National Aeronautics and Space Administration

NASA Update to IAWN Fall 2023

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Washington, DC

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Planetary Defense Coordination Office (PDCO)

The PDCO was established in January 2016 at NASA HQ to manage planetary defense-related activities across NASA and coordinate with both U.S. interagency and international efforts to study and plan response to the asteroid impact hazard.

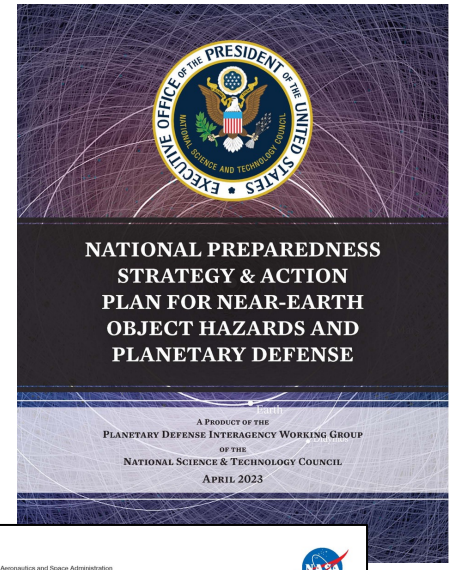
Mission Statement

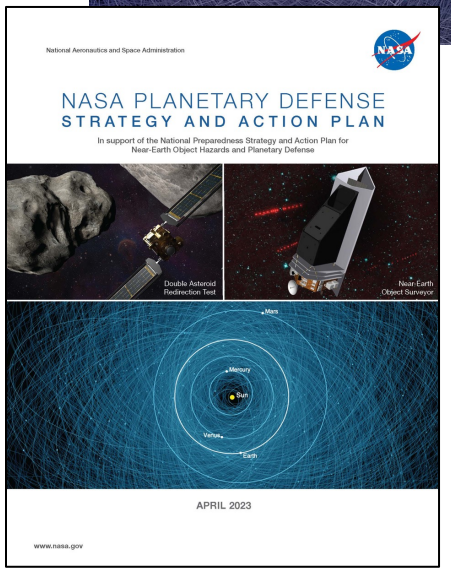
Lead national and international efforts to:

- Detect any potential for significant impact of Earth by natural objects
- Appraise the range of potential effects by any possible impact
- Develop strategies to mitigate impact effects on human welfare

Planetary Defense for the Next Decade (2023 - 2033)

- NASA's DART mission pushed planetary defense into a new era, but despite this achievement, less than half of NEOs capable of catastrophic Earth damage have been found
- Because of this, the White House OSTP released its **National Preparedness Strategy and Action Plan for NEO Hazards and Planetary Defense**, outlining six key national goals to address the NEO hazard for the next 10 years
- NASA released a complementary **Planetary Defense Strategy and Action Plan**, aiming to further specify NASA's – and the PDCO's – role in achieving the national plan's objectives
- **National Plan Strategic Goals (1, 3, and 4 are of "critical focus" for 10-year horizon)**
    1. Enhance NEO detection, tracking, and characterization capabilities
    2. Improve NEO modeling, prediction, and information integration
    3. Develop technologies for NEO reconnaissance, deflection, and disruption missions
    4. Increase international cooperation on NEO preparedness
    5. Strengthen and routinely exercise NEO impact emergency procedures and action protocols
    6. Improve U.S. management of planetary defense through enhanced interagency collaboration
- **NASA Plan Strategic Goals**
    7. Improve organization of NASA's planetary defense activities
    8. Enhance strategic communications related to planetary defense






PLANETARY DEFENSE COORDINATION OFFICE
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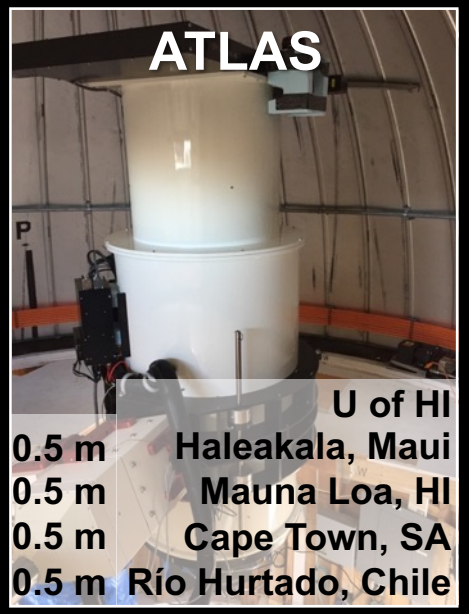
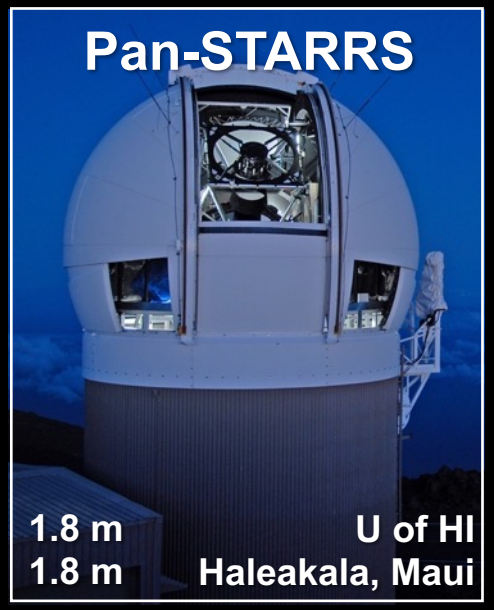
PLANETARY
DEFENSE
ASSESS
Determine NEO population survey completeness and hazard from NEOs that pose the highest risk
CENTER FOR NEAR-EARTH OBJECT STUDIES (CNEOS)
SEARCH, DETECT & TRACK
Find the natural near-Earth objects – asteroids and comets – and track to determine those whose orbits create an impact hazard to Earth
GROUND & SPACE-BASED OBSERVATORIES, MINOR PLANET CENTER (MPC), INTERNATIONAL ASTEROID WARNING NETWORK
MITIGATE
Demonstrate technologies and techniques to divert or disrupt asteroids in space or inform emergency response activities on the ground
DOUBLE ASTEROID REDIRECTION TEST (DART), FEMA EXERCISES
CHARACTERIZE
Determine physical characteristics of NEOs (size, shape, composition, rotation) to understand their natural state
INFRARED TELESCOPE FACIITY, GOLDSTONE SOLAR SYSTEM RADAR, NEOWISE
PLAN & COORDINATE
Work with the U.S. interagency and international collaborations on effective actions for impact threat response
SPACE MISSION PLANNING ADVISORY GROUP, PLANETARY IMPACT EMERGENCY RESPONSE WG, PLANETARY DEFENSE IWG

