United Nations A/AC.105/C.1/L.308

General Assembly

Distr.: Limited
16 December 2010

Original: English

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Forty-eighth session
Vienna, 7-18 February 2011
Item 11 of the provisional agenda*
Near-Earth objects

Near-Earth objects, 2010-2011

Interim report of the Action Team on Near-Earth Objects

I. Introduction

1. The Action Team on Near-Earth Objects[1] was established in response to recommendation 14 of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) and was given the following terms of reference:

(a) Review the content, structure and organization of ongoing efforts in the field of near-Earth objects (NEOs);

(b) Identify any gaps in the ongoing work where additional coordination is required and/or where other countries or organizations could make contributions;

(c) Propose steps for the improvement of international coordination in collaboration with specialized bodies.

2. At its fifty-first session, in 2008, the Committee on the Peaceful Uses of Outer Space noted with satisfaction the work carried out by the Working Group on Near-Earth Objects of its Scientific and Technical Subcommittee and by the Action Team

* A/AC.105/C.1/L.306.

[1] A near-Earth object (NEO) is an asteroid or comet whose trajectory brings it within 1.3 astronomical units of the Sun and hence within 0.3 astronomical units, or approximately 45 million kilometres, of the Earth's orbit. This includes objects that will come close to the Earth at some point in their future orbital evolution. NEOs generally result from objects that have experienced gravitational perturbations from nearby planets, moving them into orbits that allow them to come near to the Earth.

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on Near-Earth Objects and endorsed the amended multi-year workplan for 2009-2011,[2] as contained in the report of the Subcommittee (A/AC.105/911, annex III). In accordance with that workplan, in 2011, the Working Group and the Action Team on Near-Earth Objects are to carry out the following tasks:

- Consider the reports submitted in response to the annual request for information on near-Earth object activities and continue intersessional work
- Finalize agreement on international procedures for handling the NEO threat and engage international stakeholders
- Review progress on international cooperation and collaboration on NEO observations and on the international capability for the exchange, processing, archiving and dissemination of data for the purpose of NEO threat detection
- Consider the final report of the Action Team on Near-Earth Objects

3. The present interim report is a summary of the input received from members of the Action Team on Near-Earth Objects for 2010-2011 and serves as an update to its previous interim report, which covered the period 2009-2010 (A/AC.105/C.1/L.301). The present report covers activities and issues relating to the NEO hazard, the current understanding of the risk posed by NEOs and the measures required to mitigate that threat. In accordance with the terms of reference of the Action Team, it is expected that an updated interim report will be issued each year to reflect the existing state of knowledge, related activities and the consensus on prioritization of the issues to be addressed and their possible solutions. More detailed descriptions of activities are provided in the annual national reports provided to the Committee by Member States, the reports of specialized bodies to the Committee and the presentations made by the Committee members and observers at the annual session of the Subcommittee.

II. Interim report of the Action Team on Near-Earth Objects

A. Near-Earth object detection and remote characterization

4. The Action Team noted that the first step in addressing the risk posed by an NEO was to detect its presence and measure its trajectory as well as infer its size from its observed brightness and albedo. The United States of America had made the most significant contribution to the field of NEO detection and remote characterization. The Near-Earth Object Program of the National Aeronautics and Space Administration (NASA) of the United States had funded five NEO search teams to operate nine separate 1-metre class survey telescopes in south-western United States and in Hawaii and one in Australia, capable of detecting objects, on average, down to magnitude 20. The Near-Earth Object Program was supplemented by orbit follow-up observation activities carried out by a variety of professional and amateur astronomers around the world.

5. The Action Team was pleased to learn that the European Space Agency (ESA) had started its space situational awareness programme, which contained a segment

[2] *Official Records of the General Assembly, Sixty-third Session, Supplement No. 20* (A/63/20), para. 153.

dealing with the NEO threat. As documented in the user requirement document, part of that programme consisted of activities focusing mainly on follow-up observations. Among other telescopes, the Optical Ground Station, a 1-metre telescope of ESA on Tenerife, had been made available for NEO observations four nights every month starting in 2010. The telescope was being used primarily for follow-up observations and to test survey strategies. A so-called "wide survey" had been proposed in ongoing studies as an important contribution by ESA to ongoing survey activities under the space situational awareness programme.

6. The Action Team recognized that significant efforts were being made internationally to detect and, to a lesser degree, follow up observations of potentially hazardous NEOs larger than 1 kilometre in diameter. As at 5 December 2010, 903 NEOs more than 1 kilometre in diameter had been found, out of a population of such objects estimated at less than 1,000. Finding an NEO larger than 1 kilometre in diameter had become a rare occurrence. The most recent discovery in that category was 2010 RO82, discovered in September 2010 by the Siding Spring Survey. However, the Action Team noted that objects with diameters ranging from 100 metres to 1 kilometre, for which the current surveys were not optimized, posed a significant impact threat.

