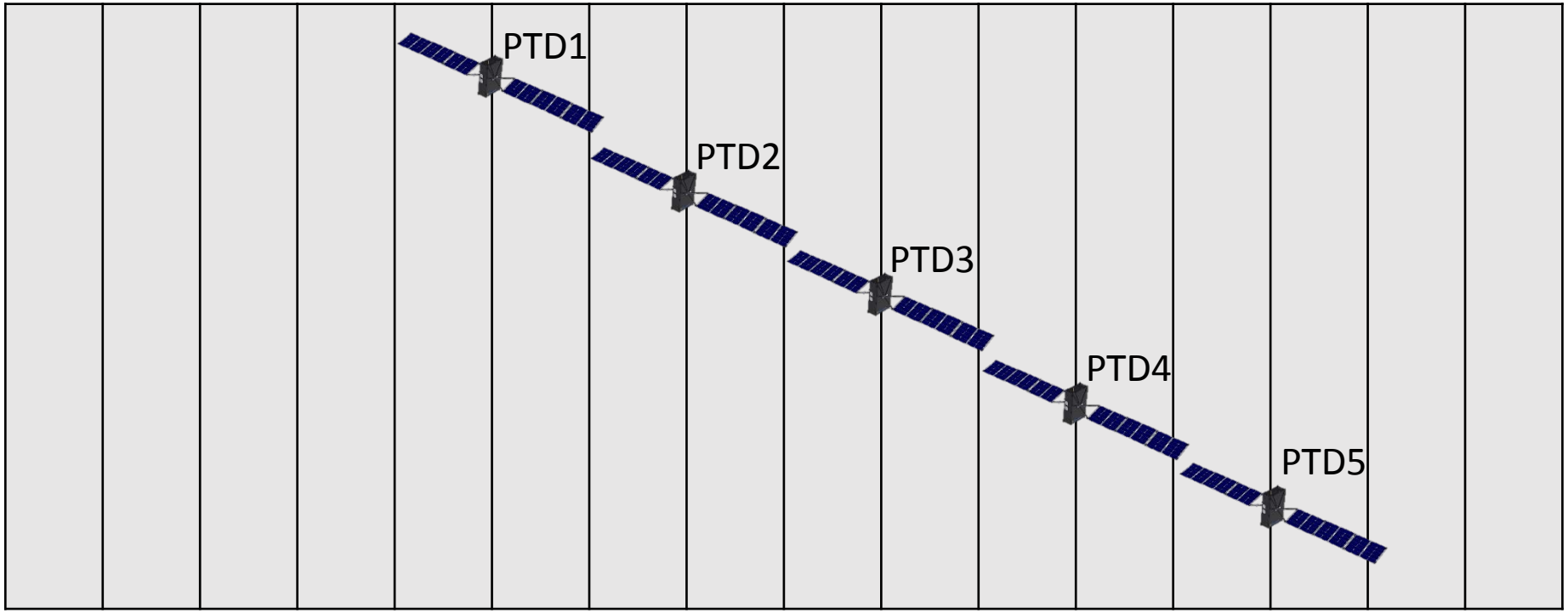


*Notional design, TBS after RFP award

PTD MISSIONS OVERVIEW

PTD MISSIONS TIMELINE

