Update on Planetary Defense

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Washington, DC

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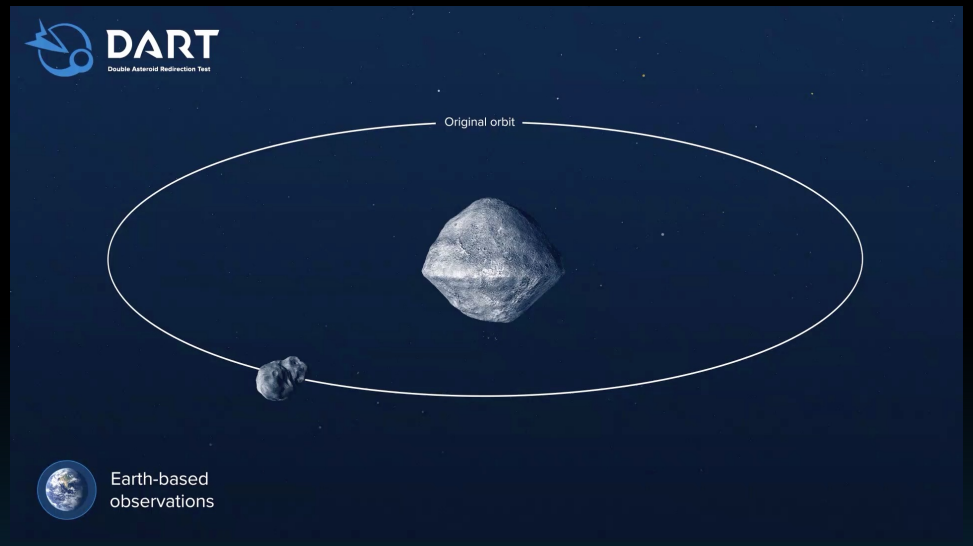
Asteroid Deflection: Kinetic Impactor (KI)

Double Asteroid Redirection Test

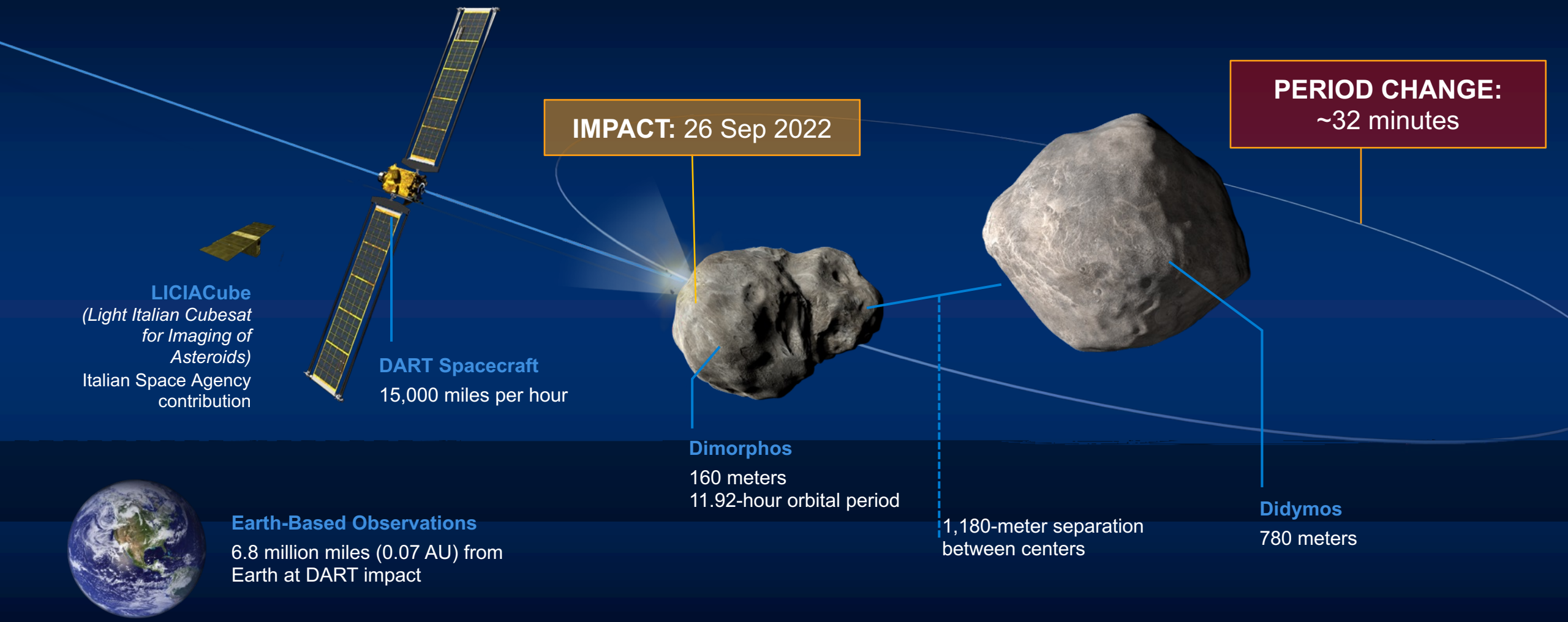
The first test of an asteroid deflection technique, by impacting a spacecraft into an asteroid.

