Planetary Defense Coordination Office

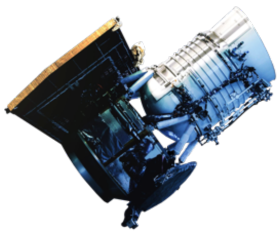
Lindley Johnson
NASA's Planetary Defense Officer

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

Update to PAC
March 9, 2020

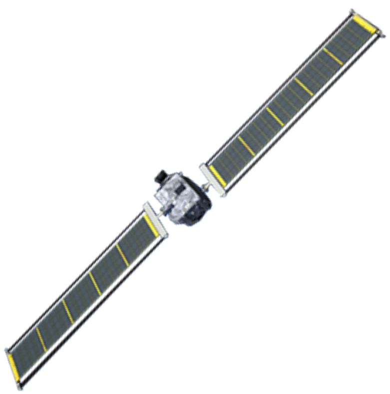
PLANETARY DEFENSE
ASSESS
[CENTER FOR NEAR EARTH OBJECT STUDIES]
IAU Minor Planet Center
SEARCH, DETECT & TRACK
[GROUND-BASED & SPACE-BASED OBSERVATIONS, IAWN]
MITIGATE
[DART, FEMA EXERCISES]
CHARACTERIZE
[NEOWISE, GOLDSTONE, ARECIBO, IRTF]
PLAN & COORDINATE
[SMPAG, PIERWG, DAMIEN IWG]

Current Planetary Defense Flight Mission Projects



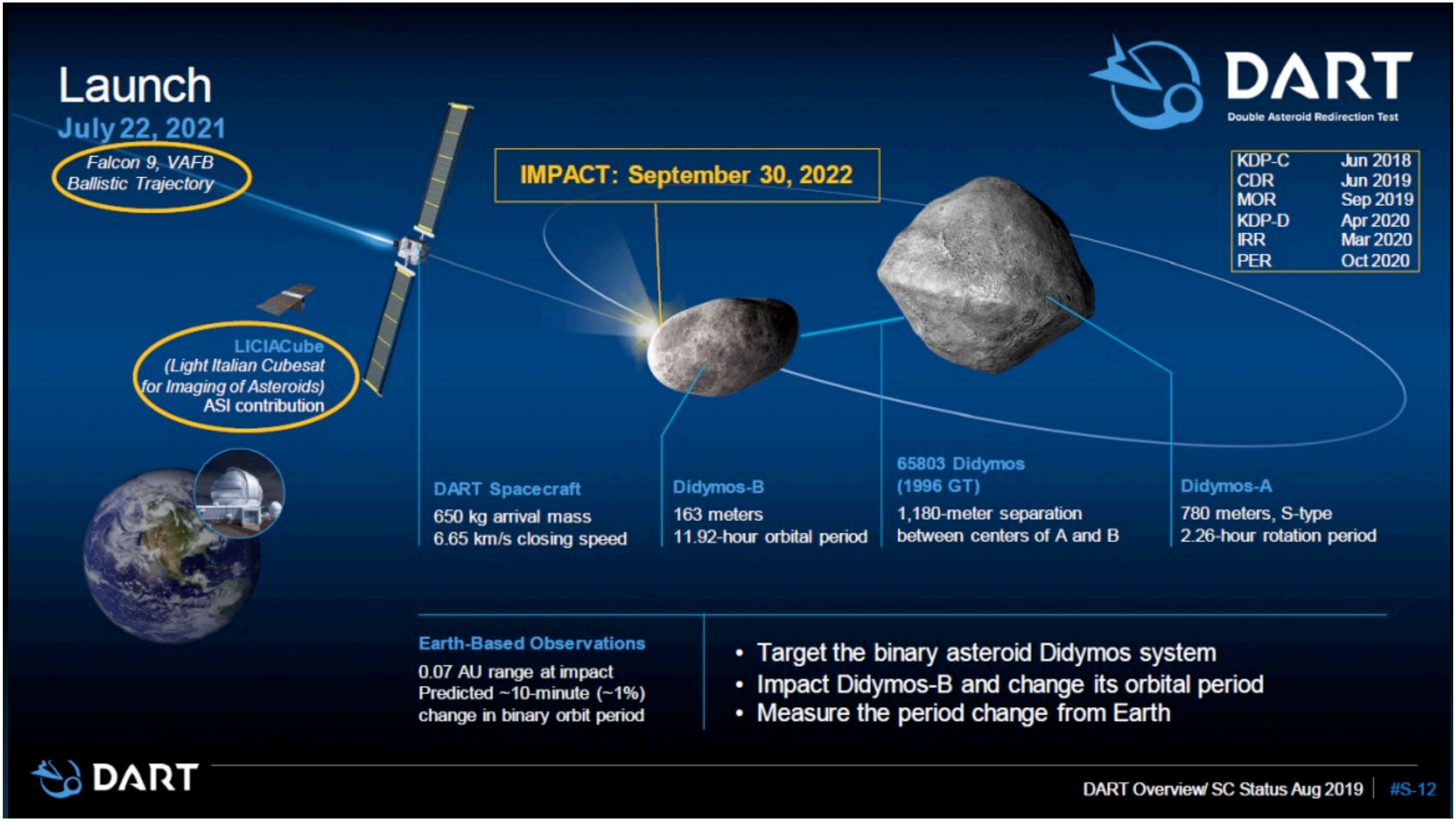
NEOWISE

- 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 late July 2021, impact late September 2022
- KDP-C "Confirmation" signed August 2018
- Mission Integration Readiness Review 11-12 March
- On track Phase C complete 1 April 2020, Declare KDP-D


