An International Policy Response to the Near Earth Object (NEO) Impact Threat

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Introduction

The growing body of scientific evidence that past encounters with NEOs have had a major influence on the evolution of life on our planet, obliges governments to examine the potential threat that future possible impacts can pose to our society. Accordingly, there is a need to assess our vulnerability to such events and to determine whether there are prudent and judicious actions that we should consider in order to minimize or mitigate their potential effects. Further, there is a need to establish a suitable policy framework to enable such actions to be undertaken when they are required.

In recent years, we have learned a great deal about the asteroids and comets that strike the Earth. Every day, thousands of small (centimeter-size) objects burn up harmlessly as meteors strike the atmosphere. Impacts of very large (multi-kilometer) NEOs have in the past been catastrophic but are, fortunately, extremely rare. Objects of intermediate size can cause significant damage when they hit the Earth at random intervals of hundreds or thousands of years. It is this relative infrequency, spanning many generations, which makes it difficult for governments to consider the NEO risk in a comparable manner to the more frequent natural hazards that we are familiar with, and which are therefore of a more immediate concern to the public.

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The consequences of a NEO impact however can be much more severe and devastating than those resulting from an earthquake or an extreme weather event. A great deal can be done to prevent some of the impacts (which can be predicted many years ahead), and to reduce the damage of others significantly, provided timely actions are undertaken. It is this combination of the potentially catastrophic consequences, the predictability of the events, and the ability to intervene which obligates governments to set in place a framework to address to the NEO threat which complements the existing response to meteorological and geological hazards.

The mitigation of large-object impacts must begin with detection. To prevent impact, larger asteroids have to be identified many years before the collision, allowing sufficient time for technology development and a possibly lengthy period of gradual deflection.

Smaller asteroids are more difficult to detect, because they are very faint at large distances from Earth. Thus, a small object might be heading towards Earth with relatively little warning. Even with little or no advance detection, some mitigation of the effects of impacts of small and medium -sized objects is still possible via existing emergency response mechanisms such as tsunami warning systems and evacuation procedures. Should any impactor be detected only months ahead of impact, deflection might still be possible via a direct high-energy intercept although the technology would need to be developed and ready to use.

Given the global nature of the NEO hazard and the scale of any effective response, it is unlikely that one country will decide independently to take action when an impact threat is identified. There must be international involvement in decision making and whatever actions are to be taken, as the consequences of action or inaction are unlikely to be constrained within a single territory. Thus any ultimate policy framework will need to be of an inter-governmental nature, requiring regional and international communication and cooperation between states. The governments of a small number of countries already have national policies which support programs to evaluate the risk from NEOs, and to detect one category of potential colliders: the large asteroids that, if they struck the Earth, could produce a global-scale catastrophe with billions of casualties. Many other governments have not undertaken any official actions related to the NEO threat, although, in some of these latter countries, scientists do participate in scientific NEO studies and observations.

There are only a few administrators or offices whose responsibilities include dealing with NEO issues as they relate to public safety. This limited consideration of NEOs as a public safety issue is a source of consternation amongst many observers as they advocate that the response to the NEO issue should be consistent with the approach adopted for more familiar natural and man-made hazards that nations may encounter. They argue that the threat to life and property from NEOs, when averaged over long time periods, can be considered to be comparable to that from geological and meteorological hazards, and accordingly a commensurate level of response to NEOs should be established by governments.

While the probability of a NEO impact is effectively the same for all points on the Earth's surface, the magnitude of the risk is not the same for all countries. It depends, amongst other factors, on the country's size, population distribution, topography, economic infrastructure, proximity to the ocean, and vulnerability to other natural hazards (e.g., earthquakes).

The evaluation of the NEO risk requires data and expertise from many scientific fields and other domains relevant to risk analysis. It is worth emphasizing however that NEOs do not recognize national boundaries and that the consequences of future impacts are unlikely to be isolated to any individual country or region. For this reason amongst others it is important that the policy framework which is established should encourage nations to work together to share data, expertise and resources to assess and mitigate the risk of a future impact, wherever it may occur on the Earth.