7. The Action Team encouraged NASA, along with its international partners, to continue to seek ways in which the threshold for the detection of NEOs could be reduced to 140 metres, as such objects were likely to pose a more immediate threat to the Earth than the smaller number of kilometre-sized objects. The Action Team encouraged ESA to implement its plans for follow-up and characterization and to support survey programmes as proposed by the current studies. Emphasis should be placed on establishing observing capabilities in the southern hemisphere. Further, the Action Team noted that discovery and precision orbit determination were the critical first steps in characterizing an NEO threat and initiating a mitigation action and that facilities and capabilities for collecting and rapidly processing the discovery data were essential. The Action Team also noted that some NEOs were binary in nature, that is, they had accompanying moons which were themselves large enough to pose a hazard and might complicate considerations for deflection plans. The Action Team was therefore pleased that the planetary radar at Arecibo, operated by Cornell University for the United States National Science Foundation, would be operating during the apparition of Apophis in 2012 and 2013. This had been made possible by new funding provided by the National Science Foundation and NASA. The use of Arecibo during that period would be important for determining whether Apophis posed a serious threat of impact with the Earth in 2036.

8. The Action Team agreed that a coordinated campaign for the observation of Apophis should be implemented at the end of 2012 and the beginning of 2013, when Apophis would have an apparent magnitude of approximately 16 (mv~16), in order to refine its ephemeris and in particular characterize the magnitude of the non-gravitational forces (Yarkovsky effect), which needed to be known for accurate orbit extrapolation. Given that Apophis would be most easily observed in the southern hemisphere, it was expected that such a campaign would involve observatories in Africa, Australia and South America.

9. The Action Team was pleased to learn that the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), funded by the United States Air Force,

had started regular survey operations and had begun providing data to the Minor Planet Center of the International Astronomical Union in 2010. The capability to detect moving objects in the collected image data and extract observations for newly discovered objects, as well as known objects, had been completed with NASA funding, and NASA was also funding a portion of the operations of the Pan-STARRS 1 telescope for NEO search purposes. It was expected that many thousands of observations will be provided to the Center as the project matures. The Planetary Science Division of NASA has also funded efforts to incorporate NEO detection capability within the data-processing segment on the Wide-field Infrared Survey Explorer (WISE) mission, sponsored by the Astrophysics Division of NASA. The primary mission of the spacecraft was to produce a detailed map of the extra-galactic sky in four infrared bands, but during the collection of those data, the infrared signature of many NEOs and other asteroids and comets, including those that do not reflect much visible light, were being extracted, processed and sent to the Minor Planet Center. The transient image data would also be archived for use in making more accurate size estimates of known objects and to provide another resource for finding pre-discovery detections. Pre-discovery observations allow the extraction of observation data from existing image archives in such a way that, once an object is discovered, its previous positions can be calculated and correlated with the archived image sets. The Action Team has been informed that the Canadian Space Agency is supporting the Near-Earth Object Surveillance Satellite (NEOSSat) project, which is fully funded and has a projected launch date of 2011. The objective of that microsatellite is to understand the orbital distribution, physical characteristics, composition, origin and history of NEOs. It was being developed to survey the near-Sun region, the only part of the sky where asteroids orbiting entirely inside Earth's orbit could be found. It would also be an efficient discoverer of Aten-class asteroids. The Action Team encouraged agencies to consider other opportunities to address such complementary primary and secondary objectives for future prospective missions.

10. The Action Team welcomed the news of progress with the Warm Spitzer NEO Survey regarding the observation of about 750 known NEOs in the two warm Spitzer channels (3.5 and 4.5 microns) and the expectation that for most targets it was anticipated to be able to derive their sizes and albedos.

11. The Action Team recognized the importance of observational efforts to physically characterize the NEO population using ground-based telescopes, including, in particular, infrared telescopes (for sizes, albedos, composition, surface characteristics, thermal properties) and radar (surface characteristics, shapes, sizes, rotation characteristics), and encouraged agencies to consider making resources available to strengthen this activity in the relevant programmes.

B. Orbit determination and cataloguing

12. The Action Team considered that it was important that objects detected from the ground were uniquely identified and that their orbits were refined to assess the impact threat to the Earth. The Minor Planet Center was fundamental in that process. The Center was operated by the Smithsonian Astrophysical Observatory, in coordination with the International Astronomical Union (IAU), on the basis of a memorandum of agreement giving the Center an international charter. Pursuant to

the memorandum of agreement, the Center had, since 1978, served as the international clearing house for all asteroid, comet and satellite astrometric (positional) measurements obtained worldwide. The Center processed and organized data, identified new objects, calculated orbits, assigned tentative designations and disseminated information on a daily basis. For objects of special interest, the Center solicited follow-up observations and requested archival data searches. The Center was responsible for the dissemination of astrometric observations and orbits via so-called Minor Planet Electronic Circulars (issued as necessary, generally at least once a day) and related catalogues. In addition to distributing complete orbit and astrometric catalogues for all small bodies in the solar system, the Center facilitated follow-up observations of new potential NEOs by placing candidate sky-plane ephemerides and uncertainty maps on the Internet via the NEO confirmation page. The Center focused specifically on identification, short-arc orbit determination and dissemination of information pertaining to NEOs. In most cases, observations of NEOs were distributed to the public free of charge within 24 hours of receipt. The Center also provided a variety of tools to support the NEO initiative, including sky coverage maps, lists of known NEOs, lists of NEO discoverers and a page of known NEOs requiring astrometric follow-up. The Center also maintained a suite of computer programs to calculate the probability that an object was a new NEO, on the basis of two sky-plane positions and magnitude. Links to those Internet resources could be found on the website of the Center (www.cfa.harvard.edu/iau/mpc.html). The Action Team also noted that, as of March 2010, the IAU website had a page listing past and future close approaches of known near-Earth objects to the Earth and providing information on relevant meetings and literature (www.iau.org/public/neo).

