

NASA Planetary Defense Missions

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SMPAG
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NASA Missions of Interest

Planetary Science Missions to Asteroids

- **OSIRIS-REx – Sample Return from asteroid Bennu**
 - All nominal in cruise return to Earth – September 2023
- **Lucy – Mission to the Jupiter Trojans**
 - Final preparations for opening of Launch period – 16 October 2021
- **Psyche – Mission to a “Metal World”**
 - In integration and test phase for August 2022 launch
- **Janus – SIMPLEx mission to two binary asteroids**
 - Continuation of development is under review

NEO Surveillance Mission

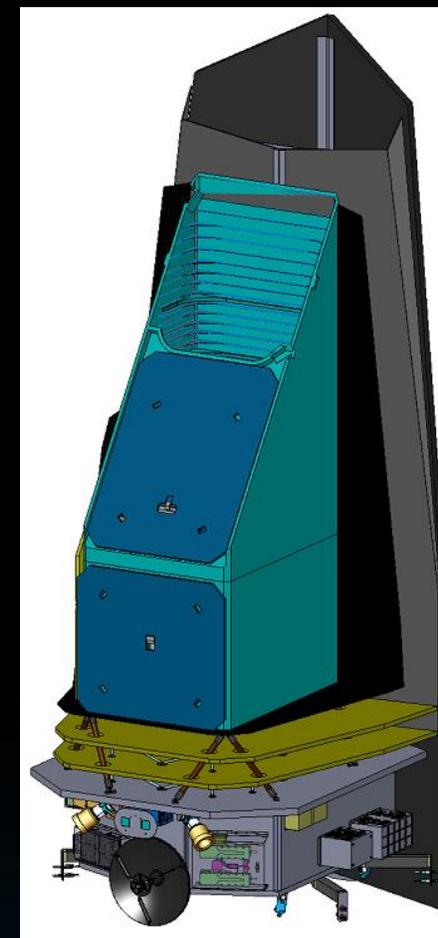
Objectives:

- Find 65% of undiscovered Potentially Hazardous Asteroids (PHAs) >140 m in 5 years (goal: >90% in 10 years)
- Estimate sizes directly from IR signatures
- Compute cumulative chance of impact over next century for PHAs >50 m and for comets
- Deliver new tracklet data daily to the Minor Planet Center

NEO Surveyor
Space-based IR
Observatory

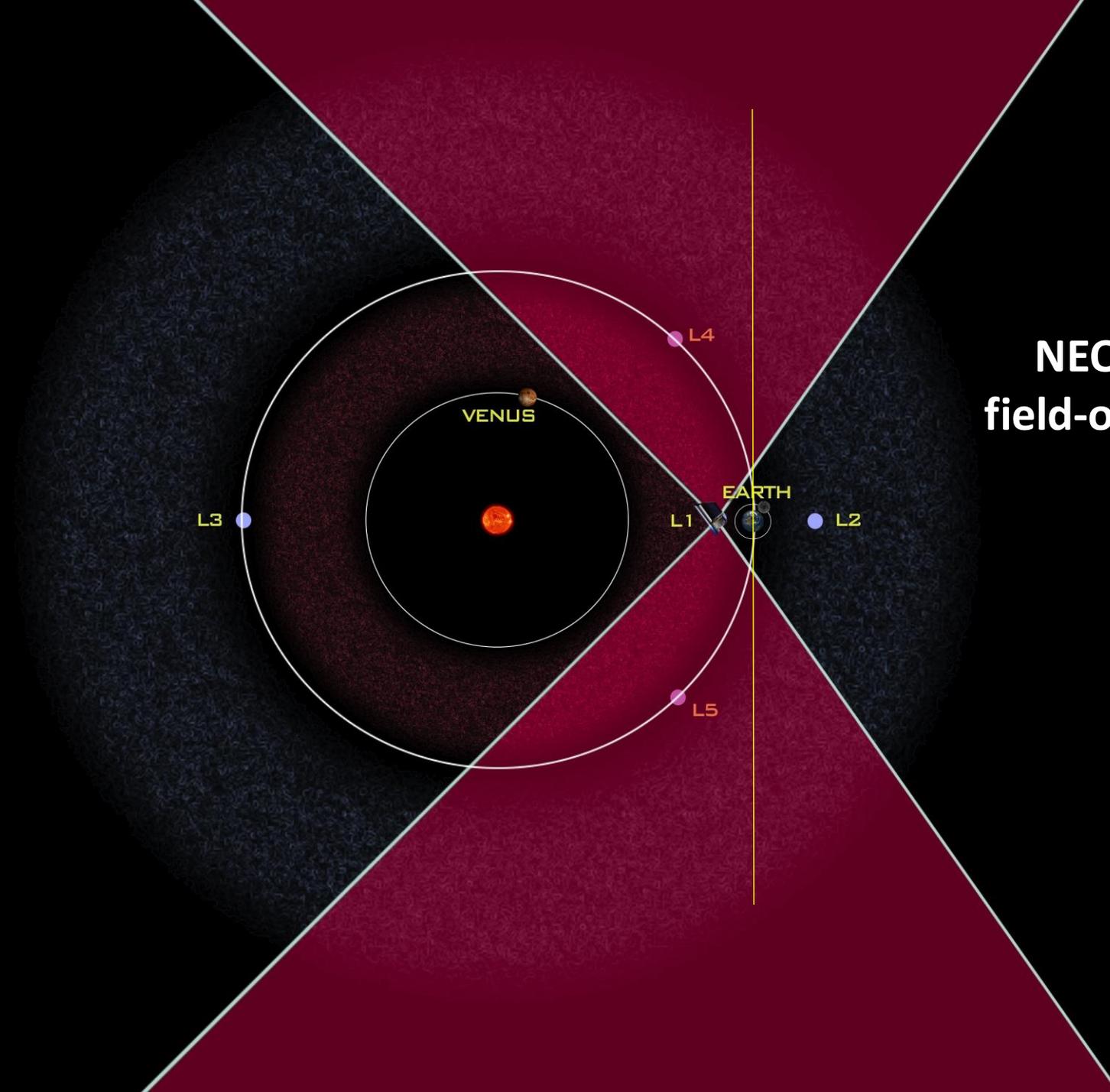
KDP-B approved 11 June 2021 for entry into “Preliminary Design” phase

President’s Budget Request for FY22 would fund NEO Surveyor for launch in 2026 if enacted



