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Asteroid Impact & Deflection Assessment (AIDA)

DART
Double Asteroid Redirection Test

DART Mission Overview

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Goddard Space Flight Center
Johnson Space Center
Langley Research Center
Glenn Research Center
Marshall Space Flight Center
Planetary Defense Coordination Office

Johns Hopkins Applied Physics Laboratory

Jet Propulsion Laboratory
California Institute of Technology

University of Colorado Boulder

University of Maryland

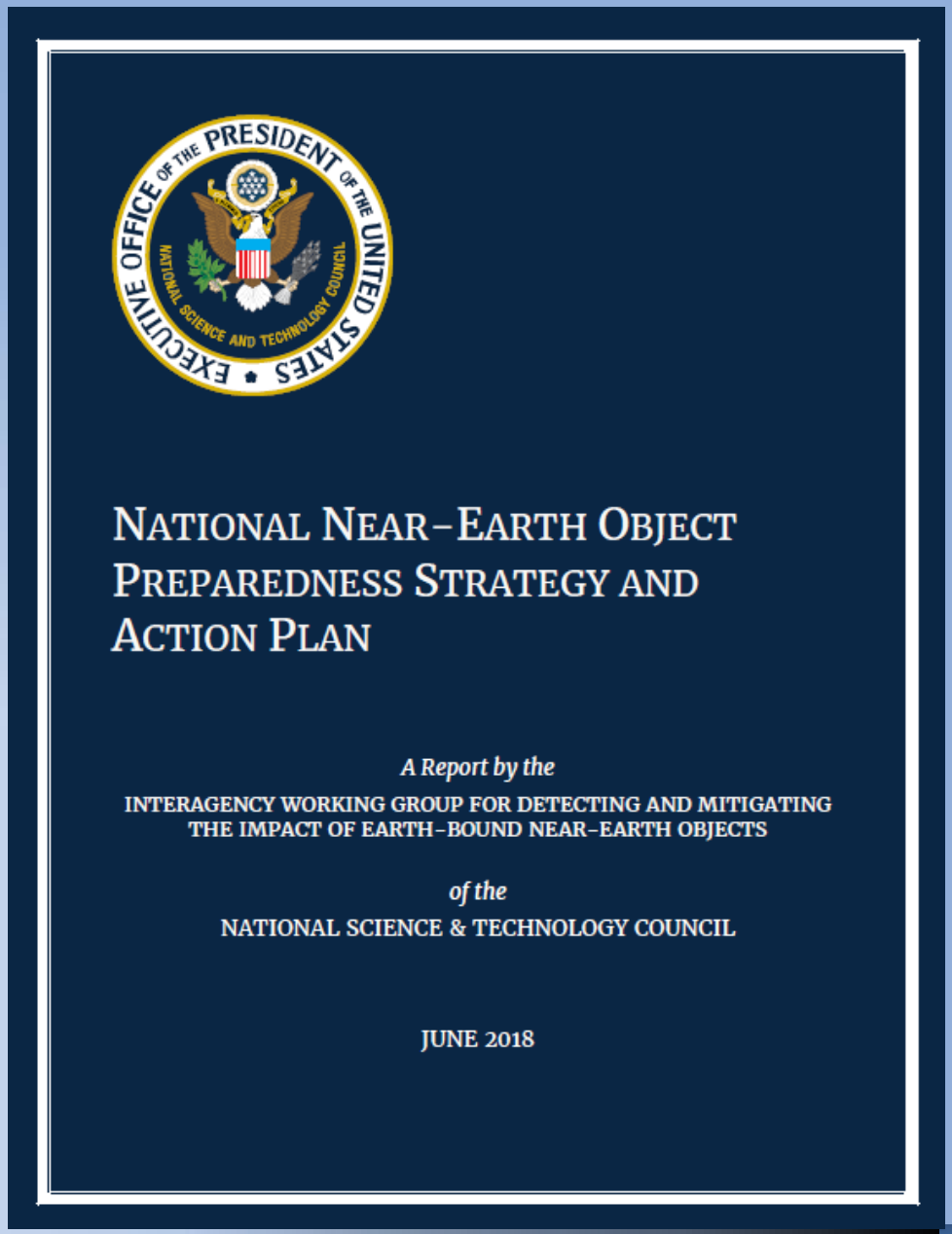
Lawrence Livermore National Laboratory

Aerojet Rocketdyne

New White House Guidance released on 20 June 2018

https://www.whitehouse.gov/wp-content/uploads/2018/06/National-Near-Earth-Object-Preparedness-Strategy-and-Action-Plan-23-pages-1MB.pdf

DART is the first mission in NASA's new Planetary Defense Program line!



EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

NATIONAL NEAR-EARTH OBJECT PREPAREDNESS STRATEGY AND ACTION PLAN

A Report by the

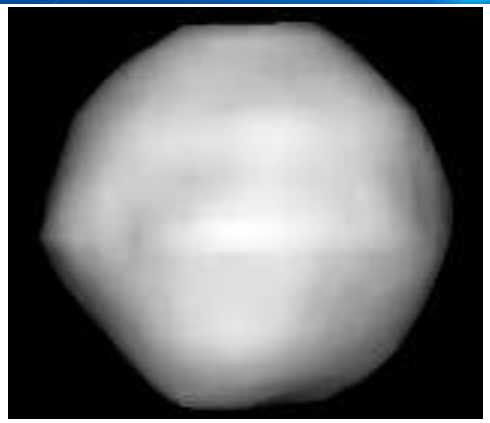
INTERAGENCY WORKING GROUP FOR DETECTING AND MITIGATING THE IMPACT OF EARTH-BOUND NEAR-EARTH OBJECTS

of the

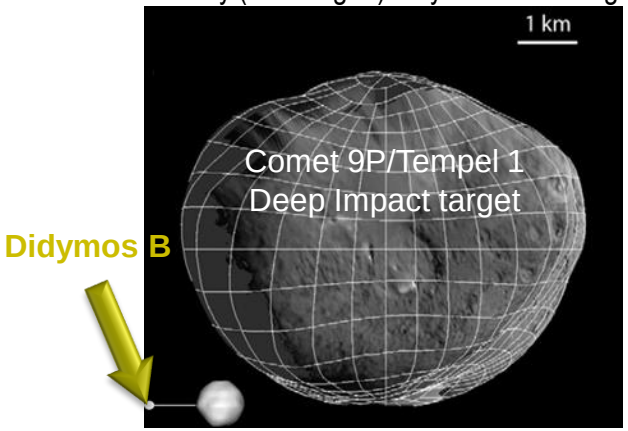
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

JUNE 2018

DART is targeting the Didymos system in October, 2022



Preliminary shape model of the Didymos primary from combined radar and light curve data, diameter ~780 m. The secondary (not imaged) may be more elongated.

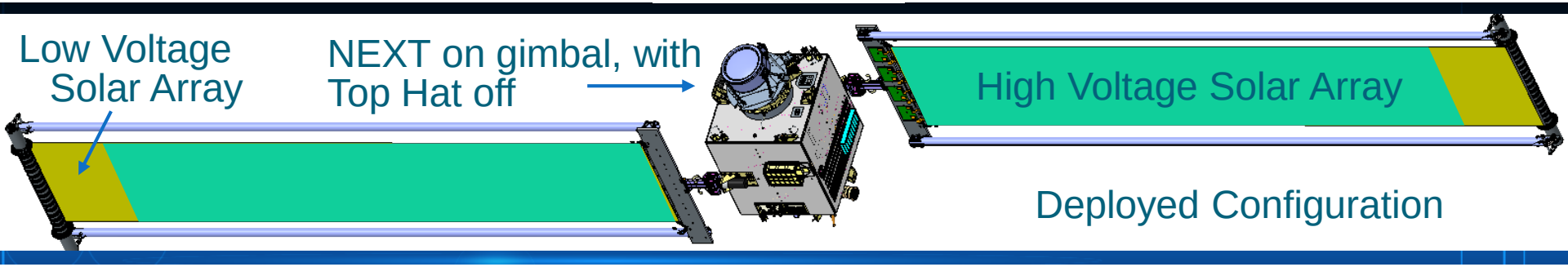


Didymos B is much smaller than the Deep Impact target.