13. The Action Team recognized that the role of the Minor Planet Center was critical to the dissemination and coordination of observations and welcomed the confirmation by NASA of its increased sponsorship of the Center to upgrade its capability to process all observations received from worldwide observatories and disseminate the resulting orbit information without charge via the Internet and to allow the Center to accommodate the anticipated significant increase in NEO observation data with “next-generation” search efforts. The Action Team noted the benefit of establishing a “mirror” capability complementing the Center, possibly hosted in Europe or Asia. The two nodes could share analysis protocols and processes, and could have a common data management and access policy, but would perform a complementary operational role, perhaps performing the same operations on a different subset of the observation data while independently maintaining a complete database. The two sites could also act to validate and verify their more critical respective outputs. The Action Team recognized that ESA had started a discussion on how to support the Minor Planet Center, possibly by setting up a backup capability in Europe, as part of its NEO programme. The Action Team encouraged the continuation of that discussion and the reaching of a support agreement. In particular, it encouraged ESA and NASA to discuss that issue and come to a mutually agreed plan.

14. On a daily basis, the Minor Planet Center made NEO astrometric data available to the Near-Earth Object Program Office at the NASA Jet Propulsion Laboratory and to a parallel, but independent, orbit computation centre in Pisa, Italy, with a mirror site in Valladolid, Spain. Through the Sentry System at the Jet Propulsion Laboratory (http://neo.jpl.nasa.gov/risk), risk analyses were

automatically performed on objects that had a potential for Earth impact, usually when the object had been recently discovered and lacked the lengthy data interval that would make its orbit well determined. Those objects were prioritized for the Sentry System according to their potential for close approaches to the Earth's orbit and according to the existing quality of their orbits. The Sentry System automatically updated the orbits of approximately 65 NEOs per day and close-approach tables were generated and posted on the Internet (http://neo.jpl.nasa.gov/cgi-bin/neo_ca). Approximately 15 risk analysis cases were performed each day, with each uncertainty analysis providing 10,000 multiple solutions through 2110. Those processes were also performed in parallel using the Near-Earth Objects Dynamic Site (NEODyS) in Pisa, Italy, and significantly non-zero-probability Earth-impact cases were manually checked at the Jet Propulsion Laboratory and at the orbit computation centre in Pisa before the risk analysis data were posted on the Internet. For recently discovered objects of unusual interest, the Minor Planet Center, the Laboratory and the centre in Pisa would often alert observers that additional future or pre-discovery observation data were needed.

15. The Action Team noted that the Sentry System and NEODyS were completely independent systems that employed different theoretical approaches to providing impact risk assessments. Hence, if the long-term orbit propagations from each converged to a single solution, the wider community could have some confidence in the predicted outcome. As with the operation of the Minor Planet Center, the Action Team considered that an independent but complementary capability to the Sentry System was critical for the purposes of independent verification and validation of predicted close approaches.

16. The Action Team was particularly encouraged to note how effectively the process outlined above had been implemented in the recent discovery and subsequent impact of NEO 2008 TC3. That very small (about 3 metres in diameter) object had been discovered by the United States Catalina Sky Survey team just 20 hours before it entered the Earth's atmosphere on 7 October 2008. Within eight hours of collection of the discovery observations, the Minor Planet Center had identified the object as a potential impactor and alerted both NASA headquarters and the Jet Propulsion Laboratory. While the Center requested follow-up from all available observers and the Jet Propulsion Laboratory produced more precise predictions and compared results with the NEODyS system, NASA headquarters started the actions required to alert the global community to the impending impact. During the subsequent 12 hours, the worldwide NEO network had provided the Center with 589 observations from 27 different observers. On the basis of the precise predictions provided by the Near-Earth Object Program Office at the NASA Jet Propulsion Laboratory, NASA had provided information for public release and dissemination via diplomatic channels to the effect that the entry would take place over northern Sudan on 7 October 2008 at 0246 hours UTC. Released six hours in advance, the information had been accurate to within seconds of the entry observed by meteorological satellites and detected by infrasound sensors.

17. The Action Team was informed that within the ESA technology programme, a number of activities were ongoing that were relevant to the NEO topic. One of them is the planetary database, covering planets, moons and small bodies of the solar system. The database will be used as the backbone of a database system, which will be part of the ESA space situational awareness programme. Another activity is

GRAVMOD, under which gravity models of asteroids are developed and stored in the database.

18. Having recognized the critical role that the Minor Planet Center played and the fact that the Planetary Science Division of NASA was continuing to fund the Center's operations and upgrades, the Action Team noted with satisfaction the progress currently being made by the ESA space situational awareness programme in establishing firm funding for the NEODyS service, the physical properties database and the European Asteroid Research Node of the German Aerospace Center (DLR) in Berlin and the ESA Spaceguard Central Node, which provides a "priority list" for observations of NEOs.

