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Near-Earth objects

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

Note by the Secretariat

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I. Introduction

In accordance with the agreement reached at the forty-second session of the Scientific and Technical Subcommittee (see A/AC.105/848, annex I, para. 20) and endorsed by the Committee on the Peaceful Uses of Outer Space at its forty-eighth session,[1] the Secretariat invited Member States and international organizations to report on their near-Earth object activities, including missions, search and follow-up, as well as plans for future activities for consideration by the Subcommittee. The present document contains reports received by 9 December 2005.

II. Replies received from Member States

Germany

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 near-Earth object (NEO) research for many years. Their 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 in the Asteroids and Comets Department of the Institute by five 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. 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, United Kingdom of Great Britain and Northern Ireland; the University of Helsinki; and the Turin Astronomical Observatory, Italy).

3. One research fellow is currently working on his PhD in this field. Photometric light curve observations of NEOs are also carried out to determine rotational properties and, in some cases, to detect companion moons (a significant fraction of NEOs have turned out to be binary asteroids). This research requires the cooperation

[1] *Official Records of the General Assembly, Sixtieth Session, Supplement No. 20* and corrigendum (A/60/20 and Corr.1), para. 151.

of other groups in Europe and the United States, currently under the leadership of a group in Prague. The Institute, in cooperation with Calar Alto Observatory (Spain), intends to operate a remotely controlled 1.2-metre telescope for photometric and astrometric observations of NEOs, starting in 2006.

(c) Theoretical studies and simulations

4. 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. The formation of craters and associated effects of asteroid and comet impacts on the Earth are currently being analysed in a theoretical study involving advanced computer modelling and simulations. This research also constitutes a PhD project in collaboration with the Technical University of Braunschweig.

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

5. The Institute is involved in the interpretation of Deep Impact data and in ground-based observations of the NEO Itokawa, which is the target asteroid of the Japanese Hayabusa mission. A strong future participation in the planning of the Don Quijote mission is foreseen. Don Quijote is a mitigation precursor mission currently under study by the European Space Agency (ESA). The Institute will be a member of a consortium, which intends to respond to the invitation to tender proposals for a phase-A study of the mission recently issued by ESA.

(e) European Fireball Network

6. The Institute 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.

(f) German Spaceguard Center

7. The Institute has proposed the establishment of a German Spaceguard Center, 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.

(g) Database of near-Earth objects

9. 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).

(h) Publications

9. Copies of publications related to the research activities described above are available on request. Annual reports are available from the website (http://solarsystem.dlr.de/KK/).

Italy

Report of national activities related to near-Earth objects 2004-2005: Italian Space Agency

(a) Introduction

1. Near-Earth objects (NEOs) include celestial bodies like asteroids and meteors that may pass the Earth's orbit. Although the probability of collision of NEOs with the Earth is very low, they represent a potential threat to the planet.

2. Over the past several years, astronomers have learned a great deal about asteroids and comets that strike the Earth at random intervals. Every day, thousands of small, centimetre-large objects burn up harmlessly as meteors in the atmosphere.

3. Impacts of very large, multi-kilometre NEOs have in the past been overwhelmingly catastrophic, but are, fortunately, extremely rare. Objects of intermediate size can cause significant damage when they hit the Earth at random intervals of tens, hundreds or thousands of years.

4. Many researchers believe that the threat to life and property from NEOs, when averaged over long periods, is comparable to that from more familiar natural hazards such as earthquakes and extreme weather events. The consequences of NEO impacts can be very severe, but a great deal can be done to prevent some of the impacts entirely and to reduce significantly the damage caused by others, provided timely actions are taken.

5. Taking into account the sufficient warning time, countermeasures to either fragment or deflect an incoming NEO could be possible. Observation, cataloguing and analysis of physical nature and the development of a strategy of possible countermeasures require a large and coordinated international effort.

6. In this connection, the Italian scientific community is deeply involved in observation campaigns for comets and asteroids, in projects aimed at investigating their inner structure and material composition and, eventually, in looking at effective strategies for destroying objects approaching the Earth or deflecting their orbits.

