

# Near-Earth Objects and Planetary Defence



UNITED NATIONS



ST/SPACE/73

Cover image: Meteor over Dolomites. © Ollie Taylor. Used by permission.

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This publication has not been formally edited.

Publishing production: English, Publishing and Library Section, United Nations Office at Vienna.

# Near-Earth Objects and Planetary Defence

## Foreword

Forging global partnerships and building resilient societies through better coordination are among the key challenges of the twenty-first century. Given the global consequences of a near-Earth object (NEO) impact and the considerable resources required to prevent a collision, the United Nations and its Office for Outer Space Affairs (UNOOSA) have been involved in the international discourse and dialogue on the topic of NEOs, raising awareness and promoting global cooperation.

Addressing such a hazard, including the identification of objects that pose a risk of impact, and planning a corresponding mitigation campaign, require cooperative action in the interest of public safety on the part of the global community.

Acting as a gateway to space in the United Nations system, UNOOSA is uniquely positioned in intergovernmental cooperation and coordination on outer space activities, and in the broader perspective of space security, including the area of planetary defence. The Office supports and cooperates with two entities established in 2014: the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG). These two entities came into being through a series of recommendations for an international response to the risk of near-Earth object impact, endorsed by

the United Nations Committee on the Peaceful Uses of Outer Space. The aim of these recommendations is to address the global challenge posed by NEOs, beginning with their detection and tracking and, subsequently, deflection and planetary defence.

The goal is to ensure that all countries, in particular developing nations with limited capacity for predicting and mitigating a NEO impact, are aware of potential risks as well as to ensure effective emergency response and disaster management in the event of a NEO impact. As this area is crucial to ensuring human security, the United Nations continues to facilitate the processes for developing an international response to a NEO-impact threat, with the Office for Outer Space Affairs playing an active role.

As Director of UNOOSA and a passionate astrophysicist myself (my personal contribution was having asteroid 21887 named “dipippo” by the International Astronomical Union), I remain supportive of these efforts towards global cooperation on NEOs.

**Simonetta Di Pippo**

Director

United Nations Office for Outer Space Affairs

Impacts from asteroids and comets have contributed to mass extinctions and the evolution of life on Earth.

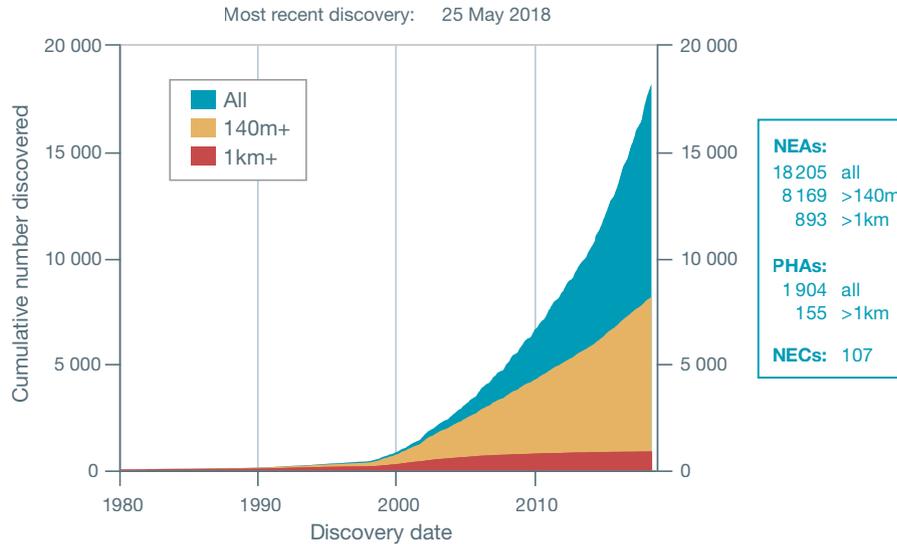
Impacts can potentially lead to significant damage to life and property on our planet. The impacts of Comet Shoemaker-Levy 9 on Jupiter in 1994 led to coordinated efforts to discover, track and catalogue NEOs, especially those that may pose a hazard to the Earth.





