Chapter 7.5

Future of space commercialisation – Mining asteroid and celestial bodies

Michael Simpson

In many ways, the issues raised by space-based mining present an opportunity to look in microcosm at the main objectives explored at the Dawan Chair's 2013 conference on space commerce and central to this volume. It also presents an opportunity to test our emerging understanding of space commercialization against the backdrop of a capability which is at once hypothetical and increasingly attainable.

While the science surrounding space mining and resource recovery is generally worked out (we know the physics of rendezvous, descent, and homebound transportation), the engineering has a long way to go. Perhaps even farther away is a credible economic model that convinces both enthusiasts and sceptics that a reasonable return on investment could be expected in a financially tolerable timeframe.

Among the technological challenges to be overcome the following are important examples of problems yet to be worked out: identification of promising targets for exploitation, execution of mining operations in an environment where even large near-earth asteroids are small enough to have their orbits altered by contact with a visiting spacecraft, preparing extracted material for delivery to earth, and possibly even robotic processing of raw material in space to permit returning higher value cargoes. Perhaps even more interesting is the unsolved problem of whether raw material extracted from celestial bodies could be transformed in space into manufactured goods for use in space without ever having to be returned to Earth. The possibility of providing satellites with spare parts or mission-enhancing new components is certainly implicit in the plans emerging for accessing high value material such as platinum group metals from asteroids or the Moon.

To understand the magnitude of these challenges it is important to reflect on the nature of asteroids and the conditions in which they orbit the sun. Asteroids are not uniform objects. Some can be nearly solid masses of metal or rock while others can be loosely aggregated collections of boulders and dust commonly referred to as rubble piles. Determining the nature and composition of an asteroid is a process known as characterization. Our current level of skill in characterization is still in its infancy. Additionally many asteroids of potential interest commercially are too small to be easily spotted from Earth and thus will require the expensive development of space-based detection systems. From a commercial standpoint this may have a bright side however since such systems may be able to produce early cash-flows from the sale of

the data they generate to governments interested in tracking asteroids to ensure they pose no collision threat with the Earth.

The orbits of near earth asteroids also pose challenges since although they may coincide with that of Earth at regular intervals, it is not possible to compute that regularity without a significant number of observations of each object we wish to track. Even with those observations in hand it may be difficult to keep track of a detected object once it moves away from Earth and is subject to perturbations caused by the gravity of the sun or other planets. Furthermore, if you would like to try some sample calculations on your pocket calculator, consider that the Earth swings around the sun in an elliptical orbit at a speed of somewhat over 100,000 kilometres an hour while asteroids sharing or crossing our orbit describe their own ellipses and travel at speeds which are similar but different with orbital years that range from a close approximation of ours to ones that can be considerably longer or shorter. Lastly, estimates presented at the recent Planetary Defense Conference in Flagstaff, Arizona, USA, indicate that the estimated number of near earth objects in the size range of the one that exploded over the Russian city of Chelyabinsk in February 2013, may be as large as 9 million, of which we have identified less than 5%.

These challenges encompass their own legal issues as well. For example what is the legal liability of altering the orbit of an object orbiting the sun in close proximity or frequent resonance with the Earth? How does one obtain clearance to return an encapsulated mass of high value material like gold, platinum, or titanium to a landing spot on Earth under conditions where the backers of the project have reasonable hope of both avoiding devastating litigable damages and preserving a right to the economic return from selling the material? What are the reporting responsibilities under the Outer Space Treaty (OST) for "discoveries" of potentially high value asteroids and how can they be reconciled with the desire to guard such characterization as a business secret? All these legal problems are as real as the physical ones presented by orbital dynamics and the solutions are likely to require very substantial investment of time, talent, and money, but as we shall see later this may contribute to a window of opportunity propitious to the reconciliation of positions separating proponents of private space mining and those who argue that such activity is foreclosed by international treaties.

Nonetheless, pending such a reconciliation of views, the enormous volume of material passing within range of Earth has provided a sufficiently tempting target for at least two companies to have incorporated with the express intent of gathering some of it profitably. Planetary Resources, Inc. announced in April 2012 that although it has several other, short term objectives, its long term objective is to mine near earth objects potentially rich in minerals with high value to weight ratios. More recently Deep Space Industries has announced its own ambitions to quarry space based material for uses both on Earth and beyond.

Not surprisingly these announcements have provided considerable energy to the long simmering debate in legal circles concerning the right, if any, to own, process, distribute and

profit from mineral resources extracted from celestial bodies. A survey of the legal literature can show that "well qualified publicists" to use the descriptor from the Statute of the International Court of Justice (ICJ) can differ widely in their opinions on this matter. In this context and in the absence of any international case law on the matter, we are forced to conclude that however lucid their arguments may be, the absolute declarations of publicists about the legal status of extracted material cannot constitute a definitive answer to the critical question: "who owns it?'