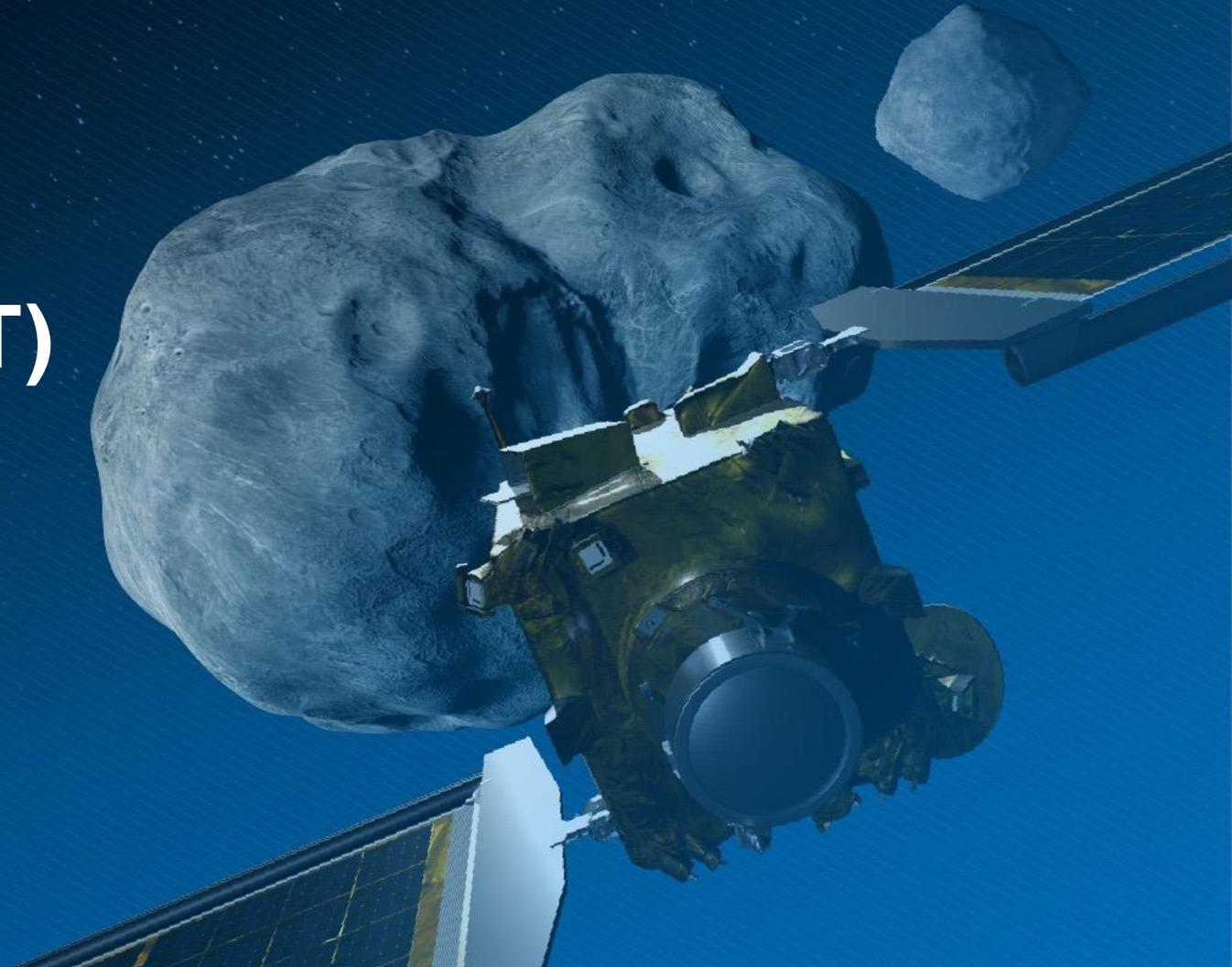
**NEOSM
field-of-regard**

**NEOWISE
field-of-regard**





Double Asteroid Redirection Test (DART) is < 6 weeks to Launch



PLANETARY DEFENSE



ASSESS

[CENTER FOR NEAR EARTH OBJECT STUDIES]



SEARCH, DETECT & TRACK

[SPACE-BASED & GROUND-BASED OBSERVATIONS, IAWN]



CHARACTERIZE

[NEOWISE, GOLDSTONE, IRTF]



PLAN & COORDINATE

[SMPAG, PIERWG, NITEP IWG]



MITIGATE

[DART, FEMA EXERCISES]



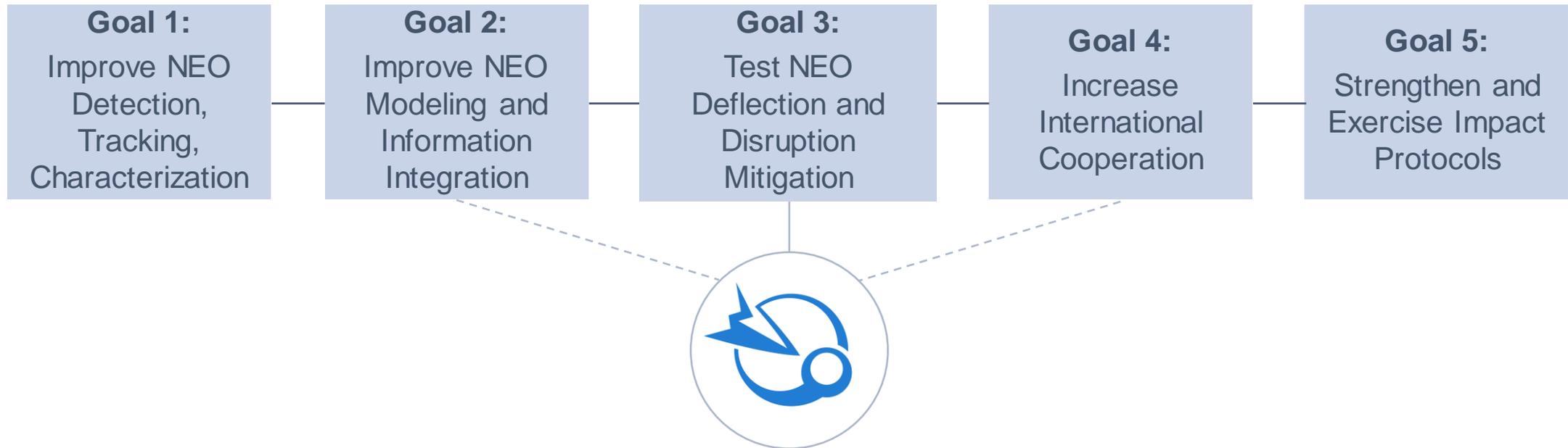
DART is the first full-scale flight demonstration of an asteroid deflection technology: kinetic impact



Part of a Larger Strategy

National Near-Earth Object Preparedness Strategy and Action Plan

A Report by the Interagency Working Group for Detecting and Mitigating the Impact of Earth-Bound Near-Earth Objects of the National Science & Technology Council, June 2018



Interagency Membership: Department of Commerce, Department of Defense, Department of Energy, Department of Homeland Security, Department of the Interior, Department of State, NASA, National Science Foundation, Office of the Director of National Intelligence, National Security Council, Office of Management and Budget, Office of Science and Technology Policy

DART = Double Asteroid Redirection Test

- **There is no known asteroid that poses an actual impact risk to Earth.**
- The impact hazard is from asteroids not yet discovered - ~60% population.
- The test is being conducted to develop a deflection capability, in case one is needed in the future.
- The binary asteroid system Didymos system is not a threat to Earth and provides a natural environment to change the orbit of a smaller asteroid orbiting a larger, rather than an asteroid orbiting the sun. This ensures the test does not accidentally create an impact hazard to Earth.

