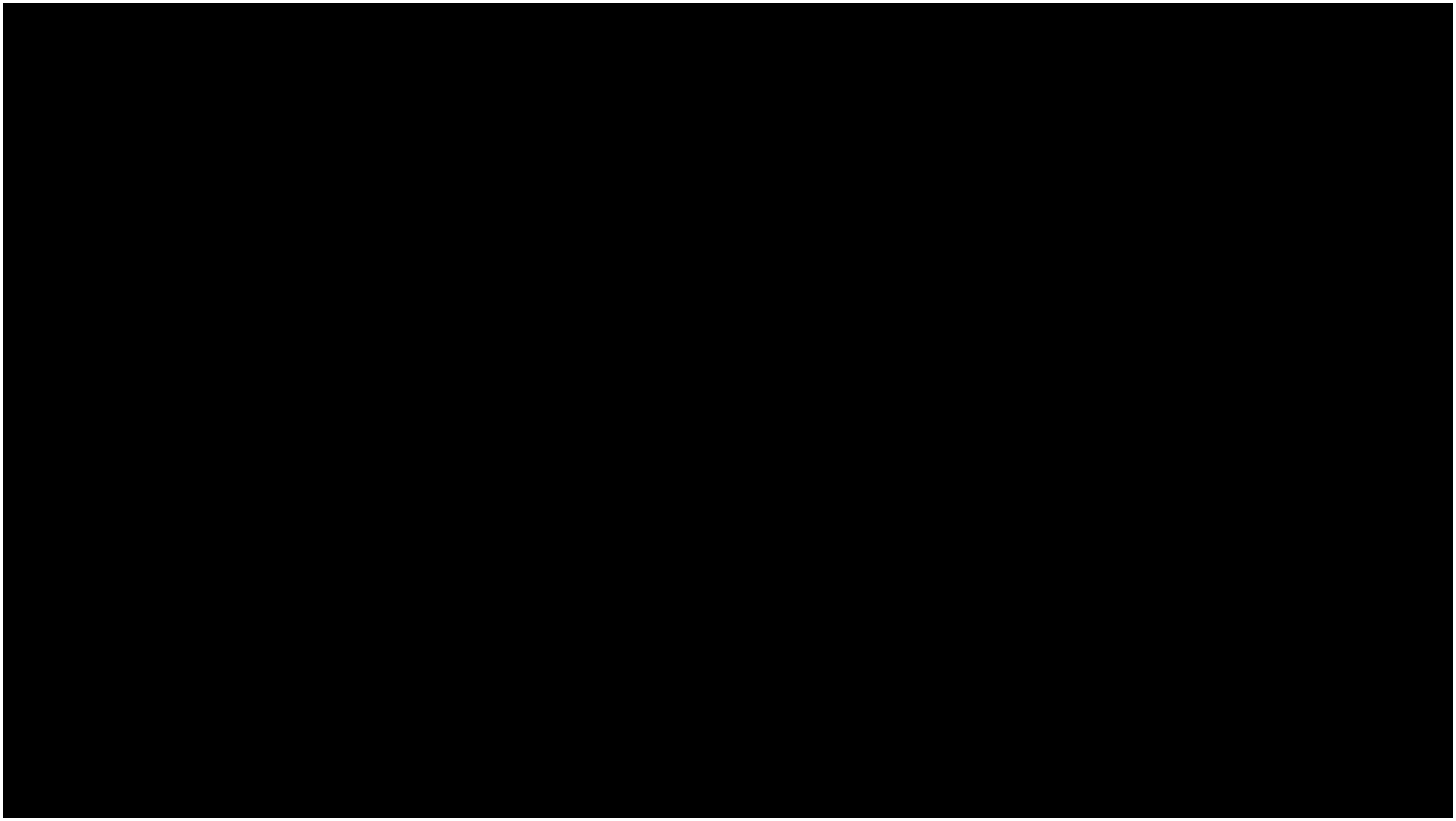
Psyche: NASA's Mission to Explore a Metal World Using Electric Propulsion

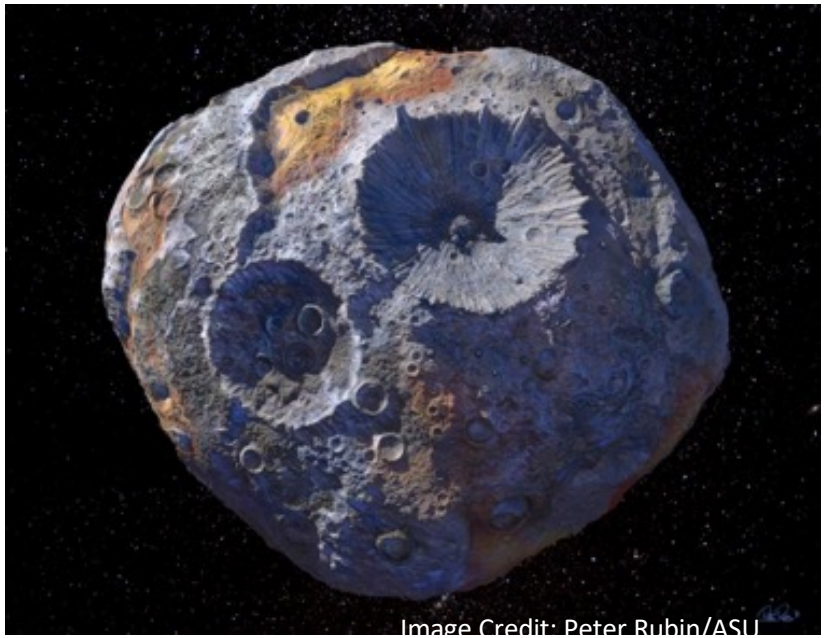
Dan M. Goebel, Ph.D.
Jet Propulsion Laboratory
California Institute of Technology
and the Psyche Team

July 9th, 2024

Launch thru Separation Video



Why (16) Psyche?



- 16th asteroid, discovered in 1852
- **Largest M-type "Metal" asteroid**
- Composition determined by radar studies
- Very high density/strong gravity
- Predicted to be 30-60% metal

- "Not just unique, but an improbable body"

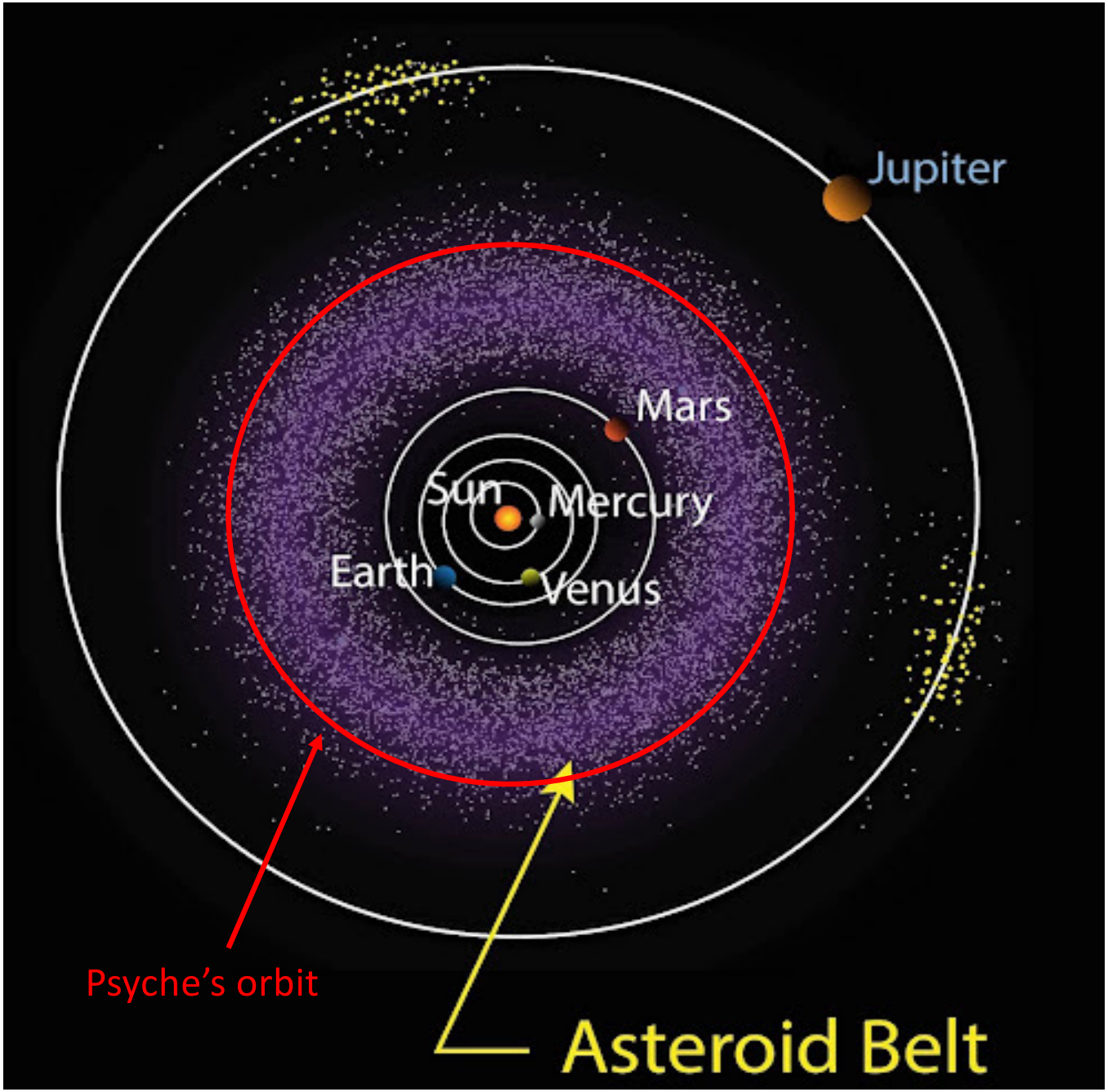
- Creation hypothesis
  - *Psyche is the exposed core of larger planet that was forming*

  or
  - *Psyche was created by a slow accretion of metal-rich material near the sun*

Psyche Size

Vemaps.com https://vemaps.com/uploads/img/large/eu-c-04.jpg

Psyche Location

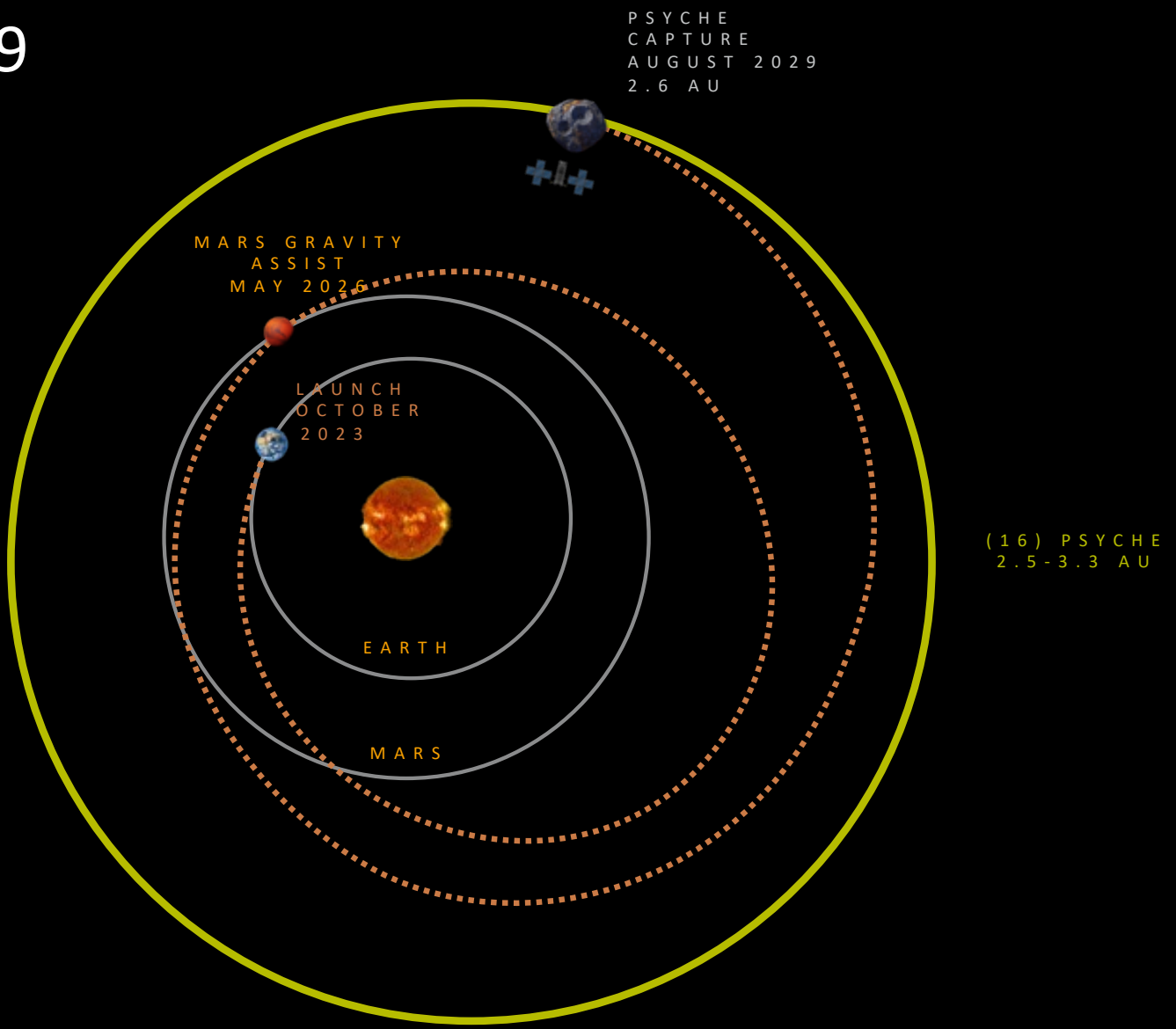


≈ 3 AU

Psyche Launch Period:

October 5-25, 2023

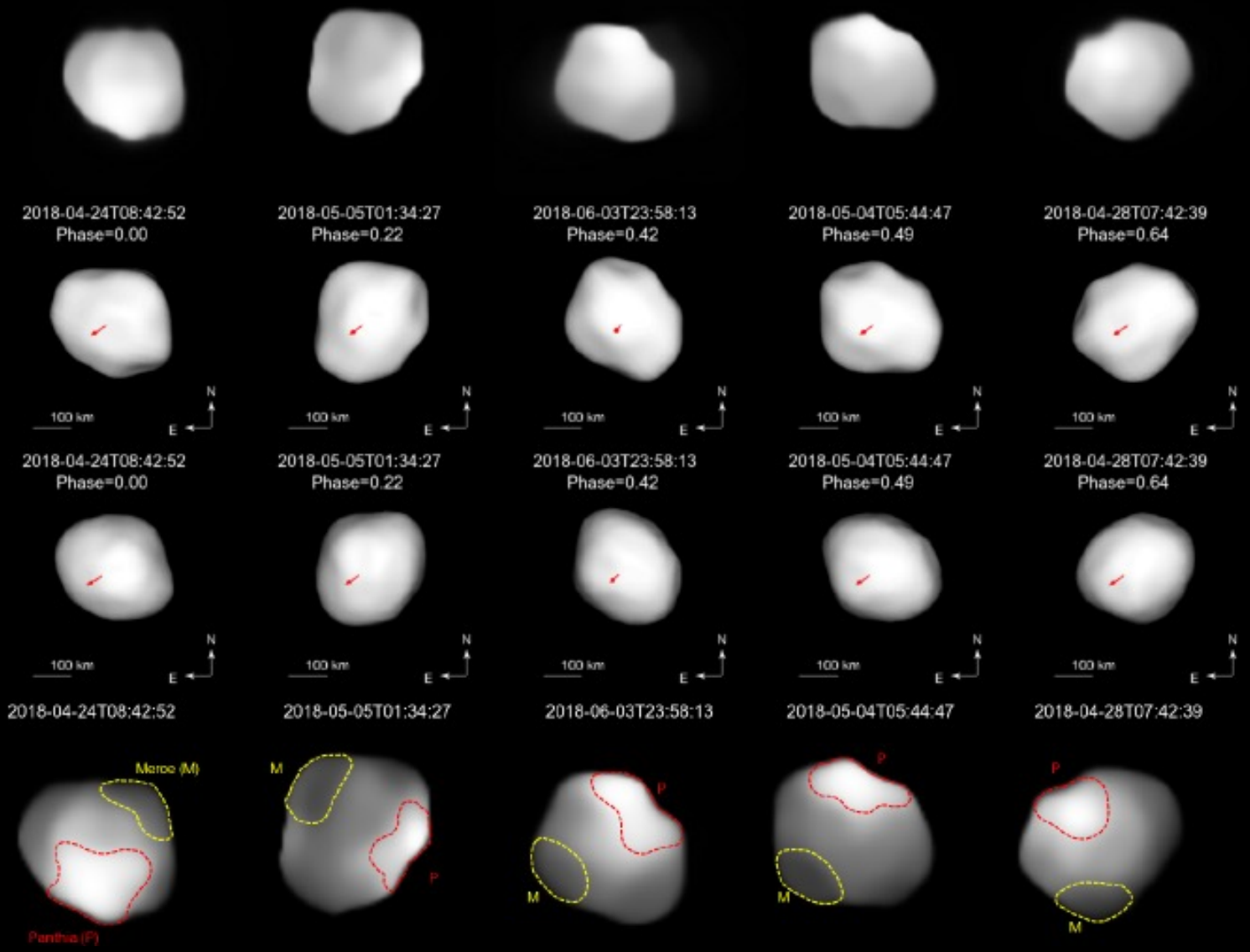
Arrival: August 2029



We do not know what Psyche looks like

Image by Patrick Young and Karen Knierman

Psyche shape

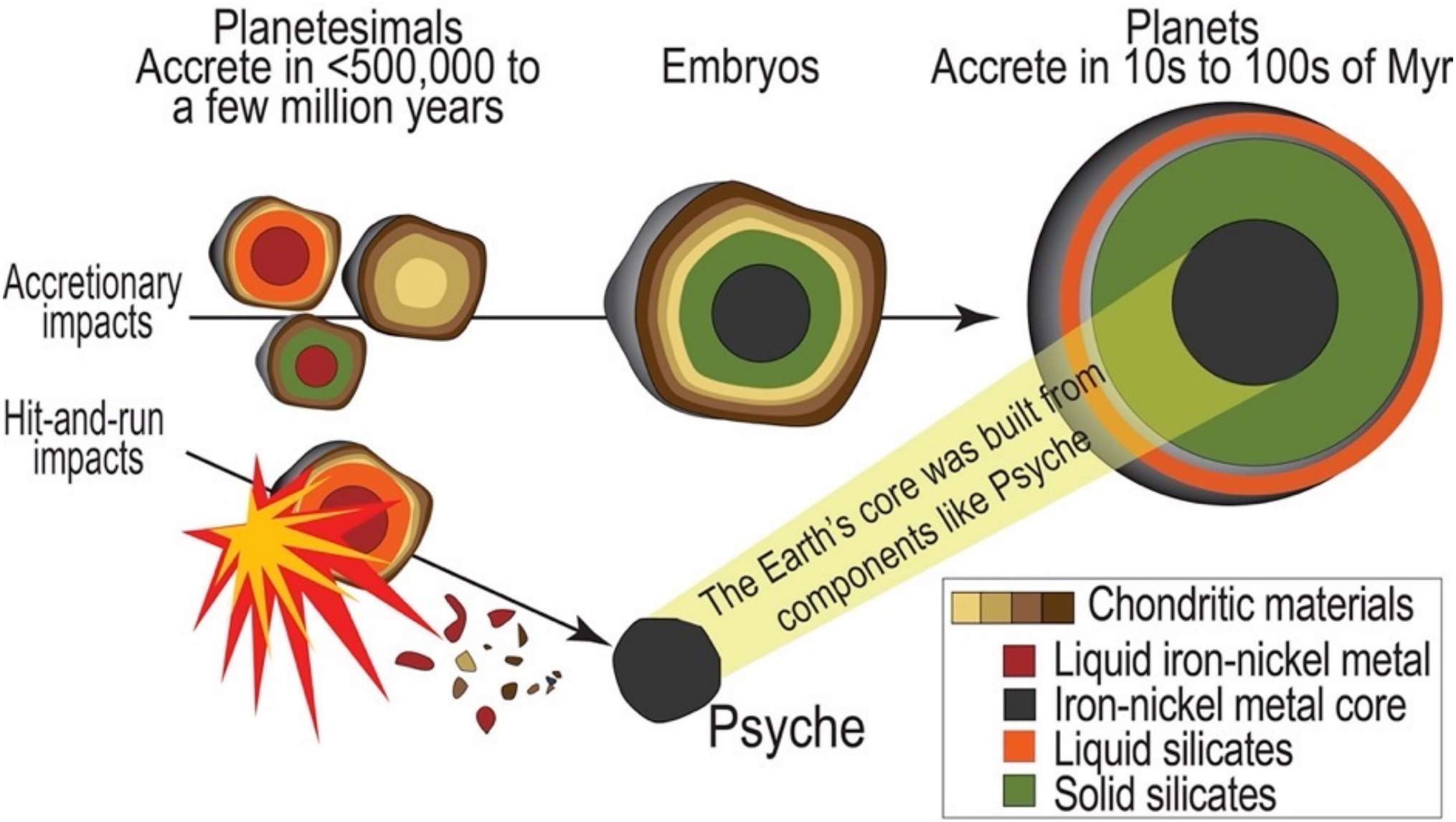


Psyche rotates every 4.2 hours, and is more of a potato shape than it is a sphere.

Viikinkoski et al. (2018) Astronomy & Astrophysics

Images taken using SPHERE, the Spectro-Polarimetric High-contrast Exoplanet Research instrument at the European Southern Observatory

How Psyche Formed*

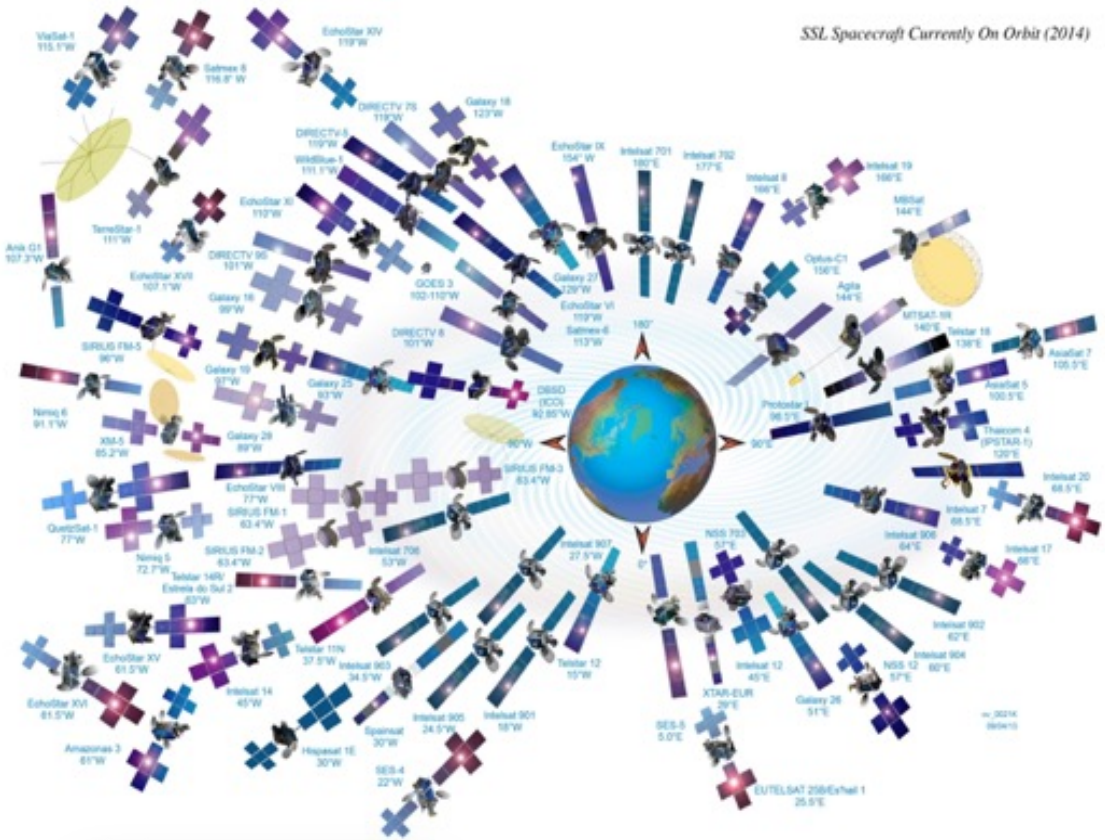


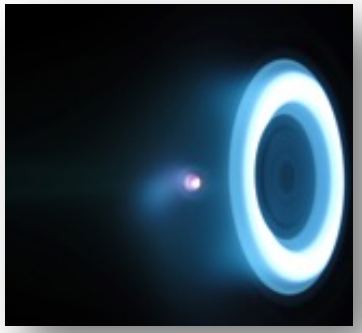
*only likely hypothesis

The Psyche Spacecraft

Maxar (formally SSL)

Commercial GEO spacecraft manufacturing



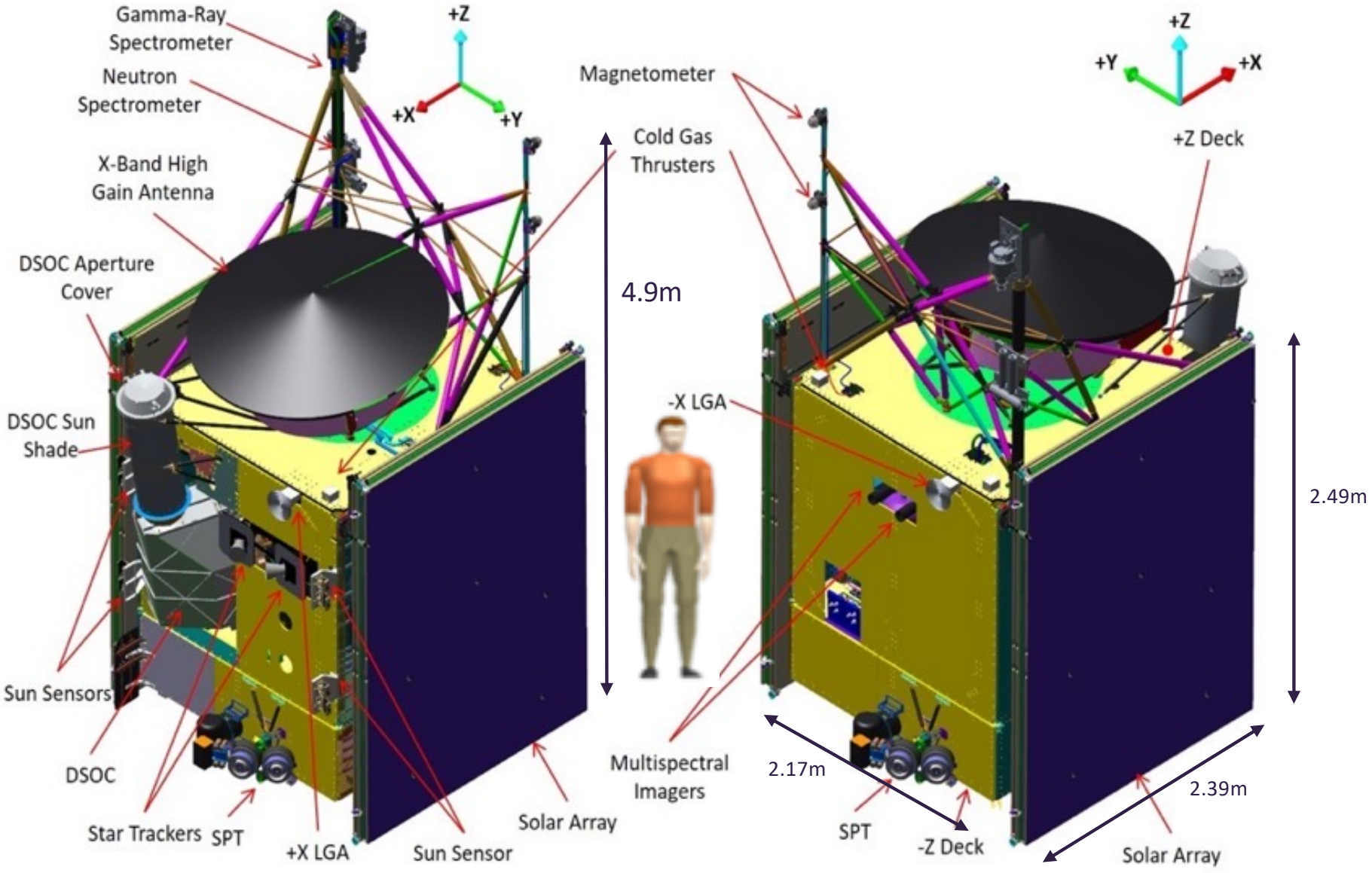


SPT-140 Hall Thruster

Electric Propulsion

High Power spacecraft (> 20 kW)

Psyche (Stowed)

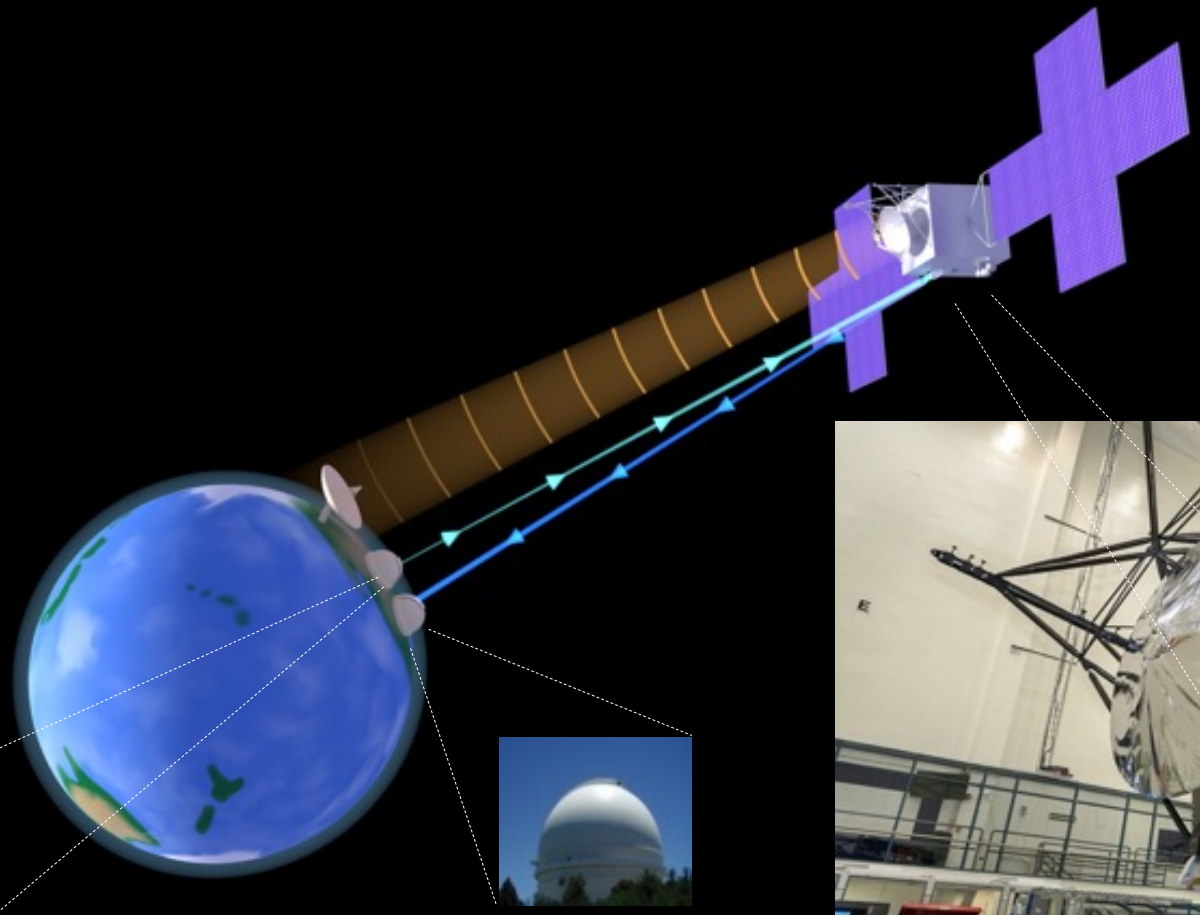


Fully Assembled Spacecraft at Launch Base

Spacecraft without solar arrays

Spacecraft without solar arrays

Deep Space Optical Communications (DSOC)