NASA's NEO Search Program

(Current Survey Systems)





Also processing of data for NEO detections from Caltech's Zwicky Transient Facility

NASA-funded Near-Earth Object Survey (Discovery) Telescopes

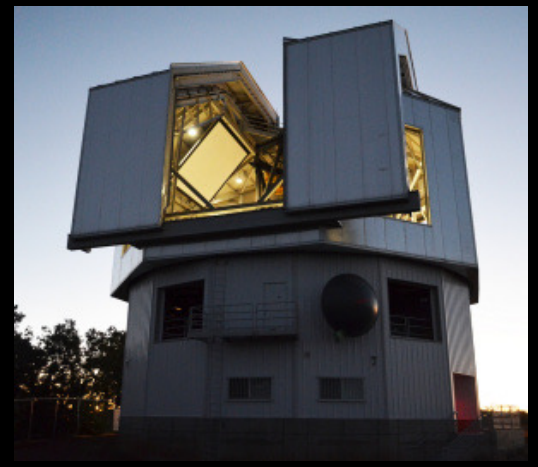
NEOWISE

NASA's NEO Astrometric Follow-up

Spacewatch (U of AZ)

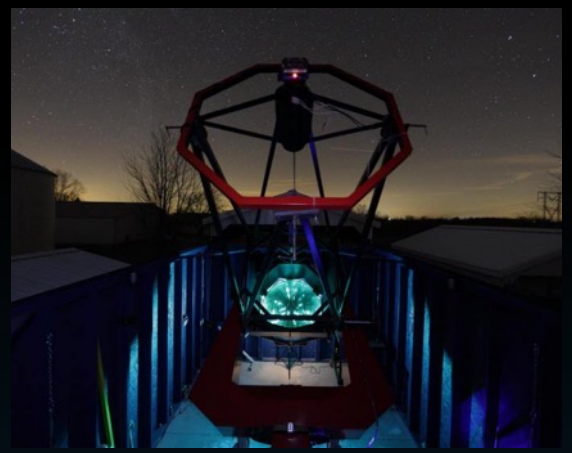
Magdalena Ridge Observatory (NM Tech)

Catalina (U of AZ)



