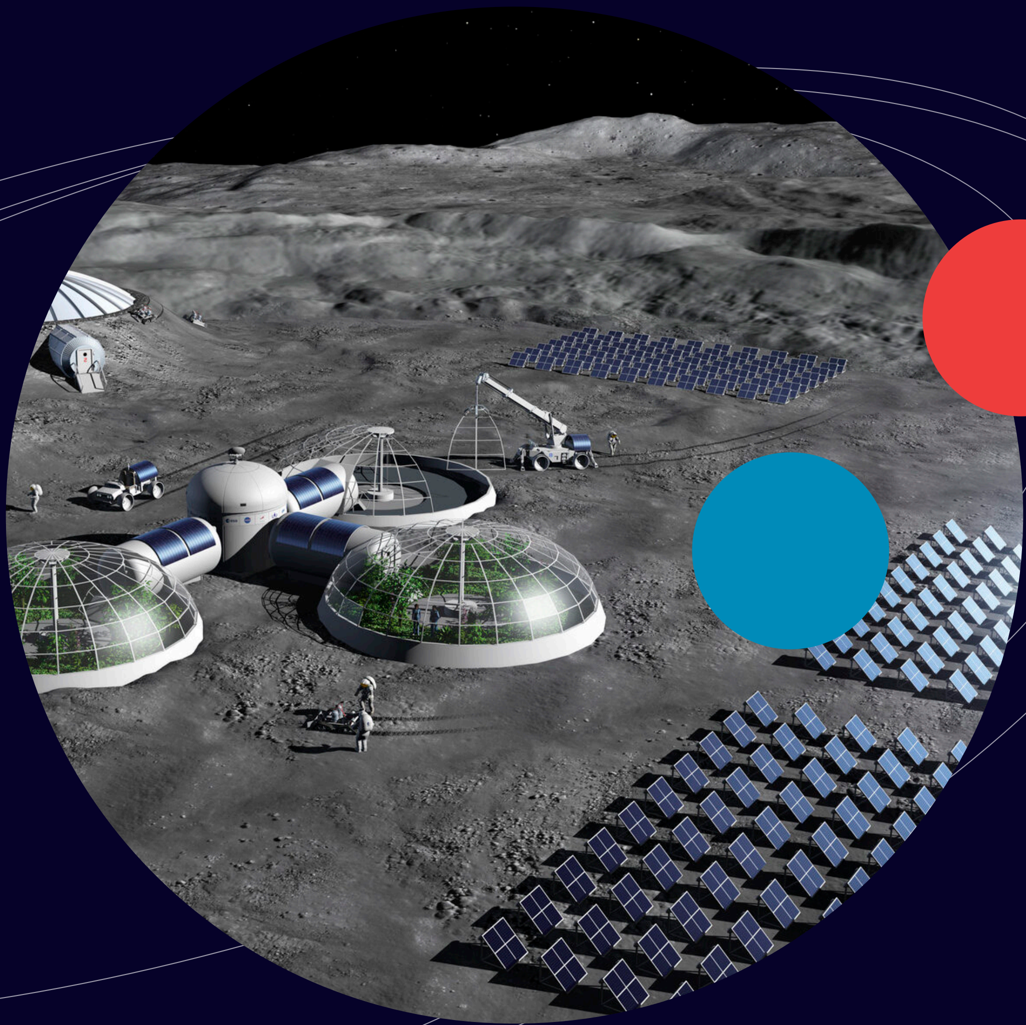

White paper

Space Resources Week 2021
Luxembourg
19-22 April 2021

www.esric.lu

powered by LSA, ESA & LIST

SPACE RESOURCES WEEK 2021: OUTCOME AND LESSONS LEARNT

A. Meurisse[1], J. Mousel[2*], A. Kapoglou[1], D. Matuleviciute[2], M. Conti[1], R. Cossu, A. Makaya[1], A. Cowley[1], J. Carpenter[1], P. Michel[3], M. Link[2,4*], and B. Hufenbach[1],

[1]European Space Agency, Noordwijk, The Netherlands.
[2]Luxembourg Space Agency, Luxembourg.
[3]CNRS/Observatoire de la Côte d'Azur, Nice, France.
[4]European Space Resources Innovation Center, Luxembourg.

