Planetary Defense Coordination Office

Lindley Johnson
NASA's Planetary Defense Officer

Planetary Defense Coordination Office
Planetary Science Division
NASA Headquarters
Washington, DC

Update to AAAC
January 23, 2020

Planetary Defense Coordination Office

The Planetary Defense Coordination Office (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

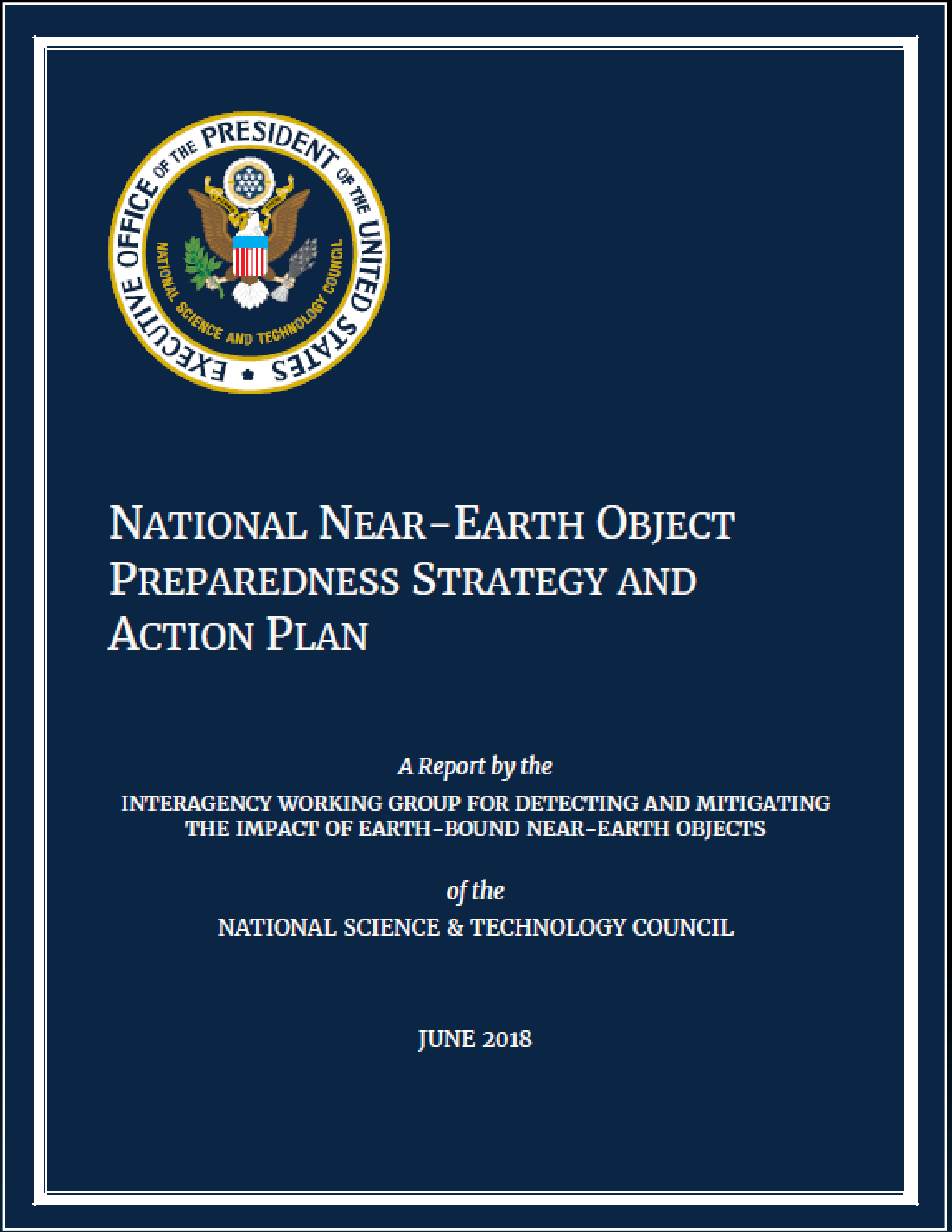
Lead national and international efforts to:

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


IAU
Minor Planet Center
PLANETARY
DEFENSE
ASSESS
[CENTER FOR NEAR EARTH
OBJECT STUDIES]
SEARCH, DETECT & TRACK
[GROUND-BASED & SPACE-BASED
OBSERVATIONS, IAWN]
MITIGATE
[DART, FEMA EXERCISES]
CHARACTERIZE
[NEOWISE, GOLDSTONE,
ARECIBO, IRTF]
PLAN &
COORDINATE
[SMPAG, PIERWG, DAMIEN IWG]

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



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

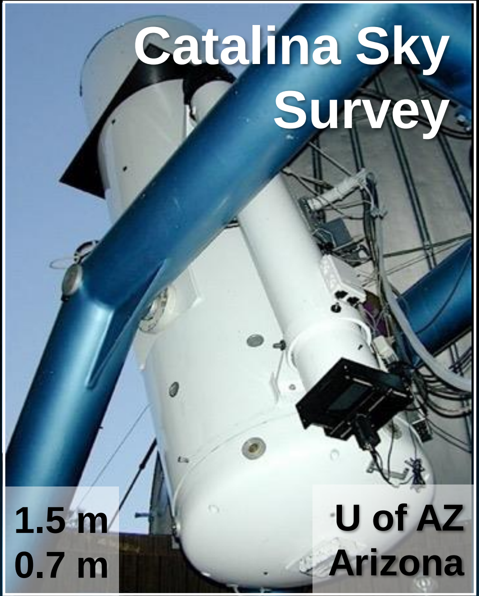
National NEO Preparedness Strategy and Action Plan