The Chelyabinsk super bolide on 15 February 2013 serves as an explicit reminder that even relatively small asteroids (~20 metres across) can penetrate the atmosphere.

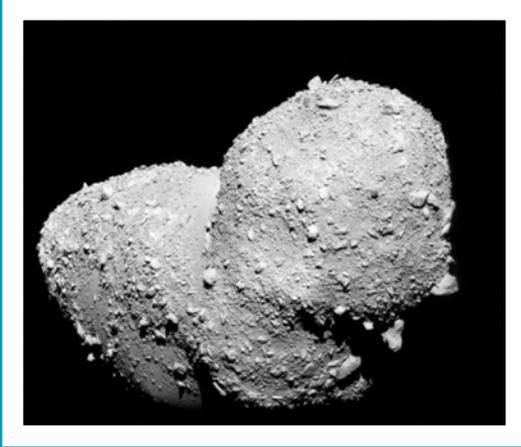
## NEAR-EARTH ASTEROIDS DISCOVERED



To date, over 18,000 NEOs have been discovered. In order to increase our awareness of these potential hazards, it is essential to find them first, and then assess the risk they may pose to our planet.

Credit: Alan Chamberlin, Center for NEO Studies, JPL/NASA

Asteroids and comets are pieces of planetary debris that never formed into a planet, and yet retain clues as to the early history of the solar system. While most asteroids are either rocky or metallic (or a mixture of the two) and maintain orbits in the main asteroid belt between Mars and Jupiter, comets are generally icy bodies that have very eccentric orbits and a wide range of orbital periods.



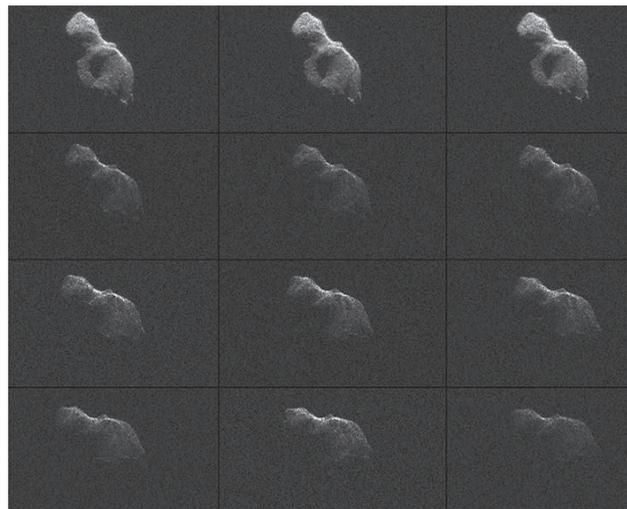
Itokawa (left) was the first asteroid to be the target of a sample return mission (the Japanese space probe *Hayabusa*) and the smallest asteroid photographed and visited by a spacecraft.

*Ceres* and *Vesta* (right) were among the first asteroids discovered over 200 years ago, orbiting the Sun between Mars and Jupiter. The image on the right shows a relative-size comparison between these large asteroids and *Eros*, the first ever near-Earth asteroid, discovered in 1898.

Credit: JAXA (left); NASA (right)

Another dynamic class of asteroids include those categorized as NEOs. In 1898, the discovery of asteroid 433 Eros established the existence of a population of asteroid-like bodies on orbits that cross those of the inner planets. NEOs include both asteroids and comets whose orbits approach the Earth's orbit around the Sun. They range in size from a few metres to as much as 34 km across, with smaller objects being far more numerous than larger objects. Cometary bodies comprise less than one per cent of the NEO population.

