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Statement of
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Committee on Commerce, Science, and Transportation
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Mr. Chairman and Members of the Subcommittee, I am pleased to have this opportunity to update the committee on NASA's programs and our approach to addressing the risks, impacts, and solutions for space threats.

Orbital Debris

Today, the Joint Space Operations Center, managed by U.S. Strategic Command, is tracking more than 23,000 objects in orbit about the Earth, of which approximately 95 percent represent some form of debris. In addition, millions of smaller debris objects that could still potentially damage spacecraft are orbiting the Earth. For over 30 years, NASA has led the world in scientific studies to characterize the near-Earth space debris environment, to assess its potential hazards to current and future space operations, and to identify and to implement means of mitigating its growth. The NASA orbital debris program has taken the international lead in conducting measurements of the environment and in developing the technical consensus for adopting mitigation measures to protect users of the orbital environment. NASA is currently working to developing an improved understanding of the orbital debris environment and the measures that can be taken to control debris growth. NASA designs spacecraft to withstand the impacts of small debris and micrometeorites, and the Agency works with the Joint Space Operations Center to avoid collisions between our space assets and other known resident space objects.

Near-Earth Objects (NEOs)

NEOs are comets and asteroids that have been nudged by the gravitational attraction of nearby planets into orbits that allow them to enter the Earth's neighborhood. Composed mostly of water ice with embedded dust particles, comets originally formed in the cold outer planetary system while most of the rocky asteroids formed in the warmer inner solar system between the orbits of Mars and Jupiter. As the primitive, leftover building blocks of the solar system, comets and asteroids offer clues to the chemical mixture from which the planets and life eventually formed, making them compelling objects for scientific study.

The events of February 15, 2013, were a reminder of why NASA has for years devoted a great deal of attention to NEOs. The predicted close approach of a small asteroid, called 2012 DA14, and the unpredicted entry and explosion of a very small asteroid about 15 miles above Russia, have focused a

great deal of public attention on the necessity of tracking asteroids and other NEOs and protecting our planet from them -- something this Committee and NASA have been working on for over 15 years.

To put these two recent events in context, small objects enter the Earth's atmosphere all the time. About 100 tons of material in the form of dust grains and small meteoroids enter the Earth's atmosphere each day. Objects the size of a basketball arrive about once per day, and objects as large as a car arrive about once per week. Our Earth's atmosphere protects us from these small objects, so nearly all are destroyed before hitting the ground and generally pose no threat to life on Earth. While objects the size of the one that exploded over Russia (a rocky asteroid about 17 meters in diameter and weighing from 7,000 to 13,000 metric tons), enter the Earth's atmosphere roughly once every hundred years, they do remind us of the potential consequence of a larger impact. Even this small object resulted in about 6,000 buildings being damaged and about 1,500 people being injured, mainly from broken glass from the shock wave of the object exploding about 15 miles above the ground.

NASA leads the world in the detection and characterization of NEOs, and provides critical funding to support the ground-based observatories that are responsible for the discovery of about 98 percent of all known NEOs. NASA also has focused flight missions to study asteroids and comets. NASA uses radar techniques to better characterize the orbits, shapes, and sizes of observable NEOs, and funds research activities to better understand their composition and nature. NASA also funds the key reporting and dissemination infrastructure that allows for worldwide follow-up observations of NEOs as well as research related activities, including the dissemination of information about NEOs to the larger scientific and engineering community. Consistent with the President's National Space Policy, NASA continues to collaborate with the Department of Defense and other government agencies on planning and exercises for responding to future hazardous NEOs.

NASA was tasked by Congress in 1998 to catalog 90 percent of all the large NEOs (those of 1 kilometer or more in size) within 10 years; these would be large enough that should one strike Earth, it would result in a global catastrophe. NASA worked with a number of ground-based observatories and partners as part of our Spaceguard survey to reach that goal; NASA has now catalogued an estimated 95 percent of all NEOs over 1 km in size. None of these known large NEOs pose any threat of impact to the Earth anytime in the foreseeable future.

In 2005, Congress directed NASA to expand the survey to "detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than 140 meters in diameter" (those that could destroy a city) and set a goal for this program to achieve 90 percent completion by 2020. NASA's NEO Observation Program (NEOO) currently funds three survey teams that operate five ground-based telescopes.

NASA has leveraged its investment in the Wide-field Infrared Survey Explorer (WISE) spacecraft by enhancing its operations to search for NEOs, resulting in the discovery of 146 previously unknown objects.

NASA's NEO Observation (NEOO) Program includes collaboration on ground-based telescopes such as the Space Surveillance Telescope with the Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force. NASA also funds the Panoramic Survey Telescope & Rapid Response System. The wide field of view survey capabilities of these two assets are expected to provide a significant increase in NEO detection rate.

However, ground-based telescopes will always be limited to the night sky and by weather. The only way to overcome these impediments is to use the vantage point of space. The privately funded B612 Foundation is planning to build a space observatory called Sentinel that would launch in 2018 and detect

100-meter sized objects and larger that could come near Earth's orbit. Sentinal will employ an infrared telescope from a Venus-orbit that will look "back" at the Earth in order to see and track near Earth objects. NASA is working collaboratively the B612 Foundation by providing technical assistance and operational support through a Space Act Agreement.