This question is central, however, to the way we address the issue of whether this aspect of commercialization will benefit all countries and peoples irrespective of their degree of economic or scientific development. If as some would argue, all space objects and their value are the common heritage of humankind, all peoples would somehow benefit from any material of value extracted from space and returned to earth. This would be the case irrespective of their contribution of time, talent, and/or treasure to the process of making it available to the market. On the other hand, if every source of extra-terrestrial material were exploitable on a first come, first served basis, it is possible that benefit would flow only to those sufficiently wealthy or sufficiently well-endowed technologically to overcome the many obstacles to extracting it and returning it to market.

Recognizing that there is a lot of middle ground between these extremes, it is worth our while to review the bases for the arguments and then discuss some possible scenarios that could lead to reasonably broad resource sharing. The first step in that direction passes through a review of some of the legal issues involved. Since issues of space law are matters of human invention, they have the distinct advantage of being more malleable than the laws of matter and orbital dynamics.

Central to both extremes of opinion related to property rights in extracted material is interpretation of two of the five space law treaties that have been drafted since 1967. The OST is by far the more widely ratified of the two agreements. Arguments referring to it rely heavily on its absolute ban on the extension of national sovereignty over any "celestial body," its prohibition of "appropriation," and its reference to the right to use outer space for peaceful purposes. The second oft-cited document is the Lunar Treaty or formally, "The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies." Of special importance to the debate is the declaration in Article 11, section 1 of this latter agreement, that the "The Moon is the common heritage of mankind." Later, in section 5 of this same article, the Lunar Treaty also calls for negotiations leading to the creation of a legal regime that can administer issues related to property rights and distribution of wealth under the treaty's terms. These elements form the foundation for most arguments concerning ownership and beneficial interest in material extracted from celestial bodies and are worth reviewing quickly.

There is broad agreement that the ban on extending national sovereignty to celestial bodies is hard law. Unlike Antarctica where claims of sovereignty are suspended not revoked, no state has sought to claim any celestial object or part thereof as national territory.

Remembering the uncertainty surrounding the race to the moon in the 1960's, the United States and the then Soviet Union had great incentive to ensure that their risks were minimized in the event that their rival got to the moon first. Although some international concern was expressed over the US decision to plant flags at the six lunar bases they established during the Apollo era, no claim of sovereignty from this symbolism ever emerged from the US authorities. Ironically, the success of this aspect of the OST complicates the question of ownership of extracted material since in the absence of a sovereign to assign title, no other authority exists to fill the vacuum.

This results in a situation similar to that confronted by many British pioneers in the early North American frontier where, through the Proclamation of 1763, the Crown had specifically prohibited British settlement beyond the Appalachian Mountains and denied any rights of settlement or private land ownership there. The response was for local self-organization around a number of strategies including the principle of "Tomahawk Rights," where a pioneer would mark off a territory no larger than could be exploited by his family with the full expectation that other pioneers would respect it. In an environment where resources appeared infinite and the greatest economic value was extractive, primarily through logging, trapping, and hunting, this system worked fine until more traditional sovereign control was established through the Northwest Ordinance after the American Revolution.

The difference between this situation and that confronted by those modern entrepreneurs who would like to exploit material extracted from celestial bodies is that international conventions exist that specifically deny states the option of ever establishing sovereign control. The lesson for those same entrepreneurs is that traditional land title or publicly certified mineral rights is not necessarily a requirement for successful and profitable development of material with economic value.

Although the ban on sovereign claims to celestial bodies may thus not be an unavoidable barrier to profitable mining operations in space, it remains to be seen whether the ban on "appropriation" presents a more difficult problem. Here one can hear a wide range of views from a clearly discordant pool of legal minds. On one side of the argument is the assertion that "appropriation" refers to any taking of a property right in a celestial body whether by a government or by a private party. On the other is the more limited understanding that states and their citizens, corporate and natural, are only prohibited from appropriating to themselves an exclusive right to a celestial body. This perspective which is very much in line with the "Tomahawk Rights" idea would assert that extracting material from a site where you make no permanent, legally enforceable claim is in fact not in violation of any widely adopted international convention. To those who argue that the extraction of material with the intent to exploit it economically is inevitably a prohibited seizure of title, those who disagree point to the fact that space based material has now been repatriated in the form of moon rocks by both Russia and the United States without there having been any successful challenge to the property rights of those two states in that lunar material. Suffice it to say that counterarguments to this point also exist.

Lastly, the Moon Treaty would seem to present the greatest obstacle to space based mining. Its unambiguous declaration that "The Moon and its natural resources are the common heritage of mankind" is strong enough to give encouragement to those who oppose exploiting off-Earth resources on any basis not providing for international control and equitable distribution

of the proceeds, but the encouragement becomes even stronger with the opening language of the treaty's Article 11, paragraph 3:

> Neither the surface nor the subsurface of the Moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity or of any natural person.

