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Near-Earth objects

Near-Earth objects, 2011-2012

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

* A/AC.105/C.1/L.310.

[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.

Team 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. At its fifty-fourth session, in 2011, the Committee on the Peaceful Uses of Outer Space endorsed the recommendation of the Scientific and Technical Subcommittee and its Working Group on Near Earth Objects[3] (A/AC.105/987, annex III, paragraph 9) that the multi-year workplan on near-Earth objects be continued for the period 2012-2013, as follows:

2012 Consider the reports submitted in response to the annual request for information on near-Earth object activities and continue intersessional work. Review progress on international cooperation and collaboration on NEO observations. Facilitate, for the purpose of NEO threat detection, a more robust international capability for the exchange, processing, archiving and dissemination of data. Continue the work begun during the intersessional period on drafting international procedures for handling the NEO threat and seek agreement on those procedures. Consider updated information as presented in an interim report of the Action Team on Near-Earth Objects. Review progress made in activating the work of the NEO Information, Analysis and Warning Network (IAWN) and the mission planning and operations group.

2013 Consider the reports submitted in response to the annual request for information on near-Earth object activities and continue intersessional work. Review progress on international cooperation and collaboration on NEO observations and on the capability for the exchange, processing, archiving and dissemination of data for the purpose of NEO threat detection. Finalize the agreement on international procedures for handling the NEO threat and engage international stakeholders. Consider the final report of the Action Team on Near-Earth Objects. Review progress made in activating the work of IAWN and the mission planning and operations group, and assess their performance.

4. The present interim report is a summary of the input received from members of the Action Team on Near-Earth Objects for 2011-2012 and serves as an update

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

[3] Ibid., *Sixty-fifth Session, Supplement No. 20* (A/65/20), para. 137

to its previous interim report, which covered the period 2010-2011 (A/AC.105/C.1/L.308). 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 risk. 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 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 Scientific and Technical Subcommittee.

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

A. Near-Earth object detection and remote characterization

5. 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.

6. The Action Team was pleased to learn that the European Space Agency (ESA) had started its space situational awareness programme, which contained a segment 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, Spain, 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. The Action Team was also pleased to learn that ESA supported part of the Near-Earth Objects Dynamic Site (NEODyS) operations, the priority list of the Spaceguard Central Node and the European Asteroid Research Node database.

7. 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 reported on the NASA Jet Propulsion Laboratory website (www.jpl.nasa.gov), as at 1 December 2011, 832 near-Earth asteroids (NEAs) with a diameter larger than 1,000 metres (including 151 potentially hazardous asteroids) had been discovered, 14 of which

had been found in 2010 and 13 in 2011 (to 1 December). The estimated number of NEAs larger than 1,000 metres had increased to 966 ± 45;[4] the figure of 832 NEAs larger than 1,000 metres corresponded to 86 ± 4 per cent of the total estimated number of NEAs. As at 1 December 2011, the total number of known NEAs of all sizes was 8,397, while the total number of near-Earth comets was 90, which brought the total number of known NEOs to 8,487. The International Astronomical Union regularly updated those figures on its website (www.iau.org/public/nea/). Finding an NEO larger than 1 kilometre in diameter had become a rare occurrence. 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.

8. 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 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, Puerto Rico, which was operated by Cornell University for the United States National Science Foundation, would be operating during the apparition of Apophis in 2012 and 2013. That 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.

9. 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.

10. 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

[4] See http://cms3.dynaweb.nl/users/esa//docs/11C03_Planetary_Defense/session2.htm.

Pan-STARRS 1 telescope for NEO search purposes. It was expected that many thousands of observations would be provided to the Center as the project matured. The Planetary Science Division of NASA had 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 did 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 allowed the extraction of observation data from existing image archives in such a way that, once an object was discovered, its previous positions could be calculated and correlated with the archived image sets.

11. The Canadian Space Agency had informed the Action Team that the Near-Earth Object Surveillance Satellite (NEOSSat) project would be launched in 2012. The objective of that microsatellite was 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. Aten asteroids were a group of NEAs with orbital semi-major axes (a) of less than 1 astronomical unit and aphelion distances greater than 0.9833 astronomical units. It was estimated that 6 per cent of the total number of NEAs were Atens. The Action Team encouraged agencies to consider other opportunities to address such complementary primary and secondary objectives for future prospective missions.

12. AsteroidFinder[5] was a space project of the German Aerospace Center (DLR). Its baseline mission would last one year and its launch was planned for 2013. The satellite would carry a 30-cm telescope mirror with a 2 degree by 2 degree field of view and operate in a Sun-synchronous low-Earth orbit. The primary goal of the mission was to search for inner-Earth objects (IEOs), a particular class of NEO with orbits lying completely within the Earth’s orbit and an apparent magnitude of as low as 18.5. Because of their proximity to the Sun, IEOs were extremely difficult to discover from the ground. About 8,500 NEOs had been discovered, of which only 10 were IEOs. However, it was thought that more than 1,000 such objects, with diameters greater than 100 metres, existed. Simulations had shown that AsteroidFinder may detect tens of IEOs in an operational period of at least one year and be able to characterize the IEO population in terms of total number, orbital properties and size distribution, and provide an impact hazard assessment.

13. 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.