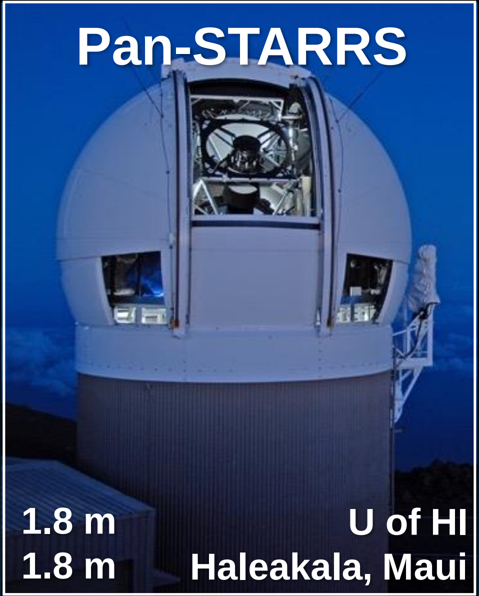
Goals in the New Action Plan

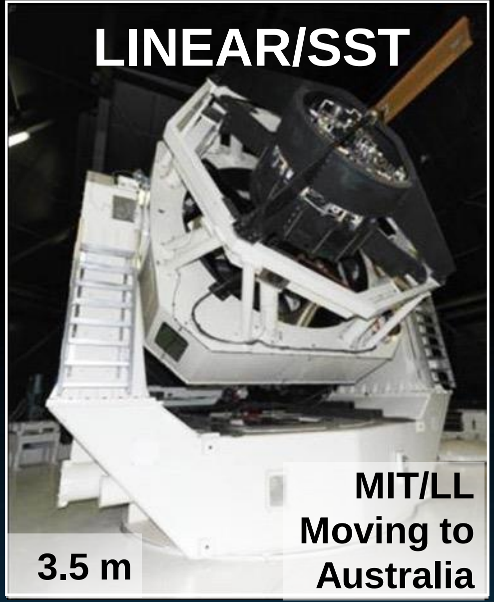
- Enhance NEO detection, characterization, and tracking capabilities
- Improve modeling, predictions, and information integration
- Develop technologies for NEO deflection and disruption
- Increase international cooperation on NEO preparation
- Establish NEO impact emergency procedures and action protocols

NASA's NEO Search Program

(Current Survey Systems)







PLANETARY DEFENSE COORDINATION OFFICE

Signatories to the International Asteroid Warning Network (IAWN)

iawn.net

National Institute of Astrophysics, Optics & Electronics (México)

European Southern Observatory

China National Space Administration

Northolt Branch Observatories (UK)

Zwicky Transient Facility (US)

Višnjan Observatory (Croatia)

Korean Astronomy Space Science Institute (KASI)

외계행성 탐색시스템 KMTNet
Korea Microlensing Telescope Network

University of Nariño Colombia

Inst. of Solar-Terrestrial Physics (Siberian Branch, Russian Academy of Sciences)

Sormano Astronomical Observatory (Italy)

Institute of Astronomy, Russian Academy of Sciences (ИНАСАН)

Crimean Astrophysical Observatory (Russian Academy of Sciences)

European Space Agency

National Aeronautics and Space Administration

SONEAR Observatory (Brazil)

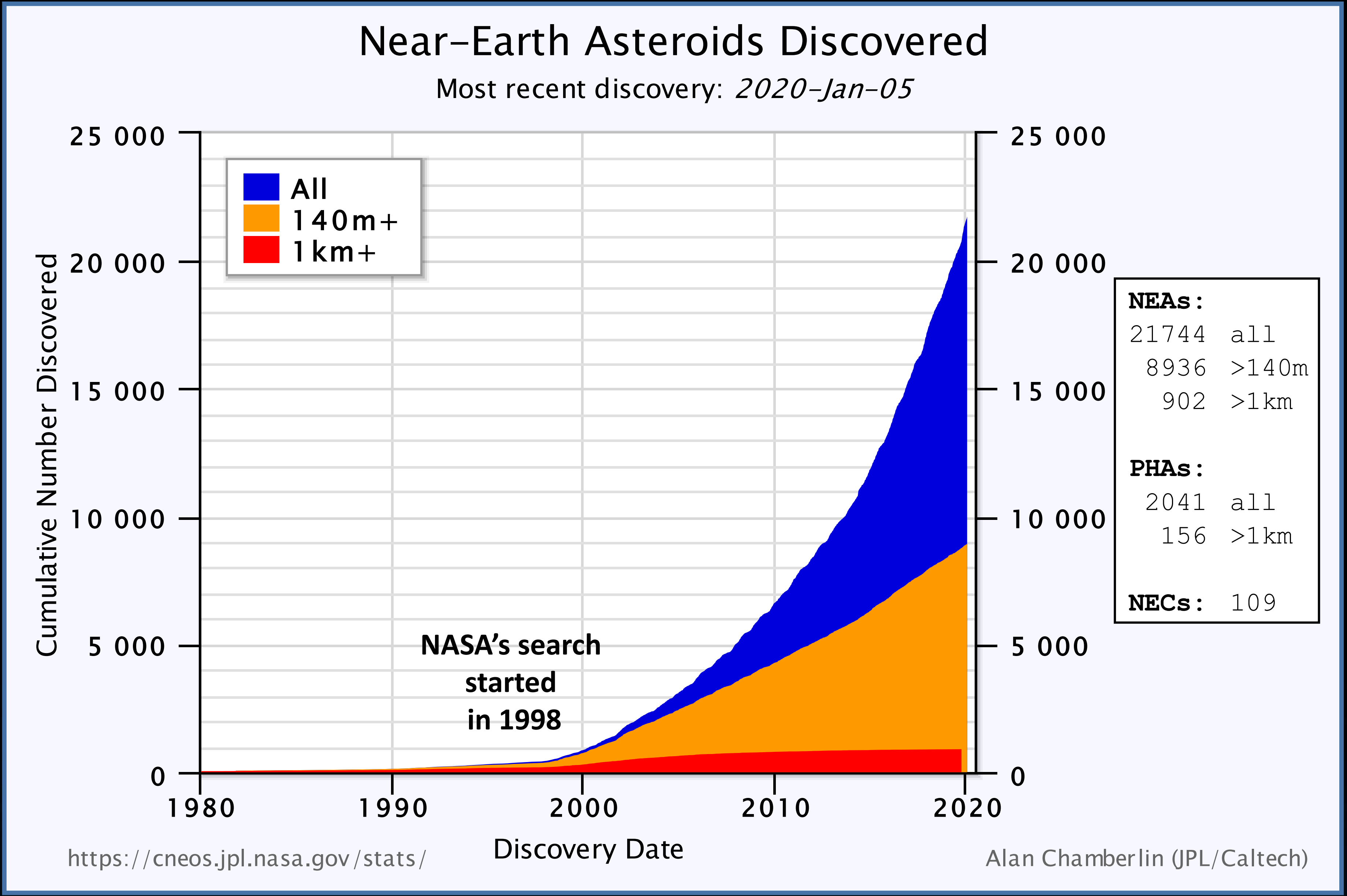
Follow-up Observers

Peter Birtwhistle (UK)
David Balam (Canada)
Patrick Wiggins (USA)

Special Astrophysical Observatory (Russian Academy of Sciences)

Kourovka Astronomical Observatory (UrFU)

