The Perils of Earth-Buzzing Meteors

By A. J. Smuskiewicz

At about 9:20 a.m., on Feb. 15, 2013, a sudden bright flash in the sky and an arching white vapor trail startled residents of the Russian industrial city of Chelyabinsk, in western Siberia. The flash was quickly followed by a frighteningly loud blast that shattered windows and windshields across the city. Car alarms blared. Cell phones went dead. More than 1,000 people were injured, mainly by shattered glass. About 50 of the injured had to be hospitalized. People were afraid, shocked, and puzzled. What had happened? At least one Russian politician claimed that the United States had launched a missile attack on Chelyabinsk.

But people soon discovered the real reason for the mayhem. A large rock from space—estimated to have been from 17 to 20 meters (56 to 66 feet) in diameter and weighing about 9,070 metric tons (10,000 tons)—had burned up as it entered Earths atmosphere at a high speed and shallow angle. The burn-up was visible as a *meteor* (a streak from a burning space rock seen in the sky). The friction of the atmosphere had caused the rock, possibly an asteroid, to explode and break up into smaller fragments about 32 kilometers (20 miles) above the ground. The explosion, equivalent to that of more than 300 kilotons (600 million pounds) of TNT, created a shock wave that spread to the ground and shook buildings. Some small meteorites (space rocks that fall to the ground) were reportedly found later in the area.

The explosive event over Chelyabinsk came as a complete surprise to everyone. Neither scientists nor military authorities had seen it coming.

Only about 16 hours after the Chelyabinsk event, an asteroid about 50 meters (165 feet) in diameter whizzed by Earth at a distance of less than 27,300 kilometers (17,000 miles). That is closer than the orbiting distance of many communications and weather satellites. Scientists were expecting that fly-by, because the asteroid—dubbed 2012 DA14—had been discovered, and its path projected, by astronomers in Spain in 2012.

The occurence of the two space events on the same day drew public attention to the scientific reality that Earth inhabits a hazardous cosmic neighborhood. A variety of objects orbit the sun along paths that regularly bring them close to Earth, with the potential to strike the planet. Some of these objects are *asteroids* (rocks from the Main Belt, between the orbits of Mars and Jupiter). Others are *comets* (icy bodies from deeper in the solar system). Still others are *meteoroids* (small fragments of larger objects). Scientists refer to all such objects as near-Earth objects (NEOs).

The extent of the threat posed by an NEO is directly related to its size. If an NEO has a diameter of 40 meters (131 feet) or less, it will probably break apart and burn up in the atmosphere because of the heat caused by atmospheric friction. The resulting explosion can be startling, but relatively little damage and only minor injuries are likely to result. The Chelyabinsk meteor fell into this category. According to NASA, such an explosive event occurs about once every 100 years. The Chelyabinsk event was the largest such explosion since the famous meteor explosion over a forest in Tunguska, Siberia, in 1908. That event left an area of flattened trees 48 kilometers (30 miles) in diameter.

An NEO with a diameter of from 40 meters to 1 kilometer (0.6 mile) would likely survive its ride through the atmosphere and crash into the surface. An impact on land, especially in a populated area, would almost certainly cause significant local destruction, including shattered buildings, fires, and injuries and deaths.

An NEO with a diameter of 2 kilometers (1.2 miles) or more has the potential to cause severe environmental and societal damage on a global scale. Dark clouds of dust and ash caused by an impact on land and the resulting fires could drift through the atmosphere for months, blocking sunlight. Temperatures would plummet, crops and other plants would be killed, and large numbers of people and animals could die of starvation during a so-called impact winter.

Scientists believe that an asteroid about 15 kilometers (9.3 miles) in diameter that slammed into the Yucatn Peninsula 65 million years ago led to a global apocalypse that wiped out the dinosaurs and many other forms of animal life. If a space rock of this size fell into the sea, the resulting tsunami (series of large ocean waves) would lead to enormous destruction from flooding.

Astronomers estimate that there are more than 1 million NEOs larger than 40 meters in diameter. Of these, there may be about 1,100 NEOs with a diameter greater than 1 kilometer. Astronomers had identified about 900 such large NEOs by 2013.

A number of countries were operating NEO identification and tracking programs in 2013. These programs consist of teams of astronomers who survey the sky with telescopes and cameras, hunting for NEOs and trying to calculate their orbital paths. In the United States, several individual programs receive funding from NASA as part of the space agencys Spaceguard program. Spaceguard was started in 1998, prompted by the collision of Comet Shoemaker-Levy 9 with Jupiters thick atmosphere four years earlier. That impact left dark bruises in the gas giants clouds and an imprint in the publics mind of the possibility of similar collisions with Earth. Some NEO observation efforts also receive funding from the U.S. Department of Defense.

As part of Spaceguard, the Lincoln Near Earth Asteroid Research (LINEAR) program, headquartered at the Massachusetts Institute of Technologys Lincoln Laboratory, has identified more than 2,400 NEOs since 1998. The LINEAR team observes the sky with two telescopes at the White Sands Missile Range in Socorro, New Mexico. That program was the most successful NEO-hunting operation until the start of the Catalina Sky Surveys, which have identified hundreds of NEOs every year since 2005. The Catalina astronomers make their observations with two telescopes at the University of Arizonas Steward Observatory near Tucson and a third telescope in Australia.

