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Capturing an asteroid

NASA's NEOWISE survey shows that more potentially hazardous asteroids, or PHAs, are closely aligned with the plane of our solar system than previously suggested. PHAs are asteroids with the closest orbits to Earth's and large enough to survive passage through the atmosphere and cause damage on a regional, or greater, scale. Credit: NASA/JPL-Caltech.

by Ben Iannotta
Contributing writer

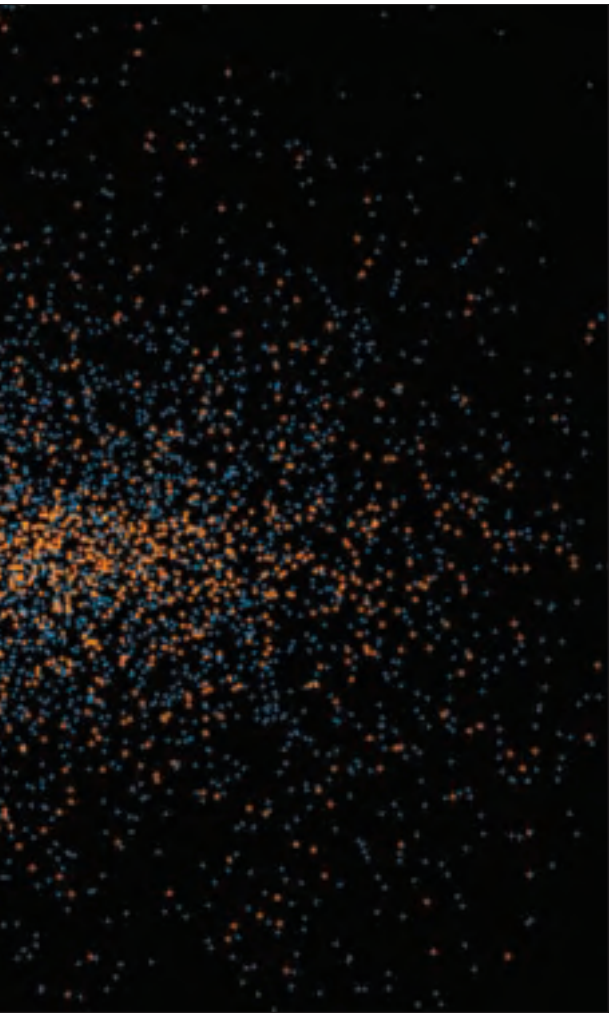
NASA's budget for 2014 includes a $105-million increase for spending on asteroid work. The agency was quick to suggest that its plan is tied to planetary defense. The money would go toward preparing for an asteroid retrieval mission in which a 7-10-m-wide asteroid would be bagged up robotically and towed closer to Earth.

The robotic phase of the mission would be launched in 2017; in 2021, astronauts would climb into NASA's new Orion crew capsule and rendezvous with the asteroid in days, instead of the months it would have taken them under the Obama administration's previous plan. Under the new plan they would then visit the asteroid, chip away samples, and bring them home.

That sounds like asteroid mining, but a senior NASA official downplayed this as a motivation for the mission: CFO Elizabeth Robinson told reporters that defending Earth from asteroids was probably "first and foremost" on President Obama's mind. Sen. Bill Nelson (D-Fla.) told the Associated Press the "plan combines the science of mining an asteroid…with developing ways to deflect one."

In reality, the retrieval mission will teach NASA little about how to deflect asteroids large enough to threaten cities, regions, or civilization itself, said agency officials and outside experts. This year's congressional budget deliberations are likely to explore whether NASA's latest plan is bold enough, given the cosmic warning shots experienced by the world on February 15, when one asteroid flew by and another object exploded over Chelyabinsk, Russia.

NASA's asteroid hunters want to make sure the retrieval mission's relevance to planetary defense is not overstated as Congress figures the way ahead: "This asteroid



NASA is making plans for bagging an asteroid, moving it to a closer orbit, and bringing a sample home. The idea is not just to study it but also to learn how best to deflect a larger one if it is found to be on a collision course with Earth. Support for the program has grown in Congress since two separate asteroid impacts took the world by surprise on February 15.

retrieval mission isn't really a demonstration for planetary defense," says Lindley Johnson, program executive in the Near Earth Object Observation program.

