Barringer Meteor Crater in Arizona is the scar of an asteroid hit from less than 50,000 years ago.

In 2004, as a massive tsunami roiled through the Indian Ocean killing hundreds of thousands of people, a dozen or so scientists quietly confronted an impending disaster potentially even more lethal. They had inside intelligence that a chunk of rock and metal, roughly 1,300 feet wide, was hurtling toward a possible collision with the most populated swath of Earth—Europe, India, and Southeast Asia. Furiously crunching numbers on their computers, the researchers put the odds of impact in the year 2029 at exactly those of hitting the number in a game of roulette: 1 in 37.

“We usually deal with one chance in a million,” recalls Steven Chesley at NASA’s Jet Propulsion Laboratory in Pasadena, California. “This was absolutely extraordinary—I didn’t expect to see anything like it in my career.” By the end of the day on December 27, 2004, to the relief of the observers, archival data turned up trajectory information that rendered the odds of a collision nil. Nonetheless, in 2029 the asteroid, dubbed Apophis—derived from the Egyptian god Apep, the destroyer who dwells in eternal darkness—will zoom closer to Earth than the world’s communications satellites do. And April 13, 2036, it will return—this time with a 1-in-45,000 chance of hitting somewhere on a line stretching from the Pacific Ocean near California to Central America.

Because Apophis was discovered during one of the world’s greatest natural disasters, the worries about the impact went largely unnoticed. But that tense day, December 26, 2004, stunned the small group of astronomers who dutifully detect and plot trajectories of hundreds of thousands of the millions of chunks of rock whizzing around the solar system. Though too small to end civilization— unlike the asteroid that may have doomed the dinosaurs—Apophis could pack a punch comparable to a large nuclear weapon. Traveling at 28,000 miles per hour, it would heat up as it passed through Earth’s atmosphere, turning the dark rock into a fiery sun as it arced across the sky. Then it would either explode just aboveground—as one most likely did in 1908, leveling a vast forest in the Tunguska
region of Siberia—or gouge a crater 20 times its size. “If it hit London, there would be no London,” says Apollo 9 astronaut Rusty Schweickart, who had closely followed the discussion of the potential 2029 impact. Slamming into the ocean, Apophis could create a tsunami dwarfing the one that killed more than 200,000 people around Indonesia.

Apophis is one of millions of asteroids roaming the solar system. None are known to pose an immediate threat, but some are bona fide civilization stompers. A monster rock discovered just this year, with the prosaic name of 2007PA8, is more than two miles across, large enough to wipe out most of humanity. Fortunately, the odds that it will hit are essentially zero. Smaller asteroids are less deadly but much more common. Planetary scientists now estimate that 150-foot-wide space rocks, comparable to the one that hit Tunguska, strike only once every thousand years or so. For a brief time in 2004, just months before the Apophis scare, astronomers feared that a 150-foot-wide asteroid was just days away from racing into the atmosphere. Fast-paced observations allowed them to calculate a more exact orbital path, which took it far from Earth.

After a number of false starts, such potential close calls have finally caught the attention of the U.S. Congress. At the request of lawmakers, scientists are struggling to pinpoint 90 percent of all seriously life-threatening asteroids by 2020 in order to assure at least some warning. The European Space Agency is contemplating a mission to test ways to push such an object off a threatening trajectory, the first serious attempt at developing a planetary defense.

But a group of astronauts, led by Schweickart, also wants their respective countries and the United Nations to prepare for avoiding a hit. “We’re living in a shooting gallery,” he warns. “We’ve evolved to the point where we can do something about this threat. We can either close our eyes as we cross the street and not know what we’ve dodged, or we can open our eyes and act accordingly.”

Amid fears about global warming, terrorism, disease, and nuclear proliferation, the threat of rocks from space may seem more the province of bad Hollywood movies than front-page news. Even professional astronomers have long dismissed asteroids as undistinguished flotsam and jetsam, would-be planets that circle the sun endlessly in a belt between Mars and Jupiter. Their derision left the field of asteroid hunting largely to amateurs and eccentrics.