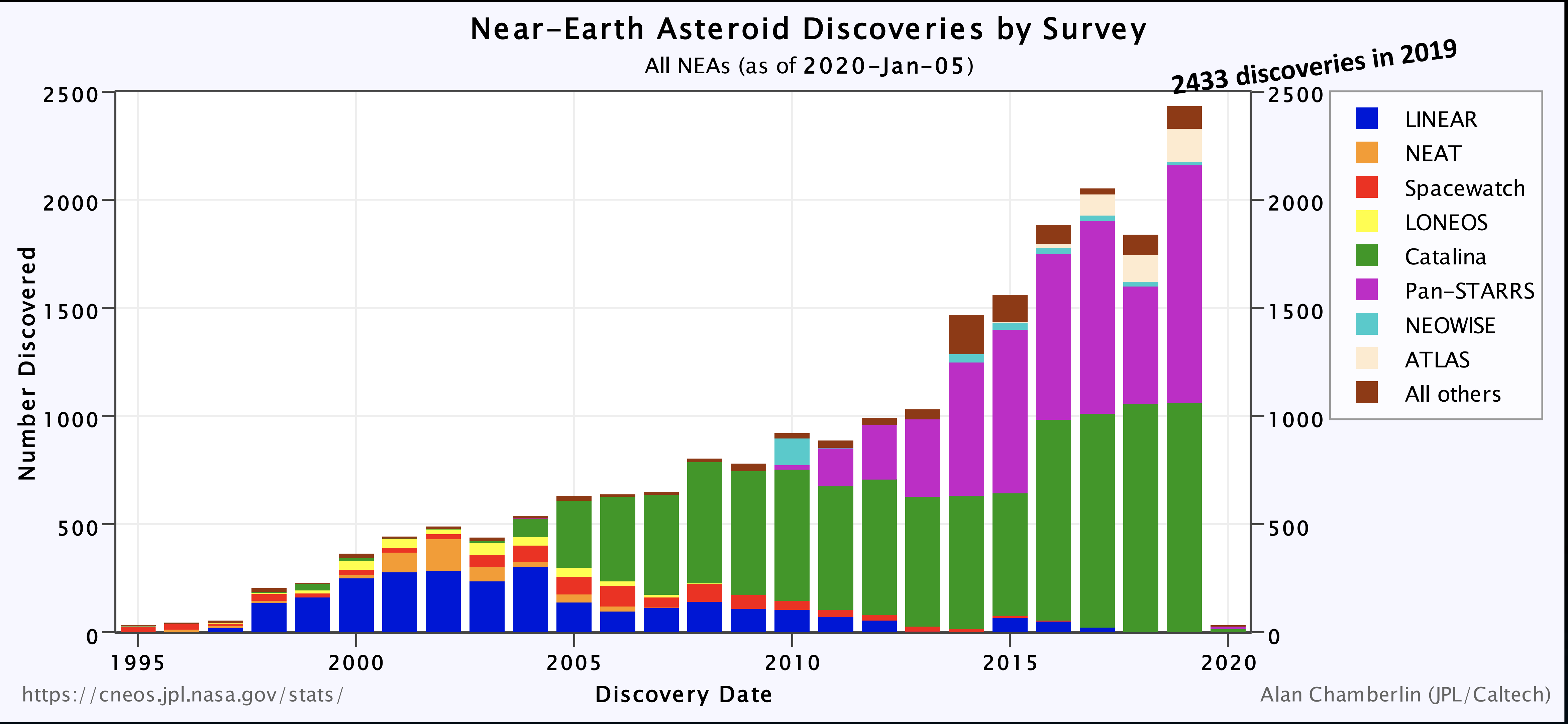
Currently 20 signatories



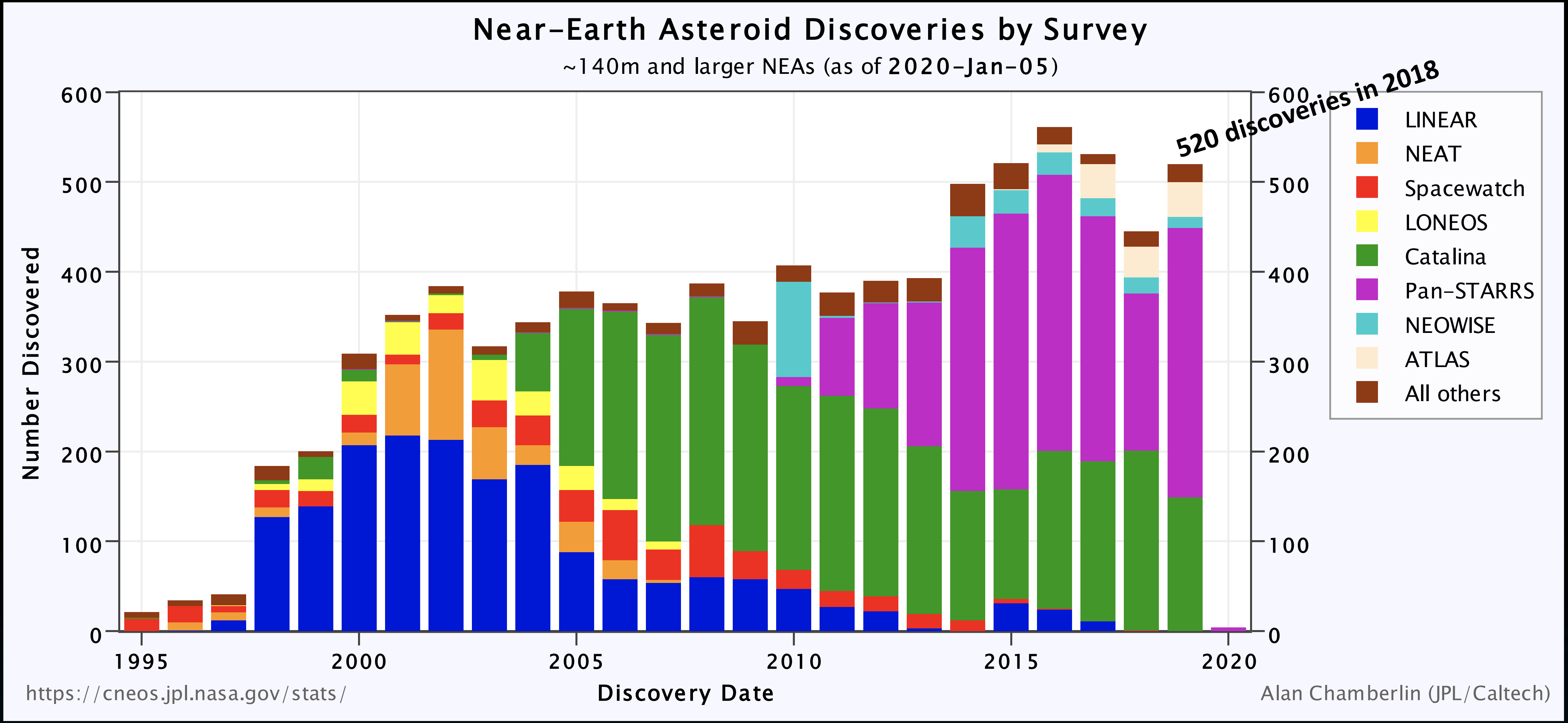
Potentially Hazardous Asteroids come within 7.5 million km of Earth orbit

nasa.gov/planetarydefense

All Near-Earth Asteroids (NEAs)

