KEY NEAR-EARTH OBJECT CHARACTERISTICS MEASUREMENTS FOR PLANETARY DEFENSE.

B. W. Barbee[1], B. Sarli[2], J. Lyzhoft[2], J. Nuth[2], L. Purves[2], R. Lewis[2], [1]NASA/Goddard Space Flight Center (GSFC), Code 595, 8800 Greenbelt Road, Greenbelt, MD, 20771, brent.w.barbee@nasa.gov, [2]NASA/GSFC

Introduction and Background: Near-Earth Objects (NEOs) are asteroids and comets whose orbital perihelion distance is <1.3 au. NEOs, therefore, have the potential to closely approach or impact our planet. Indeed, numerous small NEOs strike the Earth harmlessly on a regular basis; some of these, on the order of one to several meters in size, are sufficiently energetic to create detectable signatures when exploding without harmful consequences in the upper atmosphere. Progressively larger NEOs collide with Earth less frequently, but such impacts become increasingly consequential with NEO size and mass, up to events that may have severe local, regional, or even global consequences. Some such events have been directly observed in modern history (e.g., the Tunguska Event of 1908, and, more recently, the Chelyabinsk impact in February 2013), and evidence of more severe impacts are found in residual Earth impact craters and the fossil record (e.g., the regionally devastating Barringer Meteor crater impact of ~50,000 years ago, and the extinction-level Cretaceous-Paleogene impact of ~65M years ago).

NASA, other United States government agencies (including the Department of Energy (DOE) and the Federal Emergency Management Agency (FEMA), and other US government agencies), and other nations' government agencies, institutions, and organizations all around the world are engaged in the development of Planetary Defense capabilities, so as to provide for defense against future Earth impacts by hazardous NEOs.

One of the primary goals of Planetary Defense capability development efforts is the early detection and tracking of potentially hazardous NEOs that may be on Earth collision trajectories, thereby affording as much warning time as possible. The more warning time available in an Earth-impacting NEO scenario, the more time is available to learn about the threatening object via both remote observations and rapid response in situ spacecraft reconnaissance, and the more flexibility is available in selecting appropriate means of mitigating the threat posed by the NEO.

In this talk we will discuss the key characteristics of NEOs to be measured via reconnaissance efforts during a potentially hazardous NEO scenario. Time will always be of the essence in such a scenario, and efficient usage of reconnaissance resources and capabilities will be imperative. Thus, prioritization of NEO characteristics to be measured for Planetary Defense purposes is an important area of current research, per actions specified in the United States Near-Earth Object Preparedness Strategy and Action Plan. [1]

Uncertainties in key NEO properties, such as orbital state and mass, may be very large during the early stages of a potentially hazardous NEO scenario. Therefore, decisions regarding NEO reconnaissance and mitigation missions may have to be made while details of the potential threat remain uncertain. Fundamental limitations on the capabilities of remote observations (e.g., via ground-based telescopes and/or space-based telescopes very distant from the NEO) mean that in situ reconnaissance of the NEO via spacecraft may be the only means of reducing key NEO characteristics uncertainties sufficiently in an adequately timely manner. Doing so would enable NEO threat mitigation to be carried out more effectively and reliably.

At a high level, the current notional prioritization of NEO characteristics to measure for Planetary Defense purposes is (in decreasing order of notional priority): Precise orbit; mass; binarity; shape (with mass, bulk density can be solved for); strength; internal structure (including porosity); mineral composition; and detailed surface topology.

In addition to informing reconnaissance and mitigation mission planning, NEO characteristics knowledge is required for modeling of potential NEO impact consequences on Earth, as well as planning for civil defense and other emergency/disaster response measures.

While more data about an NEO can be gathered via a rendezvous spacecraft reconnaissance mission than a flyby spacecraft reconnaissance mission, flyby missions may be more responsive because flyby mission launch opportunities are generally more plentiful in a given hazardous NEO scenario, and can often reach the NEO more quickly after launch. Thus, we are motivated to learn the capabilities and limitations of flyby missions for rapid response NEO reconnaissance to inform Planetary Defense efforts, and this is also an area of current research that will be discussed.

Finally, we will discuss the types of sensor systems necessary for effective NEO reconnaissance, what sensor technologies may be prioritized for development for Planetary Defense purposes, what trades and sensitivity studies are being planned to answer the research questions under consideration, how NEO characteristics measurement requirements and prioritization may change as a function of the fundamental nature of the potentially hazardous NEO scenario at hand (e.g., the requirements and priorities for reconnaissance of an incoming asteroid in a relatively Earth-like orbit might differ from the requirements and priorities for reconnaissance of an incoming hyperbolic comet), and how new developments in the area of risk-informed Planetary Defense mission design processes and analyses may affect the prioritization of NEO characteristics measurements.

References: [1] National Science and Technology Council, *National Near-Earth Object Preparedness Strategy and Action Plan*, www.whitehouse.gov (2018)