2010 ACUNS 23 rd
ANNUAL MEETING
Vienna, Austria, 3-5 June 2010-06-05
Panel on Space Security

The institutional dimension of asteroid threat mitigation

Walther Lichem

The issue of considering the defence of our planet against impacts by Near Earth Objects reflects in many ways the new Global Agenda the international community is facing. Addressing the threat of asteroids is almost incomprehensibly complex, requiring the essential input from the scientific and technical sectors of our societies yet is at the same time in need of decision-making at political levels with the corresponding dimension of political responsibility.

Mitigating the threat of asteroids requires very long-term perspectives for the development of capacities for decision-making and for the implementation as well as for crisis and disaster management in case of an impact hitting the Earth under conditions of uncertainty. As with so many other issues of our Global Agenda, the possible impact of an asteroid ignores any national boundaries, nation state concepts and is inherently transnational, global. Yet while everyone, every region is equally potentially affected by asteroid impacts the capacity to counter these threats is limited to very few countries whose role and potential contribution to the welfare and survival of humankind is not really defined.

Asteroid mitigation implies a profound challenge to implementing the basic concepts of our current agenda – equity, human security, international solidarity and justice. While every spot on Earth is potentially threatened by an impact the populations and regions along the concrete risk path will have to live trade-offs of community security against regionally and temporarily enhanced risks in processes of asteroid deflection.

And yet, for the first time in humankind's 4,5 billion year history the international community has the technical capacity of defending this planet against such disasters and prevent such cosmic collisions irrespective of their limited frequency. The challenge is to have the international community capable of making timely decisions for avoiding the loss of life and property resulting from an asteroid impact. This will require not only enhanced and improved technical processes but there is a fundamental need for institutional development both at national and at international levels. Apart from certain ad hoc events and certain intergovernmental and non-governmental platforms for the exchange of information and experience, such as the Working Group on Near Earth Objects of the Scientific and Technical Sub-Committee of the UN General Assembly's Committee on the peaceful uses of outer space, there is yet no institutional set up of the international community capable of steering a detection and mitigation process and of assuming the potentially far-reaching political, economic, financial and societal responsibilities associated with it.

And there are issues of international law related to asteroid mitigation programmes which may require affirmation, interpretation and adjustment of the pertinent norms.

The Earth's geological and biological history has been shaped by impacts from outer space. Sixty-five million years ago the dinosaurs and possibly 80% of the Earth's species succumbed to an asteroid impact which created the Chicxulub crater 180 km across Yucatan in Mexico.

Only 100 years ago a comparatively small piece of space-borne rock with a diameter of only about 45 m exploded above Tunguska in Siberia destroying 80 million trees on 2000 km2. The blast had the destructive capacity of 300 atomic bombs of the Hiroshima size.

In 2002 an asteroid undetected by the astronomic network suddenly passed the Earth at a distance of only 120.000 km, one third of the distance to the moon.

And not yet even one year ago a rock of only 1 m diameter landed near Carancas, a small village in Peru, creating a crater of about 14 m diameter but causing the astronomic expert community to research how such a small object could have penetrated the protective shield of the Earth's atmosphere.

Near Earth Asteroids are mostly collisional fragments from the inner half of the asteroid belt and range in composition from porous, carbonaceous-chondrite-like to metallic. About 20 % of them are binary. Small asteroids of less than 40m are considered to be of no threat to Earth. Every day thousands of small bodies burn entering the atmosphere. The size of asteroids may extend to several dozen km with their probability of impact, however, decreasing. Large Near Earth Objects with a diameter of several km can threaten the survival of human beings and of our biological system.

In 1981 only 18 NEAs were known. By 2004 2700 NEA's were detected and tracked, by 2009 the number had reached more than 7.000. Most of these are of no hazard to the Earth yet current detection identifies about 900 Asteroids as being potentially hazardous, a number constantly on the rise in particular also as there is a growing recognition that also the impact of smaller bodies with a much higher probability of reaching the Earth, can have disastrous consequences.

NASA was tasked in 1998 to detect and track within ten years 90 % of asteroids of a diameter of 1km or more. This work will soon be accomplished. By 2007 721 asteroids of an estimated total of about 1000 were identified with a non-zero probability of hitting the Earth. An impact of such asteroid would cause regional or globally effective loss of life and destruction. The impact debris of such NEO size would spread throughout the Earth's atmosphere so that plant life would suffer from acid rain, partial blocking of sunlight and from the firestorms resulting from the heated impact debris raining back down upon the Earth's surface. The estimated frequency of NEOs larger than 1 km is once in 100.000 to 1 million years. NEOs larger than 10km (so called extinction class objects) have a calculated frequency of occurrence only once in 50 to 100 million years.

