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Executive Office of the President of the United States
to the
Committee on Science, Space, and Technology
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(updated)

Chairman Smith, Ranking Member Johnson, and Members of the Committee, I am pleased to be here with you today to discuss the status and coordination of U.S. activities to detect, track, and characterize near-Earth objects (NEO) and to develop the capability to deflect any of dangerous size discovered to be on a collision course with Earth. This is a very timely topic — as underscored by the asteroid explosion over Russia on February 15 and the close flyby of an even larger asteroid the same day — and I am looking forward to sharing with you the Administration’s perspective on this issue.

I want to start by acknowledging the emphasis that the Congress has placed on understanding and mitigating the threat from NEOs. I thank you for working with the Administration to address this important topic. Through multiple pieces of legislation, Congress has provided direction to pursue enhanced NEO-detection activities and assign responsibility for threat mitigation.

The NASA Authorization Act of 2005 (in a section labeled the George E. Brown, Jr. Near-Earth Object Survey Act) directed NASA to detect, track, catalogue, and characterize 90 percent of all NEOs with a diameter of 140 meters or greater by 2020. This legislation extends Congressional direction from 1998 that tasked NASA with locating at least 90 percent of all NEOs with a diameter of one kilometer or greater — those judged by many experts to have the potential to threaten civilization — within ten years.

The one-kilometer goal was achieved in 2011, with statistical calculations indicating that more than 90 percent of near-Earth objects of this size had been found. The task of detecting 90 percent of NEOs larger than 140 meters is much more challenging, and I will describe the United States’ efforts on this front later in this testimony.

More-recent legislation has focused on government-wide preparations to address the threat of a NEO impact. The NASA Authorization Act of 2008 directed the Office of Science and Technology Policy (OSTP) to develop a policy for notifying Federal agencies and relevant emergency-response institutions of an impending threat; it also tasked OSTP with recommending a Federal agency or agencies to be responsible for protecting the United States from an expected NEO collision and implementing a deflection campaign, should one be necessary.

Building on the 2008 language, the NASA Authorization Act of 2010 called for OSTP to implement the policy on threat notification and assign a Federal agency or agencies to be responsible for protecting the United States in the event of a potential collision. In an October 2010 letter to this Committee, I reported that OSTP, in concert with the National Security Staff

(NSS) and the Office of Management and Budget (OMB), had developed an approach I'll outline later in this testimony for delegating responsibility and notifying Federal agencies and relevant emergency-response institutions of an impending NEO threat. In addition, the President's 2010 National Space Policy reinforced NASA's role to "pursue capabilities, in cooperation with other departments, agencies, and commercial partners, to detect, track, catalog, and characterize" NEOs.

Several Federal departments and agencies have significant roles in the pursuit of these goals and they cooperate in important ways. NASA sponsors various activities relating to the search for NEOs, including the collection and correlation of NEO orbit data, precision tracking and characterization of NEOs, and assessments of NEO orbits and impact probabilities in conjunction with other U.S. government agencies including the U.S. Air Force and other Department of Defense (DoD) organizations, the U.S. Department of Energy (DOE), and the National Science Foundation (NSF), each of which plays a key role in funding ground-based astronomical assets that are used to detect and track NEOs.

BACKGROUND

Near-earth objects (NEOs) are defined as those non-manmade objects in space whose orbits bring them within a set distance of the Earth generally equivalent to approximately 50 million kilometers (31 million miles), with a portion of these objects traveling sufficiently closer to make an eventual collision a possibility. The larger NEOs (those with a maximum physical dimension of more than a meter¹) are generally referred to as either asteroids or comets, while smaller objects are referred to as meteoroids. Large or small, they are all called meteors upon fiery transit of Earth's atmosphere. When pieces of a meteor survive transit through the atmosphere to strike the surface of the Earth, they are called meteorites.