*Corresponding email: contact@esric.lu

1. Introduction

Europe's interest in space resources is growing. Over the last 5 years, an outstanding increase and diversification of the European space resources community was noticed through different workshops and events organised by the European Space Agency (ESA) [1] and the Luxembourg Space Agency (LSA) [2-4]. Joining forces, ESA and LSA organised the first Space Resources Week in 2019 in Luxembourg, which has been at the forefront in Europe to enable commercial space resources activity and develop a legal framework. This event gathered the broad international space resources community: after two days of professional lectures on space resources, over 350 professionals from the space sector, mining sector, oil and gas industry, academia, law and regulation, education, and finance exposed their visions of the field during a workshop. Presentations covered the state-of-the-art and latest findings on the economics and financing, but also the value chain of space resources, from prospecting and excavation to processing for extracting oxygen and water. The success of this event led to a second edition in 2021, focused on space resources utilisation scenarios.

The 2021 edition of the Space Resources Week was organized in the frame of the new European Space Resources Innovation Centre (ESRIC), jointly launched by ESA, LSA and the Luxembourg Institute of Science and Technology (LIST) in November 2020 Due to the Covid-19 pandemic, it was organised as a hybrid event. The event started with an online space resources course which gathered over 80 young and senior professionals. The course gave a broad overview of the space resources field, with knowledge of available resources in the solar system; the resource identification, collection, extraction, and processing systems currently being developed; economic and technical feasibility studies; legal and policy issues; and space exploration architectures and commercial ventures that may be enabled by utilising extra-terrestrial resources. The course concluded with work on a Moon case study and an overview of the technology development efforts and near-term missions to identify and extract lunar resources.

The Space Resources Week then continued with a 4-day hybrid workshop. Key Luxembourgish speakers were able to join the workshop venue and the worldwide audience participated remotely through an online platform. More than 1000 participants from 66 countries followed the workshop, with oral presentations and discussions of over 120 speakers. In addition, 82 posters were available on the online platform. The latest mission updates for exploring the Moon, Mars and asteroids were showcased to the community and industry was also given the opportunity to present their capability for accessing the Moon, finding lunar water, drilling, rendez-vous with an asteroid, and allow deep space communication and navigation.

The key focus of the 2021 edition was however on utilisation scenarios for space resources and associated relevant topics such as the regulatory framework, financing and business models, the vision of the terrestrial companies, the latest R&D achievements. All the lessons learnt in these sessions are presented in this paper and will serve the update of the ESA space resources strategy.

2. Space Resources: Status and Agency Perspectives

The opening session of the Space Resources Week 2021 included talks by heads and high-level representatives from the Luxembourg Ministry of the Economy, ESA, the Italian Space Agency (ASI), the German Space Agency (DLR), NASA, LSA, as well as ESRIC. Overall, the importance of space resources utilization was stressed, allowing a more efficient exploration of the solar system as well as laying the ground for a future in-space economy. The agency representatives highlighted the rapid evolution of this topic in recent years, on the scientific and technical side, with several demonstration missions ongoing and planned of high relevance for space resources exploration and utilization. They also noted the increasing interest from companies and private investors, emphasizing the need for a future international governance framework for these activities. In this regard, they welcomed recent achievements at bilateral and multilateral level, like the Artemis Accords, as well as progress at the United Nations COPUOS.

The opening session also included technical presentations presented by several groups working on space resources utilization. ISECG presented the outcome of the extensive work done by its ISRU Gap Assessment Team. It examined and identified technology needs and gaps that must be addressed in order to implement foreseen missions of ISECG’s members. There was also a presentation from ESA’s ISRU topical team, stressing the need for an increased knowledge of potential resources to design the right processes, as well as the need for more guidance and transparency from downstream operations. This will allow a better understanding of the limitations or operating ranges of the proposed technology. The Lunar Exploration Analysis Group (LEAG) presented a summary of its recent activities and findings from its latest annual meeting. It emphasized that lunar resources and ISRU remain critical to sustainable human exploration, and strongly recommended further characterization and utilization of lunar resources.