Launch
July 22, 2021
Falcon 9, VAFB
Ballistic Trajectory
LICIACube
(Light Italian Cubesat
for Imaging of Asteroids)
ASI contribution
IMPACT: September 30, 2022
DART
Double Asteroid Redirection Test
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

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 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

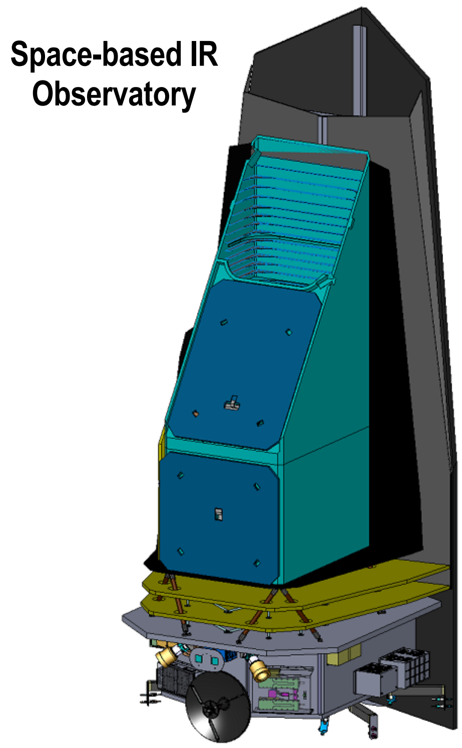
Designed to meet George E. Brown Act goals in mid-2030s, accelerating completion by at least 15 years (NASEM, 2019)

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

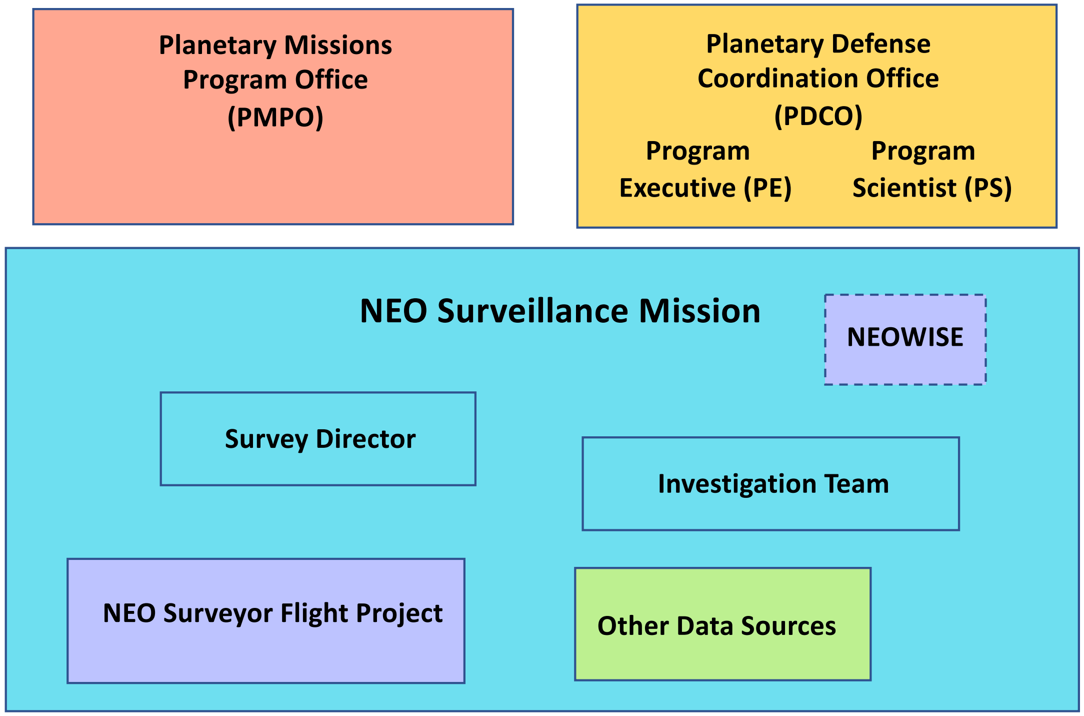
NEO Surveillance Mission Concept High-Level Description

- 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)

