WHITE PAPER

KEY POINTS AND RECOMMENDATIONS

FROM THE

1ST IAA PLANETARY DEFENSE CONFERENCE

HELD

27-30 APRIL 2009

GRANADA, SPAIN

EXECUTIVE SUMMARY

The 1st IAA Planetary Defense Conference was held on April 27-30, 2009, in Granada, Spain. The meeting was sponsored by 19 organizations and attended by over 170 individuals.

A primary conclusion from the conference is that we are making slow progress in many of the areas critical to detecting a threat and mounting an effective deflection campaign, with many of these areas of work underfunded or not funded at all. Clearly, discovery of threatening objects is essential and discovery efforts have been funded to find larger objects but smaller objects, that could still cause a regional disaster, remain largely undetectable. There has been very little work on designing a deflection campaign or testing possible deflection techniques. We don't have a good understanding of the relationship between object size and disaster scale, and disaster response agencies have yet to consider in detail the types of disasters that even a small Near Earth Object (NEO) impact might cause. Finally, efforts are progressing to build a framework for the process for deciding to act, but the threat posed by near Earth objects is global and demands a new level of international cooperation and involvement in funding and development of critical technologies.

Primary recommendations from the meeting were:

- **A concerted effort must be made to discover and track objects of 140 meters in size and larger.** Wide field, large-aperture telescopes, such as LSST and PanSTARRS are critical for ground-based efforts, and sufficient international funding should be provided as soon as possible to bring these instruments on line and maintain their operations.

- **Funding for Arecibo and other instruments capable of providing precise dynamical and physical characterization data for objects that pose a threat to Earth must be maintained.** These instruments will be essential for refining the risk and determining whether a deflection effort is warranted.
- **International participation in funding and research related to NEO discovery, tracking, and mitigation must increase.** Planetary defense is an issue without boundaries. International participation in funding, research, and in NEO exploration and deflection related missions should increase.
- **Deflection-related testing should be included as part of science missions to asteroids and comets to increase information relevant to the mitigation process.** For example, these missions could characterize the compositions, bulk densities, and structures of various spectral classes of asteroids, provide precision asteroid tracking and perhaps provide end-of-mission tests for slow-push techniques such as gravity tractoring.
- **Simulations of NEO atmospheric entries and land and water impacts should be funded in order to develop reliable relationships between NEO energies and impact consequences.** This information will be critical for making decisions related to NEO deflections and for planning responses to NEO-related threats.
- **Additional studies should be conducted to understand and quantify the momentum transferred to comets and asteroids by impulsive deflection techniques (kinetic impact and standoff, contact, and sub-surface explosions).**
- **Protocols and assigned responsibilities must be developed for a global response to a NEO threat.** A major challenge will be to coordinate international activities and decide to act. We should define the pathway for action before a threat is discovered.

INTRODUCTION

The 1st IAA Planetary Defense Conference led by the International Academy of Astronautics (IAA) was held in Granada, Spain on April 27-30, 2009. The meeting was the third in a series of Planetary Defense Conferences, the previous two held in 2004 and 2007 in the United States. Details and findings of those conferences may be found at http://www.planetarydefense.info.

The 2009 meeting was supported by 19 sponsoring organizations, attended by over 160 participants from 18 different countries (see Attachment 1), and included over 130 submitted abstracts. Major sponsors were the European Space Agency (ESA), which also handled logistical and administrative details of the meeting, The Aerospace Corporation, the National Aeronautics and Space Administration (NASA) through the Jet Propulsion Laboratory, and the Secure World Foundation. Other sponsors were: American Institute of Aeronautics and Astronautics (AIAA), The Applied Physics Laboratory, Association of Space Explorers, Ball Aerospace and Technologies Corporation, B612 Foundation, Spanish National Research Council, Deimos Space, GMV, HE Space Operations, Japan Aerospace Exploration Agency (JAXA), The Planetary Society, Indian Space Research Organization (ISRO), Space Generation Advisory Council, and the Southwest Research Institute.

The meeting's Organizing Committee (members listed in Attachment 2) used special emphasis on asteroid (99942) Apophis to set the program. Apophis is an approximately 270-meter size Near Earth Object which will make a very close approach to Earth in 2029 and has a minuscule chance of impacting our planet in 2036.

