Crash course

Can NASA learn enough about an approaching asteroid to rule out a collision in 2036?

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Dan Durda illustration
Using gravity as a towline, a proposed "tractor" diverts an asteroid from a collision course with Earth.

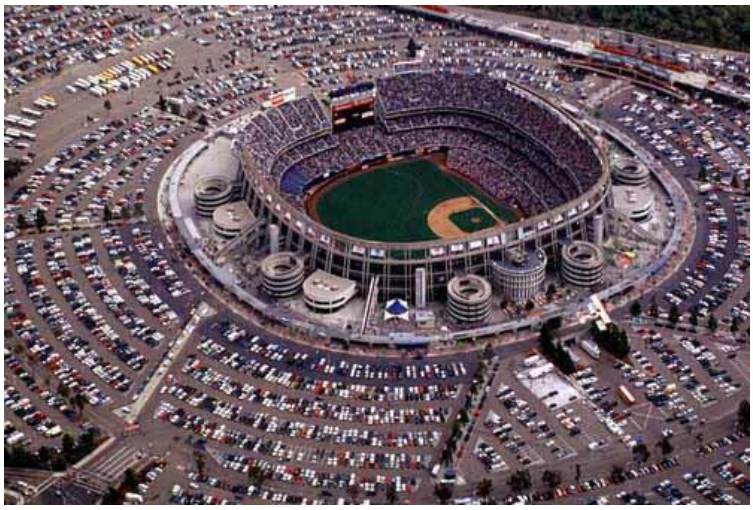
Shortly after sunset Friday, April 13, 2029, if the sky is clear enough, people across Europe and North Africa will see an asteroid appear as a bright point of light flying 19,400 miles overhead before it disappears silently below the western horizon.

A short time later, if astronomers' worst fears are realized, the asteroid will pass through a region of space less than 2,000 feet across. At that place, the gravitational pull of Earth will yank the asteroid into a new orbit around the sun – and on a collision course with Earth seven years later.

It all sounds like the premise of “Armageddon,” “Deep Impact” or some other blockbuster Hollywood film. But the asteroid, named 99942 Apophis, is science fact, not science fiction. In December 2004, astronomers caused a brief stir when their calculations estimated that the newly discovered asteroid – named after the ancient Egyptian god, Apep, the Destroyer – might collide with Earth in 2029.

Additional tracking data quickly ruled out the possibility of a 2029 collision. But the potential for a strike in 2036, should the asteroid enter that crucial gravitational space, places it at the top of NASA's list of 3,800 near-Earth asteroids the agency has identified.

Based on the latest information, the asteroid, which is nearly twice the size of Qualcomm Stadium, has a 1-in-6,250 chance of colliding with Earth on April 13, 2036.



Qualcomm Stadium (a circle with a diameter of 72 meters or 122 acres)

“We're very concerned that people put this in perspective,” said Russell Schweickart, a former Apollo astronaut and head of a foundation that focuses public attention on the threat from asteroids and comets.

“This is not something to lose sleep over, (but) it is something the government needs to attend to.”

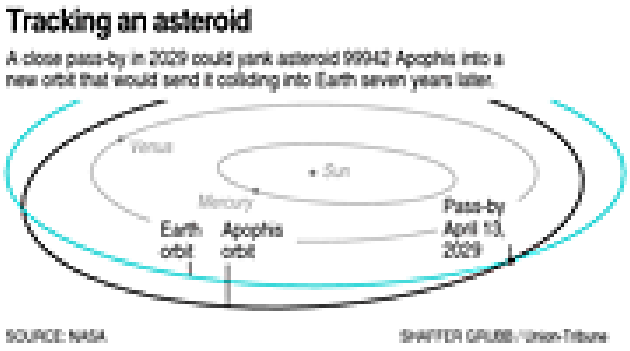
Right now, NASA is doing little more than looking for asteroids and keeping track of them, Schweickart said. Plans to deflect Apophis, if it becomes necessary, exist only in the pages of a few academic papers.

Last year, Schweickart's group, the B612 Foundation – named for the asteroid in the book, “The Little Prince” – corresponded with NASA officials about the threat of Apophis.

“It would have devastating consequences if it hit,” Schweickart wrote. “There is the serious question of whether, if it is headed toward impact, we will know enough to make a timely decision.”

Schweickart and other scientists urged NASA to place a data-tracking radio transponder on the asteroid's surface by 2014.

A transponder would help nail down orbital alterations caused by a phenomenon called the Yarkovsky effect. This is produced when an asteroid absorbs energy from the sun and re-radiates it back into space as heat. With one side of the asteroid lit and the other in darkness, the imbalance in thermal radiation produces a tiny acceleration. A transponder would help scientists understand how the Yarkovsky effect is influencing the asteroid's orbit.



Tracking an asteroid

NASA responded to the urging with a wait-and-see proposal. “We conclude a space mission based solely on any perceived collision hazard is not warranted at this time,” wrote Mary L. Cleave, associate administrator for NASA's Science Mission Directorate.

The agency believes continued optical and radio telescope observations will rule out Apophis as a threat. If not, NASA would launch a mission to the asteroid by 2018. A radio transponder, placed either in orbit or on its surface, would determine the asteroid's position in 2029 down to a few hundred feet, according to NASA.

