

Close Encounters of the Worst Kind: How Safe Are We from Killer Asteroids?

Largest near-Earth objects are already well characterized, but smaller ones could surprise

By John Matson, Scientific American

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In 1998, the year *Deep Impact* and *Armageddon* duelled for the attentions of apocalypse-from-the-heavens moviegoers, Congress tapped NASA to prevent such a cosmic cataclysm from becoming reality. The space agency was charged with cataloguing over the next decade the vast majority of nearby space objects larger than 0.62 mile (one kilometer) in size—those asteroids, and more rarely comets, capable of inflicting catastrophic damage to Earth.

Eleven years later—just behind schedule—the task appears to be nearly complete. Congress had requested that 90 percent of these large near-Earth objects (NEOs) be catalogued, and around 800 of them, roughly 80 to 85 percent of the entire population, have been tallied. (Astronomers can estimate how much of the lot has been surveyed by studying the gradual drop-off in discovery rates.) According to NASA's impact-threat catalogue, only two of the kilo-



BIG BUT RARE: Luckily for us, meteorite impacts such as the one that formed 45-mile-wide Manicouagan Crater in Canada are quite infrequent. NASA

meter-size NEOs so far identified pose a very slim risk in the next century; the more threatening of the two has a one in 116,000,000 chance of colliding with Earth. (That object, known as 2009 CR2, was just discovered last week; with further observation it may prove not to be a threat at all.)

Now sky sentries are turning their gaze to smaller NEOs. In 2005 Congress asked NASA to extend its survey to include objects as small as 460 feet (140 meters) across—not dinosaur-killers but still big enough to outdo the largest nuclear weapon ever tested if they ever cross paths with Earth. "The objects that people who have studied the risk from this sort of thing are worried about are the 300-meter [1,000-foot] class of objects," says astronomer Edward Beshore, co-investigator for the Catalina Sky Survey (CSS) at the University of Arizona, currently the most prolific NEO-finding program. "They could create regional destruction. A 300-meter object landing off the western coast of the U.S. could inundate coastal cities" with a massive tsunami, Beshore adds.

The task will be complicated by the sheer number of such objects and by their diminished brightness—smaller asteroids and comets reflect less light and so more easily escape detection. "Like gravel in a

stream bank, there are more smaller objects than there are larger objects," Beshore says. "And so we expect to find something on the order of 50,000 to 60,000 [near-Earth] objects down to 140 meters in size." So far, only 4,000 or so NEOs in that size range have been tracked down.

Astronomer Donald Yeomans, manager of NASA's Near-Earth Object Program office, says officials are studying the best way to tackle the 140-meter challenge: Should efforts be focused on ground-based observations, as they have been in the kilometer-size census? Or, would a space-borne infrared telescope be more effective? Whatever the case, Beshore says, better instruments are needed to meet Congress's request that 90 percent of the smaller group be tracked by 2020. "With the systems that are currently online," he says, "you'd be looking at decades before you could begin to approach finishing that problem."

An even more intractable problem would be locating the plentiful NEOs in the 30-meter-plus range, which probably number in the millions. According to Clark Chapman, a space scientist at the Southwest Research Institute in Boulder, Colo., the odds of our planet encountering one of those bodies in the next century might be as high as 50 percent. Such an object would not impact the ground but would produce a multimegaton airburst in the lower stratosphere, Chapman says. Over a populated area with flimsy structures, that could be deadly, but in the more likely event of an explosion over the ocean, the effects would be relatively minor.

At present, the most threatening known asteroids all have a relatively low probability of ever striking Earth. One small body called 2007 VK184, which is 130 meters (425 feet) in diameter, has about a one in 3,000 chance of smacking into the planet in 2048. A much larger asteroid known as 1999 RQ36, 560 meters (1,800 feet) across, packs a more significant impact probability of one in 1,400, but not for another 160 years. It's worth noting that over time these odds of impact are often revised, sometimes negating the objects' threat entirely, as further observations better define NEO orbits or as those orbits are deformed by the gravitational pull of celestial bodies.

"That's one of our main problems—as soon as you make a very close approach to a planet, including Earth, the subsequent motion gets much less certain," Yeomans says. "The small errors you have in the orbit get magnified as a result of the close approach."

One tiny asteroid that did strike, burning up on entry, provided a test of CSS and NASA's efforts. In October, a CSS observer picked up a relatively common two-meter (six-foot) object at close range, and astronomers correctly predicted that it would disintegrate over northern Africa the next night. Although last-minute discovery of a larger NEO would be problematic for evacuations, Yeomans notes that being able to pinpoint the location of a brilliant fireball even hours in advance can have great geopolitical value. Armed with accurate NEO information, scientists can warn "countries that might be arguing with one another that this kiloton blast in the sky is not a man-made event," he says. "What if this thing were spotted over the border between Pakistan and India? It could have been a real problem had it not been predicted ahead of time."

For larger inbound NEOs, of course, early detection might allow human intervention to skirt catastrophe. Fulfilling lawmakers' mandate for tracking 90 percent of 140-meter objects would "retire 99 percent of the risk to Earth from all objects of all sizes," Yeomans says. "By retire, I mean, if we know they're coming and they pose a threat, we have the technology to deal with it"—options include detonation or disrupting the object's orbit by ramming into it or tugging it off-course with a nearby spacecraft. "There's any number of ways to mitigate," he says, "but you have to find them well in advance of a threatening encounter in order to undertake any of them."