# LICIACube: CubeSat Unique Engineering Challenges on the DART Mission

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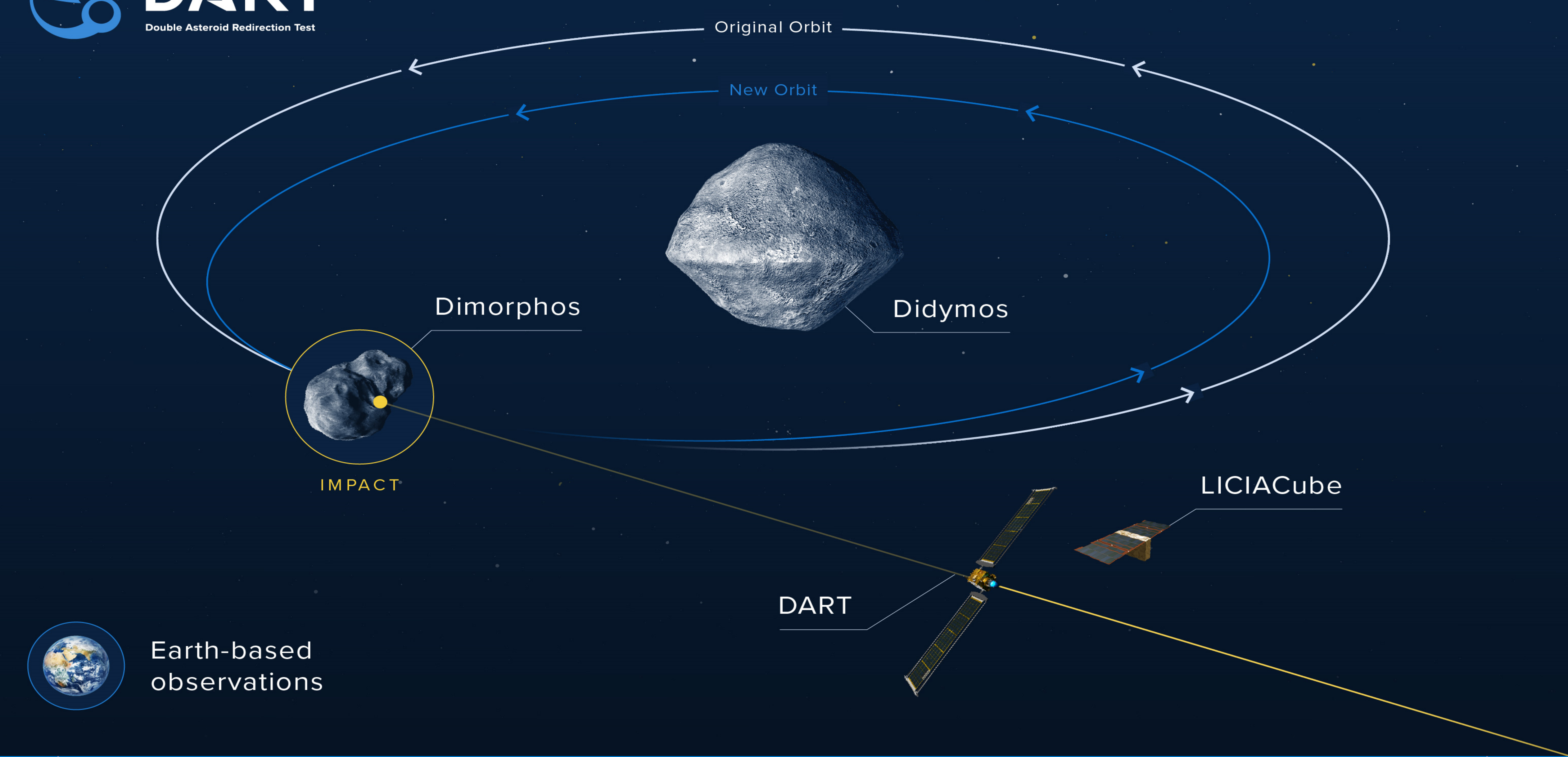
# Agenda

