



DART Mission – Getting to Dimorphos Impact and Lessons Learned

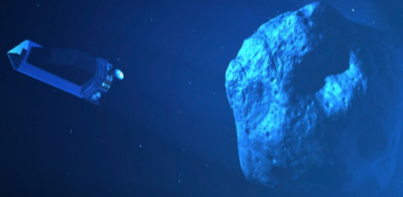
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Johns Hopkins University Applied Physics Laboratory



ASSESS

[CENTER FOR NEAR EARTH OBJECT STUDIES]



SEARCH, DETECT & TRACK

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



MITIGATE

[DART, FEMA EXERCISES]



NASA Planetary Defense Coordination Office (PDCO): established 2016



CHARACTERIZE

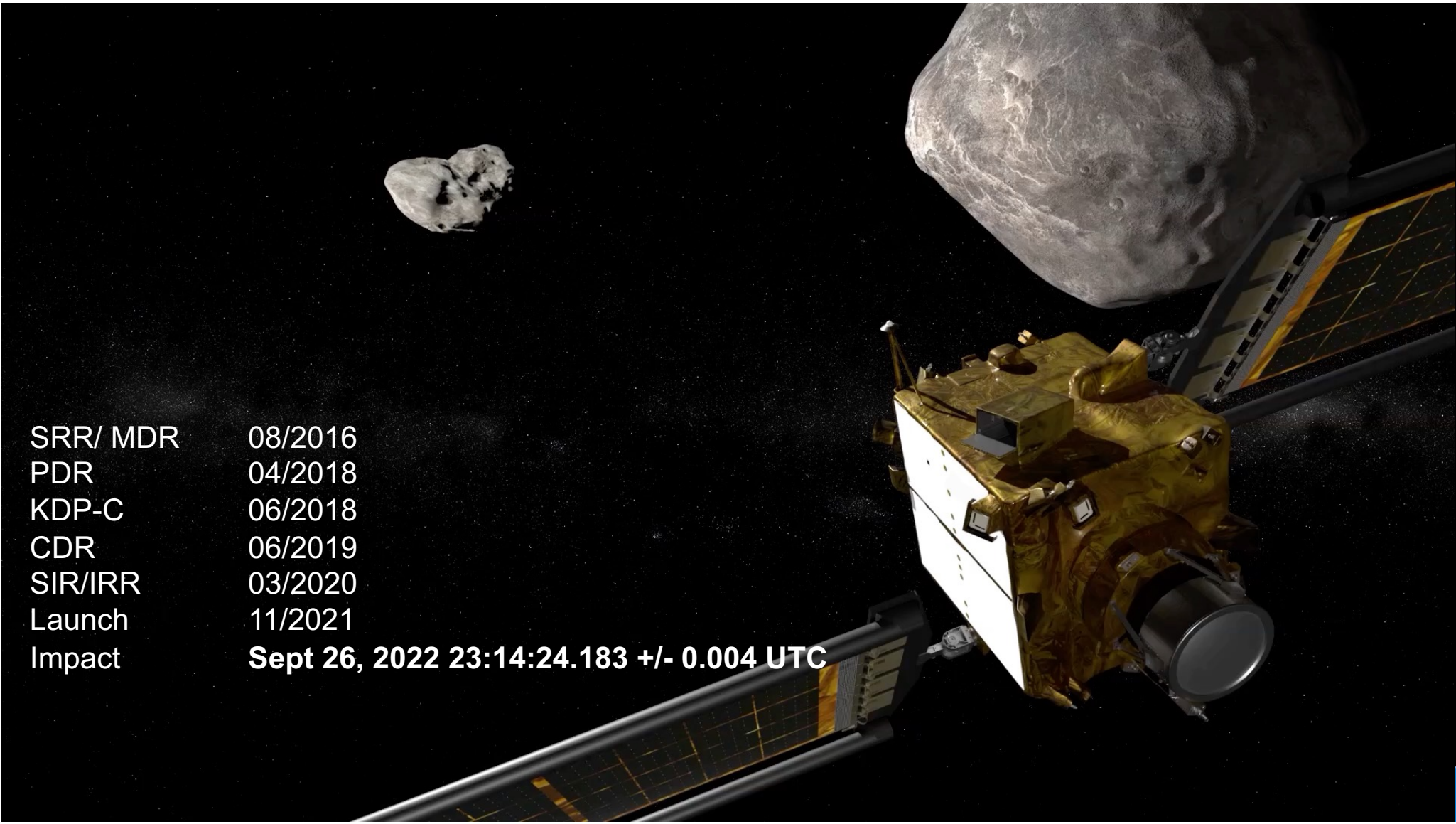
[NEOWISE, GOLDSTONE, IRTF]