DART
Double Asteroid Redirection Test

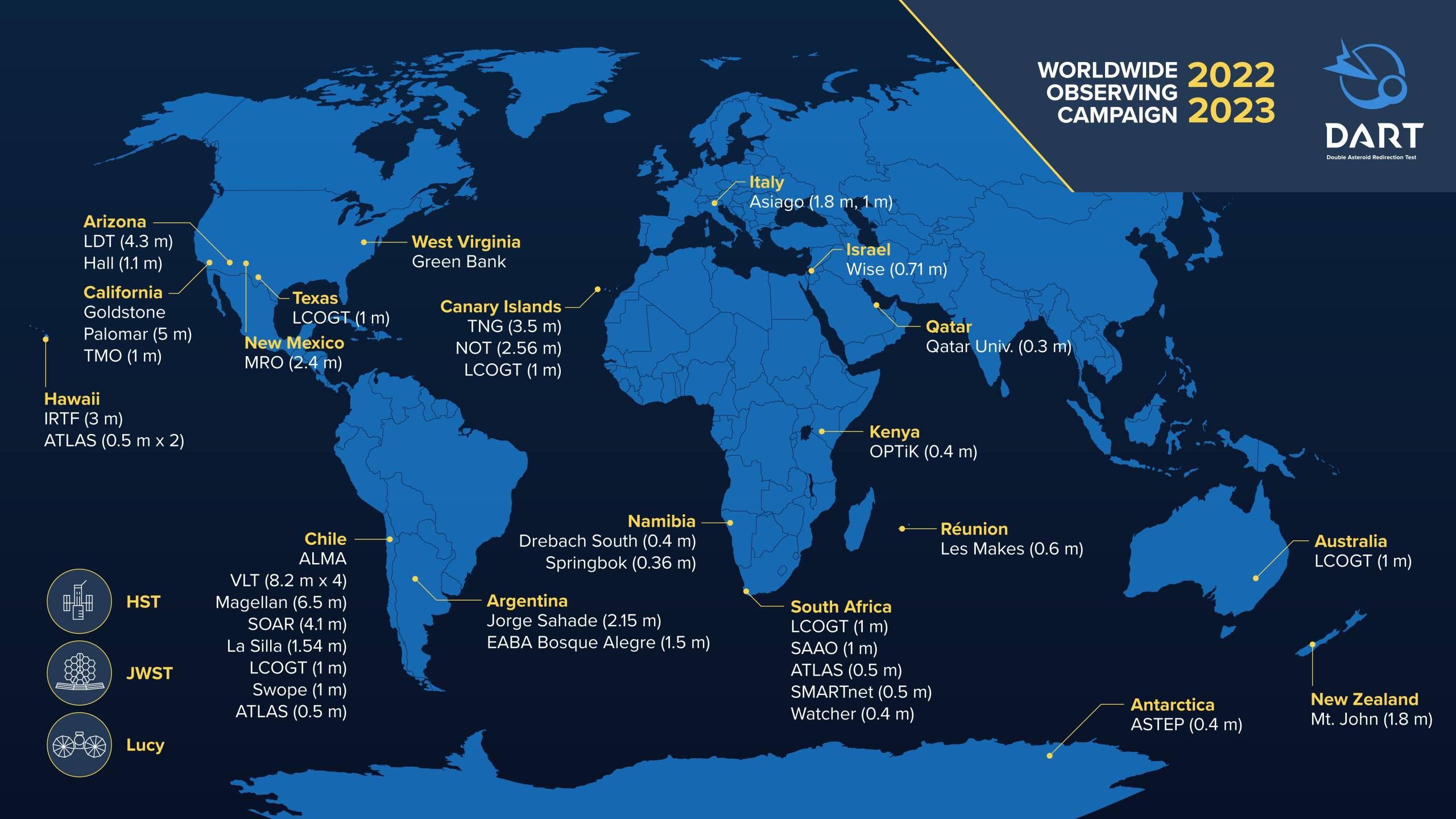


DART Mission Goals:

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



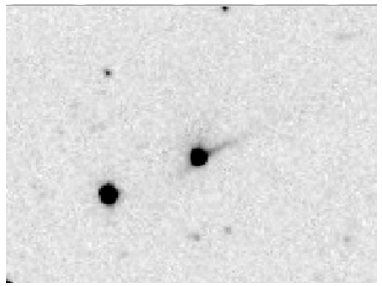
DART Impact Replay


WORLDWIDE OBSERVING CAMPAIGN 2022 2023
DART
Double Asteroid Redirection Test
Arizona
LDT (4.3 m)
Hall (1.1 m)
California
Goldstone
Palomar (5 m)
TMO (1 m)
Hawaii
IRTF (3 m)
ATLAS (0.5 m x 2)
Texas
LCOGT (1 m)
New Mexico
MRO (2.4 m)
West Virginia
Green Bank
Canary Islands
TNG (3.5 m)
NOT (2.56 m)
LCOGT (1 m)
Italy
Asiago (1.8 m, 1 m)
Israel
Wise (0.71 m)
Qatar
Qatar Univ. (0.3 m)
Kenya
OPTiK (0.4 m)
Namibia
Drebach South (0.4 m)
Springbok (0.36 m)
Réunion
Les Makes (0.6 m)
Australia
LCOGT (1 m)
Chile
ALMA
VLT (8.2 m x 4)
Magellan (6.5 m)
SOAR (4.1 m)
La Silla (1.54 m)
LCOGT (1 m)
Swope (1 m)
ATLAS (0.5 m)
Argentina
Jorge Sahade (2.15 m)
EABA Bosque Alegre (1.5 m)
South Africa
LCOGT (1 m)
SAAO (1 m)
ATLAS (0.5 m)
SMARTnet (0.5 m)
Watcher (0.4 m)
Antarctica
ASTEP (0.4 m)
New Zealand
Mt. John (1.8 m)
HST
JWST
Lucy

ATLAS South Africa (University of Hawai’i/NASA PDCO)

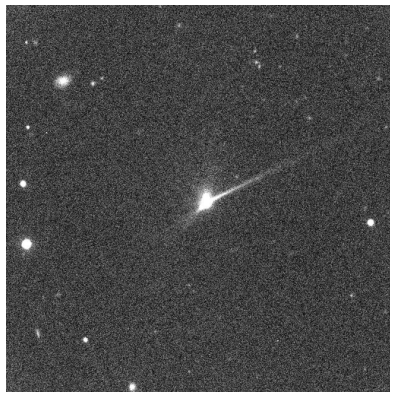
Telescopic observations from around the world

Africa (South Africa)



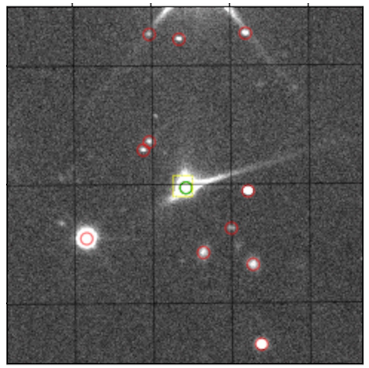
ATLAS project, HQ at U. Hawai'i.

North America (United States)



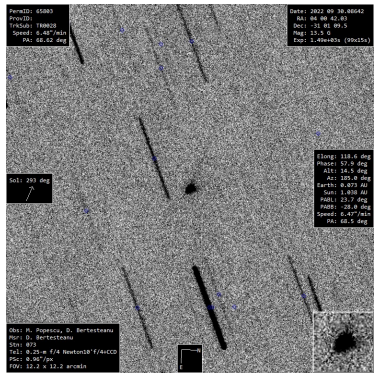
Bill and Eileen Ryan: Magdalena Ridge Obs. NM Tech

South America (Chile)



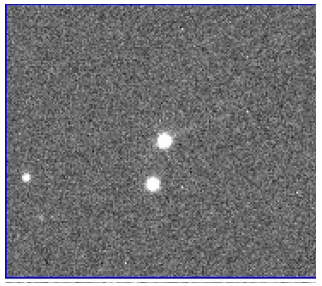
T. Lister, J. Chatelain, E. Gomez / Las Cumbres Observatory

Europe (Romania)



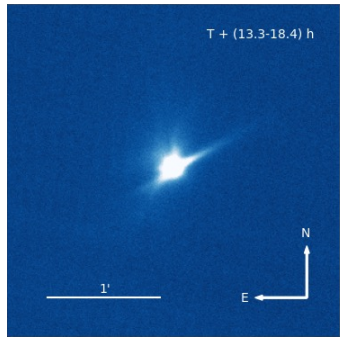
Popescu: Astronomical Institute of the Romanian Academy

Asia (Israel)



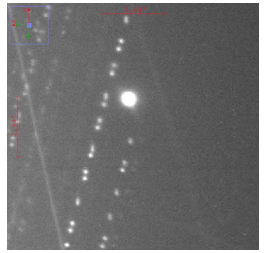
Ofek/Polishook, Weizmann Institute of Science.