The Organizing Committee elected to focus the 3.5-days of discussion into six topic areas:

- Discovery, Tracking and Characterization
- Mission and Campaign Design
- Deflection Technologies and Simulations
- NEO Impacts and Consequences
- Policy, Preparedness, Deciding to Act
- What's Happening Now?

A final session was a wrap-up discussion, where key points and recommendations of the meeting were collected and discussed. These findings and conclusions are summarized in this document. As a general point, it was recognized that there are outstanding recommendations from the two previous conferences that have yet to be addressed.

Background

Throughout the history of our solar system, objects circling our sun have been under bombardment by other objects orbiting our sun. Evidence of such bombardment is clearly visible on all planets and moons whose surfaces have been observed by optical or other sensors.

Bombardment of Earth by objects larger than a few meters in diameter continues at a rate that is, fortunately, very low on scales of human life spans, and impacts posing any significant threat to humans occur in intervals of hundreds to thousands of years. A recent example is the 1908 explosion of an asteroid or comet over a desolate region in Siberia that leveled over 2000 square kilometers of forest. As updated with analysis presented at this conference, the impacting object is estimated to have been 30 to 50 meters in size and the resulting explosion above the Earth's surface is estimated to have been equivalent to 3 to 5 megatons of TNT. An impact of an object this size is estimated to occur once every few hundred to two thousand years and as our population continues to grow, the risk to humans increases.

In recent years, the seriousness of the threat posed by such events has been recognized, as has our increasing ability to detect and deflect an oncoming object. In 1998, the U.S. Congress authorized NASA to discover and catalog (develop validated orbits for) at least 90% of objects larger than 1 km in size that could possibly impact Earth in the foreseeable future. Objects 1 km in size and larger are those that could cause significant global consequences including civilization-ending or even extinction-level events should they impact our planet. Since 1988, the detection and tracking effort has almost achieved the desired goal. There are estimated to be about 940 such objects larger than 1 km, with 777 having been discovered. Fortunately, none currently known pose a risk of impact in the next 100 years. As a result, the catalog of known Near Earth Objects (NEOs) of various sizes has increased to 6230 at the time of the 1st IAA PDC conference, with 777 of an estimated size larger than 1 km.

In addition to the larger objects, about 15 larger than a few meters in size have the potential (at any point in time) to pose a threat to Earth in the next 50 years. One particular object, (99942) Apophis, will pass within 36,000 km of the Earth's surface in 2029 and currently has a probability of 1 in 45,000 of collision in 2036. Other objects currently (June 2009) have a higher probability of impact, but as with Apophis, those figures are also likely to reduce over time.

Recognizing the threat posed by these smaller objects, in 2005 the US Congress requested that NASA develop a plan to detect and catalog 90% of Near Earth Objects larger than 140 meters in size. Technical approaches to accomplish this were delivered by NASA in a report in early 2007, but no additional funding has yet been appropriated. However, it is evident that the discovery, tracking and cataloging of potentially threatening objects is the absolutely critical task — we can't take action against what we don't find.

Mitigating a threat posed by an approaching object could involve disruption - fragmenting the object to minimize adverse effects, or deflection - imparting a velocity increment in amount and direction designed to eliminate the future intersection of the NEO and Earth positions. If reaction time permits, deflecting the whole object away from Earth's position is generally believed to be the most palatable option, since the original object would remain and additional mitigation efforts would be possible should the initial deflection attempt have less than the desired result.

While believed technically possible, deflecting a threatening object is not a simple matter. The deflection techniques involved seem to fall into two basic categories:

"impulsive," meaning that they impart a velocity increment by a sudden force such as an explosion or high-velocity impact, and "slow-push," which apply a small force to the object over a relatively long period of time. A practical approach may involve a number of impulsive actions to get close to the desired deflection, then possibly "trimming" the deflection using a slow-push concept, possibly provided by an observing spacecraft, to eliminate the possibility of a future close approach.

In addition to technical issues, discovery of a serious threat will test our ability to make a decision to act and to coordinate related activities worldwide, and the unexpected impact of an untracked object of sufficient size could cause a significant regional disaster.

Discovery, Tracking, and Characterization

Excellent progress was reported by NASA relating to meeting the goal established by the U.S. Congress of cataloging the 1 km and larger NEO objects.

Objects smaller than 1 km in size also pose significant risk of damage and disruption should they strike Earth, with the frequency of impact increasing as the size and level of damage from an object decreases. In 2005, the U.S. Congress requested that NASA develop a plan for discovering 90% of objects larger than 140 meters in size within 15 years, but funding has not yet been approved for such an effort.