Bagging a 500-ton body and towing it millions of kilometers is a technique that cannot be scaled up to the larger asteroids that are the real threats.

Johnson is not alone in that assessment: "Five hundred tons is 500 tons. That's a lot of stuff to move around," says Al Globus, a NASA-funded research engineer at San Jose State University. Moving a larger asteroid would require deflecting it, he says.

Shifting the focus

Globus was part of an informal team called the Asteroid Mining Group that drafted a 2012 AIAA paper critiquing NASA's previous plan to send astronauts on a six-month ride to rendezvous with an asteroid by 2025. "A Comparison of Asteroid Near-Earth Object Missions" argued for robotically dragging an asteroid back to lunar space.

A parallel study by the Caltech/JPL Keck Institute for Space Studies laid the groundwork for NASA to shift its asteroid plan to a retrieval mission.

In terms of planetary defense, the best thing advocates can say about the retrieval proposal is that grabbing an entire asteroid would be a first. It also would give impetus to improving detection of such objects, because it would entail quickly identifying one that is not too big or spinning too fast for thrusters to slow its rotation for the tow.

Politically, the proposal does something members of Congress in Florida and Texas want: It spells out a role for the Orion crew capsule and the new Space Launch System. Some lawmakers also see February 15 as a clarion call for a bold planetary protection plan. It is not clear whether the retrieval mission will satisfy them.

According to the B612 Foundation, "Sentinel is a space-based infrared survey mission to discover and catalog 90% of the asteroids larger than 140 m in Earth's region of the solar system." Credit: Ball Aerospace.

In hearings after the February 15 events, lawmakers asked lots of tough questions. They wanted to know who would be in charge of planetary defense in a crisis. They wanted to see a clear set of technology milestones established in collaboration with other countries. That way, with budgets tight everywhere, the cost of new detection telescopes or deflection demonstrations could be shared.

"I'd like to include all countries—except China," said Rep. Dana Rohrabacher.

Slow progress

As it stands, NASA does not have any firm plans on the books for a deflection demonstration mission or for a space-based telescope that would find the thousands of asteroids that are eluding ground telescopes.

NASA is spending a few hundred thousand dollars a year on an international research project called the Asteroid Impact & Deflection Study, a collaboration by ESA, Germany's DLA aerospace center, and the Johns Hopkins University Applied Physics Lab. The idea is that NASA would do the deflecting, and another spacecraft would observe from a distance to see if the attempt succeeded.

On the detection front, NASA calculates that 95% of the solar system's 1-km-class planet-killers have been identified by a federation of ground-based telescopes and amateur astronomers. That leaves thousands of smaller asteroids that could wipe out regions or cities. The trouble is that many of these bodies cannot be seen with ground-based telescopes.

There is consensus that the best way to find them would be to launch an asteroid-hunting infrared instrument into space. Its sensitivity would be improved outside the atmosphere, and it would have a better view of the asteroid belt without the Earth or the Sun in the way. "The Chelyabinsk object came in from the daytime side of the Earth, so there's no way that we could detect it from ground-based telescopes," NASA's Johnson says.

NASA has no plans to launch such a satellite. This is true even though in April JPL announced that its proposed Near Earth Object Camera passed a test mimicking the temperatures and pressures of deep space. Advocates wanted to launch it under the agency's Discovery Program, but the proposal was not funded.

The best chance for a free-flying asteroid hunter rests in the hands of a nonprofit group called the B612 Foundation (named for the asteroid in a children's book by Antoine de St.-Exupery). The group's chairman, former astronaut and Google executive Ed Lu, must inspire millionaires and billionaires to chip in money to build Sentinel, a Kepler-sized infrared satellite. It would be sent to an orbit trailing Venus, where it would stare out at the asteroids lurking beyond Earth.

