Infrared near-Earth-object survey modeling for observatories interior to the Earth's orbit

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The search for and dynamical characterization of the near-Earth population of objects (NEOs) has been a busy topic for surveys for many years. Most of the work thus far has been from ground-based optical surveys such as the Catalina Sky Survey and LINEAR. These surveys have essentially reached a complete inventory of objects down to 1 km diameter and have shown that the known objects do not pose any significant impact threat. Smaller objects are correspondingly smaller threats but there are more of them and fewer of them have so far been discovered. The next generation of surveys is looking to extend their reach down to much smaller sizes. From an impact risk perspective, those objects as small as 30–40 m are still of interest (similar in size to the Tunguska bolide). Smaller objects than this are largely of interest from a space resource or in-situ analysis efforts.

A recent mission concept promoted by the B612 Foundation and Ball Aerospace calls for an infrared survey telescope in a Venus-like orbit, known as the Sentinel Mission. This wide-field facility has been designed to complete the inventory down to a 140 m diameter while also providing substantial constraints on the NEO population down to a Tunguska-sized object. I have been working to develop a suite of tools to provide survey modeling for this class of survey telescope. The purpose of the tool is to uncover hidden complexities that govern mission design and operation while also working to quantitatively understand the orbit quality provided on its catalog of objects without additional followup assets. The baseline mission design calls for a 6.5 year survey lifetime.

This survey model is a statistically based tool for establishing completeness as a function of object size and survey duration. Effects modeled include the ability to adjust the field-of-regard (includes all pointing restrictions), field-of-view, focal plane array fill factor, and the observatory orbit. Consequences tracked include time-tagged detection times from which orbit quality can be derived and efficiency by dynamical class. The dominant noise term in the simulations comes from the noise in the background flux caused by thermal emission from zodiacal dust. The model used is sufficient for the study of reasonably low-inclination spacecraft orbits such as are being considered. Results to date are based on the 2002 Bottke NEA orbit-distribution model. The system can work with any orbit-distribution model and with any size-frequency distribution. This tool also serves to quantify the amount of data that will also be collected on main-belt objects by simply testing against the known catalog of bodies.

The orbit quality work clearly shows the benefit of a self-followup survey such as Sentinel. Most objects discovered will be seen in multiple observing epochs and the resulting orbits will preclude losing track of them for decades to come (or longer). All of the ephemeris calculations, including investigation of orbit determination quality, are done with the OpenOrb software package.

The presentation for this meeting will be based on results of modeling the Sentinel Mission and other similar variants. The focus will be on evaluating the survey completion for different dynamical classes as well as for different sized objects. Within the fidelity of such statistically-based models, the planned Sentinel observatory is well capable of a huge step forward in the efforts to build a complete catalog of all objects that could pose future harm to planet Earth.

Acknowledgements: Support for this work was provided by internal research funding from Southwest Research Institute.