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
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]

PLANETARY DEFENSE

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

IMPACT: September 30, 2022

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
700 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 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
Near-Earth Object Observations Program

Kelly Fast
Near-Earth Object Observations Program Manager

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*
All Near-Earth Asteroids (NEAs)

Near-Earth Asteroid Discoveries by Survey
All NEAs (as of 2020-Mar-07)

2431 discoveries in 2019
560 so far in 2020

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

Alan Chamberlin (JPL/Caltech)
NEAs 140 Meters and Larger

Near-Earth Asteroid Discoveries by Survey
~140m and larger NEAs (as of 2020-Mar-07)

Number Discovered

Discovery Date


524 discoveries in 2019
102 so far in 2020

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

Alan Chamberlin (JPL/Caltech)
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.

nasa.gov/planetarydefense
# 77 Detected Close Approaches <1 Lunar Distance in 2019

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

<table>
<thead>
<tr>
<th>Object</th>
<th>Close-Approach (CA) Date</th>
<th>CA Distance Nominal (LD</th>
<th>au)</th>
<th>Estimated Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2019 AS5)</td>
<td>2019-Jan-06 00:37 ± 00:01</td>
<td>0.04</td>
<td>0.00010</td>
<td>0.93 m - 2.1 m</td>
</tr>
<tr>
<td>(2019 AF9)</td>
<td>2019-Jan-12 11:09 ± 00:01</td>
<td>0.18</td>
<td>0.00067</td>
<td>9.9 m - 22 m</td>
</tr>
<tr>
<td>(2019 BG)</td>
<td>2019-Jan-16 01:13 ± 00:01</td>
<td>0.33</td>
<td>0.00150</td>
<td>6.4 m - 14 m</td>
</tr>
<tr>
<td>(2019 BV1)</td>
<td>2019-Jan-24 20:51 ± 00:01</td>
<td>0.46</td>
<td>0.00090</td>
<td>4.9 m - 11 m</td>
</tr>
<tr>
<td>(2019 BV2)</td>
<td>2019-Jan-27 23:29 ± 00:01</td>
<td>0.51</td>
<td>0.00132</td>
<td>4.8 m - 11 m</td>
</tr>
<tr>
<td>(2019 CN5)</td>
<td>2019-Feb-11 07:23 ± 00:03</td>
<td>0.61</td>
<td>0.00158</td>
<td>7.3 m - 16 m</td>
</tr>
<tr>
<td>(2019 CE2)</td>
<td>2019-Feb-26 07:38 ± 00:24</td>
<td>0.65</td>
<td>0.00166</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</td>
<td>0.000116</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</td>
<td>0.00016</td>
<td>2.5 m - 5.7 m</td>
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<tr>
<td>(2019 EN2)</td>
<td>2019-Mar-13 23:38 ± 00:01</td>
<td>0.86</td>
<td>0.00221</td>
<td>8.0 m - 18 m</td>
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<tr>
<td>(2019 FA)</td>
<td>2019-Mar-16 01:14 ± 00:01</td>
<td>0.60</td>
<td>0.00154</td>
<td>4.8 m - 11 m</td>
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<tr>
<td>(2019 F2)</td>
<td>2019-Mar-23 01:03 ± 00:01</td>
<td>0.80</td>
<td>0.00200</td>
<td>5.6 m - 13 m</td>
</tr>
<tr>
<td>(2019 FQ)</td>
<td>2019-Mar-23 18:17 ± 00:01</td>
<td>0.86</td>
<td>0.00220</td>
<td>10 m - 23 m</td>
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<tr>
<td>(2019 FC1)</td>
<td>2019-Mar-28 05:46 ± 00:01</td>
<td>0.27</td>
<td>0.00069</td>
<td>20 m - 45 m</td>
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<tr>
<td>(2019 FY1)</td>
<td>2019-Mar-31 25:27 ± 00:01</td>
<td>0.87</td>
<td>0.00223</td>
<td>4.6 m - 10 m</td>
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<tr>
<td>(2019 GP21)</td>
<td>2019-Apr-12 07:05 ± 00:01</td>
<td>0.93</td>
<td>0.00233</td>
<td>3.0 m - 6.6 m</td>
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<tr>
<td>(2019 QG2)</td>
<td>2019-Apr-12 07:05 ± 00:01</td>
<td>0.98</td>
<td>0.00332</td>
<td>14 m - 33 m</td>
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<tr>
<td>(2019 G6)</td>
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<td>0.57</td>
<td>0.00146</td>
<td>13 m - 30 m</td>
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<tr>
<td>(2019 HE)</td>
<td>2019-Apr-20 21:12 ± 00:01</td>
<td>0.58</td>
<td>0.00150</td>
<td>12 m - 28 m</td>
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<tr>
<td>(2019 JK)</td>
<td>2019-Apr-30 08:12 ± 00:01</td>
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<td>0.00178</td>
<td>6.7 m - 15 m</td>
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<td>(2019 X1)</td>
<td>2019-May-02 12:39 ± 00:01</td>
<td>0.47</td>
<td>0.00120</td>
<td>4.0 m - 8.9 m</td>
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<tr>
<td>(2019 JV)</td>
<td>2019-May-05 17:12 ± 00:01</td>
<td>0.58</td>
<td>0.00159</td>
<td>3.2 m - 7.2 m</td>
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<tr>
<td>(2019 HT)</td>
<td>2019-May-07 16:00 ± 00:01</td>
<td>0.19</td>
<td>0.00048</td>
<td>6.1 m - 13 m</td>
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<tr>
<td>(2019 K7)</td>
<td>2019-May-28 03:48 ± 00:01</td>
<td>0.85</td>
<td>0.00217</td>
<td>13 m - 29 m</td>
</tr>
<tr>
<td>(2019 V4)</td>
<td>2019-Jun-06 01:30 ± 00:01</td>
<td>0.22</td>
<td>0.00056</td>
<td>7.3 m - 16 m</td>
</tr>
<tr>
<td>(2019 W4)</td>
<td>2019-Jun-09 17:04 ± 00:01</td>
<td>0.65</td>
<td>0.00166</td>
<td>9.3 m - 21 m</td>
</tr>
<tr>
<td>(2019 M1)</td>
<td>2019-Jul-02 06:45 ± 00:01</td>
<td>0.69</td>
<td>0.00171</td>
<td>2.6 m - 5.7 m</td>
</tr>
<tr>
<td>(2019 MM5)</td>
<td>2019-Jul-09 07:02 ± 00:01</td>
<td>0.81</td>
<td>0.00215</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</td>
<td>0.00253</td>
<td>6.4 m - 14 m</td>
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<tr>
<td>(2019 N93)</td>
<td>2019-Jul-10 16:29 ± 00:01</td>
<td>0.83</td>
<td>0.00214</td>
<td>29 m - 66 m</td>
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<tr>
<td>(2019 OS)</td>
<td>2019-Jul-14 11:31 ± 00:01</td>
<td>0.33</td>
<td>0.000295</td>
<td>54 m - 120 m</td>
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<tr>
<td>(2019 ON)</td>
<td>2019-Jul-25 01:22 ± 00:01</td>
<td>0.19</td>
<td>0.00048</td>
<td>59 m - 130 m</td>
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<tr>
<td>(2019 OD3)</td>
<td>2019-Jul-28 05:52 ± 00:01</td>
<td>0.49</td>
<td>0.00212</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</td>
<td>0.00143</td>
<td>7.4 m - 16 m</td>
</tr>
<tr>
<td>(2019 Q81)</td>
<td>2019-Aug-20 11:54 ± 00:01</td>
<td>0.32</td>
<td>0.00083</td>
<td>8.7 m - 20 m</td>
</tr>
<tr>
<td>(2019 QQ2)</td>
<td>2019-Aug-20 18:12 ± 00:08</td>
<td>0.13</td>
<td>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</td>
<td>0.00200</td>
<td>4.7 m - 11 m</td>
</tr>
</tbody>
</table>
## Signatories to the International Asteroid Warning Network (IAWN)