PLAN & COORDINATE

[SMPAG, PIERWG, NITEP IWG]

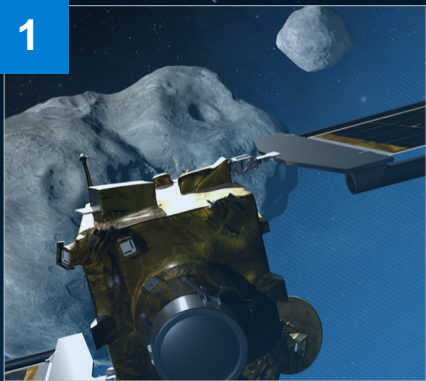




SRR/ MDR	08/2016
PDR	04/2018
KDP-C	06/2018
CDR	06/2019
SIR/IRR	03/2020
Launch	11/2021
Impact	Sept 26, 2022 23:14:24.183 +/- 0.004 UTC

DART Level 1 Requirements

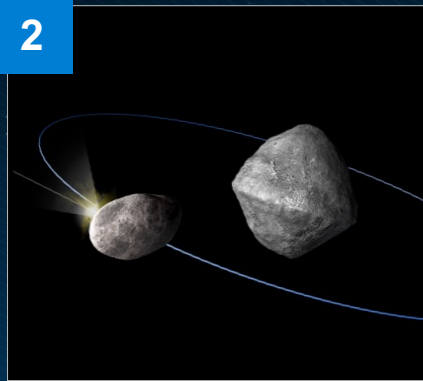
1



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