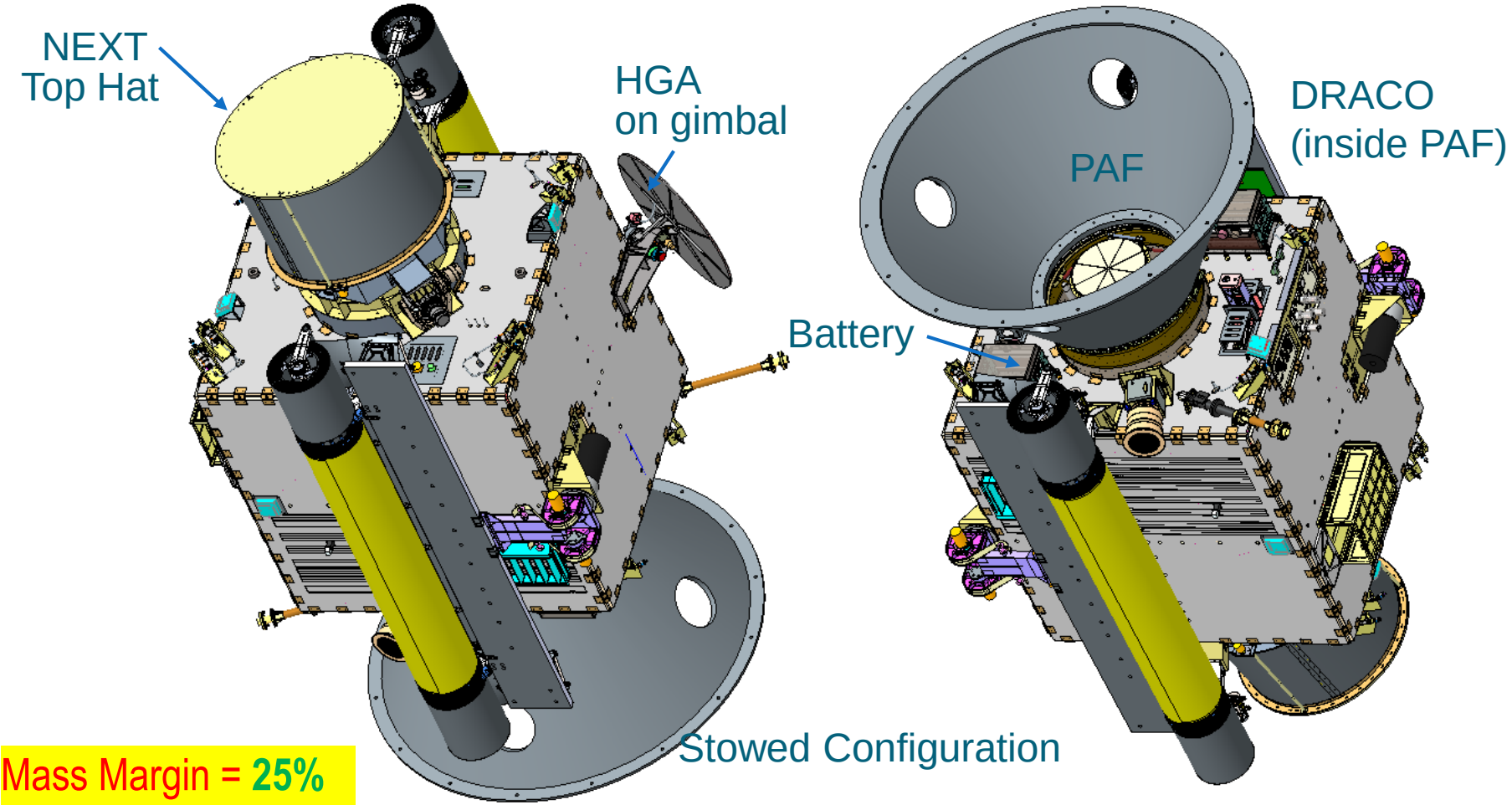
Primary Diameter	**780 m ± 10%**
Secondary Diameter	**163 m ± 18 m**
Total System Mass	**$(5.278 \pm 0.54) \times 10^{11}$ kg**
Component Bulk Density	**2,100 kg m^{-3} ± 30%**
Primary Rotation Period	**2.2600 ± 0.0001 h**
Component Separation	**1180 +40/-20 m**
Secondary Orbital Period	**11.920 +0.004/−0.006 h**
Spectral Class	**S**