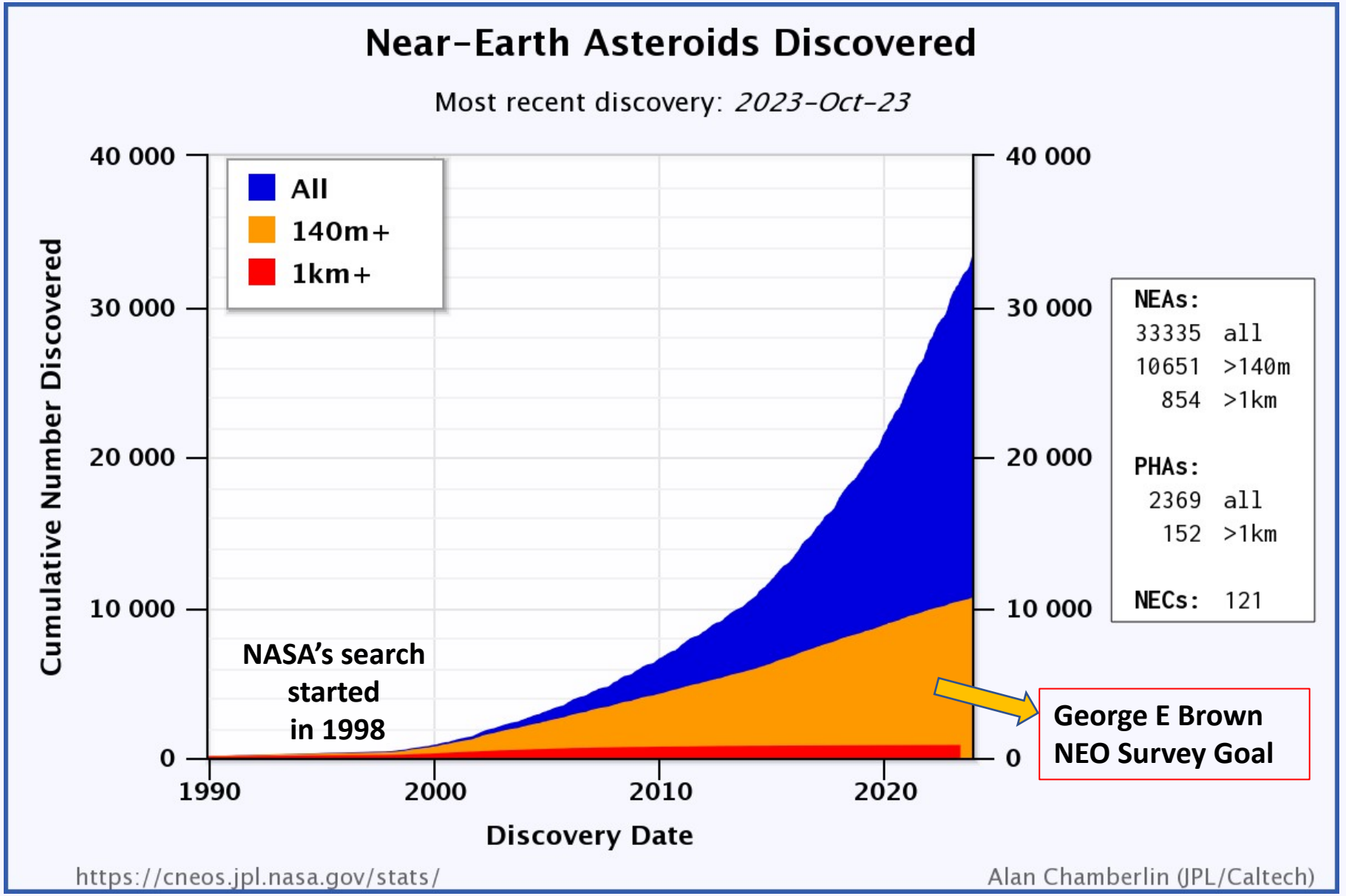
Lowell Discovery Telescope

U of Hawai'i follow-up with UH 2.2m and Canada France Hawai'i Telescope

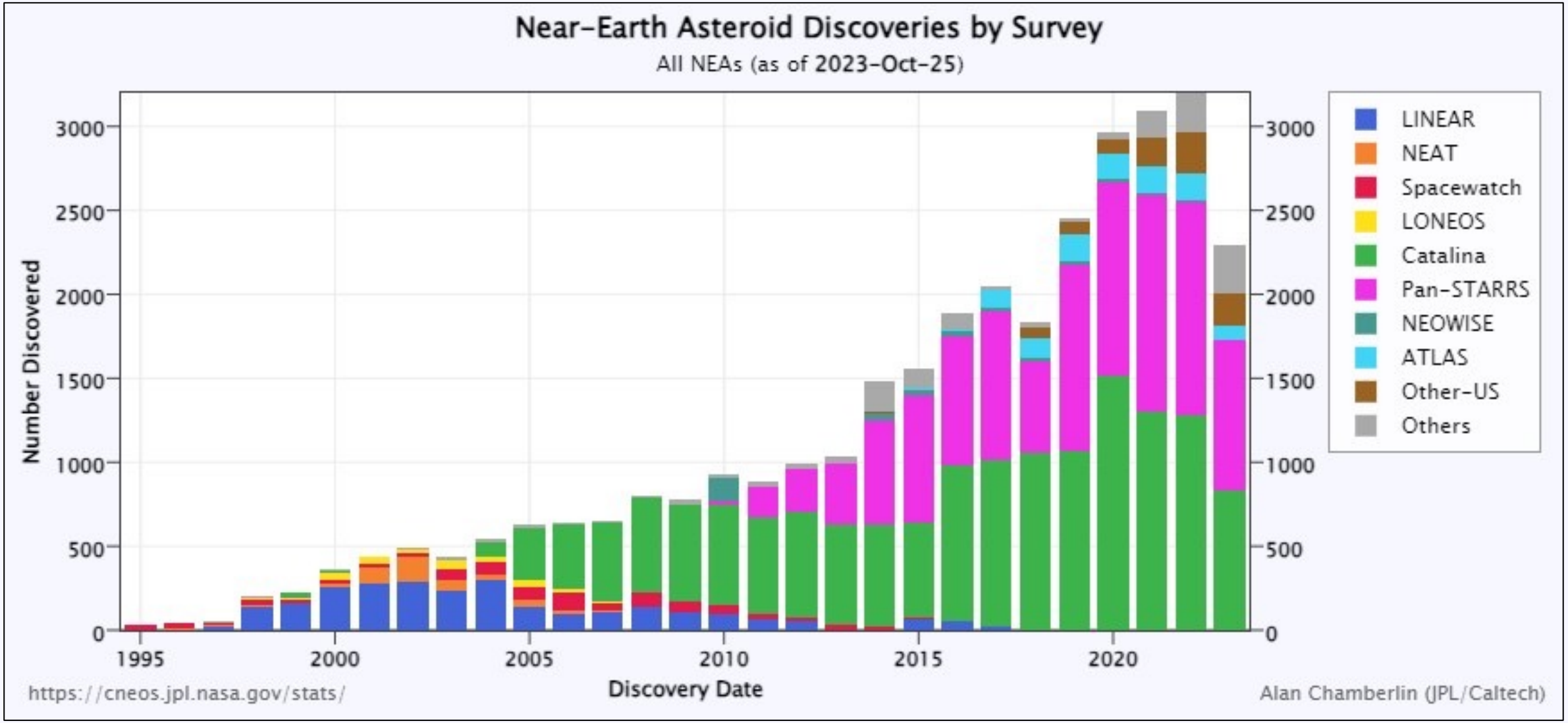


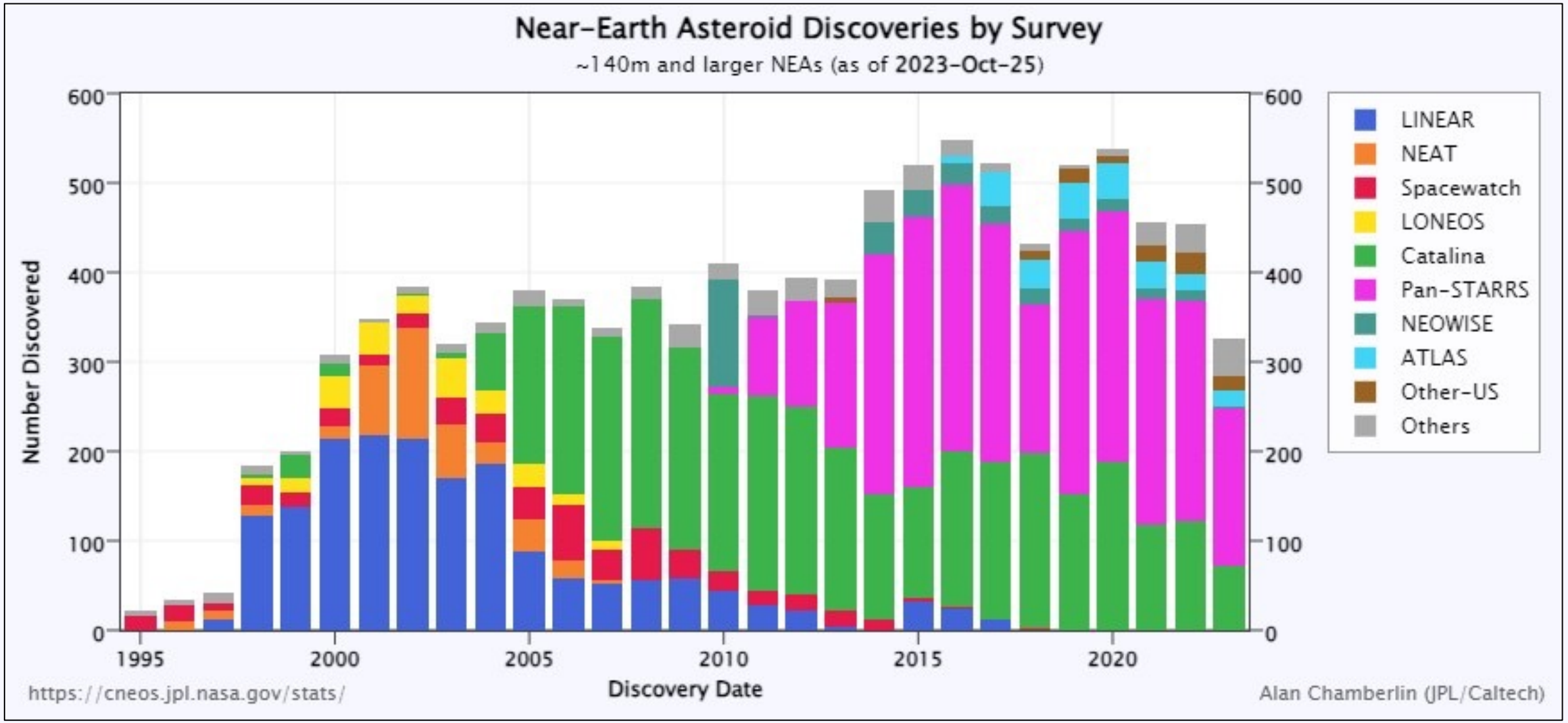
Astronomical Research Institute (Illinois and Chile)