Only recently have researchers glimpsed the dangers lurking in our deceptively quiet neighborhood. “Impacts are a fact of life in the universe, but when we look up, it’s not what we see,” says Carolyn Shoemaker, who, together with her late husband, Gene, pioneered ways of spotting asteroids and comets. It was geologists who first noticed the evidence of huge impact craters on Earth that had formed long after the solar system settled into its present form, prompting biologists to speculate on whether those collisions dramatically altered life’s evolution. Later, using new technologies on the ground as well as robotic spacecraft, scientists like Shoemaker started to track, catalog, and closely examine the objects.

With each new sighting, asteroids turn out to be far more varied, unruly, and bizarre than astronomers dreamed. Many have companions. Some are rubble heaps held together only loosely by their own gravity. Others are extremely dense nickel-iron objects. Their colors can range from a deep dark chocolate to a glinty white. Even the old distinction between comets (dirty snowballs) and asteroids (hard rocks) has become blurred. Some comets eventually turn into asteroids as they burn off their ice and lose their tails while traveling through the warm inner solar system. And comets—which mostly reside in the solar system’s far fringes—pop up occasionally in the asteroid belt. They may even be directly responsible for life on Earth. Donald Yeomans, who calculates the orbits for near-Earth objects at NASA’s Jet Propulsion Laboratory, says that comets flung out from that belt pummeled our planet.
shortly after its formation and could have left behind water, possibly creating the conditions that allowed Earth to become a cradle for life.

The vast bulk of asteroids—millions of individual objects ranging from 560-mile-wide Ceres to pea-size pieces of space shrapnel—reside in a broad zone between the orbits of Mars and Jupiter, the legendary asteroid belt. If pulled together, all this material would form a mass smaller than Earth’s moon, but the immense gravitational force of Jupiter prevents the bits from coalescing into a solid planet. When the rocks approach Jupiter, the occasional asteroid can find itself pushed out of the procession and into deep space; some spin out beyond Pluto’s orbit, while others fall toward the sun, each with its own unique orbit. Some even find a home around other planets. Mars’s two moons, Phobos and Deimos—along with several of Jupiter’s and Saturn’s satellites—may be captured asteroids.

What most interests and worries scientists like Chesley and Yeomans, however, are near-Earth asteroids—those with orbits disconcertingly close. Members of this class apparently ushered the dinosaurs off the evolutionary stage 65 million years ago and left a three-quarter-mile-wide hole in the Arizona desert less than 50,000 years ago. A few scientists think a near-Earth asteroid on a bull’s-eye path might even have reshaped human history (see “Did a Comet Cause the Great Flood?”).

Somewhere in space, one of their kind is orbiting its way to an inevitable rendezvous with Earth: The question isn’t if we will be struck again, but when. There are scattered reports of deaths by meteorites through recorded history, like a Chinese chronicle asserting that thousands died during a 1490 meteor shower. One prediction is indisputable: With growing populations comes greater risk. Had the 1908 impact in Siberia landed in an urban area, for example, it would have been as devastating as the 2004 Indian Ocean tsunami.

Yet it wasn’t until the early 1970s that anyone seriously pursued how to track these potentially deadly objects. A few pioneers like the Shoemakers began to catalog the faint smudges on the glass plates they used to photograph the night sky. University of Arizona astronomer Tom Gehrels revolutionized that work by turning to charge-coupled devices, or CCDs—electronic light detectors, now common in cameras—to gather much better data than was possible using plates. In 1992, NASA set up the first formal effort to detect near-Earth asteroids.

The race was on, and it swept up a new generation of scientists, like Tim Spahr. As a graduate student at the University of Florida in Gainesville in 1996, he and fellow student Carl Hergenrother noticed an asteroid the length of two football fields heading almost directly toward Earth. Further calculations showed that the object, named 1996 JA1, would pass by at less of a distance than the moon is from Earth, spawning the first widespread media coverage of an asteroid threat. “It’s the reason I have my job,” says Spahr, now director of the Minor Planet Center run by the Smithsonian Institution and Harvard University in Massachusetts. “And it changed everything.”

Just two weeks after Spahr’s asteroid whizzed by, researchers at the MIT Lincoln Laboratory, given the task by the military of spotting enemy spy satellites, unveiled a novel approach for monitoring large areas of the sky using sophisticated software. The MIT group found nearly 50 asteroids within a couple of months—far faster than their competitors. “Soon the other surveys were getting their butts kicked,” recalls Spahr, who joined one of two University of Arizona teams rushing to incorporate the latest technology into their efforts.