If an impact seems probable, a rocket would be launched to deflect the asteroid. The design phase would have to be completed by 2020 in order to launch by 2024, NASA noted.

Schweickart said he doesn't necessarily disagree with NASA's analysis, as long as the agency can design, build, launch and successfully complete such a mission before 2029. “The danger is being overly optimistic about how long it takes to do that.”

If a deflection mission becomes necessary, scientists agree, it will need to be completed before 2029 when Apophis would commit itself to a future collision course. Due to the physics of gravity and orbital mechanics, delaying action would require much, much more energy to move the asteroid.

“That (will be) an impossible task, I'll tell you right now,” Schweickart said.

Cosmic pinball

The threat of an asteroid strike has always been with us. More than four billion years ago, a lot of debris was left over after the ring of gas and dust swirling around a young sun coalesced into planets and moons.

During a close encounter, the larger object – a planet, for example – can yank the smaller one – an asteroid – out of its orbit. As the two part ways, there is a slight chance that the asteroid will pass through a region of space – astronomers call it a keyhole – where the planet's gravitational pull can alter the asteroid's orbit, setting them on a future collision course.

The physics of this “keyhole” phenomenon are well-understood.

“Based on current knowledge of the orbit of Apophis, we cannot exclude the possibility of it passing through a keyhole and hitting Earth on a subsequent pass,” NASA scientist David Morrison concluded in an article last summer.

Most of the rubble in the solar system is the size of pebbles, even smaller. When these bits collide with Earth, they burn up high in the atmosphere and appear from the ground as streaks of light – shooting stars.

But there are others much, much larger.

Scientists estimate that an asteroid about 7.5 miles in diameter struck the Yucatan Peninsula 65 million years ago, causing or at least contributing to the extinction of the dinosaurs and reshaping evolution.

The consequences of such a strike today remain staggering. “Material thrown out of the Earth's atmosphere would rain back toward the ground, filling the sky with blazing fireballs and incinerating an area perhaps as large as India or twice the size of Europe,” suggests Mark Chapman, an astronomer at the Southwest Research Institute in Boulder, Colo. Dust from such a blast would block sunlight for many months, killing plant and animal life.

In 1998, Congress directed NASA to find and track, by 2008, 90 percent of inner solar system asteroids more than two-thirds of a mile in diameter. Of 3,800 or so asteroids now tracked by NASA, 824 are in this category, but none appears to pose a threat to Earth for at least another 100 years.

Astronomers estimate there may be hundreds of thousands of asteroids in the inner solar system that are much smaller. Of the 3,800, 748 are designated “potentially hazardous” because they come within 4.6 million miles of Earth's orbital path and are larger than 500 feet in diameter. Apophis, at 1,050 feet, is one of these.

Chapman has estimated the chances of a strike by an asteroid more than two-thirds of a mile in diameter during this century at 0.02 percent, and a smaller one like Apophis at 0.2 to 1.0 percent.

If Apophis assumes a collision course, it would crash into Earth's atmosphere at about 28,000 miles per hour and explode with a force of an 870-megaton blast – an explosion 58,000 times more powerful than the bomb dropped on Hiroshima.

Apophis would likely hit along a narrow corridor in the Pacific Ocean, sending monstrous tsunami waves toward the West Coast, the B612 Foundation has estimated. Immediate damage in the U.S. – independent of deaths and subsequent economic fallout – could top $400 billion.

Gravity tow

Two astronomers have proposed an alternative to such a catastrophe.

Edward T. Lu and Stanley G. Love of NASA's Johnson Space Center suggest parking an unmanned spacecraft beside a threatening asteroid – in essence flying in formation with the rock.

Any object with mass exerts gravity, so the spacecraft – without touching the asteroid – could over time drag the asteroid slightly off its orbital path.

“The spacecraft will simply hover above the surface,” Lu and Love wrote in *Nature* in November. “The spacecraft will tow the asteroid with no physical attachment, using gravity as a towline.”

A one-ton gravitational tractor could sufficiently divert Apophis outside the keyhole by hovering next to it for about a month, Lu and Love said.

A gravity tow approach would avoid the risks associated with pushing or crashing into the asteroid, which might destabilize it and break it apart.

“It's a completely controlled deflection method,” Schweickart said.

As scientists ponder that proposal, time marches on toward 2029 and 2036. Beginning this year, astronomers will lose visual and radar contact with Apophis, and the asteroid will not become visible again until 2013.

“We'll go many years with basically no additional information on where it's headed,” Schweickart said.

Schweickart, Chapman and others have noted that for the first time in history humans have the ability to do something about this impending threat now 40 million miles from Earth.

“An impact can be predicted in advance in ways that are imperfect,” Chapman wrote. “(But) in contrast with the dinosaurs, human beings have the insight and capability to avoid extinction.”

Whether they will do that is not yet clear, Schweickart said. This month he plans to speak about the issue at a United Nations meeting in Vienna and is continuing discussions with NASA. Even if Apophis eludes Earth, he emphasizes, it won't be the last dangerous asteroid headed for Earth.

“We need to know about them, and at the same time we need to be developing the technology (to divert one), and somebody needs to be in charge,” he said.

“I can say that till I'm blue in the face, but it doesn't make any difference if there isn't anybody with the responsibility to do it.”