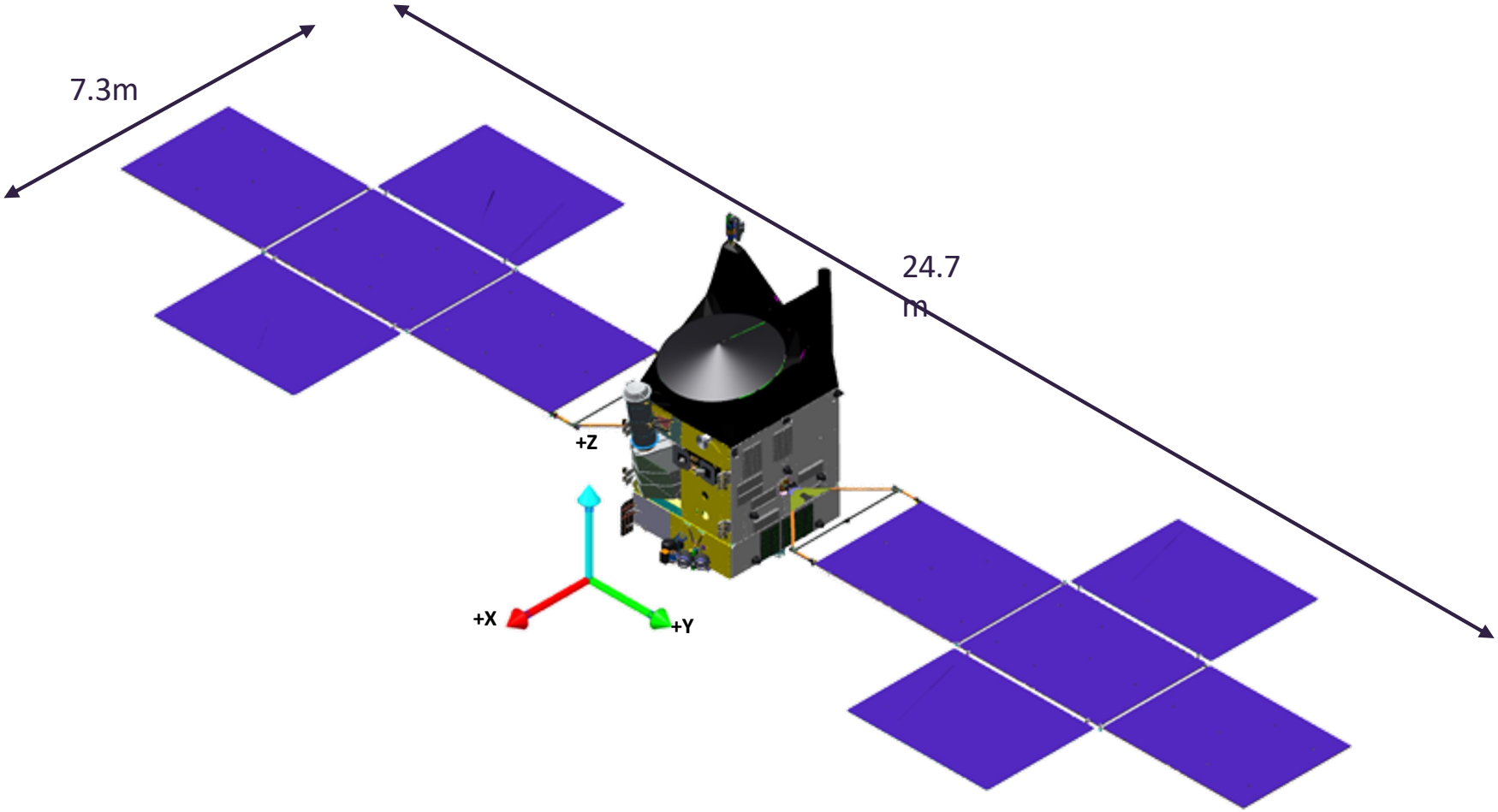


Ground Laser Transmitter (GLT)
Table Mountain, CA
1m-OCTL Telescope (5 kW)

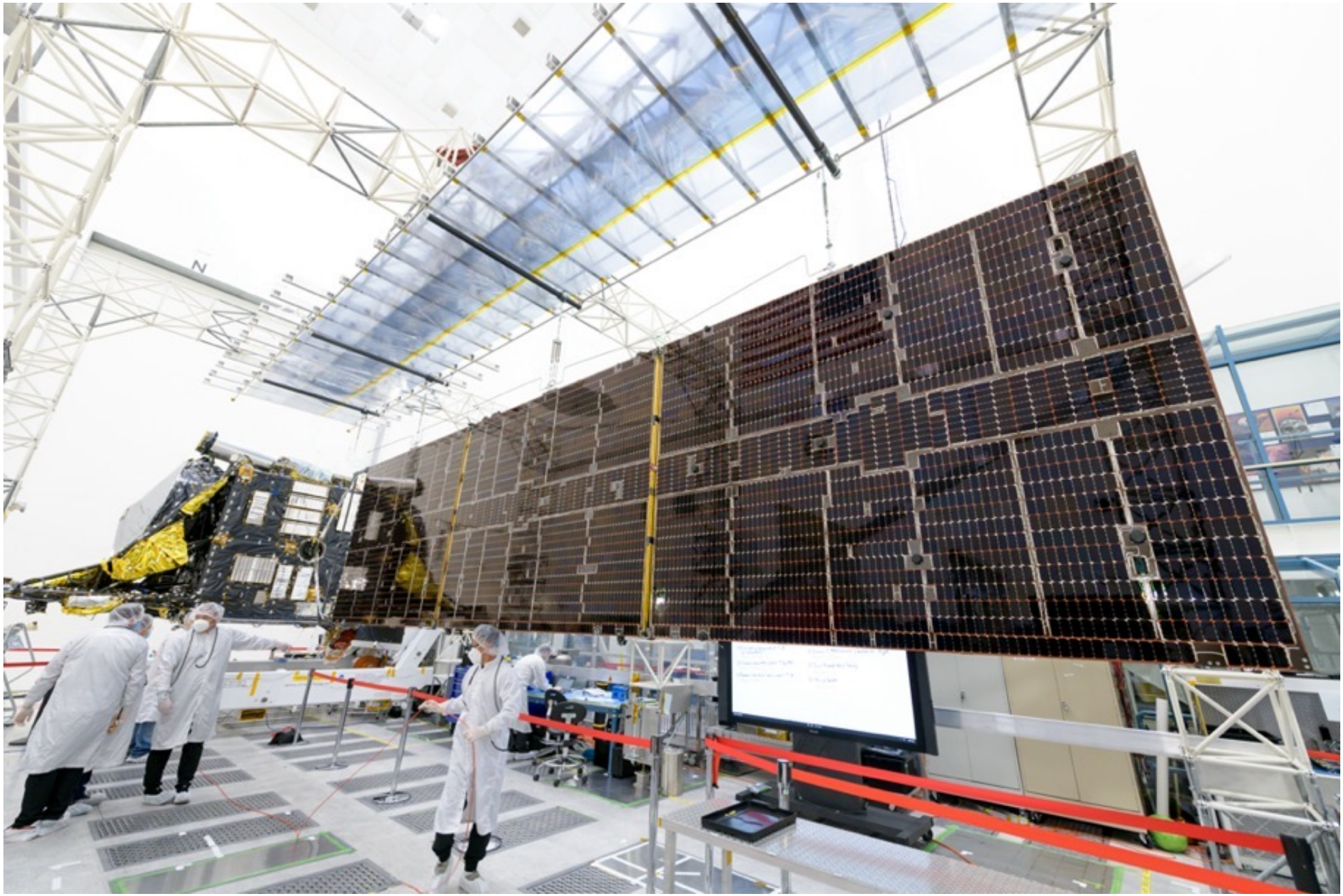
Ground Laser Receiver (GLR)
Palomar Mountain, CA
5m-dia. Hale Telescope

Flight Laser Transceiver

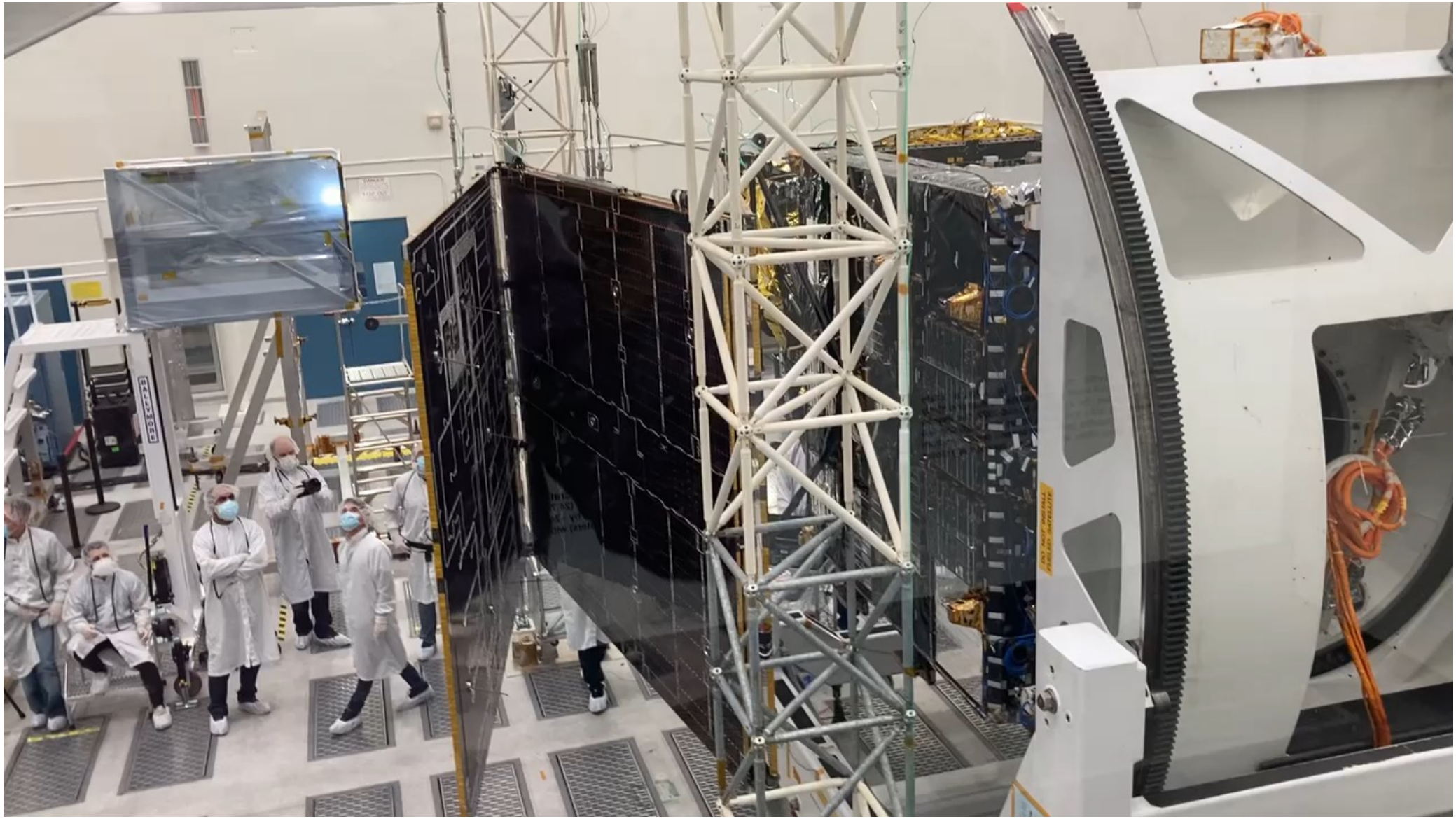
Psyche (Deployed)



With one solar array wing partially deployed



Solar array deployment test



In sine vibration testing

Science Goals

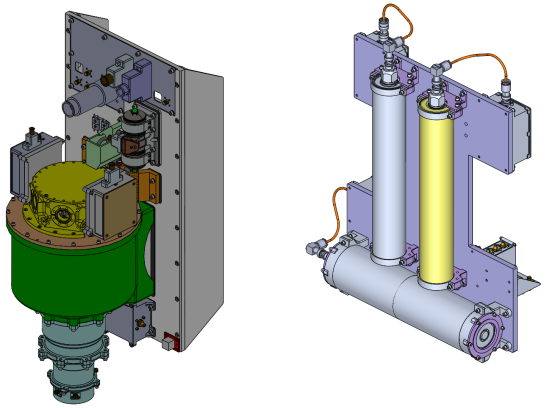
1. Understand a previously unexplored building block of planet formation: Iron cores

2. Look inside the terrestrial planets, including Earth, by directly examining the interior of a differentiated body, which otherwise could not be seen.