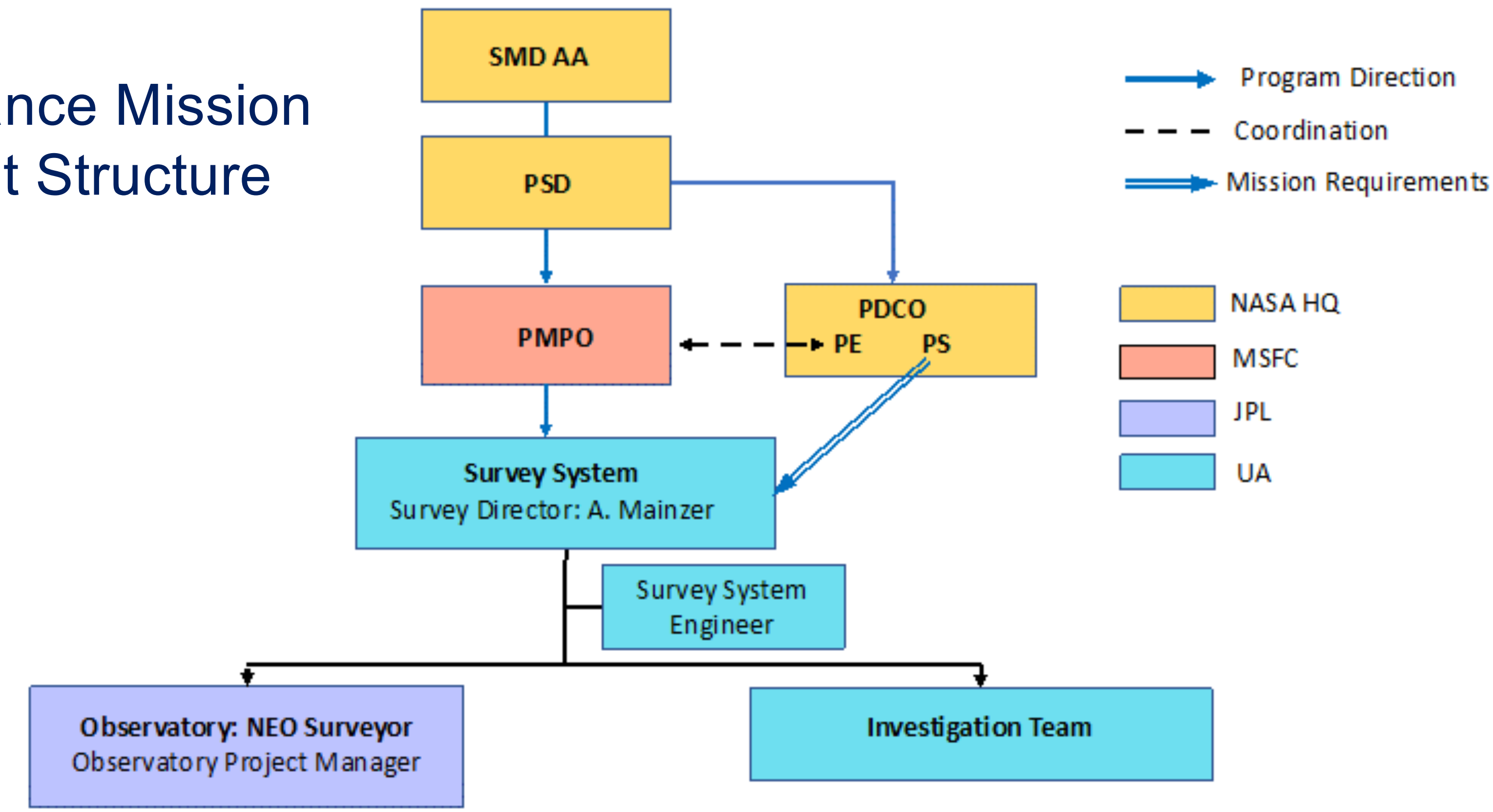
"Surveillance – Keep a close watch on something", e.g. Near-Earth space for PHOs



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

NEO Surveillance Mission Management Structure



PLANETARY DEFENSE
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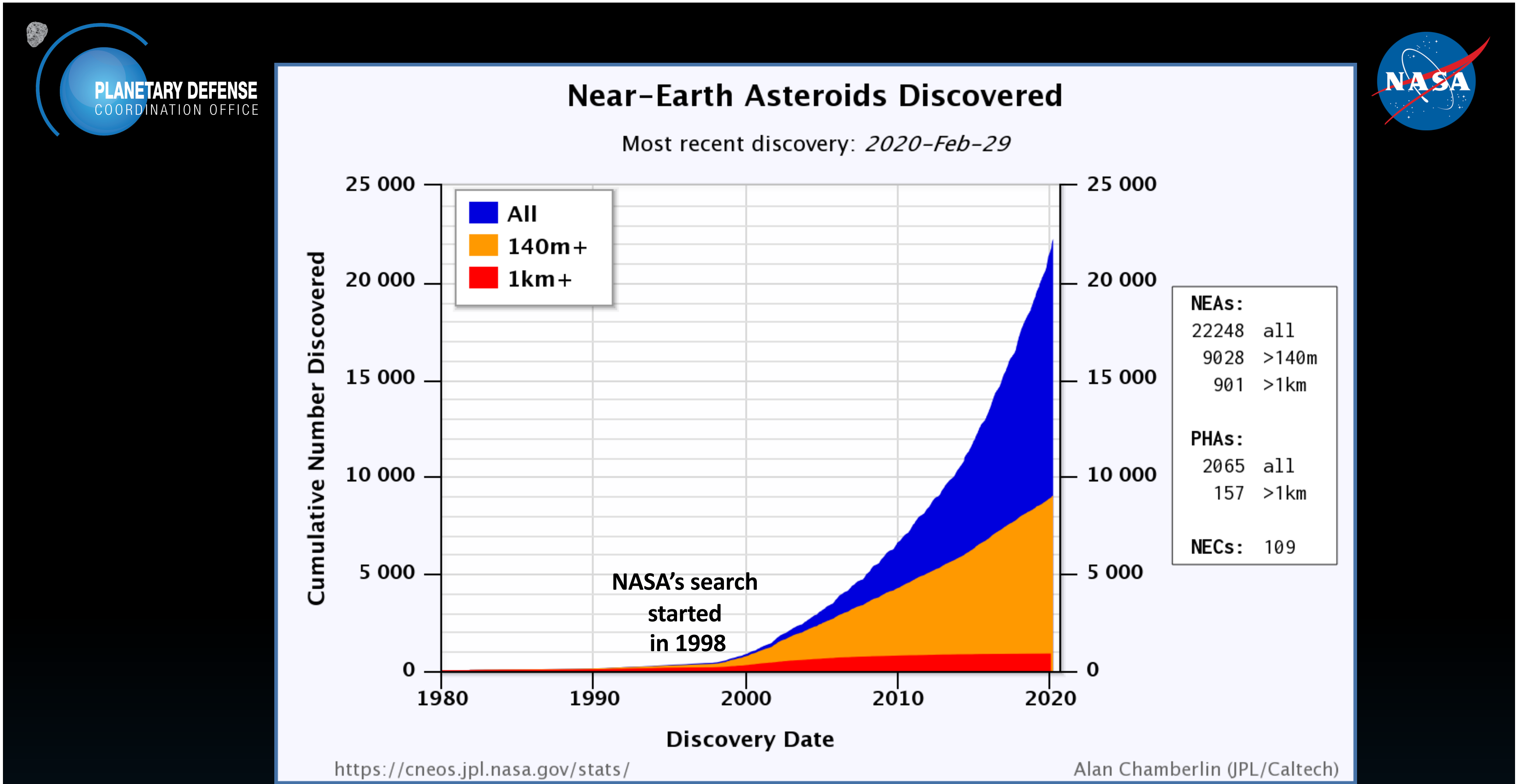
Near-Earth Object Observations Program