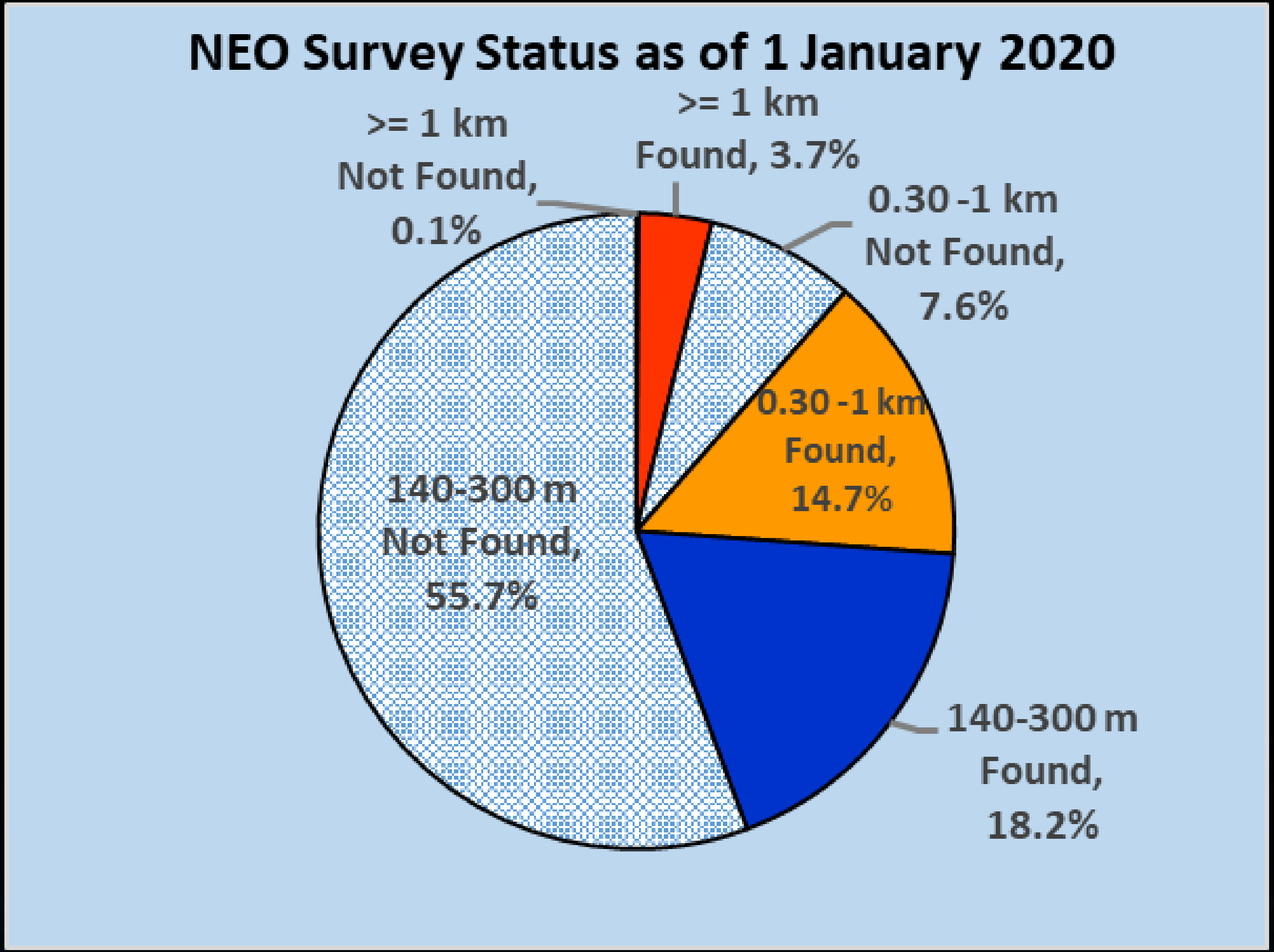


NEAs 140 Meters and Larger



Progress: 140 Meters and Larger

Total Population estimated to be ~25,000



At current discovery rate, it will take more than 30 years to complete the survey.

PLANETARY DEFENSE COORDINATION OFFICE

NASA

77 Detected Close Approaches <1 Lunar Distance in 2019

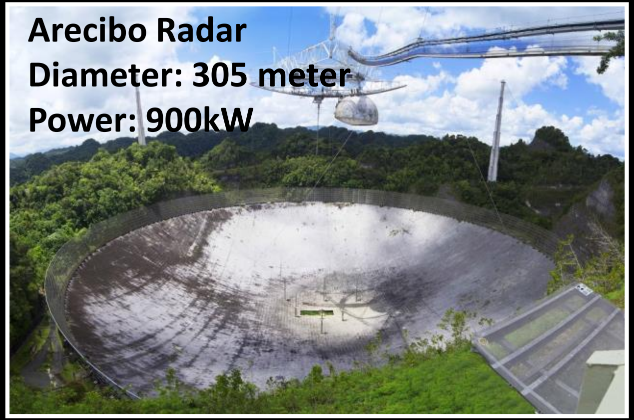
Up to 24 larger than 20m. Up to 2 larger than 100m.

