United Nations A/AC.105/896

General Assembly

Distr.: General
4 December 2007

Original: English

Committee on the Peaceful Uses of Outer Space

Information on research in the field of near-Earth objects carried out by Member States, international organizations and other entities

Note by the Secretariat

Contents

V.07-88711 (E) 210108 220108

I. Introduction

1. At its forty-fourth session, in 2007, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space adopted the new multi-year workplan for the period of 2008-2010 (A/AC.105/890, annex III, para. 7). In accordance with the workplan, the Subcommittee will, at its forty-fifth session, in 2008, consider reports submitted in response to the annual request for information from Member States and international organizations on their near-Earth object activities.

2. The present document has been prepared by the Secretariat on the basis of information received from the following Member States: Germany, Japan, Poland and the United Kingdom of Great Britain and Northern Ireland.

II. Replies received from Member States

Germany

[Original: English]

German Aerospace Center, Institute of Planetary Research, Berlin

(a) Introduction

1. Scientists at the Institute of Planetary Research of the German Aerospace Center (DLR) in Berlin-Adlershof have been engaged in international research on near-Earth objects (NEOs) for many years. The work includes observation campaigns for physical characterization of NEOs using major ground-based and space-borne astronomical telescopes, the maintenance of a database for physical properties of NEOs, risk assessment and impact mitigation, development of impact simulation tools and contributions to space missions to NEOs.

2. DLR is in close contact with the German Federal Foreign Office to support activities of the Action Team on Near-Earth Objects and the Working Group on Near-Earth Objects within the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

(b) Observation of near-Earth objects

3. Observational work in the thermal infrared spectral region with telescopes such as those of the Keck Observatory and the National Aeronautics and Space Administration (NASA) of the United States of America Infrared Telescope Facility, both on Mauna Kea in Hawaii, and the NASA Spitzer Space Telescope currently represents one of the major areas of activity. Data from those observations make it possible to determine crucial parameters such as the size and albedo of NEOs and provide information on surface characteristics via thermal inertia. The interpretation of those observations requires extensive theoretical work and computer modelling of the physical characteristics of NEOs.

4. In addition to those front-line research activities, an online database of physical properties of all known NEOs is maintained, which is available on the Internet (http://earn.dlr.de) and is updated on a daily basis.

(c) Theoretical studies and simulations

5. Various potential techniques for diverting asteroids and comets from a collision with the Earth have been investigated and modelled. In the course of the work, a software package has been developed to simulate a possible impact hazard and to determine an optimal deflection strategy.

6. A theoretical study involving advanced computer modelling and simulations analyses the formation of craters and associated effects of asteroid and comet impacts on the Earth.

(d) Space missions

7. A strong future participation in the planning of the Don Quijote mission is foreseen. Don Quijote is a mitigation precursor mission currently undergoing a feasibility study by the European Space Agency (ESA). DLR is also involved in other space missions to investigate minor NEOs, such as Rosetta and Dawn.

(e) German spaceguard centre

8. The Institute of Planetary Research has proposed the establishment of a spaceguard centre in Germany, which, like its existing counterparts in the United States (the Near-Earth Object Program Office of the Jet Propulsion Laboratory) and the United Kingdom (the Near-Earth Object Information Centre), should act as a link between research activities and the general public, convey scientifically based information in easily understandable terms to the public and governmental departments and be prepared to support policymakers in administering German participation in international activities relating to the impact hazard and NEO mitigation plans. That proposal has been considered by the authorities in DLR, and a decision on establishing the centre is pending.

Japan

[Original: English]

1. Japanese NEO activities started with the establishment of the Japan Spaceguard Association (JSGA) in 1996. JSGA has constructed a 1-metre NEO detection wide-field telescope, which became operational in 2002 and which was mainly used for follow-up observations. JSGA repaired the telescope in 2006 and is now able to detect NEOs down to a 20.5 magnitude, which is comparable to detections by the Catalina Sky Survey and the Spacewatch Project in the United States. In the table below, a list of NEO follow-up observations is shown.

2. JSGA has carried out various educational activities over the last 10 years. JSGA has now produced a useful educational package in English, Japanese and Spanish on NEO detection for public outreach and has published two books and a number of articles in journals and newspapers.

