Avoiding Armageddon

The urgent search for near-Earth objects

- In 1995, scientists, astronomers, policymakers, and representatives from various nations met in New York to discuss how to mitigate the threat of near-Earth objects (NEOs) – celestial bodies that could wipe out life on Earth.
- Guided by the direction set by the conference, scientists are slowly but steadily working on identifying and mapping NEOs to tackle them when they turn rogue.
- Professor Hans J Haubold at the Office for Outer Space Affairs of the United Nations, New York and Vienna, and collaborators believe that combating NEOs requires close international collaboration.

In 1998, American actor Bruce Willis blew up an asteroid and himself to save Earth's inhabitants from extinction. The asteroid in question, roughly the size of Texas, was fictional, but the film, *Armageddon*, encouraged the millions who watched it to consider the actual scenario of a strike by one of the many celestial bodies that brushes past us. The film was inspired by a convention of leading scientists a few years earlier. Ever since, decisions made at that convention have guided international efforts to take action when a rogue asteroid has Earth in its sights.

It's tempting to think there's little in Earth's path as it hurtles through space, but in reality, it must dodge innumerable obstacles. Space is not a wilderness; it bristles with all manner of activity. Much of it stays far away, but some travel to our neck of the woods. Some we can see coming, others we can't. These visitors have a name – near-Earth objects or NEOs – and not all are benign.

Between August 28 and September 1, 1995, the United Nations hosted a conference to address the potential threat posed by NEOs. The International Conference on Near-Earth Objects brought together experts, scientists, astronomers, policymakers, and representatives from various nations to discuss the scientific, technical, legal, and policy aspects of NEOs. Between them, they established the scientific basis for an international organisational framework to support the necessary research and collective actions to mitigate a potential NEO threat to the planet. Now, thirty years later, there is a clearer picture of what's out there and what we could do when an NEO enters our orbit.

> **NEO detection is gathering momentum, enabling scientists to probe further into mysteries surrounding NEOs.**

The Chelyabinsk event

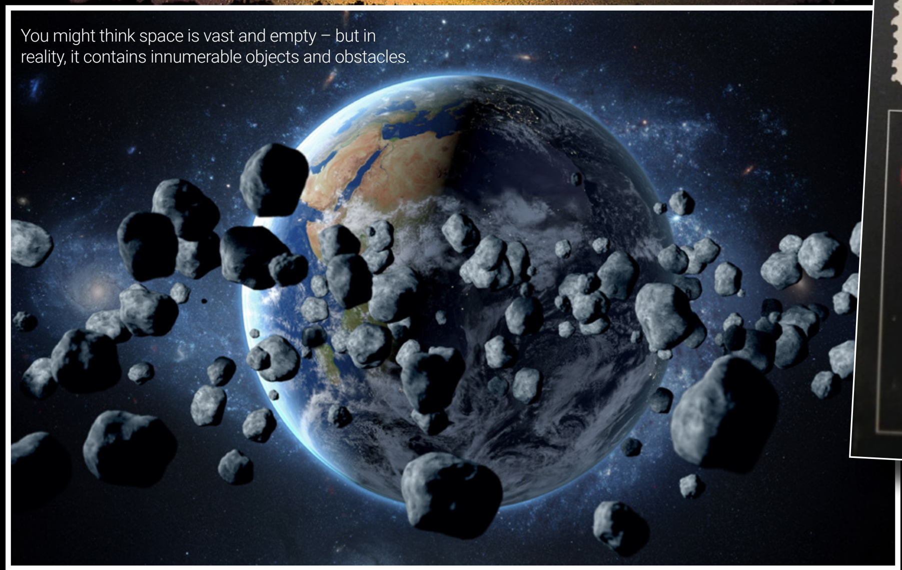
On the morning of February 15, 2013, an asteroid about the size of a bus suddenly disintegrated upon entering the Earth's atmosphere above the Russian city of Chelyabinsk. No one saw it coming – for the thousands of scientists and astronomers working together to help construct an action plan in the face of an NEO threat, this unforeseen event was a stark reminder of two things: how vulnerable we are and how vital their work is.

Since the 1995 Conference, there has been significant development around the core focus points – NEO detection and tracking, risk assessments and impact scenarios, development of mitigation strategies, and the international cooperation and coordination needed to enable these strategies. We now know that the space around us is a lot more cluttered. There are an estimated 1 million near-Earth asteroids. Not all are considered extremely dangerous – at least 140 metres in diameter – but thousands are larger than a kilometre across – according to NASA, big enough to erase humanity. In 2005, NASA issued a congressional directive to identify at least 90% of the extremely dangerous NEOs by 2020, a work that is still ongoing. As more and more equipment examines space and the technology becomes increasingly sophisticated, NEO detection is gathering momentum, enabling scientists to probe further into mysteries surrounding NEOs. However, the more we know, the more we realise how much we don't.