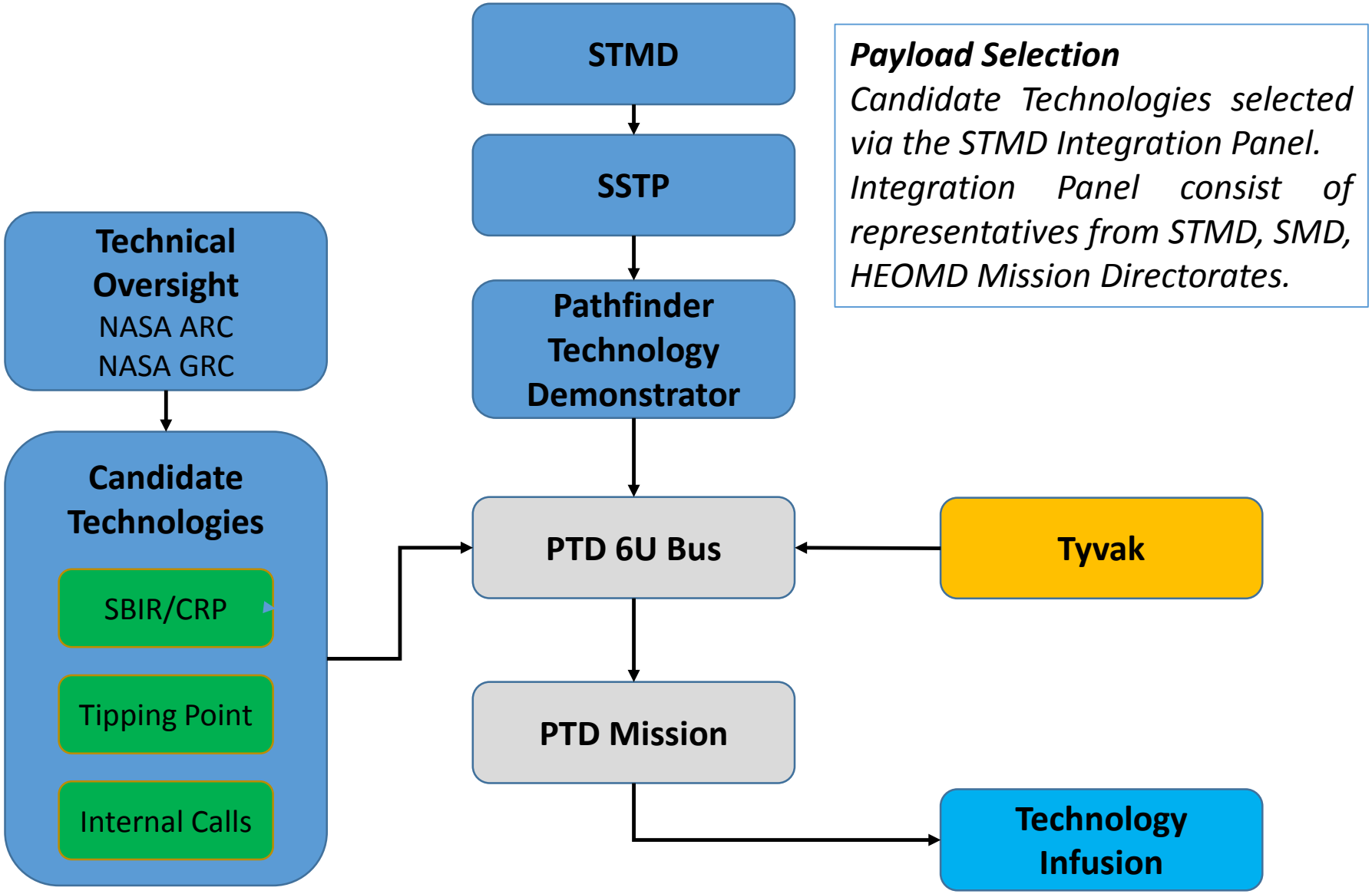
FY 2018				FY 2019				FY 2020				FY 2021			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4