C. Consequence determination

19. The Action Team recognized that, in considering a science-based policy to address the risk posed by NEOs, it was important for Governments to evaluate the societal risk posed by such impacts and to compare those risks with the thresholds established for dealing with other natural hazards (for example, meteorological and geological hazards) so that a commensurate and consistent response could be developed. The Action Team felt that more work needed to be done in that area, especially on impactors of less than 1 kilometre in diameter. The issue was discussed in detail at the Tunguska Conference, held in Moscow in June 2008, hosted by the Russian Academy of Sciences. The 1908 Tunguska airburst from a small asteroid had generally been estimated to have had an energy of 10-15 megatons. The corresponding size for a rocky impactor was roughly 60 metres in diameter. The Action Team noted that new supercomputer simulations developed at Sandia National Laboratories, United States, required less energy in the explosion because of the inclusion of a substantial downward momentum of the rocky impactor, rather than modelling it as a stationary explosion. If that revision (down to an estimated energy of 3-5 megatons and a corresponding diameter of perhaps as little as 40 metres) was correct, the expected frequency of such impacts would change from once every couple of millenniums to once every few hundred years, with consequent implications for hazardous impact event statistics. The Action Team looked forward to further scientific and technical results that might be presented at the Planetary Defence Conference of the International Academy of Astronautics, to be held in Romania in May 2011.

D. In situ characterization

20. The Action Team noted the importance of the Hayabusa (MUSES-C) mission, which had rendezvoused with the near-Earth asteroid 25143 Itokawa in late 2005 and provided scientific knowledge that had been gained on the characteristics of the asteroid, such as topography and composition. The mission had also provided important operational lessons that had been learned from rendezvous and proximity operations in a very low gravity environment. Those lessons had implications for future in situ investigations and possible mitigation activities. Hayabusa followed a long line of successful missions, such as Near Earth Asteroid Rendezvous, Deep Space 1, Stardust and Deep Impact, which had provided unique insights into the characteristics of the surprisingly diverse population of NEOs. Detailed NEO

characterization could not be derived from remote observations and the Action Team noted that on 13 June 2010, the asteroid sample capsule of the Hayabusa spacecraft had returned to Earth and that the material brought back was being analysed. The Action Team looked forward with anticipation to the results of that analysis and to the prospective AsteroidFinder spacecraft mission of Germany and other upcoming missions to NEOs.

21. The Action Team was encouraged by the news that, in June 2010, the Space Council of the Russian Academy of Sciences and the Russian Federal Space Agency had agreed on a coordinated and comprehensive response to the asteroid/comet impact hazard problem. A feasibility study for a low-cost space mission to Apophis in 2019 and 2020 had been initiated. The major goal of the mission was to put a transponder in a circum-asteroid orbit, thereby improving the accuracy of the Apophis orbit determination. The Action Team welcomed the news that the Planetary Science Division of NASA had also funded a concept study for a low-cost, small-satellite, in situ characterization mission to Apophis during its next apparition in 2012 or 2013. A suite of miniaturized cameras and other instruments would fully characterize the potentially hazardous asteroid and provide sufficient high-precision ranging data to fully determine the orbit of the asteroid on subsequent close approaches over the following century. ESA has concluded three parallel industrial studies for a sample return mission from an NEO called Marco Polo. NASA had also funded a United States science team to participate in that study.

E. Mitigation

22. Mitigation in this context is the process of either negating or minimizing the impact hazard posed to Earth by the subclass of NEOs called “potentially hazardous objects” — either through some form of intervention or interaction with the risk body or by minimizing its impact on the population through evacuation or a similar response.

23. The Action Team noted that, in addition to the probability of impact and the time to impact, other parameters that would influence the response strategy would be the anticipated locus of intersection on the surface of the Earth and the vulnerability of that area to the impact. The various options for deflection and the implications (technical readiness, political acceptability, cost of development and operation and translation of locus of intersection) of a particular deflection strategy would also have to be weighed against the alternatives. The Action Team acknowledged that it was possible that a specific impact might threaten only non-spacefaring nations and that the threat would need to be addressed internationally. It might be considered more attractive for one capable actor to take the lead in mounting a particular deflection mission, rather than a group of agencies with different roles, owing to the complexity of the mission and the political expediency of protecting sensitive technical information. The Action Team therefore envisaged a range of options, with agreed responses to a range of impact scenarios and with identified players performing specific roles. In this respect, the Action Team identified the need for an international technical forum wherein a range of probable impactor scenarios could be determined and a corresponding matrix of mitigation options developed to a level of maturation to permit reliable mission

timelines to be mapped onto a decision timeline for the international community in response to a specific threat. Further, the Action Team considered that the current state of knowledge was an inadequate basis on which to decide the relative effectiveness of different mitigation strategies, recognizing that while the Deep Impact mission demonstrated some elements of kinetic deflection, the deflection was not measurable owing to the size of the target comet (6 kilometres in diameter) and the effects of cometary outgassing. Accordingly, the Action Team considered that a true demonstration of kinetic deflection remained to be done, that the development and execution of mitigation test missions were prudent and top-priority goals for the near future and that those tasks should be carried out with international participation. The Action Team further noted that the Seventh Framework Programme of the European Commission (EC FP7) included "Prevention of impacts from Near Earth Objects (NEOs) on our Planet" (SPA.2011.2.3-01) with a call for proposals issued on 20 July 2010 to invite partners, such as the Russian Federation and the United States to participate in the first preliminary study of mitigation techniques.