Not all asteroids are alike

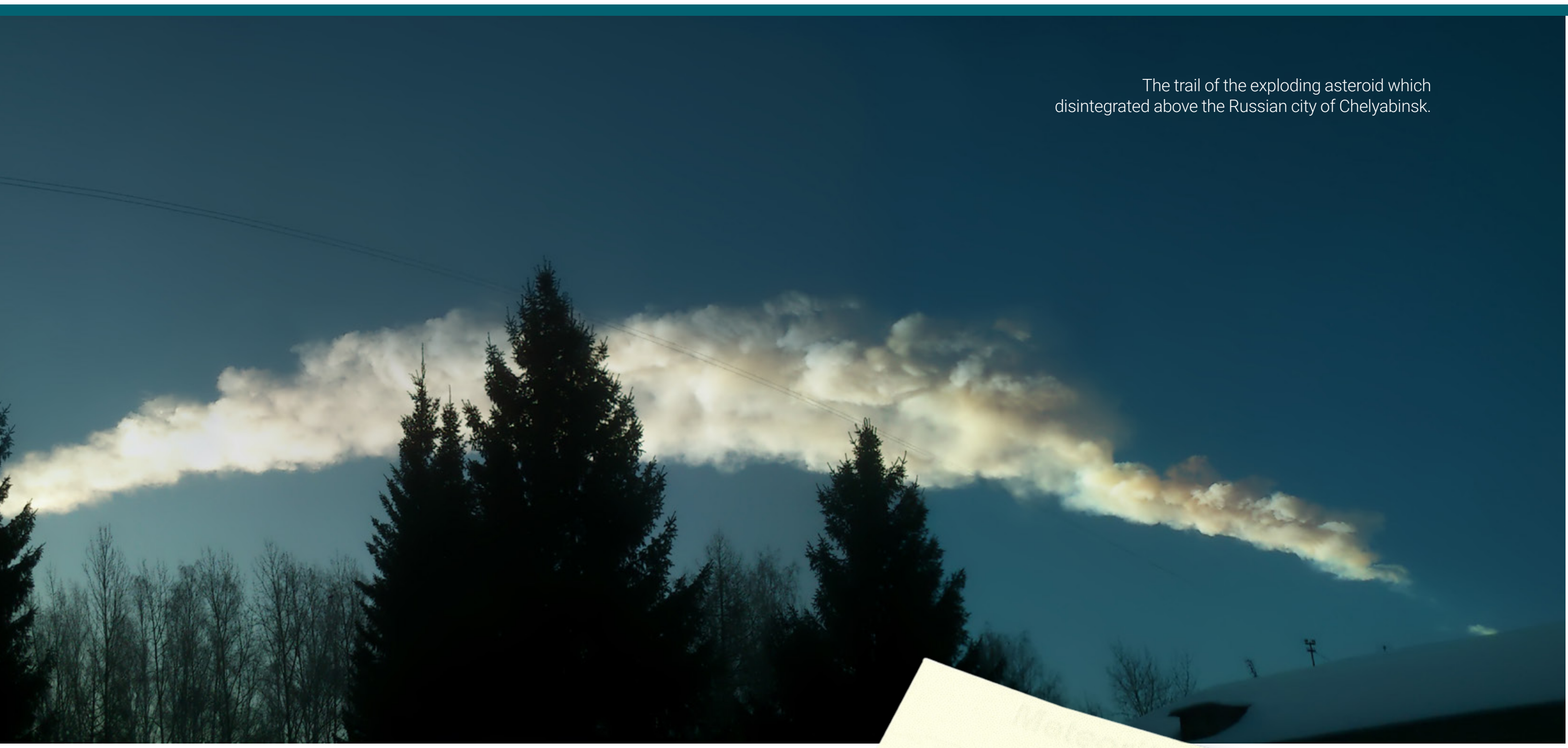
We now know that there's no such thing as a 'typical' asteroid. A key priority of the 1995 Conference was not only getting to know what asteroids are out there and how they move, but also what they're made of. This is not purely for scientific interest; to stop or deflect a NEO, we must know what's needed to do so, and a lot of that depends on its nature. This is why, since 1995, several international missions have had a closer look at asteroids.