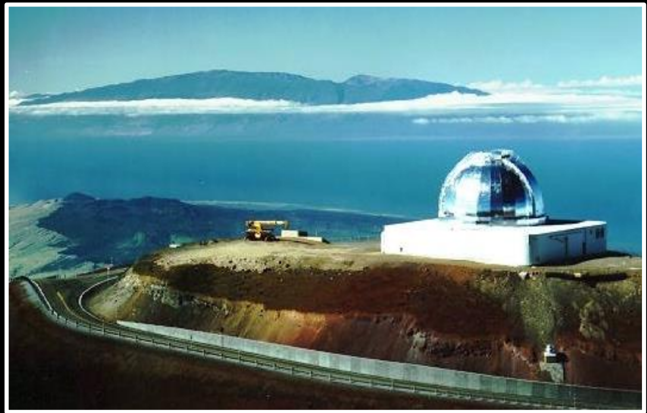
Object	Close-Approach (CA) Date	CA Distance Nominal (LD | au)	Estimated Diameter
(2019 AS5)	2019-Jan-08 00:37 ± < 00:01	0.04 | 0.00010	0.92 m - 2.1 m
(2019 AE9)	**2019-Jan-12 11:09 ± < 00:01**	**0.26 | 0.00067**	**9.9 m - 22 m**
(2019 BO)	2019-Jan-16 01:13 ± < 00:01	0.18 | 0.00046	6.3 m - 14 m
(2019 BV1)	2019-Jan-24 20:53 ± < 00:01	0.35 | 0.00090	4.9 m - 11 m
(2019 BZ3)	2019-Jan-27 23:29 ± < 00:01	0.13 | 0.00032	4.8 m - 11 m
(2019 CN5)	2019-Feb-11 07:23 ± 00:03	0.31 | 0.00079	7.3 m - 16 m
(2019 DG2)	2019-Feb-26 07:39 ± 00:24	0.61 | 0.00158	5.4 m - 12 m
(2019 DF)	2019-Feb-26 21:11 ± 00:09	0.45 | 0.00116	2.9 m - 6.5 m
(2019 EH1)	2019-Mar-01 17:38 ± < 00:01	0.06 | 0.00016	2.5 m - 5.7 m
(2019 EN2)	2019-Mar-13 23:38 ± < 00:01	0.86 | 0.00221	8.0 m - 18 m
(2019 FA)	2019-Mar-16 01:14 ± < 00:01	0.60 | 0.00154	4.8 m - 11 m
(2019 EA2)	**2019-Mar-22 01:53 ± < 00:01**	**0.80 | 0.00205**	**18 m - 41 m**
(2019 FQ)	**2019-Mar-23 18:17 ± < 00:01**	**0.86 | 0.00220**	**10 m - 23 m**
(2019 FC1)	**2019-Mar-28 05:46 ± < 00:01**	**0.27 | 0.00069**	**20 m - 45 m**
(2019 FV1)	2019-Mar-31 05:27 ± < 00:01	0.87 | 0.00223	4.6 m - 10 m
(2019 GP21)	2019-Mar-31 19:00 ± 07:46	0.93 | 0.00238	3.0 m - 6.6 m
(2019 GN20)	**2019-Apr-12 07:06 ± < 00:01**	**0.98 | 0.00253**	**14 m - 31 m**
(2019 GC6)	**2019-Apr-18 06:41 ± < 00:01**	**0.57 | 0.00146**	**13 m - 30 m**
(2019 HE)	**2019-Apr-20 21:12 ± < 00:01**	**0.58 | 0.00150**	**12 m - 28 m**
(2019 JK)	2019-Apr-30 08:12 ± < 00:01	0.69 | 0.00178	6.7 m - 15 m
(2019 JX1)	2019-May-02 12:39 ± < 00:01	0.47 | 0.00120	4.0 m - 8.9 m
(2019 JY2)	2019-May-05 17:12 ± < 00:01	0.38 | 0.00098	3.2 m - 7.2 m
(2019 JH7)	2019-May-16 00:06 ± < 00:01	0.19 | 0.00048	3.1 m - 7.0 m
(2019 KT)	**2019-May-28 03:48 ± < 00:01**	**0.85 | 0.00217**	**13 m - 29 m**
(2019 LY4)	2019-Jun-06 01:30 ± < 00:01	0.22 | 0.00056	7.3 m - 16 m
(2019 LW4)	**2019-Jun-08 17:04 ± < 00:01**	**0.65 | 0.00166**	**9.3 m - 21 m**
(2019 NK1)	2019-Jul-02 09:49 ± < 00:01	0.69 | 0.00177	2.6 m - 5.7 m
(2019 MB4)	**2019-Jul-09 07:20 ± < 00:01**	**0.82 | 0.00211**	**16 m - 35 m**
(2019 NF7)	2019-Jul-09 12:07 ± < 00:01	0.98 | 0.00253	6.4 m - 14 m
(2019 NN3)	**2019-Jul-10 16:29 ± < 00:01**	**0.83 | 0.00214**	**29 m - 66 m**
(2019 OD)	**2019-Jul-24 13:31 ± < 00:01**	**0.93 | 0.00239**	**54 m - 120 m**
(2019 OK)	**2019-Jul-25 01:22 ± < 00:01**	**0.19 | 0.00048**	**59 m - 130 m**
(2019 OD3)	**2019-Jul-28 02:56 ± < 00:01**	**0.49 | 0.00126**	**11 m - 25 m**
(2019 ON3)	2019-Jul-29 01:19 ± 00:14	0.56 | 0.00143	7.4 m - 16 m
(2019 QB1)	**2019-Aug-20 11:54 ± 00:01**	**0.32 | 0.00083**	**8.7 m - 20 m**
(2019 QH2)	2019-Aug-20 18:12 ± 00:08	0.13 | 0.00033	2.2 m - 5.0 m
(2019 QD)	2019-Aug-22 01:28 ± < 00:01	0.78 | 0.00200	4.7 m - 11 m
(2019 QR8)	2019-Aug-26 08:51 ± 01:08	0.80 | 0.00207	6.6 m - 15 m
(2019 QQ3)	2019-Aug-26 15:14 ± 00:01	0.25 | 0.00064	3.7 m - 8.2 m
(2019 RQ)	2019-Sep-02 16:45 ± < 00:01	0.29 | 0.00074	2.1 m - 4.6 m
(2019 RP1)	2019-Sep-05 22:04 ± < 00:01	0.10 | 0.00025	7.3 m - 16 m
(2019 RC1)	2019-Sep-07 10:48 ± < 00:01	0.48 | 0.00123	4.6 m - 10 m
(2019 SJ)	2019-Sep-16 18:56 ± < 00:01	0.64 | 0.00163	8.3 m - 19 m
(2019 SU2)	2019-Sep-21 02:48 ± 00:01	0.19 | 0.00048	2.6 m - 5.8 m
(2019 SD1)	2019-Sep-21 06:46 ± < 00:01	0.73 | 0.00187	5.5 m - 12 m
(2019 SS2)	2019-Sep-21 07:12 ± 00:02	0.30 | 0.00077	2.0 m - 4.4 m
(2019 SS3)	**2019-Sep-22 22:48 ± 00:21**	**0.73 | 0.00188**	**15 m - 34 m**
(2019 SX8)	2019-Sep-28 07:50 ± < 00:01	0.99 | 0.00255	4.3 m - 9.7 m
(2019 TE)	2019-Sep-28 20:31 ± 01:31	0.93 | 0.00238	6.8 m - 15 m
(2019 TD)	2019-Sep-29 18:49 ± 00:01	0.34 | 0.00087	3.9 m - 8.7 m
(2019 SM8)	2019-Oct-01 13:56 ± < 00:01	0.41 | 0.00106	3.8 m - 8.6 m
(2019 SP3)	**2019-Oct-03 06:33 ± < 00:01**	**0.97 | 0.00249**	**14 m - 31 m**
(2019 TN5)	2019-Oct-05 22:38 ± < 00:01	0.32 | 0.00083	5.5 m - 12 m
(2019 UU1)	2019-Oct-18 06:23 ± < 00:01	0.59 | 0.00151	2.2 m - 5.0 m
(2019 UG)	2019-Oct-18 09:23 ± < 00:01	0.84 | 0.00215	6.3 m - 14 m
(2019 UL3)	2019-Oct-19 22:22 ± < 00:01	0.77 | 0.00199	5.9 m - 13 m
(2019 UN8)	2019-Oct-23 16:41 ± 00:17	0.93 | 0.00240	3.1 m - 6.9 m
(2019 UO8)	2019-Oct-25 13:30 ± < 00:01	0.41 | 0.00105	3.7 m - 8.3 m
(2019 UX12)	2019-Oct-26 03:07 ± 00:01	0.99 | 0.00255	4.8 m - 11 m
(2019 UD10)	2019-Oct-27 10:08 ± 00:02	0.44 | 0.00112	6.3 m - 14 m
(2019 UB8)	2019-Oct-29 06:30 ± < 00:01	0.50 | 0.00127	4.3 m - 9.7 m
(2019 UN13)	2019-Oct-31 14:45 ± < 00:01	0.03 | 8.43e-5	1.0 m - 2.2 m
(2019 UG11)	**2019-Nov-01 20:42 ± < 00:01**	**0.55 | 0.00140**	**12 m - 28 m**
(2019 VA)	2019-Nov-02 17:28 ± < 00:01	0.28 | 0.00071	5.8 m - 13 m
(2019 VD)	**2019-Nov-04 09:56 ± < 00:01**	**0.45 | 0.00117**	**8.7 m - 20 m**
(2019 VR)	2019-Nov-04 10:30 ± < 00:01	0.35 | 0.00091	6.4 m - 14 m
(2019 VS4)	**2019-Nov-06 16:28 ± < 00:01**	**0.36 | 0.00093**	**9.2 m - 21 m**
(2019 VB5)	2019-Nov-09 17:29 ± < 00:01	0.38 | 0.00097	1.2 m - 2.7 m
(2019 VF5)	2019-Nov-09 23:16 ± < 00:01	0.49 | 0.00127	8.1 m - 18 m
(2019 WH)	**2019-Nov-19 08:01 ± < 00:01**	**0.22 | 0.00057**	**15 m - 35 m**
(2019 WV1)	2019-Nov-19 23:51 ± 00:09	0.72 | 0.00185	6.2 m - 14 m
(2019 WG2)	**2019-Nov-23 08:44 ± < 00:01**	**0.47 | 0.00121**	**27 m - 60 m**
(2019 WJ4)	2019-Nov-30 20:05 ± < 00:01	0.85 | 0.00219	5.5 m - 12 m
(2019 YB)	2019-Dec-18 00:12 ± 00:03	0.44 | 0.00113	3.1 m - 7.0 m
(2019 YS)	2019-Dec-18 15:12 ± < 00:01	0.17 | 0.00044	1.3 m - 3.0 m
(2019 YU2)	**2019-Dec-23 19:28 ± < 00:01**	**0.26 | 0.00066**	**8.9 m - 20 m**
(2019 YV4)	**2019-Dec-25 21:41 ± 11:01**	**0.98 | 0.00251**	**9.3 m - 21 m**