Table Mountain Obs. (JPL)



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

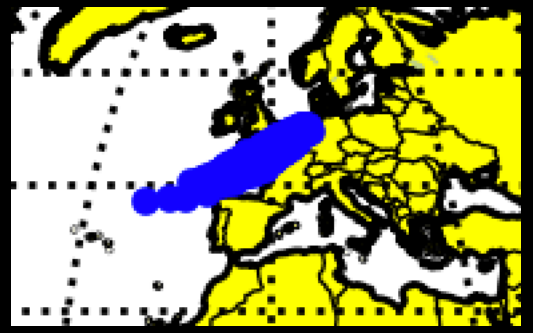

Near-Earth Asteroid Discoveries by Survey
All NEAs (as of 2023-Oct-25)
Number Discovered
0
500
1000
1500
2000
2500
3000
1995
2000
2005
2010
2015
2020
Discovery Date
LINEAR
NEAT
Spacewatch
LONEOS
Catalina
Pan-STARRS
NEOWISE
ATLAS
Other-US
Others
https://cneos.jpl.nasa.gov/stats/
Alan Chamberlin (JPL/Caltech)


Near-Earth Asteroid Discoveries by Survey
~140m and larger NEAs (as of 2023-Oct-25)
Number Discovered
Discovery Date
0
100
200
300
400
500
600
1995
2000
2005
2010
2015
2020
LINEAR
NEAT
Spacewatch
LONEOS
Catalina
Pan-STARRS
NEOWISE
ATLAS
Other-US
Others
https://cneos.jpl.nasa.gov/stats/
Alan Chamberlin (JPL/Caltech)

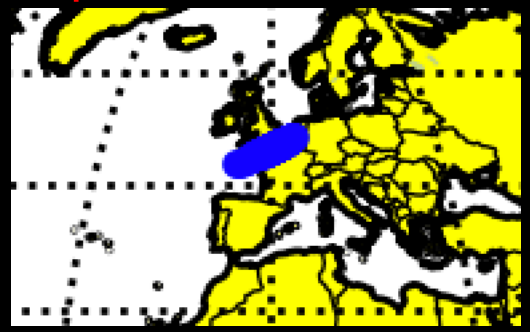
Impact of small asteroid 2023 CX1 on February 12, 2023

Evolution of JPL CNEOS impact solutions

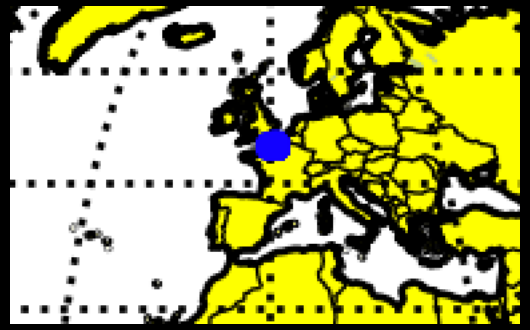
Impact minus 6 hours



Impact minus 5.5 hours

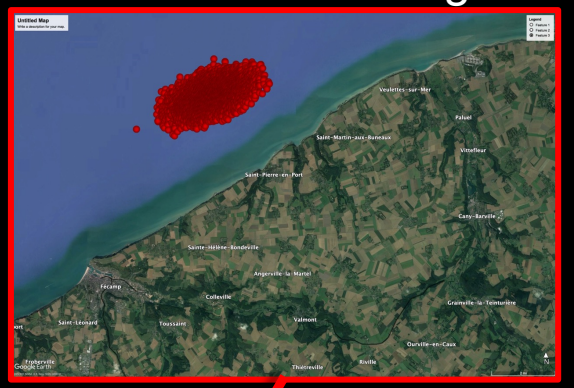


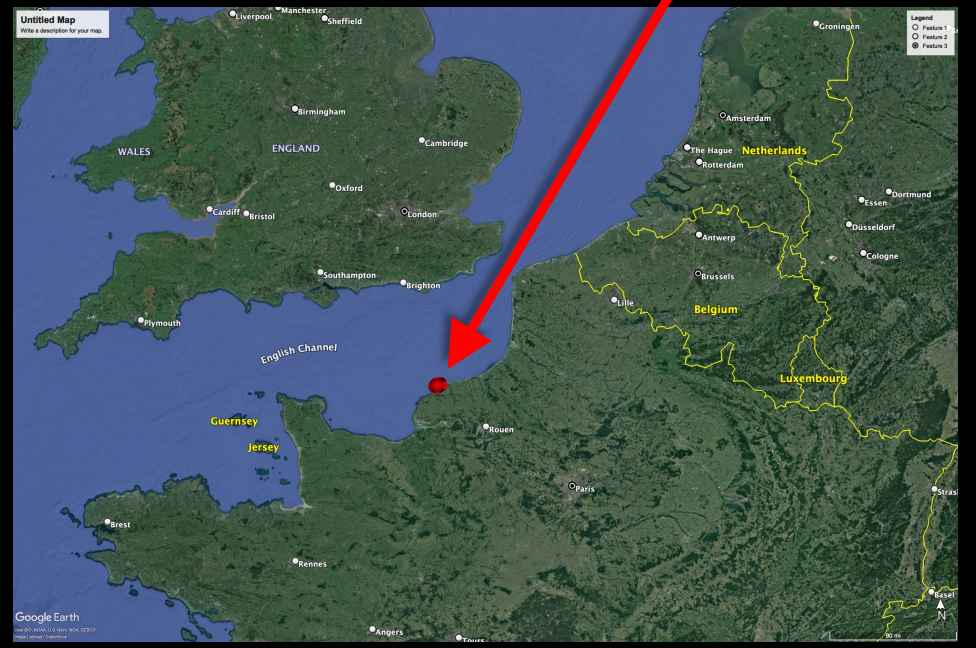
Impact minus 4 hours



- First observed by Hungarian observatory GINOP-KHK (K88) and reported to the Minor Planet Center (K88 also discovered impactor 2022 EB5)
- JPL's Center for NEO Studies (CNEOS) Scout system identified a potential impact and warned PDCO
- ESA's NEO Coordination Centre similarly identified a potential impact
- The uncertainty region for the impact narrowed as additional observations helped CNEOS and NEOCC refine their orbit calculations