24. The Action Team welcomed the work of the Space Generation Advisory Council and its recognition of the importance of the International Year of Astronomy in acting as a framework to raise awareness about NEO issues among the public and, in particular, youth. Among its initiatives, the Move an Asteroid 2010 technical paper competition, held annually since 2008, focused on asteroid warning systems. The entries were reviewed by experts and the winner of the competition was awarded a trip to present the paper at the Council's annual Space Generation Congress and at the 61st International Astronautical Congress, in 2010. The Council intended to continue raising awareness and involving youth in the NEO field, as well as to inform youth about current issues such as the work of the Action Team.

F. Policy

25. The Action Team recognized that the threat of impact posed by NEOs was real and that any such impact, although its probability was low, was potentially catastrophic. It was also recognized that the effects of such an impact would be indiscriminate (that is, they might not be confined to the country of impact) and that the scale of those effects was potentially so great that the NEO hazard should be recognized as a global issue that could be addressed effectively only through international cooperation and coordination. Thus, the United Nations had an important role to play in the process of developing the required policy.

26. A further challenge for the global community was that it would likely be confronted in the next 15 years with a perceived impact threat (though it would most likely turn out to be a near miss), making it necessary to push forward to critical decisions about whether and what action should be taken to protect life on Earth from a potential NEO impact before the reality of the threat was completely understood. That was because of the accelerating discovery of the population of NEOs and the evolution of human capability to intervene in an anticipated impact by proactively deflecting the NEO. The probability of the spacefaring nations having to decide between action and non-action was further heightened by the likely necessity of having to decide prior to the availability of certain knowledge that an

impact would or would not occur. The need for decision-making could therefore be significantly more frequent than the incidence of impacts. Given early warning that a possible impact was predicted and knowing that a deflection capability existed to prevent the impact from occurring, humankind could not avoid responsibility for the outcome of either action or inaction. Since the entire planet was subject to NEO impact and since the process of deflection would intrinsically result in a potential but temporary increase of risk to populations not initially at risk, the United Nations could be called on to facilitate the global effort to evaluate trade-offs and arrive at decisions on what actions to implement collectively.

27. Having recognized the need to advance the NEO decision-making process, the Committee on Near-Earth Objects of the Association of Space Explorers concluded, in September 2008, a series of international workshops and transmitted its widely anticipated report to the Action Team (see A/AC.105/C.1/L.298, annex). The Action Team welcomed that important contribution to a possible NEO policy framework and recognized its value in informing the workplan of the Working Group on Near-Earth Objects in its review of potential policies related to the handling of the NEO hazard and its consideration of drafting international procedures for handling such a threat.

28. The Action Team met during the forty-sixth session of the Scientific and Technical Subcommittee, in February 2009, to review the report of the Association of Space Explorers with a view to developing draft international procedures for handling an NEO threat. The Action Team completed a first review of the document during the fifty-third session of the Committee on the Peaceful Uses of Outer Space, in June 2009, and included the first draft of the international procedures in the annex to its interim report to the Subcommittee (A/AC.105/C.1/L.301). In February 2010, the Working Group reviewed the draft procedures during the forty-seventh session of the Subcommittee. At that session, the Working Group heard statements on the report entitled “Legal aspects of NEO threat response and related institutional issues”, prepared by the University of Nebraska-Lincoln (United States), in which key legal and institutional issues linked to potential future threats posed by NEOs were examined. The Working Group was also informed about a workshop on the establishment of an NEO information, analysis and warning network, organized by the Association of Space Explorers and the Secure World Foundation, with support from the Regional Centre for Space Science and Technology Education for Latin America and the Caribbean and held in Mexico City in January 2010.

29. In its report to the Subcommittee (A/AC.105/958, annex III, paras. 5 and 7), the Working Group agreed that the executive summaries of the Mexico City workshop and of the report prepared by the University of Nebraska-Lincoln could be considered by the Action Team between the sessions to be held in 2010 and 2011 and that intersessional work for the period 2010-2011 could include workshops involving experts in various subjects related to the draft recommendations made by the Action Team. The Action Team met during the fifty-third session of the Committee, in June 2010, and considered the executive summaries referred to above. The Secure World Foundation, the Association of Space Explorers and ESA sponsored a workshop entitled “NEO Mission Planning and Operations Group” that was held in Darmstadt, Germany, from 27 to 29 October 2010 to address NEO deflection mission campaign planning and operations. The executive summary of

that workshop was provided to the Action Team. The present interim report, including the draft recommendations for an international response to the near-Earth object impact threat, contains information resulting from the intersessional work summarized above.

