10 things you should know about planetary defense

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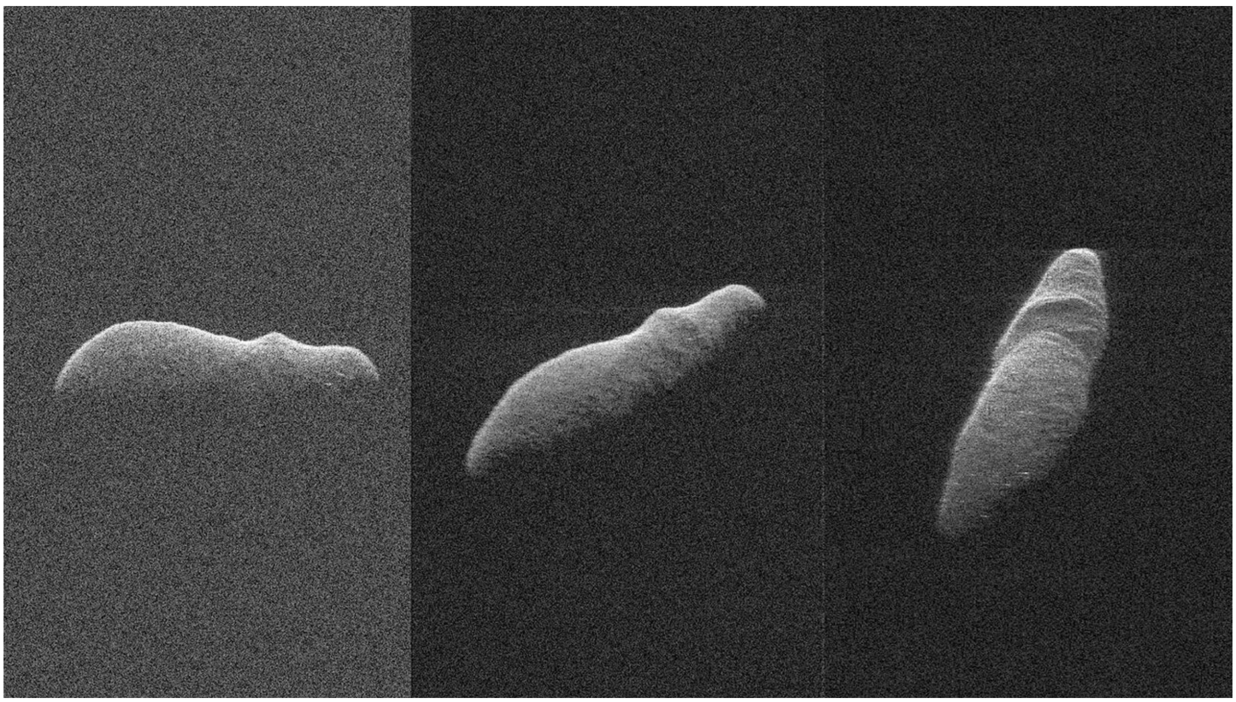

These three radar images of near-Earth asteroid 2003 SD220 were obtained on Dec. 15-17, by coordinating observations with NASA's 230-foot (70-meter) antenna at the Goldstone Deep Space Communications Complex in California and the National Science Foundation's (NSF) 330-foot (100-meter) Green Bank Telescope in West Virginia. Credit: NASA/JPL-Caltech/GSSR/NSF/GBO

1. Why Asteroids Impact Earth

Why do asteroids and meteoroids collide with Earth? These objects orbit the Sun just like the planets, as they have been doing for billions of years, but small effects such as gravitational nudges from the planets can jostle the orbits, making them gradually shift over million-year timescales or abruptly reposition if there is a close planetary encounter. Over time, their orbits may cross Earth's path around the Sun. During the millennia when an asteroid is in an Earth-crossing orbit, it is possible the asteroid and Earth may find themselves in the same place at the same time. An asteroid needs to arrive at the intersection point with Earth's orbit at the very same time Earth is crossing that point for an impact to occur. But even Earth is relatively small compared to the size of asteroid orbits, which is why asteroid impacts are so rare.

2. A Current Hazard

We didn't always know that asteroid impacts were a modern-day possibility. In fact, this realization didn't come until scientists started proving that many of the craters on Earth were caused by cosmic impacts rather than volcanic eruptions (and similarly for the craters on the Moon). In the 1980s, scientists discovered evidence that the demise of the dinosaurs 65 million years ago was likely caused by an asteroid impact. After scientists found the Chicxulub Crater in the Gulf of Mexico, this idea became more certain. In 1994, the world witnessed similar-sized impacts happening in near-real time, when fragments of comet Shoemaker-Levy 9 impacted Jupiter—that's when we really started to understand that large asteroid impacts could still happen today.

3. Frequency of Impacts

Every day, roughly 100 tons of interplanetary space material rain down on our planet, most of it in the form of tiny dust particles. Small planetary debris the size of grains of sand, pebbles and rocks also rain down daily into Earth's atmosphere, producing the meteors—commonly called "shooting" or "falling stars—that you can see on any dark clear night. Occasionally, Earth passes through denser streams of small debris released from comets—that's how we get meteor showers. Sometimes larger, chair-sized or even car-sized space objects enter Earth's atmosphere and create really bright meteors, called fireballs or bolides, which disintegrate as they explode in the atmosphere. Very rarely, every few decades or so, even larger objects enter the atmosphere, such as the house-sized object that streaked across the sky over Chelyabinsk, Russia, in 2013, producing a super-bright fireball and a shock wave that blasted out windows and broke down doors.