In looking for a formal response from government in relation to the NEO hazard, we also need to be realistic and pragmatic. The current surveys have demonstrated that a global-scale asteroid impact is not imminent, and so there are few immediate actions which need to be taken, the most urgent perhaps being the need to reduce the size threshold of detection of the survey programs to include objects which still pose a very significant threat to society should they impact the Earth. Instead we need to exploit existing policy platforms and infrastructures where appropriate, and bridge the gaps in capability (whether it be process or infrastructure) with specific actions related to NEOs. There is however a compelling argument for embarking on the establishment a policy framework to address NEOs now.

We need to use this finite window of opportunity, before a specific impact threat has been identified, to develop our policies in a balanced and objective manner. Experience has shown us that decisions made "in the heat of the moment" can be flawed, ill-judged, and compromised by emotion and subjective influences such as exposure to an impact threat (or lack of it). Mitigating the impact of a NEO will represent one of the greatest challenges ever posed to society, and the resulting

technical solutions will be intrinsically coupled with wide ranging policy implications. We are obliged to ensure that a policy framework is set in place which will support these efforts rather than undermine them.

2. An Appropriate National Response from Governments

In looking to governments to take action in response to a potential NEO threat, we also need to understand how they might interpret the threat. Whereas an individual may simply consider risk to life posed by an impact, governments will see the broader spectrum of consequences such as financial cost of infrastructure damage and environmental impact along with the scale of casualties. Governments also tend to draw a distinction between the risk to an individual and the risk to groups of people.

Individual risk is defined as the frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards, whereas societal risk is the relationship between the frequency and the number of people suffering from a specified level of harm in a given population from the realization of specific hazards. There is a widely held view that while the individual may primarily be concerned about risk to self (i.e. individual risk) the 'state' should be concerned with societal risk. The UK Health and Safety Executive's interpretation of societal risk, "the risk of widespread or large scale detriment from the realization of a defined hazard, the implication being that the consequence would be on such a scale as to provoke a socio-political response, and/or that the risk provokes public discussion and is effectively regulated by society as a whole through political processes and regulatory mechanisms", is well suited to dealing with the infrequent but potentially catastrophic events characteristic of asteroid or cometary impacts with the Earth. Thus a set of criteria should be established which require action to be taken to assess the consequences of a specific impact threat, and then consider the range of options for managing the risk.

In addition to the probability of, and time to impact, the other parameters that will influence the response strategy will be the anticipated intersect locus on the surface of the Earth and the vulnerability of that area to the impact. Further the different options for deflection and the implications (technical readiness, political acceptability, cost of development and operation, translation of intersect locus) of a particular deflection strategy will also have to be weighed up against the alternatives. It is quite possible that countries without the capability to mount a deflection mission may be threatened by an impact, whereas those with the capability are not. Further it may be considered more attractive for one capable actor to take the lead in mounting a particular deflection mission rather than a grouping of agencies with different roles, due to the complexity of the mission, and the political expedient of protecting sensitive technical information. Hence one can envisage a matrix of options, with agreed responses to a range of impact scenarios, with identified players performing specific roles.

In considering this matrix of responses, we can identify a timeline from the initial detection of a potentially hazardous object through characterisation of the body and its potential effect should it impact, on to development of a solution tailored to that object and the development and production of the necessary infrastructure, followed ultimately by the deployment and operation of a deflection mission. It would seem prudent that prior to the emergence of a specific threat, that we should develop a number of solutions encompassing the range of impact scenarios that could be encountered, and to advance the solutions along the timeline to a level of maturation appropriate to the likelihood of implementation and cost-effectiveness of the associated activities. Hence for the full range of impact scenarios that we can envisage, we could evaluate deflection concepts employing all feasible technology

solutions and consider the implications for their deployment. Hence we might anticipate taking all scenarios through initial requirements capture, establishing performance requirements and identifying possible mission concepts, along with outline cost and schedule estimates and determination of critical mission elements. This could be followed by initial feasibility studies to explore and evaluate possible system concepts, and refine costs, schedule and utilisation constraints, leading to a preliminary system concept selection.