Another NASA project, the Jet Propulsion Laboratorys Sentry System, is an advanced computer system that automatically and continually scans the most current catalog of known NEOs, calculating the risk of impact of each NEO over the next 100 years. European nations, Australia, Japan, and China also fund NEO observation and risk-evaluation projects, and several of these countries participate in the Spaceguard effort. Even with all these observations and calculations, scientists can give only rough odds of when the next big NEO impact might be. The best predictions suggest that, on average, Earth is hit by one or two 2-kilometer-wide asteroids about every 1 million years. In other words, you have about a 1 in 40,000 chance of dying from such an event.

The main problem with these risk calculations is that many NEOs have not been discovered. So there is always the possibility—however remote—that one of those could catch us completely by surprise. And the surprise might be far more catastrophic than the Chelyabinsk event.

A project designed to provide us with greater certainty is the NASA-funded Asteroid Terrestrial-Impact Last Alert System (ATLAS), scheduled to be fully operational in 2015. ATLAS will consist of eight small telescopes equipped with high-resolution cameras that scan the sky from their base on the Hawaiian Islands twice a night for faint objects. The system, operated by University of Hawaii astronomers, is expected to provide a one-week warning of a close approach of a city-killer asteroid 45 meters (148 feet) in diameter, and a three-week warning of a county-killer asteroid 137 meters (449 feet) in diameter. Such warning intervals would theoretically provide enough time to evacuate people from expected impact sites and to prepare for possible tsunamis generated by ocean impacts.

Testifying before the U.S. Congress in March 2013, White House science advisor John Holdren argued that the single most useful project for keeping us safe from NEOs is the placement of an *infrared*- (heat-) sensing telescope in orbit around the sun near Venuss orbital position. From that perspective, the telescope could look back at Earth and discover NEOs in our neighborhood that are lost in the suns glare from the vantage point of Earth-based telescopes. The Sentinel Space Telescope, a privately funded project planned by Ball Aerospace and Technology Corp. of Boulder, Colorado, and the B612 Foundation of Mountain View, California, is designed exactly for this purpose. The leaders of this telescope project hoped to launch Sentinel as early as 2017.

A week after the unexpected NEO exploded over Chelyabinsk and 2012 DA14 made its close fly-by, a group of scientists affiliated with the United Nations (UN) attended a previously scheduled meeting in Vienna, Austria, to consider ideas on developing an international early warning system for NEOs. The fact that Russias sophisticated missile defense radar system—or any other space monitoring system—had not detected the incoming Chelyabinsk rock highlighted the gaps in the worlds NEO tracking capabilities. The preliminary plan approved by the UN Office for Outer Space Affairs subcommittee called for the creation of an International Asteroid Warning Network that would pool data from, and coordinate the efforts of, various NEO identification programs. The goal of the new network would be to identify all NEOs, issue early warnings of close fly-bys and potential impacts, and develop contingency plans to minimize damage should an impact be inevitable. The NEO warning network plan was expected to be submitted to the UN General Assembly for approval by late 2013.

But are evacuation and preparation for impacts the best we can do? What about those movies where astronauts fly to the threatening asteroid to blow it up? Many experts say we would need at least a 10-year warning to send a spacecraft to intercept an asteroid and strike it with conventional or nuclear weapons in an attempt to either destroy it or deflect it. Some scientists have been more imaginative. Researchers at the University of California-Santa Barbara and California Polytechnic State University had a plan on the drawing board in 2013 for a space-based solar-powered laser system that would zap and vaporize large NEOs.

To learn more about ways to deflect NEOs, the European Space Agency and NASA planned to launch the Asteroid Impact and Deflection Assessment (AIDA) mission in 2019. In 2022, one AIDA craft was to crash into the smaller of two asteroids that make up the Didymos binary asteroid (which poses no threat to Earth), while a second AIDA craft was to observe the impact. Scientists hoped that data from the mission would provide new insights into how asteroids might be successfully deflected from Earth-threatening paths. An even more ambitious NASA plan to learn about asteroids involves a proposed mission to capture an asteroid and move it into lunar orbit for study by astronauts in the 2020s.

There may be insurmountable problems with all plans to destroy or deflect threatening NEOs. Blasting a big rock with weapons could simply create a lot of small rocks, which would still threaten the planet. Moreover, a very large asteroid could have so much mass and momentum that it may be impossible to deflect. Yet another problem is that the gravitational effects of Venus, Mars, or other planets could alter the paths of incoming asteroids in unpredictable ways—throwing all carefully generated calculations out the window.

Some scientists argue that the large amounts of time, effort, and funding being devoted to plans to protect us from NEOs are wasteful. They point out that there exists no evidence that a major impact is going to happen in the foreseeable future, and they propose that scientific energies and public funds would be better spent elsewhere. Despite these arguments, further investigations into NEOs are planned. Hopefully, those investigations will reveal more precise estimates of the actual risks of impacts from large NEOs.