Near-Earth object observations by the Japan Spaceguard Association (as at September 2007)

	Near-Earth asteroids			*Comets*	
Year	*Number observed*	*Number of position measurements*	*Sum of position measurements*	*Number observed*	*Number of position measurements*
2000	23	205	4 240	20	113
2001	29	560	5 907	16	275
2002	24	243	2 018	13	339
2003	54	567	4 938	18	165
2004	23	233	2 908	4	20
2005	8	42	2 431	0	0
2006	25	297	3 224	5	66
2007	26	365	2 178	14	101
Total	**212**	**2 512**	**27 844**	**90**	**1 079**

3. Another important activity on NEOs is the Hayabusa mission to NEO “Itokawa”. The scientific purpose is to gain valuable information on the mysteries behind the genesis of the solar system by analysing the composition of the asteroid. It is therefore essential to develop technology to bring back samples of asteroids. In autumn 2005, when NEO Itokawa approached closer, many enlarged images were obtained, and a trial return sample of Itokawa surface materials was taken. The return of the Hayabusa mission, which is ongoing, is scheduled for June 2010. The Japanese Aerospace Exploration Agency is now considering the next sample return mission from another type of NEO, and it is hoped that the mission will take place in the near future.

Poland

[Original: English]

1. In 2007, the work on NEOs in Poland was carried out by the Space Research Centre of the Polish Academy of Sciences, the Chorzów Planetarium, the Polish Fireball Network and the Polish Astronautical Society. The Centre carried out research on potentially hazardous asteroid collision orbits with the Earth. The Chorzów Planetarium and the Polish Fireball Network conducted visual and radio observations of NEOs. The Polish Astronautical Society studied a robotic mission to the asteroid Apophis.

United Kingdom of Great Britain and Northern Ireland

[Original: English]

(a) Introduction

1. The British National Space Centre (BNSC) maintains an active role in addressing the NEO problem by encouraging coordination at the national, European and international levels to reach an agreement on understanding and developing effective measures to address the threat posed by NEOs. This leadership role is demonstrated by, among other things, the United Kingdom's chairmanship of the Action Team on Near-Earth Objects and the Working Group on Near-Earth Objects.

2. The United Kingdom has strong NEO research capabilities, building on its astronomy, planetary science and space surveillance capabilities, which BNSC regularly calls upon for impartial technical support and advice. In 2006, United Kingdom organizations conducted a wide range of activities, a number of which are summarized below.

(b) Remote observation and measurement of the NEO population

3. A partnership of United Kingdom astronomers, from Durham University, Queen's University of Belfast and the University of Edinburgh, has joined a group of United States and German institutions to use an advanced new telescope, the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), equipped with the world's largest digital camera, located on the Hawaiian island of Maui, to observe and determine the characteristics of NEOs and other bodies in the solar system and beyond. The telescope is currently on track to start operations in April/May 2008. Once operational, it will more than double the current discovery rate of NEOs per month.

4. Astronomers at Queen's University of Belfast, in cooperation with colleagues in Germany, the Czech Republic, Slovakia and the United States, successfully measured the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect for the first time, by studying NEO (54509) 2000 PH5 over several years. That theoretical effect causes NEOs to spin up or spin down through the action of being heated by the Sun. The YORP effect is probably the primary method of the creation of binary NEOs and acts in unison with the Yarkovsky effect in delivering asteroids to Near-Earth space.

5. Astronomers at Queen's University of Belfast continued to obtain astrometric data on NEOs with an identified small risk of hitting the Earth in the next 100 years, with the aim of improving their orbits. So far, they have measured positions and improved the orbits of over 200 NEOs.

6. A study was made of NEO (10302) 1989ML, which has an orbit allowing it to be easily reached by spacecraft. The team of astronomers from Queen's University of Belfast and from Berlin showed that, due to its size and composition, the NEO was unfortunately an unsuitable target for the proposed ESA Don Quijote mitigation test mission, for which it had been the primary target.

7. The Open University is researching light curves of slowly rotating (mostly main belt) asteroids, using data from the super Wide Angle Search for Planets

(WASP) sky cameras, and is continuing to publish NEO observation results (thermal modelling and infrared spectroscopy).

(c) In situ observation and measurement of the NEO population

8. At the Open University, in addition to theoretical studies aimed at understanding the formation of smaller bodies in the solar system, a number of experimental programmes are also under way. Among them is the development of a penetrometry rig to simulate a high-mass, low-speed impact of a penetrometer fixed to a landing spacecraft. Penetrometers will be key to enabling in situ measurements on NEO surfaces, which are likely to be delicate in nature, in order to obtain structural and mechanical information on the body. Such information is critical for successful mitigation and negation of NEO bodies. The Open University has an interest, more broadly, in instrumentation for the in situ physical and geochemical investigation of NEOs and other smaller solar system bodies. That has helped the Open University to gain a lead scientific role in the "Marco Polo" NEO sample return mission proposed through the ESA Cosmic Vision programme, which was selected to go to the next stage of evaluation and selection within the ESA Science Programme. In addition, research of the Open University on NEOs continues in the field of meteoritics and extraterrestrial sample analysis, using its world-class suite of geochemical laboratories, which forms part of the United Kingdom Cosmochemical Analysis Network.