iawn.net

<table>
<thead>
<tr>
<th>Country/Institution</th>
<th>Signatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Institute of Astrophysics, Optics &amp; Electronics (México)</td>
<td><strong>Peter Birtwhistle</strong> (UK) <strong>David Balam</strong> (Canada) <strong>Patrick Wiggins</strong> (USA) <strong>Gennady Borisov</strong> (MARGO Observatory) <strong>Jordi Camarasa</strong> (Observatori Paus B49)</td>
</tr>
<tr>
<td>European Southern Observatory</td>
<td><strong>University of Nariño Colombia</strong></td>
</tr>
<tr>
<td>China National Space Administration</td>
<td><strong>Inst. of Solar-Terrestrial Physics (Siberian Branch, Russian Academy of Sciences)</strong></td>
</tr>
<tr>
<td>Northolt Branch Observatories (UK)</td>
<td><strong>Special Astrophysical Observatory (Russian Academy of Sciences)</strong></td>
</tr>
<tr>
<td>Zwicky Transient Facility (US)</td>
<td><strong>Kourovka Astronomical Observatory (UrFU)</strong></td>
</tr>
<tr>
<td>Višnjan Observatory (Croatia)</td>
<td><strong>Special Astrophysical Observatory (Russian Academy of Sciences)</strong></td>
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<tr>
<td>Instituto de Astrofísica de Canarias (Spain)</td>
<td><strong>Zwicky Transient Facility (US)</strong></td>
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<td>Sormano Astronomical Observatory (Italy)</td>
<td><strong>European Space Agency</strong></td>
</tr>
<tr>
<td>SONEAR Observatory (Brazil)</td>
<td><strong>European Space Agency</strong></td>
</tr>
<tr>
<td>Fondazione GAL Hassin (Italy)</td>
<td><strong>European Space Agency</strong></td>
</tr>
</tbody>
</table>

Currently 25 signatories

nasa.gov/planetarydefense
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