The bulk of the NEO population originates from the inner part of the main asteroid belt. The gravitational influence of Saturn, Jupiter and Mars, coupled with some collisional activity within this source population, serves as the main reservoir for these primitive bodies that dynamically evolve into NEOs.



Working together, the Goldstone (left) and Arecibo (top left) dishes produced this spectacular image of a potentially hazardous object, asteroid 2014 HQ124 (top right).



Of the over 18,000 NEOs known today (June 2018), there are nearly 2,000 objects classified as potentially hazardous objects (PHOs).

By definition, a NEO is an asteroid or comet that comes within 1.3 astronomical units (au) of the Sun. This implies that they can come at least within 0.3 au—about 50 million km—of the Earth's orbit. By contrast, PHOs come much closer and have a minimum orbital intersection distance of less than 0.05 au—about 7.5 million km—from the Earth's orbit, measuring more than ~140 metres across. An object of this size is large enough to cause devastation on a regional scale with possible global consequences.

However, objects much smaller than 140 metres can also cause considerable damage, although without producing global consequences. A NEO as small as 10 metres, under certain conditions, could be hazardous and its impact could lead to damage to buildings such as broken windows and result in some injuries to people.

## UNITED NATIONS AND NEAR-EARTH OBJECTS

The United Nations International Conference on Near-Earth Objects was held at United Nations Headquarters in New York in 1995. Organized by UNOOSA, the Conference raised the awareness of Member States to the potential threat from NEOs and proposed an expansion of existing observation campaigns to detect and track NEOs. It was one of the first gatherings of this magnitude to discuss the phenomenon at an international level. Policy perspectives emerged from the Conference to increase awareness of the threat from NEOs and to provide guidelines for cooperative observation, research and mitigation programmes. It was argued that there was a need to estimate probabilities of potential NEO impacts, due to the potentially severe consequences of medium to large-sized asteroids or comets.



## NEAR-EARTH OBJECTS AT THE UNISPACE III CONFERENCE

In 1999, the issue received further attention at the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), which resulted in the Vienna Declaration on Space and Human Development. The Vienna Declaration contained 33 specific recommendations, endorsed by the United Nations General Assembly, one of which was to address the need to improve international coordination of activities related to near-Earth objects.

In order to implement that recommendation, in 2001 the Committee on the Peaceful Uses of Outer Space established the Action Team on near-Earth Objects (Action Team 14). The work of this Action Team resulted in recommendations for an international response to the threat of near-Earth object impacts.

## UNITED NATIONS COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE-ENDORSED RECOMMENDATIONS FOR BUILDING AN INTERNATIONAL RESPONSE TO THE NEO-IMPACT THREAT

The recommendations (as contained in document A/AC.105/L.330) provide for an international response to the NEO-impact threat, agreed under the auspices of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and welcomed by the General Assembly in its resolution 68/75 of December 2013. They propose to ensure international information sharing in discovering, monitoring and physically characterizing potentially hazardous NEOs with a view to making all countries aware of potential impact threats, particularly developing countries with limited capacity in predicting and mitigating a NEO impact. They emphasize the need for effective emergency response and disaster management in the event of the discovery of a NEO-impact threat.



## INTERNATIONAL ASTEROID WARNING NETWORK AND SPACE MISSION PLANNING ADVISORY GROUP: PLANETARY DEFENCE AT A GLOBAL LEVEL

The International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) are two entities established in 2014 as a result of the United Nations-endorsed recommendations, and represent important mechanisms at the global level for strengthening coordination in the area of planetary defence.

## UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, INTERNATIONAL ASTEROID WARNING NETWORK AND SPACE MISSION PLANNING ADVISORY GROUP

The United Nations Office for Outer Space Affairs (UNOOSA) works with IAWN, which maintains an internationally recognized clearing house for the receipt, acknowledgement and processing of all NEO observations collected from observatories worldwide, by facilitating the dissemination of information related to near-Earth objects to Member States.