(d) Risk assessment

9. The Astronautics Research Group at the University of Southampton is conducting a significant amount of research into the effects of NEO impacts on the Earth. A software tool was developed in the period 2004-2005 to assess how impact-generated effects will affect the human population, and the software was exploited in 2006 to analyse particular impact case studies. The first of these was an evaluation of the casualty numbers resulting from ground and sea impacts in the regional neighbourhood of the United Kingdom, and the second was a study of the effects on the human population resulting from the potential impact of the asteroid 99942 Apophis in 2036. The results of these studies were published in the Proceedings of the International Astronomical Union Symposium held in Prague in August 2006 and presented at the Planetary Defense Conference held in Washington, D.C., in March 2007.

10. The NEO research programme at the University of Southampton is aimed at assessing the global threat to the Earth posed by small NEOs less than 1 km in diameter. The impact-generated effects resulting from an NEO impact would have an effect on the Earth's ecosystem and serious consequences for the human population. The primary challenge in the research is accounting for each impact-generated effect and developing an adequate model to simulate it. To this end, the computer simulation tool under development has the capability of modelling small NEO impacts. The tool models the hazard on both the local and the global scale, tracking the consequences of an impact on the human population. Each of the impact-generated effects will affect the human population and infrastructure to varying degrees. Therefore, the analysis of mortality rates and infrastructure cost is the key feature of the simulation. The overall hazard assessment of an NEO

impact event will be rated by the calculated number of casualties and level of infrastructure damage.

11. The computer simulation tool first tracks the object as it enters the Earth's gravitational sphere of influence. Its path through the atmosphere is then simulated as it experiences ablation and aerodynamic forces. The object's energy is either fully spent in the atmosphere, resulting in an airburst, or it causes a ground impact. The impact event is modelled using algorithms based on current literature. The simulation of land impacts includes the effects from seismic activity, shock waves, radiation generated by the developing fireball and ejecta distribution. The simulation of ocean impacts requires the modelling of a tsunami wave, which would inundate coastlines across the globe.

12. The simulation output shows how each impact-generated effect can affect human populations, and the analysis can be performed for any location in the world. Casualty figure estimates will be complemented by an indication of the economic cost due to lost infrastructure. Those two indicators will enable an assessment of the NEO hazard on a global and a country-by-country basis. Investigations can be carried out on the involvement of individual countries in any known NEO events. Furthermore, numerical modelling techniques will provide an analysis of the threat, leading to a global understanding of the risk to individuals due to potential NEO impact events.

13. This work is being further advanced with the development of a more capable software tool, called the "NEO impactor", which will be used for global studies of the effects of NEO impacts on both the population and on infrastructure. The tool contains sophisticated models of the effects of airbursts, ground impacts and ocean impacts. Completion of the research programme, which is funded jointly by the University of Southampton and BNSC, is expected in 2007.

(e) Mitigation

14. The objective of work conducted by the University of Glasgow is to develop fundamental optimal control theory and apply it to the interception of hazardous NEOs. Different parameters (time, mass, orbital corrections and maximum deviation) will be optimized. A study of the robustness of the methods will also be performed to take into account uncertainties with respect to both NEO dynamics and boundary conditions. A variety of propulsion methods, ranging from solar sails to nuclear propulsion, will be considered, and the advantages and disadvantages of each method will be assessed. Numerical simulations in a realistic scenario will be developed in order to investigate the performance of such methods, and, in order to evaluate the optimal trajectories and deviation methodologies, the simulation data will be animated. That work is a three-year programme funded by the Engineering and Physical Sciences Research Council. Currently in the second year of the three-year programme, the study has been moving along two parallel paths. The first has been the development of global optimization algorithms for an interplanetary trajectory. The tools developed are used to generate a number of possible trajectories to intercept NEOs. The trajectories are robust with respect to uncertainties of both spacecraft and NEO parameters. The second path has been the comparative assessment of different deviation methods. In particular, researchers have investigated both kinetic (nuclear and impactor) and low-thrust (mass-driver, solar collector and electric propulsion) deviation methods with respect to three key

parameters: achieved miss-distance at the Earth, warning time and total mass into orbit. In addition, the research team has performed a technology readiness analysis of the different methods. Future work will develop more accurate models of static and dynamic asteroid properties to determine how they may influence and perhaps invalidate certain deviation methods, as well as continuing the assessment of other methods such as a gravity tractor and the Yarkovsky effect.