Oceania (New Zealand)



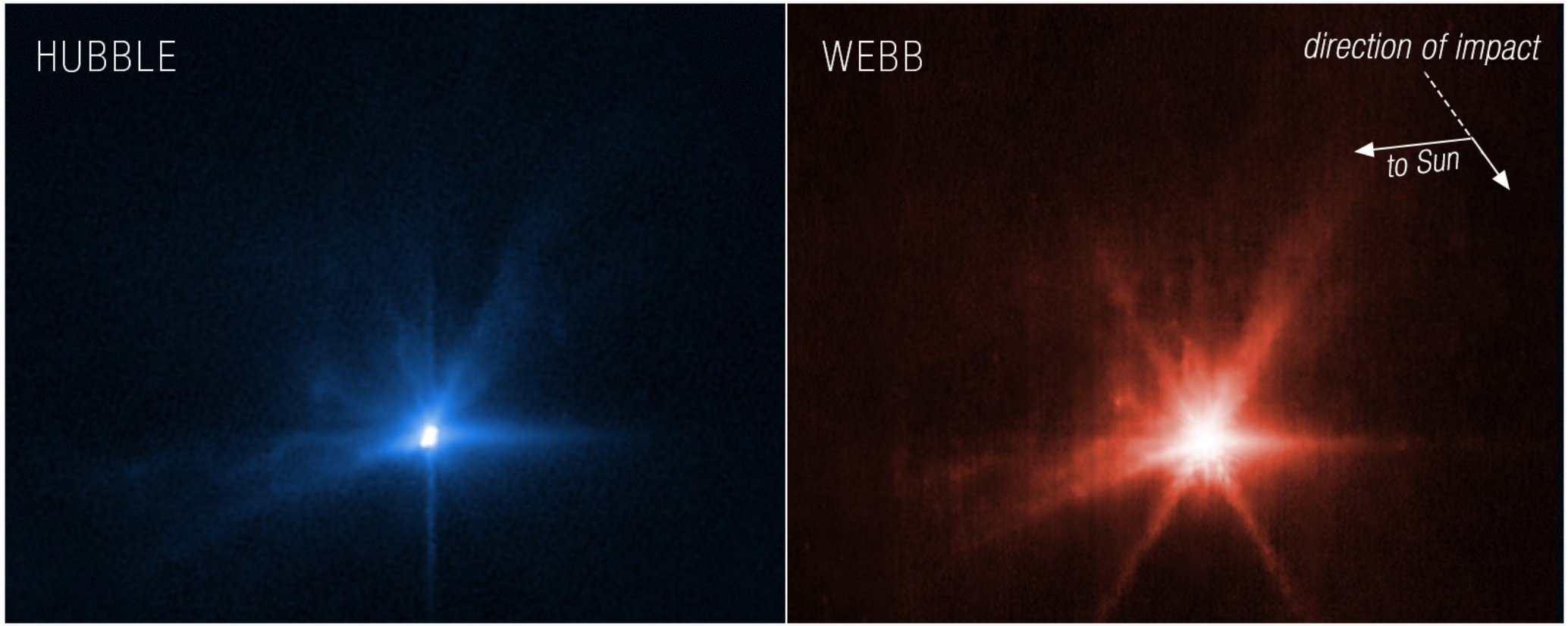
R. Ridden-Harper/M. T. Bannister/N. Tan/T. Brown/P. Tristram, U. Canterbury

Antarctica (Concordia)

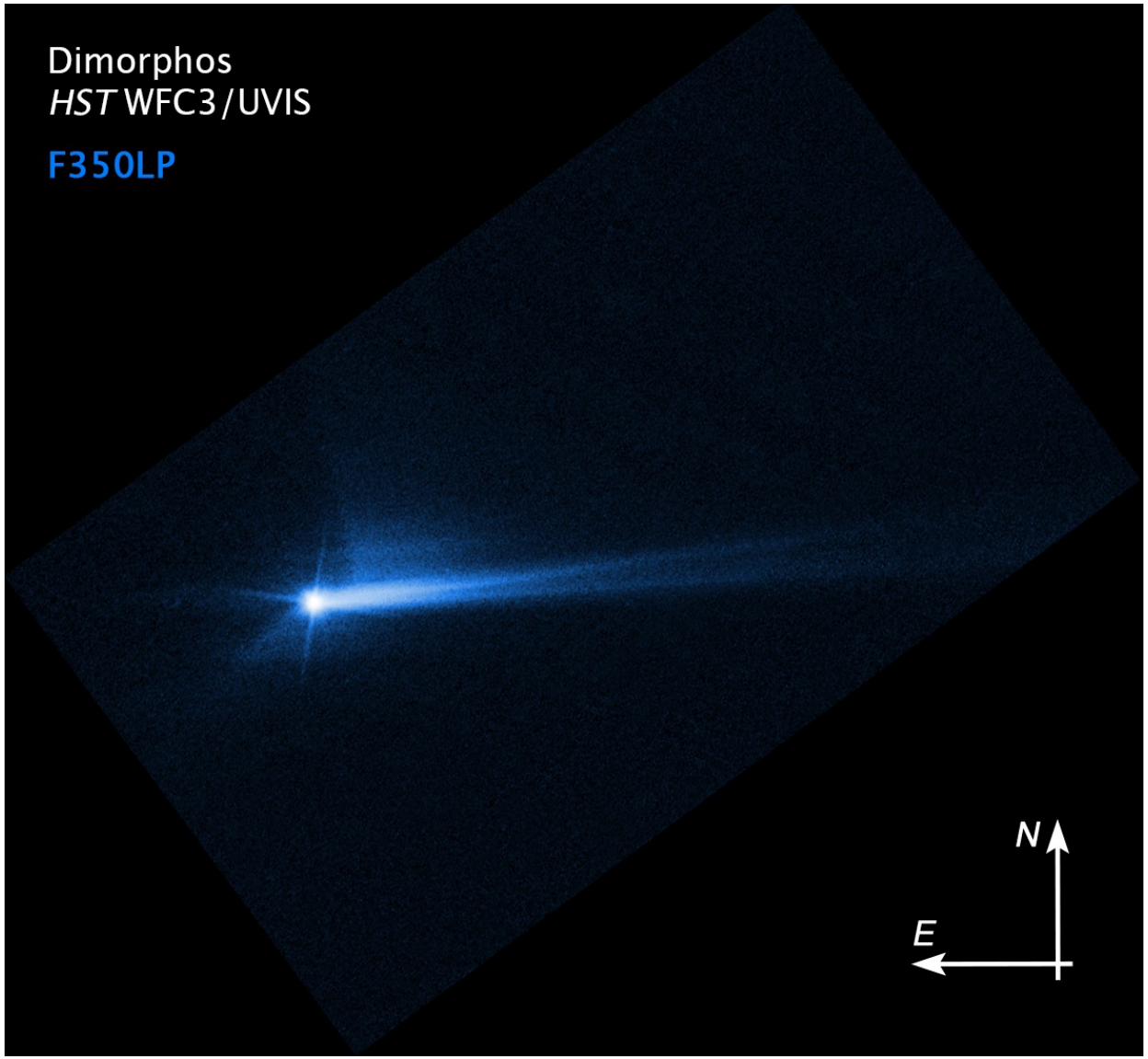


Abe/Guillot: Antarctic Search for Transiting ExoPlanets Project

And this is just a snapshot! There is so much more than this and telescopes continue to provide new data daily.