The asteroid which since 2004 caused the astronomical community to be mobilized has been the asteroid 99942 Apophis of about 300 m diameter which has been classified as a potentially hazardous asteroid. Its probability of hitting the Earth has been assessed in the different analyses of 1 in 37 and, more recently, of 1 in 45.000. The risk path of Apophis (the Greek name for an Egyptian God of destruction) has been already rather clearly identified. It runs from Siberia, the Pacific, Nicaragua, Costa Rica, Columbia, Venezuela, the Atlantic to the West Coast of Africa. Ecuador, in case of an impact in the Pacific, would most likely also be threatened by a tsunami carrying the impact energy to the coastal zones which would be destroyed over hundreds of kilometres. Striking the Earth at a speed of about 20 km/sec Apophis could gauge a crater 5 km wide and burn everything over a space of 10.000 km2. The resulting earthquake would measure more than 6 on the Richter scale. Current tracking predicts that Apophis will pass a mere 36.000 km from Earth inside the geostationary orbits through a keyhole on 13 April 2029 and could hit the Earth on 13 April 2036. A more precise assessment will be available at the next appearance of Apophis in 2012.

In the process of detection there was growing recognition that also asteroids of a diameter of less than 1 km could cause enormous damage. An asteroid of only 140 m diameter in case of impact would unleash a destructive power equivalent to about 2000 times the nuclear bomb dropped on Hiroshima. Such asteroid would not only cause entire cities to disappear but with direct and indirect damages will cause costs into the hundreds of billions if not even trillions of US$. The total damage caused by the terrorist attacks to the New York World Trade Centre on 9-11-2001 provoked infrastructure costs for the city of 15 bio US$, the impact on the world economy, however, amounted to 180 bio US$. We can imagine the infrastructural, economic, social, system damages in case of an asteroid impact in world marked by enhanced patterns of urban settlements, and increasing technical, economic, social, environmental and infrastructural interdependencies. Today almost every impact of an asteroid will have very important regional and global consequences.

In 2005 a new mandate was given to NASA to identify and track until 2020 90 % of asteroids with a diameter of more than 140 m. This survey, when completed in about 15 years, will reveal that there could be up to 500.000 NEOs including 10 - 20.000 objects with a diameter of 140 m or more with non-zero impact probability.

It is, however, a fact that even smaller NEOs of only 50 m diameter (size of the Tunguska asteroid) can survive entry through the Earth's atmosphere with a frequency estimate of only once every 100 to 500 years.

There is a growing recognition that technologies for detection and tracking will have to be improved to determine with more precision location and timing of possible impacts and to launch respective deflection missions. While the path of risk of a specific NEO may be rather soon defined – a relatively small track of a few km wide crossing the Earth's surface – whether and where its impact will occur can be determined only with more advanced methods and technologies of detection including with space based observation and rendezvous missions with the NEO.

While we have tornado and hurricane warnings we do not yet have institutional provisions for NEO warnings which of course will not occur often but with considerable predictability if the technological and institutional developments have been achieved.

Improving the capacity of detection and tracking Near Earth Objects is therefore of fundamental importance for their possible deflection providing with early detection the necessary time range for launching a deflection mission. Even a relatively late detection with only 3 – 6 days of warning will still allow for preparing for the disaster including the evacuation of the population affected by threatening impact.

The international community, it is rightly argued, will have to move tracking “from science to security”. Our civilisation does dispose of the necessary technology to deflect the threats of Potentially Hazardous Objects yet it has not yet been operationalised.

Let me briefly mention the main types of technologies and related concepts of how to prevent an asteroid from impacting on the Earth. Two broad categories of deflection are currently considered

- rendezvous missions and
- intercept missions.

The rendezvous missions employ “slow push” techniques such as the gravity tractor and the mass driver to change the asteroids velocity and thus cause it to miss the Earth. This technology has not yet been tested and is currently not yet really available. However, as it will be used only for deflection operation with a long lead time of up to several decades and for smaller objects of up to 400 meters application can be implemented in the testing phase of this technology, in particular also in view that it will not cause additional hazards to the Earth. While some argue that “slow push” deflection can possibly fulfill multiple tasks of pre- or post-deflection tracking in addition to gravity tractor applications it is argued that it is to be considered the most expensive technology having the lowest level of readiness.