Several key points made during the presentations and discussion were that:

- Current surveys for Near Earth Objects are finding and cataloging Potentially Hazardous Objects (PHOs) that have a real risk of someday impacting the Earth. This work must continue and the effort to find smaller objects should receive increased priority.
- The Spaceguard survey is nearly complete at 2 km diameter, which is close to the probable threshold for globally catastrophic impacts. As a result, the Spaceguard Survey has actually "retired" more than 90% of the total impact risk. Almost half of all NEAs as large as Apophis have already been discovered.
- By optimizing 15% of the total observing time for NEO detection, the proposed Large Synoptic Survey Telescope (LSST) has the capability to achieve the goal of discovering and tracking 90% of objects larger than 140 meters in size within 12 years, but continued funding support and prioritization are required to achieve this goal.
- Optical instruments can detect and track NEOs, but these instruments are unlikely to provide accurate estimates of the size of the observed objects without an object classification to provide a reasonable estimate of albedo, shape, etc. Size (with derived mass) is a critical factor in determining the energy that must be delivered to deflect an NEO.
- Satellites in Earth or Solar orbits and equipped with IR telescopes could detect NEO objects relatively efficiently and could provide better size estimates than their ground-based visible light counterparts. Thermal-infrared and polarimetric

observations to obtain sizes are also possible with some ground based telescopes, although time on such telescopes has to be sought on a scientifically competitive basis.

- The NASA Wide–field Infrared Survey Explorer (WISE)[1] will survey the entire sky at infrared wavelengths. It can be expected to find hundreds of thousands of asteroids in our solar systems asteroid belt and hundreds of additional asteroids that come close to the Earth. Surveying in infrared WISE will see otherwise dark objects.
- Detecting and cataloging NEOs whose orbits are primarily or totally within that of Earth will continue to be a challenge for ground-based sensors due to the interference of the Sun. The NEOSSat space mission, in dawn-dusk sun synchronous orbit, planned for early 2011 launch, will have a marked advantage for detecting such objects, finding an estimated one third to one half of this population over 3 years.
- The unique case of 2008 TC3, which was discovered prior to impact and where samples were subsequently recovered, showed that even with the current survey systems it is possible to detect a small NEA very close to impact and accurately predict the impact time and place. This is also our first chance to directly compare remote sensing observations of the parent object in space with "ground truth" from recovered samples. TC3 has greatly increased interest in detection of small asteroids within a few days of impact.
- There are inherent errors and uncertainties associated with estimating the orbits of NEOs based on optical tracking. One such error that can be corrected is a small bias that has been discovered in reference star catalogs employed to generate the astrometric data used in NEO orbits. Other errors are induced by un-modeled forces, such as those caused by the Yarkovsky effect, which depends upon the rotation rate, rotational axis, shape and other physical properties of the NEO.
- For objects within range, high-power radars can provide precision data for orbit determination and reliable estimates for the sizes, shapes, and rotational states of NEOs, as well as precision data for orbit determination. Arecibo is the world's most capable radar for such measurements. The Arecibo radar is currently funded by the U.S. National Science Foundation, and funding to continue operation of the instrument has been an issue for several years. The Arecibo radar will be critical for obtaining more precise tracking and physical characterization data for Apophis during its 2012-2013 apparition.
- Comets remain a relatively small but significant threat. Comets that approach Earth from far out in our solar system can have approach velocities and sizes much larger than those of asteroids, and may not be detected until less than a few months prior to reaching Earth's orbit. In addition, the cometary out-gassing caused by

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[1] WISE - http://www.jpl.nasa.gov/news/features.cfm?feature=2183

solar heating will increase the uncertainty in the comet's orbit and collision probability. Deflecting or dispersing a large comet would be a particularly difficult or even impossible task.

- While there are significant and noteworthy small-scale international efforts, the U.S. has provided the primary financial support for NEO discovery and tracking efforts to date.