15. The Space Research Centre of Cranfield University developed a design for a precursor asteroid rendezvous and investigation mission during the period 2006-2007. The study was largely performed by a team of graduate students in astronautics and space engineering and represents approximately three man-years of design and analysis. The mission's aim is to characterize a potentially hazardous asteroid so that a subsequent impact mitigation mission will more likely be successful. Some of the issues that the precursor mission is designed to resolve are precise orbit determination and the assessment of the object's composition. Without that information the need for mitigation is less certain, and any mitigation attempt is less likely to be successful. The asteroid Apophis was chosen as the prime target because it represents the most likely impact risk and the highest current asteroid threat to the Earth. In order to develop the baseline design, the team initially identified a range of mission concepts and then chose the best of those, using an assessment of trade-offs, based on the various attributes of the concepts. The next phase was to develop outline designs for each subsystem, focusing on issues that could affect mission feasibility. The resulting baseline design consists of a 600-kilogram spacecraft with electric propulsion and a lander containing a tracking beacon, to be placed on Apophis. Asteroid composition is measured by radar and seismometry. The results so far indicate that the concept is feasible, although further work is required, especially in the areas of low-thrust trajectories for asteroid rendezvous and technologies for the tracking transponder, for measuring asteroid composition and for attaching equipment to an asteroid on which gravity is weak and surface composition is uncertain.

16. The company QinetiQ, Open University and the company SciSys are involved in the phase A studies of the ESA Don Quijote mission. In addition, Queen's University of Belfast and Open University staff members have continued their ongoing membership of the ESA Near-Earth Object Mission Advisory Panel.

17. On behalf of ESA, the company Astrium Ltd performed a reference study on NEO sample return technology, to take a sample from a primitive asteroid back to the Earth. The company participated in phase A mission studies of Don Quijote, the ESA mission concept to impact an asteroid while monitoring the impact and the asteroid's trajectory (before and after) from a second spacecraft.

18. With support from the Open University, the company Astrium Ltd submitted a concept design, called "APEX", for the Apophis Mission Design competition organized by the Planetary Society. The APEX concept is a rendezvous mission aimed at measuring and modelling the orbit of the potentially hazardous asteroid 99942 Apophis to unprecedented accuracy. The concept could also serve as a template for predicting the trajectories of dangerous asteroids with a greater level of confidence than is possible using Earth-based tracking.

(f) Information dissemination

19. The United Kingdom continues to be home to two centres providing information on NEOs to the public and media.

20. The first centre is the Spaceguard Centre, located at the former Powys Observatory, near Knighton in Mid Wales. As the International Spaceguard Information Centre, it represents the Spaceguard Foundation. The Centre has set up the nationwide Comet and Asteroid Information Network and has a well-established outreach programme. It currently liaises with Spaceguard organizations in 17 countries worldwide and encourages the establishment of new ones. The Centre is also the primary science adviser for the Faulkes Telescope (Las Cumbres Observatory Global Telescope Network) Asteroid Project, and is developing a robotic NEO astrometry system (Spaceguard NEO Astrometry Project), deployed in the United Kingdom and Kenya. A serious NEO search capability will be added if the Centre can secure funding to move the 24-inch Schmidt camera from the Institute of Astronomy in Cambridge to Wales.

21. The second centre is the United Kingdom Near Earth Object Information Centre, which was established in response to recommendations 13 and 14 of the report on NEOs of the United Kingdom Government's Task Force on Potentially Hazardous Near-Earth Objects. The Information Centre is operated by a consortium led by the National Space Centre, under contract to BNSC. The main centre is based at the National Space Centre in Leicester, which houses an NEO exhibition and provides a primary contact point for public and media enquiries. A network of academic institutions active in the field of NEOs advises the Centre: Queen's University of Belfast; the United Kingdom Astronomy Technology Centre; the Natural History Museum; Queen Mary, University of London; Imperial College; and the University of Leicester. In addition, there are three regional centres with linked exhibits and access to the Information Centre facilities. These are based at W5 in Belfast, the Natural History Museum in London and the Royal Observatory in Edinburgh. The website of the Information Centre (www.nearearthobjects.co.uk) provides a virtual exhibition, a resources section for educators and the media and the latest NEO news, including answers to frequently asked questions. The site also allows access to the report of the Task Force on Potentially Hazardous Near-Earth Objects.

22. The Open University's undergraduate course S250 "Science in Context" had its second presentation in 2007. One of the seven topics covered in the course is NEOs and the impact hazard, delivered by means of a book and DVD. Of the 514 students registered for the course, 465 submitted the first tutor-marked assignment covering NEOs. In addition to the science of NEOs, the course also addresses the related themes of communication, risk, ethical issues and decision-making. The University also continues to include NEOs in its outreach activities, including responding to media enquiries and giving talks to clubs and societies.

(g) Policy approach

23. In the United Kingdom, the underlying policy approach to NEOs is to recognize that the threat posed by such impactors is real and that, although such an impact is a low-probability occurrence, it would be potentially catastrophic. That policy approach also recognizes that such objects do not respect national boundaries

and that the scale of their potential effects is such that the NEO hazard constitutes a global issue and can be effectively addressed only through international cooperation and coordination.