PTD1 – TUI Hydros Thruster Demonstration

PTD2 – BCT HyperXACT Demonstration

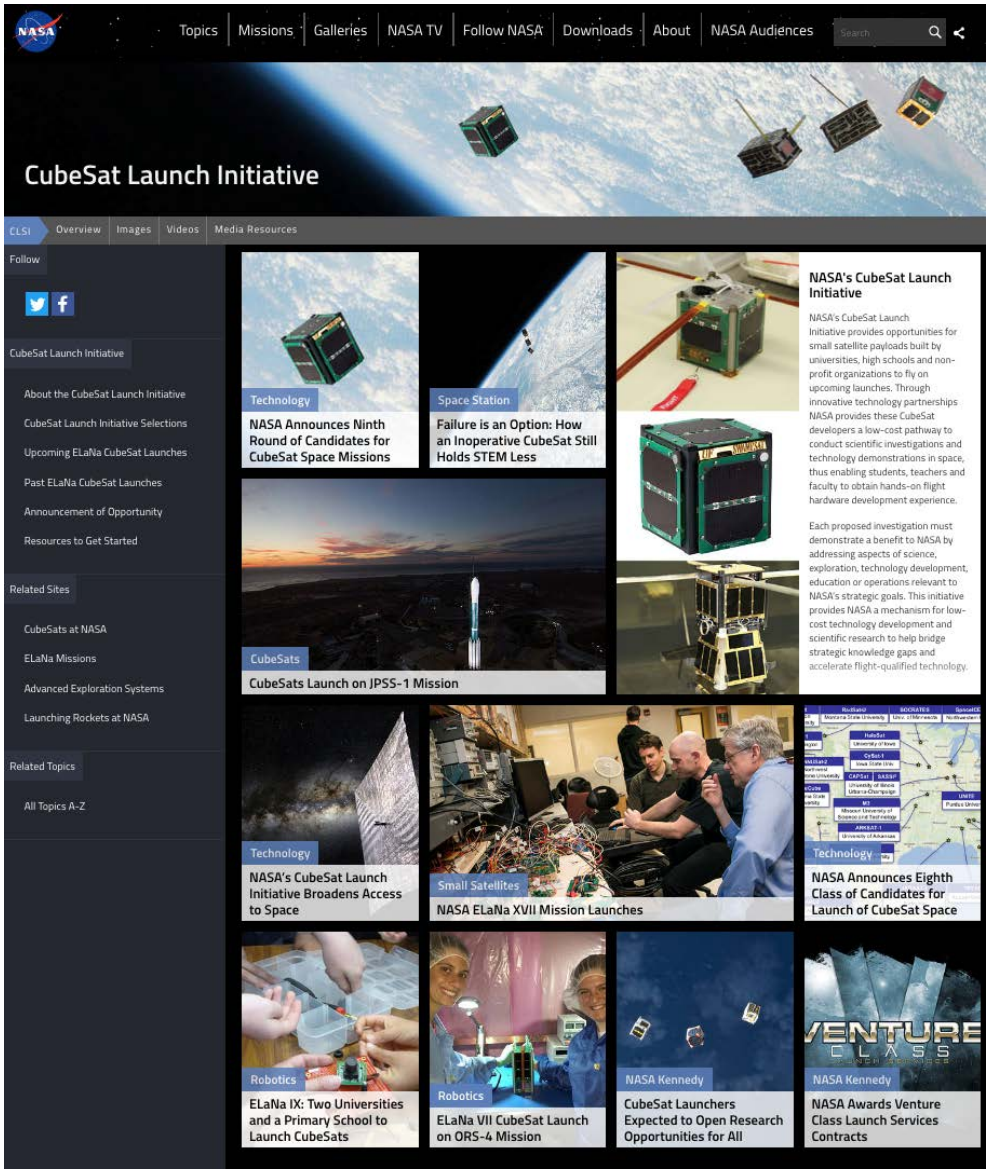
PTD Mission Development



Payload Selection

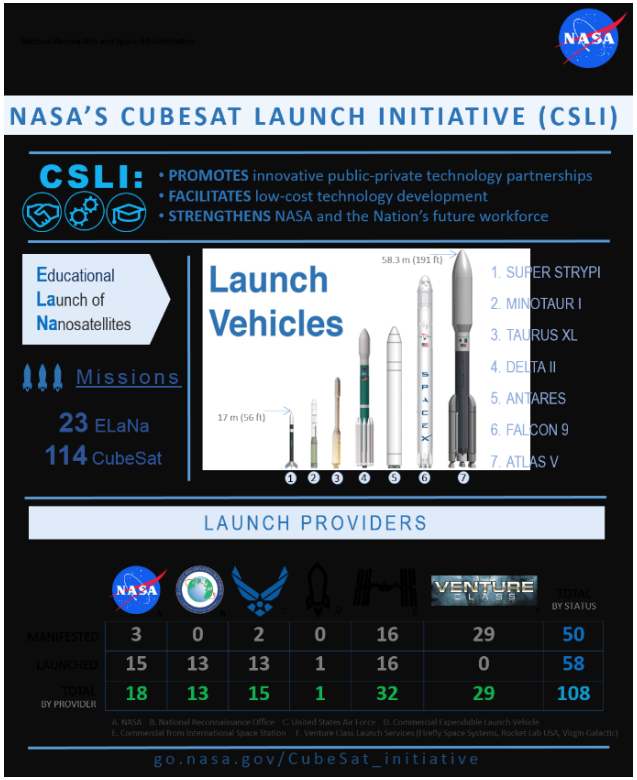
Candidate Technologies selected via the STMD Integration Panel. Integration Panel consist of representatives from STMD, SMD, HEOMD Mission Directorates.