The next step would be to advance the chosen solutions through to preliminary definition phase resulting in a precise definition of performance requirements, a coherent definition of the system, identification of sourcing of components of system, and pre-development work on critical technologies where necessary.

On completion of the preliminary definition phase, a particular solution would be adopted for each impact scenario and the associated critical technologies would be brought up to a minimum level of technical maturation. Cost and schedule estimates can then be developed with some confidence to feed into the overall decision timeline. It is important that this process is conducted in a coordinated manner to ensure that the full range of probable impactor scenarios and deflection options are considered and to avoid duplication of effort. Additionally, the baseline conditions for evaluation of the mitigation options and the metrics for comparing solutions would need to be agreed and applied consistently. Hence there is a need for a forum to be identified with the mandate to coordinate this activity and manage the process of establishing baseline mitigation options for the range (size, composition, orbit, epoch) of impactor scenarios.

It could be anticipated that different space agencies would be prepared to fund advancement to this preparatory stage without recourse to others, although the actual cost of mounting a deflection mission would be on a different scale. Each of the possible mitigation responses will also have a range of consequences from a technical, political and economic standpoint. Each of these consequences would need to be addressed before the solution could truly be considered a viable option. It would seem practicable for those promoting specific capability to champion a particular solution, working through the consequences, and working as advocate and agent for action within the appropriate forums, with informed and implicit support from the wider international community on whose behalf the action would be taken. This would require a degree of transparency, either within the technical forum, or subsequently when the political and economic consequences of a particular technology solution are considered. We can anticipate a number of issues that would result from developing this matrix of baseline responses to the impact threat. In all cases where the intersect locus on the Earth is modified through active intervention by an actor, it is important that this is conducted with the full understanding and support of the international community on whose behalf the action is being taken. Further where the nature of intervention requires nuclear technology, there are treaty issues which would need to be addressed. Again, it would seem prudent to scope these issues and advance the debate to a stage where necessary modifications to existing treaties could be identified and drafted.

Whereas the technical solutions would be best developed amongst a group of capable space-faring nations, it would be appropriate for the policy aspects of the anticipated actions to be developed and debated by global community within an international policy forum. However it would be premature to embark on this debate before consensus had been reached within the technical forum and the outline solutions introduced into a corresponding international body for consideration and general endorsement.

3. Supranational Issues

However, there are a number of policy aspects of the NEO mitigation strategy, which are independent of the deflection solution, and which are pertinent to the international community. One issue is the consideration of whether to act or not, i.e. where it might be decided not to mount a deflection mission and instead to allow the NEO to strike the Earth, but to minimise the impact on the population and infrastructure through a combination of evacuation and protection. This would require consideration of the range of hazards presented by NEOs, namely impact debris, blast waves, heating, tsunami waves, material injection into the atmosphere and electromagnetic pulse for a specific location. The approach to this analysis and the results would need to be endorsed by the community as a whole.

A second aspect is when a decision should be made to launch a deflection mission, or otherwise. Although this is somewhat dependent upon the impactor scenario (i.e. the time we would have to make a decision and mount a deflection mission), experience tells us that it would be prudent to make this decision as soon as a credible threat has been identified. These criteria and thresholds would need to agreed in advance of implementation, and hence are an immediate, if not urgent, requirement.

Finally, it is clear that consideration should be given to the political implications of deflection, regardless of the technology used to effect this. Hence a review of existing treaties and legal instruments should be conducted to understand the implications of action, and to identify possible means of indemnification and/or cross-waiver of liability for agreed actions on behalf of the international community. The constraints on the parameters for this action would need to be agreed by all parties and addressed through a form of "contract" or "Memorandum of Understanding" between the acting agency and the international community.