Launch Period

Nov. 24, 2021 – Feb. 15, 2022

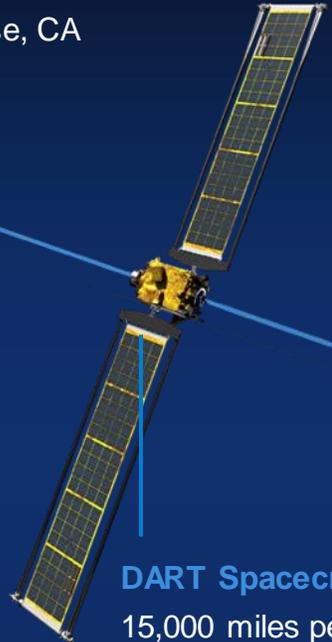
SpaceX Falcon 9

Vandenberg Air Force Base, CA

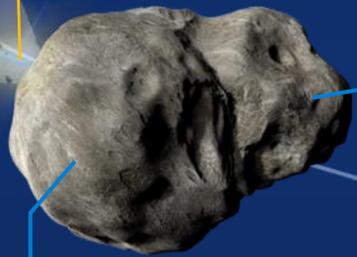
- Target the binary asteroid Didymos system
- Impact Dimorphos and change its orbital period
- Measure the period change from Earth

IMPACT: Late Sept. – Early Oct., 2022

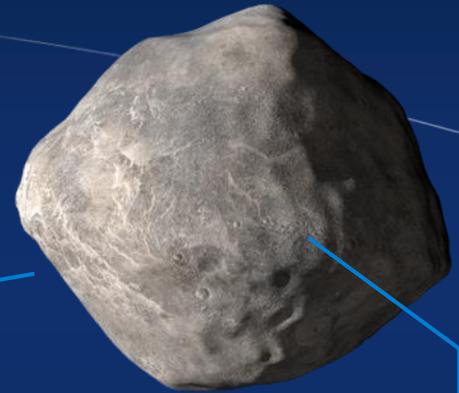
LICIACube
(Light Italian Cubesat for Imaging of Asteroids)
Italian Space Agency contribution