3. Explore a new type of world. For the first time, examine a world made not of rock or ice, but of metal.

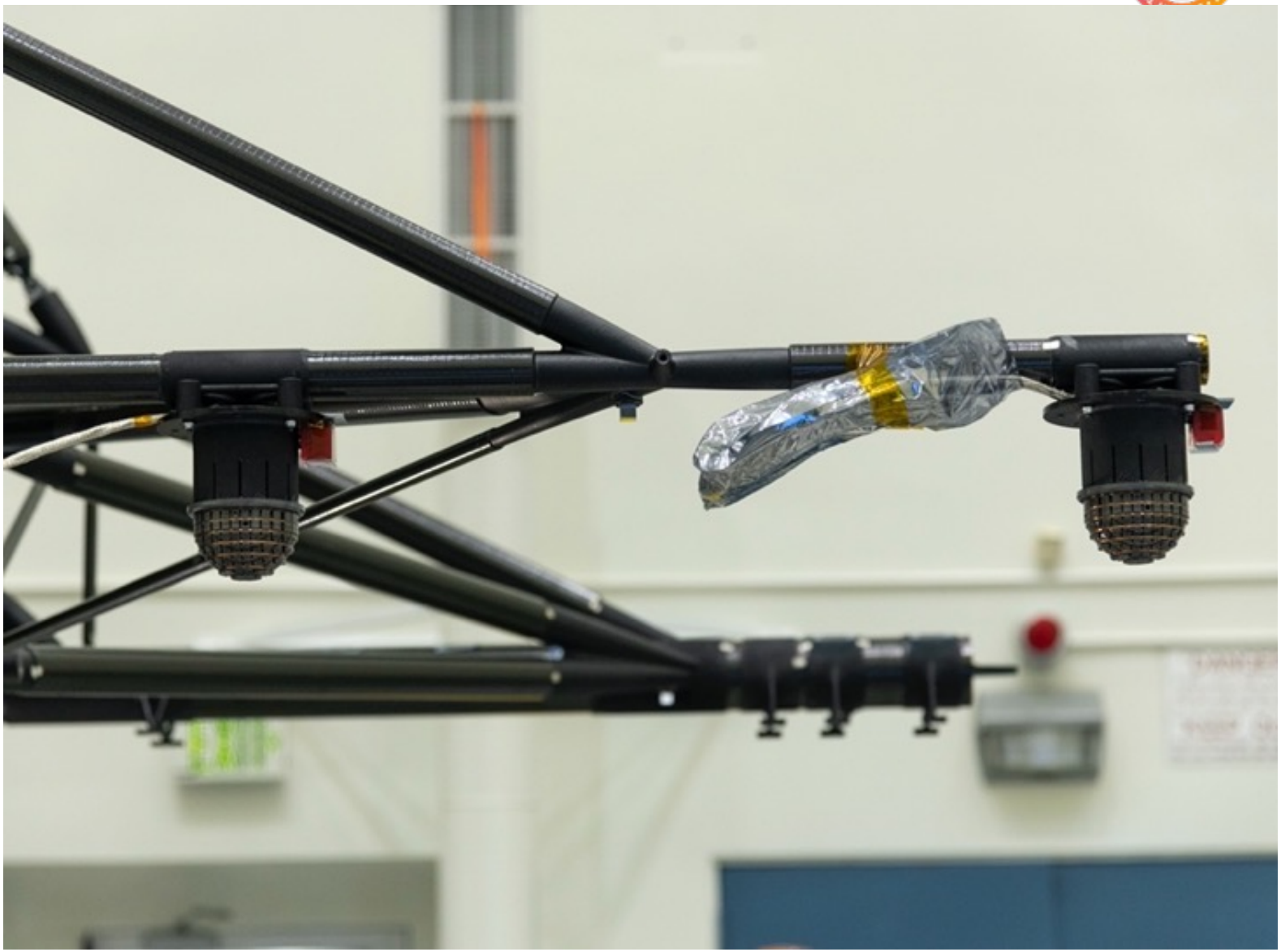
Multispectral Imager

Magnetometer



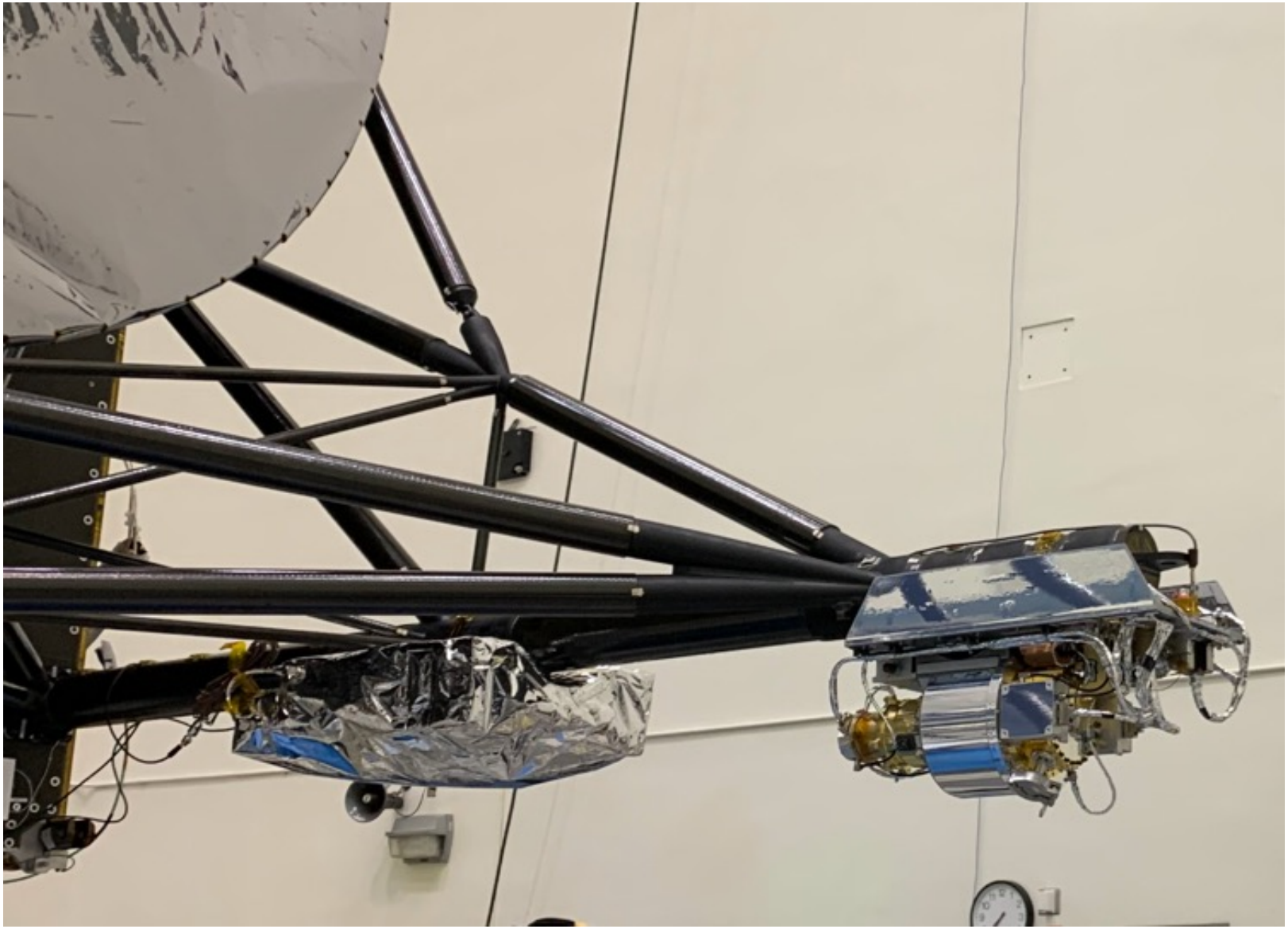
Gamma-Ray and Neutron Spectrometer

Magnetometers installed on the spacecraft



NASA Psyche mission

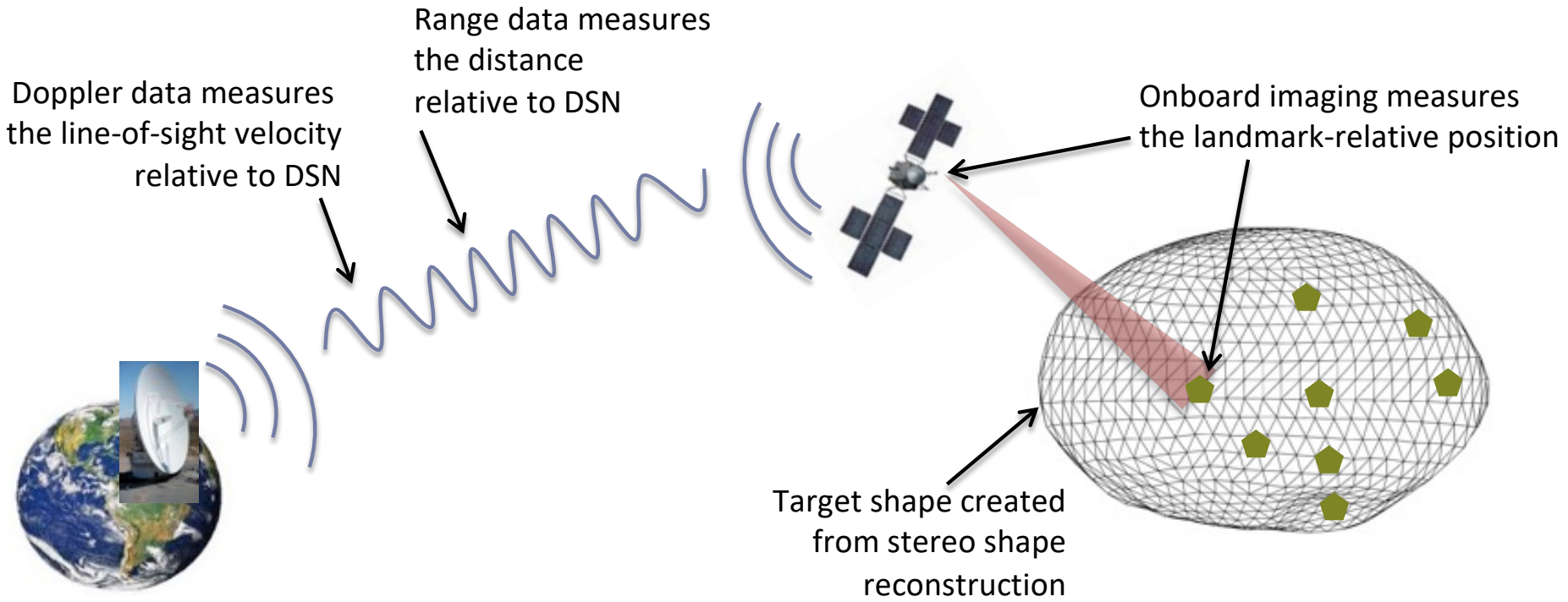
Gamma ray and neutron spectrometer installed Aug. 2021



NASA Psyche mission

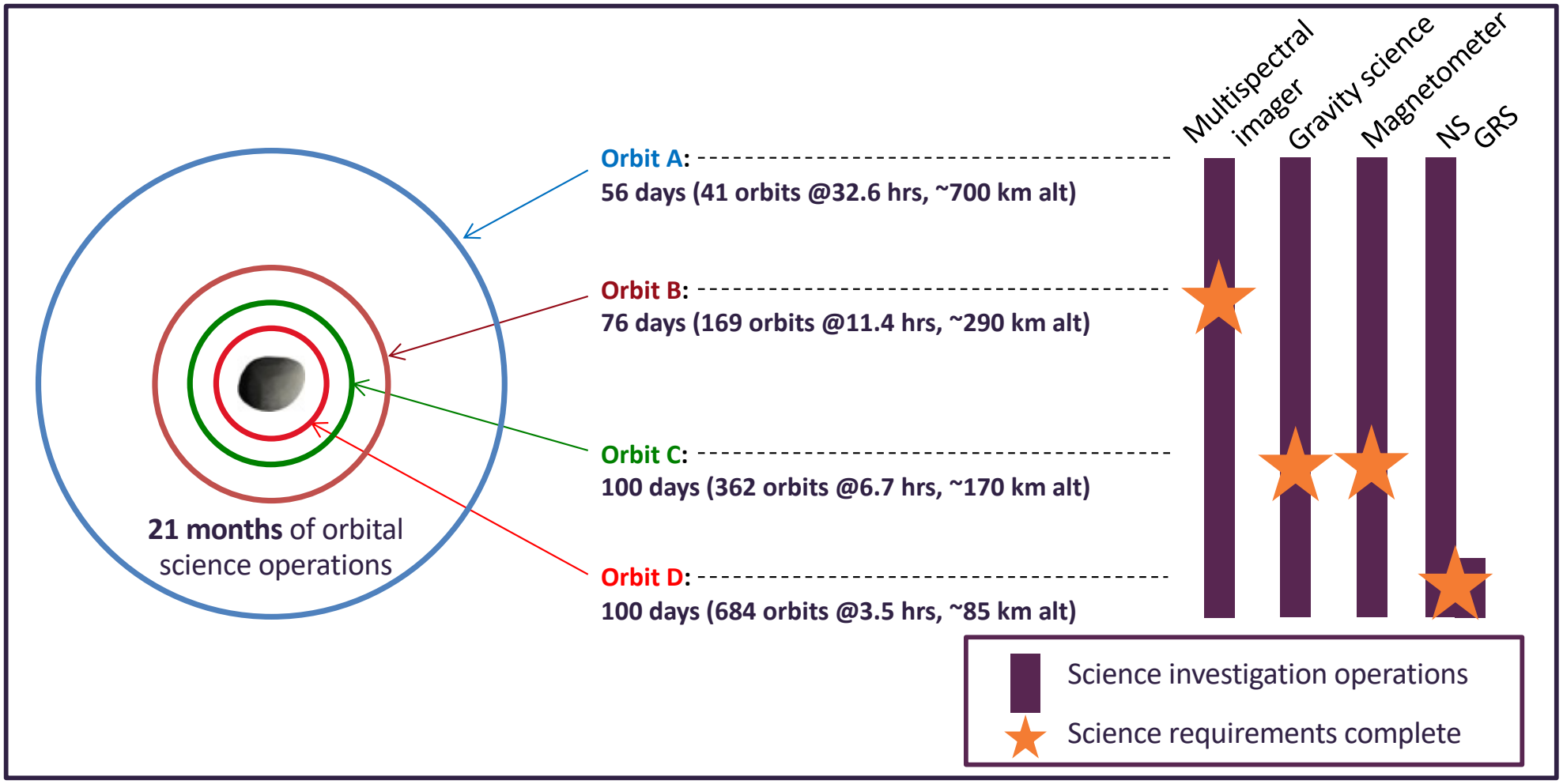
Also need shape/gravity models to navigate around it