(b) Involvement in space missions related to near-Earth objects

7. The Italian Space Agency (ASI) is involved in the Dawn Discovery mission of the National Aeronautics and Space Administration (NASA) of the United States (scheduled for launch in July 2006), which will undertake a journey towards two of the largest asteroids of our solar system: Vesta, which will be reached in 2010, and Ceres, where Dawn will arrive in 2015. The mission's scientific goals are to study and compare these two very different bodies, one primitive and wet, the other differentiated and dry, to understand the conditions and processes in place at the

beginning of the formation of the solar system. Dawn's science instruments will measure the asteroids' mass, shape, volume, spin state and mineral composition. These data will make it possible to determine the thermal history and evolution, bombardment and tectonics, and to get some insight into the internal structure and core size of the two proto-planets.

8. Italy is providing the Dawn spacecraft with the visible infrared (VIR) mapping spectrometer. VIR will provide data on the mineralogical composition and distribution of both asteroids. Such information will make it possible to better investigate the origin and evolution of such bodies together with their internal structure and bulk physical properties. (Principal investigator: A. Coradini, National Institute for Astrophysics (INAF)/Institute for Interplanetary Space Physics (IFSI), Rome).

9. ASI participates in the European Space Agency (ESA) Rosetta Cornerstone mission. Its main target is to orbit around comet 67P/Churyumov-Gerasimenko for about one year as it heads towards the Sun and to release the Philae lander on the surface of the nucleus to perform in situ experiments. Rosetta was launched on 2 March 2004 and will reach the comet in 2014 after two asteroid fly-bys, of Steins in 2008 and Lutetia in 2010.

10. Comets provide important information about the origin of the solar system because they are the most primitive objects in the system and their chemical composition has not changed very much since their formation. Their composition thus reflects that of the solar system when it was very young and still "unfinished", more than 4,600 million years ago. By orbiting comet 67P/Churyumov-Gerasimenko and landing on it, Rosetta will enable us to reconstruct the history the Earth's own neighbourhood in space. Rosetta will also make a great contribution to understanding whether comets contributed to the beginnings of life on Earth. Comets are carriers of complex organic molecules, which, brought to Earth through impacts, perhaps played a role in the origin of life. Moreover, "volatile" light elements carried by comets may also have played an important role in forming the Earth's oceans and atmosphere. With the fly-bys of the two asteroids, Steins and Lutetia, Rosetta will increase knowledge about the nature and the characteristics of such bodies, whose collision with the Earth would be potentially threatening.

11. ASI provided the following payloads and subsystems for both the Rosetta orbiter and the Philae lander:

(a) *Grain impact analyser and dust accumulator (GIADA)*. GIADA will measure the number, mass, momentum and velocity distribution of dust grains coming from the comet nucleus and from other directions (reflected by solar radiation pressure). (Principal investigator: L. Colangeli, INAF/Astronomical Observatory of Capodimonte, Naples, Italy);

(b) *Visible and infrared mapping spectrometer (VIRTIS)*. VIRTIS will map and study the nature of the solids and the temperature on the surface of the nucleus. It will also identify comet gases, characterize the physical conditions of the coma and help identify the best landing sites. (Principal investigator: A. Coradini, INAF/IFSI, Rome);

(c) *Wide-angle camera (WAC) of the optical, spectroscopic and infrared remote imaging system (OSIRIS)*. OSIRIS is a wide-angle camera and a narrow-

angle camera to obtain high-resolution images of the comet's nucleus and the asteroids that Rosetta passes on its voyage to comet 67P/Churyumov-Gerasimenko. It will help in identifying the best landing sites. (WAC has been produced in Italy under the responsibility of the Italian co-investigator, C. Barbieri, University of Padua, Italy);

(d) *Sample and distribution device (SD2)*. SD2 will drill more than 20 centimetres into the surface, collect samples and deliver them to different ovens or for microscopic inspection. (Principal investigator: A. Ercoli Finzi, Politecnico, Milan, Italy);

(e) *Solar array (SA)*. The solar array will provide power to the experiments on board the Philae probe after landing. (Scientific staff responsible for the instrument: A. Ercoli Finzi, Politecnico, Milan, Italy).