NASA's Primary NEO Characterization Assets

Interplanetary Radar
Goldstone and Arecibo

- Increased time for NEO observations
- Streamlined Rapid Response capability
- Increased resolution (~4 meters)



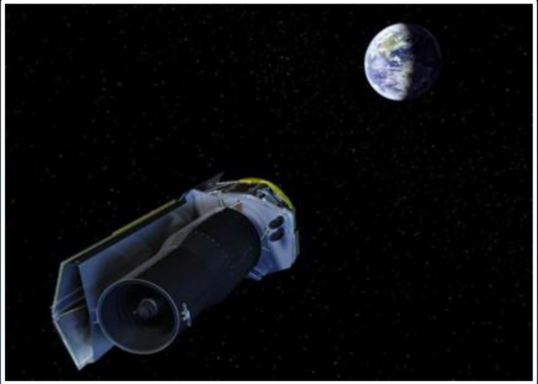


NASA Infrared Telescope Facility (IRTF)

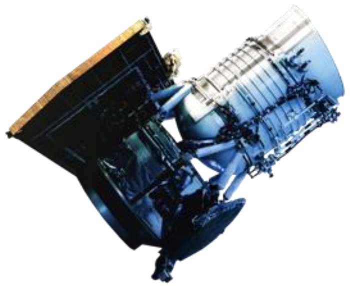
- 3.5 meter telescope optimized for infra-red band
- Rapid Response call-up for NEA observations
- Improved instrumentation for spectroscopy and thermal signatures

Spitzer Infrared Space Telescope

- Orbit about Sun, ~176 million km trailing Earth
- In extended warm-phase mission
- Characterization of comets and asteroids
- Thermal signatures, albedo/sizes of NEO