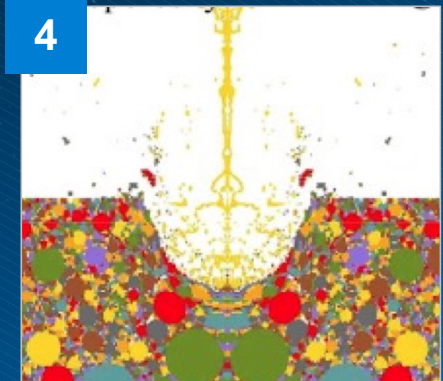
3



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



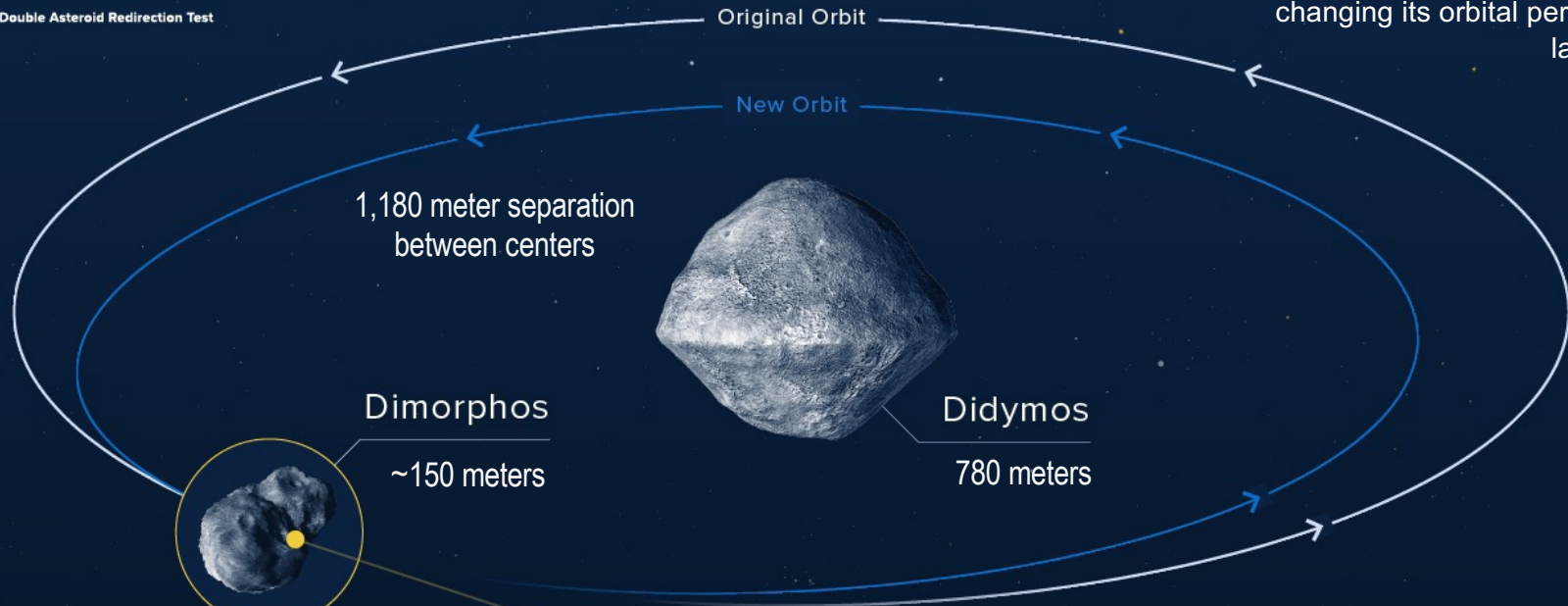


DART

Double Asteroid Redirection Test

The Ideal Target

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



1,180 meter separation between centers

