



Planetary Defense Coordination Office

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> Update to SMPAG February 6, 2020





[CENTER FOR NEAR EARTH OBJECT STUDIES]

SEARCH, DETECT & TRACK

-K

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

MITIGATE [dart, fema exercises]

PLANETARY **DEFENSE**

IAU

Planet

NIT

CHARACTERIZE

[NEOWISE, GOLDSTONE, ARECIBO, IRTF]

PLAN & COORDINATE [SMPAG, PIERWG, DAMIEN IWG]

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



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





Signatories to the International Asteroid Warning Network (IAWN) iawn.net





Currently 20 signatories



Near-Earth Asteroids Discovered

Most recent discovery: 2020-Jan-05



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



PLANETARY DEFENSE





NEAs 140 Meters and Larger

PLANETARY DEFENSE





77 Detected Close Approaches <1 Lunar Distance in 2019



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

PLANETARY DEFENSE

COORDINATION OFFICE

0	bject	Close-Approach (CA) Date	(LD au)	Estimated Diameter	Object	Close-Approach (CA) Date	(LD au)	Estimated Diamete
(2	2019 AS5)	2019-Jan-08 00:37 ± < 00:01	0.04 0.00010	0.92 m - 2.1 m	(2019 QR8)	2019-Aug-2608:51 ± 01:08	0.80 0.00207	6.6 m - 15 m
(2	2019 AE9)	2019-Jan-12 11:09 ± < 00:01	0.26 0.00067	9.9 m - 22 m	(2019 QQ3)	2019-Aug-2615:14 ± 00:01	0.25 0.00064	3.7 m - 8.2 m
(2	2019 BO)	2019-Jan-16 01:13 ± < 00:01	0.18 0.00046	6.3 m - 14 m	(2019 RQ)	2019-Sep-02 16:45 ± < 00:01	0.29 0.00074	2.1 m - 4.6 m
(2	2019 BV1)	2019-Jan-24 20:53 ± < 00:01	0.35 0.00090	4.9 m - 11 m	(2019 RP1)	2019-Sep-05 22:04 ± < 00:01	0.10 0.00025	7.3 m - 16 m
(2	2019 BZ3)	2019-Jan-27 23:29 ± < 00:01	0.13 0.00032	4.8 m - 11 m	(2019 RC1)	2019-Sep-07 10:48 ± < 00:01	0.48 0.00123	4.6 m - 10 m
(2	2019 CN5)	2019-Feb-1107:23 ± 00:03	0.31 0.00079	7.3 m - 16 m	(2019 SJ)	2019-Sep-16 18:56 ± < 00:01	0.64 0.00163	8.3 m - 19 m
(2	, 2019 DG2)	2019-Feb-26 07:39 ± 00:24	0.61 0.00158	5.4 m - 12 m	(2019 SU2)	2019-Sep-2102:48 ± 00:01	0.19 0.00048	2.6 m - 5.8 m
(2	2019 DF)	2019-Feb-26 21:11 ± 00:09	0.45 0.00116	2.9 m - 6.5 m	(2019 SD1)	2019-Sep-2106:46 ± < 00:01	0.73 0.00187	5.5 m - 12 m
(2	2019 EH1)	2019-Mar-01 17:38 ± < 00:01	0.06 0.00016	2.5 m - 5.7 m	(2019 SS2)	2019-Sep-2107:12 ± 00:02	0.30 0.00077	2.0 m - 4.4 m
(-	2019 FN2)	2019-Mar-13 23·38 + < 00.01	0.86 0.00221	80m - 18m	(2019 SS3)	2019-Sep-22 22:48 ± 00:21	0.73 0.00188	15 m - 34 m
(2	2019 EN2,	2019-Mar-16 01:14 + < 00:01	0.60 0.00154	48m-11m	(2019 SX8)	2019-Sep-28 07:50 ± < 00:01	0.99 0.00255	4.3 m - 9.7 m
(2	2019 FA2)	2019-Mar-22 01:53 + < 00:01	0.80 0.00205	18 m - 41 m	(2019 TE)	2019-Sep-28 20:31 ± 01:31	0.93 0.00238	6.8 m - 15 m
(2	2019 ER2,	$2019-Mar-22.01.03 \pm < 00.01$	0.86 0.00200	10 m - 23 m	(2019 TD)	2019-Sep-29 18:49 ± 00:01	0.34 0.00087	3.9 m - 8.7 m
12		2019 Mar $28.05 \cdot 46 \pm < 00.01$	0.37 0.00069	20 m 45 m	(2019 SM8)	2019-Oct-01 13:56 ± < 00:01	0.41 0.00106	3.8 m - 8.6 m
(4		$2019 - 10a1 - 28 03 + 0 \pm < 00.01$		16 m 10 m	(2019 SP3)	2019-Oct-03 06:33 ± < 00:01	0.97 0.00249	14 m - 31 m