Annex

Draft recommendations for an international response to the near-Earth object impact threat

A. Introduction

1. At its fifty-first session, in 2008, the Committee on the Peaceful Uses of Outer Space noted with satisfaction the work carried out by the Working Group on Near-Earth Objects of the Scientific and Technical Subcommittee and by the Action Team on Near-Earth Objects and endorsed the amended workplan for the period 2009-2011, under which it was expected, inter alia, to continue to review policies and procedures related to the handling of the near-Earth object (NEO) threat at the international level and consider drafting international procedures for handling that threat.[a]

2. In 2009 and 2010, the Action Team and Working Group carried out their work in accordance with the amended workplan. During its meetings, the Action Team discussed and reviewed a report by the international Panel on Asteroid Threat Mitigation of the Association of Space Explorers, entitled "Asteroid threats: a call for global response",[b] and considered information provided by its members, NEO-related activities and documents submitted to it as summarized in paragraphs 28 and 29 of the present report. On the basis of the discussions held both during its meetings and by electronic mail, the Action Team has prepared the following updated version of the draft recommendations for an international response to the near-Earth object impact threat for further consideration by the Working Group during the forty-eighth session of the Scientific and Technical Subcommittee.

1. Background

3. The Committee established the Action Team on Near-Earth Objects (Action Team 14) in 2001 in response to a recommendation of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) with a mandate to: review the content, structure and organization of ongoing efforts in the field of NEOs; identify any gaps in the ongoing work where additional coordination is required and/or where other countries or organizations could make contributions; and propose steps for the improvement of international coordination in collaboration with specialized bodies. For the purposes of this document and the work of the Committee, a potentially hazardous NEO is an asteroid or comet whose orbit periodically comes to within 0.05 astronomical units (19.5 times the lunar distance) or approximately 7.5 million kilometres of the Earth's orbit.

4. Since the establishment of the Action Team, it has become a common understanding among the international community that there is evidence that the Earth's geological and biological history has been punctuated by repeated and

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[a] *Official Records of the General Assembly, Sixty-third Session, Supplement No. 20* (A/63/20), para. 153.

[b] www.space-explorers.org/committees/NEO/docs/ATACGR.pdf.

devastating impacts from space and that NEOs continue to pose an impact risk to humankind and planet Earth as a whole. The global nature of the NEO impact hazard and the need for coordinated international response have also been recognized. The consequences of NEO impact events, although less frequent than more familiar geological and meteorological hazards, can be much more severe than hazards resulting from phenomena such as earthquakes or extreme weather events. Perhaps uniquely among natural hazards, there is the potential to prevent NEO impact events through timely actions, and it is the combination of the potentially catastrophic scale, the predictability of events and the opportunity to intervene that obligates the international community to establish a coordinated response to the NEO threat.

5. In 2007, the Working Group on Near-Earth Objects was established by the Scientific and Technical Subcommittee in the expectation that international procedures to address the NEO threat would be proposed by the Working Group for consideration by the Committee. In 2007 and 2008, the Association of Space Explorers convened its Panel on Asteroid Threat Mitigation, consisting of renowned non-governmental, multidisciplinary experts in science, diplomacy, law and disaster management from around the world. In 2008, the Association submitted its recommendations in a report entitled “Asteroid threats: a call for global response” to the Action Team and for consideration by the Working Group. In addition, the international community of entities engaged in NEO-related activities has conducted many workshops and conferences in recent years, including the first International Academy of Astronautics Planetary Defence Conference held in Granada, Spain, in April 2009, which have made a number of recommendations for response to the NEO impact threat.

6. Response to the NEO impact hazard requires measures to detect, track and characterize the orbital and physical properties of potentially hazardous NEOs, including measures to modify the trajectory of potentially hazardous NEOs in order to prevent an impact and measures to limit the consequences on the ground, such as evacuation and other forms of disaster mitigation and emergency response.

2. Rationale

7. According to current scientific knowledge, the population of NEOs increases as the size of the objects decreases. Within the next decade, it is expected that advanced telescopes will greatly facilitate detection of the more numerous smaller NEOs and thus make it possible to discover a significantly larger number of potentially threatening NEOs. Because NEO collisions can have disastrous effects on Earth, the international community will need to decide on a necessary response to a detected impact threat.

8. As NEO search, tracking and prediction capabilities improve, astronomers will not only predict more impacts of small objects that do not penetrate the atmosphere to strike the surface, but will also discover many larger near-Earth asteroids, in the range of 40-140 m, which present a worrisome probability of impact. The key to finding these objects in time to take action to prevent a possible damaging impact is to detect them early through a vigorous international search and tracking programme.

9. Since substantial time is needed to execute an NEO deflection campaign and, in some cases, there may be limited time before the expected impact, a decision may need to be made quickly on what action to take. There may be occasions when the international community will need to act before it is certain that an impact will occur. The longer the international community delays in deciding to undertake responsive actions, the more limited the options become and the greater the risk that any option finally chosen may have undesirable consequences. It is recognized that, if there is no agreed decision-making process, the international community may miss the opportunity to act against an NEO in time, leaving evacuation and disaster management as the only responses to an impending impact. The prompt adoption of an international programme of coordinated activities and a set of preparatory measures for action is therefore considered a prudent and necessary step in anticipation of such a potential impact event. To be effective, such a programme must establish action criteria and campaign plans that can be implemented rapidly, without the need for extended debate.