- **Didymos is a well-characterized asteroid that approaches close to Earth, enabling ground-based observations of impact demonstration**
- **The secondary ("Didymoon") is realistic scale**
  - **Small enough to deflect kinetically and measure result**
  - **Smaller NEOs represent a more frequent threat to Earth**

Cheng AF et al. (2015) Acta Astron., 115: 262
Cheng AF et al. (2016) Planet. Space Sci., 121:27
Michel P et al. (2016) Adv. Space Res., 57:2529



Deployed Configuration

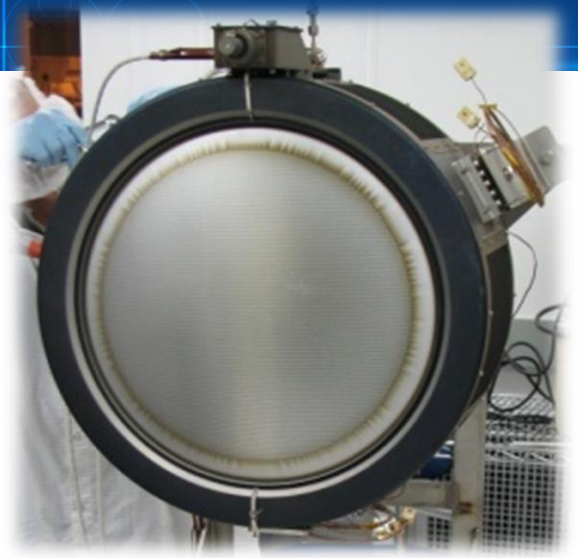


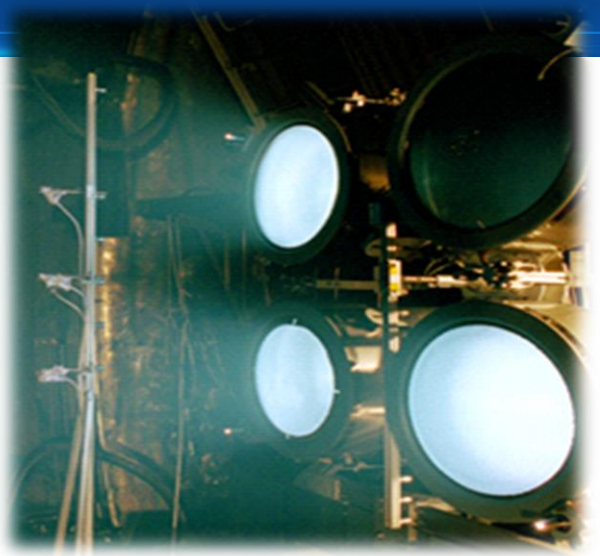
Stowed Configuration

Mass Margin = 25%
Power Margin = 25%

DART
Double Asteroid Redirection Test

NEXT-C Project: DART Collaboration





Performance Characteristics	
Thruster Power, kW	0.5 – 6.9
Specific Impulse, sec	2500 - 4200
Thrust, mN	25 - 235
Thrust –to-Power, mN/kW	32 - 48
Thruster Efficiency	0.32 – 0.7
Lifetime - Xenon Throughput, kg	> 600