Overall, the opening session was the occasion to take stock of the rapid progress in the field of space resources exploration and utilization, to give an indication of the priorities for the next years, and to set the scene for more detailed talks during the 4 days of the Space Resources Week.

3. Utilisation Scenario

Space resources utilisation scenarios are manifold: from using resources to sustain space activities, building large space infrastructure that cannot be launched, to developing a market based on bringing back materials that are scarce on Earth; agencies and industry have identified opportunities from which they could benefit from in the short, medium and long-term. At the Space Resources Week 2021, the launcher industry and academia presented economic models addressing asteroid mining to retrieve precious metals. They highlighted a potential trillion-dollar market. Academic work also looked into reflying ESA missions, this time making use of space resources. Access to propellant depots around the Moon could have reduced the transfer length of the Rosetta mission or give an extra 100kg of scientific payload to Mars Express, as examples.

New ideas also originated from an ESA call for idea aiming to explore and assess a landscape of potential applications that would make use of the resources available locally, to understand what the consumption of such resources would be and to investigate where the utilisation of those resources would take place (e.g., Moon, Mars, GEO, LEO, asteroids, and Earth). Ideas ranged from the biological systems for life support, to manufacturing and infrastructure creation as well as service providing rovers and means to create new resources.

Three major utilisation scenarios were however identified by the broad community as first use cases and main enabler to the development of many other utilisation scenario, namely: landing pad manufacturing, rocket refuelling and sustainable infrastructure. Expert panels were organised to understand where existing challenges stand and what the community could do to de-risk, demonstrate and advance thesescenarios.

3.1. Landing Pad Manufacturing

On the topic of in-situ construction with space resources, a panel of experts discussed the need for landing pads (or similar large surface feature engineering) for future lunar exploration activities. Small scale demonstration of in-situ construction should precede any larger implementations, but the panel also cautioned that many of the technologies currently being developed would need to tackle scale – for example, processing the amount of regolith needed to produce a 20-30m landing pad is not a trivial exercise and some processes (e.g. laser sintering) may not scale effectively.

In terms of the deployment and demonstration of these technologies, in-situ demonstration is considered key, and should be done at the early stages of Artemis (e.g. Phase 1 or 2) or similar exploration programmes (e.g. E3P). Only with early testing on the lunar surface can we identify what we missed, engineering wise, on Earth.

The panel considered the cost of energy for in-situ construction, and the consensus was that this may not be a significant metric. While some processes may be energetically unfavourable, others such as direct solar or microwave processing of lunar regolith will be energetically favourable for this task. Some chemical binders, brought in small quantities, may allow for even lower energy processes to be realised. Binders were discussed as a means to bridging a gap to a more holistic, pure local resources approach in later phases of exploration. The panel suggested that initial implementations of construction, potentially aided by binder materials, could be demonstrated in a rough way, which would then lead to larger, more refined approaches.

Lastly, the fundamental advantages of large ISRU enabled construction was debated by the panel, where the need for landing pads was challenged. The consensus was that such infrastructure will be needed to protect surrounding equipment in a landing zone, and also to potentially minimise the impact of ejecta reaching critical velocities (i.e. escaping to orbit). However, caution was advised as poorly implemented ISRU constructed solutions may cause more difficulties, for example, chippings or loose elements being blown away.

3.2. Rocket Refuelling

Refuelling rockets using space resources is considered as one of the first and most important use cases. Extracting water from the Moon, Mars or asteroids could supply valuable propellant depots at the surface or in orbit of planetary bodies, in order to replenish rockets using liquid hydrogen and liquid oxygen as cryogenic propellants. Oxygen extracted from extra-terrestrial soils could also be a valuable element for rockets using a different sort of cryogenic propellants, such as LCH_4/LOx mixtures. Fuel depots would change the architecture of space missions, offering the capability to up-launch more payload from Earth or to reduce the number of stages of a rocket.