DART Spacecraft
15,000 miles per hour



Dimorphos
160 meters
11.92-hour orbital period



1,180-meter separation between centers

Didymos
780 meters



Earth-Based Observations
6.8 million miles (0.07 AU) from Earth at DART impact



DART's Level 1 Requirements

Defining the Mission's Planetary Defense Investigation

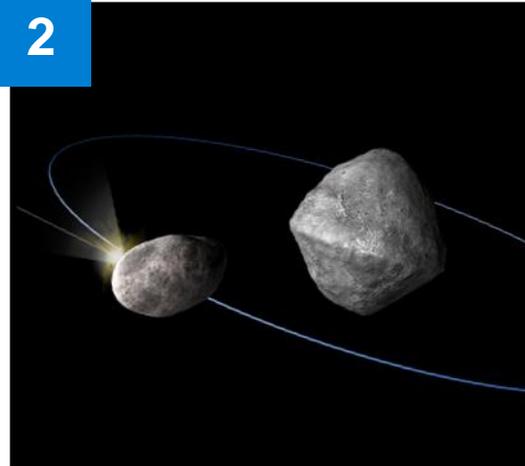
1



Impact Dimorphos

During its Sept/Oct 2022 close approach to Earth

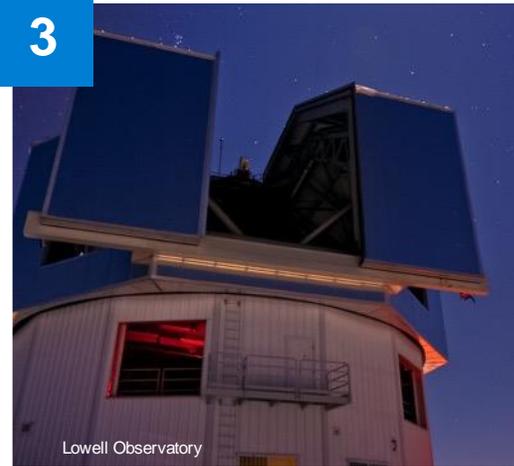
2



Change the binary orbital period

Cause a ≥ 73 -second change in the orbital period of Dimorphos

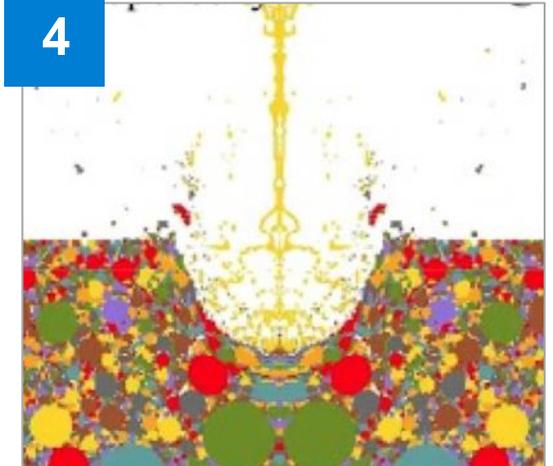
3



Measure the period change

To within 7.3 seconds, from ground-based observations before and after impact

4



Measure "Beta" and characterize the impact site and dynamics

Beta = the momentum enhancement factor

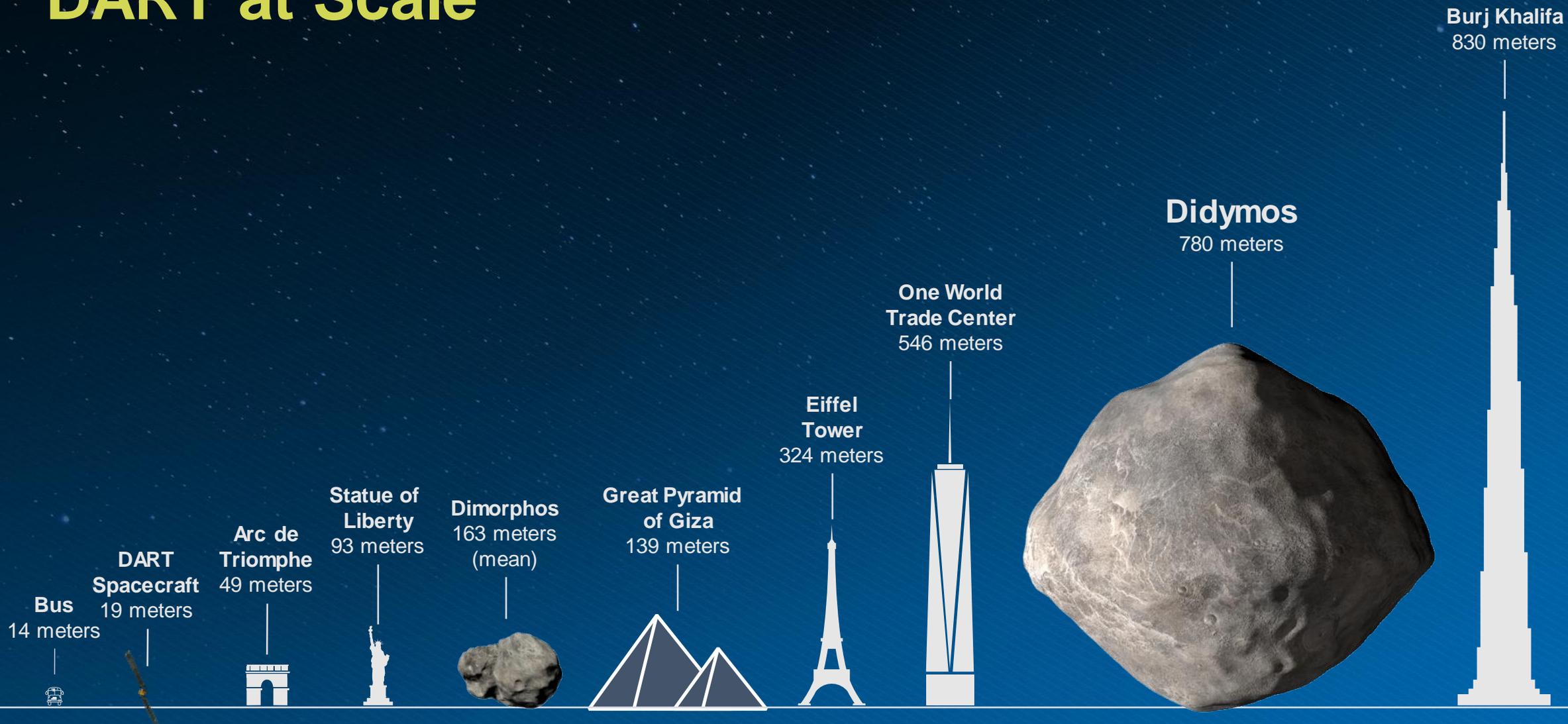
DART spacecraft ops



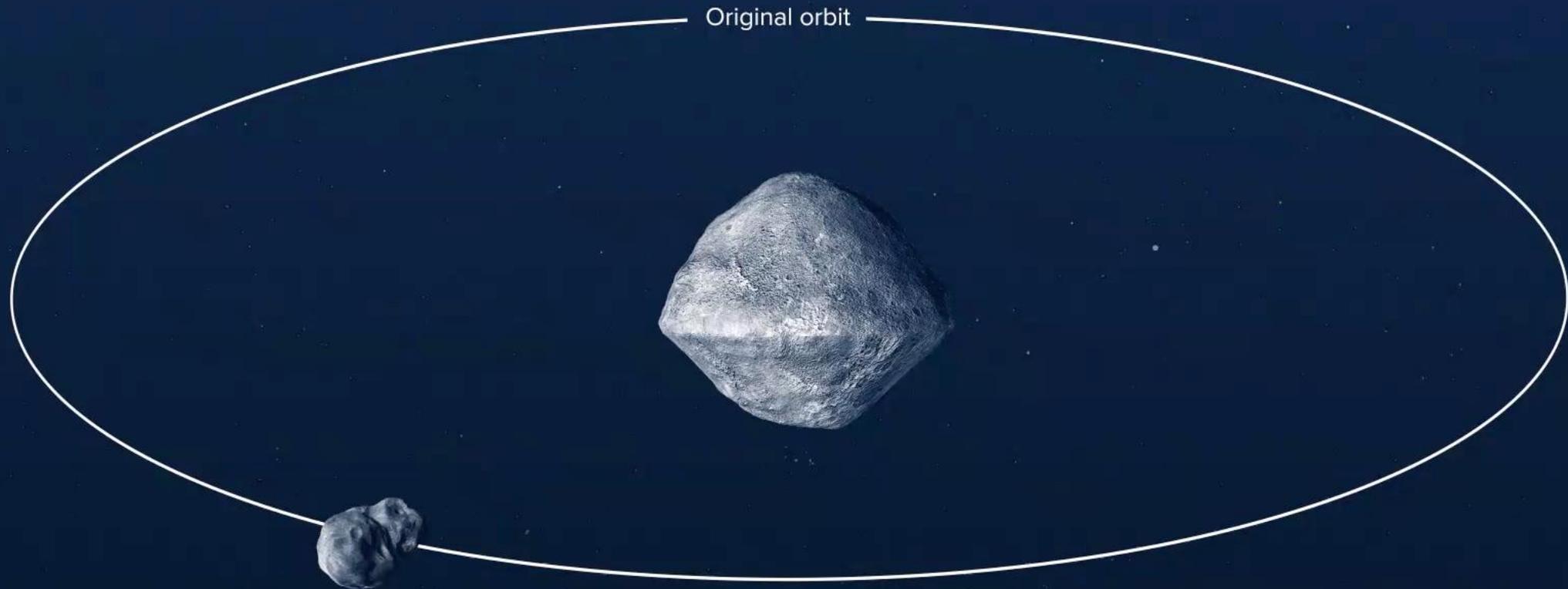
No DART spacecraft ops



DART at Scale

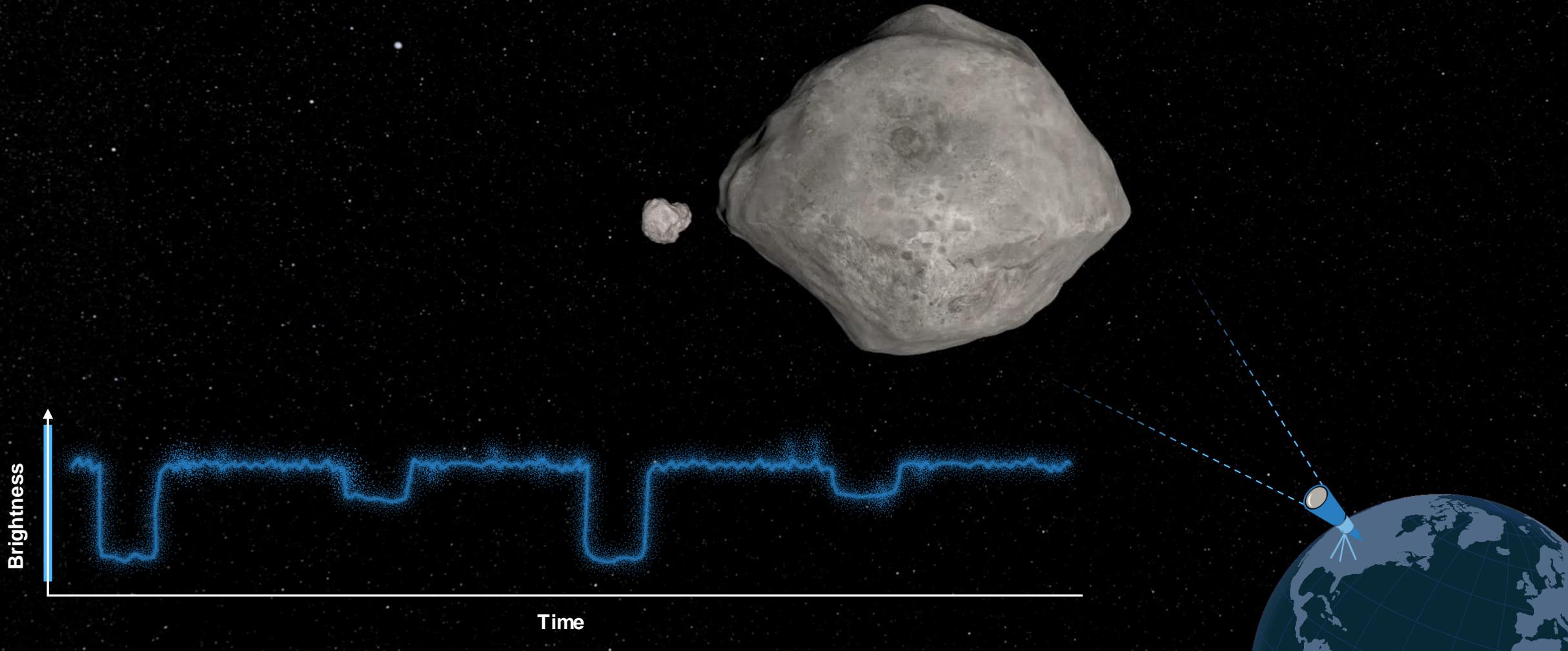


It allows a deflection demonstration on an asteroid of the relevant size by changing its orbital period by ~1% about the larger asteroid.



Earth-based
observations

Measuring result of the impact from Earth: new orbit for Dimorphos



A photograph of the Lowell Discovery Telescope at night. The telescope's large, dark, rectangular aperture is open, revealing the internal structure. The telescope is mounted on a white, cylindrical base. The background is a dark blue night sky with several stars visible. The lighting is from the telescope's own lights, creating a warm glow around the structure.

2020–2021

Didymos Observations:

- *Lowell Discovery Telescope (AZ, US)*
- *Palomar (CA, US)*
- *Keck (HI, US)*
- *Gemini (HI, US)*
- *Canada-France-Hawaii Telescope (HI, US)*
- *Large Binocular Telescope (AZ, US)*
- *Galileo National Telescope (Spain)*
- *Nordic Optical Telescope (Spain)*
- *Asiago (Italy)*
- *Pic du Midi (France)*

Lowell Discovery Telescope
(credit: Lowell Observatory)

DART Spacecraft

mass: NLT 670 kg
power: ~5000 W

NEXT-C cover
(top hat)

High Gain
Antenna (RLSA)

DRACO
(with cover on)

Hydrazine
Thrusters

LICIACube
Cubesat

NEXT-C
Ion thruster

2.6 m

2 m

Roll Out Solar Arrays (ROSA)