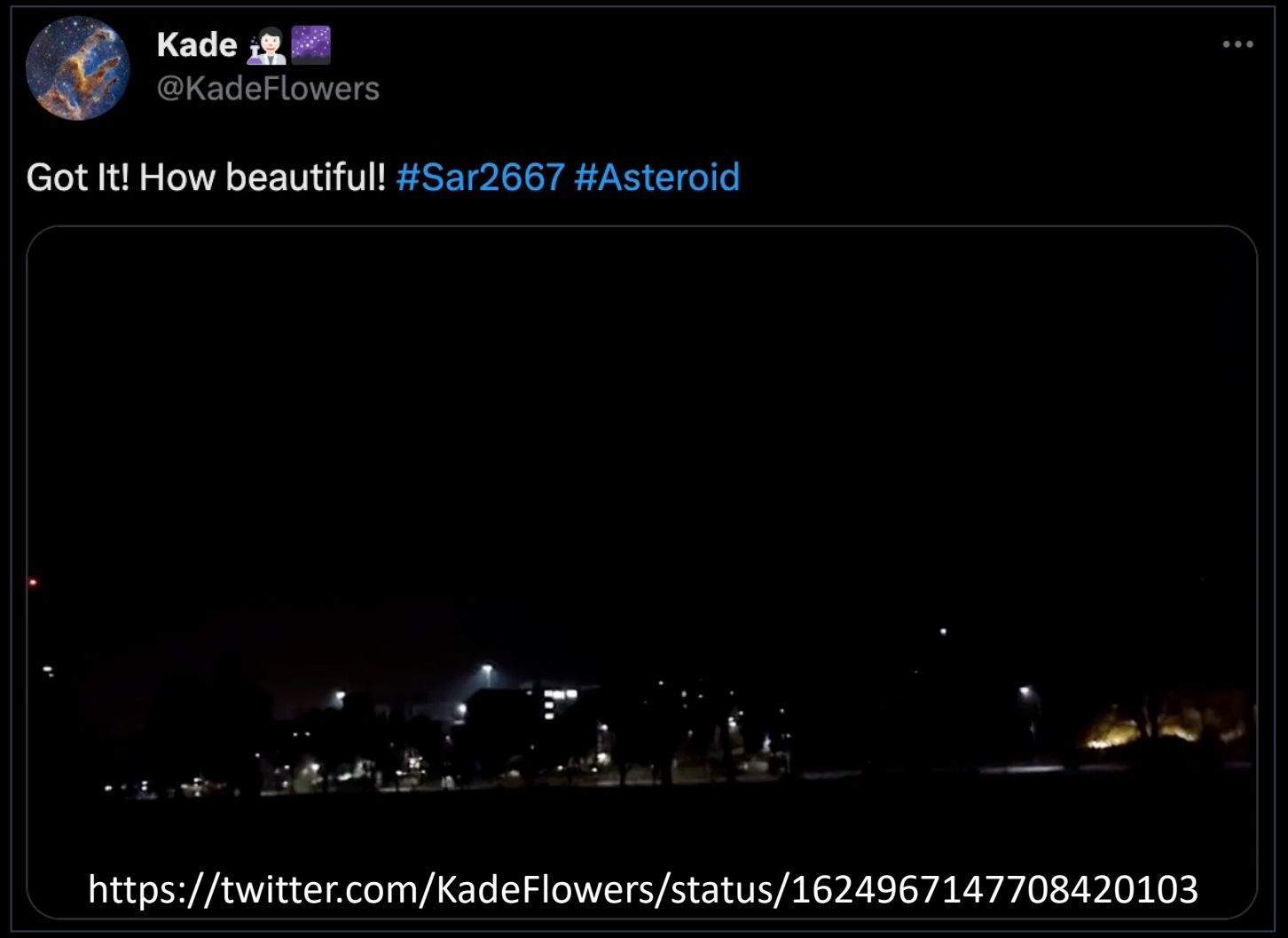
CNEOS impact solutions converge





Impact of small asteroid 2023 CX1 on February 12, 2023

- ESA and NASA notified the public, and many watched the impact as it happened
- The asteroid posed no threat since it was so small (~1 m) but it was an excellent test of planetary defense capabilities to find and track and to accurately predict an impact location



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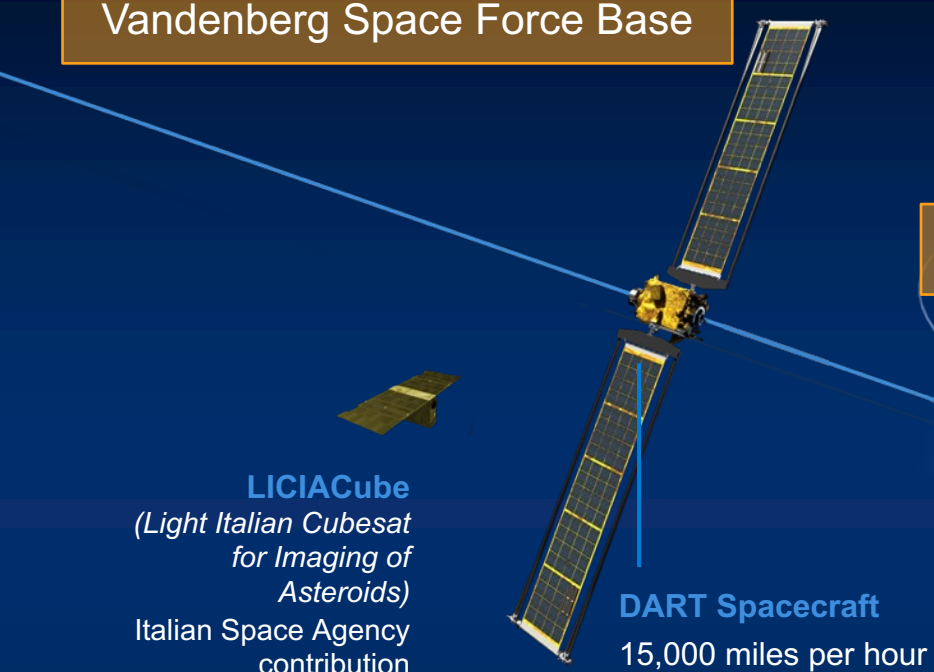
DART Mission Goals:

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

LAUNCHED: 24 Nov 2021
Vandenberg Space Force Base



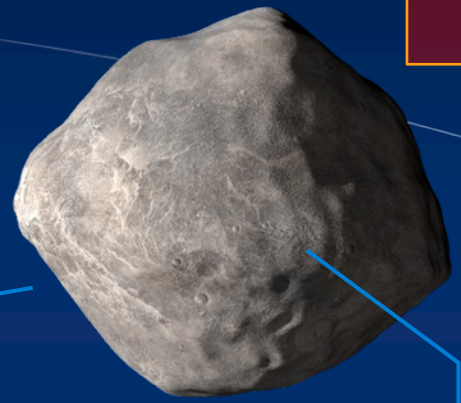
LICIACube
(Light Italian Cubesat for Imaging of Asteroids)
Italian Space Agency contribution

DART Spacecraft
15,000 miles per hour

IMPACTED: 26 Sep 2022

Dimorphos
160 meters
11.92-hour orbital period

1,180-meter separation between centers



PERIOD CHANGE:
~33 minutes

Didymos
780 meters

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

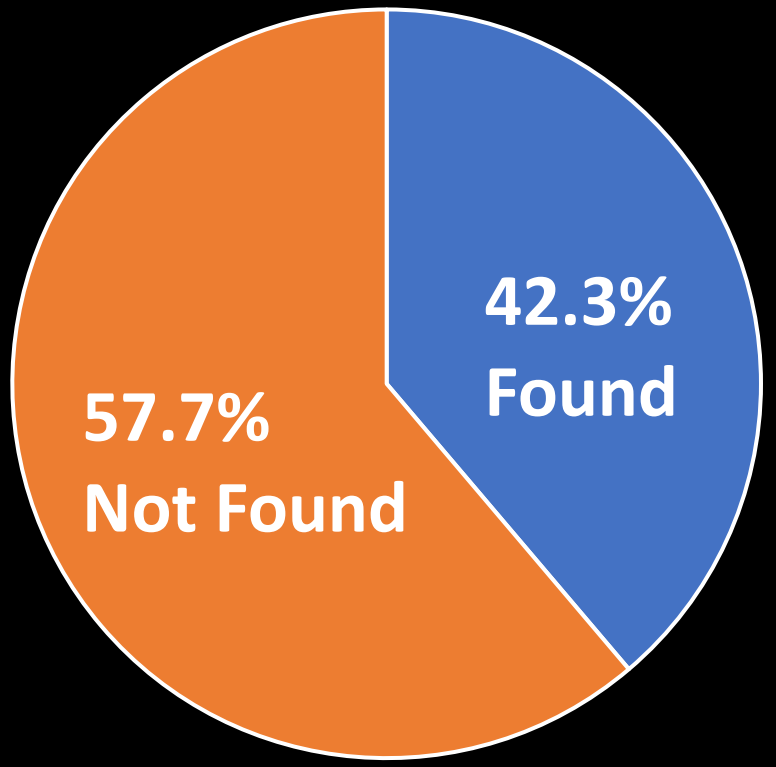
Progress Toward Finding 90% of NEOs 140 Meters and Larger

Total Population estimated to be ~25,000

NEO Survey Status as of 31 Dec 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.

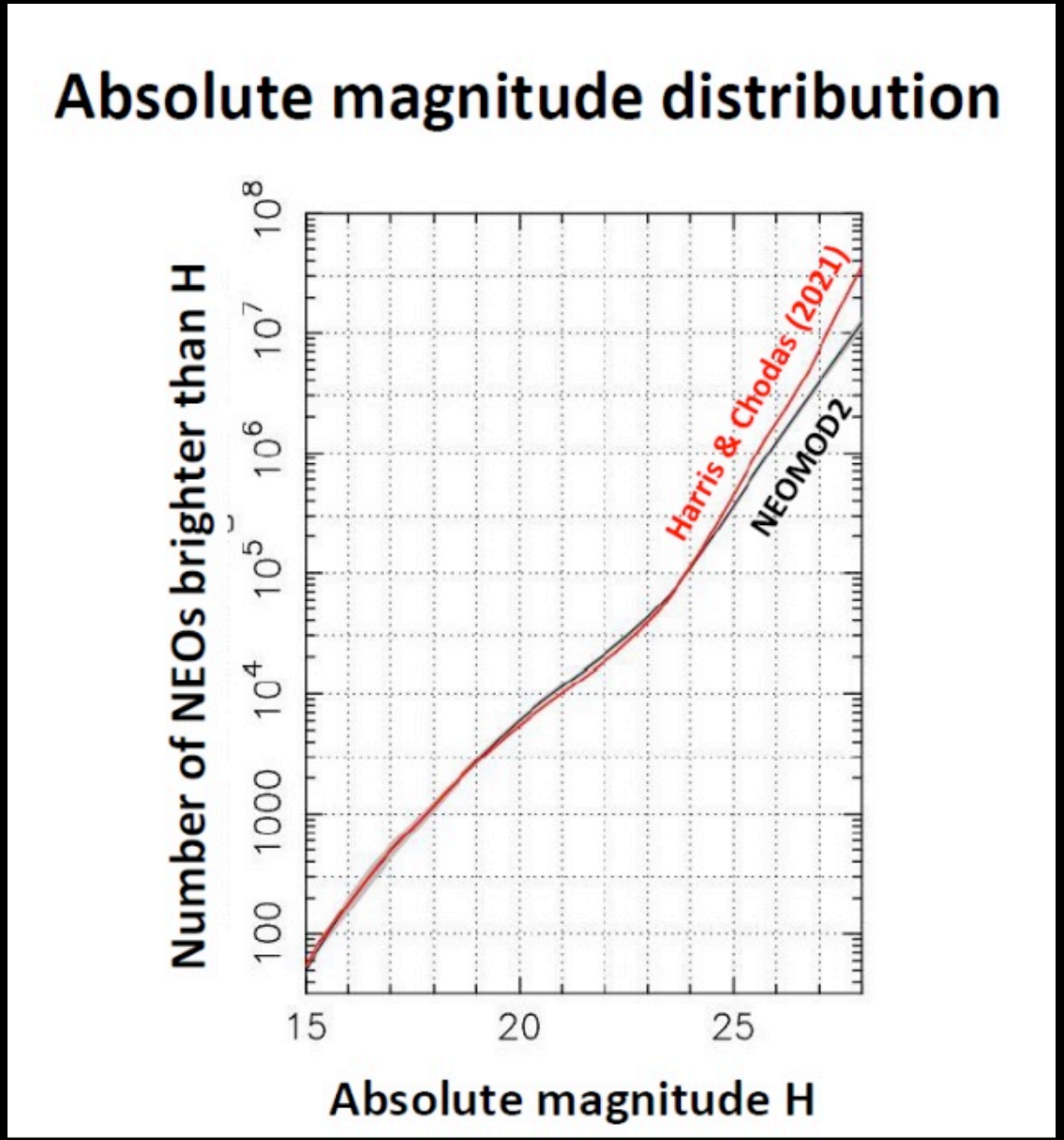
New capabilities in development will cut that time in half.