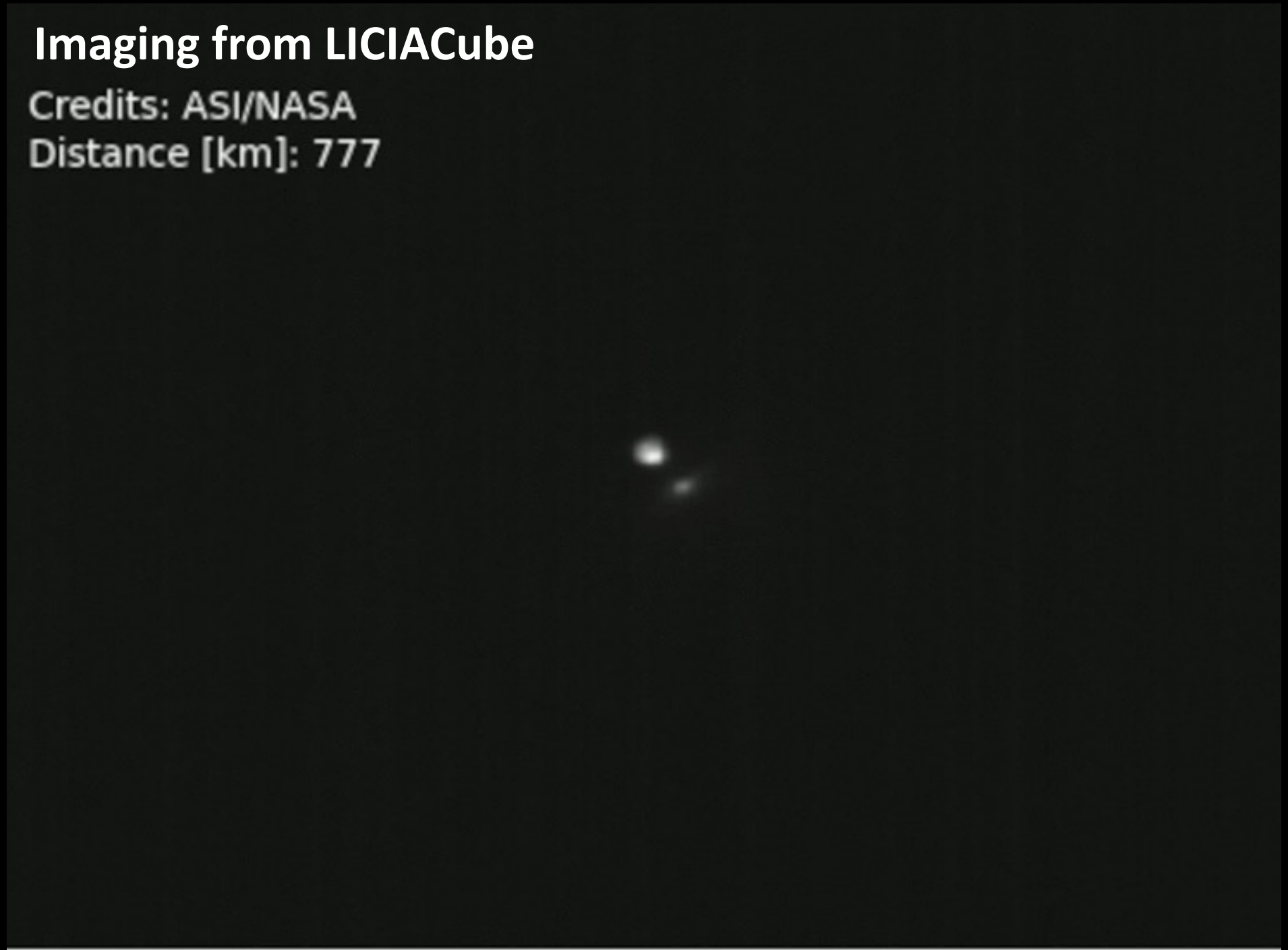
Webb, Hubble Capture Detailed Views of DART Impact
These images, Hubble on the left and Webb on the right, show observations of the Didymos-Dimorphos system several hours after NASA's Double Asteroid Redirection Test (DART) intentionally impacted the moonlet asteroid.
Credit: Science: NASA, ESA, CSA, Jian-Yang Li (PSI), Cristina Thomas (Northern Arizona University), Ian Wong (NASA-GSFC); image processing: Joseph DePasquale (STScI), Alyssa Pagan (STScI)



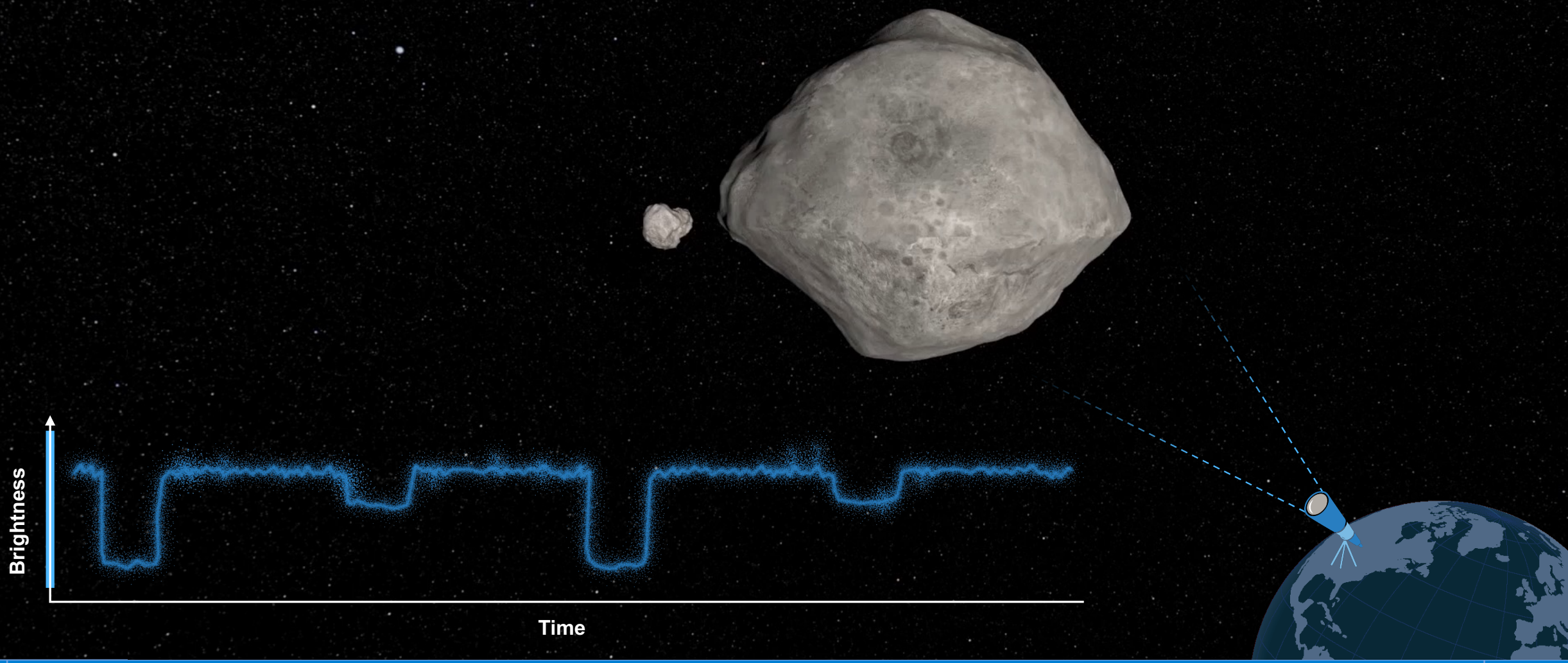
Hubble Captures Detail in Debris Trail

This imagery from NASA's Hubble Space Telescope from Oct. 8, 2022, shows the debris blasted from the surface of Dimorphos 285 hours after the asteroid was intentionally impacted by NASA's DART spacecraft on Sept. 26. The shape of that tail has changed over time. Scientists are continuing to study this material and how it moves in space, in order to better understand the asteroid. **Credits: NASA/ESA/STScI/Hubble**