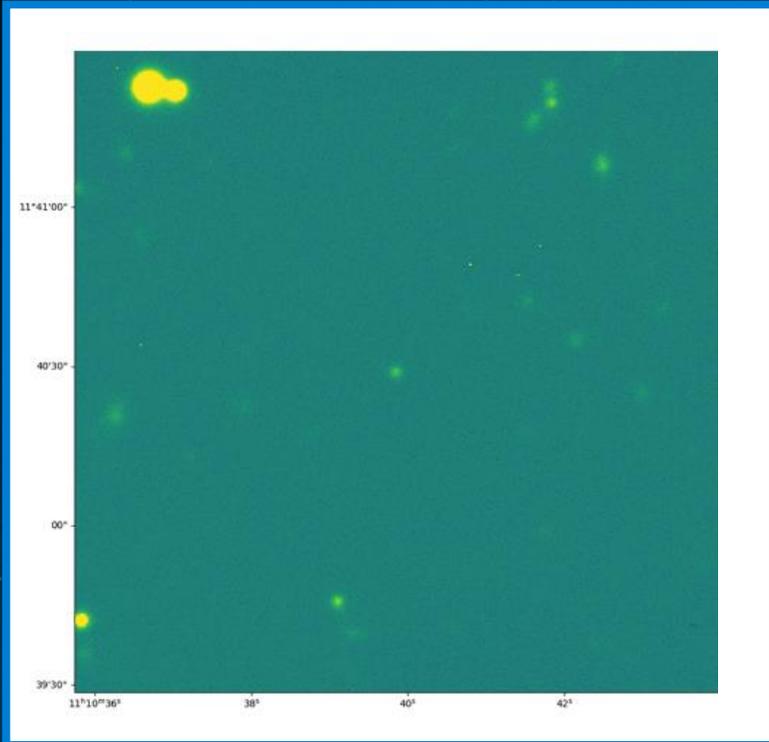
18 m



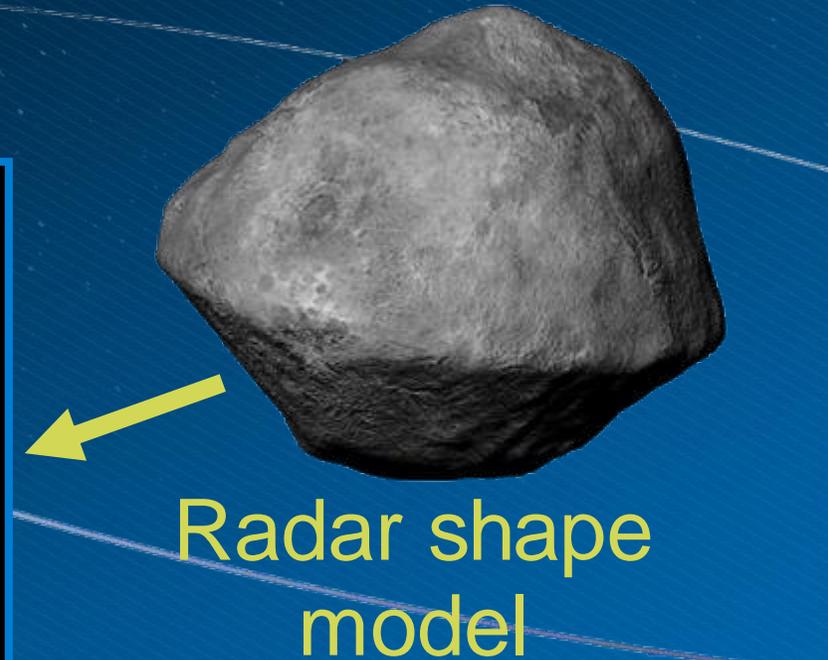
Our eyes: DRACO Instrument



Know little about the object we are going to hit

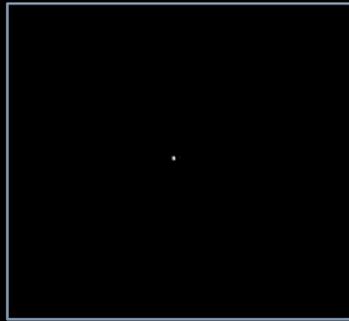


Images centered on Didymos, moving through star fields
Taken from VLT in Chile, March/April 2019



Preliminary shape model of the Didymos primary asteroid from combined radar and light curve data, diameter ~780 m.

And won't know much more in time to hit it!



24,000 kilometers
 Didymos – 6.5 pixel
 Dimorphos – 1.4 pixel
 Target becomes observable



1600 kilometers
 Didymos – 99 pixel
 Dimorphos – 21 pixel
 Final divert maneuver corrections



800 kilometers
 Didymos – 197 pixel
 Dimorphos – 41 pixel
 Divert maneuvers complete, drift to impact



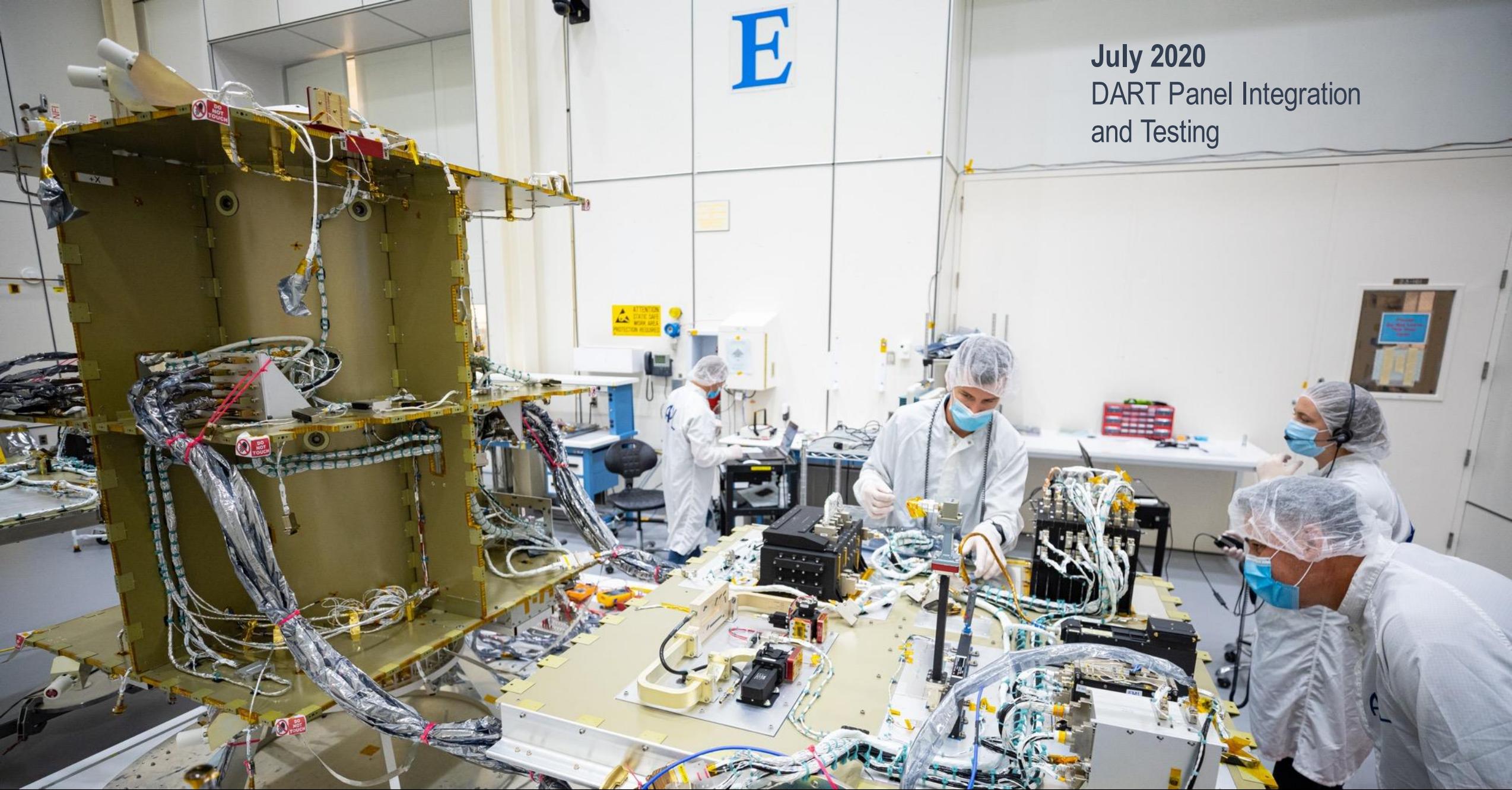
130 kilometers
 Didymos – N/A
 Dimorphos – ~300 pixel
 Pixel-scale requirements met