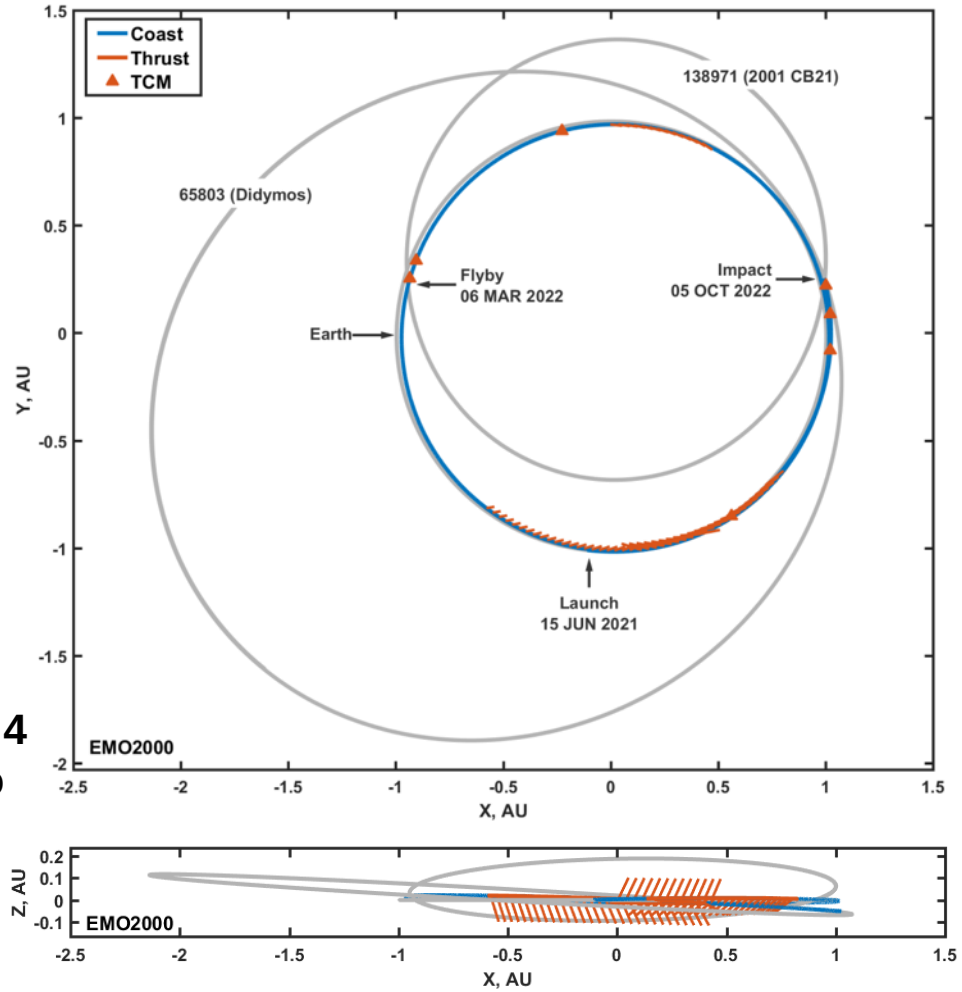
- **NASA's Evolutionary Xenon Thruster (NEXT) began as a technology development project**
- **NEXT-C project's objective is to transition the NEXT technology to flight and create a commercially available product (Managed by NASA GRC)**
- **The NEXT-C project is producing two flight qualified thrusters and two Power Processing Units (PPUs). A single thruster and PPU (with simulators, testbeds, test data & documentation) are GFE to the DART project.**
- **Flight project preparing to support a mission(s) with GFE flight hardware delivery in early 2019**

DART is the first flight of NEXT and will qualify it for future deep space missions

