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Statement of
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before the

Subcommittee on Space and Aeronautics
Committee on Science and Technology
U.S. House of Representatives

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the goals and accomplishments of NASA's Near Earth Objects (NEOs) Observation Program. The Subcommittee's invitation to testify identified a series of six questions, and I have structured my testimony around your specific concerns.

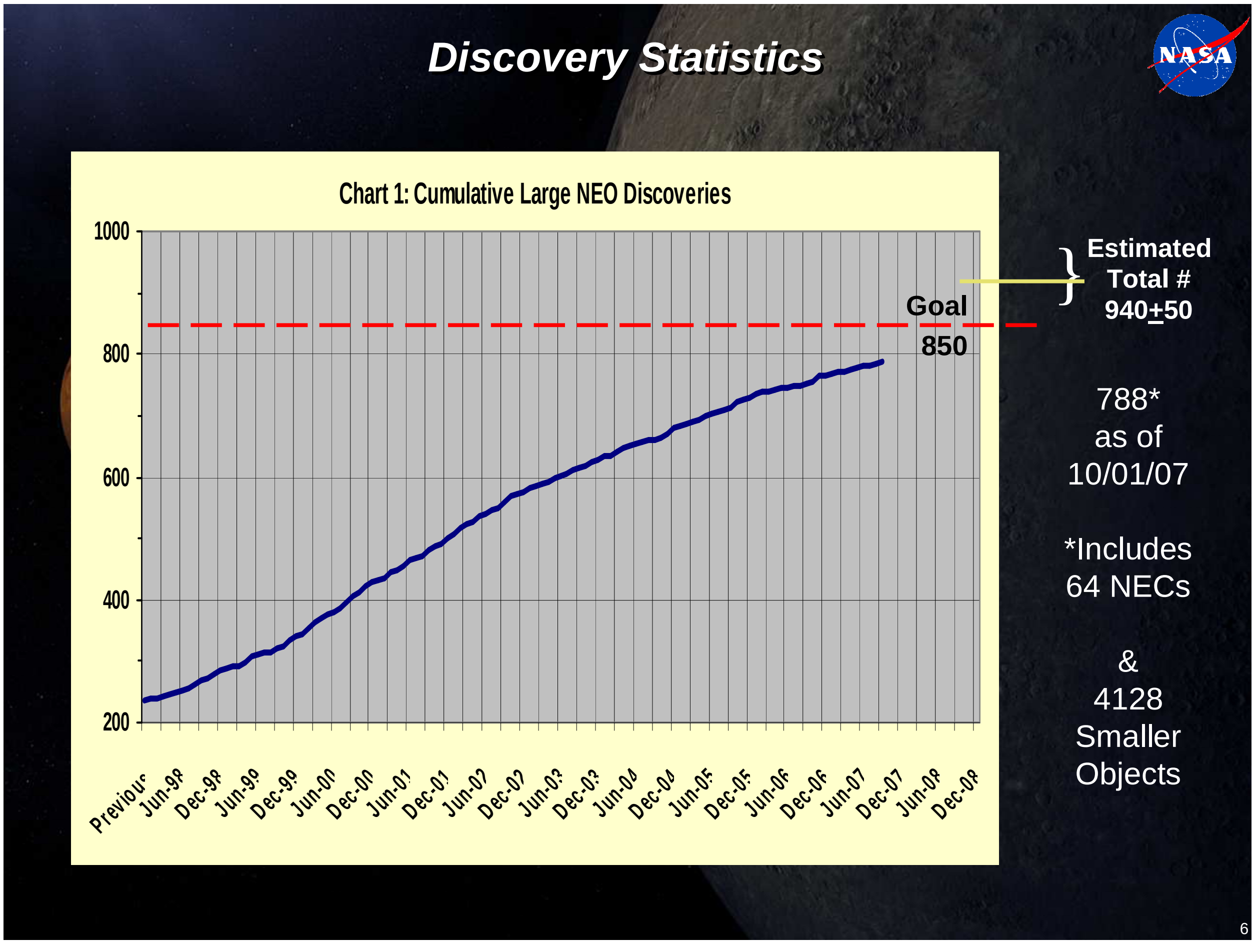
Question 1:
Please describe NASA's NEO Program and the infrastructure and operations in place to support the ongoing Survey (e.g., use of observatories, survey processing and NEO databases, analysis of identified objects, research, and sensor development)?