Kelly Fast
Near-Earth Object Observations Program Manger

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

Update to PAC
March 9, 2020



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

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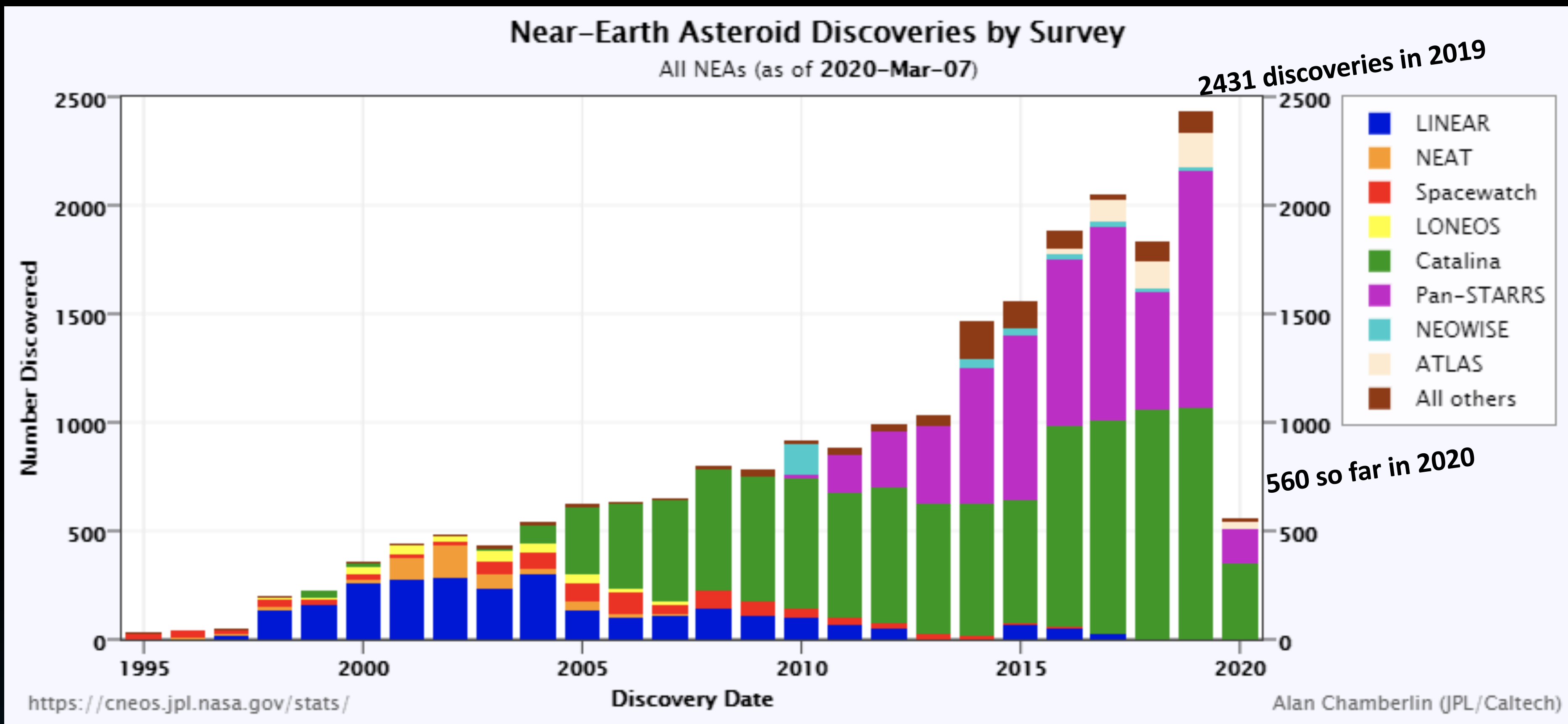
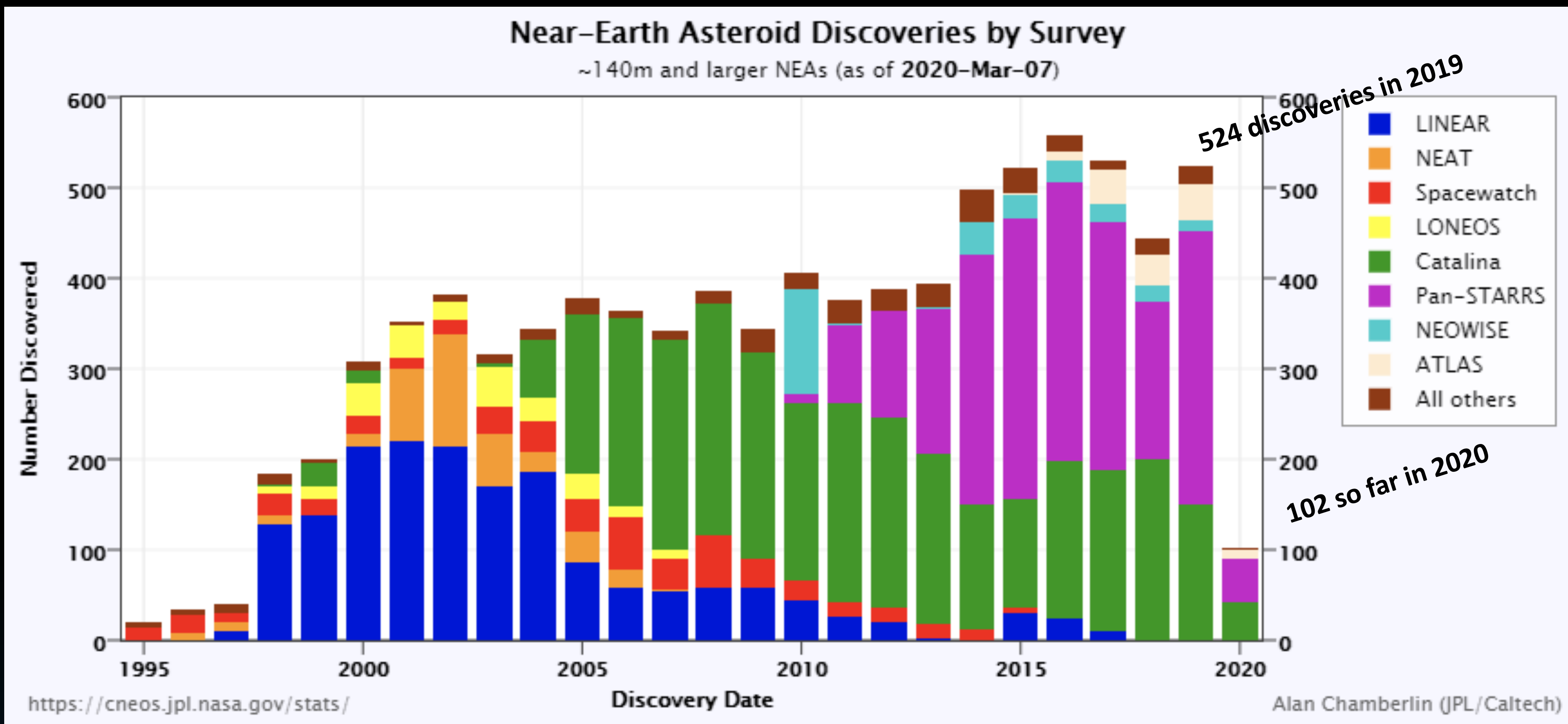
All Near-Earth Asteroids (NEAs)