Recommendations in this topic area were:

- A concerted effort must be made to discover and track objects of 140 meters in size and larger. Wide field, large-aperture telescopes, such as Pan-STARRS-4 and LSST are critical for ground-based efforts, and sufficient funding should be provided to bring these instruments on line and to maintain their operations as soon as possible. Opportunities for space-based detection and tracking capabilities should also be sought and pursued.
- Precise astrometric and physical characterization data for objects such as Apophis, which pose a threat to Earth within the next 100 years, will be essential for refining the risk and determining whether a deflection effort is warranted. Funding for Arecibo and other instruments capable of providing precision information should be maintained. Opportunities for testing tracking devices on or about potentially threatening NEOs should be included in future science missions.
- Since planetary defense is an issue without boundaries, international participation in and support of NEO discovery and tracking should increase.
- International funding should be pursued to ensure that the next generation of survey telescopes (e.g., PanSTARRS, LSST) comes on-line as soon as possible.
- The community should be using updated reference star catalogs where the position biases have been removed. Orbit errors can also be reduced by making additional future observations and using available pre-discovery data.
- Concepts for increasing the warning times for potentially threatening comets should be developed in due course.
- Data from existing sensors capable of detecting entry of natural objects into Earth's atmosphere, commonly called "fireball" or "bolide" events, should be made available on a timely basis to the scientific community to aid potential recovery of surviving fragments and to inform the study of the size-frequency distribution at the small end. Both add considerably to our knowledge of the level and nature of the natural impact threat. Previously provided military satellite data on the entry of large bolides should again be made generally available.
- It has recently been recognized that the existing Spaceguard Survey, as well as the proposed next generation surveys, can – in principle – recognize at least 30% of all threatening impacts by NEOs >30 m diameter several weeks before impact, even if they have not been previously cataloged (which is generally true for the smaller NEOs). Possibilities for improving searches for these short-term warning cases and for implementing timely data-reduction and reporting procedures should be

studied so that opportunities for evacuation and other civil defense measures will be possible.

Mission and Campaign Design

As reported at the 2007 Planetary Defense Conference, ESA has developed a conceptual mission to send a spacecraft to orbit an asteroid and to observe and measure the consequences of a high-speed impact of a second vehicle on the asteroid. The Don Quijote (original spelling) mission has not yet been selected for implementation.

Key points were:

- Much has been done to refine and characterize aspects of NEO missions since the 2004 Planetary Defense Conference. The Japanese Hayabusa mission has provided valuable insights about mission operations around small objects. A Planetary Society-sponsored competition has yielded a winning design for a radio transponder mission to Apophis.
- While not critical for planetary defense, a manned mission to a NEO, undertaken for other purposes, could provide useful information about operating in the vicinity of a small object that could be useful for designing and refining possible NEO deflection options.
- The proposed Don Quijote mission would provide useful information about the effects and effectiveness of the kinetic impact deflection technique and would also help to characterize and verify orbit control about a small object. The mission could also provide precise asteroid tracking information that could verify that the desired deflection actually took place, demonstrating the essential role of an observer spacecraft.
- Increased international participation and funding might increase the likelihood of selection for the Don Quijote mission, and assigning responsibilities of different mission capabilities or phases to other nations (such as having the U.S. responsible for the kinetic impact phase) has been done successfully in the past (e.g., the Huygens Titan probe on the Cassini mission to Saturn) and should be considered.
- ESA has included discovery and tracking of NEOs as part of its emerging Space Situational Awareness (SSA) program and this synergy in capabilities should be considered by the US and other SSA communities.
- Limited work has been done on detailed design for a deflection campaign, the overall effort required to deflect a threatening object with high reliability. An end to end campaign design is needed incorporating the proposed deflection options and designs might include the use of various techniques (impulsive and slow-push) and multiple phases where feasible.

Recommendations from this topic area are:

- ESA's Don Quijote mission should be funded. Opportunities for international involvement and support for this mission should be pursued.

- Tests related to verifying and characterizing vehicle orbit and control schemes related to the gravity tractor concept should be included in the Don Quijote mission.
- Future conferences should encourage the development of deflection campaigns designed to lower the probability of a NEO impact to below a specified threshold value. The campaign design should specify the campaign and mission timelines, launch vehicle(s) and spacecraft, deflection option(s), and resource requirements for such an effort.