Every day, a continual influx of these objects strikes Earth's atmosphere. Most of them are dust-sized particles, but they add up; it's been estimated that on a typical day, these particles total from 50 to 150 tons of matter. Asteroids of the order of a few meters in size strike the atmosphere roughly annually. Damage on Earth's surface is likely only when the kinetic energy of the object – the energy it carries by virtue of its mass and velocity when it enters the atmosphere – is in the range of a few hundred kilotons of TNT equivalent or above. (By comparison, the Hiroshima atomic bomb was roughly 13 kilotons of TNT equivalent.) Asteroids with this much energy are thought to strike the Earth only every 100 years or so. The more frequent, less energetic ones generally deposit that energy high enough in the atmosphere that no effects are felt at Earth's surface.

Asteroids can be divided into three broad categories on the basis of their composition: carbonaceous, stony, and metallic. Metallic asteroids are denser than the other varieties and therefore have greater destructive power, being both more massive for a given size and less likely to disintegrate during atmospheric entry. Stony asteroids are the most common variety; at a typical

¹ Only the largest asteroids — those few with diameters in the range of hundreds of kilometers — are spherical. Smaller ones are of irregular shape.

approach velocity of 16 kilometers per second² (36,000 miles per hour), a stony asteroid would have to be around 20 meters in size to deliver the few hundred kilotons of TNT equivalent needed to do significant damage at the surface. (The asteroid that exploded over Chelyabinsk on February 15 is estimated to have been about 17 meters in size.)

The 1908 explosion over Tunguska in Siberia, which leveled trees over an area of more than 2,200 square kilometers (850 square miles), is thought to have been caused by a stony asteroid between 45 and 60 meters in diameter, imparting between 10 and 20 megatons of TNT equivalent. Such a strike is believed to be a once-in-a-thousand-year event (or, put differently, having a 1 in 1,000 chance of occurring in any given year). An energy release of this size could cause hundreds of thousands of casualties and massive destruction if it occurred over an urban area. The probability of this occurring, however, is much smaller than the one-in-one-thousand odds I just mentioned, inasmuch as land covers only 30 percent of the area of the planet and cities only 2-3 percent of the land area. Of course, a similarly sized or even larger asteroid that made it to the surface intact could cause significant damage even if it hit the ocean, by virtue of the resulting tsunami.

Depending on its composition and velocity, an asteroid of 140 meters in diameter could have an impact energy in the range of 50 to 500 megatons of TNT equivalent and would be capable of causing destruction over a large region. The probability of a strike of this magnitude has been estimated at about 1 in 30,000 per year. As I noted earlier, it is believed that more than 90 percent of all NEOs 1 kilometer or greater in diameter have now been identified. None of those identified so far appears to pose a risk of collision, which is fortunate as the impact of an object of this size would release between 20,000 and 200,000 megatons of TNT equivalent and likely imperil all of civilization. The object that impacted the Earth just off the Yucatan Peninsula 65 million years ago, and that is believed to have been responsible for mass extinctions across the planet, was an asteroid estimated to have been 10 kilometers in diameter.

RECENT EXAMPLES

In recent years, several NEOs have made close passes by Earth. Two unrelated asteroids, estimated to have been between six and 20 meters in diameter, passed between the Earth and the Moon on September 8th, 2010. Neither posed a risk of striking the Earth, but they served as a reminder that these kinds of close flybys are not rare. It's estimated that almost every day, at least one 10-meter near-Earth asteroid (part of the undiscovered population of about 50 million) passes the Earth inside the orbit of the Moon.