(2	2019 FV1)	2019 -Mai-3103:27 $\pm < 00.01$	0.87 0.00223	4.6 m - 10 m	(2019 TN5)	2019-Oct-05 22:38 ± < 00:01	0.32 0.00083	5.5 m - 12 m
(2	2019 GP21)	2019-Mar-3119:00 ± 07:46	0.93 0.00238	3.0 m - 6.6 m	(2019 UU1)	2019-Oct-18 06:23 ± < 00:01	0.59 0.00151	2.2 m - 5.0 m
(2	2019 GN20)	2019-Apr-12 07:06 ± < 00:01	0.98 0.00253	14 m - 31 m	(2019 UG)	2019-Oct-18 09:23 ± < 00:01	0.84 0.00215	6.3 m - 14 m
(2	2019 GC6)	2019-Apr-18 06:41 ± < 00:01	0.57 0.00146	13 m - 30 m	(2019 UL3)	2019-Oct-19 22:22 ± < 00:01	0.77 0.00199	5.9 m - 13 m
(2	2019 HE)	2019-Apr-20 21:12 ± < 00:01	0.58 0.00150	12 m - 28 m	(2019 UN8)	2019-Oct-23 16:41 ± 00:17	0.93 0.00240	3.1 m - 6.9 m
(2	2019 JK)	2019-Apr-30 08:12 ± < 00:01	0.69 0.00178	6.7 m - 15 m	(2019 UO8)	2019-Oct-25 13:30 ± < 00:01	0.41 0.00105	3.7 m - 8.3 m
(2	2019 JX1)	2019-May-02 12:39 ± < 00:01	0.47 0.00120	4.0 m - 8.9 m	(2019 UX12)	2019-Oct-26 03:07 ± 00:01	0.99 0.00255	4.8 m - 11 m
(2	2019 JY2)	2019-May-05 17:12 ± < 00:01	0.38 0.00098	3.2 m - 7.2 m	(2019 UD10)	2019-Oct-27 10:08 ± 00:02	0.44 0.00112	6.3 m - 14 m
(2	2019 JH7)	2019-May-16 00:06 ± < 00:01	0.19 0.00048	3.1 m - 7.0 m	(2019 UB8)	2019-Oct-29 06:30 ± < 00:01	0.50 0.00127	4.3 m - 9.7 m
(2	2019 KT)	2019-May-28 03:48 ± < 00:01	0.85 0.00217	13 m - 29 m	(2019 UN13)	2019-Oct-31 14:45 ± < 00:01	0.03 8.43e-5	1.0 m - 2.2 m
(2	2019 LY4)	2019-Jun-06 01:30 ± < 00:01	0.22 0.00056	7.3 m - 16 m	(2019 UG11)	2019-Nov-01 20:42 ± < 00:01	0.55 0.00140	12 m - 28 m
(2	2019 LW4)	2019-Jun-08 17:04 ± < 00:01	0.65 0.00166	9.3 m - 21 m	(2019 VA)	2019-Nov-02 17:28 ± < 00:01	0.28 0.00071	5.8 m - 13 m
(2	2019 NK1)	2019-Jul-02 09:49 ± < 00:01	0.69 0.00177	2.6 m - 5.7 m	(2019 VD)	2019-Nov-04 09:56 ± < 00:01	0.45 0.00117	8.7 m - 20 m
(2	2019 MB4)	2019-Jul-09 07:20 ± < 00:01	0.82 0.00211	16 m - 35 m	(2019 VR)	2019-Nov-04 10:30 ± < 00:01	0.35 0.00091	6.4 m - 14 m
(2	2019 NF7)	2019-Jul-09 12:07 ± < 00:01	0.98 0.00253	6.4 m - 14 m	(2019 VS4)	2019-Nov-06 16:28 ± < 00:01	0.36 0.00093	9.2 m - 21 m
(2	2019 NN3)	2019-Jul-10 16:29 ± < 00:01	0.83 0.00214	29 m - 66 m	(2019 VB5)	2019-Nov-09 17:29 ± < 00:01	0.38 0.00097	1.2 m - 2.7 m
(2	2019 OD)	2019-Jul-24 13:31 ± < 00:01	0.93 0.00239	54 m - 120 m	(2019 VF5)	2019-Nov-09 23:16 ± < 00:01	0.49 0.00127	8.1 m - 18 m
(2	2019 OK)	2019-Jul-25 01:22 ± < 00:01	0.19 0.00048	59 m - 130 m	(2019 WH)	2019-Nov-19 08:01 ± < 00:01	0.22 0.00057	15 m - 35 m
(2	2019 OD3)	2019-Jul-28 02:56 ± < 00:01	0.49 0.00126	11 m - 25 m	(2019 WV1)	2019-Nov-1923:51± 00:09	0.72 0.00185	6.2 m - 14 m
Ľ	2019 ON3)	2019-Jul-29 01:19 ± 00:14	0.56 0.00143	7.4 m - 16 m	(2019 WG2)	2019-Nov-23 08:44 ± < 00:01	0.47 0.00121	27 m - 60 m
(2	2019 OB1)	2019-Aug-20 11:54 + 00:01	0.32 0.00083	8.7 m - 20 m	(2019 WJ4)	$2019 - NOV - 30 20:05 \pm < 00:01$	0.85 0.00219	5.5 m - 12 m
12		2019-Aug-2018:12 + 00:01	0 13 0 00033	2 2 m - 5 0 m	(2019 YB)	2019-Dec-18 00:12 ± 00:03	0.44 0.00113	3.1m - 7.0m
(2		$2019 \text{ Aug} 20 10.12 \pm -00.00$	0.78 0.000000	<u>4.7 m - 11 m</u>	(2019 YS)	2019-Dec-1815:12 ± < 00:01	0.17 0.00044	1.3 m - 3.0 m
(2		2015 Aug-22 01.28 1 < 00.01	0.78 0.00200			2019-Dec-23 19:28 ± < 00:01		8.9 m - 20 m
						$2019006-7571.41 \pm 11.01$	T 9X 1 11 10251	93m - 21m