NEAs 140 Meters and Larger



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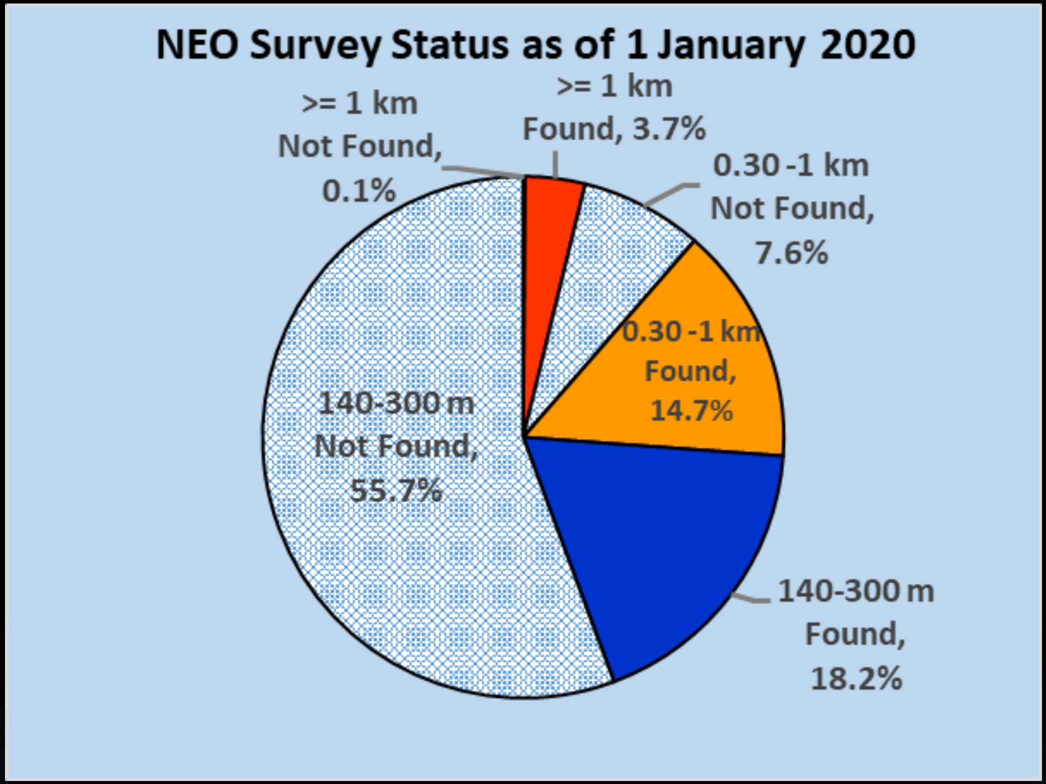
Progress: 140 Meters and Larger