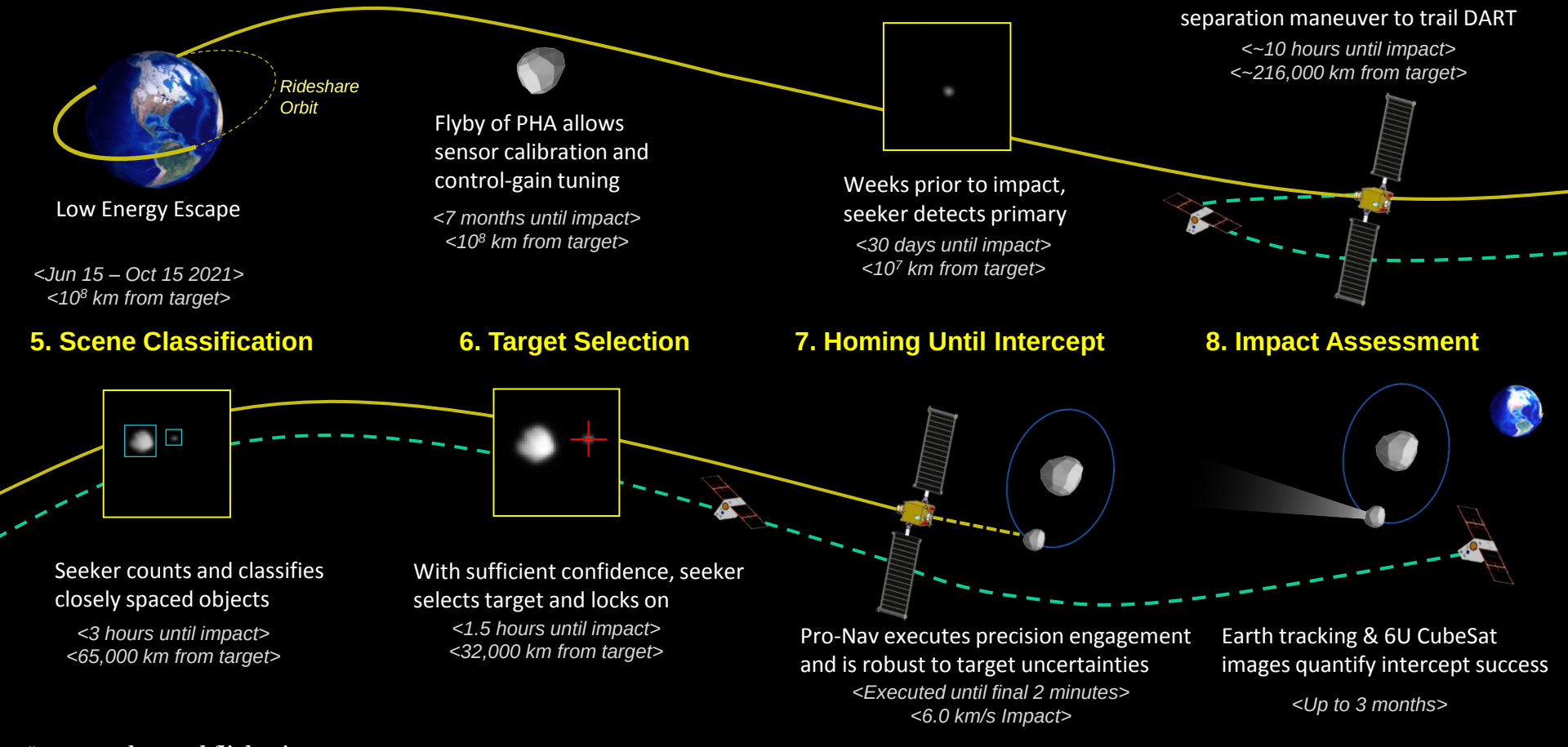
DART Double Asteroid Redirection Test

Baseline heliocentric transfer trajectory delivers DART to Didymos in Oct 2022

- **The baseline is a design reference**
  - **Occurs at Launch Period Open: Jun 2021**
  - **It's designed to the worst-case launch direction for that date**
  - **NEXT-C enabled asteroid flyby: 06 Mar 2022**
  - **Impact: 05 Oct 2022**
  - **Mission Duration: ~15 months**
- **DART uses the NEXT-C to thrust for roughly 140 days in 3 arcs**
  - **DART drifts ahead of Earth and changes its inclination to impact Didymos in its 2022 apparition**
  - **The impact occurs below the ecliptic plane**
- **OpNavs are used to design sets of 3 and 4 chemical TCMs for final targeting prior to Flyby and SMART Nav**
- **Low thrust allows impact geometry to be optimized**



Path To Terminal Guidance
*2022 Intercept (~10.9M km; 6.8M miles from Earth)**
Autonomous Navigation and Targeting



