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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

Addendum

Contents

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I. Introduction

1. At its forty-second session, in 2005, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space amended the work plan of the agenda item on near-Earth objects for the years 2006 and 2007 (A/AC.105/848, annex I, para. 20), which had been adopted by the Subcommittee at its forty-first session in 2004 (see A/AC.105/823, annex II, para. 18). In accordance with the amended work plan, the Subcommittee will, at its forty-fourth session, in 2007, consider reports received from Member States and international organizations on their near-Earth object activities, including missions, search and follow-up, as well as plans for future activities.

2. The present document has been prepared by the Secretariat on the basis of information received from the following Member States: Germany, Japan, Latvia, 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 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, for which observation time is awarded on a competitive basis. Data reduction and analysis, theoretical investigations and the publication of results in major refereed journals are also major activities of the group in this field. This work is carried out mainly by the Asteroids and Comets Department of the Institute by six scientists and, on average, two research students.

(b) Observation of near-Earth objects

2. Observational work in the thermal infrared spectral region with telescopes such as Keck 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 these 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 these observations requires extensive theoretical work and computer modelling of the physical characteristics of NEOs. Recent successful proposals from the Institute of Planetary Research for observation time with the NASA Spitzer Space Telescope include a study of the physical characteristics of a very small, rapidly rotating NEO and the determination of the size and nature of a potential target of the Don Quijote mission of the

European Space Agency (ESA). This work is carried out in collaboration with groups in the United States (the Massachusetts Institute of Technology and the University of Hawaii) and in Europe (the Queen's University of Belfast, the University of Helsinki and the Turin Astronomical Observatory). One research fellow is currently working on his Doctorate of Philosophy (PhD) in this field.

3. In collaboration with Scandinavian institutes (the University of Helsinki, the University of Uppsala, the University of Oslo and the University of Copenhagen) an observation programme of NEOs has continued. The programme uses the Nordic Optic Telescope on the island of La Palma, Spain, to carry out photometric light curve observations of NEOs and perform astrometric follow-up of newly discovered NEOs.

4. In cooperation with the Calar Alto Observatory in Spain, the Institute of Planetary Research intends to operate a remote-controlled 1.2-metre telescope for photometric and astrometric observations of NEOs starting from 2007.

(c) Theoretical studies and simulations

5. In the course of a PhD project, in cooperation with the Dresden University of Technology, various potential techniques for diverting asteroids and comets from 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. This work has led to a successful dissertation at the Technical University of Berlin.

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. This work also constitutes a successfully completed PhD project in collaboration with the Technical University of Braunschweig.

(d) Space mission involvement related to near-Earth objects

7. A strong future participation in the planning of the Don Quijote mission is foreseen. Don Quijote is a mitigation precursor mission of ESA currently under feasibility study by a consortium of European industrial and academic partners. The Institute of Planetary Research is a member of the consortium, which has successfully completed a phase A study of the mission recently issued by ESA.

(e) Database of near-Earth objects

8. In addition to the above-listed frontline research activities, an online database of physical properties of all known NEOs is maintained and available on the Internet (http://earn.dlr.de). It is updated on a daily basis.

(f) European Fireball Network

9. The Institute of Planetary Research is involved in the operation of a network of all-sky cameras that record the tracks of large meteoroids colliding with the Earth. The European Fireball Network provides fundamental data for the computation of the mass flux near the Earth and the probability of collisions with larger bodies. This project is carried out in collaboration with the Ondrejov Observatory of the Czech Republic.

(g) German spaceguard centre

10. 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.

(h) Publications

11. Copies of publications related to the research activities described above are available on request. Annual reports are available from the following website: http://solarsystem.dlr.de/KK/. Further publications of the Institute of Planetary Research can be found on the following website: http://elib.dlr.de/perl/search/.

Japan

[Original: English]

1. Japanese NEO activities started with the establishment of the Japan Spaceguard Association (JSGA) in 1996. The main activity of JSGA is public outreach. JSGA has published two books and many articles in journals and newspapers.

2. JSGA has constructed 1-metre NEO detection wide-field telescopes, which became operational in 2002. There was, however, a problem with tracking and a poor limiting magnitude (18.5 magnitude). As a result, JSGA could only detect one new NEO and carry out follow-up observations of NEOs detected by other telescopes. In the table below, a list of NEO follow-up observations is shown. JSGA is planning to repair the 1-metre telescope later in 2006 and, consequently, will be able to detect up to 20.5 magnitude, which is comparable to the detection rate of the Catania Group and the Spacewatch Group in the United States.

Table
Near-Earth object observations by the Japan Spaceguard Association (as at August 2006)

	Near-Earth asteroids			*Comets*	
Year	No. observed	No. of position measurements	Sum of position measurements	No. observed	No. 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	17	221	2 488	2	10
Total	**178**	**2 071**	**24 930**	**73**	**922**

3. Since its establishment 10 years ago, JSGA has produced an educational package (in Japanese and English) on NEO detection for public outreach purposes. JSGA intends to visit over 1,000 people to present its programmes.