12. In 2005, ASI and Italian scientists collaborated with the Centre national d'études spatiales (CNES) of France on an assessment study of a near-Earth object space mission. The final report of the assessment will be released in 2005 and Phase A will start in 2006.

(c) Cooperation in the field of near-Earth objects with other related entities

13. A contribution to the understanding of NEOs comes from the Spaceguard Foundation (http://spaceguard.rm.iasf.cnr.it/), an international association set up in Rome on 26 March 1996, aimed at protecting the Earth's environment from the bombardment of objects of the solar system (comets and asteroids). Its main activities are carried out within the most general framework of scientific research and it pursues the following purposes:

(a) To promote and coordinate activities for the discovery, pursuit (follow-up) and orbital calculation of NEOs at the international level;

(b) To promote study activities, at the theoretical, observational and experimental levels, of the physical-mineralogical characteristics of minor bodies of the solar system, with particular attention to NEOs;

(c) To promote and coordinate a ground network, the Spaceguard System, backed up by a possible satellite network, for discovery, observation and astrometric and physical follow-up.

14. In January 2004, following the presentation of six parallel pre-phase A "Near-Earth Objects Space Mission Preparation" studies conducted in the context of its General Studies Programme, ESA established an international panel, the Near-Earth Object Mission Advisory Panel (NEOMAP), with the objective of discussing the results of the studies and making recommendations for the next steps. The panel was composed of six scientists from ESA member States with expertise in various aspects of NEOs (detection, orbit, determination and physical characterization) and the impact threat to the Earth. Among the six NEOMAP members was an Italian researcher, G. B. Valsecchi (INAF/IASF).

15. In July 2004, at the ESA European Space Research Institute (Frascati, Italy), NEOMAP presented the final report of its study, "Space mission priorities for near Earth object risk assessment and reduction", to the scientific and industrial

community in a public event, to which representatives of other national space agencies were also invited. NEOMAP was in particular responsible for:

(a) Identifying the advantages of and defining a solid rationale for the utilization of space missions for the assessment of impact hazard;

(b) Identifying which of the advantages associated with the utilization of space systems can best complement ground-based observation and data;

(c) Revising the scientific rationale for the six missions studied in the light of current knowledge and international initiatives;

(d) Producing a set of prioritized recommendations for observatory and rendezvous missions in an international context.

16. Phase A studies for new missions are one of the main objectives of the ESA General Space Programme. ESA has been solicited by various parties, including the European Council, the Organization for Economic Cooperation and Development and the United Kingdom Task Force on Potentially Hazardous NEOs, to investigate how space means could contribute to mitigation of a NEO threat. Phase A constitutes the logical next step for ESA on the way to proposing a mission to the international community. Of the missions reviewed, NEOMAP considers the Don Quijote concept to be the most compatible with the criteria and priorities selected. Don Quijote has the potential to teach researchers a great deal, not only about the internal structure of a NEO, but also about how to interact with it mechanically. Don Quijote is thus the only mission that could provide a vital missing link in the chain from threat identification to threat mitigation. The Don Quijote concept has also aroused considerable interest in countries outside Europe, whose possible participation is key to the financial and programmatic affordability of the mission. It is therefore expected that such a mission, which would be based on this reference concept, would be implemented in the framework of international cooperation, with the ESA contribution most likely part of a technology demonstration mission to be launched in 2011-2014.

17. The team involved in the Don Quijote mission is Deimos (the prime contractor), Astrium, the University of Pisa, the Spaceguard Foundation, the Paris Geophysical Institute (IPGP) and the University of Bern.

Norway

The Institute of Theoretical Astrophysics, University of Oslo, carries out limited activities on near-Earth objects. The programme is supervised by Professor Kaare Aksnes and utilizes observations from the Nordic Optical Telescope at La Palma in the Canary Islands (Spain). This is a collaboration between astronomers and students at the universities of Helsinki, Copenhagen, Uppsala (Sweden) and Oslo. The objective is to study the physical and dynamical properties of asteroids crossing the Earth's orbit, with particular emphasis on those which have the potential to hit the Earth. The programme started in 2003 and will continue until the end of 2006.