

**IAU Near-Earth Object Working Group
Inter-Division A-F, Functional
Annual Report 2021-2022**

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The NEO Working Group is a functional inter-Division A-F WG. It continues its task of monitoring and participating to the international activities focused on planetary defense, of representing the IAU in international groups, such as the UN-endorsed International Asteroid Warning Network (IAWN; see: <https://iawn.net>). It also highly contributes to public outreach efforts, noting that the NEO and planetary defense topics are of high interest for the public.

In 2021, the Planetary Defense Conference took place virtually on April 26-30, hosted by the United Nations Office of Outer Space Affairs (UNOOSA). Over 900 individuals registered, and total attendance included over 700 individuals, with 250 to 300 individuals participating at any given time. As described in the report of the conference (<https://iaaspace.org/wp-content/uploads/iaa/Scientific%20Activity/conf/pdc2021/pdc2021report.pdf>), a primary outcome of the conference was unanimous attendee support for an International Year of Planetary Defense (formal name to be defined) similar to the 2009 International Year of Astronomy. The 2029 close passage of Apophis is a natural opportunity to hold the event, raise awareness about the hazard, demystify the topic, and connect current and future communities. A group has been set up to make a proposal to the UN. Also, a highlight of the conference was the Asteroid Threat Exercise. As in several previous conferences, the purpose of the asteroid threat exercise for the 2021 conference was to acquaint conference participants and decision-makers with an asteroid threat representative of the type of threat that might be possible given limitations of current discovery capabilities. The conference was then organized around several sessions covering all the topics that are relevant to planetary defense, such as the DART and Hera missions that will perform the first asteroid deflection test, results from the Hayabusa2 and OSIRIS-REx missions, NEO discoveries and characterization, deflection and disruption testing, mission and campaign design, impact effects, disaster management, the decision to act, public education and communication, Apophis and others, far and near: future characterization opportunities from NEO close approach.

Highlight lectures were also given at the International Astronautical Congress (IAC) in Dubai, in October 2021, concerning the results of OSIRIS-REx and Hayabusa2. The IAF World Space Award was given to the Hayabusa2 Team during the Congress. A planetary defense special session also took place titled: The Grand Planetary Defense DART/HERA missions Interactive Q&A.

The IAWN and Space Mission Planning Advisory Groups met three times, in March and October 2021, as well as in February 2022. They cover a wide range of activities, related to observations of NEOs, space missions and also legal aspects. Reports of IAWN meetings can be found here: <https://iawn.net/meetings.shtml>, while reports of SMPAG meetings can be found here: <https://www.cosmos.esa.int/web/smpag>.

2021 once again saw an increase in the discovery rate of NEOs, with a record 3090 new objects being found and having good enough orbits for provisional designations to be assigned. Although most were discovered by the big 3 surveys (PanSTARRS, Catalina and ATLAS), over 200 were found by smaller discovery efforts.

The science of NEOs also made amazing advances thanks to the different publications concerning to the asteroids Bennu and Ryugu, from OSIRIS-REx and Hayabusa2 data, respectively. Both asteroids are of carbonaceous type, and one of the great discovery is that they behave almost like cohesionless bodies, as demonstrated by the Hayabusa2 impact experiment that produced a gravity-controlled crater and the sampling mechanism (TAGSAM) of OSIRIS-REx that felt almost no resistance of the soil when touching it. This information is crucial in the framework of deflection missions. Furthermore, a preliminary investigation of samples of Ryugu brought back by Hayabusa2 showed that the density of the samples (about 1.3 g/cc on average) is much lower than the density of meteorites of the same group. Compared to the bulk density of Ryugu (1.19 g/cc), if the density of samples is representative of the density of Ryugu's material, this tells us that most of the porosity of Ryugu is microporosity and not macroporosity, which has different implications on how to deflect such a body.

One amazing highlight of 2021 is the launch of the NASA DART mission at 1:21 a.m. EST on November 24, from the Vandenberg Air Force base (California) onboard a SpaceX Falcon 9 rocket. This marvelous launch will be followed by the impact of DART on Dimorphos, the small moon of the binary asteroid Didymos, on September 26, 2022, at 6:15 pm EST. Before doing so, DART will deploy the Italian LICIACube, which will observe the impact and the 130 seconds following it, giving us previous data on the impact and its early ejecta. On October 2024, the ESA Hera spacecraft with its two Cubesats Juventas and Milani will launch to get to Didymos at the end of 2026, providing us detailed measurements of DART impact outcome and full characterization of the asteroids, including for the first time subsurface and internal properties. The Asteroid Impact & Deflection Assessment (AIDA) international collaboration, which supports the development and data interpretation of DART and Hera, will then provide a fully documented impact experiment and deflection test at actual asteroid scale, including the impact conditions provided by DART and LICIACube, the ejecta properties provided by LICIACube, the change in the orbital period of Dimorphos provided by ground based observation, and the full characterization of the DART impact outcome and target properties by Hera and its two Cubesats.

The NEO Surveyor mission is also in development at NASA for a possible launch in 2026. It will allow making the inventory of NEOs larger than 140 meters (including direct measurement of their diameter) in about 10 years for space and therefore assessing the threat of such objects on a short-middle timescale. Other funded NEO missions include the

extension of Hayabusa 2 to a flyby of 2001 CC21 in 2026 and a rendezvous with the 60-meter-sized NEO 1998 KY26 with a 10 mn spin rate in 2031, and the Destiny+ mission to the active NEO 3200 Phaethon. At an early stage of development, the NEOMIR concept is being studied at ESA. This mission survey mission would overlap with NEO Surveyor but be targeted at smaller solar elongations.

In Europe, the European Union and its Horizon 2020 program is funding two projects in the time frame 2020-2023: NEO-MAPP (Near Earth Object Modelling and Payload for Protection) that supports activities related to the Hera mission and future NEO missions (see: <https://neomapp.eu>) and NEOROCKS that performed studies oriented on ground based observations and characterizations of NEOs and impact predictions (see: <https://www.neorocks.eu>).

In 2022, several workshops and meetings are taking place that are relevant to NEO and planetary defense activities:

- The Apophis T-7 workshop is taking place on May 11-13, 2022 virtually and will present the activities related to this asteroid, as well as possible space mission projects (see: <https://www.hou.usra.edu/meetings/apophis2022/>).

- The Hera international workshop is taking place on May 30-June 3, 2022, in Nice (France) and will give an overview of the various activities and their advances regarding this mission (see: <https://www.heramission.space/heraworkshop2022>).

- The IAU Symposium S374 Astronomical Hazards for Life on Earth will be held at the XXXI IAU General Assembly in Busan, Republic of Korea, in the week of August 8-11, 2022 (see: <http://hazards.astronomia.edu.uy>)

- The IAU Focus Meeting 8 Planetary Astronomy via Telescopic and Microscopic Approaches will also be held at the XXXI IAU General Assembly in Busan, Republic of Korea, on August 2-11, 2022 (see: <https://iau2021fm8.kasi.re.kr>).

- A Planetary Defense session is organized at the European Planetary Science Congress (EPSC) 2022 on September 18-23, in Grenada (see: <https://meetingorganizer.copernicus.org/EPSC2022/session/44648>).

- A Plenary Session on Planetary Defense has been proposed for the IAC 2022 in Paris on September 18-23 (see: <https://iac2022.org>).

NEOs and Planetary Defense are active areas of research, and we are looking forward to the DART impact that will take place in this year.

Patrick Michel

On behalf of the NEO WG.

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