- Mission Introduction
  - Spacecraft
  - LICIACube
- DART Development Challenges
  - Mechanical Design Considerations
  - Electrical Interface Considerations
  - Integration of LICIACube
- Conclusions

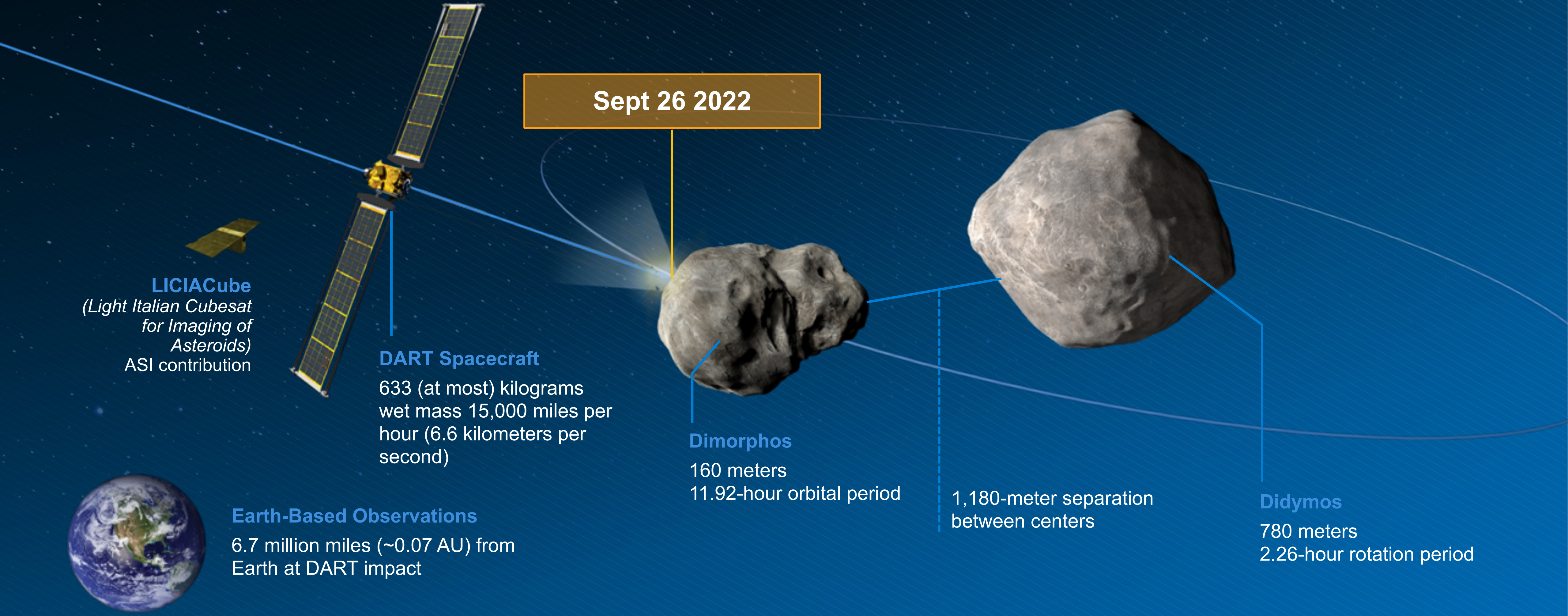
# Mission Introduction



# Launch

**Nov 24, 2021**

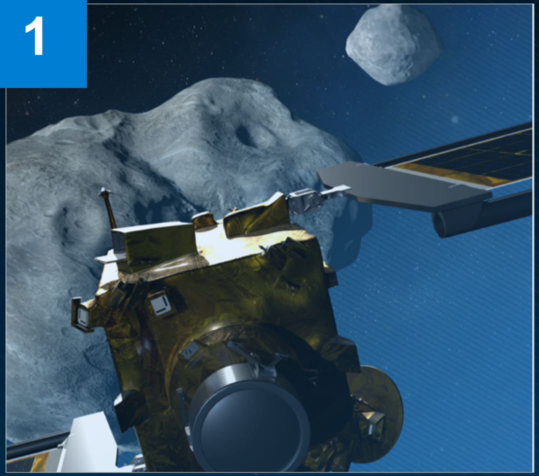
- Target the binary asteroid Didymos system
- Impact Dimorphos and change its orbital period
- Measure the period change from Earth



