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Deep impact: how to deflect an asteroid

Shattered glass. Howling car alarms. Buildings evacuated. On 15 February 2013, the city of Chelyabinsk in the Urals region of Russia felt the full force of a shockwave caused by an unexpected fireball exploding some 15-20 km above it. As the lump of space rock burned up in the sky above the city, windows were blown out and local buildings shook. Hundreds were left injured.

29 April 2013 - By DEBORAH FORSYTH

Later that same day, Asteroid 2012 DA14, which was first spotted by astronomers in Spain last year, whizzed by the Earth – at a distance of 27 000 km from our planet's surface. Estimated to be between 45-50 m in diameter, more than twice the size of the Chelyabinsk rock, this asteroid – had it crashed into Earth – would likely have wreaked far greater devastation than the Chelyabinsk fireball.

To keep the chances of a fateful asteroid collision with Earth to a minimum, researchers are working out how to deflect potentially dangerous asteroids from their courses. Since January 2012, the EU-backed project NEOShield, or Near Earth Object (NEO) Shield, has been testing the theory and techniques behind the best ideas put forth to date on how to fend off Earth-bound asteroids.

Its work will be complemented by another EU project, STARDUST, which kicked off in February 2013 and that plans to build up a network of researchers trained in asteroid and space debris deflection over the course of the next four years.

Both projects bring together several research partners, not all of them European. Russia and the US are involved in NEOShield for example, as ultimately the project is looking to draw up a global response to the challenge of deflecting asteroids – after all, asteroids can strike anywhere.

Coming to a place near you

While it's clear that there are asteroids out there, what is the actual probability that the Earth will be hit by one? 'Ah, to that, I can only say "how long is a piece of string?"' says NEOShield Researcher, Professor Alan Fitzsimmons of Queen's University Belfast. 'Asteroids come in all sizes, and rather like pebbles on a beach, it's the small ones that are most likely to hit us, simply because there are more of them.'

'A one kilometre-wide asteroid is likely to hit us once every 800 000 to 1 million years. A small one like that seen over Chelyabinsk – about 17 m in diameter – is likely to hit us every 80 to 100 years.'

Most asteroids orbit the sun within the asteroid belt, which is located between the orbits of Mars and Jupiter. A relative few, however, orbit the sun on a trajectory that brings them close to Earth – so-called Near Earth Objects – of which only a small number come so near to Earth that they pose a threat.

At NEOShield, the focus is on dealing with asteroids slightly larger than the one that exploded above Chelyabinsk. 'Detecting tiny asteroids is still extremely difficult. There are so many of them, it's hard to keep track,' says NEOShield Coordinator, Professor Alan Harris of Berlin's DLR (German Aerospace Centre) Institute of Planetary Research.

'Most small asteroids will explode before they hit the ground. We are concerned about the ones that are around 100 metres upwards in diameter that are heavier and will most likely not only hit the ground but leave a crater,' says Harris. 'To put this in context, there are presently an estimated 20 000 Near Earth Objects with a diameter of 100 metres or more. Astronomers have detected 25 % of them. But 75 % of them have not yet been found.'

Kick, tug or nuke

Part of NEOShield's work is to find out more information on the properties of known NEOs. These details are essential when it comes to testing proposed asteroid deflection techniques; what works well for deflecting one asteroid may not work well for another. An asteroid's mineral composition and porosity, for example, will affect its behaviour in relation to a chosen deflection technique.

‘Ideas on asteroid deflection have been around for a few years,’ says Fitzsimmons. ‘But we’ve never yet tried to implement one for real. Through numerical calculations, physical measurements and modelling, we are testing the best techniques proposed to date. By the end of the project, we will recommend a method that could eventually be tested by a space mission on a real asteroid.’

The three main asteroid deflection techniques under scrutiny are the ‘Kick’, ‘Tug’, and ‘Nuke’ approaches. Referring to the ‘Nuke’ approach Harris explains: ‘We can’t conduct a nuclear explosion, but we can weigh up the efficiency of such a technique. Blowing up a nuclear explosive close to an asteroid could turn out to be the best way to get rid of an asteroid, or it could result in the rock splintering into millions of pieces that would cause yet more damage.’

Under the ‘Kick’ method, formally known as the Kinetic Impactor Mitigation method, a spacecraft alters an asteroid’s velocity and eventual path by crashing into it. The momentum of the impacting body is thus transferred to the asteroid, causing it to veer from its original path.

The ‘Tug’ method employs a ‘gravity tractor’ to move the asteroid. The tractor is essentially a spacecraft which hovers above the asteroid and uses its gravitational attraction to pull the asteroid slightly off course.

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Of stardust and satellites

Once NEOShield gives its final recommendation on the design of a future space mission, it is possible that experts trained through the STARDUST project could help take the mission a stage further.

‘During the project, we intend to recruit 15 people for training in asteroid and space debris deflection in academic institutes and space research centres across Europe,’ says Massimiliano Vasile, who is coordinating the project from his Advanced Space Concepts Laboratory at the University of Strathclyde UK. ‘There are many individual projects looking into this subject,’ he adds, ‘but we would like to create a core group of experts dedicated to its development and who are ready to act as decision-makers in the future.’

STARDUST recruits will be trained variously in modelling and simulation, orbit and altitude estimation and prediction, and active removal or deflection of uncooperative targets.

An ‘uncooperative target’ could either be an asteroid or a piece of space debris. ‘In addition to asteroids orbiting the sun, we have a cloud of man-made objects, or space debris, orbiting the Earth,’ says Vasile.

‘Humans created this junk, which mainly consists of satellites, employed for communications or observation purposes. We need experts now to track and keep this space debris under observation. Like asteroids, expended satellites are not controllable. We might be able to renew software on satellites, but once a satellite becomes defunct, usually after 10 years, we cannot yet physically repair them. Until we can, we need to find ways of effectively disposing of them because otherwise there’s a good chance of satellites colliding, causing a dangerous chain reaction in space.’

Final countdown

To date, the idea of the Earth colliding with an asteroid has generally been considered the stuff of sci-fi movies. But February’s events have changed perceptions. ‘Since Chelyabinsk, asteroid deflection is no longer being viewed by the public as a marginal consideration,’ says Harris. ‘It’s an issue that needs to be addressed.’

While no giant asteroid is predicted to come our way tomorrow, asteroid watchers remain vigilant. ‘In 2029, the asteroid, Apophis, which is about 300 m in diameter, is due to fly past Earth. It is predicted to miss us by only 30 000 km,’ says Harris. ‘We should be ready for that.’

More info

NEOShield

STARDUST

Stephen Hawking’s 'Life in the Universe' lecture