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Societal Risk Evaluation Of The Near Earth Object Impact Hazard

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Background

Since its formation four and a half billion years ago, the Earth has been subject to impacts from space. Although the frequency of encounters and the characteristics of the impactors have changed over time, the Earth still encounters a significant flux of these objects as it sweeps through interplanetary space. They range from micron-size dust particles, of which hundreds of tonnes enter the upper atmosphere virtually unobserved each day, through to much larger bodies, with diameters measured in kilometres, which strike the Earth with globally catastrophic consequences over much larger timescales. In between these extremes are many thousands of moderately sized objects (of the order of 100 metres in diameter) that can cause significant regional damage and result in major casualties. The relative frequent entry of these intermediate objects can result in the production of blast waves, injection of material into the atmosphere, generation of tsunamis (ocean waves), and propagation of electromagnetic effects.

We are obliged to examine the potential threat that future NEO impacts can pose to our society, to assess our vulnerability to such events, and to determine whether there are prudent and judicious actions that we should undertake in order to minimise or mitigate their potential effects. In order to address these issues, the Organisation of Economic Cooperation and Development (OECD) under the auspices of the Global Science Forum (GSF), convened a meeting of government representatives and international experts in the fields of NEOs and risk analysis in Frascati, Italy from January 20-22, 2003. The Workshop identified a need to inform NEO policy development at a national level, thereby enabling a response by governments to the NEO issue (co-ordinated at an international level) that is consistent with the approach adopted for more familiar hazards such as earthquakes and extreme weather events that nations may encounter, namely to:

- Assist OECD countries in formulating a science-based policy on the NEO hazard, which has recognition at an international level as being an appropriate methodology to address the issue
- Enable OECD governments to compare NEOs with the more familiar natural and man-made hazards that their nations encounter, so that, as NEOs relate to public safety, a commensurate level of response can be developed
- Present a risk methodology for the NEO hazard addressing such factors as a country's size, topography, proximity to the ocean, population distribution, economic infrastructure and vulnerability to hazards in a consistent manner

In considering how to quantify the extent of casualties and property damage caused by a NEO impact, we must consider a number of objective (wave propagation) and subjective (vulnerability of society and infrastructure) aspects. In identifying appropriate risk methodologies, we have considered the issue of the availability of models to represent the characteristics of NEOs, their interaction with the atmosphere and the oceans of the Earth, and the transmission of the hazard to properties and persons. Due consideration has also been given to the availability of digital models representing the physical nature of countries, in particular bathymetric and elevation data at coastlines, and population distributions. These tend to break up the globe into cells of latitude and longitude, offering a choice of resolution in both cell size and elevation. Developing a computational tool capable of performing a detailed analysis (especially for the tsunami risk), even for a single country, is a major undertaking both in time and resource, and should not be embarked on lightly, or without justification.

The UK has developed a comprehensive methodology identifying the overall logic and detailed algorithms required to determine the NEO risk, derived from previous studies in this field. Before embarking on the development of a computational tool employing such a deterministic approach, we have adopted a statistical solution to conduct a first-look analysis for the UK and other OECD countries. In the case of air-burst/ground impact, we have considered the size of a country and its population characteristics. In the case of an impact-induced tsunami, our approach has been to establish how far from a country an impactor of a particular size can fall and still generate a wave height above a pre-defined critical value at its coastline. The distance from the coast (range) and the exposure of the coastline gives the area into which an impactor of a particular size can fall, this area then determining the probability (or frequency) of the initial impact event.

We have developed our analysis in terms of societal risk which is considered the most appropriate mechanism for addressing natural hazards such as NEOs as it is well suited to dealing with the infrequent but potentially catastrophic events characteristic of asteroid or cometary impacts with the Earth. Further 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*.

In our statistical analysis of ground impact for OECD countries, we find that for the UK, the risk is such that we are obliged to examine our national risk in much greater detail to confirm these findings, to understand the specific vulnerabilities of the UK population and infrastructure, and to identify appropriate measures for mitigation.

Our statistical analysis of tsunami risk has been applied in a limited manner to the UK and other OECD countries. It is clear that countries whose coastlines share exposure to particular oceans have comparable risks, both in magnitude and characteristics. There is value in regional groupings of countries (e.g. North America, the Asia-Pacific Region and Europe) pooling the resources needed to perform a more detailed analysis of impact-induced tsunami risk in their region. The UK is now committed to the development of a comprehensive computational tool employing the detailed methodology identified above, to translate tsunami rates into potential casualties, and would aim to contribute to such an effort accordingly.

It is clear that there are countries which were not the subject of this study but which have high population densities, and are exposed to large expanses of ocean, and who do not currently have the capability to estimate their level of risk. It is likely that the impact risk for these countries will be very significant and some mechanism should be sought, or forum identified, which can address this shortcoming.

The paper outlines the summary findings of our initial study and national plans for a more comprehensive follow-on phase.