PLANETARY DEFENSE COORDINATION OFFICE

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.

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), <u>NASA should fund a dedicated space-based</u> <u>infrared survey telescope</u>. 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 Characteristics

- If included in future budget requests, this mission concept would be designed to be consistent with NASA's Planetary Defense strategy
- Would benefit from technology development and extended Phase A from NEOCam
- Anticipated mission costs for future Phase B-D would be in the \$500-600M range, including options for shared or dedicated launch vehicle
- Funds supporting research and analysis would be bookkept separately

Designed to meet George E. Brown Act goals in mid-2030s, accelerating completion by at least 15 years (NASEM, 2019)

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



The Mission is Surveillance for Potential Hazardous Objects (PHOs)

"Surveillance – Keep a close watch on something", e.g. Near-Earth space for PHOs



The NEO Surveyor Flight Project – directed to JPL – is a critical tool to accomplish:

- 1) Finding the >140 meter NEA population (to >90% complete)
- 2) Characterize the remaining hazard





APOPHIS T-9 YEARS:

Knowledge Opportunities for the Science of Planetary Defense

APRIL 23 - 24, 2020 NICE, FRANCE



Workshop Location and Dates

We are happy to announce the Apophis T–9 Years: Knowledge Opportunities for the Science of Planetary Defense workshop scheduled for April 23–24, 2020 at the Hôtel Le Saint Paul, Nice, France.

Indication of interest https://www.hou.usra.edu/meetings/apophis2020/