Current Planetary Defense Flight Mission Projects

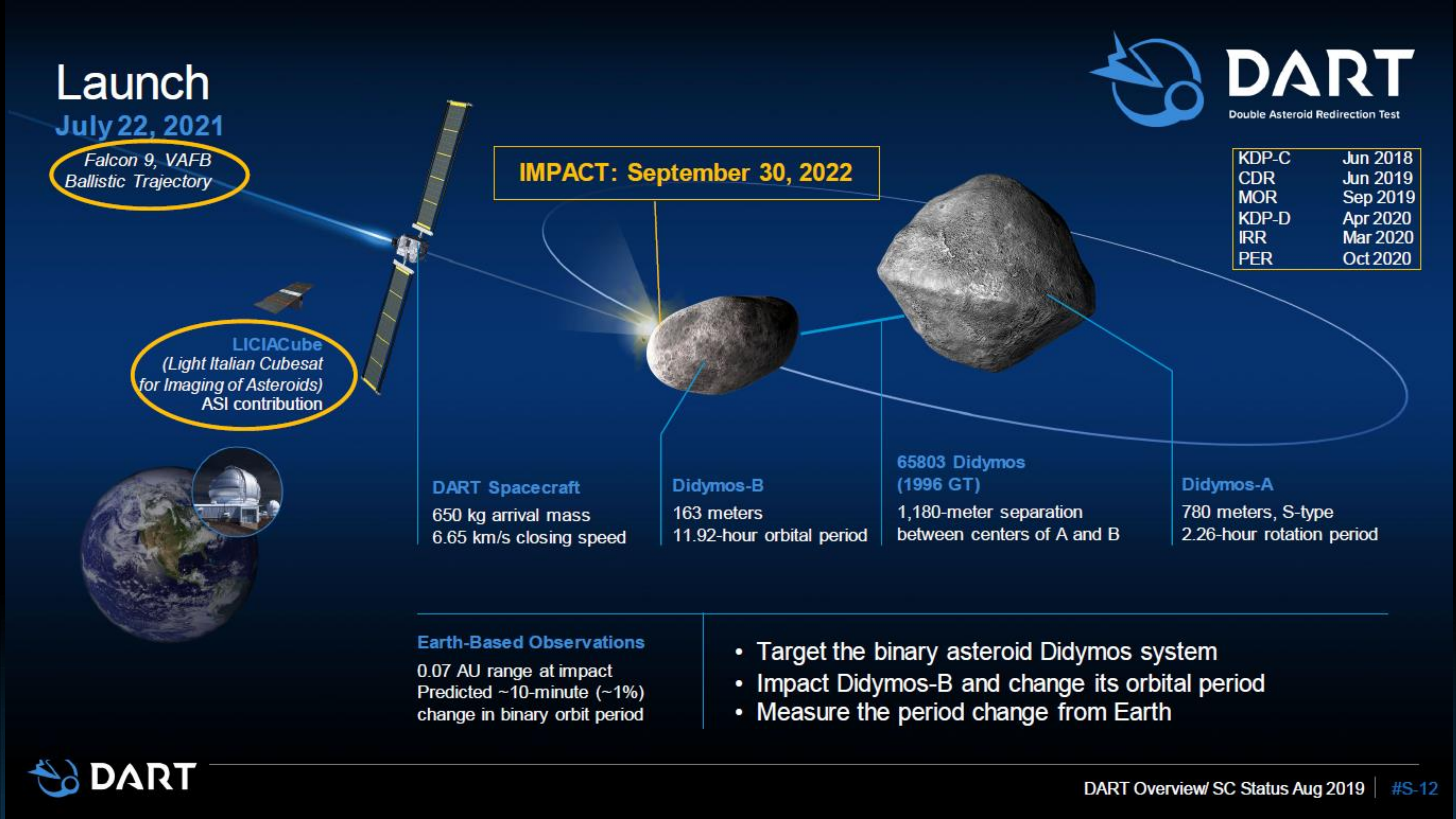


NEOWISE

- Continues in extended NEO survey operations
- Expected to exceed maximum useful temperatures in ~Summer 2020

DART: Double Asteroid Redirection Test

- Demonstration of kinetic impactor technique
- Target - Moon of 65803 Didymos
- Launch NET July 2021, impact September 2022
- Completed Mission-level PDR April 2018
- KDP-C “Confirmation” signed August 2018
- CDR completed June 2019, DPMC completed August 2019
- Phase C complete by 1 April 2020


DART
Double Asteroid Redirection Test
Launch
July 22, 2021
Falcon 9, VAFB
Ballistic Trajectory
LICIACube
(Light Italian Cubesat for Imaging of Asteroids)
ASI contribution
IMPACT: September 30, 2022
KDP-C Jun 2018
CDR Jun 2019
MOR Sep 2019
KDP-D Apr 2020
IRR Mar 2020
PER Oct 2020
DART Spacecraft
650 kg arrival mass
6.65 km/s closing speed
Didymos-B
163 meters
11.92-hour orbital period
65803 Didymos (1996 GT)
1,180-meter separation between centers of A and B
Didymos-A
780 meters, S-type
2.26-hour rotation period
Earth-Based Observations
0.07 AU range at impact
Predicted ~10-minute (~1%) change in binary orbit period
• Target the binary asteroid Didymos system
• Impact Didymos-B and change its orbital period
• Measure the period change from Earth
DART
DART Overview/ SC Status Aug 2019
#S-12

Planetary Defense Mission Approach

- NASA Planetary Defense missions are focused on NEO search/characterization or mitigation technology development
- NASA does NOT approach planetary defense as a science-driven mission line; instead, the Agency approaches these future mission concepts more like space weather, NOAA or other operational programs
- Where possible, and following other government programs focused on operations and data-gathering, missions are operationally focused, targeted, and goal-driven
- The missions contain only the science activities needed to sufficiently design, validate/verify, and operate the mission, and ground-based astronomical support for meeting mission success criteria
- *The order of these mission concepts is subject to future budget decisions and the availability of funding; the Agency will not start a new mission until the Planetary Defense line can support the next mission concept in the series*

National Academies Study (2019)

- Since 2013, the NEO Wide-field Infrared Explorer (NEOWISE) has assisted NASA’s efforts to identify and characterize populations of near-Earth asteroids and comets
- NASA’s Chief Scientist requested the National Academies of Sciences, Engineering, and Medicine (NASEM) evaluate the relative advantages and disadvantages of infrared and visible observations of NEOs
  - The NASEM report was issued in June 2019
- One key finding was that a “space-based mid-infrared telescope designed for discovering NEOs and operating in conjunction with currently existing and anticipated ground-based, visible telescopes is the most effective option for meeting the George E. Brown Act completeness and size determination requirements in a timely fashion”

2019 NASEM Study Recommendations

- Objects smaller than 140 meters in diameter can pose a local damage threat. When they are detected, their orbits and physical properties should be determined, and the objects should be monitored insofar as possible.

- If the completeness and size requirements given in the George E. Brown, Jr. Near-Earth Object Survey Act are to be accomplished in a timely fashion (i.e., approximately 10 years), NASA should fund a dedicated space-based infrared survey telescope. Early detection is important to enable deflection of a dangerous asteroid. The design parameters, such as wavelength bands, field of view, and cadence, should be optimized to maximize near Earth object detection efficiency for the relevant size range and the acquisition of reliable diameters.

- Missions meeting high-priority planetary defense objectives should not be required to compete against missions meeting high-priority science objectives.

- If NASA develops a space-based infrared near Earth object (NEO) survey telescope, it should also continue to fund both short- and long-term ground-based observations to refine the orbits and physical properties of NEOs to assess the risk they might pose to Earth, and to achieve the George E. Brown, Jr. Near-Earth Object Survey Act goals.

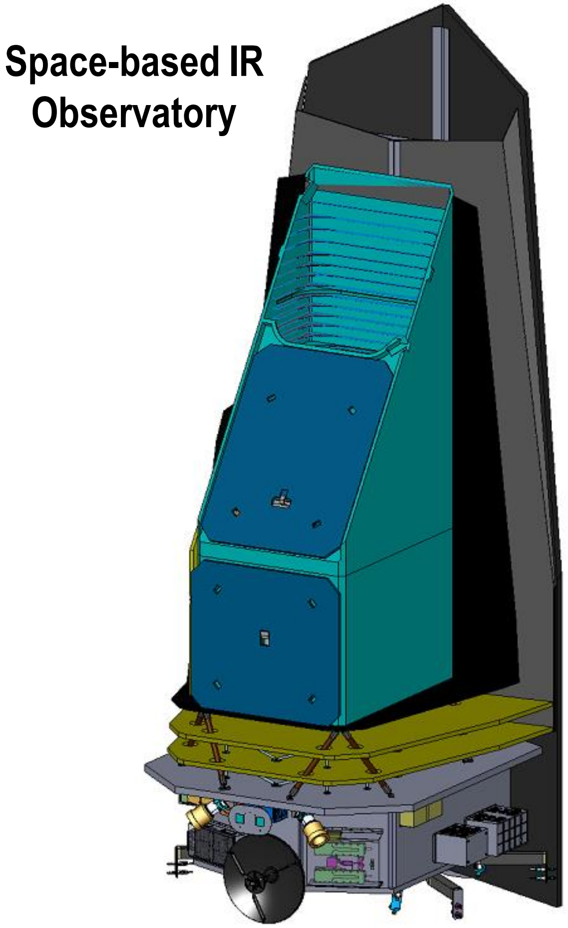
- All observational data, both ground- and space-based, obtained under NASA funding supporting the George E. Brown, Jr. Near-Earth Object Survey Act, should be archived in a publicly available database as soon as practicable after it is obtained. NASA should continue to support the utilization of such data and provide resources to extract near Earth object detections from legacy databases and those archived in future surveys and their associated follow-up programs.