May 2020
Spacecraft Structure
in Clean Room



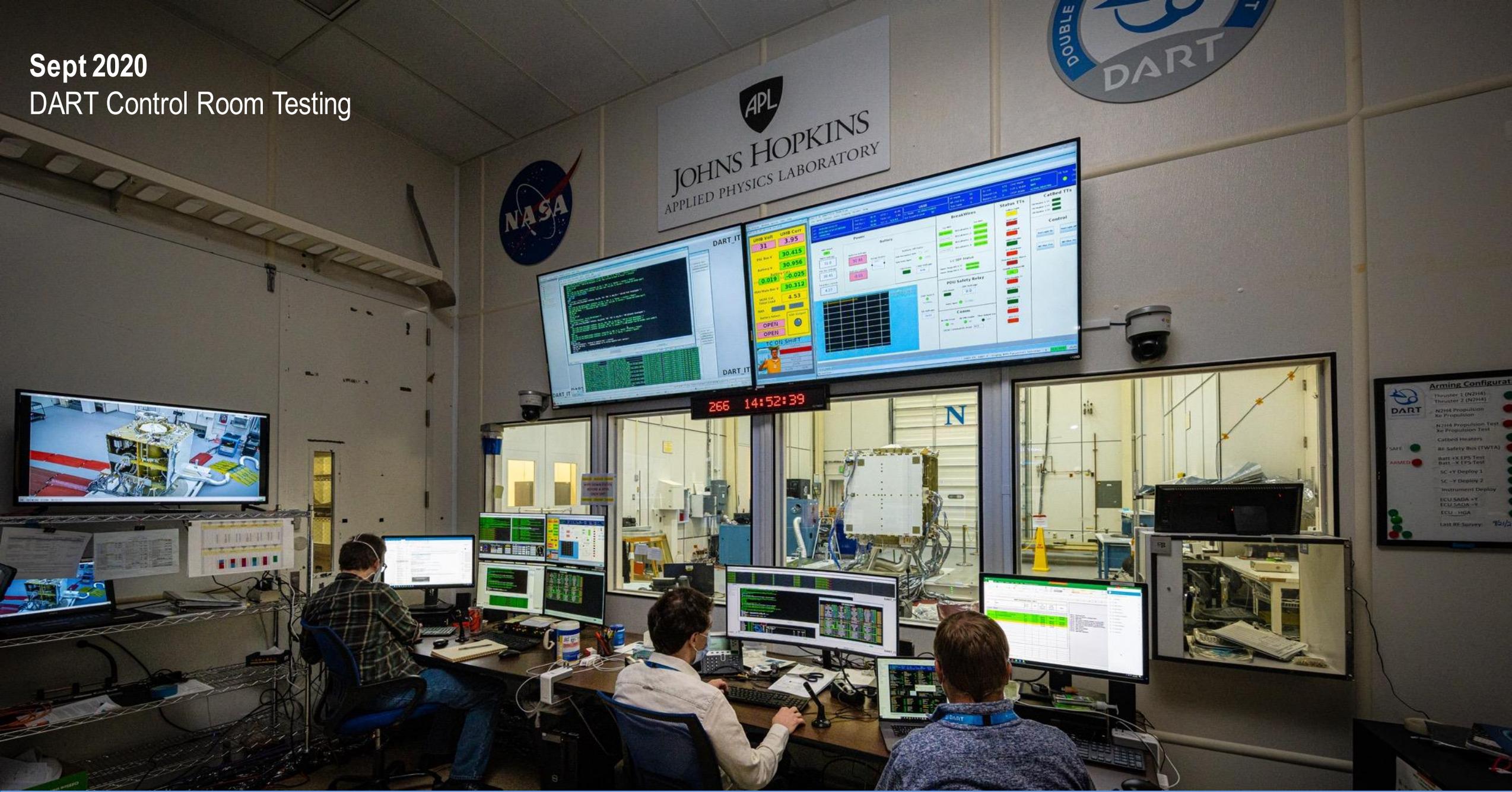
July 2020
DART Panel Integration
and Testing