The Chelyabinsk asteroid strike of February 15 lit up the sky and unleashed a series of shock waves that shattered windows over a wide area. Approximately 1,500 people were injured and 60 were hospitalized; the regional governor said that two-thirds of the injuries were light wounds from shattered glass and other materials. More than 4,000 buildings were damaged. According to NASA estimates, the velocity of approach of the incoming asteroid was about 18 kilometers per second and its energy was about 400 kilotons of TNT equivalent. These estimates enable us to calculate a corresponding mass of 11,000 metric tons. Early measurements in the hours

² Most asteroids with orbits crossing that of the Earth would impact with velocities between 12 and 20 kilometers per second, hence the choice of 16 kilometers per second as an intermediate figure.

following the event underestimated the energy (and therefore the mass) of the asteroid, but with the addition of data in the following days both from the ground and from orbiting satellites that witnessed the asteroid's entry, the energy measurement was refined. The entire event from the asteroid's atmospheric entry to its disintegration at an altitude of about 20 kilometers took only 32.5 seconds. Thus far, approximately 50 small meteorites resulting from this explosion have been found. One piece blasted a six-meter-diameter hole in the ice covering one of Siberia's many lakes.

On the same day as the unexpected Chelyabinsk event, the 45-meter asteroid 2012 DA14 safely passed nearly 27,700 kilometers (17,200 miles) from Earth, a close flyby that had been predicted many months in advance. This asteroid had been tracked since its February 2012 discovery. Tracking data and orbit calculations made by the various Federal agencies with responsibilities in this area made it clear over a year ago that this asteroid did not pose a threat to Earth, the International Space Station, or satellites in orbit. This event allowed researchers to measure the object's path and orbit with greater precision, improving estimates of future near-Earth passes.

Analysis of data collected during these two contemporaneous events indicates that the asteroid that exploded over Chelyabinsk was almost certainly unrelated to the larger asteroid 2012 DA14; the smaller asteroid's trajectory was not consistent with its being a fragment that came off the larger one. It's notable that while the Chelyabinsk "fireball" was unusual for its size and visibility, thousands of smaller strikes that still explode with enough energy to produce a fireball (defined as being brighter than the brightest planet) occur each day. Most fireballs are not noticed because they occur over oceans or uninhabited regions or are masked by daylight. Nearly all of them are caused by objects too small to be detected before they enter Earth's atmosphere... and also too small to do damage on Earth's surface.

DETECTION AND MITIGATION EFFORTS

The ability to detect NEOs and to determine whether a collision with Earth is likely depends on the distance, size, and reflectivity of the object and the number and capabilities of the telescopes that are looking for it. In general, detection of NEOs and prediction of future orbits are challenging endeavors, especially when one considers that orbits can change as a result of encounters with other objects.

NASA sponsors a number of activities relating to the search for NEOs under its Near Earth Object Observation (NEOO) program, including work at the international Minor Planet Center (MPC), located at the Harvard-Smithsonian Center for Astrophysics, which collects and correlates NEO orbit data; research at two radio-telescope facilities that help provide precision tracking and characterization of NEOs; surveys conducted by ground-based optical telescopes; and activities at the NASA NEO Program Office at the Jet Propulsion Laboratory (JPL), which coordinates assessments of NEO orbits and impact probabilities. There are also cooperative projects involving NASA, the National Science Foundation (NSF, which has a key role within the United States for ground-based astronomical assets), and the U.S. Air Force (USAF) Panoramic Survey Telescope and Rapid Response System (PanSTARRS) program, as well as non-government academic and space research organizations. Additionally, NEO detection is a major science driver for the proposed Large Synoptic Survey Telescope. NASA is also working

with the Canadian Space Agency (CSA) on processing of data that will be collected from the CSA Near-Earth Object Surveillance Satellite (NEOSSat) launched last week (February 25).

The Administration places a high priority on tracking asteroids and protecting our planet from them, as evidenced by the five-fold increase in the budget for NASA's NEOO program since 2009. The United States has an effective program for discovering larger NEOs, but we need to improve our capabilities for the identification and characterization of smaller NEOs. Specifically, with our current or near-future capabilities, both on the ground and in space, it is unlikely that objects smaller than 100 meters in diameter on collision courses with the Earth will be detected with greater than weeks of advance warning – a matter of some concern since the larger objects in this range could be city-destroyers.

ADMINISTRATION POLICIES AND BUDGETS

Finally, I'd like to underscore some Administration policy and budgetary decisions relating to NEOs, which will buttress ongoing detection and tracking activities going forward.

