PDC2015
Frascati, Roma, Italy

☐ **Planetary Defense – Recent Progress & Plans**
☐ **NEO Discovery**
☒ **NEO Characterization**
☐ **Mitigation Techniques & Missions**
☐ **Impact Effects that Inform Warning, Mitigation & Costs**
☐ **Consequence Management & Education**

IAA-PDC-15-P-18

ASTEROID SURFACE GRAVIMETRY FOR CHARACTERIZING ASTEROID MASS AND INTERNAL STRUCTURE

Kieran A. Carroll[1], Henry Spencer[2], and Robert E. Zee[2]
[1]*Gedex Inc., 407 Matheson Blvd. East, Mississauga, Ontario, Canada L4Z 2H2, +1-289-374-3347,*
[2]*Space Flight Laboratory, University of Toronto Institute for Aerospace Studies*

Keywords: *Asteroid, mass, density, surface, gravimetry*

ABSTRACT

Surface gravimetry is a standard terrestrial geophysics exploration technique. As nothing blocks gravity, this approach can detect subsurface structures with contrasting densities, both shallow and deep. In principle this technique can be used on any planetary body's surface, to probe the subsurface structure, and to date it has been used once off-Earth --- Apollo 17 carried the Lunar Traverse Gravimeter to the Moon's surface, where it was used to conduct a 10 km traverse survey.

This technique could be useful in characterizing asteroids as well. In the simplest form of characterization, a gravimeter on an asteroid's surface can, by measuring the local gravitational acceleration, effectively "weigh" the asteroid, i.e., determine the asteroid's mass. For the smaller asteroids (which are also the most numerous), say of size less than a few tens of metres, this appears to be the *only* feasible technique for determining total mass. Accomplishing this only requires landing a suitable gravimeter on an asteroid at a known location, and making a single measurement. Of course, knowledge of an asteroid's mass, and hence its density, is important in making plans to mitigate impact risk.

If such a gravimeter is carried by a more capable lander, one which is capable of moving around the asteroid's surface, then more sophisticated physical characterization can be carried out, by conducting a gravimetric survey --- making measurements at multiple locations. From this, the asteroid's internal density distribution can be estimated; that in turn can say much about the asteroid's internal structure and composition, things which cannot be determined by purely remote-sensing means. These could, for example, help determine the asteroid's response to attempts to deflect it, i.e., whether it is likely to hold together or to fragment.

Accomplishing this requires a suitable gravimeter. An important functional requirement is that the gravimeter be able to operate properly in an asteroid's gravity field, which is to say with a local gravitational acceleration as low as 1 microG, and likely less than 100 microG. The main performance requirement is to make measurements accurately enough for the intended purpose. For the simple asteroid-weighing application, this calls for an accuracy of perhaps 100 nanoG. For the more-sophisticated asteroid surface surveying application, a repeatability of better than 10 nanoG is likely required.

Until recently, there was no gravimeter available that could meet these requirements; while the best terrestrial gravimeters meet the performance requirement, they only function in a 1 G environment, and all commercial accelerometers have absolute accuracy of much worse than 1 microG, due to bias-drift effects. Gedex is developing a new gravimeter, dubbed the Vector Gravimeter for Asteroids (VEGA), intended to meet these requirements. That instrument will be described --- its basic parameters being a size of 10x10x15 cm, a mass of 1.5 kg, and 1-10 nanoG accuracy in measuring the complete gravity vector (magnitude and direction), with no need for leveling.

This paper will also describe a 15 kg asteroid lander/rover (GRavitational Asteroid Surface Probe, or GRASP) for which Gedex and the Space Flight Laboratory at the University of Toronto have developed a preliminary design, which provides a platform suitable for carrying a VEGA gravimeter to an asteroid's surface, and roving about the asteroid's surface to conduct a gravimetric survey. This spacecraft's design is based on SFL's extensive heritage in developing many of the world's high-capability low-cost nanosat missions.