"The big challenge is convincing people that they can make a difference in the future of the Earth," Lu says. "It's happening. It's a slow process." People do not sit right down and send "a $10-million check," he says. Confidence must be built.

NASA has a cashless Space Act Agreement with B612 to provide software, technical advice, and Deep Space Network communications time as Sentinel is launched. Ball Aerospace, which built the Kepler planet-hunting space telescope, is on contract to develop Sentinel, although B612 has raised only a fraction of the funds it would need to pay Ball.

Sentinel and other options

The foundation figures it should cost about $400 million to build and launch Sentinel. That is quite a bit less than NASA's rough estimate of $750 million for commissioning and managing construction of an asteroid hunter. B612 would gladly accept a cash contribution from NASA for Sentinel, but that looks unlikely: "If we had that in our budget, we'd probably be building it ourselves," Johnson says.

The government's attitude toward B612 may be shifting, though. Lawmakers pressed John Holdren, President Obama's science advisor, to explain what the U.S. is doing to find asteroids before they find us. Holdren pointed to B612, saying, "…the single most important thing we could do to improve our capacity to see any asteroid of potentially damaging size coming would be an orbiting infrared telescope of the sort that the B612 Foundation is working on."

Sentinel would be built on the same model satellite frame as the 1,052-kg Kepler infrared spacecraft, but Kepler cannot be used for asteroid hunting. It is tuned to look for Earthlike planets thousands of light-years away, not asteroids at a distance of only 50 million km. It does not have the right focal plane or field of view for asteroid searches, says Johnson. So far, B612 has some prototype personal-pizza-sized in-

frared detectors manufactured under a contract with Ball Aerospace, the Kepler prime contractor.

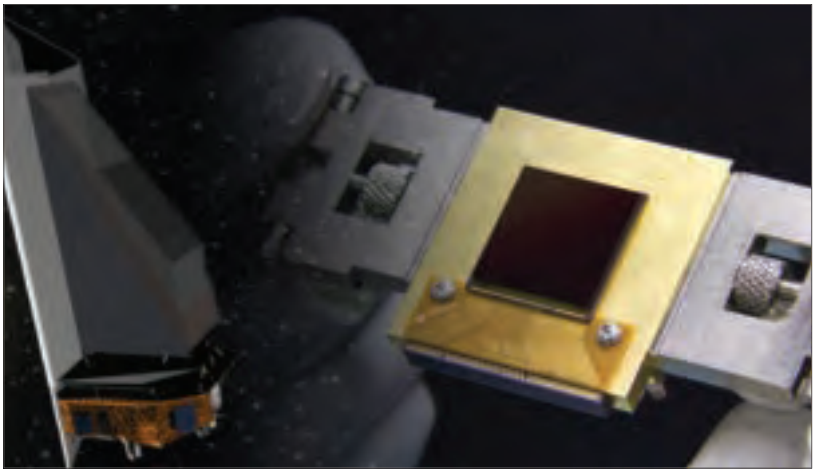
Another idea would be to install an infrared sensor on one of the commercial or government geosynchronous satellites now on the drawing board or in development. Last August, NASA issued a request for information, inviting experts to submit ideas for a 75-kg IR sensor that could ride as a hosted payload on one of those satellites. NEOCam remains a candidate for that application, Johnson says.

Later this year in Socorro, New Mexico, NASA also plans to get a turn testing a new ground device called the Space Surveillance Telescope. It was designed by DARPA and the Air Force with a primary mission of detecting space debris and threats to satellites.

Surprise visitors

NASA Administrator Charles Bolden has a word he likes to use to describe progress toward planetary defense, and the word is incremental. The question is whether that will be enough for Congress, given what happened on February 15.

The main event that day was supposed to be the close approach of 2012 DA14, a 40x15-m asteroid discovered about a year earlier by a Spanish astronomer. But as that asteroid was closing in, another object, later estimated to be 17 m wide, exploded over the city of Chelyabinsk, breaking windows, raining down chunks of itself, and reportedly injuring a thousand people. No one saw it coming.



The NEOCam sensor (right) is the linchpin for the proposed Near Earth Object Camera, or NEOCam (left), space mission. Image credit: NASA/JPL-Caltech/ Teledyne.