The sudden popular interest had some embarrassing side effects. Hollywood went to work on a series of moderately ludicrous disaster movies—Deep Impact, Armageddon, and Asteroid (featuring the other guy from The Terminator). But there was also tangible progress. In 1998, Congress ordered NASA to spot all near-Earth asteroids two-thirds of a mile in diameter and larger—the ones that scientists say could wipe out civilization—by 2008. Meanwhile, the world’s space agencies began to bring their expertise to bear on the problem. Just a few months before Spahr’s discovery, NASA launched NEAR (for near-Earth asteroid rendezvous), a spacecraft to visit the near-Earth asteroid Eros. (Gene Shoemaker died while the probe was en route, and NASA renamed it NEAR-Shoemaker.) Arriving in 2000, the probe orbited for a year before controllers crashed it into Eros—but not before it sent back tens of thousands of detailed images of the 20-mile-wide banana-shaped asteroid. Eros’s surface—boulder strewn, heavily cratered, strangely smooth—was a geologic puzzle.

The Japanese got in the game too. In 2005, the Japanese probe Hayabusa hovered a dozen miles away from a lumpy asteroid named Itokawa, then collected some material in anticipation of a 2010 return to Earth. Radio contact with the probe was lost for a while, however, and it is uncertain whether it will return to Earth.

By 2005, lawmakers in Washington asked NASA what it would take to be able to spot 90 percent of near-Earth asteroids more than 460 feet in diameter by 2020. Astronomers say that incoming asteroids smaller than that would have a regional, rather than global, effect; ones that are less than about 180 feet are likely to disintegrate in the atmosphere. “There aren’t very many huge objects, so you don’t get hit by them very often,” Spahr says. “But as you get smaller, there are more and more.”

Finding smaller asteroids requires a whole new level of technology, and NASA is struggling to find ways to deliver the information Congress requested. Some astronomers have proposed a satellite orbiting near Venus that could easily spot asteroids that are hard to see from the ground. But NASA is in a budget crunch, so space-rock hunters are pinning their hopes on two earthbound projects. The National Science Foundation plans early in the next decade to build the Large Synoptic Survey Telescope with a 28-foot mirror. Meanwhile, aided by pork-barrel money won by a Hawaiian senator, work is under way on Pan-STARRS, a set of telescopes to be sited on Mauna Kea that will cover most of the sky every few nights down to a dim 24th order of magnitude. When these telescopes see light within the next few years, the result will be dramatic. David Morrison, a leading impact researcher at NASA’s Ames Research Center in California, predicts a hundredfold increase in discoveries, which will make Schweickart’s shooting gallery metaphor more believable. “We tend to find one scary asteroid a year,” Morrison says. “Soon it will be one a week!”
The details of Apophis’s discovery in 2004 showcase the evolving art of asteroid detection. Roy Tucker, David Tholen, and Fabrizio Bernardi spotted the object while trolling the skies at the University of Arizona’s Steward Observatory on Kitt Peak. Fans of the TV series Stargate SG-1, the three astronauts named the asteroid after an alien intent on destroying Earth. Science fiction, however, quickly took a turn toward reality show. At the Minor Planet Center—which absorbs asteroid data from all over the world—Spahr’s colleague Kyle Smalley took a closer look at the object’s path. “All the main-belt asteroids move across the sky in a procession,” he says. “And this thing was stepping out of line in this parade, so it caught my eye. It was obvious this thing was coming close to Earth.”

Across the continent at JPL, Steven Chesley began to fine-tune the orbit. On December 20, he placed the odds of a collision at 1 in 5,000. Three days later, with more data, those odds grew to 1 in 250. “We kind of missed Christmas that year,” he says. The odds kept getting higher as he analyzed the trajectory more thoroughly. By the day after Christmas—the day of the Indonesian tsunami—the odds reached an alarming 1 in 37. The researchers quietly plotted the likely plane along which the asteroid would pass but did not release the information to the media. If that plane intersected Earth, then the impact area would lie somewhere along a narrow band crossing the North Atlantic, Europe, and southern Asia. “We know there is an asteroid out there with our name on it,” adds Chesley. “We just didn’t expect to find one so soon.”

