Developing Standardized Terminology Reference Guidelines and Resource and Reserve Reporting Codes for the Space Resource Industry. S. Casanova[a]*, C. Espejel[bc]*, A.Dempster[d], R.C. Anderson[e], S. Saydam[a],[a] *School of Minerals and Energy Resource Engineering, UNSW Sydney, Sydney, Australia.* [b]*ispace Europe, Luxembourg, Luxembourg.* [c]*Faculty of Science, Technology and Communication (FSTC), The University of Luxembourg, Esch-sur-Alzette, Luxembourg.* [d] *Australian Centre for Space Engineering Research (ACSER), UNSW Sydney, Sydney, Australia.*[e] *Jet Propulsion Laboratory/California Institute of Technology, Pasadena CA, USA.* * Corresponding Authors: s.casanova@unsw.edu.au; c-espejel@ispace-inc.com

Introduction: Growing interest to expand current robotic and human activities on The Moon and eventually Mars, has resulted in a need to find low-cost solutions to meet the near-term and future resource demands of an emerging cis-lunar and Martian in-space economy. The extraction, production and sale of local resources from the Lunar and Martian surface and near earth asteroids has the potential to meet these demands but only when it is economically viable to do so. Endeavours of this kind, as is also seen in the terrestrial extractive industries, carry substantial financial risk, particularly in the early stages when a project has both large geological and development uncertainties. It is now becoming critically important, as the space resource industry advances, to develop the right processes and frameworks to evaluate and communicate uncertainties and risk in prospective projects, in order to encourage investment and reduce market uncertainty. The current absence of an agreed upon code for reporting resource and reserve estimates and established terminology standards to reference them, is prohibitive to clear communication and transparency. By undertaking a thoughtful approach, which takes into account the unique conditions in which these activities will take place, this study provides preliminary recommendations for terminology and practices governing the development of a space resource and reserve estimation code and discusses some of the challenges that will be faced in doing so. Establishing guidelines of this kind will enable effective communication between stakeholders and facilitate robust decision-making at all stages of investment, both in the present day and into the future as the industry matures.

Space Resource Industry Terminology: The space resource industry is an emerging industry and thus the establishment of a standard vernacular that is well defined and commonly used by industry participants is still being developed. At present language is typically adapted from the terrestrial extractive industries but the use and application of these terms in the space resource sector has typically been haphazard and inconsistent. The misapplication of terrestrial based terminology risks misrepresenting the likelihood of successful project outcomes leading to investor and stakeholder confusion. The adoption of terminology that has been developed for a terrestrial setting and market conditions is also at times insufficient or incapable of properly being adapted to the unique environment in which the space resource industry will operate. For example the terminology used to classify resources and reserves based on the geologic certainty and chance of commercial development is very well defined for the terrestrial mining and energy industries. However how these classifications may be applied when used to refer to mineral or volatile deposits of interest for extraction and use in space is at present unclear. In order for companies, governments and investors to make qualified decisions as to whether a proposed space resource extraction project is worth the investment, there is a requirement for an established means to communicate understanding of both the risks and uncertainties across the entire life of a project, in a way that is easily and clearly understood by all parties.

Developing a Space Resource and Reserves Codes of Practice: The absence of clear definitions is particularly impairing when it comes to discussions regarding resource and reserve estimation and classifiaction. On Earth, a variety of codes have evolved over time in response to local requirements for both energy and minerals resources (i.e. JORC [1], PRMS [2]). The terms resource and reserve have very specific meaning to the terrestrial extractive industries, although some differences are apparent between the different industries and codes, thus it is important to state which code is being used as the basis for company reporting. In general, resources are defined as either the known or unknown quantities of a commodity of interest. Reserves, are the subset of remaining resources (not already extracted or captured), that are both known and judged to be recoverable under the current economic and technological circumstances. Estimation of the quantity of resources and reserves is therefore determined by a combination of geological, technological, economic and socio-political factors. It is important to keep in mind that not all space resources will be extracted for commercial purposes. Resource and reserve estimates underpin most, if not all, of the management and business decisions that a mining company will face and are used to benchmark a company's performance, worth and outlook. Despite their importance establishing methods of estimating resources and reserves has remained largely ignored

in space resource studies. Without a framework to guide the above business processes evaluating the potential of a company to succeed is extremely difficult. It is, however not considered appropriate by the authors, to simply undertake a wholesale adoption of any one of the currently used terrestrial codes as these are not suitable for catering to the unique geological, technological, political, environmental, social conditions and uncertainties therein that will be faced by the space resource industry nor are they reflective of the current industry maturity. Like the terrestrial codes however the new space resource code should provide a tool for consistent reporting by industry participants, with clear resource management policies and evaluation standards. Thus it is recommended that major stakeholders in the space resource industry, with cross-disciplinary representation, come together to develop an endorsed industry resource estimation and classification code of practice. Important in this discussion is not only establishing guidelines for the geological, technological and economic components of resource and reserve reporting and classification but also consensus on industry standard behaviors and expectations, particularly in regards to the social and environmental license to operate. As we increase our usage of space it is important that we thoroughly consider and incorporate past learnings and ensure that policy is enacted early to protect vulnerable and valuable environments. This responsibility should be championed by the emerging space resource industry community, with input from stakeholders outside of the industry, in order to set clear expectations that can be upheld and monitored.

Off-Earth Business Processes, Investment Stages and Project Elements Terminology: In order to write a resource and reserve code of practice for the space resource industry there is also a requirement for agreement on common terminology that will be used as part of typical operations and activities. These may range from establishing criteria in how to refer to a mineral or volatile deposit of interest in a way that is reflective of our level of geological understanding, to referenceing of business processes and activities *i.e.* the supply chain and stages of the mining / production cycle. Developing these terms will require consideration of the geological environment as well as the likely techniques and technologies that will be employed to identify, evaluate, extract and sell the commodity of interest. In this study we make some key recommendations for terminology that will be useful in this regards.

Conclusion: This study takes a detailed look at the terminology used by the terrestrial extractive industries and terminology already in use by the space resource industry, identifies current deficiencies and seeks to provide new definitions as well as recommendations for where industry consensus is required. The need for an industry standard for space resource estimation and classification is now imminent given the current development plans. Establishing guidelines and frameworks for industry terminology is however only useful if the terms and the respective definitions are fit for purpose and commonly adopted and accepted by industry participants. It is expected that this terminology will continue to evolve as the industry matures and thus finding a common language will be an iterative process.

References:

1. Code, J., et al., *The JORC code and guidelines.* 2012.
2. Ross, J., *Guidelines for Application of the Petroleum Resources Management System.* 2011.