Psyche Radio Science

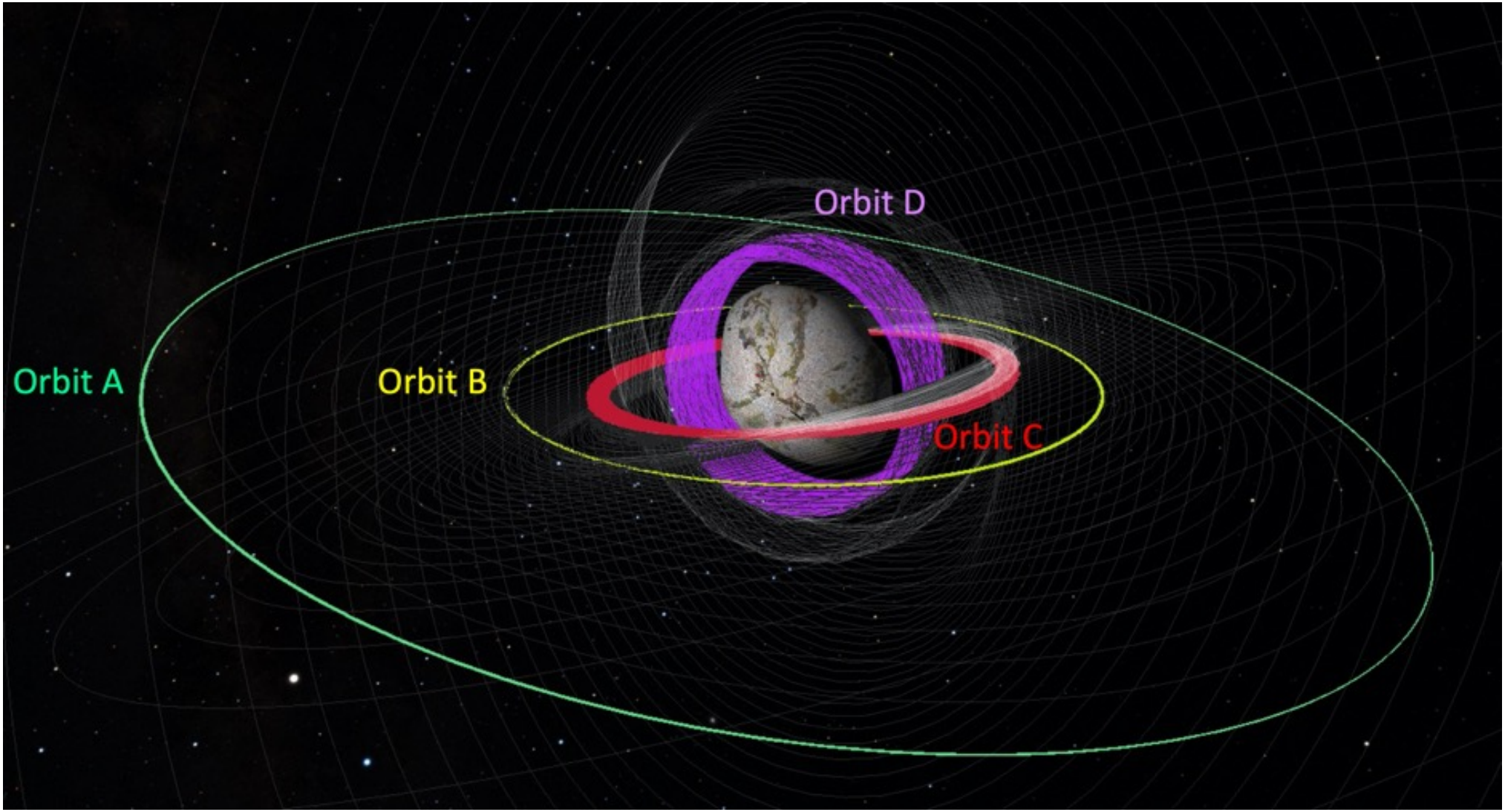


Developed by JPL+MIT with heritage from Dawn

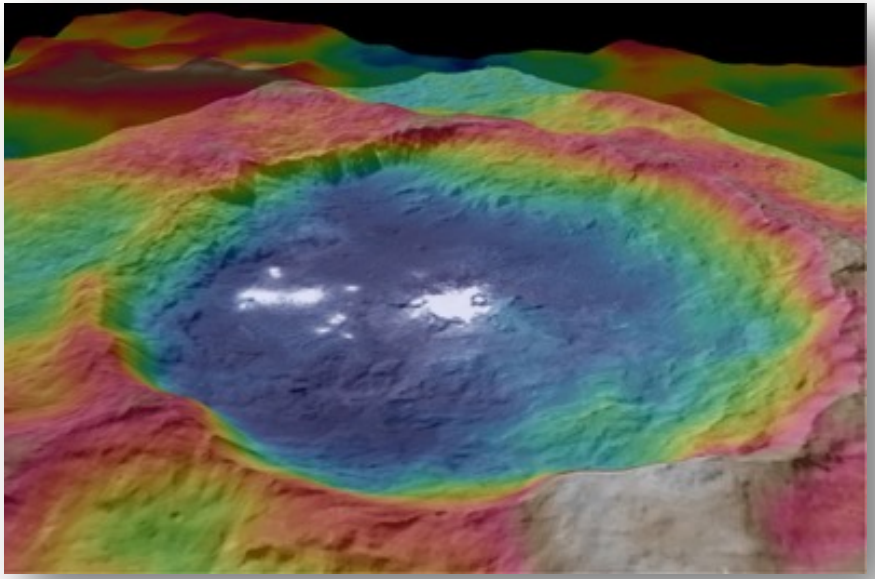
Science operational modes are in 4 orbits



Science orbits

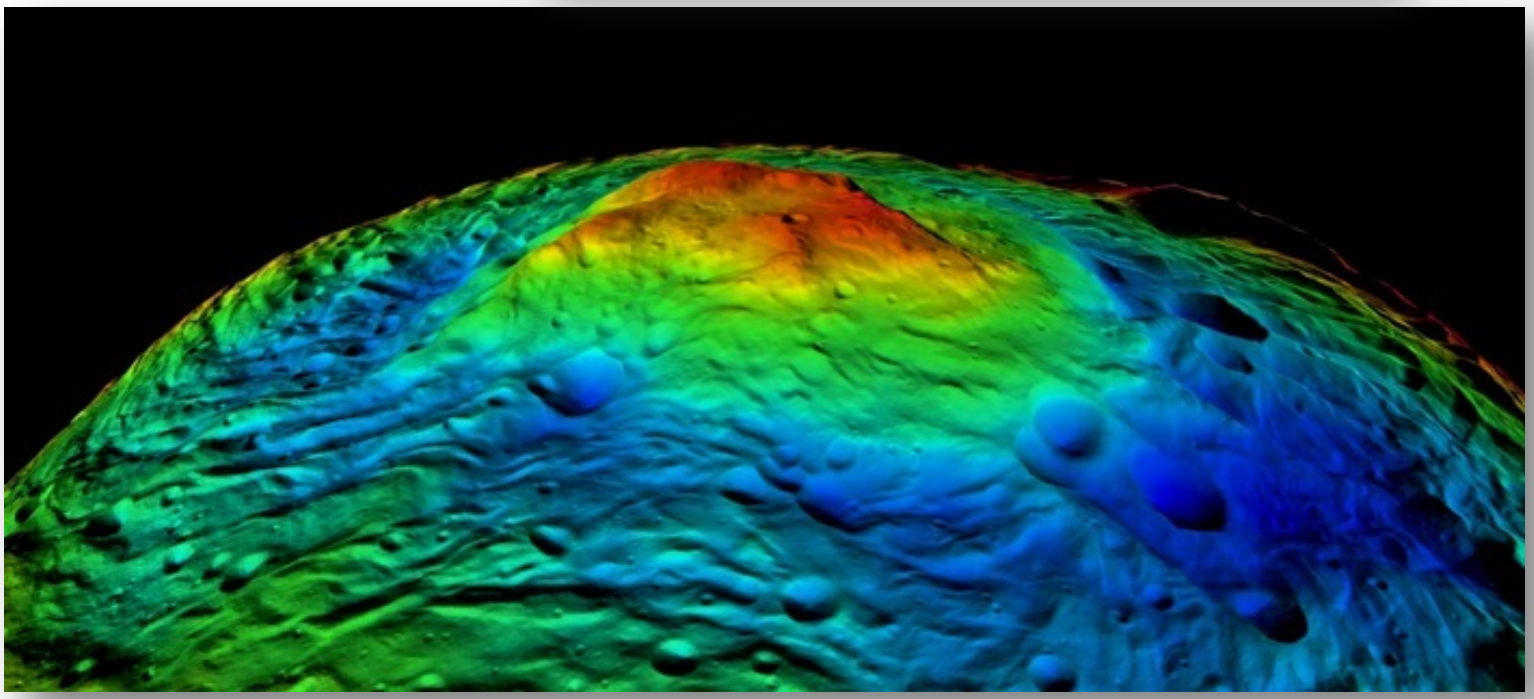


Characterize Psyche's surface



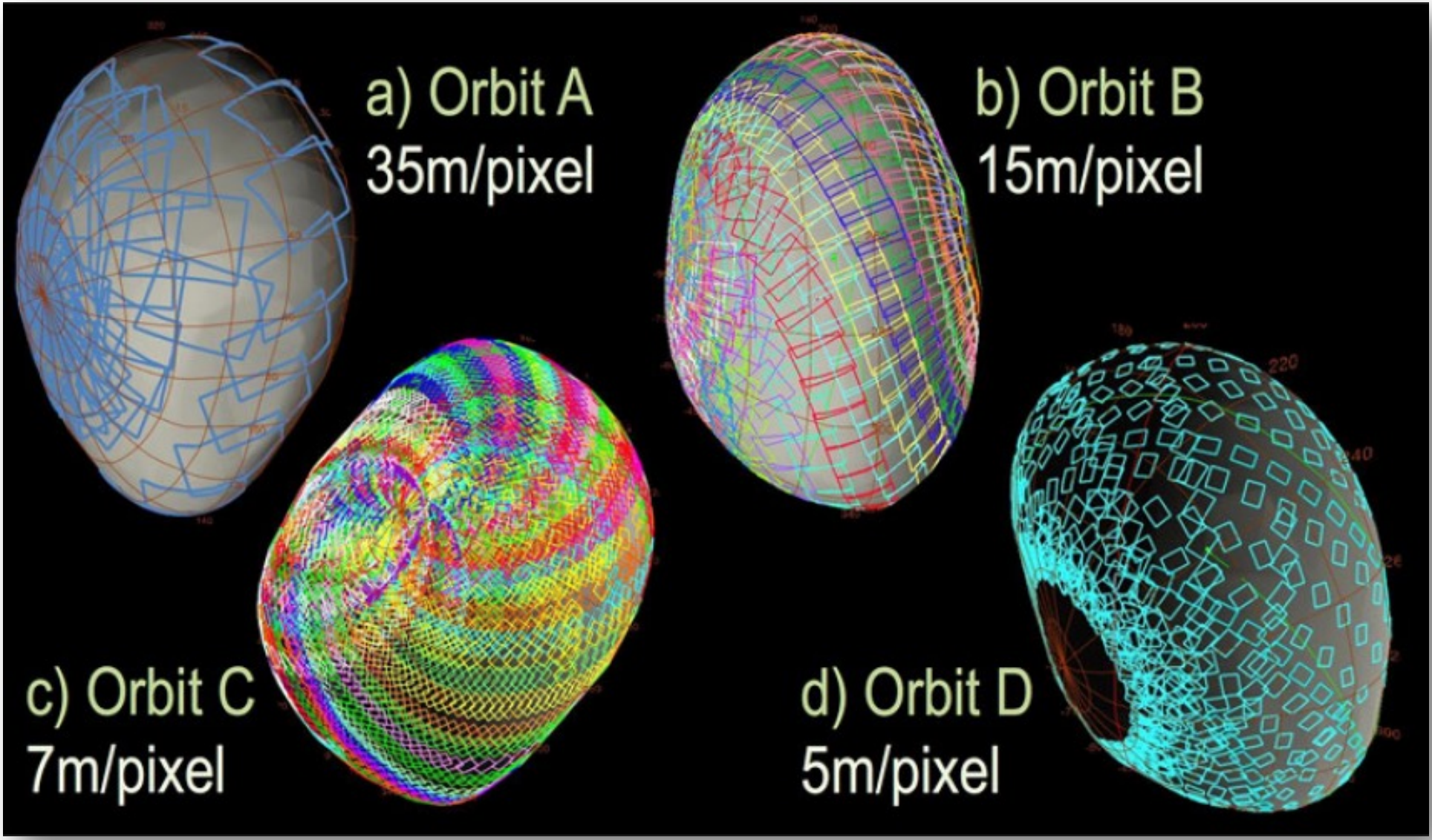
Ceres (top) and
Vesta (bottom)