# DART's Level 1 Requirements

## Defining the Mission's Planetary Defense Investigation

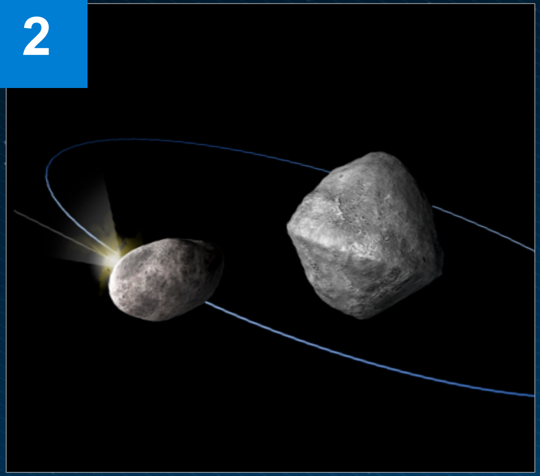
1



### Impact Dimorphos

During its Sept 2022 close approach to Earth

2



### Change the binary orbital period

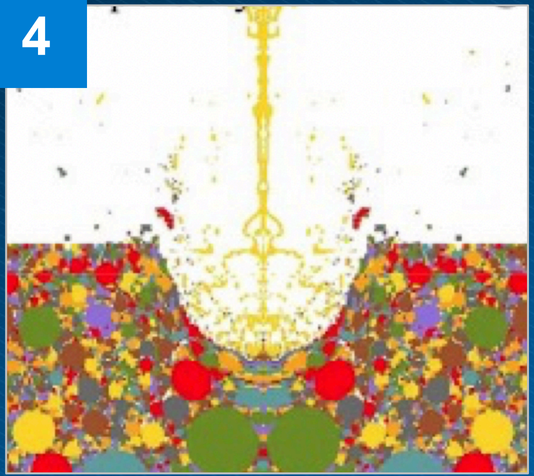
Cause a ≥73-second change in the orbital period of Dimorphos

3


### Measure the period change

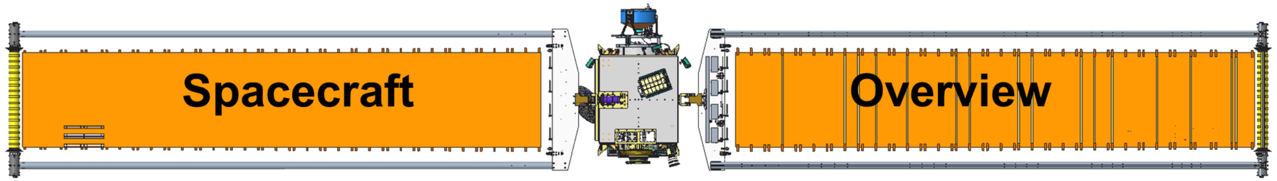
To within 7.3 seconds, from ground-based observations before and after impact