NEO Surveillance Mission Concept Objectives

- Find 65% of undiscovered Potentially Hazardous Asteroids (PHAs) >140 m in 5 years (goal: 90% in 10 years)
- Produce sizes from IR signatures
  - Compute albedos when visible data are available
- Compute cumulative chance of impact over next century for PHAs >50 m and comets
- Deliver new tracklet data daily to the Minor Planet Center
  - Images and extracted source lists every 6 months to archive

NEO Surveillance Mission Concept High-Level Description

- Wide-field Infrared (IR) instrument
- Heritage-based spacecraft
- Observatory compatible with two launch vehicles
  - Falcon 9 or Atlas 401
  - S/C wet mass CBE < 1300 kg
- Launch possible 346 days of the year
- Operations in Sun-Earth L1 halo orbit
- Fixed survey pattern; 12-yr life (extended mission)
- Deep Space Network (DSN) for telecom and navigation
- IPAC for data processing and analysis



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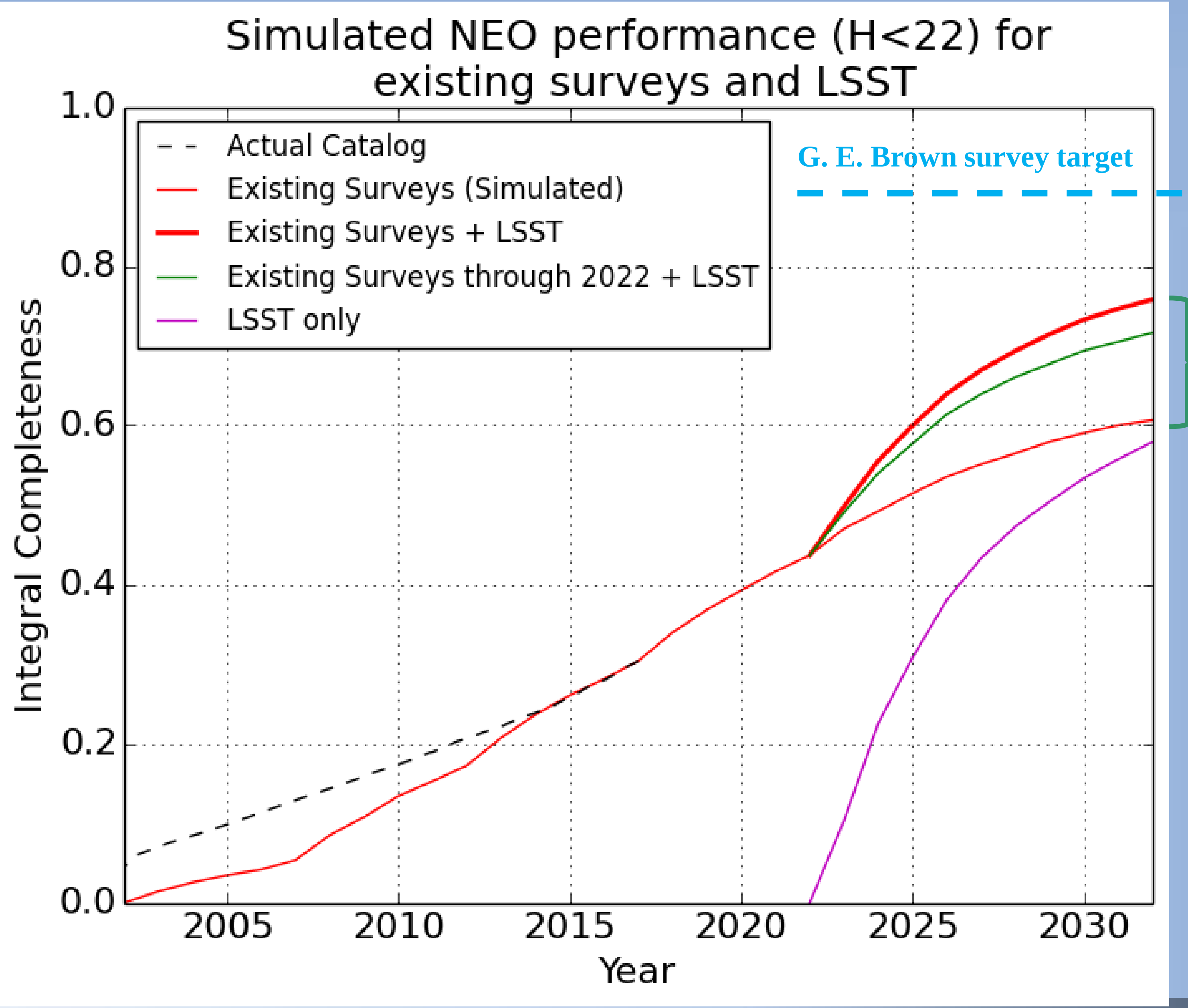
Back up Slides

From NASA/NSF study report



LSST reduces the distance to the goal in 2032 roughly by half, compared to where we would be with currently operating surveys alone.

"NEO-optimized" LSST cadences tested so far increase completeness by only a few %.

Study of LSST's Capabilities for NEO Discovery

Major Consensus Results

- LSST's nominal strategy of two visits per night per field can be successful in discovering NEOs after 12 days of data collection. False detections are not a serious obstacle, based on a rate demonstrated in Dark Energy Camera data. The conclusion is robust to factors of a few in the false positive rate.
- Assuming that existing NEO surveys continue to operate and incrementally improve, the H < 22 NEO catalog is likely to surpass 75% completeness after LSST's 10-year baseline survey. Continuing the same survey would increase completeness by about 1% per additional year, up to 5 years.
- A completeness level of 90% is likely beyond reach without major system modifications or contributions from another next-generation survey.
- PHA completeness would be about 5 percentage points higher than NEO completeness, owing to PHAs' closer mean proximity to Earth.
- Changing the observing strategy to 3 or 4 visits per night per field would not improve linking efficiency, and therefore would reduce survey completeness due to reduced sky coverage.