Deflection Technologies and Simulations

The discussion covered a number of concepts that have been proposed, but testing of these technologies is limited. Key points were:

- Research on deflection or mitigation of a threat is receiving essentially no funding at present. As a result, development of new deflection techniques is proceeding at a slow pace and characterization of proposed deflection methods is in its early stages.
- Kinetic impact, striking a NEO with an object traveling at a high relative velocity, will alter the NEO's orbit. The overall effectiveness of a single impact will depend on the characteristics of the object, the impact velocity and mass of the impactor, and the quantity of ejecta released by the impact. A successful deflection mission may require "pulses" by several impactors which would also provide some redundancy. The Deep Impact mission involved the high-speed impact with comet Tempel-1 and demonstrated NEO targeting technologies, but effects on the comet's orbit were by mission design tiny and not measurable.
- Slow push technologies such as focusing solar or laser energy on a NEO, reducing or even canceling the Yarkovsky effect, or the Gravity Tractor have the potential to alter the orbit of a threatening object, but none has been tested and no campaign designs using these techniques have been presented. Focusing solar and laser energy on the surface of a NEO will generate plumes of material that may affect the overall effectiveness of these techniques. These types of effects have not been investigated.
- "Keyholes" represent narrow regions on the plane passing through Earth and perpendicular to an NEO's approach direction where, if an NEO passes through a keyhole, Earth's perturbations put the NEO on a resonant return that ensures an Earth impact on a subsequent Earth return. The existence of keyholes should be a consideration during the design of a mitigation campaign, with the objective being to deflect the NEO into a region where there are no possibilities of future close approaches to Earth. Slow-push techniques such as the Gravity Tractor might be used as an orbit "trim" capability to move the NEO away from a particular keyhole and into an area with no other keyholes.
- Nuclear technologies deliver the greatest energy per unit mass to a target object, their basic capability has been tested in space, and their overall effects on a target

object can be predicted reasonably accurately. Nuclear energy devices may be the only technology that could provide significant orbit change to objects exceeding 1 km in size in a relatively short time. The proper functioning of a nuclear device for high-velocity impacts (~10 km/sec) has not been verified. There could be significant political and legal issues and concerns that would affect the development, maintenance, or use of nuclear devices for the deflection or destruction of a threatening Near Earth Object.

Recommendations from this topic area are:

- Continue to develop, test, and refine capabilities for spacecraft operations in the vicinity of NEOs. Such opportunities might also be used to test slow push techniques such as the Gravity Tractor.
- Initiate studies and discussions to define situations where use of nuclear energy devices might be proposed for planetary defense purposes and assess possible public response to their proposed use. Continue to study the effects of nuclear energy devices for deflection of NEOs of differing size and composition and consider the value of disruption as a mitigation technique.
- Fund research and conduct flight experiments to characterize and refine the effectiveness of Kinetic Impact as a deflection technique. The Don Quijote mission is seen as a good candidate for a test mission.
- Study plume production and dynamics for laser and solar energy focusing strategies in order to determine the feasibility and the real capabilities of these concepts.

Impacts and Consequences

A reasonable understanding of the relationships between object size, entry conditions, and impact location (land or water) may be critical for estimating the level of hazard posed by a potential threat. Such information is essential for assessing the threat posed by a particular NEO, for deciding whether deflection is warranted for small NEOs, and for disaster and mitigation planning. A key finding is that:

- Recently updated simulations of impacting bodies do not fully model significant phenomenon related to the transfer of energy of an impacting body to the Earth's environment. While significant improvements have been made in these models, the size of entering NEOs that could cause concern for tsunamis and other consequences is still not well defined.
- It is estimated that the remaining risk from the undiscovered NEO population (expressed as average annual fatalities) is currently roughly 20/yr from local/regional land impacts, 4/yr from impact tsunamis, and 54/yr from globally catastrophic events (the undiscovered big ones). Once completed, the next generation surveys will find 90% of NEAs larger than 140 m and ~25% of the NEOs in the smallest size range capable of causing ground damage, further reducing impact risk and consequence projections for the undiscovered population.

- Impacts of objects in the smaller size range present mainly tsunami risk and may be less frequent and less damaging than previously estimated. Careful cost-benefit accounting is in order to evaluate programs and policies.

Recommendations from this topic area are:

- Fund more complete simulations of the entry and impact of NEOs in the size range of 20 to 500 meters. These simulations should include the transfer of energy into land and water, with the goal of developing reliable relationships between NEO energies and impact consequences. These simulations should also be adapted and integrated into modeling tools for providing validated information to decision makers.
- Encourage a broadly based range of environmental studies into the effects of NEO impacts on the ozone layer, electromagnetic effects on electronic and electrical infrastructure, and the true limits and effects of small object impacts.