Dawn mission
NASA/JPL-Caltech/UCLA/MPS/DLR/IDA



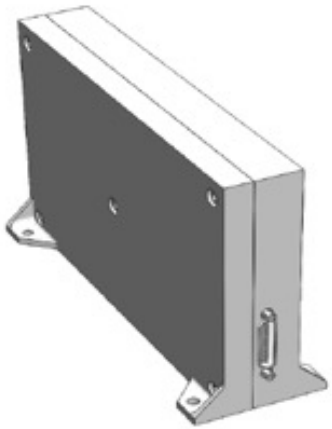
Surface structure
and
Composition

Orbit the asteroid and take thousands of pictures



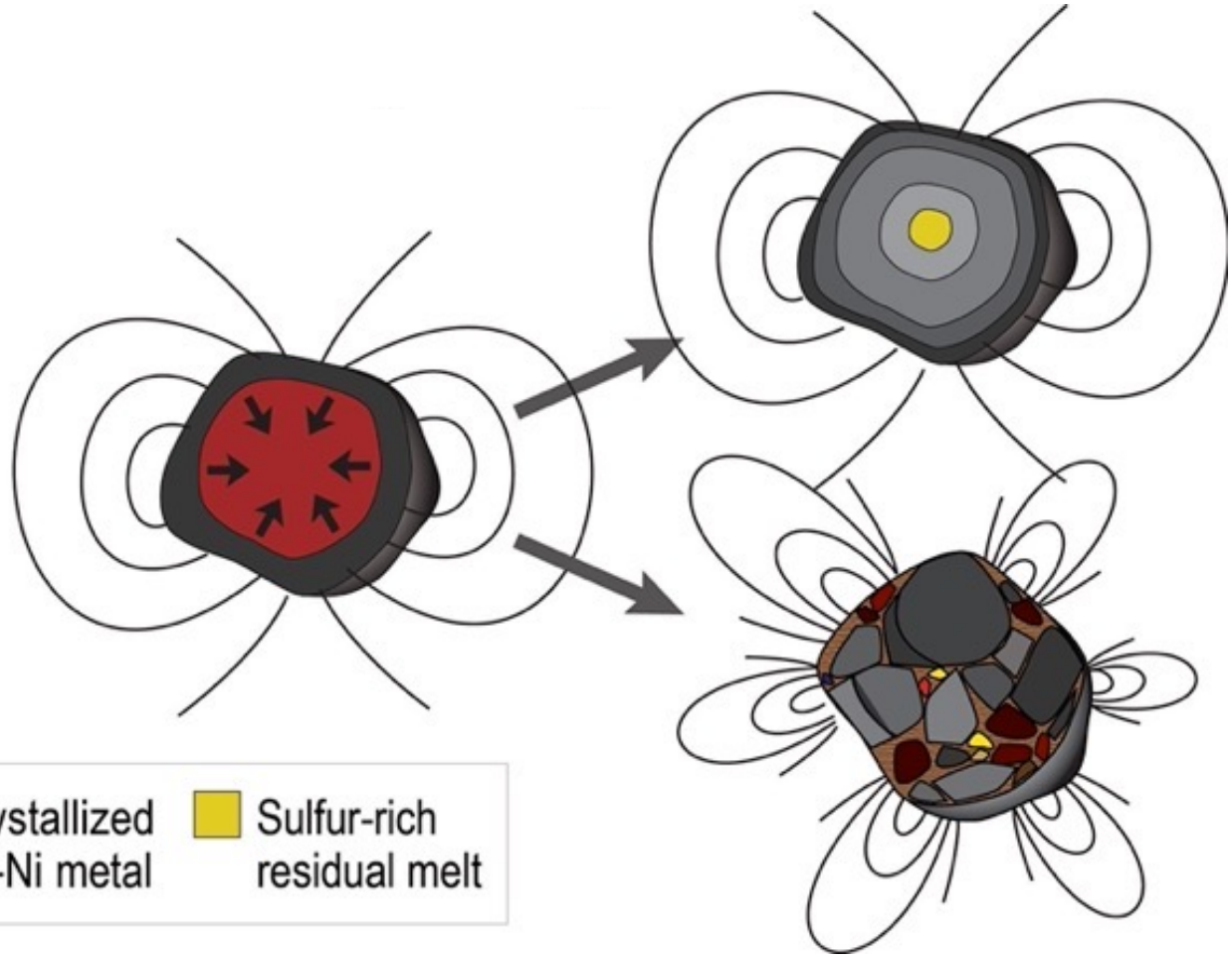
Measure the magnetic field*

Magnetometers



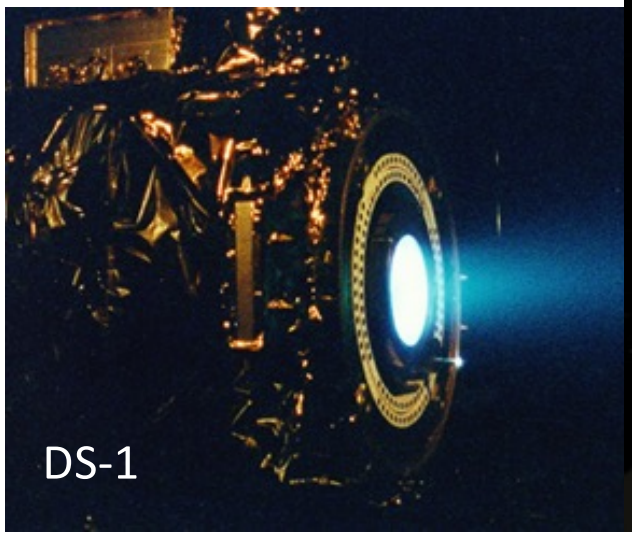
Single Electronics

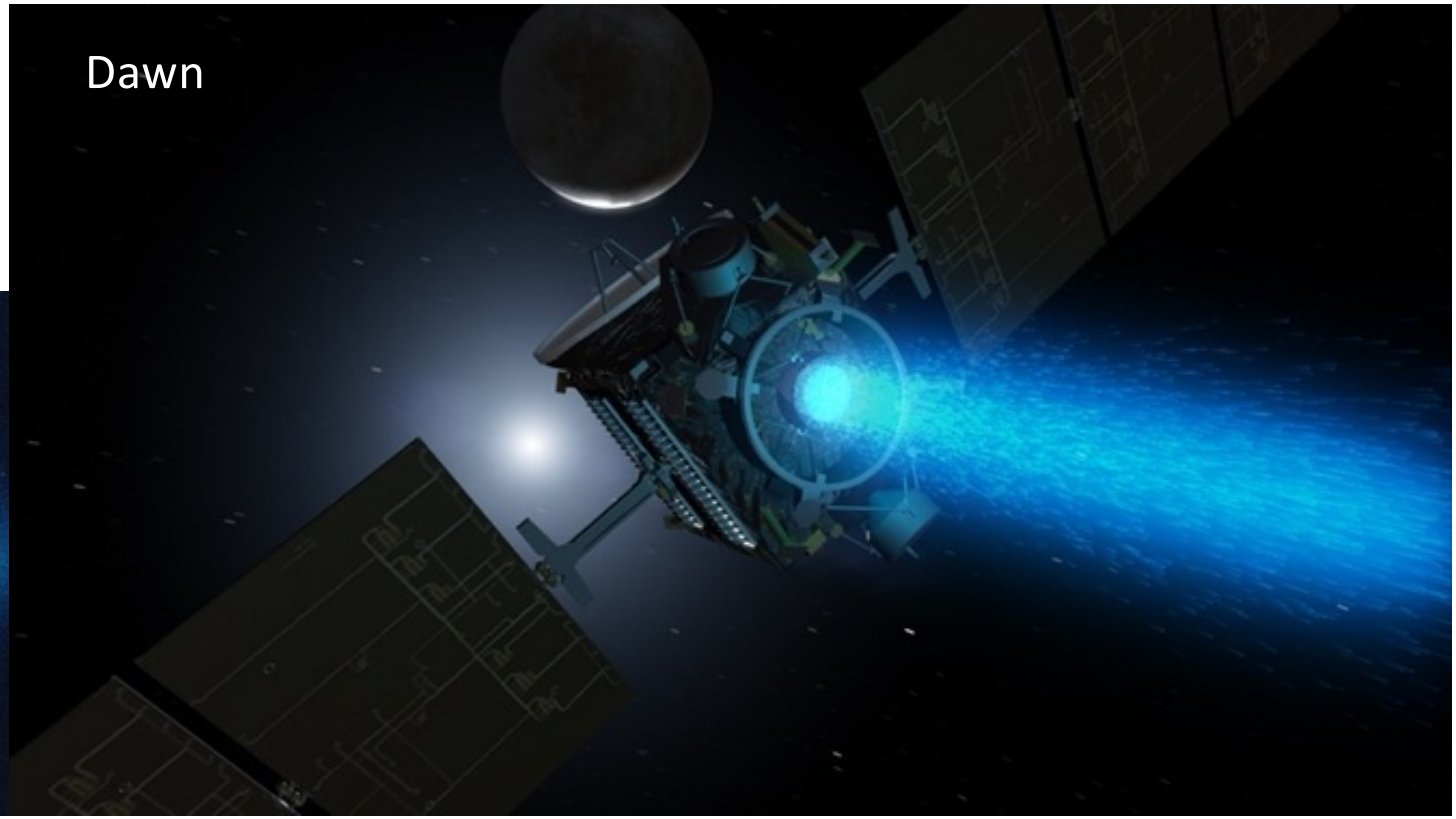
Single Sensor



*hopefully there is one; then Psyche is definitely a core!

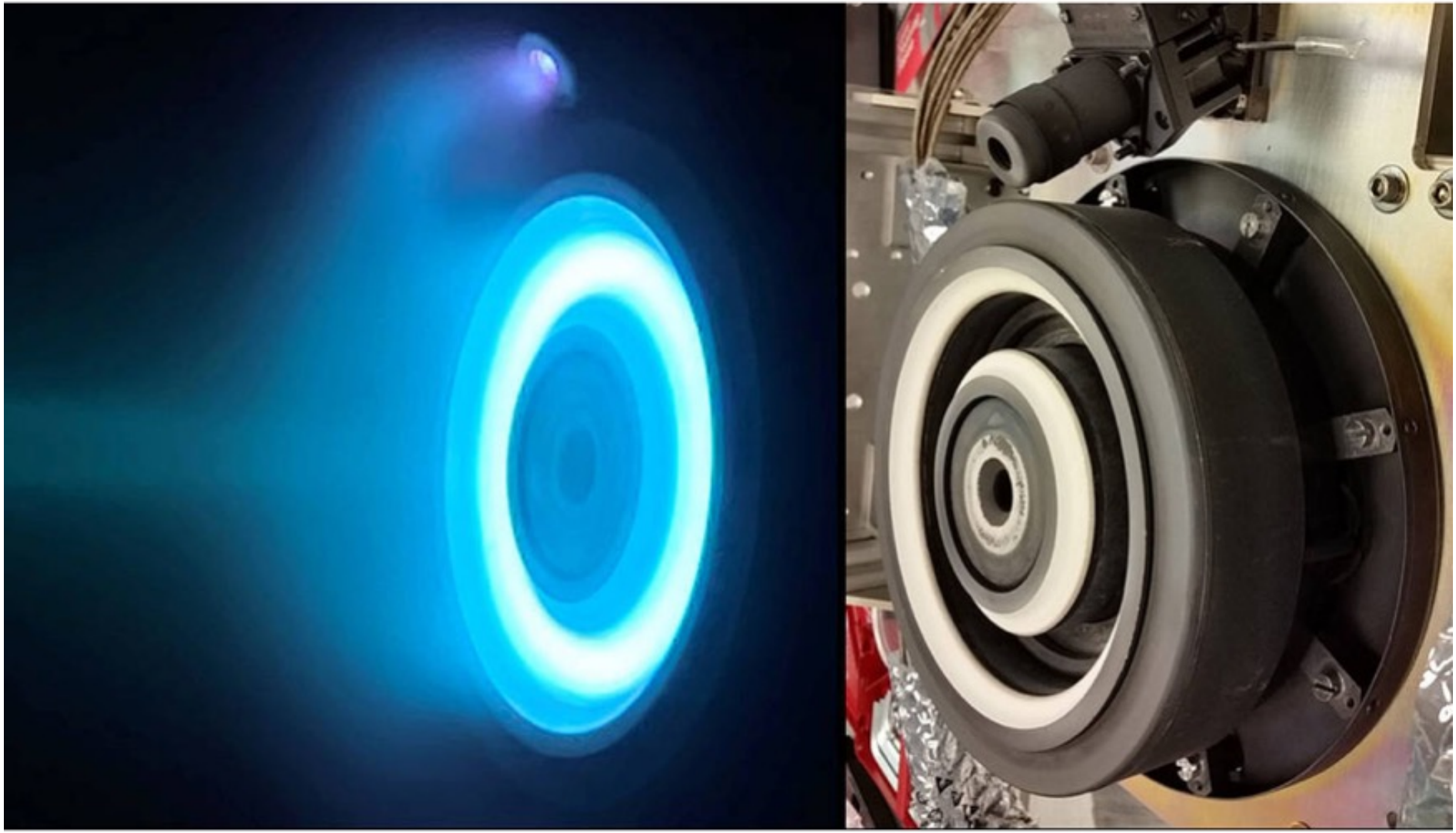
Solar Electric Propulsion





Thruster	NASA NSTAR	SPT-140
Spacecraft	Deep Space 1, Dawn	Geocom S/C, Psyche
Type	NSTAR Ion thruster	SPT-140 Hall thruster
First flight	1998	2018/2023
Maximum power	2.3 kW	4.5 kW
Max thrust	91 mN	262 mN

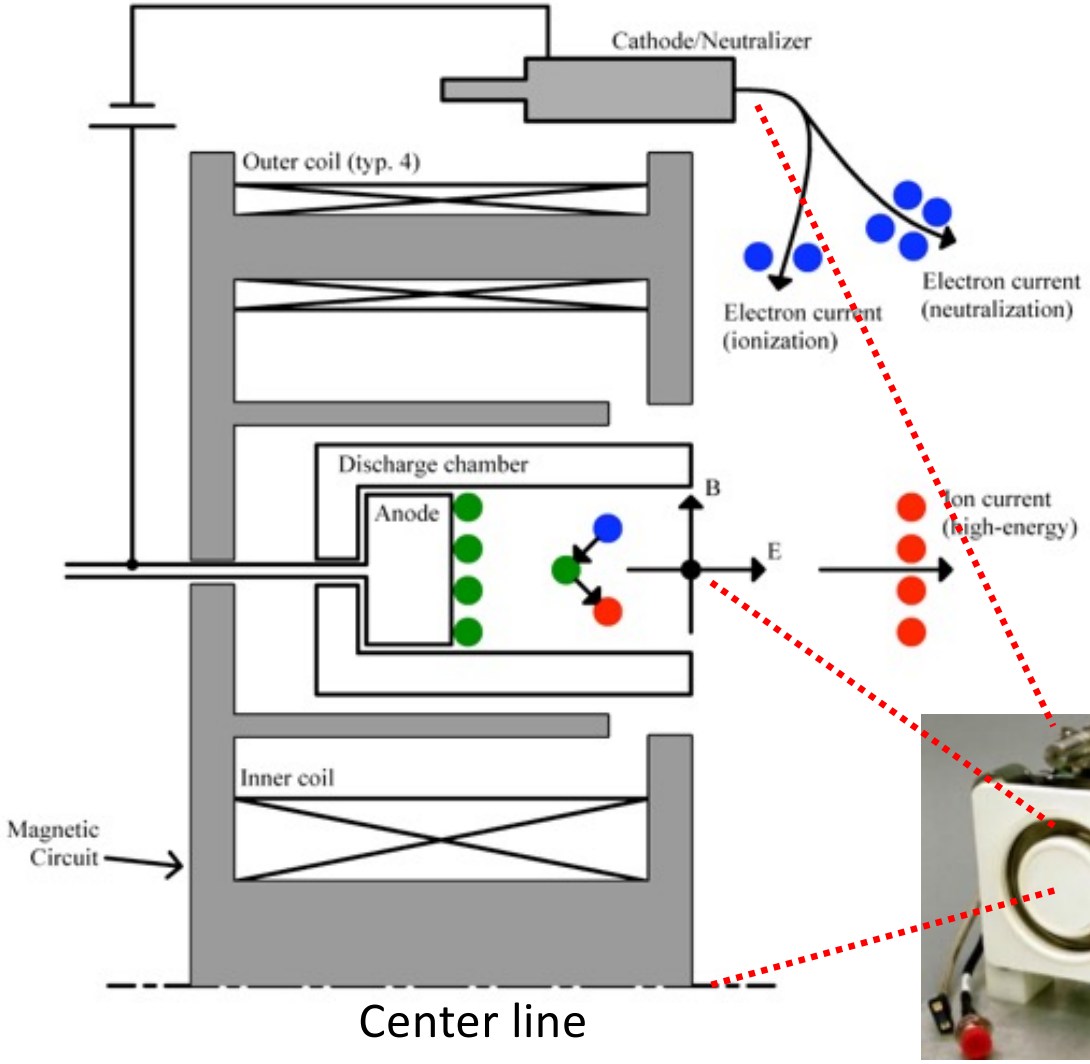
SPT-140 Hall Thruster

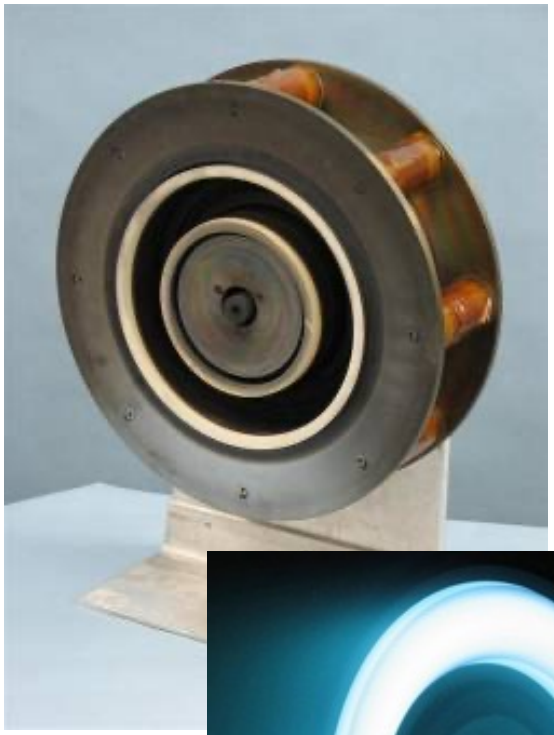


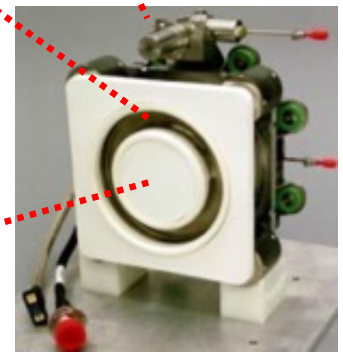
IEEE SPECTRUM MAGAZINE, FEBRUARY 2022

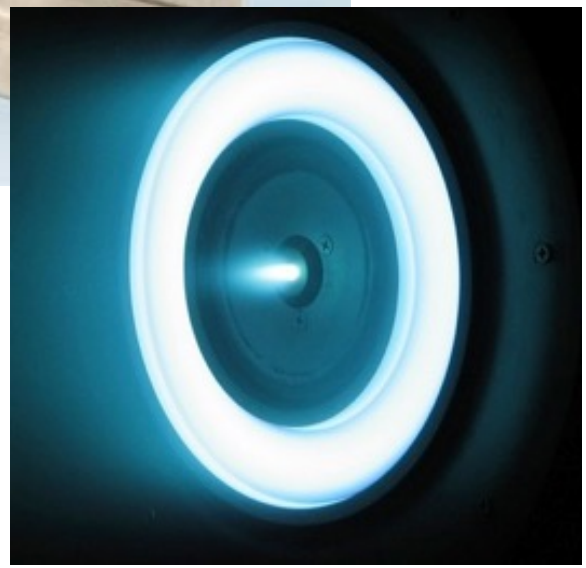
Hall Thruster Geometry

Ion accelerated from an annular channel by applied electric and magnetic fields





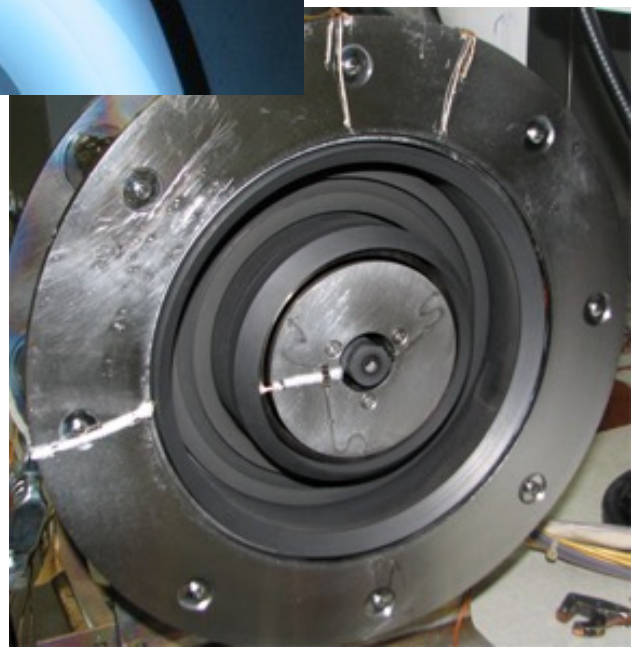




32

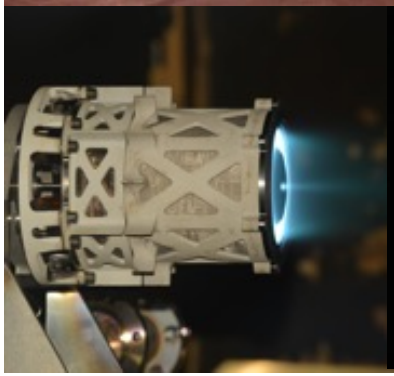
Advances in Hall Thrusters

2010-2012



2012-

High Efficiency, Isp & Power (1 to 100 kW)