Representatives of large rocket manufacturers, Gateway and satellite refuelling, propellant purification and storage, and mining academia joined a panel to discuss their vision on the role of space resources for enabling refuelling capabilities and highlight existing challenges. Their first assessment was that as of 2021, the only refuelling demonstration performed was with hydrazine. No refuelling demonstration with LOx nor LH_2 was ever performed in space. Hydrazine remains the propellant of choice, together with xenon, for many satellites and rocket applications. The Gateway will also be refuelled with xenon. Cryogenic propellants, due to the thermal complexity and energy demand to be kept in liquid form, are not used for long missions that would require a durable storage of the propellants. Rocket engines can also only fire a limited number of times and are not suited for long pauses between burns. The bottleneck varies depending on the engine technology, but it can be linked to ice formation in fuel pipelines, or to the resistance of the thruster material. Once the research will close the technical gaps, the panel agreed that the first refuelling demonstration of cryogenic propellant will be done with propellant launched from Earth, and the use of propellants sourced in space will be used when economically more viable. Mastering refueling from lunar material would however be a clear advantage for the entities owning the technology and the fuel depots.

If the community wants space resources to be utilized for rocket refueling, the panel made some recommendations:

- Cadence enabler: exploration missions have a too slow pace to be a driver in the development of rocket and refueling technology for cryogenic propellant. There is a need to access the existing market of satellite refueling in Earth orbit (LEO and GEO).
- Versatility: refueling systems need to be able to refuel satellites of various sizes, spacecraft for rocket fuel but also other elements that could benefit from oxygen or hydrogen (e.g. fuel cells).
- Public Private Partnerships: PPP with different stakeholders should be supported and driven by institutions. Institutions are needed to support the initial investment and help closing challenging business cases.
- Standards: interfaces for rendez-vous, docking, and refueling operations (e.g. cooling, pressurization) between satellites and spacecrafts from different nations or companies

need common standards, extending the existing International Docking System Standard (IDSS), already existing for deep space spacecraft (e.g. Gateway).

- Sub-scale demonstrations: after advancing the technology on ground, more testing at sub-scale level on-board existing missions are needed to build-up expertise. Trying and failing more will help understand what is technologically feasible and economically viable. Demonstrations give credibility. The Gateway could become the ideal platform for such testing.
- International endeavor with regulations: international cooperation, together with an international regulatory framework, must be developed to enable and facilitate refueling operations in space.
- Awareness: raising awareness on the needs of the different stakeholders is critical, considering the whole value chain end-to-end.

As for the recommendations specific to space resources propellant, the panel mentioned:

- Prospecting: Missions are needed to understand the distribution and accessibility of water at the poles.
- Purity: The quality control of the product before refueling is critical. Some impurities could potentially be tolerated by the rockets, but the quality of the fuel must be known and consistent.

3.3. Sustainable Infrastructure

Representatives from companies in space engineering, manufacturing technologies and architecture design, all involved in several space infrastructure concepts, provided their vision on the needs to develop sustainable infrastructures. They first highlighted the importance of demonstrations at an early stage. The need for scaling of the technologies involved in infrastructure construction is not that far-off, therefore efforts to develop those technologies should already get started. Many ISRU construction concepts can already be developed, without a perfect understanding of the local resources from prospection: the goal must be to design for robustness and use simple and *resource-agnostic* processes. The complexity of the construction and manufacturing methods can be increased as the knowledge of local resources increases. Some transversal aspects, such as sustainable resource management strategies, can already start from very early stages. A new design thinking also needs to be adopted from the early stages of infrastructure definition: design for ISRU, instead of repeating terrestrial designs and adapting them to space. There is a need to break away from the *addiction to supply chains* which drives the way we design and build on Earth.

Regarding the extensive transportation capability, the panel notes that not everything can be resupplied from Earth, especially for distant destinations (e.g. Mars). Over-dependence on a single (re-)supply chains carries a risk (see Suez canal incident in March 2021). Space resources and sustainable design and construction approaches then become a risk reduction factor, that reduces European dependence to large non-European launchers. Integrating sustainability in the design is also part of the European DNA.

For sustainability to be ensured, the infrastructure and associated activities need to be implemented in a circular way. In particular, manufacturing and construction technologies should be developed as *zero-waste* processes. Materials which present versatility of use in multiple applications should be privileged. Sustainability also means ensuring repeatability of the processes. Space destinations should be treated like we treat Antarctica: nothing should be left behind.