Policy, Preparedness, Deciding to Act

As noted, once a threatening NEO is detected, a decision is required on whether to take action and if so, the type of action to be taken. Such a decision will involve policy makers, government officials, and technical experts from many nations. Key points from this discussion are:

- Since the lower limit of NEO sizes that could cause significant damage is not well known and may vary by object type, there is concern that when a small NEO is detected only a short time before impact (e.g., days to weeks), notice may not reach entities that might be responsible for responding to a disaster. Work needs to be done to define and develop agreements, procedures, and protocols for communicating even small NEO events and threats to decision makers, disaster response agencies and the public since this is the most likely kind of event to happen in the next decades.
- A recent simulation conducted by the U.S. Air Force examined the response of U.S. agencies to the hypothetical impact of a NEO.[2] This was the first such simulation and the effort provided very valuable insights of how responses to such a threat might evolve. For example, a scenario where disaster recovery agencies are required to respond to an "Apophis-level" impact in the South Atlantic Ocean would need to bring together national leaders and disaster relief agencies for nations on both sides of the Atlantic. Alternatively an Apophis impact in the Pacific Ocean would bring together national leaders and disaster relief agencies for nations along the Pacific Rim. Existing disaster response scenarios may not anticipate coordination on such a large scale.
- A recent conference on legal issues associated with planetary defense enhanced legal and policy perspectives on potential NEO threats and threat mitigation. A

[2] http://neo.jpl.nasa.gov/neo/niaa2008.html

possibility for the future would be to pose specific NEO threat and mitigation scenarios to be considered by legal and policy experts, with results presented at, or developed as part of, future Planetary Defense Conferences.

Recommendations from this topic area are:

- Develop protocols for providing timely warnings to responsible entities in the event that even a small NEO is detected shortly before impact.
- Conduct and report at the 2011 conference on a simulation of a NEO impact disaster and/or a NEO warning involving appropriate agencies at the international level.
- Develop and maintain authoritative, web-based resources that can be used to provide the most up-to-date information to the public and decision makers on the NEO threat, mitigation options, and legal and policy issues associated with planetary defense.
- Increase outreach to professional organizations in arenas beyond just the aerospace community, whose members might be involved in planetary defense should a threat be discovered or an impact occur. Papers and presentations at their meetings should be developed to acquaint these individuals with the nature of the NEO threat and their representatives should be invited to future PDCs and related meetings.

What's Happening Now

The final session provided an update on current activities related to moving forward on planetary defense. Highlights include:

- The IAA reported on its recently completed study titled "Dealing with the Threat to Earth from Asteroids and Comets."[3] The report covered technical issues, behavioral factors, and the sociological and psychological aspects of a threat and possible mitigation attempts.
- The Association of Space Explorers, an organization of astronauts and cosmonauts who have flown in space, presented a report on the work of the international Panel on Asteroid Threat Mitigation and its "Call for Global Response: the Challenge to the International Community."[4] The report has been submitted to the UN committee on the Peaceful uses of Outer Space (COPUOS) and is currently entering a process of deliberation and potential action within the UN.
- The National Academy of Sciences National Research Council's NEO Surveys and Hazard Mitigation panel is conducting a study addressing requests from the

[3] http://iaaweb.org/content/view/229/356/.

[4] http://www.space-explorers.org/committees/NEO/neo.html

U.S. Congress regarding the challenge of surveying potentially hazardous NEAs at smaller sizes, to reach 90% completeness at a diameter of 140 m. They are also considering a wide variety of techniques for characterization and mitigation. Congressional staff members have told the NAS-NRC steering committee that the Congress is interested in understanding how international collaboration should work in this area. This NRC study and recommendations should be completed at the end of 2009.

- The case for a high level primer to introduce the subject of NEO's and the related research and mitigation requirements was made together with the need to ensure online sources of information are relevant and correct.
- A high level tool to assess the Earth's vulnerability to the NEO impact hazard has been developed. Work needs to continue, including the incorporation of the latest results from the topics reported at the meeting as well as including the latest population and bathymetric data.

Recommendations from this session are:

- Develop protocols and assign responsibilities for a global response to a NEO threat, taking into account proposals from the Association of Space Explorers.
- Assure that there is a web site where factual, objective information on planetary defense is available and that information is current.
- Continue development of tools that can be used to assess the implications of NEO impact.

NEXT CONFERENCE

THE 2nd IAA Planetary Defense Conference will be held on May 9-14, 2011 in Bucharest, Romania.

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