REALISTIC SURVEY SIMULATIONS FOR KILOMETER CLASS NEAR EARTH OBJECTS.

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Introduction: The effort to discover and characterize "earth-crossing asteroids" dates back to 1970s [1, 2] and has become much more apparent in recent years. Currently, there are about ten telescopes dedicated to regular NEO survey in both hemispheres. With a detailed survey simulator reproducing distributions of orbital elements and absolute magnitude as well as number of discovered NEOs, we are able to (i) evaluate whether on-going survey programs can meet NASA's Spaceguard Goal and how long it would take to discover all kilometer class objects, (ii) verify if the current NEO population model is properly established, (iii) test the overall efficiency of existing NEO search programs and derive better detection strategies, and (iv) plan next generation survey programs and optimize their search strategies.

We note that earlier NEO survey simulations attempts are all made for a specific survey program with relatively well known performance and operational parameters [e.g., 3]. It should be emphasized that previous simulations mimicking the Lincoln Near Earth Asteroid Research (LINEAR) program would not provide reliable NEO detection estimates any longer because (i) due to recent upgrades of telescope and detector systems, the search volume of current surveys has changed significantly, (ii) the contribution from the LINEAR program has been considerably decreased while the Catalina Sky Survey (CSS) now takes the lead in the NEO discovery, and finally (iii) the Siding Spring Survey (SSS) started operation in early 2004 and is reporting discoveries made in the southern sky. As a result, a "pseudo-LINEAR" algorithm cannot reproduce the current discovery statistics nor properly predict the future discovery rate.

Method: We present a new NEO survey simulator [4] which incorporates the four-dimensional population model of 4668 NEOs [5, 6] and the observing strategies of most asteroid search programs. In this paper, we incorporate observational constraints and strategies of wide-field surveys to the maximum extent possible; we superposed simplified search patterns adopted by all major wide-field surveys in operation in both hemispheres. We defined five different simulation periods to follow the evolution of survey efficiencies reflecting changes in either search volume as a result of upgrades of telescopes and instruments or in observing schedules. We then compare discovery statistics and distributions of orbital elements of the real populations with our simulated detections. Our simulations cover the next 10 years, in which we examine the achievability of the NASA's goal and beyond with every major survey resources available today.

Results and Discussion: The simulator [4] makes remarkably good reproductions of actual survey results as of December 2005, not only the total number of detections but also (a, e, i, H) ('H' means absolute magnitude of an asteroid) distributions. An extended experiment provides excellent predictions for discovery statistics of NEOs ($H < 18$) reported to the Minor Planet Center in 2006. These support that our simulator is a plausible approximation of real surveys. We further confirm that, with the Bottke et al. [5, 6] population model and present survey capability, the 90% completeness level of kilometer-sized NEOs will be achieved by 2010 or 2011. However, about 8% of the kilometer-sized or larger NEOs would remain undetected even after 10-year operation (2007-2016) of all current NEO survey facilities. They are apparently faint, with orbits characterized by large semimajor axis and higher eccentricity; these "hardest-to-find" objects tend to elude the search volume of existing NEO survey facilities. Our simulation suggests that 15% of undetectable objects are Atens and Inner Earth Objects. Because of their orbital characteristics, they will remain within ±45° from the Sun, thus cannot be discovered in the forthcoming decade if our effort is limited to current ground-based telescopes [4].

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