10. Once in place, these measures should enable the global community to identify a specific impact threat and quickly implement effective prevention or disaster responses. A series of outline recommendations relating to a decision-making programme for a global response to asteroid threats has been developed by the community of entities engaged in NEO-related activities, including the Panel on Asteroid Threat Mitigation and planetary defence conferences. The Committee acknowledges the benefit of such a series of high-level recommendations having wide acceptance among the global space and disaster response community. The Working Group on Near-Earth Objects has therefore derived such a set of international measures for handling the NEO threat, based on those outline recommendations and in accordance with the United Nations treaties and principles on outer space.

3. Application

11. Member States and international organizations should take measures, through national or other applicable mechanisms, to support the implementation of these recommendations to the greatest extent feasible. Building on existing relationships, institutions and activities, this support should include the availability of a commensurate level of resources to address the specific potential threat posed by NEOs.

12. These recommendations are applicable to Governments, intergovernmental, regional and non-governmental organizations, institutions and relevant United Nations entities with responsibility for the coordination of space activities, the safety of citizens and disaster reduction functions.

13. It is recognized that the implementation of individual recommendations or elements thereof is governed by the provisions of United Nations treaties and principles.

B. Draft recommendations for near-Earth object threat mitigation functions

1. Information, analysis and warning

14. Capacities should be established in an entity whose functions would be similar to the Information, Warning and Analysis Network (IAWN), proposed in the report prepared by the Panel on Asteroid Threat Mitigation of the Association of Space Explorers, and those capacities should be sustained by, or on behalf of, the international community. The entity would have the capability:

(a) To discover and monitor the potentially hazardous NEO population using optical and radar facilities and other assets based in both the northern and southern hemispheres and in space;

(b) To provide an internationally recognized clearing-house function for the receipt, acknowledgment and processing of all NEO observations;

(c) To act as a global portal, serving as the international focal point for accurate and validated information on the NEO population;

(d) To coordinate campaigns for the observation of potentially hazardous objects;

(e) To recommend policies regarding criteria and thresholds for notification of an emerging impact threat;

(f) To assess hazard analysis results and communicate them to entities identified by Member States as being responsible for the receipt of notification of an impact threat in accordance with established policies;

(g) To assist Governments in the analysis of impact consequences and in the planning of mitigation responses.

15. To perform these functions, the entity should first continue the well-executed work of institutions currently engaged in NEO detection, tracking, cataloguing and impact prediction. The evolving observation network includes the Spaceguard and Sentry programmes of the Jet Propulsion Laboratory of the National Aeronautics and Space Administration (NASA) of the United States, the Minor Planet Center and the Near-Earth Objects Dynamic Site (NEODyS) group of the University of Pisa, the growing NEO survey and follow-up elements of the space situational awareness programme of the European Space Agency.

16. IAWN should develop a communications strategy using well-defined communication plans and protocols, grounded in the science of risk communications and psychology. News and information should be distributed using words that are easily understood by the public and policymakers and should be accurate, timely and aimed at responding promptly and directly to misinformation and media errors. IAWN should investigate the communication channels and contacts used by other disaster warning networks to communicate with the disaster management community. IAWN could benefit from the large body of knowledge about the human response to other natural disasters and should therefore include among its members risk analysis experts familiar with the behavioural and psychological elements of

disaster management. It should also draw on the lessons learned from other disaster response and risk management organizations.

17. In order to educate the public about the NEO risk, IAWN should develop an outreach and education plan. It should also identify the major NEO risk factors to be communicated to the public and coordinate an NEO outreach plan using entities such as the International Astronomical Union, the American Geophysical Union, space agencies and amateur astronomical observer organizations.

18. Continued research will be essential to the efficient functioning of IAWN. IAWN should therefore identify and call for necessary NEO-related research in order to address gaps in knowledge of impact prediction, impact effects or other areas necessary for the IAWN mission.

19. A steering group should be created to propose and assist the long-term development of IAWN. Such a group would then be in an ideal position to integrate IAWN with the functions to be carried out by a mission authorization and oversight group and a mission planning and operations group. The steering group could consider the many issues related to the establishment of IAWN, such as:

(a) *Financing*: How can Member States best support IAWN and put it on a more permanent financial foundation?

(b) *Structure*: What is the proper balance between a permanent centre of operations and external resources connected virtually to IAWN?

(c) *Institutional model*: While keeping the need for financial resources and central authority at a minimum, what model best enables IAWN to assume effective responsibility for global NEO information release?

(d) *Designating authority*: Which institution can officially "designate" IAWN as the authoritative body on NEO information issues?

(e) *Legal issues*: An impact, and the response to it, may produce or fail to prevent property damage and mass casualties, and questions of authority and liability may ensue. What legal expertise may be needed for IAWN to function properly?

20. Member States should ensure that IAWN facilities are supported at an appropriate level to enable them to perform their critical functions. Further, as appropriate, Member States should establish capacities and procedures needed to facilitate the following actions for impact warning response at the national and regional levels:

(a) To receive notification of an impact threat that meets established notification policies;

(b) To take appropriate action in response to an impact threat notification.

