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Author: Dr. Craig Lindley
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Dr. Charlotte Sennersten
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

AN ASTEROID RESOURCE MODELLING METHODOLOGY FOR UTILISATION PLANNING

Abstract

The research described in this paper is developing and demonstrating an Asteroid Resource Modelling methodology that can drive mining and utilisation planning for individual asteroids. This is analogous to the use of resource block models in terrestrial mining to drive short, medium and long term mine planning.

Terrestrial resource block models are three dimensional Euclidean models of a mineral deposit, voxellised into shape units with associated attributes such as metal grades and density that provide the foundations for economic and operational planning of mining activity. The methods used for terrestrial resource modelling must be heavily adapted to take into account key differences between asteroid and terrestrial ore deposits.

Mining asteroids requires different coordinate systems (e.g. ellipsoidal rather that Euclidean), and many attributes in addition to those included in Earth-based block models. For individual asteroid resource shapes (or blocks), these attributes include: local gravitational forces, rotational acceleration and inertia, rotation rates and distances from possibly multiple rotation axes, vectors to the centre of gravity of the body, specific heat, thermal conductivity, heat flux, inferred particle size distribution, particle cohesion, etc. (many of which may be changed due to mining or engineering operations). Metals within asteroids may show different isotopic compositions, the targets of mining interest may include non-metallic compounds and elements, and non-target materials are a critical factor in the selection and implementation of mining and processing technologies.

Major differences are also required in the methods used to infer the internal composition of an asteroid compared to a terrestrial ore deposit. Terrestrial resource models are primarily derived from datasets obtained by exploration drilling and drill core analysis. Prior to direct sampling, asteroid compositions are inferred from spectral and albedo studies, spin parameters, families/locations, and detailed analysis of orbital motions of smaller bodies (e.g. spacecraft or moons) around asteroids (as a basis for inferring mass and internal density distributions).

These factors, together with the position of the asteroid/mine in space and its full orbital elements, provide critical inputs to mission design and costing, which also need to be propagated to the calculations of costs associated with individual asteroid resource blocks, subdivided between intrinsic (dependent upon asteroid properties) and extrinsic (e.g. dependent upon access infrastructure) cost factors.

The Asteroid Resource Model has been implemented in a modelling, simulation and interactive 3D visualisation tool. Ongoing work will further refine the models and methodology, including more fully developed valuation functions for resource model elements.