4. World Asteroid Data Repository

The Minor Planet Center has a modest name, but this office has a major job. Located in Cambridge, Massachusetts, and operating out of the Smithsonian Astrophysical Observatory, the Minor Planet Center (MPC) is the world's repository of all observations and computed orbits of asteroids and comets in the solar system, including all the near-Earth object (NEO) data. An NEO includes any asteroid, meteoroid or comet orbiting the Sun within 18,600,000 miles (30 million kilometers) of Earth's orbit. Any time an astronomer observes an NEO using a telescope on the ground or in space, they send their measurements of the object's position to the Minor Planet Center. The MPC's complete set of observations of an object from observatories around the world can be used to calculate the most accurate possible orbit around the Sun for the object to see if it could pose a risk of impact on Earth.

5. Who Searches for Near-Earth Objects?

In 1998, in response to a congressional directive, NASA established the Near-Earth Object Observations (NEOO) Program and has been tirelessly detecting, tracking and monitoring near-Earth objects ever since. Several astronomer teams around the country operate under NASA's NEO Observations Program, helping us discover, monitor and study NEOs. The observatories that currently make most of the NEO discoveries are the Catalina Sky Survey telescopes in Arizona and the Panchromatic Survey Telescope And Rapid Reporting System (Pan-STARRS) telescopes in Hawaii. NASA's NEOWISE space telescope also discovers NEOs and provides critical data on their physical size. Additional astronomers supported by the Near-Earth Object Observations Program use telescopes to follow up the discoveries to make additional measurements, as do many observatories all over the world. All these observers send their measurements of NEO positions to the Minor Planet Center. The Center for Near-Earth Object Studies, based at NASA's Jet Propulsion Laboratory, also uses these data to calculate high-precision orbits for all known near-Earth objects and predict future close approaches by them to Earth, as well as the potential for any future impacts.

6. How to Calculate an Asteroid's Orbit

Scientists determine the orbit of an asteroid by comparing measurements of its position as it moves across the sky to the predictions of a computer model of its orbit around the Sun. This model takes into account all of the known forces acting on the asteroids motion, consisting mostly of the gravity of the Sun, all the planets and some of the other larger asteroids. Then, for each asteroid, they refine the orbit model to determine what most accurately predicts the observed locations in the sky at the times of those observations. It is possible to calculate a rough orbit with only three observations, but the more observations that are used, and the longer the period over which those observations are made, the more accurate is the calculated orbit and the predictions that can be made from it.

7. Finding the Large Ones

NASA's NEO Observations Program began searching in earnest in 1998, when only about 500 near-Earth asteroids were already known. By 2010, NASA and its partners had identified more than 90 percent of the estimated 1,000 near-Earth asteroids that are 1 kilometer or larger. Large asteroids were the first priority in NASA's search because an impact by any one of these could have global effects. NASA's search programs are still finding a few of these large asteroids every year, and astronomers think there are still a few dozen yet to be found. Because of NASA's efforts, 90% of the risk of sudden, unexpected impact of an unknown large asteroid has been eliminated.

8. Close Approach

You may have heard about an asteroid or comet making a "close approach" to Earth. That happens when the object in its natural orbit about the Sun passes particularly close to Earth. There's no firm rule on what counts as "close," but it's not at all uncommon for small asteroids to pass closer to Earth than our own Moon. That might seem too close for comfort, but remember that the Moon orbits Earth about 239,000 miles (385,000 kilometers) away. If you represented Earth by a basketball in a scale model, the Moon would be the size of a tennis ball and about 21 feet (7 meters) away—the distance between the two posts of a professional soccer goal. At this scale, a 100-meter-wide (328-foot-wide) asteroid would be much smaller than a grain of sand, even smaller than a speck of dust.

9. Studying a Near-Earth Object Up Close

There's currently a NASA mission called OSIRIS-REx studying a near-Earth object up close—an asteroid named Bennu. Scientists recently calculated that this asteroid has a 1 in 2,700 chance of hitting Earth in the late 22nd century (that's over 150 years away for now), but it has no chance of impacting any time before then.

Right now, OSIRIS-REx is orbiting the asteroid and studying its surface to prepare to take a sample and return it to Earth in 2023. The spacecraft is also studying a phenomenon called the Yarkovsky effect—which is a small force that shifts the asteroid's orbit slightly as its Sun-heated surface radiates heat back into space. By studying Bennu close-up with OSIRIS-REx, scientists will be able to understand just how much heat is being radiated from the various parts of the asteroid, which will help them ultimately better understand the Yarkovsky effect and better predict Bennu's orbit and its possible hazard to Earth.

10. Asteroid Deflection

Asteroid impacts are the only potentially preventable natural disaster—provided we spot the threatening asteroid with enough lead time to launch a mission into space to deflect it. NASA and its partners are studying several different approaches to deflecting a hazardous asteroid. The most advanced of these techniques is called a kinetic impactor, and a mission to demonstrate this technology is called the Double-Asteroid Redirection Test (DART), is slated to launch in 2021.

Of course, we aren't going to meddle with the orbit of an asteroid that could pose a risk to Earth for a test. The target for DART is Didymos B, the moon of a larger asteroid, called Didymos A. The Smart Car-sized DART spacecraft will slam into the football-stadium-sized Didymos B at a speed of 13,000 mph (22,000 kph) to not only confirm the robustness of the targeting system, but also to see how much the collision changes the asteroid moon's orbit around Didymos A. Scientists have determined B's orbit around A from the ground, and will then measure the orbit again after the DART collision to see how much the orbit has changed.

That will tell us how much the kinetic impactor could change an asteroid's path around the Sun if we needed to do so.

If a hazardous asteroid is found a decade or more before a potential impact, there would likely be time to launch a deflection mission to the asteroid, and we would only need to shift its orbit by just a bit—just enough to make it cross Earth's orbit only about 10 minutes "late," so to speak—to avoid the collision with our planet.

Provided by Jet Propulsion Laboratory