To achieve NASA's stated goal of finding over 90% of the NEOs greater than one kilometer in diameter, the Agency's NEO Observation Program currently funds four survey teams that operate eight ground-based telescopes of mostly one meter class apertures essentially dedicated to the NEO search effort. Two of the teams are sponsored by the University of Arizona Lunar and Planetary Laboratory, Tucson, Arizona, one by Lowell Observatory in Flagstaff, Arizona, and one by the Massachusetts Institute of Technology Lincoln Laboratory. Each team conducts independent operations for 14 to 20 nights per month, as weather permits, avoiding approximately a week on either side of the full moon when the sky is too bright to detect these extremely dim objects from the ground.

All collected observations believed to be of known or previously unknown NEOs are sent to the international "clearinghouse" for small body observation data, the Minor Planet Center (MPC). The MPC maintains the database of observations and orbits on all known small bodies (asteroids, comets, dwarf planets, Kuiper Belt Objects (KBO), etc) in the Solar System under the sanction of the International Astronomical Union. It is hosted by the Smithsonian Astrophysical Observatory's Center for Astrophysics in Cambridge, Massachusetts, but is largely funded by NASA. The MPC verifies and validates the observations by determining if they are of an already known object (by comparing them to the known orbits), or are indeed a new discovery. The MPC then determines and publishes an initial orbit for the new discovery so that observatories world-wide may look for the object and confirm its existence. Sometimes it takes a few nights of additional observations to adequately determine, or "secure", the orbit of a new object so that it may be regularly observed.

Once a new object's orbit is secured, its potential for impacting the Earth is assessed. Well over 99% of all objects discovered (which also include Main Belt Asteroids, comets, Trojans, Centaurs and KBOs) have no potential for Earth impact even over many millennia, but the small fraction which do are tagged as Potentially Hazardous Objects (PHOs). More detailed and refined analysis of a PHO's orbit is conducted by NASA's NEO Program Office at the Jet Propulsion Laboratory in Pasadena, California, which also aids in coordinating the activities and operations of NASA's NEO projects. Observations on PHOs are automatically forwarded to JPL and their orbits updated with high precision analysis to determine a level of probability of the object impacting the Earth in the next 100 to 200 years. The results of this analysis is constantly updated and published on the NEO Program website at http://neo.jpl.nasa.gov .

Since the program's inception in 1998, NASA has funded over $30M in NEO search efforts using funds from the Science Mission Directorate's Research and Analysis program. To date, these efforts have found the vast majority of the 724 one-kilometer Near Earth Asteroids and 64 Earth approaching comets now known, as well as the 4,128 known smaller NEOs. At the current discovery rate, we will have found about 50 more NEOs larger than one kilometer by the end of 2008, bringing us very close to achieving our 90% goal, measured against the current estimate of about 940 total one-kilometer objects. This work has retired the majority of the risk that Earth could be struck by a large asteroid in the foreseeable future.



Question 2: *What roles do other U.S. government institutions, universities, private and not-for-profit organizations, and international entities play in contributing to the NEO Survey and how is NASA coordinating with these institutions?*

As discussed above, NASA does not directly own or operate any of the NEO Survey assets, but fully or partially funds several universities and private institutions to conduct the necessary elements of the survey using existing ground-based astronomical facilities. The University of Arizona (UofA) operates most of the search telescopes, either directly or in partnership with others. Two telescopes are operated at Kitt Peak by the UofA Spacewatch project, while the UofA Catalina Sky Survey operates two telescopes at Mt Lemmon Observatory and one in partnership with the Australian National Observatory at Siding Spring Observatory in New South Wales, Australia, which is currently our only southern hemisphere survey site. Lowell Observatory, a private institution, operates a smaller search telescope outside Flagstaff, Arizona. The remaining search team, funded by NASA at MIT/Lincoln Laboratory, operates on two US Air Force-owned one-meter class telescopes at the Stallion Air Force Station on White Sands Missile Range near Socorro, New Mexico. The Minor Planet Center is operated by the Smithsonian Astrophysical Observatory using mostly NASA funding, and the NEO Program Office is at the Jet Propulsion Laboratory, managed by the California Institute of Technology.