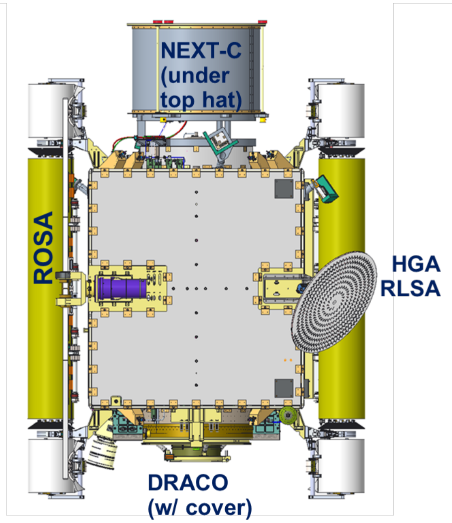
4



### Measure "Beta" and characterize the impact site and dynamics

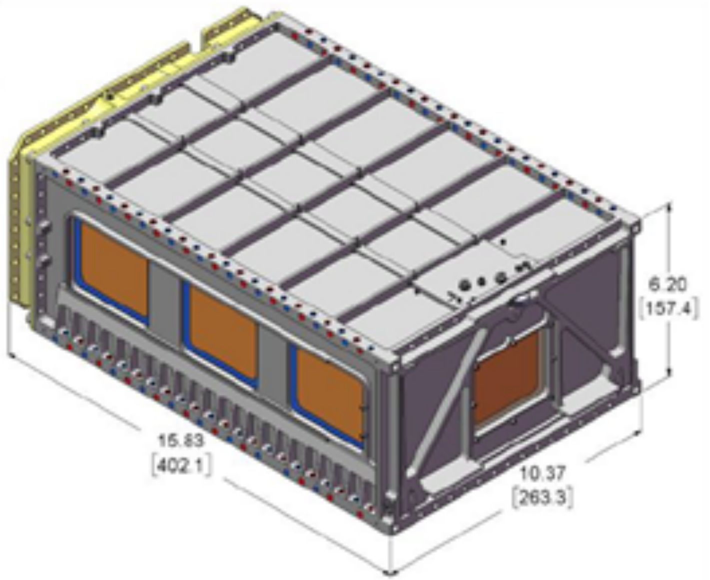
***Beta*** *= the momentum enhancement factor*

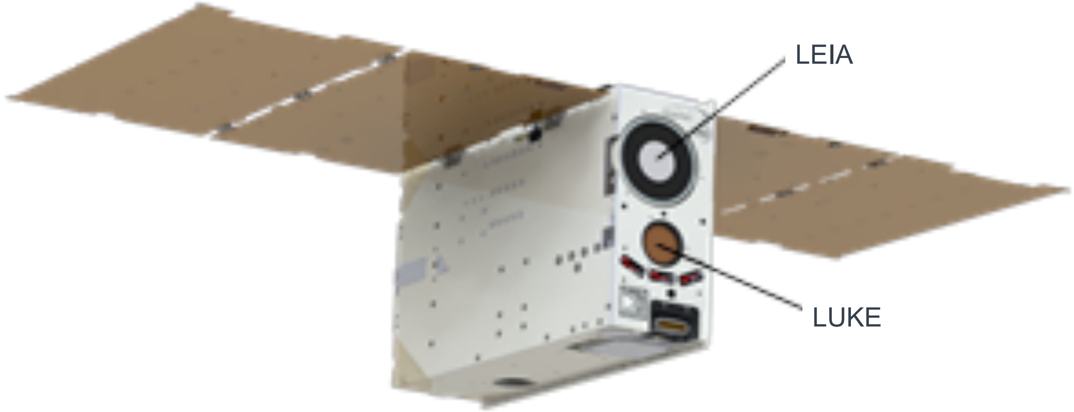




- DRACO instrument and LICIACube
- 633 kg maximum launch wet mass
- Reference dimensions
  - Stowed: 1.8m (W) x 2.1m (L) x 2.6m (H)
  - Deployed: 1.8m (W) x 18.9m (L) x 2.6m (H)
- “Box” spacecraft configuration
- Two propulsion systems: EP using NEXT-C Engine; Hydrazine monoprop, 12 thrusters
- Roll Out Solar Arrays (ROSA) divided into LV and HV sections
  - LV: ~550 W S/C electrical power available at impact
  - HV: ~4200 W EP electrical power available during EP calibration
- Thruster-only control, using SMART Nav during terminal phase
- 0.64 m Radial Line Slot Array (RLSA) HGA, 65W TWTA X-band DL
- Impact downlink rate: 3 Mb/s