Intercept missions would consist of a kinetic impactor which approaches a NEO at a very high relative velocity and through impact changes the orbit of the NEO so that it misses Earth. Non-nuclear kinetic impactors are considered the most mature approach especially against a single, small solid NEO body which could be delivered at relatively short warning time.

A report prepared by NASA on NEO deflection options argued strongly for the application of nuclear explosives against threatening asteroids in space. The report distinguishes three types of application

- Nuclear standoff explosions – in NASA’s opinion these are to be 10 to 100 times more effective than the non-nuclear alternatives (a position strongly contested by experts and such institutions as the Association of Space Explorers, the Foundation B612 etc.). Nuclear explosives are considered to be the best available technology for NEOs larger than 400 m diameter and those with short lead time.
- Nuclear surface explosions and
- Nuclear sub-surface explosions. It is, however, recognized in NASA’s report that subsurface explosions would run the severe risk of fragmentation of the NEO with consequent possibly even heightened impact damages on Earth

The NASA report rightly draws attention to the fact that the overwhelming number of potentially hazardous NEOs cannot yet be addressed because they are beyond the capability of presently available launch systems. This is another front of technological development needed dealing with comparative advantages of available chemical propulsion, electric propulsion, solar sails, nuclear propulsion etc.

The brief description of the technical dimension of asteroid threat mitigation should make it clear that the options available have multiple political, institutional and legal implications all of which have not really been addressed by the international community.

The other defining element derives from the fact that the international community will be challenged by many low-probability threats weighing the cost of action against the potential cost of inaction should the threat materialize. The fact that each potentially hazardous object has its own path of risk boiling down to the question who will be at risk in each case and whose risks might be enhanced in the course of a potentially flawed deflection operation.

Related thereto is the question of who is to decide, who is to act, what type of defence is the international community taking in each case and how can it meet the time constraints between identification, tracking, threat assessment and deflection options.

Let me sum up some of the more concrete institutional issues which will have to be addressed in the context of decision-making and capacity-building in the near future:

- Which (national/international) institution is to be responsible for detecting and tracking NEOS and for identifying potentially hazardous objects? Who would be in a position to provide such services to the international community? How and by whom would such a mandate be assigned. Should there be one or should there be at least two or several such institutions?
- Who is to develop new technologies for NEO detection and tracking?
- Who is to assess available data and issue a warning to the public and by which criteria (e.g. size, composition, probability of impact?
- Who assumes the responsibilities of disaster management including post-impact effects of a cosmic disaster, evacuations at global, regional, national levels?
- Who is to develop technologies that can be used for deflection operations?
- Who is to develop general criteria for deflection decision-making?
- Who decides about the use of nuclear explosives keeping in mind their express prohibition in international law?
- Who is to decide on launching a deflection operation?
- Who is responsible in case of deflection failure and impact damages to areas and populations originally not at risk?
- Who is to compensate for damages inflicted by nuclear devices returning to the Earth as part of space debris?
- How are costs for detection and deflection operations to be covered?

All these questions are still to be answered by the international community. There are a number of circumstances which will be marking the institution-building process.

First, the institutional response of the international community to these challenging questions will be defined by the fact that only a handful of the 192 UN member countries currently have NEO detection capabilities and even fewer could provide the technical equipment for deflection operations. While the theoretical temptation may be there to just forget about the United Nations, as articulated by some experts in the field, the global reach of responsibility for the space powers rather requires an international anchoring and a sharing of what ultimately is just another application of the “responsibility to protect”.

Second, the needed institutional set-up will have to take account of the technical complexity of the issues at hand and the need to have the necessary expertise participate and share in the various elements of what ultimately should probably still be an intergovernmental decision-making structure.

Third, the time dimension in asteroid-related decision-making is marked by the fact that as time passes deflection options vanish, leaving at the end of the decision-making process maybe only the nuclear option or the option of “taking the hit”. This implies that the basic decision criteria will have to be defined free of the pressures of time and beyond the concrete national/regional interests related to potential victimisation.

The apparent scarcity of decision occasions is not to be underestimated If we consider a 45 m diameter object impacting the Earth every 700 years and if we are willing to address all threats with a probability rate lower than 1 in 70 decisions will have to be taken on deflection operations at least once every 10 years.

It will be useful to approach the institutional questions from a functionalist perspective aiming at developing institutions that make optimal use of the special capacities of space faring nations and space experts while providing for an anchoring of decisions in the overall responsibility of the institutions of the international community.