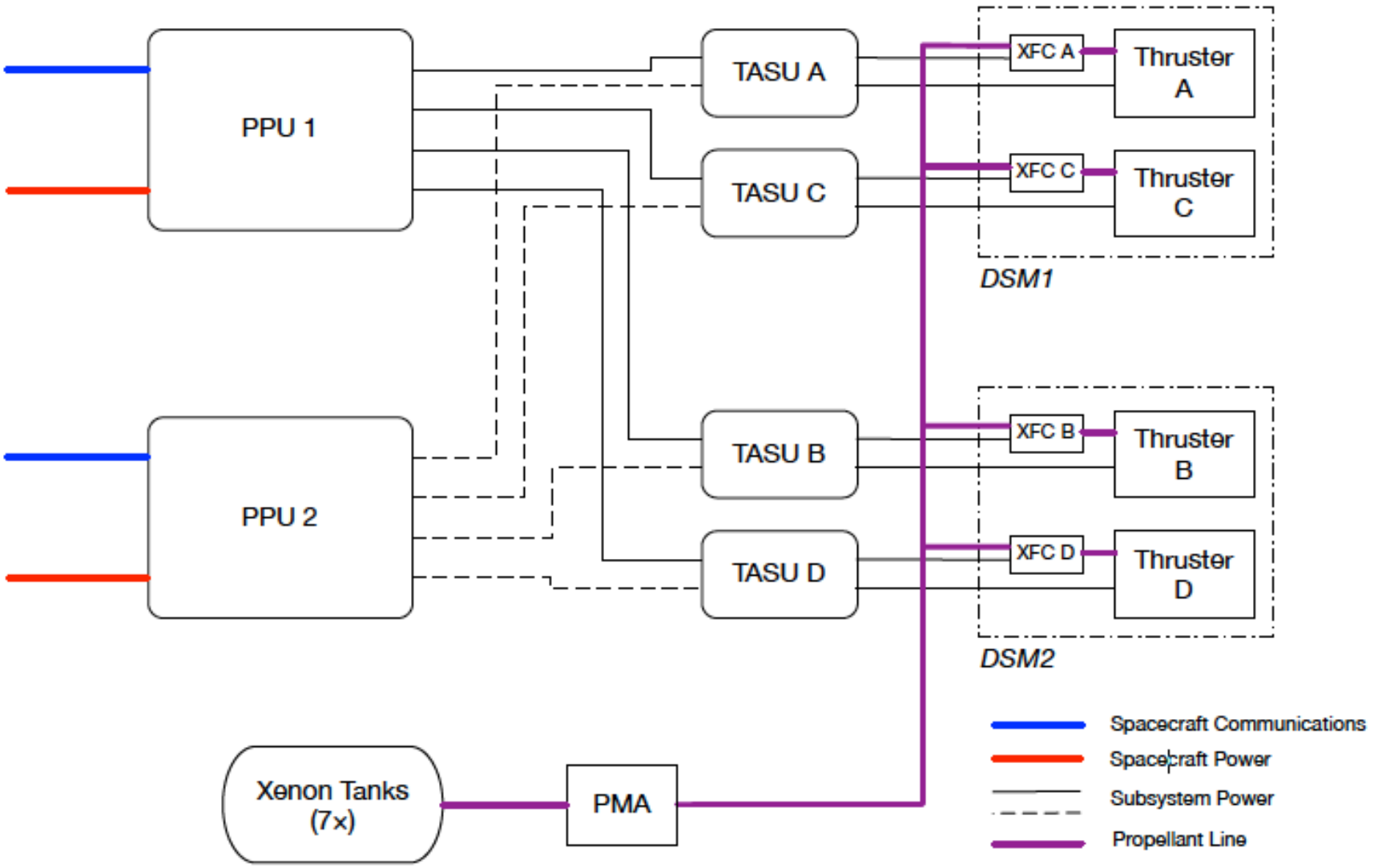
MaSMi thruster (1 kW)

X3 thruster (100 kW)

Major Innovation: **magnetic-shielding** lifetime technology is demonstrated by JPL

Leads to the Black Edition Carbon Wall Hall Thruster

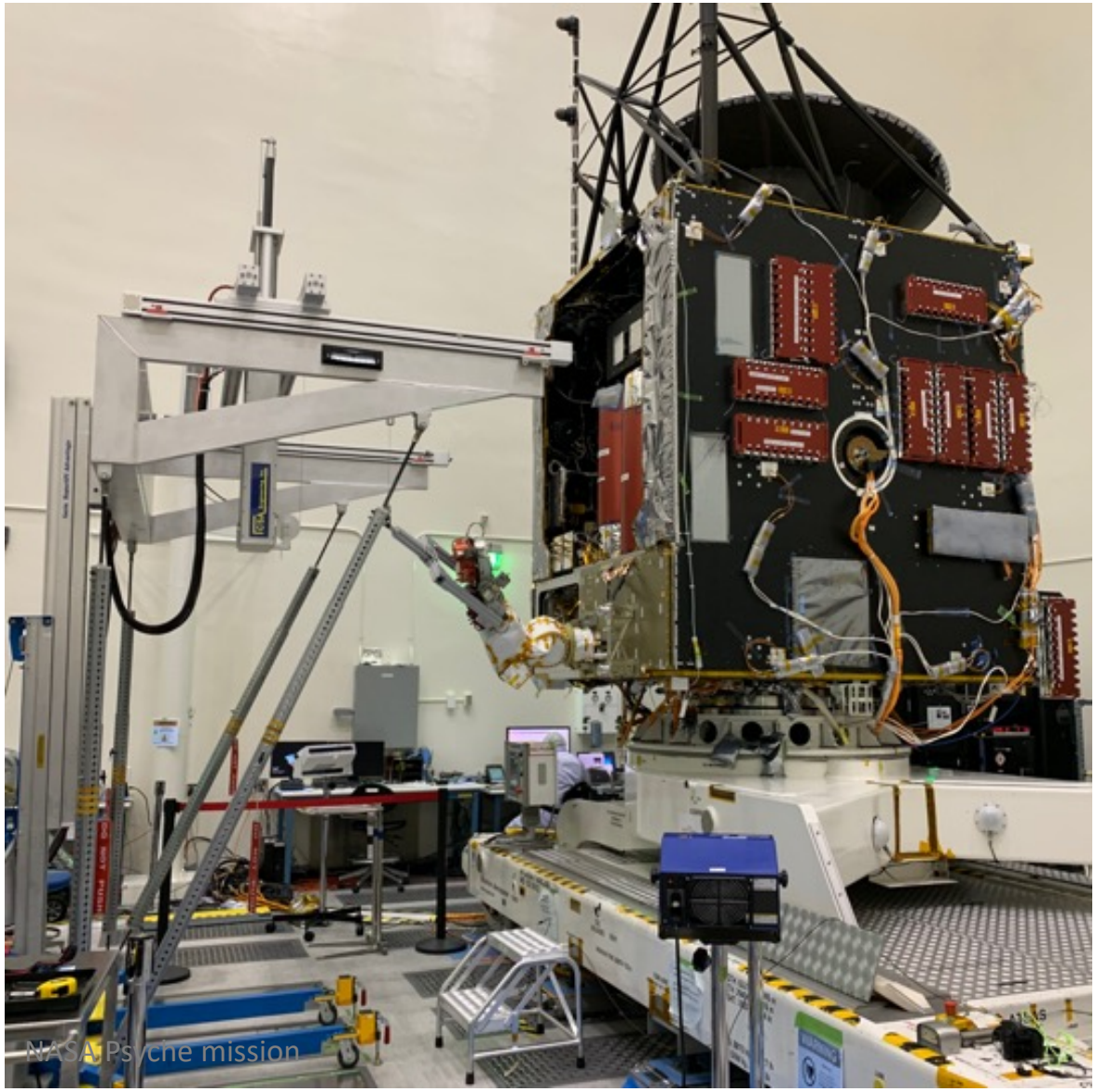
EP Block Diagram

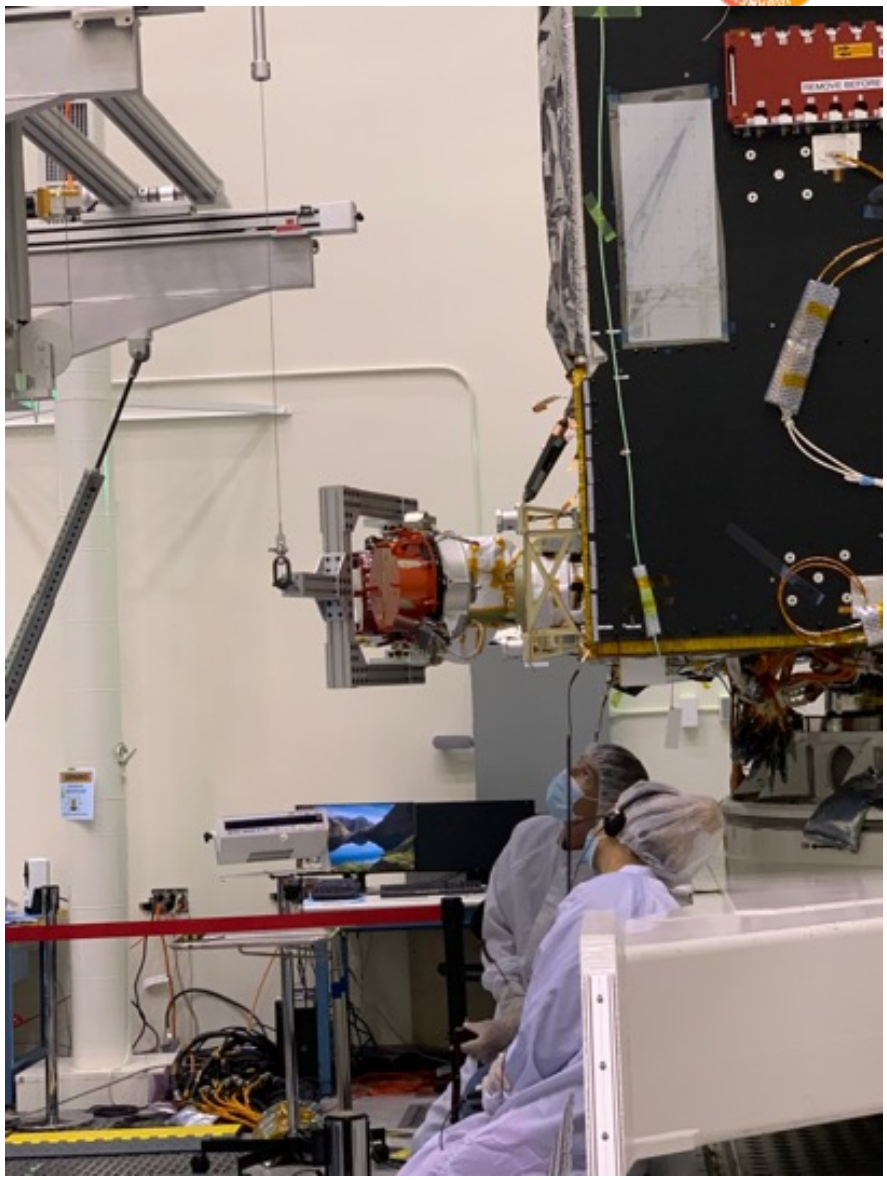


J.S. Snyder, et al. "Electric Propulsion for the Psyche Mission: Development Activities and Status", AIAA- 2020-3607, Joint Propulsion Conference, Virtual Event, August 24-28, 2020.