NEOMOD 2: An Updated Model of Near-Earth Objects from a Decade of the Catalina Sky Survey Observations

Nesvorny, Vokrouhlicky, Shelly, Deienno, Bottke, Christensen, Jedicke, Naidu, Chesley, Chodas, Farnocchia and the NEOMOD team
(SwRI, JPL, Charles Univ., Univ. of Hawaii, Univ. of California)

Model Highlights:

- Improved orbital model for NEOs with an extended magnitude range (H=15-28).
- Calibrated on the Catalina Sky Survey (CSS) observations from 2013 to 2022. New method for computing the observational bias: detailed characterization of photometric/trailing losses.
- Fits executed with the powerful MultiNest sampler (*Feroz & Hobson 2008*) on the NASA Pleiades Supercomputer. Realistic uncertainties and correlations of model parameters.



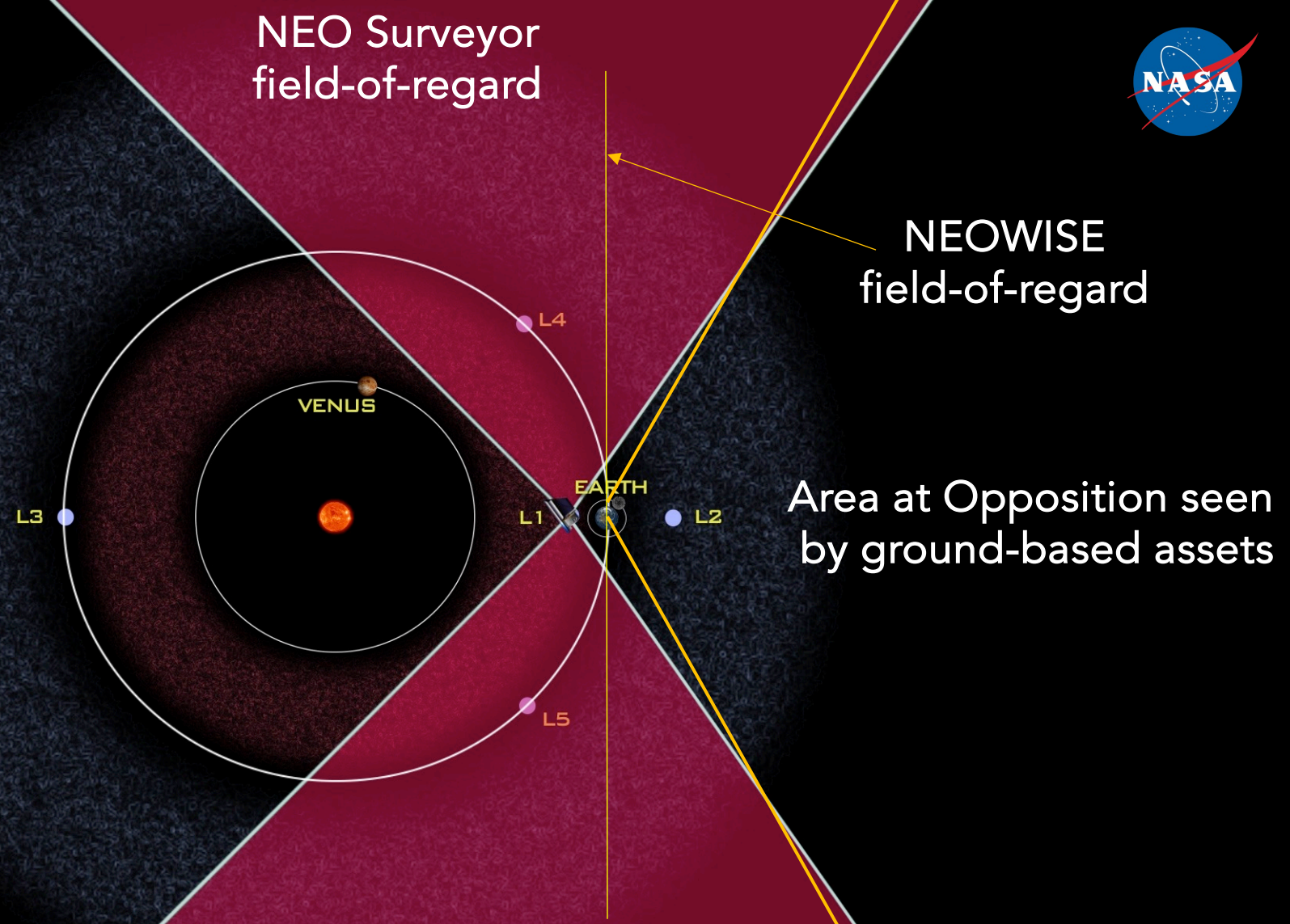
Estimated completeness of NEO population (Nov. 2022)