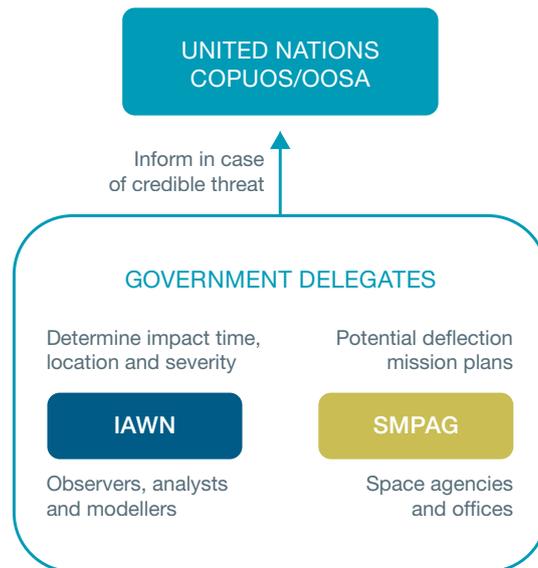


Pursuant to General Assembly resolution 71/90 of 6 December 2016, UNOOSA acts as secretariat to SMPAG, which works on laying out the framework, timeline and options for initiating and executing space mission response activities, as well as promoting opportunities for international collaboration on research on technology and techniques for NEO deflection.

Both IAWN and SMPAG submit an annual report to COPUOS and its Scientific and Technical Subcommittee under the agenda item on NEOs. In 2016, SMPAG also agreed to establish the SMPAG Ad Hoc Working Group on legal issues to address possible legal questions related to the work plan items of SMPAG.

## IN THE EVENT OF A CREDIBLE IMPACT PREDICTION ...

In the event of a credible impact threat prediction, warnings will be issued by IAWN. If the object is larger than about 50 metres and the impact probability is larger than one per cent within the next 50 years, SMPAG will start to assess mitigation options and implementation plans for consideration by the Member States. The goal is the global protection of the eco-system, of human beings and their property on Earth, and of the civilization of humankind from the effects of a devastating asteroid impact.



This figure shows the relationship of IAWN and SMPAG to the United Nations. IAWN and SMPAG provide annual progress reports to the Scientific and Technical Subcommittee (STSC) of COPUOS on their work. They have non-permanent observer status at the meetings of the STSC. Information flow is facilitated via their parent government delegations.



## INTERNATIONAL ASTEROID WARNING NETWORK

The International Asteroid Warning Network (IAWN) is a partnership of space agencies, scientific institutions, observatories and other interested parties performing observations, orbit computation, modelling and other scientific research related to the impact potential and effects of asteroids on the Earth. It endeavours to foster a shared understanding of the NEO hazard and optimize the scientific return on these small celestial bodies.

IAWN signatories include members from Europe, Asia, and South and North America. IAWN's primary functions are to:

- Conduct and coordinate the search for NEOs that may pose a hazard to the Earth
- Make follow-up observations and characterization of NEOs
- Communicate the risks and benefits of NEOs to the public
- Maintain a clearing house for NEO data
- Maintain a database of impact consequences, and ultimately,
- Serve as the principal trusted source of information on NEOs

Since the discovery rate of NEOs is continually on the rise, it suggests that the need for the functions of IAWN will also increase substantially in the future.

Further information on IAWN can be found at

[www.iawn.net](http://www.iawn.net)

## SPACE MISSION PLANNING ADVISORY GROUP

The Space Mission Planning Advisory Group (SMPAG) is a forum that links the space agencies of Member States with other relevant entities. Its responsibilities include proposing options and implementation plans for initiating and executing space mission response activities as well as promoting opportunities for international collaboration in research on technology and techniques for near-Earth object deflection.