Imaging from LICIACube



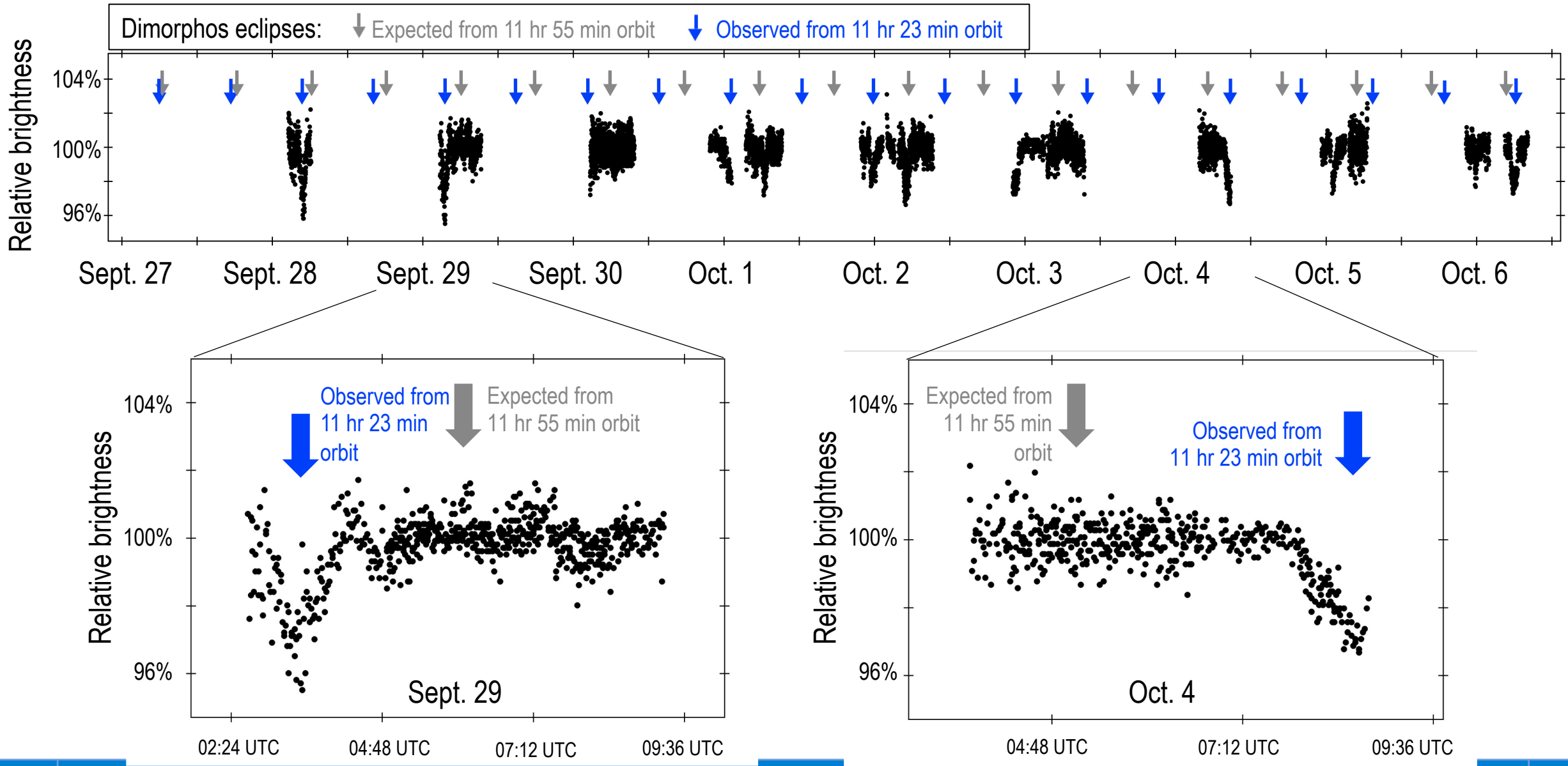
Measuring result of the impact from Earth: new orbit for Dimorphos



Observations after DART impact show orbit change

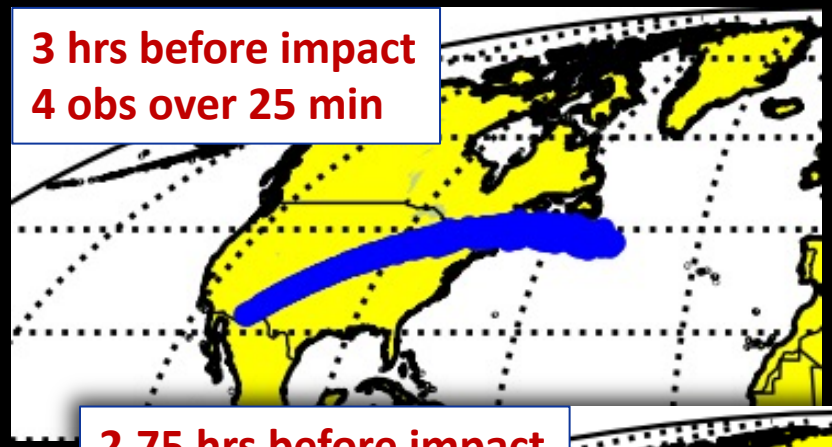
- Prior to DART's impact, it took Dimorphos 11 hours and 55 minutes to orbit its larger parent asteroid, Didymos.
- Since DART's intentional collision with Dimorphos on Sept. 26, astronomers have been using telescopes on Earth to measure how much that time has changed.
- Now, the investigation team has confirmed the spacecraft's impact altered Dimorphos' orbit around Didymos by **32 minutes**, shortening the 11 hour and 55-minute orbit to 11 hours and 23 minutes.
- This measurement has a margin of uncertainty of approximately plus or minus 2 minutes

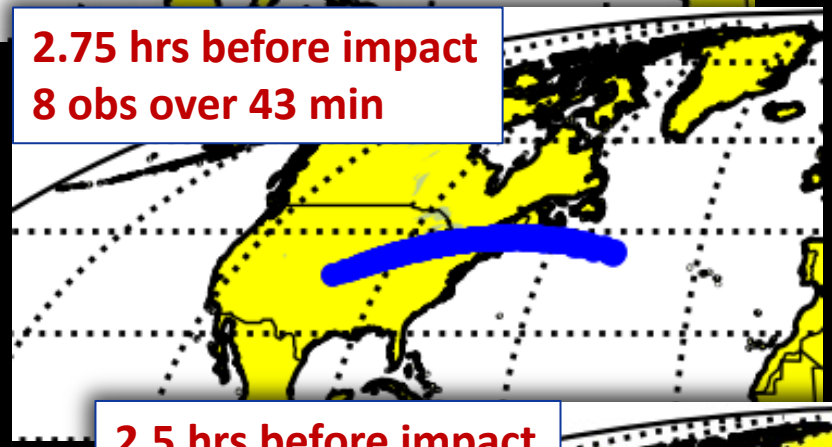
Observations after DART impact show orbit change

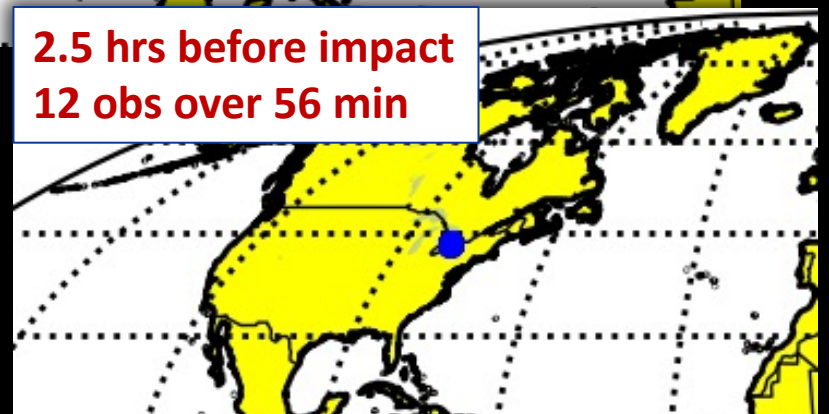


Credit: NASA/Johns Hopkins APL/Astronomical Institute of the Academy of Sciences of the Czech Republic/Lowell Observatory/JPL/Las Cumbres Observatory/Las Campanas Observatory/European Southern Observatory Danish (1.54-m) telescope/Northern Arizona University