Total Population estimated to be ~25,000



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

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77 Detected Close Approaches <1 Lunar Distance in 2019

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

<table>
<tr><th>Object</th><th>Close-Approach (CA) Date</th><th>CA Distance Nominal (LD | au)</th><th>Estimated Diameter</th></tr>
<tr><td>(2019 AS5)</td><td>2019-Jan-08 00:37 ± < 00:01</td><td>0.04 | 0.00010</td><td>0.92 m - 2.1 m</td></tr>
<tr><td>(2019 AE9)</td><td>2019-Jan-12 11:09 ± < 00:01</td><td>0.26 | 0.00067</td><td>9.9 m - 22 m</td></tr>
<tr><td>(2019 BO)</td><td>2019-Jan-16 01:13 ± < 00:01</td><td>0.18 | 0.00046</td><td>6.3 m - 14 m</td></tr>
<tr><td>(2019 BV1)</td><td>2019-Jan-24 20:53 ± < 00:01</td><td>0.35 | 0.00090</td><td>4.9 m - 11 m</td></tr>
<tr><td>(2019 BZ3)</td><td>2019-Jan-27 23:29 ± < 00:01</td><td>0.13 | 0.00032</td><td>4.8 m - 11 m</td></tr>
<tr><td>(2019 CN5)</td><td>2019-Feb-11 07:23 ± 00:03</td><td>0.31 | 0.00079</td><td>7.3 m - 16 m</td></tr>
<tr><td>(2019 DG2)</td><td>2019-Feb-26 07:39 ± 00:24</td><td>0.61 | 0.00158</td><td>5.4 m - 12 m</td></tr>
<tr><td>(2019 DF)</td><td>2019-Feb-26 21:11 ± 00:09</td><td>0.45 | 0.00116</td><td>2.9 m - 6.5 m</td></tr>
<tr><td>(2019 EH1)</td><td>2019-Mar-01 17:38 ± < 00:01</td><td>0.06 | 0.00016</td><td>2.5 m - 5.7 m</td></tr>
<tr><td>(2019 EN2)</td><td>2019-Mar-13 23:38 ± < 00:01</td><td>0.86 | 0.00221</td><td>8.0 m - 18 m</td></tr>
<tr><td>(2019 FA)</td><td>2019-Mar-16 01:14 ± < 00:01</td><td>0.60 | 0.00154</td><td>4.8 m - 11 m</td></tr>
<tr><td>(2019 EA2)</td><td>2019-Mar-22 01:53 ± < 00:01</td><td>0.80 | 0.00205</td><td>18 m - 41 m</td></tr>
<tr><td>(2019 FQ)</td><td>2019-Mar-23 18:17 ± < 00:01</td><td>0.86 | 0.00220</td><td>10 m - 23 m</td></tr>
<tr><td>(2019 FC1)</td><td>2019-Mar-28 05:46 ± < 00:01</td><td>0.27 | 0.00069</td><td>20 m - 45 m</td></tr>
<tr><td>(2019 FV1)</td><td>2019-Mar-31 05:27 ± < 00:01</td><td>0.87 | 0.00223</td><td>4.6 m - 10 m</td></tr>
<tr><td>(2019 GP21)</td><td>2019-Mar-31 19:00 ± 07:46</td><td>0.93 | 0.00238</td><td>3.0 m - 6.6 m</td></tr>
<tr><td>(2019 GN20)</td><td>2019-Apr-12 07:06 ± 00:01</td><td>0.98 | 0.00253</td><td>14 m - 31 m</td></tr>
<tr><td>(2019 GC6)</td><td>2019-Apr-18 06:41 ± < 00:01</td><td>0.57 | 0.00146</td><td>13 m - 30 m</td></tr>
<tr><td>(2019 HE)</td><td>2019-Apr-20 21:12 ± < 00:01</td><td>0.58 | 0.00150</td><td>12 m - 28 m</td></tr>
<tr><td>(2019 JK)</td><td>2019-Apr-30 08:12 ± < 00:01</td><td>0.69 | 0.00178</td><td>6.7 m - 15 m</td></tr>
<tr><td>(2019 JX1)</td><td>2019-May-02 12:39 ± < 00:01</td><td>0.47 | 0.00120</td><td>4.0 m - 8.9 m</td></tr>
<tr><td>(2019 JY2)</td><td>2019-May-05 17:12 ± < 00:01</td><td>0.38 | 0.00098</td><td>3.2 m - 7.2 m</td></tr>
<tr><td>(2019 JH7)</td><td>2019-May-16 00:06 ± < 00:01</td><td>0.19 | 0.00048</td><td>3.1 m - 7.0 m</td></tr>
<tr><td>(2019 KT)</td><td>2019-May-28 03:48 ± < 00:01</td><td>0.85 | 0.00217</td><td>13 m - 29 m</td></tr>
<tr><td>(2019 LY4)</td><td>2019-Jun-06 01:30 ± < 00:01</td><td>0.22 | 0.00056</td><td>7.3 m - 16 m</td></tr>
<tr><td>(2019 LW4)</td><td>2019-Jun-08 17:04 ± < 00:01</td><td>0.65 | 0.00166</td><td>9.3 m - 21 m</td></tr>
<tr><td>(2019 NK1)</td><td>2019-Jul-02 09:49 ± < 00:01</td><td>0.69 | 0.00177</td><td>2.6 m - 5.7 m</td></tr>
<tr><td>(2019 MB4)</td><td>2019-Jul-09 07:20 ± < 00:01</td><td>0.82 | 0.00211</td><td>16 m - 35 m</td></tr>
<tr><td>(2019 NF7)</td><td>2019-Jul-09 12:07 ± < 00:01</td><td>0.98 | 0.00253</td><td>6.4 m - 14 m</td></tr>
<tr><td>(2019 NN3)</td><td>2019-Jul-10 16:29 ± < 00:01</td><td>0.83 | 0.00214</td><td>29 m - 66 m</td></tr>
<tr><td>(2019 OD)</td><td>2019-Jul-24 13:31 ± < 00:01</td><td>0.93 | 0.00239</td><td>54 m - 120 m</td></tr>
<tr><td>(2019 OK)</td><td>2019-Jul-25 01:22 ± < 00:01</td><td>0.19 | 0.00048</td><td>59 m - 130 m</td></tr>
<tr><td>(2019 OD3)</td><td>2019-Jul-28 02:56 ± < 00:01</td><td>0.49 | 0.00126</td><td>11 m - 25 m</td></tr>
<tr><td>(2019 ON3)</td><td>2019-Jul-29 01:19 ± 00:14</td><td>0.56 | 0.00143</td><td>7.4 m - 16 m</td></tr>
<tr><td>(2019 QB1)</td><td>2019-Aug-20 11:54 ± 00:01</td><td>0.32 | 0.00083</td><td>8.7 m - 20 m</td></tr>
<tr><td>(2019 QH2)</td><td>2019-Aug-20 18:12 ± 00:08</td><td>0.13 | 0.00033</td><td>2.2 m - 5.0 m</td></tr>
<tr><td>(2019 QD)</td><td>2019-Aug-22 01:28 ± < 00:01</td><td>0.78 | 0.00200</td><td>4.7 m - 11 m</td></tr>
</table>