**Planetary Systems Corporation (PSC) CubeSat Dispenser (CSD):** 6U dispenser with access panels removed

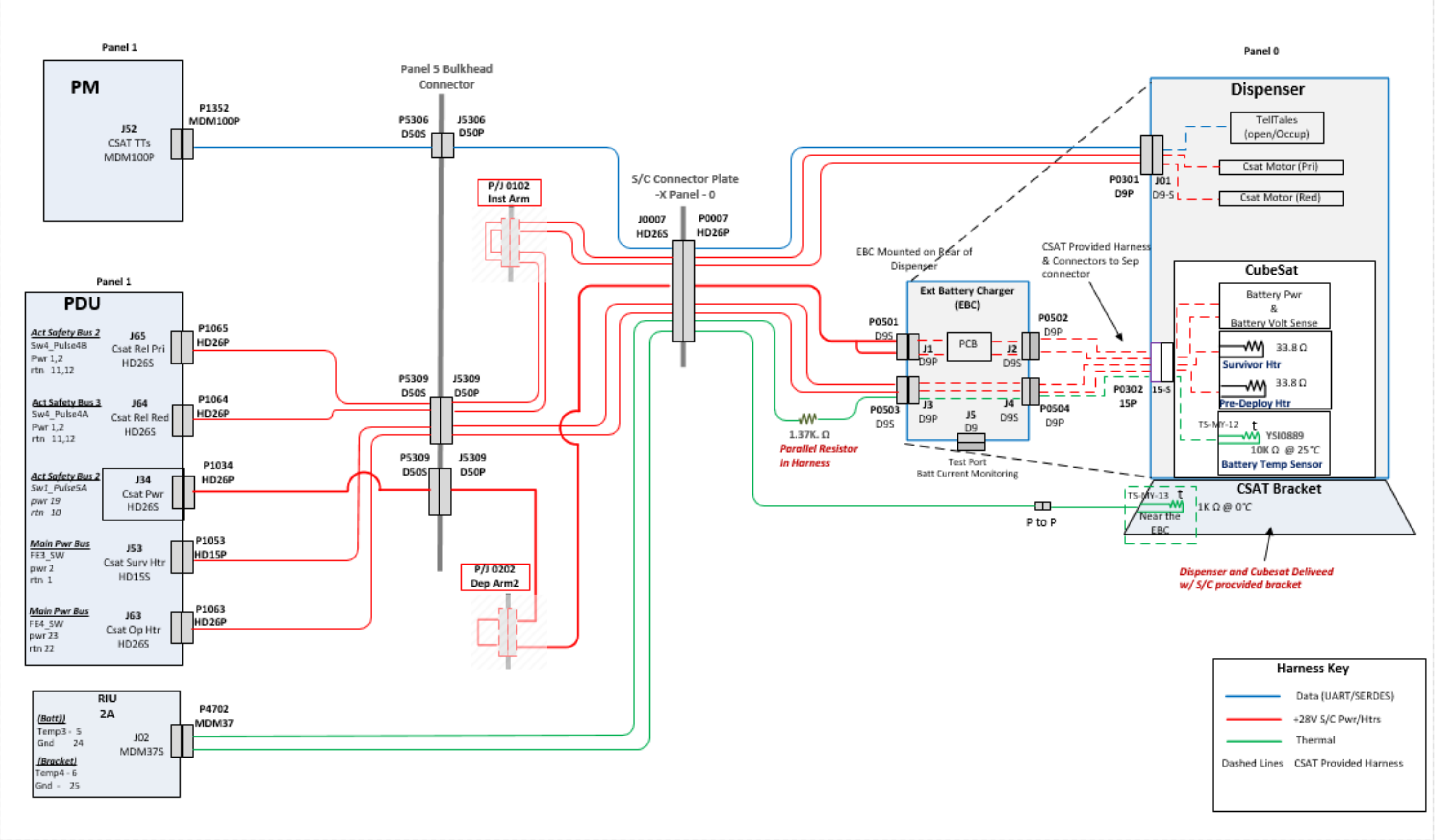



## **LICIACube** showing LUKE and LEIA payloads




LUKE = LICIACube Unit Key Explorer
LEIA = LICIACube Explorer Imaging for Asteroid