2022 WJ1 - Warned Impact on Nov. 19, 2022, 08:27 UTC (3:27 AM EST)

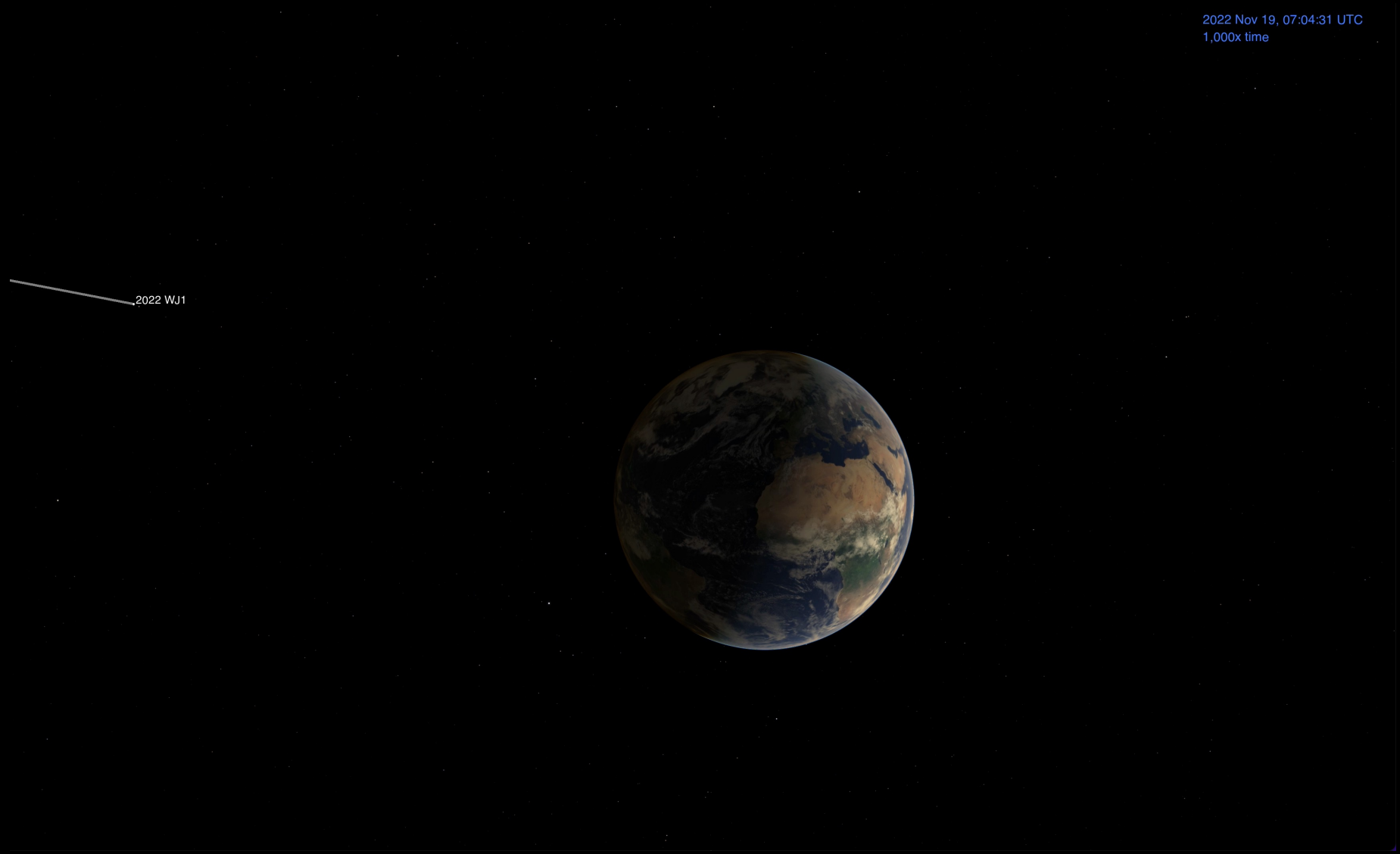






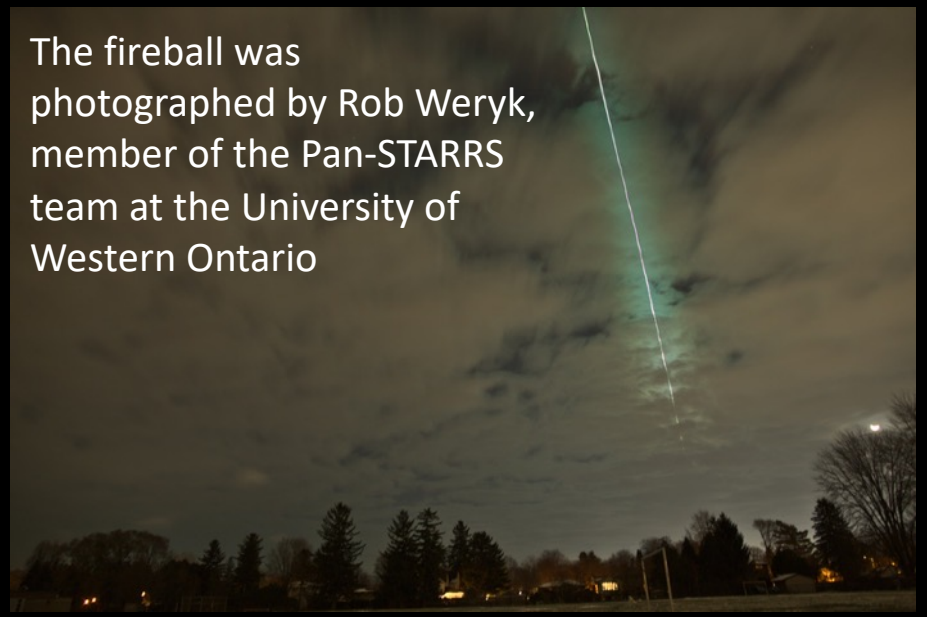
- First observed by the **Catalina Sky Survey**
- Placed on the NEO Confirmation Page by the **Minor Planet Center**
- Impact probability and corridor calculated within minutes by the **Center for Near-Earth Object Studies (CNEOS) Scout** system.
- Additional observations by the Catalina Sky Survey and **Farpoint Observatory, Northeast Kansas Amateur Astronomers' League** allowed Scout to narrow the impact location to Southern Ontario, Canada
- Observations by the community continued and ground observers were notified

2022 WJ1 - Warned Impact on Nov. 19, 2022, 08:27 UTC (3:27 AM EST)



Cosmographia animation courtesy of Davide Farnocchia (JPL/CNEOS)

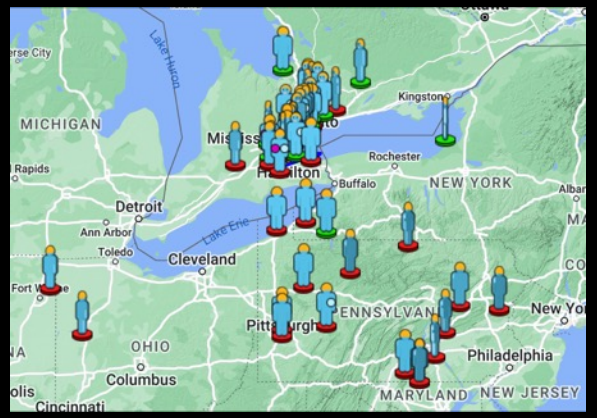
2022 WJ1 - Warned Impact on Nov. 19, 2022, 08:27 UTC (3:27 AM EST)



