

ANTICIPATE

Utilizing Space Resources for Collective Prosperity

Abstract

The minerals locked up in the most valuable asteroid in our solar system are worth \$15 quintillion, according to estimates from startup [Planetary Resources](#). The number should be taken with a grain of salt, but even if it's off by several orders of magnitude, the sum would still be colossal. The ability to mine these minerals is at least 25 years away and the economic benefits still uncertain, but their scale demonstrates the enormous opportunities lying beyond Earth's atmosphere. Taking advantage of this abundance is beyond any one country or industry and will require renewed multilateralism to ensure the global commons of space benefits all of humanity. Setting the stage for a new, collaborative approach to using space resources will also have nearer-term impacts as we expand our use of low-Earth orbit and prepare to go to the Moon.

- What is the potential scale of space resources, and will we be able to exploit them?
- Will/Should space resources boost development on Earth or fuel off-world expansion?
- What rights should countries have to own or exploit resources beyond Earth's orbit?

Participants

Moderated by:

Adriana Marais, Director, Foundation for Space Development Africa; Member, South African Government Ministerial Task Team on the fourth Industrial Revolution; Faculty, Singularity University and Duke Corporate Education, South Africa

With:

Niklas Hedman, Chief of Committee, Policy and Legal Affairs Section, UNOOSA, Sweden (*remotely*)

Mathias Link, Director, European Space Resources Innovation Centre (ESRIC); Director, International Affairs and Space Resources, Luxembourg Space Agency, Luxembourg

Tanja Masson-Zwaan, Assistant Professor and Deputy Director, International Institute of Air and Space Law, Leiden University; President Emerita, International Institute of Space Law, The Netherlands (*remotely*)

Su Meng, Founder, Origin Space Corp., China (*remotely*)

Patrick Michel, Senior Researcher, CNRS (Observatoire de la Côte d'Azur), Team Leader, TOP (Théories et Observations en Planétologie), France

Highlights

The commercial era of space tourism is upon us – though limited mainly to billionaires and other well-heeled adventurers for the time being – and it is by no means the only business pursuit that governments and entrepreneurs such as Jeff Bezos, Richard Branson and Elon Musk are chasing in the vast regions just beyond Earth's atmosphere. Already, nations and companies alike are seeking profits, strategic advantages, and glory in the realms of global communications, planetary observations, space exploration, and prospective mining. A poll at the start of this session showed that, by a four-to-one margin, attendees believed the pursuit of minerals and other space resources is worthwhile, but that it should primarily benefit people on Earth, not any off-world expansion.

As astronauts delve ever deeper into the universe, however, Mathias Link emphasized that the most important and immediate benefits of the gases, water and metals that could be found in space would be the life support they offer, in terms of refuelling satellites and rockets, or providing raw materials for homes and antennae in spatial environments. Moreover, the costs of bringing space minerals to Earth are prohibitive: as much as \$115 million per kilogram, by some estimates. "It's more important to use these resources in space," said Link, an expert in space resources, who was astonished at how fast the topic had become relevant. Only months earlier, NASA's extraction of oxygen on Mars marked the first use of space resources on that planet. "Five years ago, this was a very niche topic."

Another concrete example came from Su Meng, founder of Shenzhen-based Origin Space. His company's long-term goal is to discover and use metals and water mined from near asteroids for space industry expansion. Origin Space is China's first space mining startup, and in the past couple of years it has developed and launched into low-Earth orbit several satellites and a prototype robot spacecraft that is being tested for asteroid mining and space debris removal. The two activities are closely linked. The technology to catch debris in space could be put to use scooping up minerals from asteroids, which is "way more difficult", said Patrick Michel, an asteroid expert. That is because asteroids behave in a way that "is totally counterintuitive, making it very difficult to touch them, even more land on them", he explained, citing two recent missions to study asteroids. "The images that they sent back showed us that all our initial assumptions were wrong about their surface composition, their low gravity." There are still more pressing reasons to study space debris removal and asteroids, Adriana Marais, who heads an organization that aims to send Africa's first mission to the Moon, contended: debris collisions can damage communications; asteroid collisions caused mass species extinctions. Since the first Sputnik

satellite was launched in 1957, she noted, more than 7,000 satellites have been put into orbit, a space increasingly crowded.

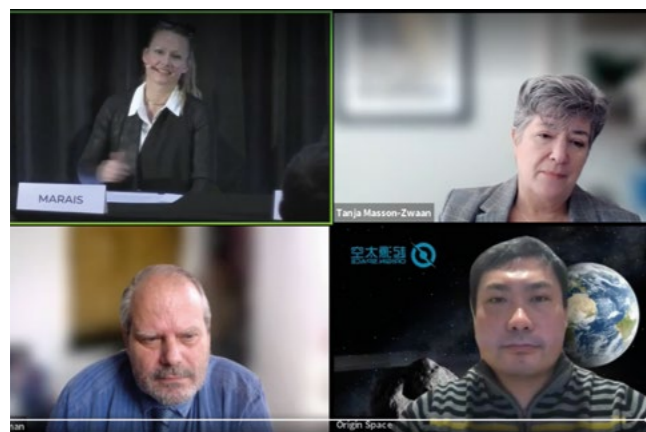
Just how those asteroids studies are carried out, and who has the capacity to undertake them, remains "a big question" because of the high costs and technical risks involved, according to Meng. "I don't think anybody has a real solution," he said. To that end, academic institutions should team up more with businesses like Meng's that are more willing to take the risks that go along with space exploration, said Michel, a longtime contributor and leader for research projects and space missions about asteroid science and defence. "Observations about asteroids from Earth provide very little data about their potential uses for mining. But we have the chance to have publicly funded missions ([DART](#) and [Lucy](#), for example) now launching to asteroids to feed us with more data," he said. "And while scientists gain this expertise, it is important that the academy work with the private industry, such as Origin Space, because they have more courage to take the necessary risks."