H_1	H_2	dN	$N(H_2)$	$N_{\rm HC}(H_2)$	$N_{\rm min}(H_2)$	$N_{\rm max}(H_2)$	$N_{\rm MPC}(H_2)$	Compl.	Range
15.25	15.75	61.2	130.	136.	124.	137.	123.	95%	(90-99)
15.75	16.25	104.	234.	235.	219.	250.	210.	90%	(84-96)
16.25	16.75	156.	390.	398.	365.	416.	361.	93%	(87-99)
16.75	17.25	218.	608.	621.	579.	639.	562.	92%	(88-97)
17.25	17.75	328.	936.	940.	898.	977.	854.	91%	(87-95)
17.75	18.25	513.	0.145E4	0.147E4	0.140E4	0.151E4	1325.	91%	(88-95)
18.25	18.75	790.	0.224E4	0.221E4	0.217E4	0.232E4	2022.	90%	(87-93)
18.75	19.25	0.117E4	0.341E4	0.323E4	0.331E4	0.350E4	2897.	85%	(83-88)
19.25	19.75	0.164E4	0.505E4	0.463E4	0.492E4	0.517E4	4021.	80%	(78-82)
19.75	20.25	0.216E4	0.721E4	0.642E4	0.703E4	0.737E4	5281.	73%	(72-75)
20.25	20.75	0.272E4	0.992E4	0.873E4	0.970E4	0.101E5	6636.	67%	(66-68)
20.75	21.25	0.350E4	0.134E5	0.118E5	0.131E5	0.137E5	8076.	60%	(59-60)
21.25	21.75	0.471E4	0.181E5	0.159E5	0.178E5	0.185E5	9480.	52%	(51-53)
21.75	22.25	0.673E4	0.249E5	0.217E5	0.244E5	0.254E5	10865.	44%	(43-45)
22.25	22.75	0.104E5	0.353E5	0.314E5	0.345E5	0.360E5	12309.	35%	(34-36)
22.75	23.25	0.173E5	0.525E5	0.476E5	0.514E5	0.536E5	13862.	26%	–
23.25	23.75	0.311E5	0.836E5	0.826E5	0.818E5	0.853E5	15673.	19%	–
23.75	24.25	0.608E5	0.144E6	0.153E6	0.142E6	0.147E6	17622.	12%	–
24.25	24.75	0.121E6	0.266E6	0.313E6	0.260E6	0.272E6	19709.	7.4%	–
24.75	25.25	0.229E6	0.494E6	0.641E6	0.482E6	0.506E6	21724.	4.4%	–

~140 m

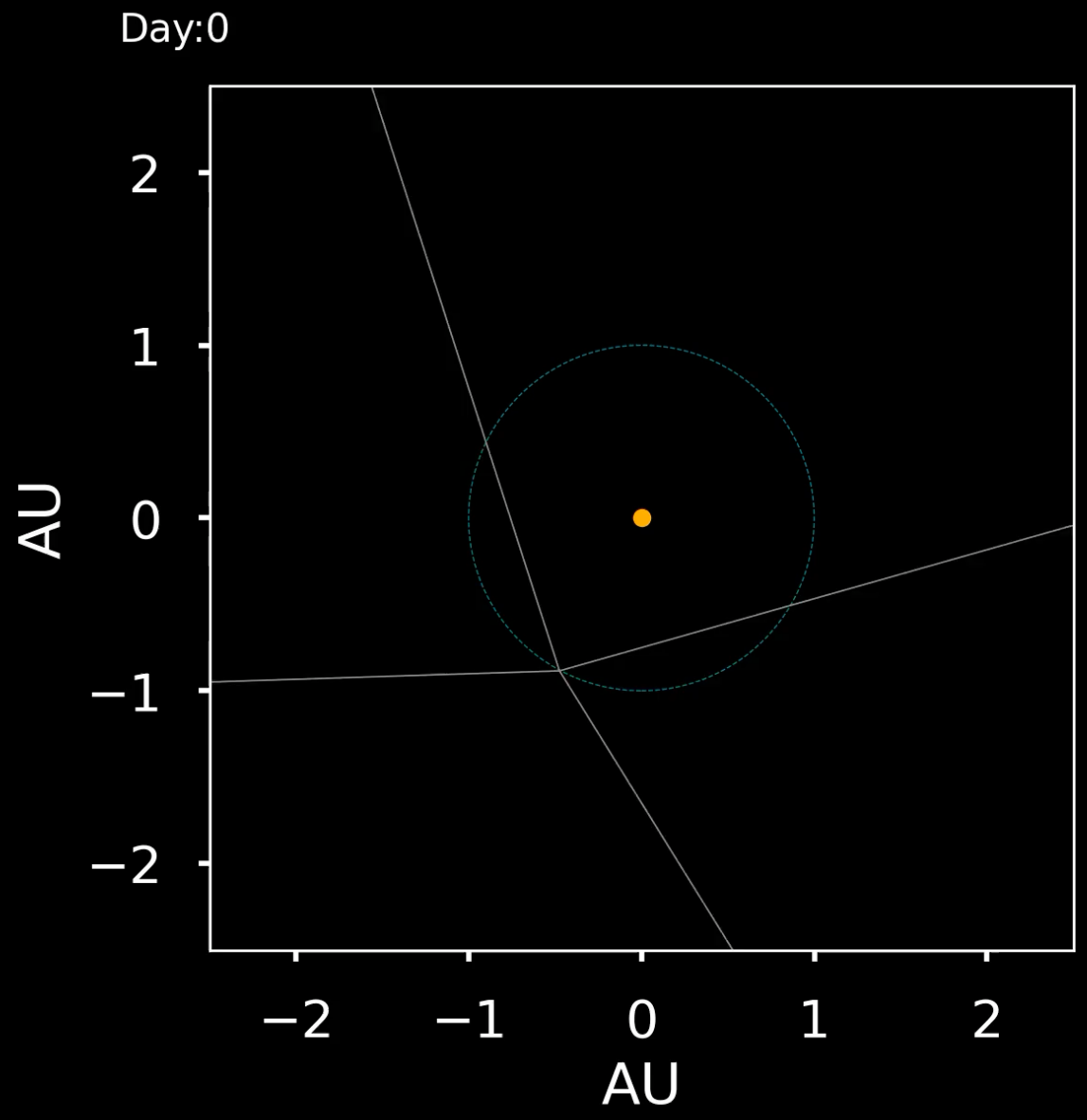
NEO Surveyor

- 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**
- **KDP-C took place on Nov. 29 2022 – mission now in Phase C**

Survey Progress vs. Time*



- The NEO Surveyor mission finds, characterizes, & catalogs Near-Earth Objects.
- Prime Mission survey of 5 years
- Launch Readiness NLT June 2028

*Only objects >140 m shown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