Should an impactor strike the Earth as a result of lack of sufficient warning time to mount a deflection mission, the failure of a deflection mission to prevent an impact on the Earth, or a decision to "take the hit", it is critical that the NEO hazard is incorporated into the mandates of both national and international agencies responsible for dealing with natural and man-made catastrophes. The existing framework for disaster management would provide an effective response to a NEO impact but would require the education of officials to recognise the unique characteristics of the NEO hazard and modify their procedures to respond accordingly.

4. An Appropriate International Forum

In considering how to address the policy requirements previously identified for NEOs, we can learn much from the approach adopted for analogous topics such as man-made debris. Within a relatively short time frame from identifying that man-made orbital debris posed a significant threat to future space operations, an inter-Agency forum was established with different nations performing complementary roles, to review and seek scientific consensus on related aspects of debris measurement, modelling, risk evaluation and identification of measures for mitigation. This Inter-Agency Space Debris Coordination Committee (IADC) is an international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space. The primary purposes of the IADC are to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options. The IADC member agencies include the following: ASI (Agenzia Spaziale Italiana), BNSC (British National Space Centre), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), DLR (German Aerospace Center), ESA (European Space

Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), NASA (National Aeronautics and Space Administration), NSAU (National Space Agency of Ukraine), ROSCOSMOS (Russian Federal Space Agency).

The resulting outputs from IADC were then used to inform the debate on the subject within the Scientific and Technical Sub-Committee of United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) which led to international agreement on a series of guiding principles2 to minimise the future proliferation of such debris. The resulting international policy subsequently became widely recognised and is in the process of being adopted in national regulatory activities with resources being made available accordingly. Such a model for policy development is appropriate for NEOs, not least because many of the assets and techniques, and the Executive Agencies involved, are the same.

An IADC analogue for NEOs involving space-faring nations would be able to deal with a number of the technical/policy issues identified previously, such as establishing data management policies/protocols, developing a recognised risk assessment methodology, and performing a technical assessment of the mitigation options for a range of impactor scenarios. Such a body would not however be well placed to identify the criteria and thresholds for the communication of a specific impact threat, or identifying the channels for communication of this risk and those responsible for subsequent action. Further, the international community may be reluctant to trust the establishment of criteria and thresholds for actions such as when to act, how, and on what basis, to a body with limited international representation, especially when the outcomes of the (in)action would have direct consequences for those not involved in the governance of that body. Hence the role of UNCOPUOS is critical to ensuring any response is proportionate, consistent, targeted, transparent and accountable.

In 2007, the Working Group on NEOs was established (by the Scientific and Technical Subcommittee of UNCOPUOS) in the expectation that international procedures to address the NEO threat would be proposed by this Working Group for consideration by UNCOPUOS. In 2007 and 2008, the Association of Space Explorers (ASE) convened a Panel on Asteroid Threat Mitigation (PATM), consisting of renowned non-governmental, multi-disciplinary experts in science, diplomacy, law, and disaster management from around the world. In 2008, ASE submitted its recommendations in a report entitled "Asteroids threats: a call for a global response" to UNCOPUOS for consideration by the NEO Working Group. UNCOPUOS welcomed this important contribution to a possible NEO policy framework, and recognised its value 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. During the 46th session of the Scientific and Technical Subcommittee of COPUOS in February 2009 the ASE Report was reviewed and as a result an associated UN document A/AC.105/C.1/2009/CRP.13 was developed building on the recommendations of the ASE Report. These draft UN recommendations will be submitted to the Working Group on NEOs and Member States for their consideration and review during the 47th session of Scientific and Technical Subcommittee to be held in Vienna from 8-19 February 2010.

There is now a real opportunity for one, or a number, of governments and/or institutions, to show leadership and champion the development of appropriate policy frameworks to address the NEO hazard. There are clearly benefits in taking such initiative, such as influencing the guiding principles for engagement on the issue, and building partnerships within the international community to share resources and responsibility to act. Further, given the scale of

economic and human costs that we would inevitably incur as a result of an impact, governments and institutions are obliged to demonstrate a credible, science-based approach to dealing with the NEO threat.

References

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