No significant NEO detection efforts are currently conducted by the international community. Less than 2% of NEOs detected in the last ten years were found by systems other than those funded by NASA.

Currently, the only organized work in the international community that is significant to the NEO Survey is the NEO Dynamics Site (NEODyS), operated by the University of Pisa in Italy. NEODys conducts independent analysis on NEO orbits similar to that performed by NASA's NEO Program Office at JPL. JPL and NEODyS constantly compare results they obtain for PHO orbits and predicted impact probabilities. If the results from one vary significantly from the other, they redo their analyses until they can resolve the discrepancy. This work offers a completely independent check of impact prediction results prior to an announcement of any significant threat.

Also worth noting is the current significant role for new discovery follow-up observations conducted world-wide by a dedicated amateur astronomer community. Through its website, the MPC supplies position information on newly discovered objects and solicits observations needed to improve the orbit from anyone who may want to attempt the work. Much of these follow-up observations are obtained by amateur astronomer individuals or clubs with relatively sophisticated but smaller telescope systems. However, once NASA moves the search to objects much smaller than one kilometer, this work quickly becomes beyond the capabilities of these amateur systems.

Coordination of efforts is largely voluntary through the use of information published on the MPC and NEO Program Office websites. The competitive nature of the grant program used to finance the search teams has encouraged them to make improvements in their systems and data processing to maintain their detection rates. This community meets either in the US or internationally annually, on average, to discuss progress and improvements to the survey effort. In addition, last year the United Nations Committee on the Peaceful uses of Outer Space (COPUOS) established an Action Team on NEOs within its Scientific and Technical Subcommittee to encourage more international work on this issue. The Action Team is focused on identifying gaps in efforts and coordination within the international community, as well as recommending improvements. NASA is charter member of this new group.

Question 3: *How do spacecraft missions to comets and asteroids, as well as other scientific spacecraft, contribute to the NEO program?*

Currently, spacecraft missions do not contribute to the detection of NEOs. However, space missions do provide the most significant and detailed information on what we know about the character and composition of them. NASA Discovery missions such as the Near Earth Asteroid Rendezvous (NEAR), Stardust, Deep Impact, and the Japanese Hyabusa mission have contributed important information to our understanding of the origin of comets and asteroids, providing insight on their evolution into the inner Solar System near the Earth, their structure and physical properties, and their composition. The recently launched Dawn mission will travel to the two largest objects in the Main Belt of Asteroids - Vesta and the dwarf planet Ceres. This area of the Solar System has been shown to be the region of origin for most of the objects that now are near Earth, and the Dawn mission will tell us many things about their nature. Other significant contributions by spacecraft include studies by the Hubble Space Telescope, Spitzer, Galileo, and other asteroid and comet flybys performed by several Solar System exploration missions.

Not only are these data important to the development of concepts to deal with any impact threat an NEO may pose, but they are also critical to an understanding of the nature NEOs for possible destinations and resources in our future exploration of the Solar System.

While NASA does not have any formal responsibility for the task of mitigation, scientific missions such as Deep Impact and the current Dawn mission to Vesta and Ceres provide information that may be critical to planning an asteroid deflection. Likewise, many of the systems and technologies that are being developed for exploration missions are directly applicable to mitigation missions. These capabilities are the hallmarks of a robust, space-faring nation.

Question 4: *What is the Arecibo facility's role in the detection, tracking, and characterization of Near Earth Objects, and what alternatives, if any, exist to carry out its role if the facility is shut down? How do the capabilities of those alternatives compare to those of the Arecibo facility?*

The National Science Foundation's Arecibo Radio Telescope facility has had no useful role in the detection of NEOs – its technical characteristics make it incapable of conducting searches for these relatively small and distant objects. However, once we know the position of an object is accessible by a focused radar beam, Arecibo plays an important role in the quick refinement of the orbit to a precision not obtainable by other means, and for understanding the object's size, shape and spin rate. Arecibo also aids in the detection of possible binary objects, (~15% of NEOs), which in turn provides data that can be used to determine their mass. When an object passes close enough to the Earth to achieve a measurable radar return (about 20 million miles depending on the size), the use of radar is one of several valuable tools for obtaining additional information about these objects.