Beyond the technical and financial risks, commercial challenges to space exploration extend to a complex web of legal and regulatory hurdles, including some yet unforeseen. "Business models still have to be sharply developed on markets that we see coming, but which don't yet exist," said Link. "Step by step, we are showing that this field is growing. Investors no longer views space resources as science fiction. It's going to happen; now it's just a matter of how," said Meng, who was optimistic that much could be accomplished in the next five years.



During the last decade, a growing number of nations and businesses have shown interest in space resources. China, Europe, Japan, Russia and the United States all have concrete plans to establish outposts on the Moon. Since its founding with 14 space agencies in 2006, the [International Space Exploration Coordination Group \(ISECG\)](#) has grown to include 26 members that agree to coordinate their mutual efforts at space exploration for the next decade. But only a few years ago did it

include space resources as part of the architecture of further space missions. That approach was mirrored in this session's initial poll, which found that respondents, by a margin of 87% to 13%, favoured using a multilateral framework rather than a liberal approach to the thorny issues surrounding the governance of space resources. "We are dealing here with novel activities that will be taken on outside of national jurisdiction, and there it becomes a matter of governance," said Niklas Hedman, one of the UN's top experts on space policy. In the game come the geopolitical interests from governments, the growing interests of the commercial sector and, lastly, the interests of the scientific community.



Just two UN-brokered treaties, he said, explicitly deal with the use of space resources: the 1967 Outer Space Treaty, which is legally binding among 111 nations and forbids the use of nuclear arms and any claims of sovereignty in space; and the 1984 Moon Agreement, which is legally binding but only among 18 nations. The Outer Space Treaty's fundamental provision is Article 1, Hedman emphasized, which states that all "exploration and use of outer space, including the Moon, and other celestial bodies, shall be carried out for the benefit and interest of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind". However, policymakers face challenges trying to apply Earth-bound rules to "extraterritorial" space resources, he said, and it was "interesting to note" that the legal subcommittee of the Committee on the Peaceful Uses of Outer Space (COPUOS) set up a working group this year to tackle this issue. So far, the 95-member committee has adopted its terms of reference and work methods for a five-year plan on how to approach the exploration and utilization of space resources. "That such issues are dealt with at the UN level is a major step to show that they now need to be discussed widely," Link said. "And it shows that in the long term, we will need to have a framework to organize [these discussions] on the international level."

Several principles should guide the use of space resources, said Tanja Masson-Zwaan, a leading space law researcher and arbitrator for space-related disputes, who called this topic "a difficult,

new endeavour for humankind" that will require lawyers to frame the issues and potential pitfalls for scientists and engineers. "So far there have not been any major disputes in space exploration, and that is, I think, a tribute to humankind, which realized that cooperation is the way forward," she said. "Definitely, this is an area where there is room for potential disputes, because here we are talking about commercial interests. There is a major difference with the exploration era we knew over the last 50 years." Most important, Masson-Zwaan said it is important to clarify areas that were "not clearly addressed in the current founding treaties" on space, such as any lack of guidelines for dealing with waste on the Moon. Among the most prominent areas in need of clarification, according to Masson-Zwaan, would be the installation of safety zones around resource extraction areas; creation of priority rights so investing companies' interests are protected; assurances that space exploration is done for all humanity, not just wealthier countries; and environmental protection measures.

For Masson-Zwaan, the use of "adaptive governance" would help avoid conflicts by regulating what is feasible now and in the near future, not on a long-term basis. Making that work would require the involvement of private entities and stakeholders not represented by UN bodies. Two groups of nations have been competing to establish lunar outposts, she noted, but over the next decade "we can work towards a strong regulatory framework to set 'common standards' for the benefit of all humankind". It is a very fast-moving area, in terms of governance and regulatory aspects, Hedman said. "It's only in a couple of years, only maybe five years, that we have on the table kind of a really good collection of already-formed building blocks and basis for further discussion," he said. The talks will extend to science and technology, not just legal issues. "This step-by-step approach actually applies to all the challenges in the field," Michel said. "In order to solve these regulatory issues, we also need to see very practically on the ground [of celestial bodies] what it actually means."

Takeaway Messages

Interest is widely growing among nations and private companies towards the identification, extraction and use of space resources.

More knowledge about asteroids is needed that goes beyond Earth observations and can only be gained through space missions. Academic institutions and space agencies are developing such missions.

Companies are willing to take on risks that space agencies prefer to avoid in the space exploration race, but the business model behind that risk-taking has yet to be fully developed.

In addition to UN discussions about the regulation of space resources, another forum at the international level is needed to encompass private sector-related issues such as extraction safety zones, environmental protection measures and mining priority rights.

In this fast-moving field, a step-by-step system of 'adaptive governance' is the best way to approach technological, financial and regulatory issues.

Equitable access to resources and technology, and efforts to broaden the involvement of developing nations, are important questions without clear answers.

Potential conflicts exist between the use of space resources for Earth or for further space exploration.

More information

[Session recording on YouTube](#)

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