The President's 2013 Budget for NASA's NEOO Program proposes more than a five-fold increase in funding (to \$20.5 million from \$4 million) from the 2009 funding level for NEO detection activities. Further, the President's National Space Policy specifically directs NASA to "pursue capabilities, in cooperation with other departments, agencies, and commercial partners, to detect, track, catalog, and characterize near Earth objects to reduce the risk of harm to humans from an unexpected impact on our planet and to identify potentially resource-rich planetary objects." This guidance also reinforces NASA's roles and responsibilities with regard to NEOs, as well as those of other Federal departments and agencies including the Department of Defense, the Department of State, and the Department of Homeland Security's Federal Emergency Management Agency (FEMA).

In furtherance of these directives, NASA has completed a number of missions to investigate asteroids and has others planned. For example, the Near Earth Asteroid Rendezvous (NEAR)-Shoemaker mission rendezvoused, orbited, and touched down on the near-Earth asteroid Eros in 2001, significantly advancing the field of asteroid studies. The United States also collaborated with Japan, through NASA, on the successful asteroid visit and sample return mission known as Hayabusa. The OSIRIS-REx mission, currently in development for launch in 2016, will study, characterize, and return to Earth a sample of near-Earth asteroid 1999 RQ36 in an effort to investigate planet formation and the origin of life. And of course NASA is committed to carrying out the President's goal of conducting a human mission to an asteroid by 2025. That mission will benefit from current efforts to detect, track, and characterize NEOs by speeding the identification of potential targets for exploration. And in return, such a mission will generate invaluable information for use in future detection and mitigation efforts.

OSTP has been working closely with several departments and agencies to draft plans and procedures, including potential mitigation strategies, that could be used in the unlikely event of a NEO impact threat. Under these plans, it is NASA's responsibility to provide initial notice of such a threat. Following such notification, communications resources and mechanisms already in place within FEMA would be used to communicate information domestically. The Department

of State's diplomatic mechanisms would come into play for international communications as needed.

With regard to risk mitigation, the Administration is committed to exploring and developing the capabilities and techniques necessary to protect the Earth in general, and the United States in particular, from NEO threats and implementing a collision mitigation campaign if necessary and appropriate. In 2008, the Executive Office of the President collaborated with NASA and the U.S. Air Force to run the first-ever disaster and deflection exercise, which included members from the National Security Staff, Joint Chiefs of Staff, Office of the Under Secretary of Defense for Policy, Missile Defense Agency, the Defense Threat Reduction Agency, the Department of Defense (DoD) National Security Space Office (now the Executive Agent for Space Staff), and the Department of Energy. The National Research Council and the NASA Advisory Council have also provided helpful recommendations and guidance on research priorities in impact mitigation techniques.

Among the highlighted needs are an improved understanding of NEO characteristics to enable more refined impact experiments; enhanced computer simulations; crewed and uncrewed *in situ* asteroid investigations; and further research and capabilities development in the domain of deflection, including explosive technologies, and impact scenarios (including design reference missions and gaming exercises). DoD and NASA have already shown tremendous leadership by taking the initiative to run multi-agency disaster and deflection exercises, and by collaborating in the development of an international disaster and deflection response scenario for the upcoming Planetary Defense Conference hosted by the International Academy of Astronautics in Flagstaff, Arizona.

In summary, the Administration, with the support of Congress, has taken many positive steps to improve NEO detection capabilities, including meeting the 90 percent detection goal for one-kilometer asteroids. Much more needs to be done, however, and it is important to note that a challenge on the scale of planetary defense cannot be met by any single nation or government alone. Rather it will be critical going forward that the Federal Government cooperate closely with domestic partners in industry, academia, and other sectors as well as with foreign governments and international organizations to achieve our shared goal of scientific discovery, exploration, and risk mitigation.

I thank the Committee for its continued support and interest in this issue and I look forward to continuing to work with you on it. I will be pleased to take any questions Members may have.