* 15 months total flight time

Didymos Encounter

timeline not to scale

30 days DRACO detects the Didymos system

7 days DSN coverage enables real-time downlink

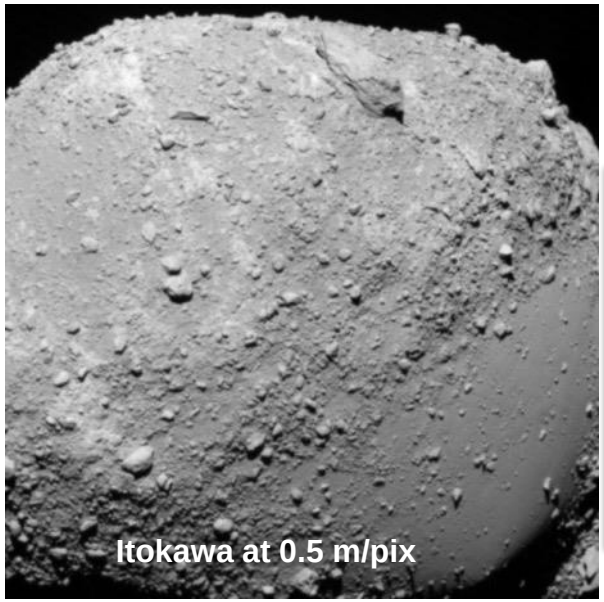
12 hrs Begin pre-terminal phase

4 hrs Begin terminal phase

4 min

2 min

17 s



DRACO achieves the 50 cm/pixel requirement ~17 sec (100 km) before impact

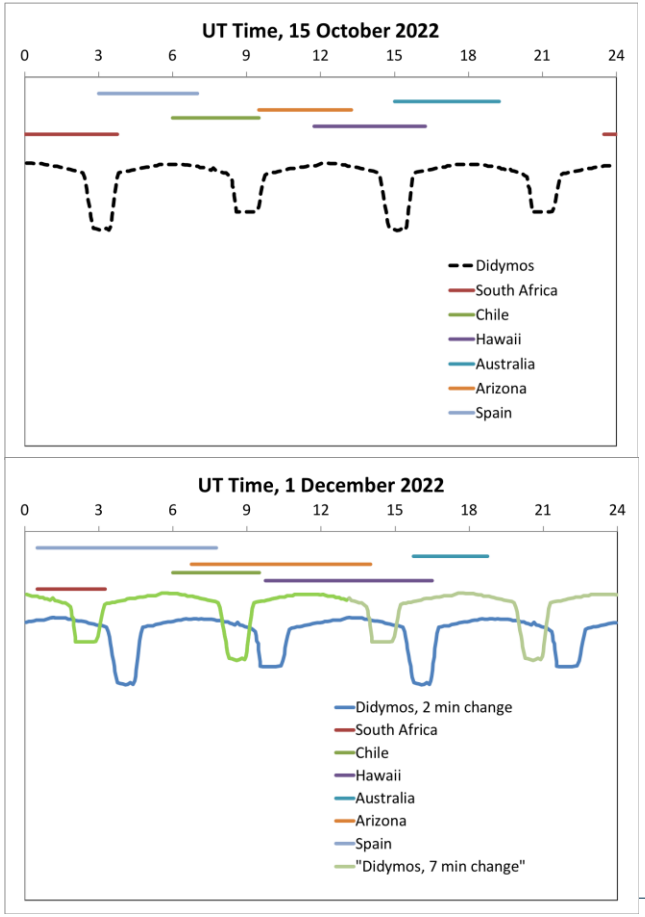
(Didymos B: ~300 pix @ 50 cm/pix)

Higher resolution images will continue to be acquired in the final seconds of the mission.

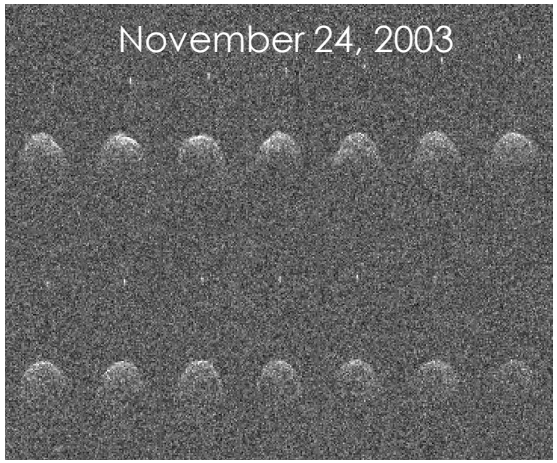
Post-Impact Observability over Fall 2022