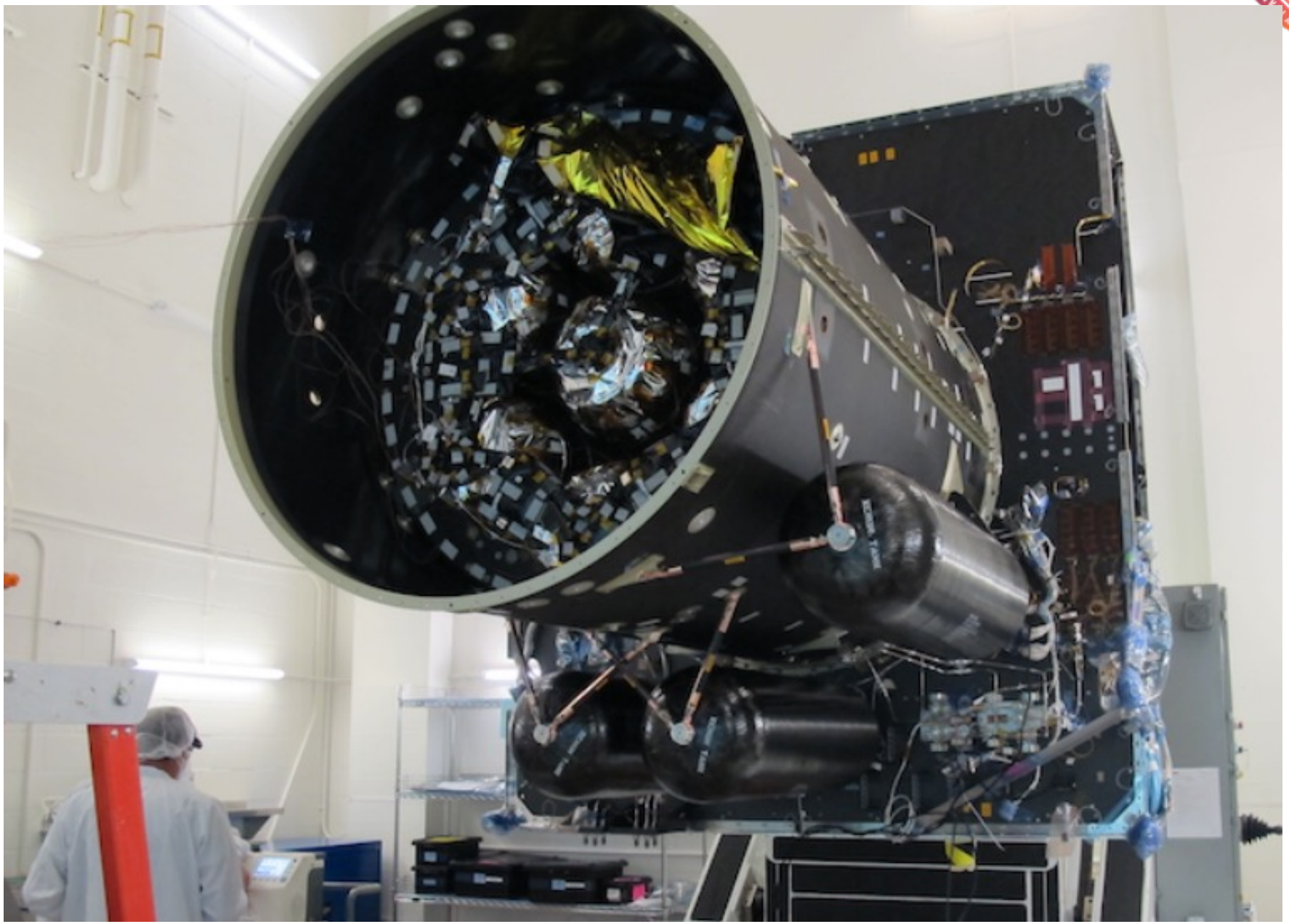
Hall thrusters installed on spacecraft

Articulating the Hall thruster gimbal





Psyche Xenon Tanks



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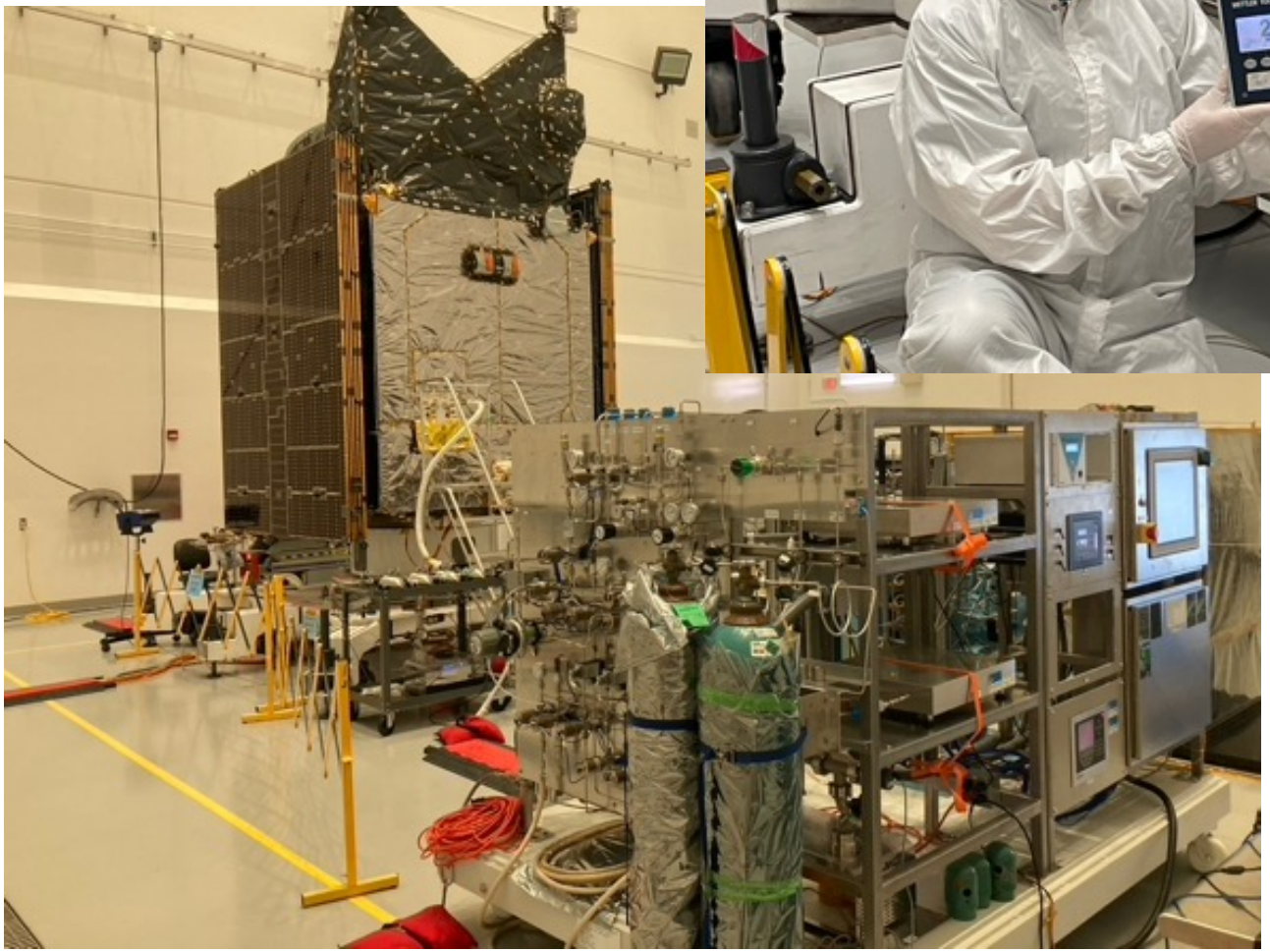
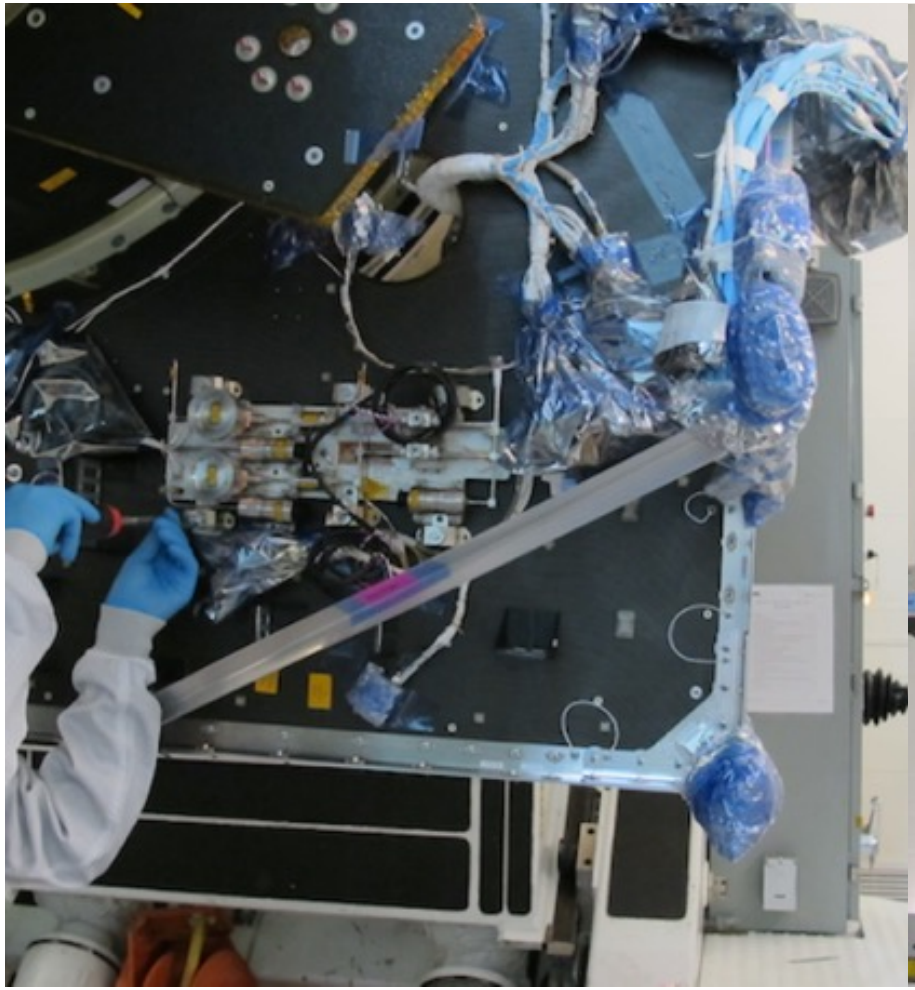
Loading 1085 kg of Xenon

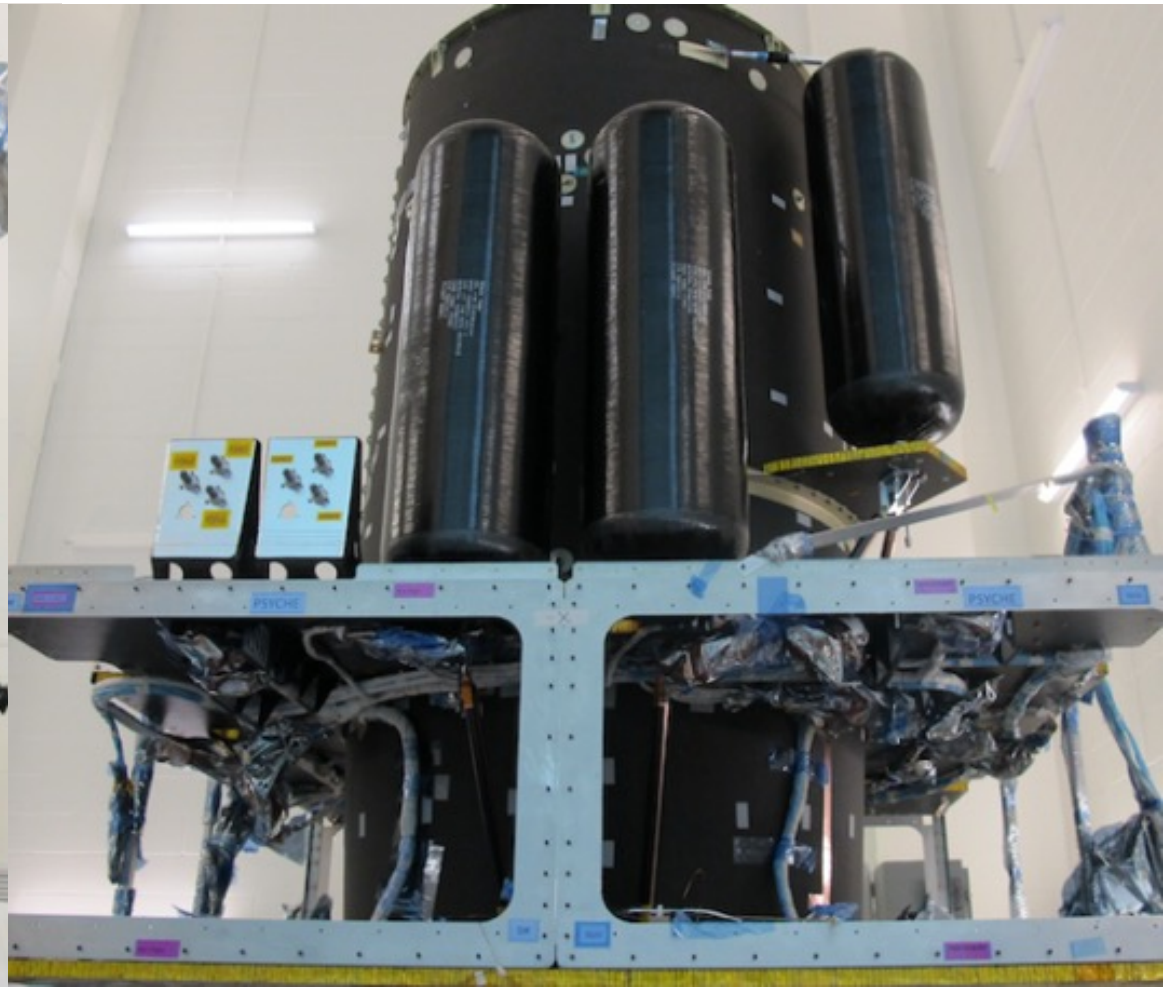


Psyche Cold-Gas Nitrogen Tanks

(for safe-mode and backup)



Propellant Management Assembly



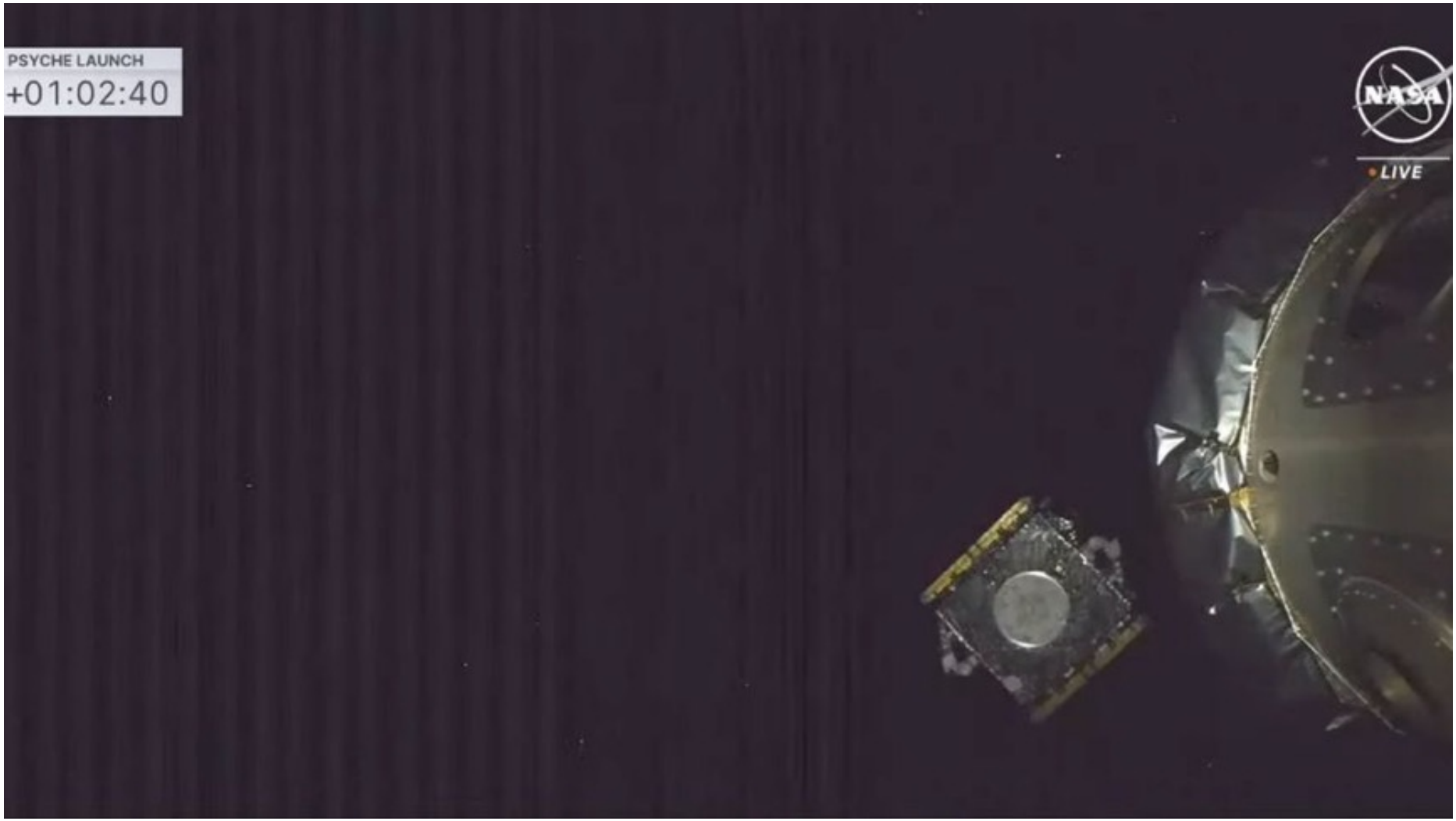
Nitrogen Cold-gas Tanks

J.S. Snyder, et al. "Electric Propulsion for the Psyche Mission: Development Activities and Status", AIAA- 2020-3607, Joint Propulsion Conference, Virtual Event, August 24-28, 2020.

Final testing at the cape before launch

Launch planned for October 2023 on a Falcon Heavy from Cape Canaveral

Psyche spacecraft separating from the Falcon Heavy LV




ASU School of Earth and Space Exploration
Arizona State University
APL
DTU
NASA Jet Propulsion Laboratory California Institute of Technology
Maxar
IPGP
Yale
DLR
MIT
GRC GLENN RESEARCH CENTER at Lewis Field
Smithsonian
SwRI
PSI Planetary Science Institute