Then researchers poking around in the University of Arizona’s Spacewatch survey archives came to the rescue. An observation made earlier in the year shifted the asteroid’s projected path just enough to one side to spare Earth. “That ruled out the possibility of an impact conclusively,” Chesley says. He and the handful of other scientists breathed a sigh of relief. But like every near-Earth asteroid, Apophis will keep orbiting, so the risk will not go away. Although the next pass has only a 1-in-45,000 chance of colliding, future encounters could pose a greater risk. Calculating odds farther ahead is extremely difficult, though, because so many slight gravitational influences change an asteroid’s path over time.

Schweickart was deeply shaken by the Apophis experience. “I don’t know how to transmit to you the emotion, the level of intensity of a group of people you could name on two hands during those days in December 2004,” he says. His interest in the asteroid threat extended back to 2001, when he and a few colleagues sat down at NASA’s Johnson Space Center in Houston just six weeks after the terrorist attacks on New York and Washington to discuss ways to deflect an incoming asteroid. That led to his founding an organization named for the asteroid that was the home of Saint-Exupéry’s Little Prince—the B612 foundation. Its goal is to alter an asteroid’s orbit in a controlled manner by the year 2015.

Since the first serious asteroid scare in 1996, astronomers have pondered a multitude of ways to deflect an incoming rock. Some researchers suggest sending nuclear weapons, Hollywood-style, to blow up the asteroid; others propose a simple crash landing that would shove the body into a slightly new orbit. Another method would unfurl mirrors that would vaporize part of the rock. Two spacecraft—NEAR-Shoemaker and Hayabusa—have already played tag with asteroids, while another has experimented with shooting a projectile into a comet. Most of the proposed defense methods would require careful study of an asteroid’s composition—you might simply create a rocky doughnut by trying to blast one apart.

The European Space Agency recently took these ideas into a more concrete direction by releasing a concept for a spacecraft called Don Quixote that could push at an asteroid while another spacecraft (called Sancho, of course) hovers nearby to monitor any change in its orbit. Schweickart and his colleagues propose instead that a space tug could rendezvous with an asteroid and change its trajectory simply by using the probe’s gravitational pull. The advantage to this approach, he says, is that you don’t need to touch the asteroid or ascertain its makeup to move it out of a dangerous trajectory. The
disadvantage is that the tug lacks muscle and could make only small adjustments to the orbit. The former astronaut has so far made little headway within NASA—which is focused instead on returning men to the moon—or even among many scientists who prefer to spend precious funds on asteroid detection.

So what would we have done if Apophis were on a collision course with Earth in 2029? Once Schweickart plotted the asteroid’s potential landfall, he suddenly realized the threat’s political and legal implications. If a city-busting rock were heading toward Iran, would the United States take the lead and spend billions of dollars to stop it? By nudging an asteroid off course, a probe would send it on a new trajectory. What if the probe could not complete the maneuver and shifted the threat elsewhere?

Such concerns led the ex-astronaut and Air Force pilot to tap members of an exclusive club he founded called the Association of Space Explorers—men and women who have, briefly, been near-Earth objects themselves. “This group of people can get the attention of national leaders all over the world,” Schweickart says. This January, the group wined and dined donors at a fund-raiser in Oakland, California, and they recently held a workshop in France, the first in a series to hash out a draft United Nations treaty to cope with the asteroid threat. To Schweickart, a matter of life and death trumps space science: “Do we really need to know more about a moon of Jupiter compared with being prepared to protect life on Earth?”

That attitude is bound to irritate a lot of space scientists. Yeomans, for example, insists that the three most important things to do are “find ’em early, find ’em early, and find ’em early.” NASA researchers have their own plan, the Near-Earth Object Program—the agency’s program to spot 90 percent of all potentially hazardous asteroids more than two-thirds of a mile wide that might hit Earth in the foreseeable future. Amateur astronomers, long major players in ascertaining the exact orbits of asteroids, are likely to play less and less of a role as professionals turn their powerful telescopes to the objects once considered too mundane for academics to study at all. One way or another, astronomers say they intend to find every sizable rock that might be rushing at Earth. By 2020, we should know whether we need to save ourselves from going the way of the dinosaurs. “We take our snapshot now,” Spahr says, “and we’ll be good for centuries.”