<table>
<tr><th>Object</th><th>Close-Approach (CA) Date</th><th>CA Distance Nominal (LD | au)</th><th>Estimated Diameter</th></tr>
<tr><td>(2019 QR8)</td><td>2019-Aug-26 08:51 ± 01:08</td><td>0.80 | 0.00207</td><td>6.6 m - 15 m</td></tr>
<tr><td>(2019 QQ3)</td><td>2019-Aug-26 15:14 ± 00:01</td><td>0.25 | 0.00064</td><td>3.7 m - 8.2 m</td></tr>
<tr><td>(2019 RQ)</td><td>2019-Sep-02 16:45 ± < 00:01</td><td>0.29 | 0.00074</td><td>2.1 m - 4.6 m</td></tr>
<tr><td>(2019 RP1)</td><td>2019-Sep-05 22:04 ± < 00:01</td><td>0.10 | 0.00025</td><td>7.3 m - 16 m</td></tr>
<tr><td>(2019 RC1)</td><td>2019-Sep-07 10:48 ± < 00:01</td><td>0.48 | 0.00123</td><td>4.6 m - 10 m</td></tr>
<tr><td>(2019 SJ)</td><td>2019-Sep-16 18:56 ± < 00:01</td><td>0.64 | 0.00163</td><td>8.3 m - 19 m</td></tr>
<tr><td>(2019 SU2)</td><td>2019-Sep-21 02:48 ± 00:01</td><td>0.19 | 0.00048</td><td>2.6 m - 5.8 m</td></tr>
<tr><td>(2019 SD1)</td><td>2019-Sep-21 06:46 ± < 00:01</td><td>0.73 | 0.00187</td><td>5.5 m - 12 m</td></tr>
<tr><td>(2019 SS2)</td><td>2019-Sep-21 07:12 ± 00:02</td><td>0.30 | 0.00077</td><td>2.0 m - 4.4 m</td></tr>
<tr><td>(2019 SS3)</td><td>2019-Sep-22 22:48 ± 00:21</td><td>0.73 | 0.00188</td><td>15 m - 34 m</td></tr>
<tr><td>(2019 SX8)</td><td>2019-Sep-28 07:50 ± < 00:01</td><td>0.99 | 0.00255</td><td>4.3 m - 9.7 m</td></tr>
<tr><td>(2019 TE)</td><td>2019-Sep-28 20:31 ± 01:31</td><td>0.93 | 0.00238</td><td>6.8 m - 15 m</td></tr>
<tr><td>(2019 TD)</td><td>2019-Sep-29 18:49 ± 00:01</td><td>0.34 | 0.00087</td><td>3.9 m - 8.7 m</td></tr>
<tr><td>(2019 SM8)</td><td>2019-Oct-01 13:56 ± < 00:01</td><td>0.41 | 0.00106</td><td>3.8 m - 8.6 m</td></tr>
<tr><td>(2019 SP3)</td><td>2019-Oct-03 06:33 ± < 00:01</td><td>0.97 | 0.00249</td><td>14 m - 31 m</td></tr>
<tr><td>(2019 TN5)</td><td>2019-Oct-05 22:38 ± < 00:01</td><td>0.32 | 0.00083</td><td>5.5 m - 12 m</td></tr>
<tr><td>(2019 UU1)</td><td>2019-Oct-18 06:23 ± < 00:01</td><td>0.59 | 0.00151</td><td>2.2 m - 5.0 m</td></tr>
<tr><td>(2019 UG)</td><td>2019-Oct-18 09:23 ± < 00:01</td><td>0.84 | 0.00215</td><td>6.3 m - 14 m</td></tr>
<tr><td>(2019 UL3)</td><td>2019-Oct-19 22:22 ± < 00:01</td><td>0.77 | 0.00199</td><td>5.9 m - 13 m</td></tr>
<tr><td>(2019 UN8)</td><td>2019-Oct-23 16:41 ± 00:17</td><td>0.93 | 0.00240</td><td>3.1 m - 6.9 m</td></tr>
<tr><td>(2019 UO8)</td><td>2019-Oct-25 13:30 ± < 00:01</td><td>0.41 | 0.00105</td><td>3.7 m - 8.3 m</td></tr>
<tr><td>(2019 UX12)</td><td>2019-Oct-26 03:07 ± 00:01</td><td>0.99 | 0.00255</td><td>4.8 m - 11 m</td></tr>
<tr><td>(2019 UD10)</td><td>2019-Oct-27 10:08 ± 00:02</td><td>0.44 | 0.00112</td><td>6.3 m - 14 m</td></tr>
<tr><td>(2019 UB8)</td><td>2019-Oct-29 06:30 ± < 00:01</td><td>0.50 | 0.00127</td><td>4.3 m - 9.7 m</td></tr>
<tr><td>(2019 UN13)</td><td>2019-Oct-31 14:45 ± < 00:01</td><td>0.03 | 8.43e-5</td><td>1.0 m - 2.2 m</td></tr>
<tr><td>(2019 UG11)</td><td>2019-Nov-01 20:42 ± < 00:01</td><td>0.55 | 0.00140</td><td>12 m - 28 m</td></tr>
<tr><td>(2019 VA)</td><td>2019-Nov-02 17:28 ± < 00:01</td><td>0.28 | 0.00071</td><td>5.8 m - 13 m</td></tr>
<tr><td>(2019 VD)</td><td>2019-Nov-04 09:56 ± < 00:01</td><td>0.45 | 0.00117</td><td>8.7 m - 20 m</td></tr>
<tr><td>(2019 VR)</td><td>2019-Nov-04 10:30 ± < 00:01</td><td>0.35 | 0.00091</td><td>6.4 m - 14 m</td></tr>
<tr><td>(2019 VS4)</td><td>2019-Nov-06 16:28 ± < 00:01</td><td>0.36 | 0.00093</td><td>9.2 m - 21 m</td></tr>
<tr><td>(2019 VB5)</td><td>2019-Nov-09 17:29 ± < 00:01</td><td>0.38 | 0.00097</td><td>1.2 m - 2.7 m</td></tr>
<tr><td>(2019 VF5)</td><td>2019-Nov-09 23:16 ± < 00:01</td><td>0.49 | 0.00127</td><td>8.1 m - 18 m</td></tr>
<tr><td>(2019 WH)</td><td>2019-Nov-19 08:01 ± < 00:01</td><td>0.22 | 0.00057</td><td>15 m - 35 m</td></tr>
<tr><td>(2019 WV1)</td><td>2019-Nov-19 23:51 ± 00:09</td><td>0.72 | 0.00185</td><td>6.2 m - 14 m</td></tr>
<tr><td>(2019 WG2)</td><td>2019-Nov-23 08:44 ± < 00:01</td><td>0.47 | 0.00121</td><td>27 m - 60 m</td></tr>
<tr><td>(2019 WJ4)</td><td>2019-Nov-30 20:05 ± < 00:01</td><td>0.85 | 0.00219</td><td>5.5 m - 12 m</td></tr>
<tr><td>(2019 YB)</td><td>2019-Dec-18 00:12 ± 00:03</td><td>0.44 | 0.00113</td><td>3.1 m - 7.0 m</td></tr>
<tr><td>(2019 YS)</td><td>2019-Dec-18 15:12 ± < 00:01</td><td>0.17 | 0.00044</td><td>1.3 m - 3.0 m</td></tr>
<tr><td>(2019 YU2)</td><td>2019-Dec-23 19:28 ± < 00:01</td><td>0.26 | 0.00066</td><td>8.9 m - 20 m</td></tr>
<tr><td>(2019 YV4)</td><td>2019-Dec-25 21:41 ± 11:01</td><td>0.98 | 0.00251</td><td>9.3 m - 21 m</td></tr>
</table>