To find the more numerous smaller asteroids near Earth, NASA is initiating a project for development of an instrument that will be hosted on geosynchronous platforms such as communications, TV broadcast or weather satellites. This modest-sized, wide field telescope will have detectors that operate in the infrared bands where these faint asteroids are more easily detected against the cold background of space,

NASA is a leading participant in the NEO activities of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). Over the past several years, a working group on NEOs under the UNCOPUOS Scientific and Technical Subcommittee has been examining the topic of Earth-threatening NEOs. Results of that work led to recommendations this year, endorsed by the Subcommittee, to broaden and strengthen the international network to detect and characterize NEOs, and to call for relevant national space agencies to form a group focused on designing reference missions for a NEO deflection campaign. NASA is at the forefront of these activities and will continue to take on that role. NASA is also in discussions with our international partners to collaborate on several missions or mission concepts that could, in the future, grant additional access by U.S. researchers to valuable data on asteroids. NASA is working with the Japan Aerospace Exploration Agency or JAXA on potential collaboration on the Japanese-led Hayabusa II mission, building on our joint success with the earlier Hayabusa mission to the near-Earth asteroid Itokawa. NASA is also discussing with the European Space Agency potential collaboration on two of their mission concepts: 1) the Marco-Polo-R mission concept which is focused on returning a sample from a primitive near-Earth asteroid in the late 2020s, and, 2) the Asteroid Impact and Deflection Assessment (AIDA) mission concept that could be used to study the binary asteroid system Didymos with two spacecraft and see if a small interceptor can affect any the change in the relative orbit of the two bodies. Finally, the Canadian Space Agency launched their Near Earth Object Surveillance Satellite or NEOSSat in February 2013 to detect and track select near-Earth asteroids, and we look forward to seeing its data..

NASA is moving forward on the Agency's planned asteroid rendezvous and sample return mission, dubbed OSIRIS-REx (for Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer), planned for launch in 2016. OSIRIS-REx will approach a near Earth asteroid, currently named 1999 RQ36 (one of the most exciting, accessible, volatile and organic-rich remnant currently known from the early Solar System), in 2019. After careful reconnaissance and study, the science team then will pick a location from where the spacecraft's arm will take a sample of between 60 nd 1000 grams (up to 2.2 lbs) for return to Earth in 2023.

Finally, NASA is working to accomplish the President's policy goal of sending an astronaut to visit to an asteroid by 2025. This mission, and the vital precursor activities that will be necessary to ensure its success, should result in additional insight into the nature and composition of NEOs and will increase our capability to approach and interact with asteroids.

Space Weather

Another threat from space being studied by NASA is space weather. Space weather refers to the conditions on the Sun and in the solar wind and near-Earth environment. Solar storms pose risks to humans in space and can cause disruption to satellite operations, communications, navigation, and electric power distribution grids; a severe geomagnetic storm has the potential to cause significant socioeconomic loss as well as impacts to national security.

Our ability to understand the Sun-Earth system is of growing importance to our Nation's economy and national security. The 2008 National Research Council report, *Severe Space Weather Events – Understanding Societal and Economic Impacts*, identified three industries whose operations would be adversely affected by severe space weather: electric power, space, and aviation. The electric power industry is susceptible to geomagnetically-induced currents, which can overload unprotected power grids and result in widespread power outages. With warning, power grid operators may be able to adjust operations to counteract such effects. In the spacecraft industry, intense geomagnetic and radiation storms have the capacity to disrupt normal operations such as satellite communication and television service. Space weather can cause irregularities in signals from Global Positioning System satellites. The aviation industry is susceptible to space weather events from both an operational and safety perspective. Communications between flights taking polar routes and air traffic control could be disrupted due to interference between the radio waves and the effects of space weather in the ionosphere. In addition, flight routes may be re-routed further south during solar weather events to reduce the radiation exposure to passengers and crew.

The National Oceanic and Atmospheric Administration (NOAA) is the official source for space weather predictions for the Nation. The U.S. government, through the National Science Foundation and NASA, sponsors research programs to further our understanding of heliophysics and space weather. NASA's Heliophysics Division is responsible for formulating a national research program for understanding the Sun and its interactions with the Earth and solar system.

NASA currently operates 18 missions studying the sun and the solar wind, which have produced a number of scientific discoveries over the last year alone. Voyager has taken us to the edge of our solar system, the twin Solar TErrestrial RElations Observatory (STEREO) spacecraft have allowed us to view space weather events throughout the solar system, the Solar Dynamics Observatory (SDO) is helping us understand the causes of solar variability and its impacts on Earth, and the recently launched Van Allen Probes have already made new discoveries within Earth's radiation belts. Furthermore, for the first time, we have complete coverage of the Sun from all angles 24 hours a day, 7 days a week. We are now able to track the evolution of solar events from the solar interior to the surface of Earth, connecting the magnetized structure in the Sun's corona to the detailed features of Earth-directed coronal mass ejections (CMEs), or solar flares, to the intricate anatomy of geomagnetic storms as they impact Earth two to three days later. Several of these research satellites have become an essential part of our Nation's space weather prediction system. One example is the Advanced Composition Explorer (ACE) mission, which serves as an operational sentry for NOAA by providing early warning of incoming solar storms. However, ACE has been operating for 15 years and is well beyond its design life. Working with NOAA, NASA is refurbishing the Deep Space Climate Observatory (DSCOVR) in part to replace ACE's capabilities. Planned for a FY2015 launch, DSCOVR will have instruments that will provide critical operational space weather measurements to NOAA.

Conclusion

NASA's portfolio of missions and research addresses fundamental questions and at the same time, helps to protect our home planet from natural hazards from space. Research and early detection and evaluation of space threats are key to assessing the risks and providing critical information for mitigation to decision makers.

Again, thank you for the opportunity to testify today, and I look forward to responding to any questions you may have.