NASA CUBESAT LAUNCH INITIATIVE

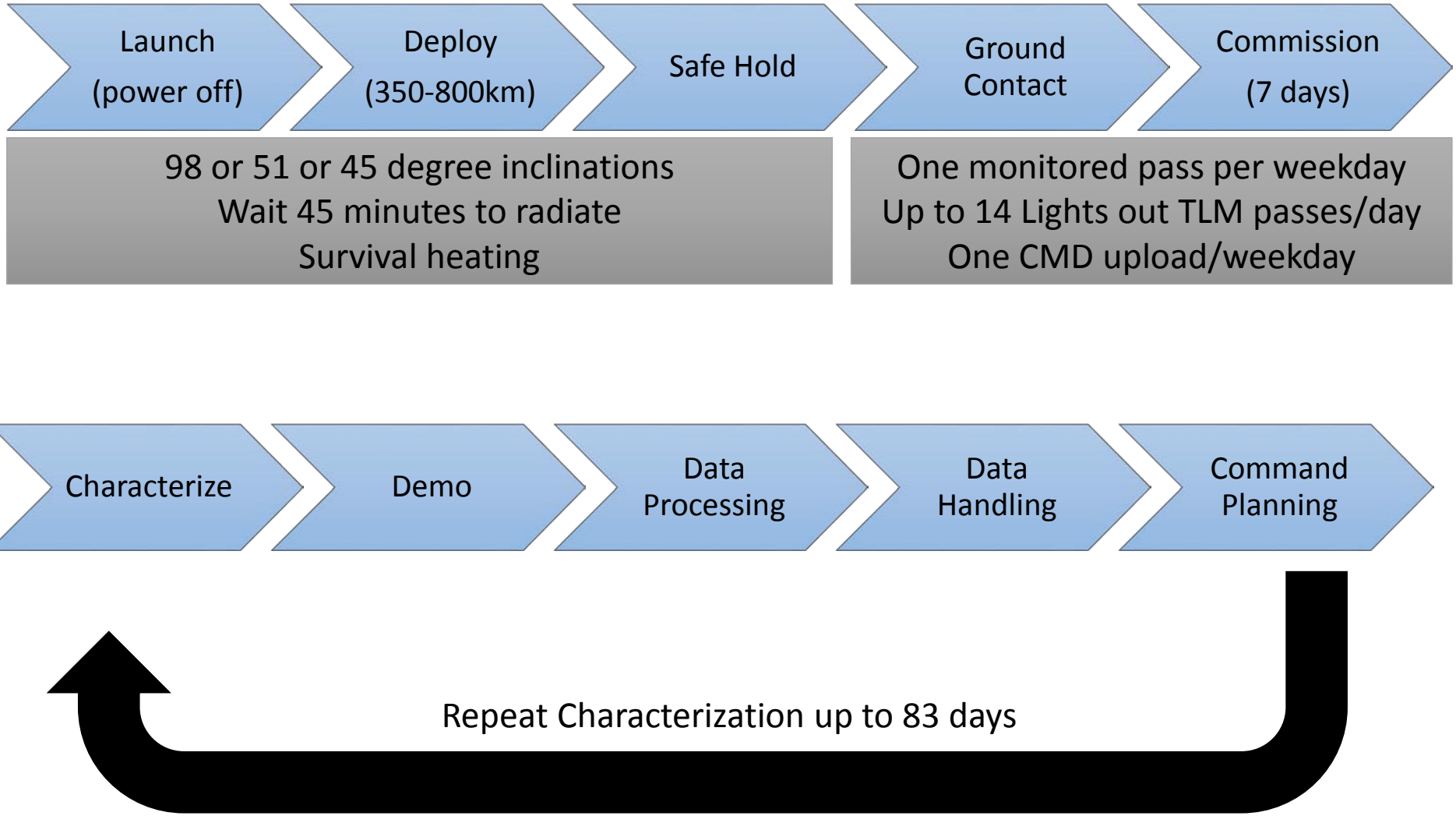


CSLI

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



PTD-1: Operational Concept



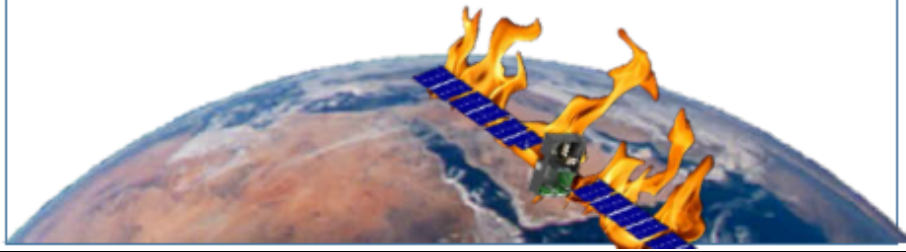
PTD-1: Operational Concept

- 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

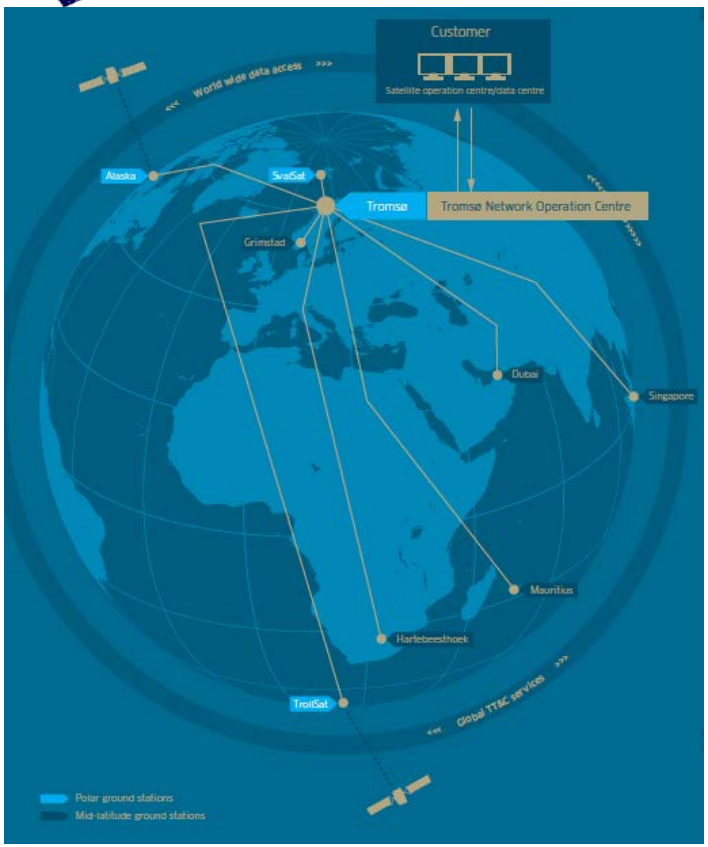
- Launch
  - Spacecraft powered off for launch, contained within deployer
  - Uncertainties in orbital insertion expected
- Deployment from Dispenser
  - Spacecraft boots up when physical inhibit switches are released
  - Significant body spin rates from deployer springs and Upper state rotation
  - 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 renters within L-25 years



