Planetary Defense Briefing to Fall PAC 2021

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Planetary Science Division
NASA Headquarters
Washington, DC

15 November 2021
UN Office of Outer Space Affairs
Committee on Peaceful Uses of Outer Space

Overview for NEO Threat Response

Inform in case of credible threat

Parent Government Delegates

Organized by NASA

International Asteroid Warning Network (IAWN)
www.iawn.net

Determine Impact time, location and severity

Observers, analysts, modelers...

Chaired by ESA

Space Missions Planning Advisory Group (SMPAG)
www.smpag.net

Potential deflection mission plans

Space agencies and offices

United Nations COPUOS/OOSA

Chaired by ESA
Signatories to the International Asteroid Warning Network (IAWN)

Currently 35 signatories
https://iawn.net/about/members.shtml

Newest Signatories to IAWN:
Xingming Observatory, China
6ROADS Company, Poland
Squirrel Valley Observatory, United States
Golden Ears Observatory Canada
Astronomical Institute of the Romanian Academy

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<tr>
<td>Brazil</td>
<td>Southern Observatory for Near Earth Asteroids Research, Brazil</td>
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<tr>
<td>Canada</td>
<td>Golden Ears Observatory US5</td>
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<td>Canada</td>
<td>Spaceguard Consulting, Canada</td>
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<td>China</td>
<td>Chinese National Space Administration, China</td>
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<td>China</td>
<td>Xingming Observatory (IAU Code C42/N88/N89)</td>
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<td>Colombia</td>
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<td>Crimea</td>
<td>Mobil Astronomical Robotics Genom Observatory</td>
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<td>Vinsjan Observatory, Croatia</td>
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<td>Europe</td>
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<td>European Space Agency, Head NEO Segment, SSA Programme Office</td>
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<td>France</td>
<td>Observatoire de la Côte d’Azur, Nice, France</td>
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<td>Israel</td>
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<td>Agenzia Spaziale Italiana</td>
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<td>Korea, Republic of Korea</td>
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<td>Peter Birtwhistle, Great Shefford Observatory, England</td>
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<td>United States</td>
<td>National Aeronautics and Space Administration (Pan-STARRS, Catalina Sky Survey, ATLAS, etc)</td>
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<td>Patrick Wiggins, Tooele Observatory, Utah, United States</td>
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<td>Squirrel Valley Observatory W34</td>
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<td>United States</td>
<td>Zwicky Transient Facility, Caltech, United States</td>
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Potentially Hazardous Asteroids come within 7.5 million km of Earth orbit

NASA's search started in 1998

George E Brown NEO Survey Goal

Most recent discovery: 2021-Nov-13

NEAs:
- 27487 all
- 9911 >140m
- 890 >1km

PHAs:
- 2229 all
- 160 >1km

NECs: 117

https://cneos.jpl.nasa.gov/stats/ Alan Chamberlin (JPL/Caltech)

nasa.gov/planetarydefense
All Near-Earth Asteroids (NEAs)

Near-Earth Asteroid Discoveries by Survey

All NEAs (as of 2021–Nov–14)

Number Discovered

Discovery Date

2959 in 2020
2752 so far...

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

Alan Chamberlin (JPL/Caltech)
NEAs 140 Meters and Larger
Double Asteroid Redirection Test (DART) is 1 week to Launch!!
DART is the first full-scale flight demonstration of an asteroid deflection technology: kinetic impact.
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

DART – Double Asteroid Redirection Test

**IMPACT: Late Sept. – Early Oct., 2022**

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

**DART Spacecraft**
15,000 miles per hour

**Dimorphos**
160 meters
11.92-hour orbital period

**Didymos**
780 meters
1,180-meter separation between centers

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

**LICIACube**
(Light Italian Cubesat for Imaging of Asteroids)
Italian Space Agency contribution
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
   \( \beta = \text{the momentum enhancement factor} \)

DART spacecraft ops: No DART spacecraft ops
Great Pyramid of Giza
139 meters

Didymos
780 meters

Eiffel Tower
324 meters

One World Trade Center
546 meters

Statue of Liberty
93 meters

Dimorphos
163 meters (mean)

Great Pyramid of Giza
139 meters

Arc de Triomphe
49 meters

DART Spacecraft
19 meters

Bus
14 meters

Burj Khalifa
830 meters
It allows a deflection demonstration on an asteroid of the relevant size by changing its orbital period by \( \sim 1\% \) about the larger asteroid.
Measuring result of the impact from Earth: new orbit for Dimorphos

Brightness

Time

DART – Double Asteroid Redirection Test

15 November 2021
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

DRACO (with cover on)

LICIACube Cubesat

NEXT-C cover (top hat)

Hydrazine Thrusters

NEXT-C Ion thruster

Roll Out Solar Arrays (ROSA)

High Gain Antenna (RLSA)

2.6 m

2 m

18 m
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

Radar shape model

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

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<th>60 minutes</th>
<th>4 minutes</th>
<th>2 minutes</th>
<th>20 seconds</th>
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- **10 days**
- **8 hours**
- **4 minutes**
- **2 minutes**
- **20 seconds**
Schedule to Launch

- Testing complete
- Load xenon
- Closeouts

Pack and ship

Arrive at Astrotech processing facility

Electrical tests

Transport to Space X processing facility

Load hydrazine Charge battery

Mate to adapter

Encapsulate in launch vehicle fairing

JHU/ APL
- now
- 9/29

10/3
10/7
10/23
10/27
11/12
11/23

Local time PST
DART in highbay at Space X processing facility
Link to Video

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

https://youtu.be/hbL07cZUEMU