Sept. 2020
DART Panel Closeout



Sept 2020 DART Control Room Testing





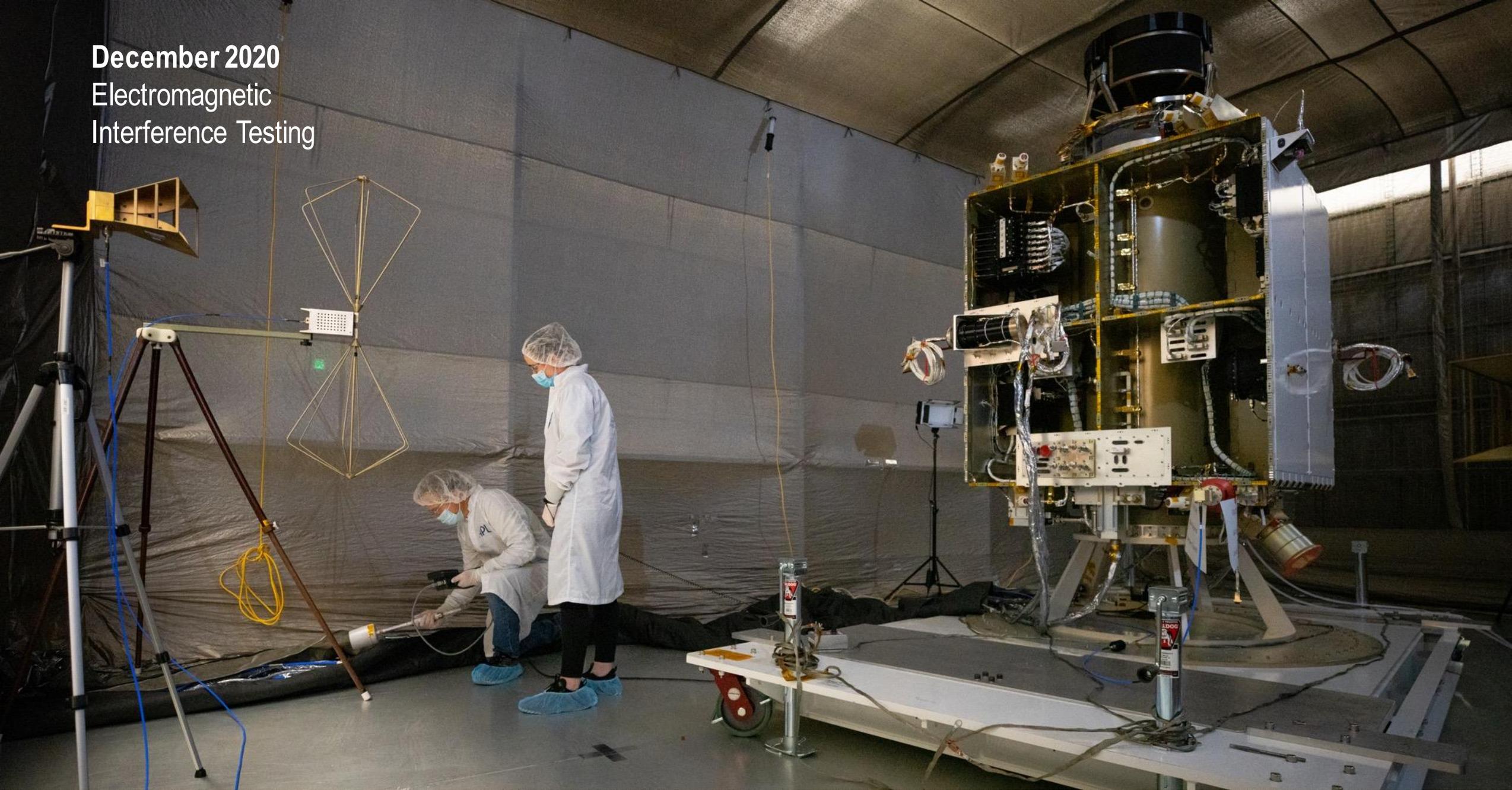
Nov 2020
RLSA Installation



Nov. 2020
NEXT-C Installation



December 2020
Electromagnetic
Interference Testing



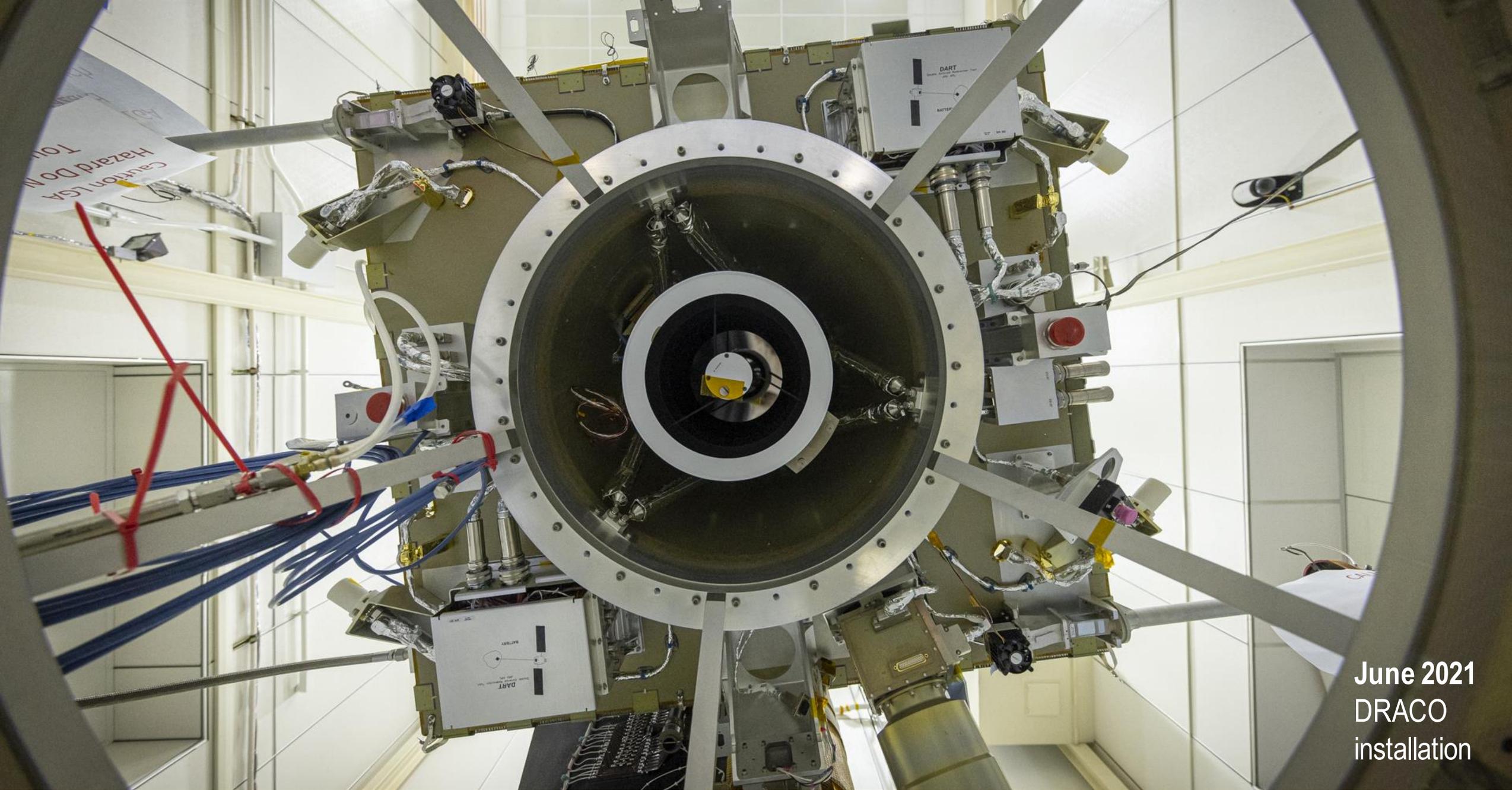


Jan 2021
Thermal Vacuum
Testing



May 2021
Solar Array
Installation





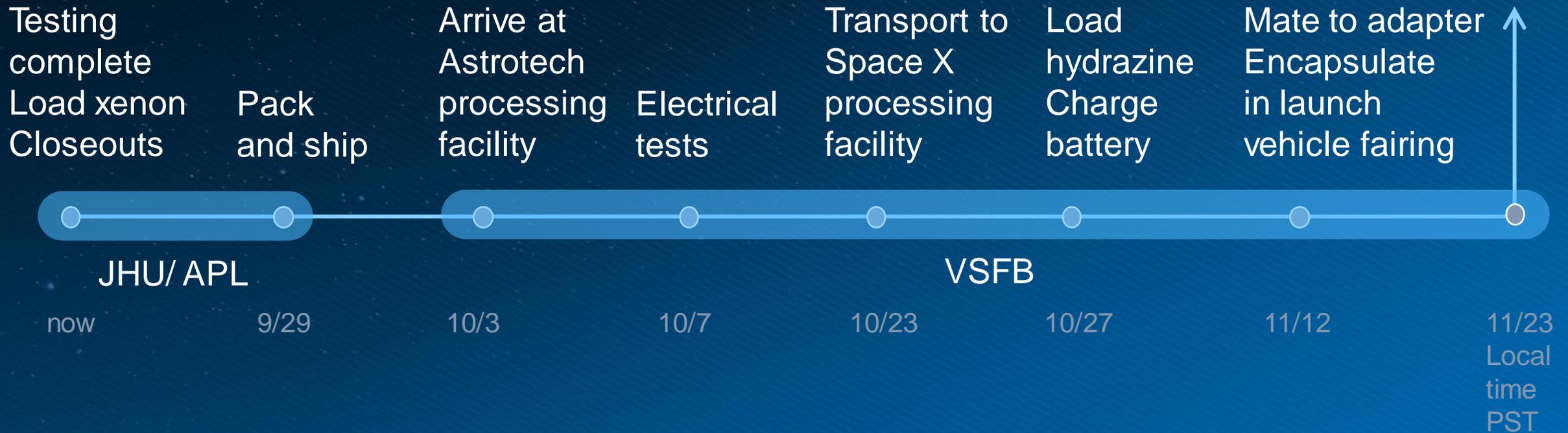
June 2021
DRACO
installation



Sept. 2021
LICIACube
installation



Schedule to Launch



Link to Video

Video Overview, DART, NASA's First Planetary Defense Mission

<https://youtu.be/hbL07cZUEMU>