Mission Operations & Ground Network

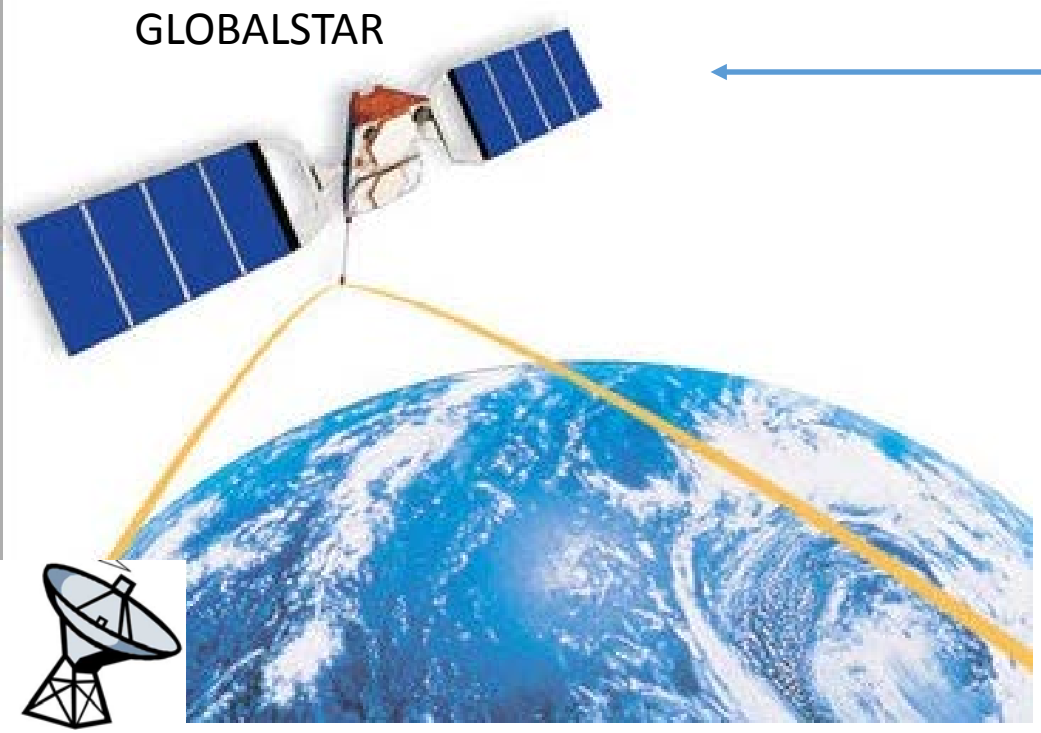
Mission Manager: NASA SST
Mission Operations Center: Tyvak
Ground Stations: Tyvak, KSAT
Communications: UHF/S-Band



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

Globalstar Gateway

Secure Internet

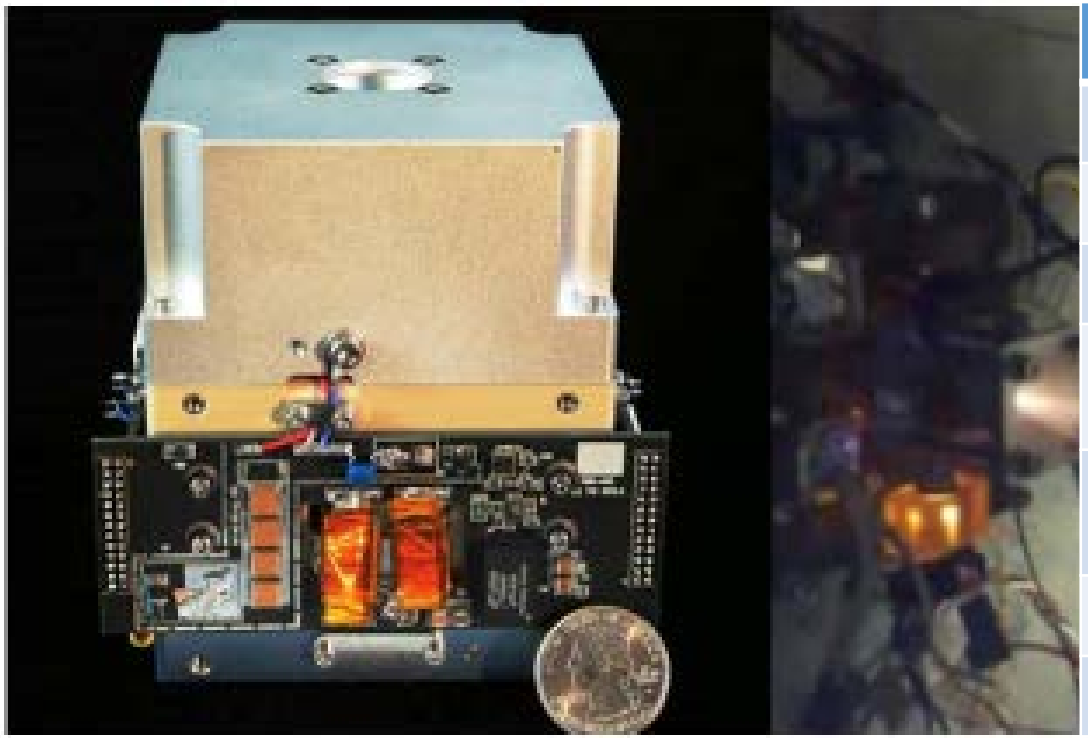
PTD – 1 PAYLOADS

National Aeronautics and Space Administration

PTD 1 TUI HYDROS H_2O THRUSTER

Vendor	**Tethers Unlimited, Inc.**
email	**www.tethers.com**
Phone	**+1 425 486 0100**
Technology	**Water based propulsion system**

