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ASIME 2016 White Paper: Answers to Questions from the Asteroid Miners

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Abstract

The aim of the Asteroid Science Intersections with In-Space Mine Engineering (ASIME) 2016 conference on September 21-22, 2016 in Luxembourg City was to provide an environment for the detailed discussion of the specific properties of asteroids, with the engineering needs of space missions that utilise asteroids. The ASIME 2016 Conference produced a layered record of discussions from the asteroid scientists and the asteroid miners to understand each other's key concerns and to address key scientific questions from the asteroid mining companies: Planetary Resources, Deep Space Industries and TransAstra. These Questions were the focus of the two-day conference, were addressed by scientists inside and outside of the ASIME 2016 Conference and are the focus of this White Paper.

The Questions from the asteroid mining companies have been sorted into the three asteroid science themes: 1) survey, 2) surface and 3) subsurface and 4) Other. The answers to those Questions have been provided by the scientists with their conference presentations or edited directly into an early open-access collaborative Google document (August 2016-October 2016), or inserted by A. Graps using additional reference materials. During the ASIME 2016 last two-hours, the scientists turned the Questions from the Asteroid Miners around by presenting their own key concerns: Questions from the Asteroid Scientists. The Questions and Answers form this field's first major reference document. These answers in this White Paper point to the Science Knowledge Gaps (SKGs) for advancing the asteroid in-space resource utilisation domain. The SKGs follow.

The thirty ASIME 2016 contributors to this White Paper are: JL Galache, Amara L. Graps (lead author), Philippe Blondel, Grant Bonin, Daniel Britt, Simone Centuori, Marco Delbo, Line Drube, Rene Duffard, Martin Elvis, Daniel Faber, Elizabeth Frank, Simon F. Green, Jan Thimo Grundmann, Henry Hsieh, Akos Kereszturi, Pauli Laine, Anny-Chantal Levasseur-Regourd, Philipp Maier, Philip Metzger, Patrick Michel, Migo Mueller, Thomas Mueller, Naomi Murdoch, Alex Parker, Petr Pravec, Vishnu Reddy, Joel Sercel, Andy Rivkin, Colin Snodgrass, and Paolo Tanga.

The White Paper can be found at: **https://arxiv.org/abs/1612.00709**

Science Knowledge Gaps for Advancing the Asteroid In-space Resource Utilisation Domain

1. **More studies are needed to map the classification of meteorites to asteroids. Presently the best-established link is between ordinary chondrites and S-type asteroids.** We need more useful published literature about the bulk composition of meteorites to help make more accurate simulants. **We need to understand the meteorite links to C-type asteroids.**

2. **Dedicated NEA discovery and follow-up instrumentation.** The best observability conditions for a given NEA are typically offered around the discovery time (brightest). Need to run observations to characterize NEAs quickly after discovery; best possible with dedicated telescope(s). What is needed: A photometric telescope of a 2-3m class (to reach V $\approx$ 21 with good S/N) available on short notice (for that the observations can be best taken right after discovery). To characterize one NEA, with full IR/vis spectral characterizations, but with 'proxies' or short-cuts to 'each NEO'.

3. **An understanding of granular material dynamics in low-gravity.** Before being sure that

we have a robust understanding of the asteroid regolith and to seriously start some systematic material extraction / utilisation programs, we must understand how this regolith with its properties responds to the envisage action, i.e. to understand granular material dynamics in low-gravity. Missions like AIM, Hayabusa 2 and OSIRIS-REx can help.

4. **Identifying the available low-delta-v (which are the objects with orbits similar to the Earth) targets are key.** What is needed is a map of low delta-v, low synodic period and low-albedo NEOs as a a first-cut to fine-tune the target possibilities.

5. **Determine if a NEO's dynamically predicted source regions is consistent with its actual physical characterisations.** Knowing the asteroid's source region, and hence, its orbital family characteristics, can enable a short-cut to characterize the small NEOs of that family which are difficult to measure spectroscopically.

6. **For making useful asteroid regolith simulants, immediate needs are: adequate data on the particle sizing of asteroid regolith and sub-asteroid- regolith surface. How does the asteroid regolith vary with depth?** If the NEOs have structure like comet nucleus 67P, then the NEO regolith is denser then the deep interior.

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