Ground-based observations after impact are critical to achieving DART Level 1s

Lightcurve change easily measurable in matter of weeks



Radar opportunity in 2022 (DART-3 & 4B)



- Earth close approach on October 4
  - **Encounter distance will be 0.071 au (1.5 x the 2003 close approach)**
- Goldstone target: Sep 25 – Nov 18
  - **Maximum SNR 1/4th as strong as 2003**
- Arecibo target from Oct 24 – Jan 04
  - **Maximum SNR 1/3rd as strong as 2003**
- Resolutions: 2x coarser than in 2003
  - **Goldstone: 150 m/pixel**
  - **Arecibo: 30 m/pixel**
- Using GBT to receive Goldstone signals will improve resolution to 75 m/pixel

DART Double Asteroid Redirection Test

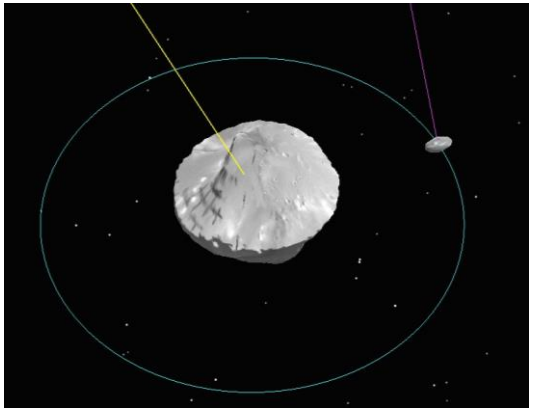
Post-Impact
2022 Observing Campaign

Selected telescopes expected to be available, baseline support of bolded observatories

Facility	Telescope(s)	Location(s)	Capability
Magellan	**2 x 6.5m**	**SH: Chile**	**Optical and NIR imaging & spectroscopy**
Las Campanas	**1 x 2.5m**	**SH: Chile**	**Optical imaging & spectroscopy**
DCT	**1 x 4.3m**	**NH: Arizona**	**Optical & NIR imaging & low res spectroscopy**
MRO	**1 x 2.4m**	**NH: New Mexico**	**Optical imaging, Optical low res spectroscopy**
LCOGT	**11 x 1m, 2 x 2m**	**NH: 1 x 2m, 3 x 1m SH: 1 x 2m, 8 x 1m**	**Optical imaging, Optical low res spectroscopy**
IUCAA	1 x 2.0m	NH: India	Optical imaging
AAO	1 x 3.9m	SH: Australia	NIR imaging & spectroscopy
SAAO	1 x 11.0m, 1 x 1.9m	SH: South Africa	Optical imaging & low res spectroscopy
IRTF	1 x 3.0m	NH: Mauna Kea	Low & high res IR spectroscopy
Keck	2 x 10.0m	NH: Mauna Kea	Low & high res Optical & IR spectroscopy, AO
Gemini	2 x 8.0m	NH: Mauna Kea, SH: Chile	Optical and IR imaging & spectroscopy, AO
WHT	1 x 4.2m	NH: Canary Islands	Optical & IR imaging & spectroscopy, AO
ESO	4 x 8.2m, 1 x 3.6m, 1 x 3.5m	SH: Chile	Optical & IR imaging & spectroscopy, AO, IR high res spectroscopy
GTC	1 x 10.4m	NH: Canary Islands	Optical imaging, Optical low res spectroscopy

DART Firsts

First mission to **measure asteroid deflection** by constraining the "ejecta momentum amplification factor" of a kinetic impactor, **as well as the initial conditions** (impact conditions, target's properties)



First mission to fly **NASA's NEXT-C** solar electric propulsion technology

First mission (with another spacecraft, if available) to **study a binary asteroid system,** its **origins** and **interior structure**

Contributes valuable data to many disciplines, i.e., planetary defense, science, human exploration and resource utilization