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Contribution of an NEO Wide Survey for the small impactors population completeness

F. Bernardi (1,2), G. B. Valsecchi (3), D. Farnocchia (2)
(1) SpaceDyS, Navacchio (Pisa), Italy, (2) Dep. of Mathematics, Univ. of Pisa, Pisa, Italy, (3) IASF-INAF of Rome, Italy
(bernardi@spacedys.com)

Abstract

In the framework of the European Space Agency - Space Situational Awareness (ESA-SSA) program, we studied the performance of a possible network of telescopes for the SSA Near Earth Objects (NEO) segment capable of scanning all the visible sky from a station in one single night (Wide Survey). The purpose of the study was the determination of the efficiency of discovering NEOs in the size range of the Tunguska-like asteroids, from 160 m down to 10 m. We developed an end-to-end simulator capable to simulate, under some assumptions, the activities of such a network from detection, to preliminary orbit determination, orbit improvement and impact risk assessment. This work presents the results of our simulations.

1. Introduction

The activities regarding the discovery of potential hazardous asteroids are at present dominated by the American surveys. These surveys can be defined as Deep Surveys, because they make use of big telescopes capable of scan in deep the nearby sky. These surveys are generally very efficient in discovering and mitigating the impact risk for objects from some km in size down to 160 m, and they can discover hazardous objects many years or decades before the occurrence of the impact. Nevertheless, they are not very efficient in detecting imminent impacts of smaller objects of which impacts may still result in very important damages and losses on ground. The reason of this inefficiency resides in the fact that their observing strategy is to cover the same area in the sky after a few days, and to take only a minimum number of images (typically two). This prevents to successfully identify objects that are going to impact within one or two days.

We propose an alternative kind of NEO survey, which we call Wide Survey, which can contribute significantly to the NEO impact hazard mitigation for small objects.

For the Wide Survey telescope we assumed the innovative fly-eye telescope concept [3] with the following main characteristics:

- an effective aperture of 1 m,
- a FoV of 45 sq. degrees (6.66 deg x 6.66 deg),
- high efficiency CCDs (80-90%) with very fast read-out times (few seconds) and very good cosmetics,
- a fill-factor 1, that is the ratio of the effectively detected area of the FoV and the FoV.

For the Wide Survey observations we assumed:

- observations that cover all the visible sky at the station but the regions with solar elongation less than 50 deg.,regions near the Moon or near the galactic plane,
- a typical limiting V magnitude of 21.5; for the follow-up mode the limiting V magnitude is 23.0,
- the visible sky is observed at least two times per night.

For the Wide Survey network we assumed:

- one dedicated survey telescope in the northern and one in the southern hemisphere
- one dedicated follow-up telescope in the northern and one in the southern hemisphere, typically 30 degrees west to the survey telescopes

2. The simulation

We used for our simulations a population of about 4950 synthetic impactors provided by [2] which had impacts in a time frame of 100 years. This impactor population had been selected within the population model by [1].

From the input population we selected the orbital elements and ran the simulation assigning a fixed value of the absolute magnitude H to all the asteroids; the simulation was repeated for integer values of H ranging between 22 and 28, roughly corresponding to diameters between 160 and 10 meters. This simulation strategy was chosen to measure the performance of the proposed network as function of the size range of the asteroids.

The population was split in 10 bins according to the impact epoch with respect to the beginning of the simulation. E.g., the first bin contains objects impacting within 10 years, the second one objects impacting between 10 and 20 years, and so on.

3. Summary and Conclusions

The most important outcome of the simulations is shown in fig. 1. It gives the detection efficiency as a function of survey duration and absolute magnitude.

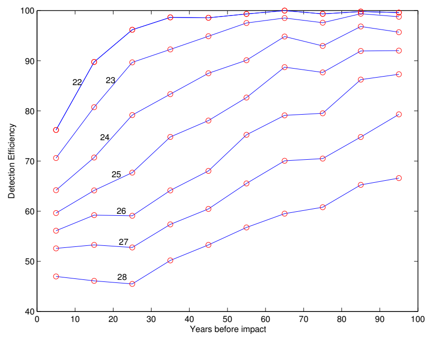

Figure 1: Detection efficiency in function of the warning time and absolute magnitude.

For impactors in the range 22<H<23 a 70% detection efficiency is achieved in the first decade, while a 90% threshold is reached after one or two more decades. For Tunguska-size impactors (24<H<25) a 60% detection efficiency is achieved in the first decade, while a 90% threshold is reached after 60 and 70 years. For smaller asteroids, H>26, the detection efficiency starts already around 50% within the first decade, while it increases slowly during the next decades as expected, due to the small size of the objects.

A fraction of undetected objects is present for all values of H. This situation typically occurs in the first decades of the simulated survey and it is due to the lack of sufficient time to allow for a favourable apparition. Figure 2 shows the asymptotic direction from which immediate impactors are seen to come. Objects with small solar elongations have the greatest chance to go undetected until impact.

Another important figure of merit is the warning time, that is the time between the first detection and the impact. Three typical cases occur: the object is never observed before its fall on the Earth, it is detected on the apparition leading to the impact, or at an earlier one. This is reflected in fig. 3, which shows the distribution of the warning times for the H=24 case.

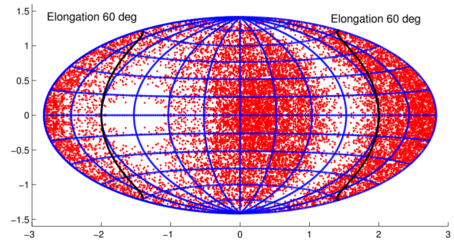

Figure 2: Radiants of the synthetic impactors in an equal area projection of the sky centered at the opposition.

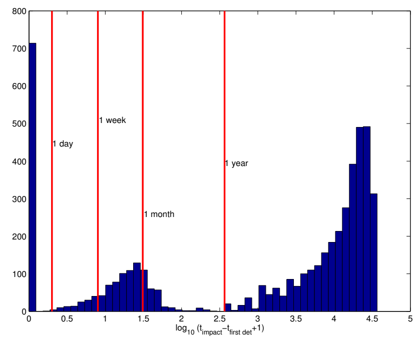

Figure 3: Histogram of the warning times for a population of H=24 and impacts within ...

Acknowledgements

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