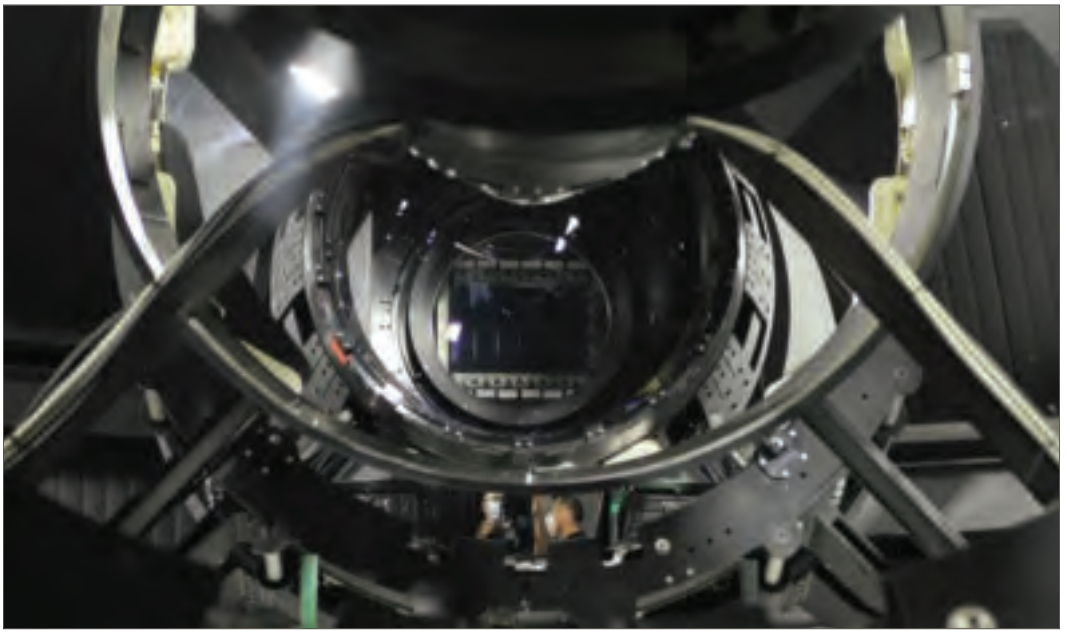
For some members of Congress, the day of the asteroids changed everything. Until then, lawmakers who talked a lot about planetary defense were seen as "on the 'kooky' side," said Rep. Bill Posey (R-Fla.) at a March hearing of the House Science, Space and Technology Committee. The asteroid coincidence (NASA insists the two events were unrelated despite Internet chatter to the contrary) proved that low probability does not mean no possibility.

Holdren said the odds of calamity remain slim, but he added that the "the potential consequences are so large that it makes sense to take the risk seriously."

But what constitutes 'seriously'?

The threat

In the retrieval mission, any asteroid that NASA plans to bag would be small enough



DARPA's Space Surveillance Telescope program enables ground-based, broad-area search, detection, and tracking of small objects in deep space for purposes such as space mission assurance and asteroid detection.

An object entered the atmosphere over the Urals on February 15, 2013. The fireball exploded above Chelyabinsk city, and the resulting overpressure caused damage to buildings and injuries to hundreds of people. Photo by Alex Alishevskikh.

to break apart high in the atmosphere and cause no damage. Experts are most concerned about objects ranging from tens of meters across to about 140 m—a size that could "devastate the better part of a continent," Holdren said.

Asteroid hunters are not sure exactly how many such asteroids are out there, but they have developed estimates by observing the part of the asteroid belt they can see with ground-based telescopes.

Former astronaut Rusty Schweickart, who helped found the B612 Foundation, compares the process to estimating crops on a farm: "You take a one-square-meter plot of typical land and you count all the mushrooms in one square meter and you multiply," he says.

NASA estimates there are 13,000-20,000 asteroids in the 140-m class. Observers have found only about 10% of them. When a new asteroid is reported, the finding is sent first to the Minor Planet Center at the Smithsonian Astrophysical Observatory, then on to NASA JPL to be charted on its Near Earth Object Program Web page.