Although this would seem to only complicate plans to mine the moon, Article 1, paragraph 1, of the treaty makes it clear that the text applies far more broadly, at least 14 billion light years more broadly in fact:

> The provisions of this Agreement relating to the Moon shall also apply to other celestial bodies within the solar system, other than the Earth, except insofar as specific legal norms enter into force with respect to any of these celestial bodies.

Although this would seem to bring any hope for legally exploiting a space mining enterprise to a dead stop, the Moon Treaty has a substantial weakness for those who would seek to make it the foundation for preventing those advocating the mining of celestial bodies from proceeding with their objectives: it has a very small number of ratifications and signatures. Furthermore among those states with even the slightest chance of being able to actually support a space mining operation in the foreseeable future with technology under their control only India and France have signed it. The signatures of China, Japan, Russia, and the United States are notably absent. Although some Moon Treaty advocates bravely attempt to argue that the document's text represents a statement of general principles of law and thus represents one of the sources of law recognized in the Statute of the ICJ it is difficult to assert a general principle when most of the world's countries have not accepted an opportunity to endorse it in the nearly thirty-five years since the Moon treaty was first open for signature. Even worse for those who would use the Moon Treaty as proof that space mining is prohibited, the fact that so many countries have not signed it may well serve as evidence that the customary practice of states (another of the sources of international law enumerated in the ICJ Statute) does not resonate with key provisions within it.

This is not to say that those who have not signed are necessarily opposed to the "common heritage" language. After all, many of these same states willingly accepted that language in the legal regime covering the mining of the deep sea bed (with the notable exception of the USA). A major component of the resistance to this treaty is centered on reluctance to impose a concept of international control over access to the economic value of celestial bodies without having a mechanism or regime in place that could legitimately exercise that control. Although the Moon Treaty provides in Article 11, Section 5 for the creation of such a regime, it has never been established:

> States Parties to this Agreement hereby undertake to establish an international regime, including appropriate procedures, to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible. This provision shall be implemented in accordance with article 18 of this Agreement.

So, as we try to reconcile the current legal regime with the ethical goal of ensuring a well-reasoned equilibrium between the rights of entrepreneurs to bring needed material to market at an attractive return and the right of peoples pursuing basic economic development to not be left out of the benefits of a 21st Century "gold rush" what key conclusions can we draw from the legal arguments surrounding the mining of celestial bodies? The most important conclusion is that no position along the whole continuum from the most extreme to the most accommodating has been able to create a clear and conclusive case for its position. The question that we posed early in this chapter, "Who owns material extracted from celestial bodies?" remains without any answer capable of sustaining a consensus.

And therein lays a great opportunity.

As technology permitting mining operations that the Moon Treaty itself pointed out are "about to become feasible" advances, so, too, does the day when unilateral decisions by states to authorize launches in support of missions, even private missions, in quest of mineral wealth. This is clearly a day that many people who hope that off Earth resources might help to relieve on-Earth poverty would like to avoid. At the same time, many entrepreneurs dream of high return investments in obtaining resources beyond Earth for which looming shortages are already creating concern on our planet. Those people confront uncertainty and ambiguity over questions of title, mineral rights and even rights of departure (since countries have not been clear about how they would react to requests for launch permits connected with mining missions.) Such ambiguity makes it nearly impossible to raise the venture capital that will ultimately be required for private efforts to exploit off-Earth resources profitably. Of course, in a world where very wealthy people are often captivated by the allure of very large and audacious projects, "nearly impossible" is not necessarily the equivalent of actually impossible.

In this context both those who want a distributive regime that relieves poverty and those who want a permissive regime where the right to private profit even under the condition of legally imposed duties, responsibilities, and obligations would both seem to have a shared interest in pursuing the legal regime provided for by Article 11, Section 5 of the Moon Treaty. To pursue such a regime does not require acquiescence to the Treaty itself although if carefully crafted it might eliminate substantial opposition to it. Even more importantly, in what currently appears to be a treaty-averse political climate in the United States and elsewhere, a 'regime" to govern the exploitation of off-Earth resources does not even need to be rooted in a treaty.

Through the adoption and coordination of national law, states could establish the conditions under which they would raise no objection to the importation and commercialization of materials acquired on celestial bodies or of products containing them. Under such a regime of coordinated law, enterprises seeking to undertake off-Earth mining operations would know the conditions under which they could gain access to markets and around which they could build business plans.

For the rest of us, we would be able to know that the possibility of continuing to move beyond the Malthusian despair that always lurks in scarcity could be extended to future generations. At the same time we would be able to seize the opportunity for a more equitable and hopeful pathway to development for those who are still not fully integrated into the post Malthusian era.