In February 2000, NASA's Near-Earth Asteroid Rendezvous (NEAR) mission started a year-long examination of the near-Earth asteroid

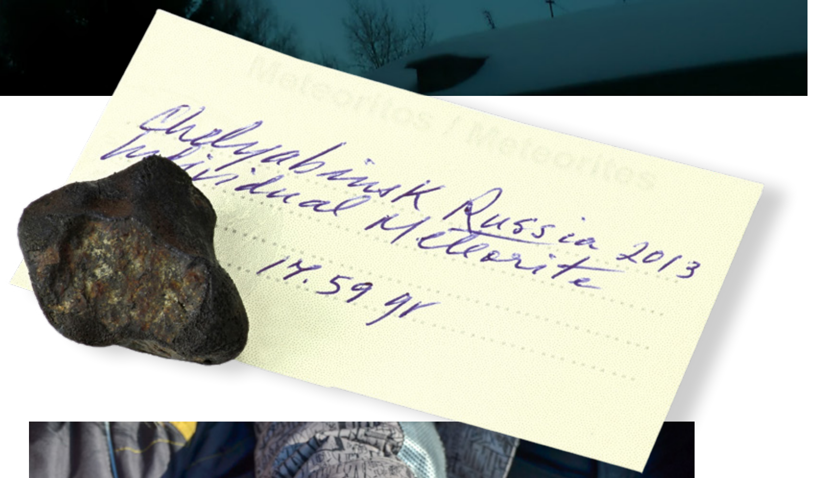


You might think space is vast and empty – but in reality, it contains innumerable objects and obstacles.

'Near-Earth Objects: The United Nations International Conference' by John L. Remo was published in 1997.



The trail of the exploding asteroid which disintegrated above the Russian city of Chelyabinsk.



Eros before successfully landing on it and continuing to send back valuable data about its bulk properties, composition, mineralogy, morphology, internal mass distribution, and magnetic field. In 2005, the Japan Aerospace Exploration Agency (JAXA) landed a robotic spacecraft called Hayabusa on a small near-Earth asteroid named 25143 Itokawa. From the samples of the asteroid's surface brought back by the craft, scientists established a relationship between telescope observations of asteroids and laboratory examinations of meteorites found on Earth.

NASA's Discovery Program continues to expand our understanding of space, including NEOs. Its Dawn spacecraft was the first to orbit two extra-terrestrial bodies, notably the two biggest asteroids in the belt that threads its way through our Solar System. Dawn learned that Vesta and Ceres are compositionally different. Vesta is dry and rocky, while Ceres is covered in ice, possibly with liquid underneath it.

UNOOSA is actively involved in the international discourse and dialogue on NEOs, raising awareness and promoting global cooperation.

Data from NEAR, Dawn, Hayabusa, and other missions to NEOs, including NASA's OSIRIS-REx, are helping scientists realise that any attempt to stop an asteroid will depend on its characteristics and behaviour – is it solid, porous, or more of an amalgam of piles of rubble; does it have a high rate of rotation, or does it spin slowly; and is it alone or does it have accompanying fragments orbiting it? Unlocking this key information acts as a first step in dealing with a possible threat. What comes next is when things get a little unclear.

Battling NEOs

In the film *Armageddon*, Willis' character is an oil driller. His mission is to land on the threatening asteroid, drill into it and plant a massive bomb that would shatter it into smaller pieces, minimising its impact. Such a plan was probably not considered at the 1995 Conference; the focus would have been on what would be needed to divert an NEO's course, arguably a safer option than smashing it to bits without sufficient knowledge about what those bits could possibly do.

Fragments of the Chelyabinsk meteorite found in 2013.

Since then, scientists have focused on addressing the obvious physics of a mission: the energy needed to shift an asteroid's momentum. Some of the options include: high-speed mechanical projectiles, probably suitable for deflecting smaller NEOs, conventional explosives at or below an asteroid's surface, and, for more sizeable challengers, x-ray or neutron radiation, such as that from a nuclear explosion. Owing to the guidance of the Conference, we now have in our arsenal an array of rocket technology with sufficient heft to deliver a single high-energy payload or multiple independently targeted payloads.