4. Another important activity on NEOs is the Hayabusa mission to NEO “Itokawa”. In autumn 2005, when the NEO approached closer, many enlarged images were obtained and a trial of sample return of the Itokawa surface materials was taken. The return of the Hayabusa mission is ongoing. In considering the NEO mitigation mission, prior to Itokawa’s collision to Earth the different physical parameters should be carefully studied. The Japanese Aerospace Exploration Agency is now considering the next sample-return mission.

Latvia

[Original: English]

1. The Ventspils International Radio Astronomy Centre (VIRAC) and the University of Latvia Institute of Astronomy, in cooperation with the Academies of Science of the Russian Federation and Ukraine, are in the process of joining a 5 GHz frequency-band radio-location observation network of NEOs. The corresponding receiver has been designed and tested. A complete incorporation in the observation programme is anticipated in 2007. The researchers of VIRAC and the Institute of Astronomy are processing the collected data.

Poland

[Original: English]

1. No significant activities were performed concerning NEOs. Some activities are related to the modelling of the NEO orbits and the effects of NEO collisions with the Earth; however, these activities are conducted on a limited scale in the academic centres in Poland.

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 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 Committee on the Peaceful Uses of Outer Space Action Team 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 2005, United Kingdom organizations have 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. This supplements ongoing research by these groups in detection, follow-up and astrometry previously reported to the Scientific and Technical Subcommittee.

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

4. 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 an NEO surface, which are likely to be delicate in nature, to give structural and mechanical information on the body, critical for successful mitigation and negation of the body. 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.

(d) Risk assessment

5. 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 this was exploited in 2005 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 other 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 will be published in the Proceedings of the International Astronomical Union Symposium on Binary Stars as Critical Tools and Tests in Contemporary Astrophysics, held in Prague in August 2006.

6. The NEO research programme at the University of Southampton is aimed at assessing the global threat to Earth posed by small, sub-kilometre diameter NEOs. The impact-generated effects resulting from an NEO impact 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. This tool tackles the hazard on both a local and 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. Overall hazard assessment of an NEO impact event will be rated by the casualty figure and level of infrastructure damage.

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

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

9. This work is being further advanced with the development of a more capable software tool, called NEO impactor, which will be used for global studies of the

effects of NEO impact-generated effects on both population and infrastructure. The tool contains sophisticated models of the effects for 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

10. 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, maximum deviation, etc. – will be optimized. A study of the robustness of the methods will also be performed to take into account the uncertainties on both the 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 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. This is a three-year programme funded by the Engineering and Physical Sciences Research Council. Currently at the first year into the three-year programme, the study has been moving along two parallel paths. The first has been the development of global optimization algorithms for interplanetary trajectory. The tools developed are then used to generate a number of possible trajectories to intercept NEOs. The trajectories are robust to uncertainties in both the spacecraft and NEO parameters. The second strand 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 be on developing more accurate models of the asteroid static and dynamic properties to see how these 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.

11. The company QinetiQ and the Open University are involved in ESA's Don Quijote phase A mission studies. The Open University is also engaged in an assessment study led by the Centre national d'études spatiales for a rendezvous and landing mission to a primitive binary NEO. The Italian Space Agency and the German Aerospace Center are also part of the study team. In addition, Queen's University of Belfast and Open University staff members have continued their ongoing membership of ESA's Near-Earth Object Mission Advisory Panel Committee.

(f) Information dissemination

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

13. The first is the Spaceguard Centre, located at the former Powys Observatory, near Knighton in mid-Wales, United Kingdom. It represents the Spaceguard Foundation as the International Spaceguard Information Centre. It 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 around the world and encourages the establishment of new ones.

14. The second is the United Kingdom's Near Earth Object Information Centre which was established in response to recommendations 13 and 14 of the United Kingdom Government's Task Force on Potentially Hazardous Near Earth Objects report on NEOs. 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 seven academic institutions active in the field of NEOs advises the Centre. These are 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 in 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 latest NEO news, including answers to frequently asked questions. The site also allows access to the report of the United Kingdom Task Force.

15. The Open University has an ongoing undergraduate course that includes NEOs as one of the seven topics covered, including not just the science but the related themes of communication, risk, ethical issues, policymaking and decision-making.

(g) Policy approach

16. The underlying policy approach in the United Kingdom to NEOs is recognition that the threat posed by such impactors is real, although it is a low probability occurrence, but potentially catastrophic when it occurs. It also recognizes that such objects do not respect national boundaries and the scale of their effect is such that the NEO hazard is a global issue and can only be effectively addressed through international cooperation and coordination.