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Signatories to the International Asteroid Warning Network (IAWN)

iawn.net

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NASA

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)

Instituto de Astrofisica de Canarias (Spain)

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)

Israel Space Agency

Peter Birtwhistle (UK)
David Balam (Canada)
Patrick Wiggins (USA)
Gennady Borisov (MARGO Observatory)
Jordi Camarasa (Observatori Paus B49)

Special Astrophysical Observatory (Russian Academy of Sciences)

Kourovka Astronomical Observatory (UrFU)

Fondazione GAL Hassin (Italy)

Currently 25 signatories

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NASA

Dr Kelly Fast presents International Asteroid Warning Network (IAWN) annual status report to United Nations Committee On Peaceful Uses of Outer Space (COPUOS) Scientific and Technical Subcommittee meeting 7 February 2020

Changes in ROSES 2020

- Solar System Observations (SSO) will contain only the scope of what was previously the Planetary Astronomy component (observations of Solar System bodies and resulting science). There no longer will be a Near-Earth Object Observations (NEOO) component.
- NEO observations and planetary defense now will be solicited through the ROSES element Yearly Opportunities for Research in Planetary Defense (YORPD)
  - NEO survey operations (search, rapid-response follow-up and characterization)
  - NEO science (observations, data analysis, laboratory investigations, modeling)
  - Impactor threat mitigation studies (understanding NEO properties for deflection/disruption)
- As always, read the ROSES program element appendices and Appendix C.1 Planetary Science Research Program Overview

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