The only other facility currently being used by NASA for routine planetary radar is NASA's own Goldstone facility, part of our Deep Space Network (DSN) for communication with spacecraft on missions beyond Earth's orbit. No international facility is capable of performing this feat on a regular basis.

There are significant differences with the planetary radar capability at Arecibo compared to Goldstone. The Goldstone radar is a 70-meter steerable dish, allowing it to access objects significantly lower to the horizon than the more limited sky area accessible to the limited pointing capability of the Arecibo radar. However, Arecibo is twice as powerful as Goldstone and has a much larger (304 meter) collection dish, which allows it to observe objects significantly farther away than Goldstone.

Question 5: *Will NASA's current NEO program satisfy the requirement established in Sec. 321(d)(1) of the NASA Authorization Act of 2005, and if not, what is NASA's plan for satisfying that requirement?*

Although the current systems funded by NASA are capable of detecting objects smaller than one kilometer in size, the objects must come significantly closer to the Earth than a one kilometer object needs to in order to be detected. It would take timescales much longer than 15 years to observe 90% of these objects with the systems we currently use.

As outlined in the report NASA submitted to Congress on March 7, 2007, pursuant to direction in section 321 of the NASA Authorization Act of 2005 (P.L. 109-155), the Agency recommended that the current survey program, funded at approximately $4M annually, be continued. In addition, NASA indicated that the Agency would look for opportunities using potential dual-use telescopes and spacecraft—and to partner with other agencies as feasible—to attempt to achieve the legislated goal within 15 years. Several alternatives as to how this might be accomplished were presented and analyzed in the March 7 report. However, due to current budget constraints, it is not possible for NASA to initiate a new program. The costs for the alternative programs ranged from $470M to in excess of $1.0B over 10 to 19 years, depending on how aggressive of a timeline would be pursued.

The current NEO program is fully funded through 2012. In addition, NASA is initiating plans to use other survey systems to increase the survey's detection sensitivity and rates. For example, NASA has begun providing funds to the Air Force Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) project so that it will be capable of providing data on NEO detections after it starts operations on its first telescope in the next year. If the Air Force continues to fund this project to its intended four telescope configuration by 2010, this system alone could discover over 70% of the potentially hazardous objects larger than 140 meters by 2020. NASA is also assessing the upgrades that must be instituted at the Minor Planet Center to absorb the substantial increase in new detection data that this system will provide.

Finally, NASA is also assessing what already planned spacecraft might contribute to the detection effort. A leading example for possible dual-use is the Wide-field Infrared Survey Explorer (WISE). Currently being developed for a late 2009 launch for a six month astrophysics mission to map the infrared sky, the WISE instrument is also capable of detecting many asteroids, of which a portion will be NEOs. We are investigating improvements to the timeliness of the spacecraft's data downlink and archival plans to increase its utility for NEO detections, as well as a possible extended mission to double the time available to detect these objects. The science community may propose a NEO survey mission under the competitively-selected Discovery program.

Question 6: *What plans, policies, or protocols does NASA have in place in the event that a previously unknown object on a near term impact trajectory is detected?*

NASA has an NEO contingency notification plan to be utilized in the very unlikely event an object is detected with significant probability of impacting the Earth. The plan establishes procedures between the detection sites, the Minor Planet Center, the NASA NEO Program Office at JPL, and NASA Headquarters to first quickly verify and validate the data and orbit on the object of interest, and then up-channel confirmed information in a timely manner to the NASA Administrator. These procedures were first exercised with the discovery of the object now known as Apophis, which was found in December 2004 in a hazardous orbit but determined to not have a significant probability of impacting the Earth in the near-term. NASA will continue to refine this internal contingency plan, and begin work with other US government agencies and institutions when directed.

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