The fireball was photographed by Rob Weryk, member of the Pan-STARRS team at the University of Western Ontario

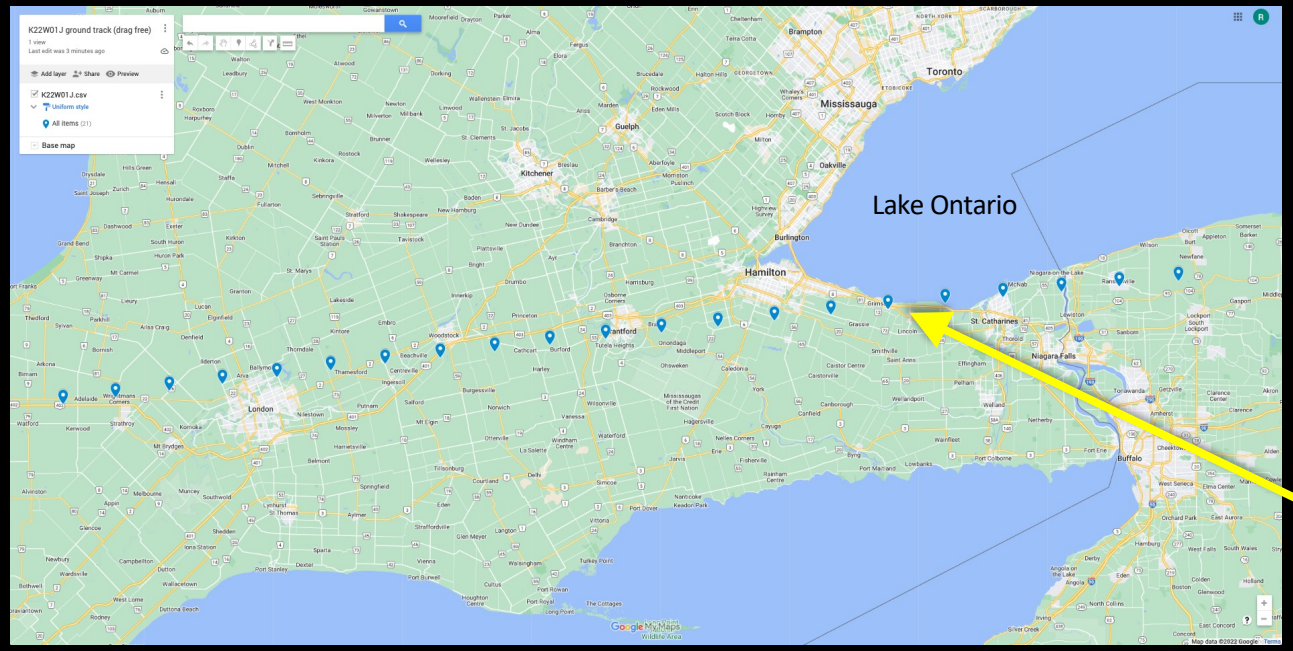
CN Tower Cam – Tower View
Toronto, Canada

University of Western Ontario
All-Sky Camera Network



Over 50 witness reports on the American Meteor Society website
https://fireball.amsmeteors.org/members/imo_view/event/2022/8984

2022 WJ1 - Warned Impact on Nov. 19, 2022, 08:27 UTC (3:27 AM EST)



Ground track based on JPL/CNEOS impact location estimates as a function of the altitude in the atmosphere that the object could have disintegrated (courtesy R. Seaman UA/Catalina Sky Survey)

Probable meteorite fall detected by NEXRAD Doppler weather radar
https://ares.jsc.nasa.gov/meteorite-falls/events/grimsby-ontario

2022 WJ1 - Warned Impact on Nov. 19, 2022, 08:27 UTC (3:27 AM EST)

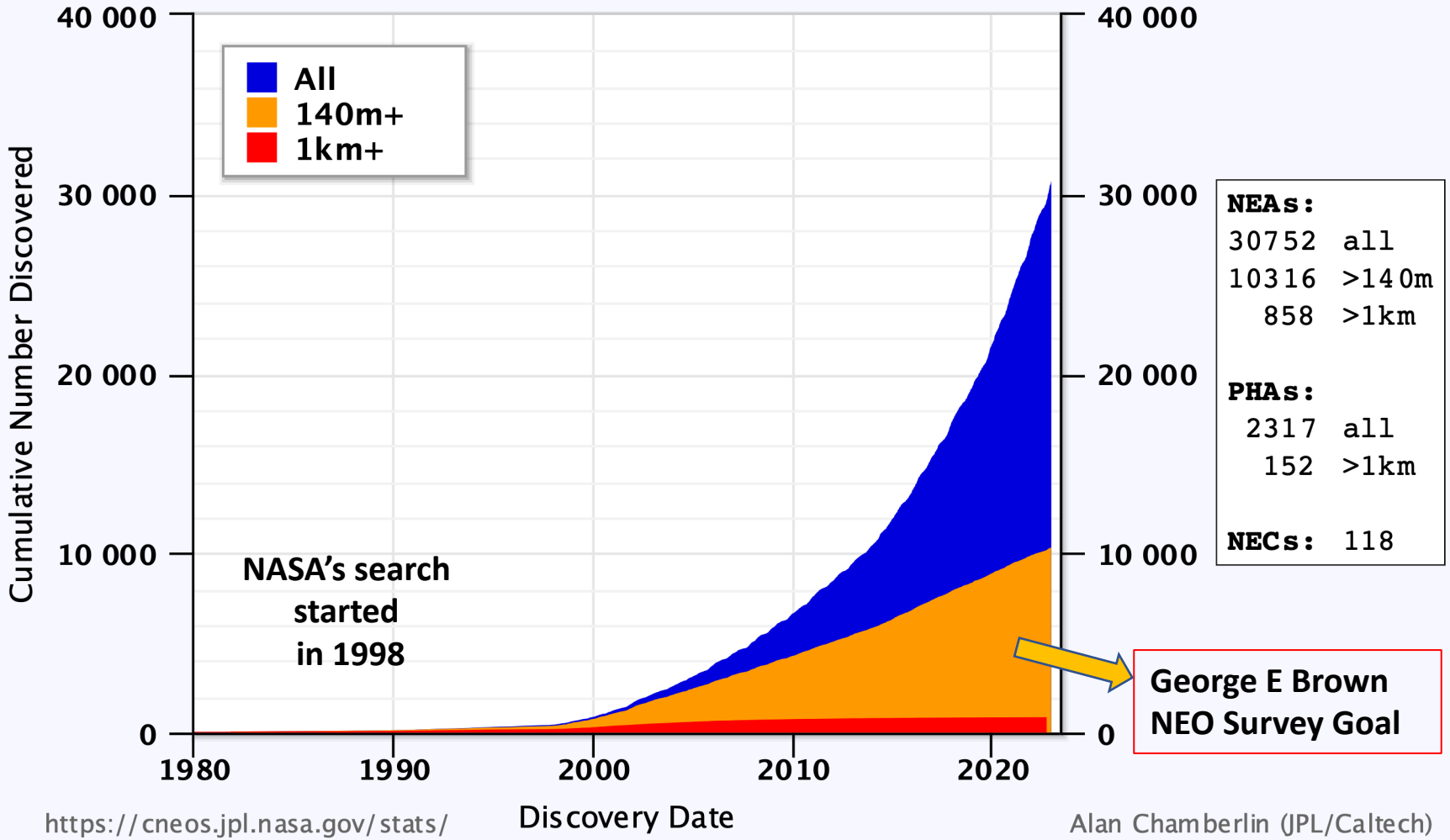
- At ≤1 meter in size, 2022 WJ1 was a much smaller object than NASA is tasked to detect and warn about since objects of that size easily disintegrate after they impact Earth's atmosphere
- This real-world event exercised capabilities and gave confidence that NASA/JPL/CNEOS impact prediction models are adequate to inform response to the potential impact of a larger object
- The success of this real-world exercise was due to routine rapid reporting and orbit determination by NASA-funded projects
- This is the sixth impact tied to observations obtained of a natural object while it was still in space (4th for Catalina Sky Survey)