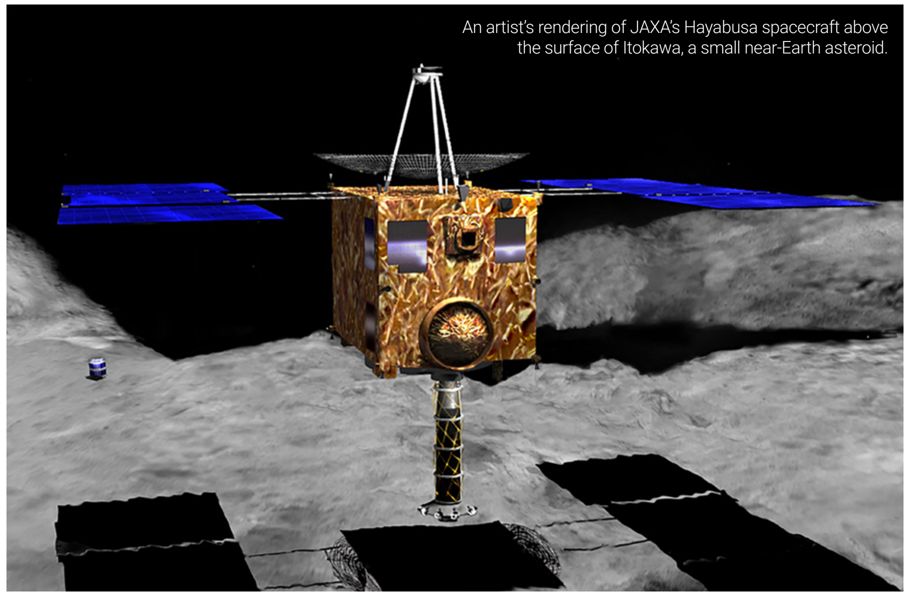
Implementing such missions is still largely academic and sits in simulators and sophisticated computer modelling built to consider the increasingly detailed threat scenarios initiated in 1995. However, in September 2022, NASA managed to test the deflection physics as part of the Double Asteroid Redirection Test when it purposefully crashed a spacecraft into Dimorphos, a small asteroid orbiting the larger Didymos. The aim was to assess how much a spacecraft could deflect an asteroid by transferring momentum in a direct head-on hit. NASA's success threshold was changing Dimorphos' orbit by a minimum of 73 seconds. Remarkably, they exceeded their boldest calculations, managing to slow its orbit by 32 minutes. Neither Dimorphos nor Didymos threatens Earth, but scientists will now follow their orbits to track the long-term effects of this major breakthrough.

On planetary defence

Today, the spirit of the 1995 International Conference on Near-Earth Objects lives on in the United Nations Office for Outer Space Affairs (UNOOSA), which is actively involved in the international discourse and dialogue on NEOs, raising awareness and promoting global cooperation. In a publication released in early 2023 titled 'Near-Earth Objects and Planetary Defence', UNOOSA pointed out how it is uniquely positioned in intergovernmental cooperation and coordination on outer space activities and the broader perspective of space security, including planetary defence. In that defence, global collaboration is critical.

Since the 1995 UN Conference, there have been numerous meetings and workshops sponsored by member states of another UN body, the UN Committee on the Peaceful Uses of Outer Space (COPUOS), to encourage momentum and development of the guidance by the original Conference. COPUOS established an action team on NEOs to continually review the ongoing efforts in the field. COPUOS emphasised that such efforts should require close international cooperation.

Professor Hans J. Haubold emphasises that such international cooperation is especially essential since the threat from NEOs can easily be misinterpreted. The asteroid that exploded over Chelyabinsk in 2013 was about 20 metres across and lit up the sky like a nuclear explosion. Indeed, initially it was speculated to be a nuclear attack, among other possibilities. In a world that is more unsettled now than it has ever been, NEOs don't have to be the size of Texas to trigger Armageddon.



An artist's rendering of JAXA's Hayabusa spacecraft above the surface of Itokawa, a small near-Earth asteroid.

Details

e: hans.haubold@gmail.com
t: +43 676 4252050
w: www.nasa.gov
w: www.unoosa.org
w: www.growkudos.com

Bio

Hans J. Haubold is a professor of theoretical astrophysics at the Office for Outer Space Affairs of the United Nations, New York and Vienna. His research focuses on the internal structure of the sun, solar neutrinos, and special functions of mathematical physics. Additionally, he is interested in the history of astronomy, physics, and mathematics.

Funding

- United Nations Secretariats in New York and Vienna
- European Space Agency (ESA)
- NASA (US)
- JAXA (Japan)
- New York Academy of Sciences
- 193 Member States of the United Nations

Collaborators

- John L. Remo (Harvard University, USA)
- Arak M. Mathai (Canada)

Further reading

United Nations Office for Outer Space Affairs (2023) Near-Earth objects and planetary defence. United Nations Office at Vienna.

Kofler, R, Garcia Yarnoz, D, Staško, M, (2019) Near-Earth objects and the United Nations. In: Schmidt, N, (eds) *Planetary Defense. Space and Society.* Springer, Cham.

Remo, JL, Haubold, H, (2014) Threats from space: 20 Years of progress. *Bulletin of the Atomic Scientists*, 70(4), 85–93.

UNITED NATIONS

sdecoret/Shutterstock.com