# LICIACube: Electrical Design Approaches

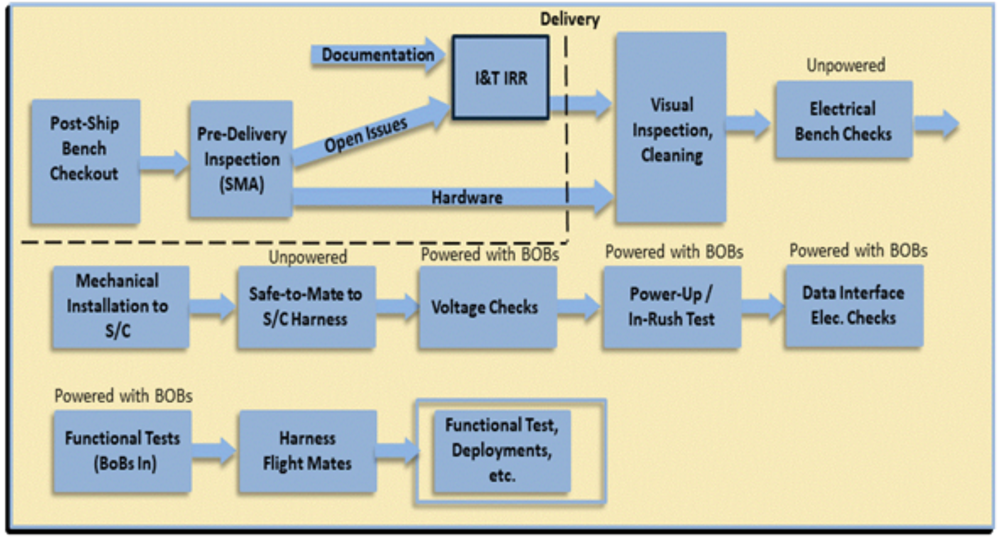



## Simplified electrical interfaces between DART Spacecraft and LICIACube

- Individual electrical power interfaces provided for LICIACube battery charging and 2 heaters
- Direct battery temperature monitoring through the SC data acquisition electronics
- SC provided additional power services directly to dispenser for door opening deployment
- Housekeeping telemetry for the canister door open/close and occupied states provided
- SC temperature sensor at the spacecraft bracket to monitor the thermal interface

# LICIACube: Integration Approach

- DART utilized a ship and shoot concept with no allocation of schedule time for integration of LICIACube at the launch site
- Several early engineering concepts were developed by the JHU/APL and the Argotec teams to mitigate and foster a successful and timely integration




## Pre-Integration

- LICIACube and associated electrical ground support equipment (EGSE) was shipped to JHU/APL prior to Argotec I&T personnel arriving
- Integration Readiness Review (IRR) completed prior to integration
- Bench checks included: functional checks of the electrical, data, and propulsion pressurization systems of the CubeSat
- With removal of red-tag items LICIACube flight ready and delivered successfully to the spacecraft I&T team

## Integration to Spacecraft

- Safe-to-mates and electrical checks were conducted by spacecraft I&T technicians
- Electrical checks included: passive and powered (voltage and current) checks into the External Battery Charge (EBC) electronics
- Flight harness mates closed out the electrical checkout
- Battery charge function checkout included powering LICIACube via the DART power distribution unit (PDU) and monitoring voltages provided from the EBC test port connection

# LICIACube:  Mechanical Design & Test Approaches

*Stowing of Thermal Simulator into Dispense in Preparation for TVAC Testing*

*LICIACube Mass Simulator Mounted on the DART Spacecraft during Vibe Testing*

*Installation of Flight LICIACube Assembly on DART Spacecraft*


*Final Closeout of LICIACube Thermal Blankets Prior to Launch*

# Conclusions

- APL and Argotec Teams faced a challenging development schedule that was complicated by COVID protocols and restrictions. The teams consolidated on an approach for minimal and clean mechanical, thermal and electrical interfaces
  - Adaptable spacecraft environmental test program accommodated LICIACube integration after completion of vibration and thermal vacuum testing through the use of a mass simulator and a thermal emulator installed in the spare dispenser
  - Delivery of the LICIACube hardware and post-shipment testing validated the hardware integrity allowing spacecraft mechanical and electrical integration activities moved forward with no issues
- Through the efforts of the international teams, the DART spacecraft arrived at the launch site with LICIACube fully integrated
- Final pre-launch checks were made on-site and the spacecraft successfully launched towards its historic rendezvous with Dimorphos as Earth's first planetary defense mission
- For more information on the DART mission, please see https://www.nasa.gov/planetarydefense/dart/dart-news and https://dart.jhuapl.edu/

**DART impact on September 26, 2022!**