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



Metric	Value
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)

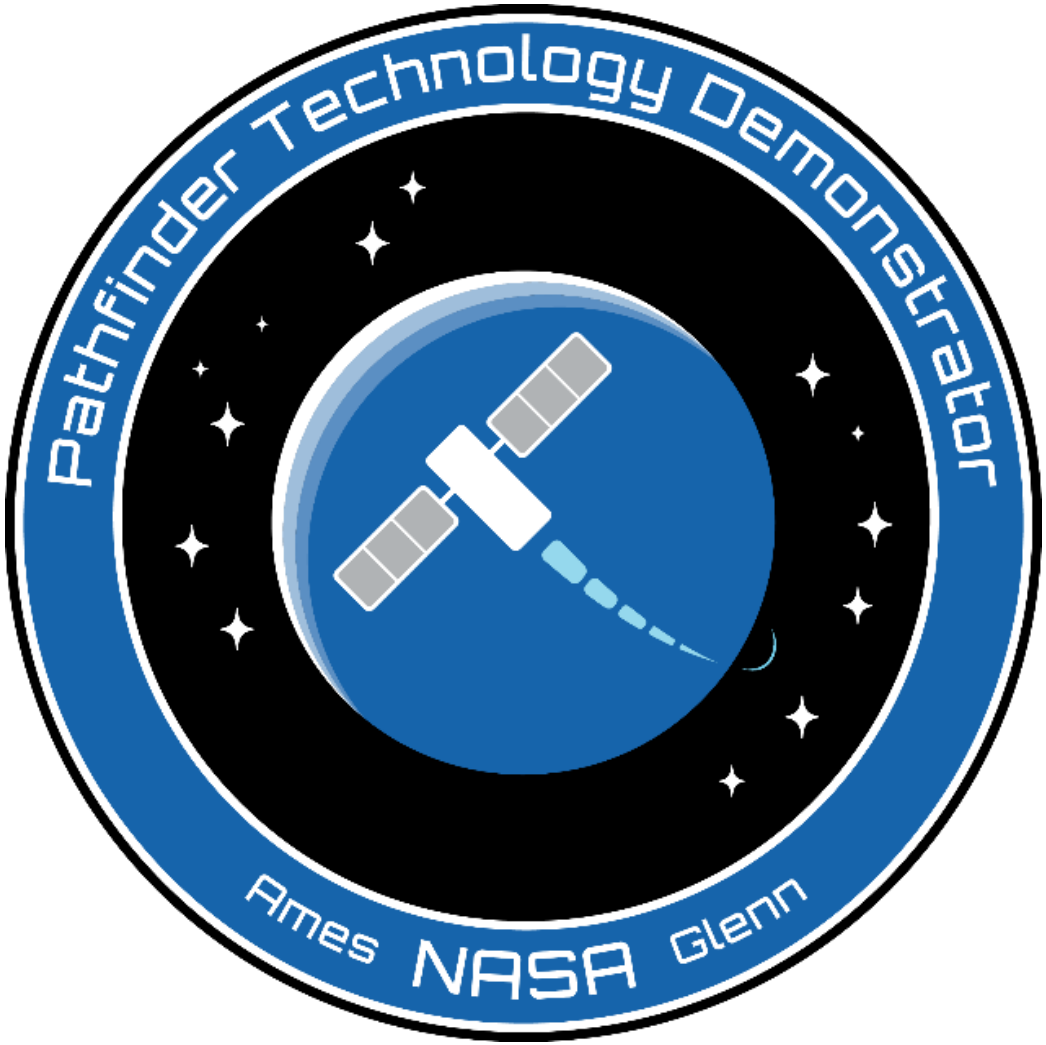
PTD-2 BCT Hyper XACT

Vendor	**Blue Canyon Technologies**
email	**http://bluecanyontech.com/**
Technology	**Attitude Determination and Control**

- *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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Ames NASA Glenn