The numbers sound scary, but Holdren emphasized that the threat has to be kept in perspective. An asteroid like the one that released 440 kilotons of energy over Chelyabinsk is a once-in-a-century event, he said. An asteroid like the one that released 15 megatons of energy over Siberia's Tunguska region in 1908 is expected only once in a thousand years.

Damage to a building belonging to the Chelyabinsk Zinc Plant company was a result of the 2013 Russian meteor event.

If such an event happened over an urban area, there would be hundreds of thousands of casualties. "But the probability of this occurring is much smaller than the one-in-a-thousand-year probability," Holdren said. "That is because land covers only 30% of the area of the Earth, and urbanized areas cover only 2-3% of the land area."

Of course, it is not as if fate has to wait a thousand years. A fact of odds-making is that a '500-year flood' can happen in successive years, noted Rep. David Schweikert (R-Ariz.).

Deflection techniques

No one has ever deflected an asteroid, but the community has a sense of the options available and the conditions under which they might be used. The closest thing to a demonstration took place when NASA's Deep Impact probe intentionally slammed into the comet Tempel 1 in 2005. That demonstrated all of the components for one kind of deflection, a kinetic impactor, Johnson says.

"The most likely technique to be used to deflect an asteroid would be a kinetic impactor, where you hit it with enough force to change the velocity by a few millimeters or centimeters per second," he adds. If that could be done when the object is still a couple of years away, the tiny change in velocity would be enough for the object and Earth to miss each other in their orbits.

Given enough time and a relatively small asteroid, another option would be to hover a spacecraft close to it and use the craft's gravity to change the asteroid's orbit slightly, a concept called the gravity tractor, says Johnson.

There is also a last resort for that asteroid that eludes detection until it is only weeks out. It is not the prayer that Bolden told the House committee he would recommend saying. A rocket or rockets with nuclear weapons would be sent into space.

"Probably nuclear energy is what we're talking about," Air Force Gen. William Shelton told the House committee.

The blast, however, would be intended to change the object's trajectory, not blow it to bits. Fragments might still be big enough to cause damage on the ground, and debris could damage communications and military satellites.

Lu examined deflection techniques before his organization switched gears to focus on detection. "True, [deflection] has not been tested, and we firmly believe someone ought to test these things before you have to use them for real. But there doesn't seem to be any sort of physical question about whether or not this is going to work,"

he said to explain the shift. "You can't deflect anything that you don't know exists yet, so you've got to do detection first."

In his view, the gravity tractor would be applied to refine a deflection. "You do what's called a primary deflection to make it miss, and then you need to go back in and make sure that you haven't just put it in a return keyhole," he said, meaning an orbit that brings the asteroid back on collision course a few years later.

Who's the boss?

The administration believes it has done enough to define who would be in charge if an asteroid were suddenly discovered to be bearing down on Earth and possibly the U.S. Holdren said the answer will depend on the asteroid.

"For some deflection missions, you'd want NASA to be in charge. For other kinds of deflection missions, you would want DOD to be in charge," he said. "It does not make sense from a standpoint of the mitigation mission to specify in advance which agency would do it."

The idea of the government sitting down in the midst of a crisis to decide who would do the deflection has been unsettling to some in Congress.

"We got about three or four minutes of chatter but we never got an answer about who's in charge," Posey said. "A good part of the population thinks it's just a matter of calling Bruce Willis in." Posey recommended that the White House establish a clearer protocol and present it to Congress.

As it stands, the Defense Dept. has no role in detecting asteroids. Military and intelligence satellites look earthward or at other satellites.

"We are focused on things in Earth orbit," as Shelton put it. He said there might be "serendipitous times" when a sensor spots something that would be helpful to asteroid hunters but that this would be rare.

One thing is certain: The issues are in clearer focus because of February 15.

"The most important question we have to answer about the solar system is, where is the next rock that's going to hit us?" Globus said. "There are other really interesting and important problems, but this is the most important one."