[5] See www.dlr.de/pf/en/desktopdefault.aspx/tabid-174/319_read-18911.

14. 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 and thermal properties) and radar (surface characteristics, shapes, sizes and rotation characteristics), and encouraged agencies to consider making resources available to strengthen this activity in the relevant programmes.

B. Orbit determination and cataloguing

15. 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, 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 astrometry (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 astrometry 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 astrometry 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 International Astronomical Union website had a page listing past and future close approaches of known near-Earth asteroids to the Earth and providing information on relevant meetings and literature (www.iau.org/public/nea).

16. 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 observatories worldwide 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.

17. The Minor Planet Center made NEO astrometric data available, on a daily basis, 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 by 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 up to 2110. Those processes were also performed in parallel using NEODyS in Pisa 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.

18. 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.

19. 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 object (of about 3 metres in diameter) 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 NEODyS, 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.

20. 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 was the planetary database, covering planets, moons and small bodies of the solar system. The database would be used as the backbone of a database system, which would be part of the ESA space situational awareness programme. Another activity was GRAVMOD, under which gravity models of asteroids were developed and stored in the database.

21. 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 DLR in Berlin, and the ESA Spaceguard Central Node, which provided a "priority list" for observations of NEOs.

C. Consequence determination

22. 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 welcomed further scientific and technical results presented at the

Planetary Defence Conference of the International Academy of Astronautics, held in Romania in May 2011.

D. In situ characterization

23. 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.

24. 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 and 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 next 100 years. ESA had concluded three parallel industrial studies for a sample return mission from an NEO called Marco Polo. NASA had funded a United States science team to participate in that study. ESA had launched a new mission, called MarcoPolo-R, which was a follow-up to Marco Polo, to continue studying an asteroid sample return mission that had a possible launch date between 2020 and 2024. The study was part of the Cosmic Vision programme of ESA.

E. Mitigation

25. 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.

26. 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 had 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. The Action Team noted with satisfaction that the selected proposal, entitled NEOShield, involved 13 Governmental and non-governmental partners from France, Germany, Russian Federation, Spain, United Kingdom of Great Britain and Northern Ireland, and United States, and would be coordinated by DLR. The NEOShield description of work included the following aspects: mitigation methods, physical properties of NEOs, technology development, demonstration missions and a global response campaign road map. Overall, funding of 538 million euros for a project lifetime of three-and-a-half years had been approved.

27. 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, young people. Among its initiatives, the Move an Asteroid 2011 technical paper competition, held annually since 2008, focused on NEO detection, deflection methods and warning systems. The entries were reviewed by experts and the winner of the competition was awarded a trip to present his or

her paper on a novel deflection method at the Council's annual Space Generation Congress and at the 62nd International Astronautical Congress, in 2011. The Council intended to continue raising awareness and involving young people in the NEO field, as well as to inform them about current issues, such as the work of the Action Team.

F. Policy

28. 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 necessary policy.

29. A further challenge for the global community was that it would likely be confronted in the next 15 years with a perceived impact threat (although 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 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.

30. 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 work plan 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.

31. 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.

32. 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 interim report of the Action Team for 2010-2011 (A/AC.105/C.1/L.308), including the draft recommendations for an international response to the near-Earth object impact threat, contained information resulting from the intersessional work summarized above.

33. At its fifty-fourth session, in June 2011, the Committee endorsed the recommendations of the Scientific and Technical Subcommittee and of its Working Group on Near-Earth Objects (A/AC.105/987, annex III, para. 10) that the Action Team should be tasked with continuing its work on the draft recommendations for an international response to the near-Earth object impact threat. The Committee also endorsed that intersessional work to be carried out in the period 2011-2012 could include workshops held under the auspices of the Action Team that would gather experts on various aspects of the draft recommendations made by the Action Team, and meetings of experts, which could facilitate the establishment of a mission planning and operations group.

34. The Workshop on International Recommendations for NEO Threat Mitigation was organized by the Action Team in Pasadena, United States, on 25 and 26 August 2011. The Workshop received substantive support from the NASA Near-Earth Object Program and financial support from the Secure World Foundation. The Workshop addressed key issues related to the response and cooperation that would be needed by a mission planning and operations group in preparing for a possible NEO impact threat to Earth. The main outcomes of the workshop were a first draft

of the terms of reference for a mission planning and operations group, which would be an essential part of the overall NEO threat mitigation system, and an updated version of the interim report of the Action Team that would be submitted to the Scientific and Technical Subcommittee at its forty-ninth session.

35. On 14 and 15 November 2011, a meeting of the Working Group on Media Communications and Risk Management was held at the Laboratory for Atmospheric and Space Physics at the University of Colorado, in Boulder, United States. The event was co-sponsored by the Secure World Foundation and the Association of Space Explorers. The Working Group, comprising reporters, media specialists and risk management experts, convened to discuss how best to inform the public of the threat of an NEO asteroid impact in a way that would avoid misinformation and to help provide guidance on the development of an outreach and education plan that would foster accurate and timely information about the possible effects of a potentially hazardous NEO.

36. The draft recommendations of the Action Team for an international response to the near-Earth object impact threat (A/AC.105/C.1/L.317), prepared by the Action Team for consideration by the Subcommittee at its forty-ninth session, contains information resulting from the intersessional work in 2011 summarized above.