Following this approach I would suggest to identify the following key functions which would then have to be allocated to specific capacities available and to different national and international institutions.

- Data collection and analysis of NEOs
  Conducted by national or regional institutions with respective financing. Currently NEO astronomic data are made available on a daily basis to the SENTRY facility of NASA Jet Propulsion Laboratory and to the orbit computation centre of the Near Earth Objects Dynamics Site NEODyS in Pisa, Italy. They are completely independent systems which employ different theoretical approaches to provide impact risk assessment..
- International exchange of information and analysis
  To be accomplished by the Working Group on NEOs of the Scientific and Technical Sub-Committee of the UN Committee on the peaceful uses of outer space which will report about it annually to the UN General Assembly

- The management of observational data is currently done by the Minor Planet Center of the Smithsonian Astrophysical Observatory in coordination with the International Astronomical Union. A Memorandum of Understanding with the IAU gave the MPC an international charter and since 1978 it is serving as a clearing house for all asteroid, comet and satellite astronomic measurements. The MPC processes and organizes data, identifies objects, computes orbits and assigns tentative names and disseminates information on a daily basis. There is, however, concern about the dependence upon the MPC alone and the suggestion is made to establish at least one mirror capability to the MPC in Europe or in Asia which could provide the institutions of the international community and the international public with asteroid threat assessment and warning.
- There is also need for establishing a common data processing policy concerning calculations, data designations, data curations, disseminations, verification and policies of data access and security.
- Leading space-faring nations will be requested by the international community to further develop detection and deflection related technologies and to report about the technical options to the UN General Assembly through its Committee on the peaceful uses of outer space
- National governments, regional and international organisations should integrate asteroid impact scenarios into their disaster management capacities. These capacities are to be assessed and made the subject of international consideration in regular intervals
- The Security Council of the United Nations would probably have to establish a Committee on Asteroid Threat Mitigation which would benefit in its deliberations from the contributions of independent qualified experts. This Committee on Asteroid Threat Mitigation i.a. would elaborate and submit to the Security Council general decision-making guidelines for the approval of deflection operations. The Security Council would submit these guidelines to the General Assembly for approval by the entire international community.
- The Committee on Asteroid Threat Mitigation would conduct regular assessments of impact threats in consultation with the data providing national and regional institutions
- Deflection operations (including, in particular, with the use of nuclear devices) would have to be approved by the Security Council following in its decision-making process the general criteria elaborated and approved by the international community. The Committee on Asteroid Threat Mitigation will contribute to the deliberations of the Security Council keeping in mind however the need for decision-making under severe time constraints
- Deflection operations will be carried out by space faring nations mandated for this task by the UN Security Council
- Deflection operations will be supported by financial contributions from a United Nations Asteroid Threat Mitigation Fund to which UN member countries pay annual contributions following the contribution key for UN peacekeeping operations
- In the case of deflection failure and ensuing damages to the Earth the damages will be compensated in all cases by the international community at large and financed through the UN Asteroid Threat Mitigation Fund

Several international organisations have dealt in the recent past with the issue of asteroid mitigation including

- the Global Science Forum of the OECD,
- the UNISPACE III conference in Vienna leading to the creation of an
- Action Team now a Working Group on NEOs within the Scientific and Technical Sub-Committee of the Committee on the peaceful uses of outer space whose reports have been submitted to the General Assembly of the United Nations.
- The Parliamentary Assembly of the Council of Europe also dealt with the issue of potentially dangerous asteroids and comets.
- The recent initiative regarding an institutional partnership between the Committee on the peaceful uses of outer space and the IAEA on issues of nuclear devices in asteroid deflection operations has to be noted in this context.

Yet, how are we going to proceed? Who is going to take the initiative? There is no doubt that the space expert community has been increasingly aware of the threats facing humankind and the growing capacities to confront them. Several international conferences, especially the 2007 Planetary Defence Conference have addressed these challenges. Yet the general public and the political structures at national, regional and global levels have not really taken notice of the newly assessed technical, institutional and also legal challenges.

As with so many items of our Global Agenda it has ultimately been the usual mix of knowledge bearers – i.e. the academic and professional experts – and the vision bearers - i.e. personalities from civil society - who have taken the initiative. The Association of Space Explorers created in 2007 a Panel on Asteroid Threat Mitigation which is to explore exactly these dimensions. It has presented its conclusions to the UN Committee on the peaceful uses of outer space and this issue of Near Earth Objects will reach the General Assembly.