SMPAG addresses the following main areas:

- Reference missions, technology road maps and collaborative research
- Communication and exchange of information
- International treaty and policy aspects—identifying issues for possible detailed reviews within appropriate forums
- Mitigation campaign planning activities

In 2015, SMPAG started developing its work plan, comprising initially of 11 work plan items, each of which is the responsibility of one or more members of SMPAG. The work plan is a road map for planetary defence at the global level, including agreements on initial criteria and thresholds for response actions to the threat of impacts, consideration of mitigation mission types and technologies, and the mapping of threat scenarios to mission types, as well as developing a plan of action in the event of the discovery of a credible threat.

Activity reports and special presentations are available on its website at

[www.smpag.net](http://www.smpag.net)



## SMPAG WORKPLAN\*

### GROUP 1

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- 5.2** Mitigation mission types and technologies to be considered (UKSA)
- 5.3** Mapping of threat scenarios to mission types (ESA)
- 5.4** Reference missions for different NEO threat scenarios (ASI)
- 5.8** Consequences, including failure, of NEO mitigation space missions (ESA)

### GROUP 2

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- 5.1** Criteria and thresholds for impact threat response actions (NASA)
- 5.9** Criteria for deflection targeting (ROSA)
- 5.10** Study of the nuclear device option (tbd)
- 5.11** Toolbox for a characterization payload (CNES)

### GROUP 3

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- 5.5** A plan for SMPAG action in case of a credible threat (NASA)
- 5.6** Communication guidelines in case of a credible threat (NASA)
- 5.7** Produce a “road map” for future work on planetary defence (DLR)

\*The activity leader (space agency) is given in brackets.

## INTERNATIONAL ASTEROID DAY

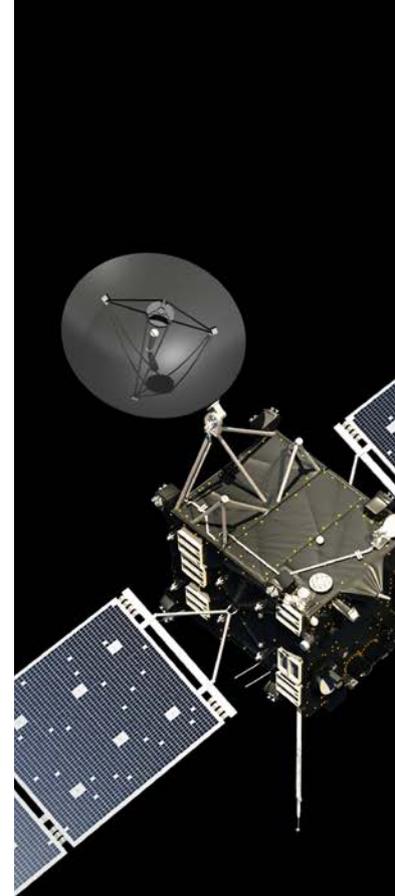
On 6 December 2016, the United Nations General Assembly proclaimed in resolution A/RES/71/90 that International Asteroid Day would be observed annually on 30 June to raise public awareness of the asteroid impact hazard.

30 June is the anniversary of the Tunguska impact over Siberia, now part of the Russian Federation, which occurred on 30 June 1908. The Tunguska asteroid impact event was the Earth's largest confirmed asteroid impact in recorded history, devastating over 2,000 square kilometres of forest.

International Asteroid Day encourages reflection on the impact hazard of asteroids and the global work undertaken in this area that UNOOSA facilitates, including work by COPUOS, United Nations Member States, IAWN and SMPAG.

All United Nations Member States, organizations of the United Nations system and other international and regional organizations, as well as civil society, including non-governmental organizations and individuals, are invited to observe International Asteroid Day.

The General Assembly's proclamation was based on a proposal by the Association of Space Explorers that was endorsed by COPUOS.





■ The United Nations Office for Outer Space Affairs (OOSA) is responsible for promoting international cooperation in the peaceful uses of outer space and assisting developing countries in using space science and technology.