Dimorphos

~150 meters

IMPACT

Didymos

780 meters

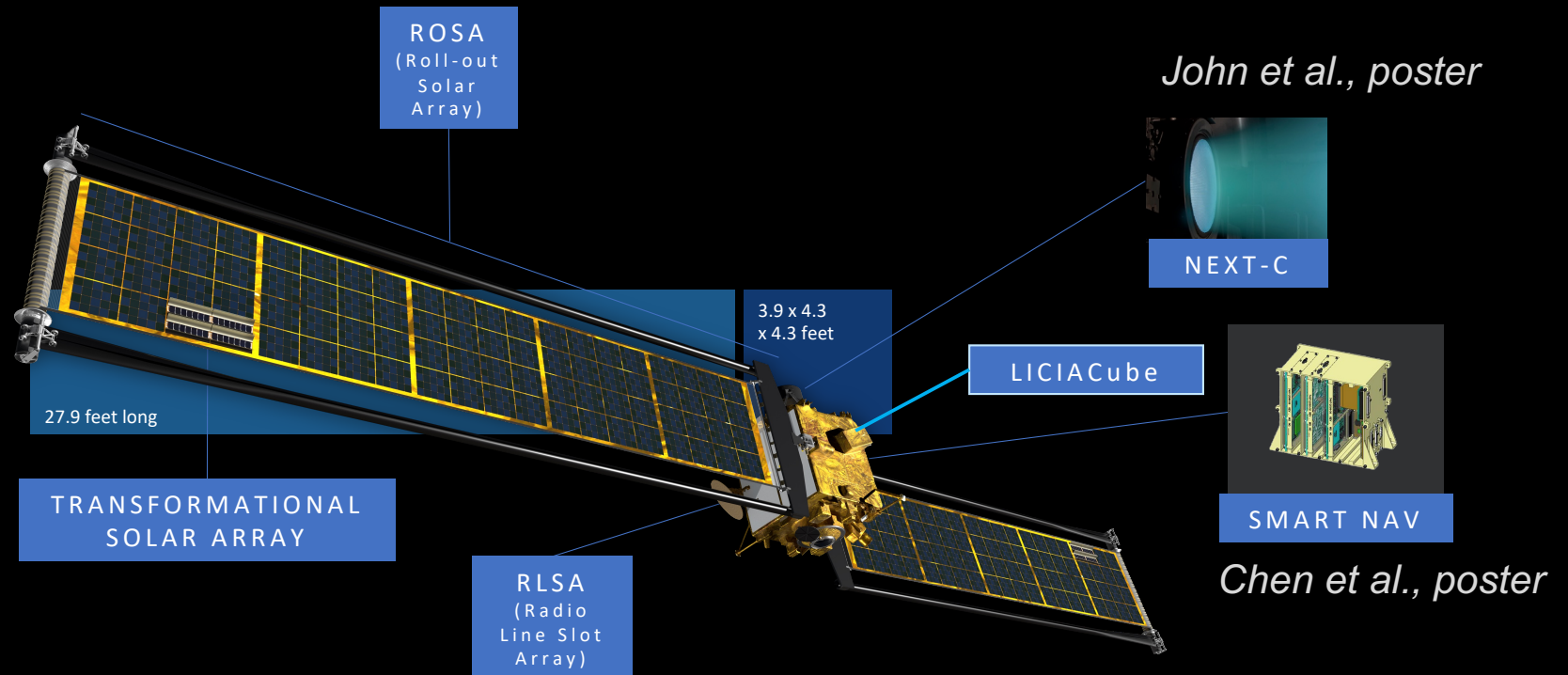
Spacecraft

LICIACube



Earth-based observations

DART Technologies





Bill Ingalls/NASA

Nov 2021
Vandenberg Space
Force Base

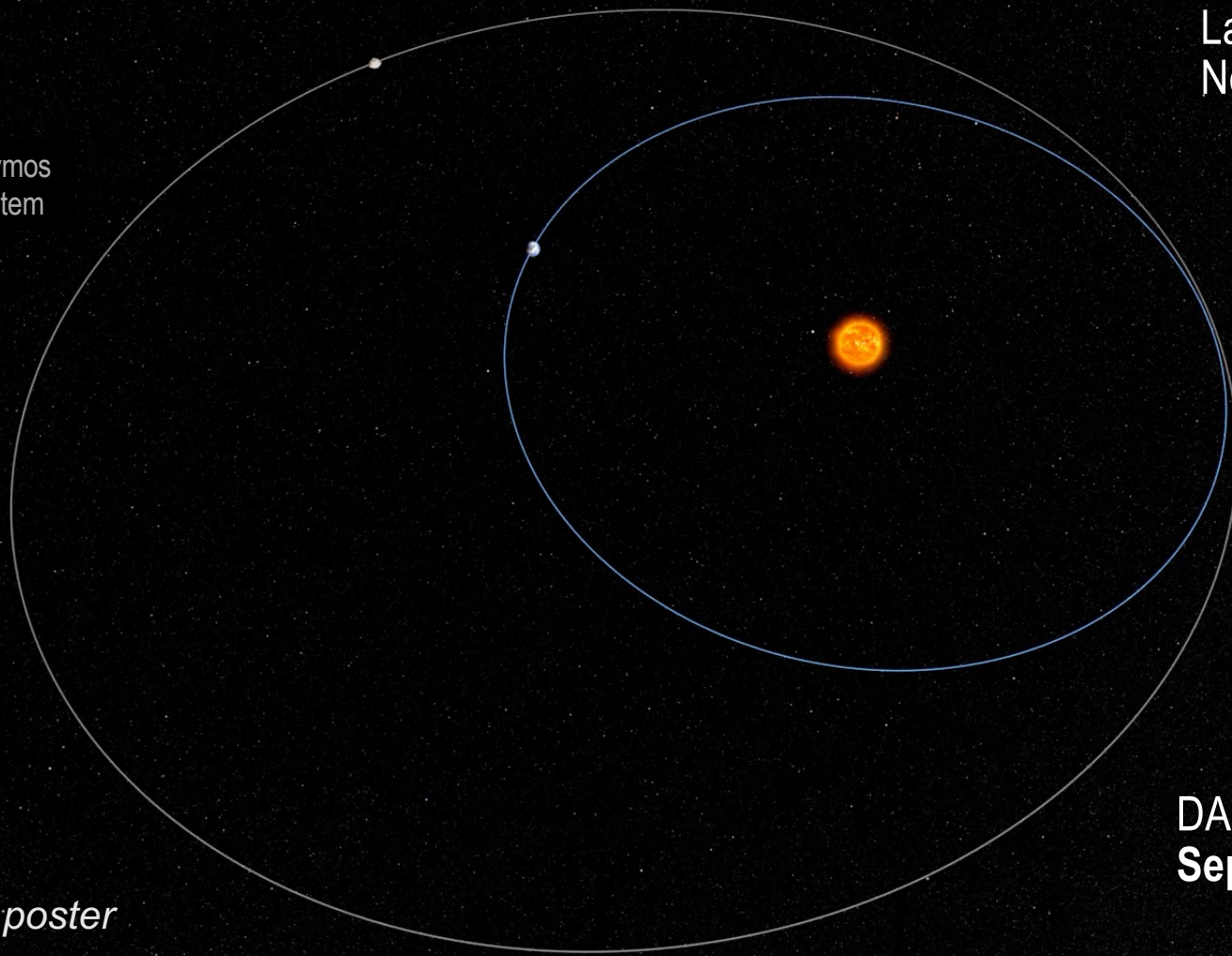


Didymos
System

Launch:
Nov. 23, 2021

DART Kinetic Impact:
Sept. 26, 2022

Atchison et al., poster



DRACO Instrument

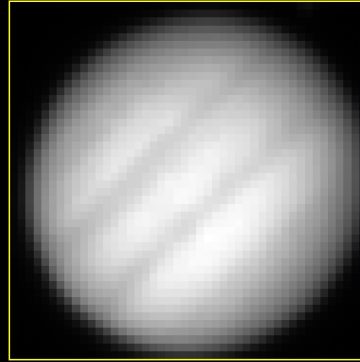
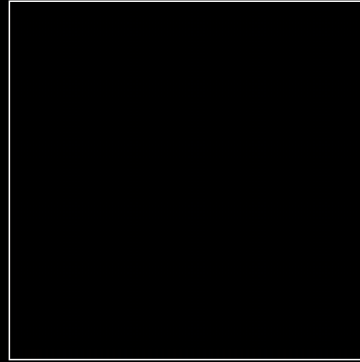


Fletcher et al., poster

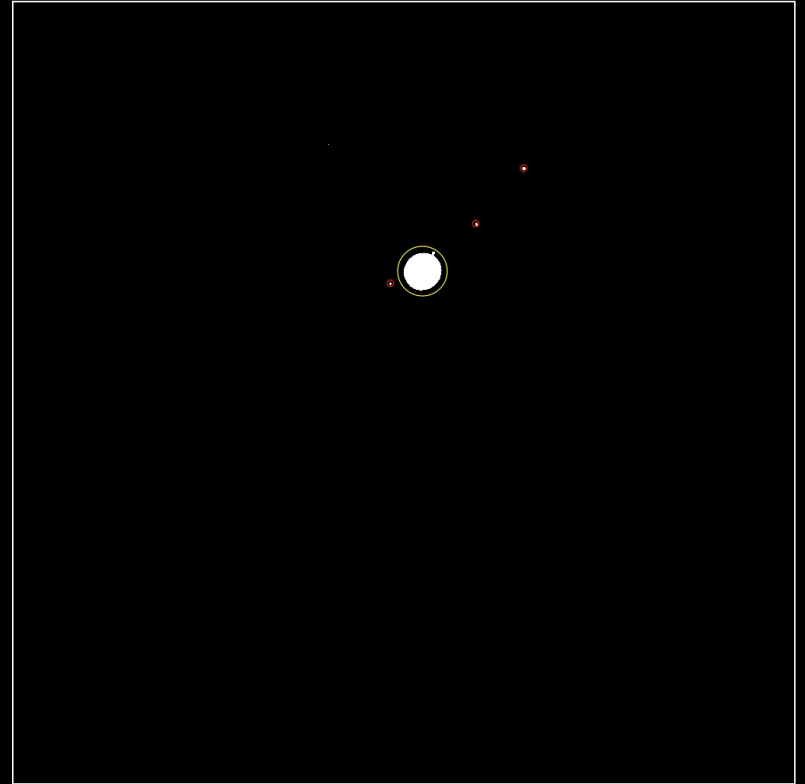




[10x Speed] T -00:04:59 dart_0397159312_38745_01 CTRD=4
LOCKING DIDYMOS



DIDYMOS



Thresholded View (DN=30)