2. Monitoring and oversight

21. The Committee should identify and recommend that appropriate organs of the United Nations sanction the establishment of an entity to be responsible for monitoring the NEO impact risk and overseeing the corresponding NEO threat response. Specifically, such an entity, whose functions would be similar to those of the mission authorization and oversight group proposed in the report of the Panel on

Asteroid Threat Mitigation, should ensure the accomplishment of the following functions:

(a) Consideration of recommended criteria and thresholds for action (e.g. notification of a significant impact risk, initiation of observation and/or mitigation campaign);

(b) Consideration of decision and event timelines for NEOs identified for mitigation campaign analysis;

(c) Consideration of the recommended process for mitigation campaign operational responsibilities;

(d) Identification, in cooperation with Member States, of methods to engage designated national and international disaster response entities and utilize existing functions and infrastructures;

(e) Development and updating of detailed agreements on the criteria and thresholds that will guide the choice and implementation of an appropriate response by the international community to a specific impact threat, from the initial identification of a potential for impact to the criteria requiring action;

(f) Communication of the agreements to the international community through the relevant United Nations organizations;

(g) Coordination of the relevant actors involved in the implementation of the agreements.

22. It is important that discussions as to how to develop an international decision-making framework within the present structure of the United Nations, notably as regards the possible roles of the Security Council and General Assembly, begin within the framework of the Committee as soon as possible.

3. Mission campaign planning and operations

23. An inter-agency body whose functions would be similar to those identified for the mission planning and operations group, as proposed in the report prepared by the Panel on Asteroid Threat Mitigation, should be established by space agencies. The Action Team could assist in that process. Once established, the group should be sanctioned by the United Nations on behalf of the international community and be composed of representatives of spacefaring nations and other relevant entities. Its responsibilities should include:

(a) Recommendation of policies regarding criteria and thresholds to initiate a mission campaign;

(b) Recommendation of generic decision and event timelines for NEOs that have the potential to impact the Earth;

(c) Determination of specific decision and event timelines for NEOs that exceed established thresholds;

(d) Recommendation of operational responsibility for mission campaigns;

(e) Assessment of various mitigation concepts based on feasibility and technical maturity;

(f) Development of specific information required to support mission campaign planning efforts.

24. The group should be established in the near term. World space agencies have in hand much of the technology needed to prevent a future NEO impact; for a modest investment, they could assemble the shared capability to deflect a threatening asteroid. Such a group would enable world space agencies to coordinate their NEO science and technology research programmes, including exploration missions, to address planetary defence objectives. The group would also plan for in situ characterization campaigns and develop general timelines, mission plans and cost estimates for representative asteroid deflection campaigns.

25. The group should identify for the benefit of space agencies the technical issues involved in planetary defence in order to take advantage of synergies among human exploration, science and NEO hazard research activities.

26. The group could recommend key research required for planetary defence. Such investigations could be addressed through ground-based NEO observations, laboratory research and deep space missions.

27. The group should propose NEO research objectives to guide space agencies in addressing those areas most critical for effective deflection strategies.

28. The group should identify research opportunities for international collaboration. Joint pursuit of technologies and techniques for NEO deflection will help to avoid costly duplication of effort and speed the development of an effective deflection capability.

29. The group should emphasize the value of finding hazardous NEOs early in order to obtain precision tracking data, thus averting the considerable costs of future deflection missions. This strategy requires upgraded NEO search and tracking capabilities:

(a) Rapid enhancements to current detection and tracking systems are a wise investment. Assessment of the impact hazard requires a thorough survey of the NEO population in order to detect the hundreds of thousands of small near-Earth asteroids (and comets) that can cause ground damage. Early execution of this survey, at a relatively modest cost, will enable repeat observations and precise orbit determination that will eliminate many spurious NEO impact scenarios and the associated deflection planning and operational costs;

(b) Priority NEO research should include an analysis of the value of space-based detection and tracking in order to accelerate identification of potentially hazardous NEOs and enable precise orbit determination.

30. The group should develop and adopt a set of reference missions addressing a variety of potential NEO impact and deflection possibilities. The reference missions will enable accurate technical planning and provide a basis for deflection campaign cost estimates. Some of the technical issues to be addressed by the reference missions include:

(a) The technical maturity of deflection techniques and accurate cost estimates for deflection reference missions. The question of how to share funding for deflection campaigns will be addressed at the policy level;

(b) The physical implications and consequences of NEO deflection techniques;

(c) Deflection targeting options (e.g. Earth miss distance). The group should reach a consensus on the minimum acceptable miss distance and provide this to the proposed mission authorization and oversight group.

31. The group should obtain specific information from IAWN in order to enable NEO deflection mission planning and develop the set of reference missions:

(a) IAWN should have a sanctioned, authoritative communications capability for dealing with NEO threat issues;

(b) The mission planning and operations group should deal with threatening objects catalogued by the IAWN search programme and develop, well in advance of necessary implementation, a jointly agreed, affordable plan for an effective deflection campaign.

32. The group should make technical recommendations to mission approval authorities, such as the envisaged mission authorization and oversight group, including:

(a) The question of which entities are best capable of undertaking the different elements of deflection campaigns;

(b) Identification, for detailed review, of any legal issues (e.g. liabilities) that may arise in undertaking NEO deflection actions.

33. Clear lines of responsibility and decision-making from policymakers to the mission planning and operations group would be necessary for a successful deflection campaign.

34. The terms of reference of the mission planning and operations group should be formulated in collaboration with the Action Team.