PLANETARY DEFENSE
COORDINATION OFFICE

NASA

Near-Earth Asteroids Discovered

Most recent discovery: *2022-Nov-29*



https://cneos.jpl.nasa.gov/stats/

Alan Chamberlin (JPL/Caltech)

**Potentially Hazardous Asteroids come within 7.5 million km of Earth orbit*

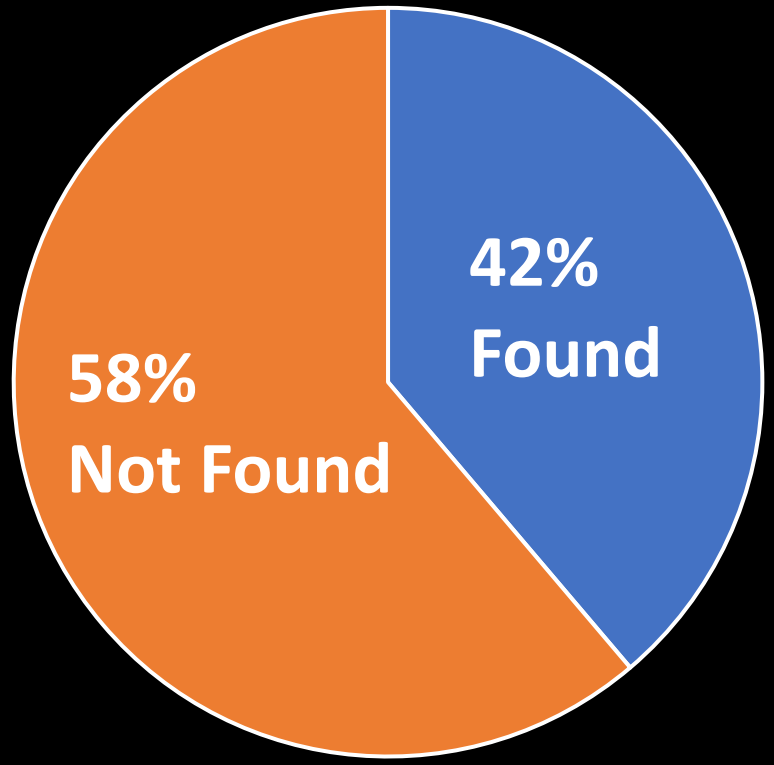
Progress: 140 Meters and Larger

Total Population estimated to be ~25,000

NEO Survey Status as of 30 Sep 2022

George E Brown NEO Survey Goal: (tasked in 2005)

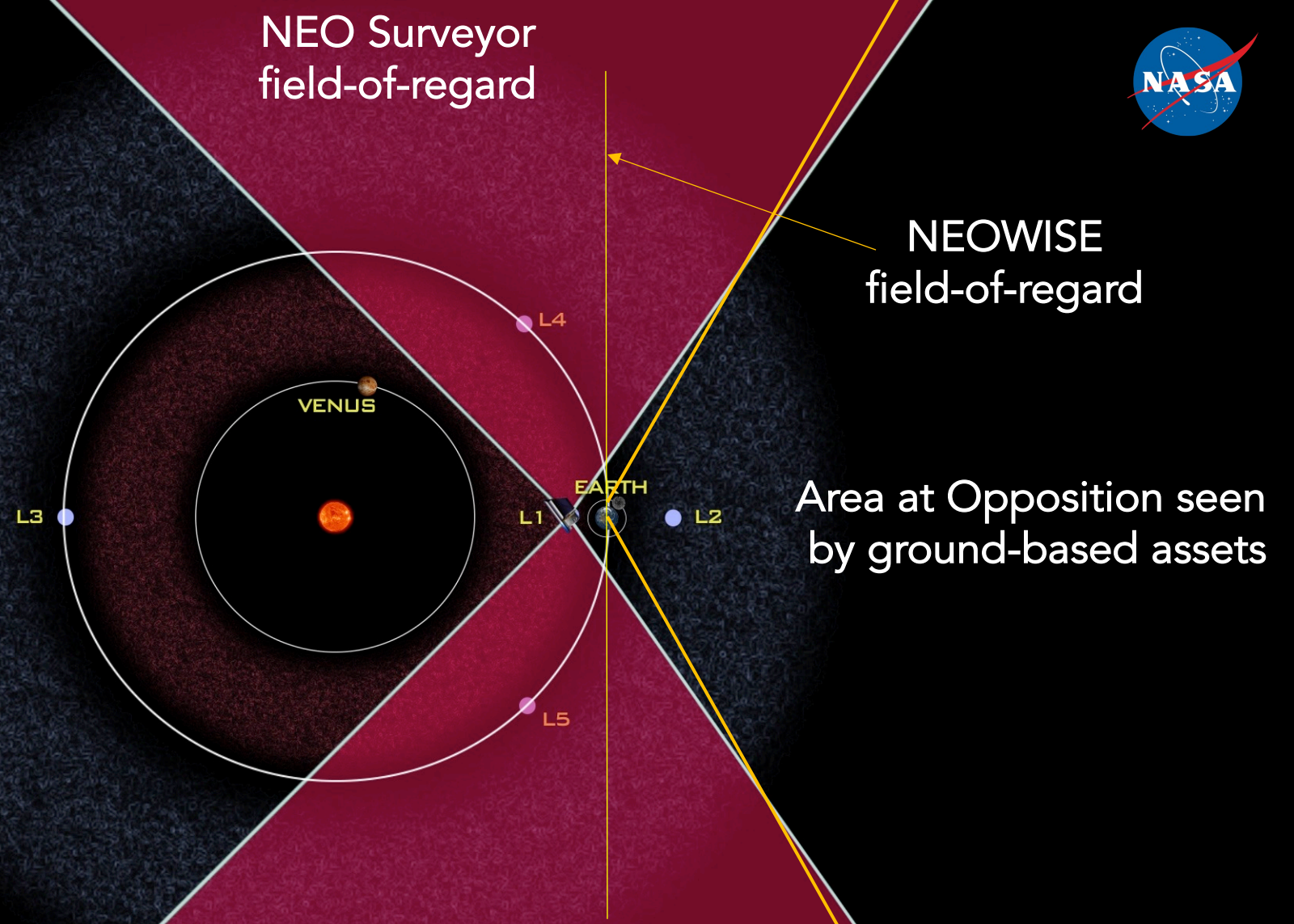
Find at least 90% of NEOs 140 meter and larger within 15 years



At the current assets' discovery rate, it will take more than 30 years to complete the survey. New capabilities in development will cut that time in half.

NEO Surveyor

- Space-based infra-red telescope
- Objectives:
  - Find 65% of Potentially Hazardous Asteroids (PHAs) >140 m in 5 years (>90% in 10 years)
  - Estimate object sizes



- **Preliminary Design Review (PDR) took place in September 2022**
- **The Project passed KDP-C and entered Phase C on Nov. 29, 2022**

National Aeronautics and
Space Administration