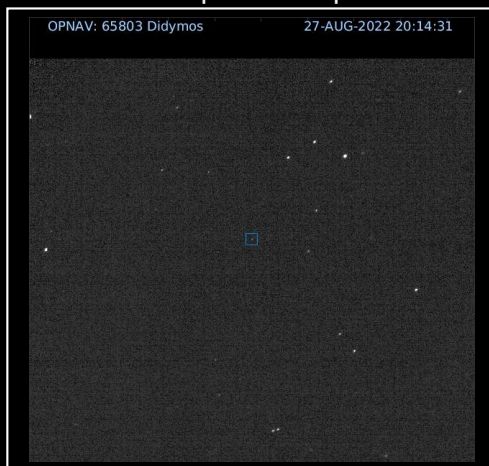
Chen et al., poster

Knew little about the object we are going to hit

Dimorphos

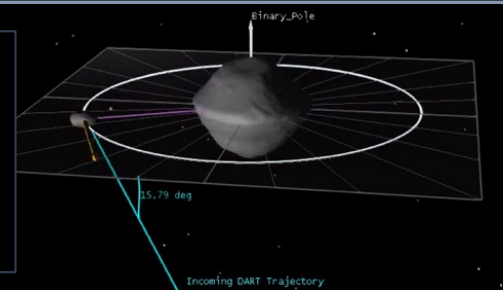
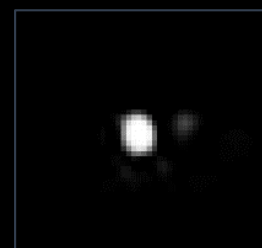


DRACO Optical Navigation Images in the last month prior to impact



Timeline to Impact

Fully Autonomous
Begin terminal phase
SMART Nav guidance is enabled



Camera detects Didymos system

LICIACube release

Continuous ground antenna coverage

Begin pre-terminal phase

30 days

10 days

8 hours

4 hours

30 days

10 days

8 hours

4 hours

60 minutes

4 minutes

2 minutes

20 seconds



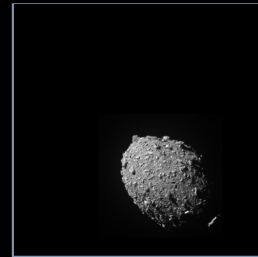
Timeline to Impact



25,000 kilometers
Didymos – 8 pixel
Dimorphos – 2 pixel
Started tracking
Dimorphos



920 kilometers
Didymos – 180 pixel
Dimorphos – 38 pixel
Final downlinked images
to contain all of Didymos



76 kilometers
Didymos – N/A
Dimorphos – 470 pixel
Final images to contain
all of Dimorphos



12 kilometers
Didymos – N/A
Dimorphos image– 31
meters across
Penultimate Image



Sept 26 7:10-7:15 pm

EST

DRACO images
streamed to Earth from
7 million miles away
10x speed



DART Performance Highlights

- All spacecraft subsystems performed nominally
- Fixes to autonomy to cycle spacecraft heaters made a big difference in ability to guide the spacecraft into Dimorphos
- Dedicated tests and calibrations in flight allowed to set best parameters for SMARTNav, and DRACO and Guidance and Control Systems
- Once autonomous, no SMARTNav maneuvers were performed until transition to Dimorphos
- Following transition to Dimorphos, spacecraft spent ~60% of the time maneuvering
- Asteroid remained fully contained (valid images for targeting) throughout
- Demonstrated ability of spacecraft to impact the target **within 25 m of the asteroid geometric center**, and **within 2 m of center of the asteroid illuminated area**
- Last full transmitted image came at 1.8 s and the last partial image at 0.8 s before impact
- Impact occurred at 23:14:183 UTC and was a smashing success!



September 26, 2022

Las Cumbres Observatory 1 m telescope in South Africa

4 minutes pre-impact to 37 minutes post-impact

*Credit: Tim Lister, Joseph
Chatelain, Rachel Street,
Edward Gomez, Joseph
Farah / Las Cumbres
Observatory.*