In addition, sustainable business models are needed as much as sustainable infrastructure. Establishing sustainable infrastructure will require contributions from multiple actors with complementary expertise, potential ground for sustainable commercial activities. The need to learn to work in new ways will have beneficial effects on innovation, and resulting commercial applications on Earth synergies can be found between technologies valid both in space and on Earth. Space agencies should act as anchor customers to provide a use case and kick-start a market for application of the relevant technologies, similar to exploration of Earth where the first customers were governments. A long-term strategy is essential: independent ad-hoc building will limit future versatility and sustainability. There is a need to formulate a vision for sustainable infrastructure. Such long-term plan needs to include definition of interfaces between various contributing elements and standardization.

The biggest challenges to achieve sustainable infrastructure will be linked to autonomy of systems, energy, and the balance between the initial mass which needs to be transported from Earth, and the limited use of consumables. The proportion between in-situ materials and consumables brought from Earth must be optimised. In the next 5 years, the panel recommended the following:

- To define a pilot case for resource extraction and utilisation (e.g. propellant, materials), and be demonstrated in an integrated ground demonstrator, with all the infrastructure elements needed to make it work. Such demonstration would serve as a proof of feasibility to gather the required support for the next steps.
- To constitute a platform for European space and non-space actors to work together.
- To identify customers.
- To regularly land on the lunar surface and demonstrate in-situ manufacturing with local materials (e.g. from regolith or from space debris).
- To have space debris recognized and accepted as a space resource.
- To define a Master Plan for sustainable infrastructure on the Moon and have selected a list of relevant materials to work with.
- To establish a clear vision and a technology roadmap identifying concrete technologies for specific use cases.
- To have more companies with a viable business case and high TRL technologies.

4. Regulatory Framework

During future space resources and other exploration missions, a significant quantity of data will be generated. Not all generated data will be of scientific nature. Depending on a mission set up and private sector involvement, some of the data might appear to be commercial and belong to a private entity. The balance between the needs of developing countries, science and pioneer private companies shall be found and innovative solutions proposed.

Provisions relevant to the data sharing are included in the Artemis Accords, signed by 8 countries in October 2020. According to the Artemis Accords, the participating countries committed to the transparency and release of scientific data. However, the Artemis Accords also recognized the private entities' interests by specifying that the "commitment to openly share scientific data is not intended to apply to private sector operations unless such operations are being conducted on behalf of a Signatory to the Accords".

The session gathered speakers from academia, NGO, terrestrial mining, private and public sectors. The panel discussion focused on upcoming opportunities and challenges related to the data sharing and future international framework for space resources activities. From the speakers' presentations, it is clear that there is a need for an open and inclusive discussion in the international forums about the legal and regulatory aspects surrounding the space resources activities. Some valuable results were achieved by informal groups such as the Hague International Space Resources Governance Working Group and Moon Village Association, which could be very valuable contributions to the discussions at COPUOS or similar forums. From a private company perspective, there is also a need for more clarity regarding the extent, quality and conditions related to the data sharing. Some data will have to be disclosed in order to build confidence between society, pioneer operator, states and intergovernmental organizations. For this purpose, terrestrial mining experience could be a good source of inspiration.

ESA's strategy on space resources does not involve legal aspects. Nevertheless, ESA already gathered experience and designed a specific framework dedicated to the data sharing for their programmes. The partners involved in space resources activities will have to reflect how the data and information will be shared, which data will be open source and which data will remain property of companies in case such data is produced on their own.

The community building and the outreach events are very important to acquire the knowledge and provide contributions to further discussions at the national or international levels.

5. Terrestrial to Space

The "Terrestrial & Space" session took the participants back to the origins of the event, namely the Mining Space Summit. Since its first edition in 2018, the goal was to create an engagement between the space resources community and terrestrial industries, including, among others, mining and oil & gas. Interest among academia is very high, but terrestrial industries still need more work and convincing. Talks at the Space Resources Week 2021 concentrated mostly on the subjects of terrestrial mining, but many more opportunities for collaboration, synergies and technology transfer between space and terrestrial applications were identified. Examples include construction and manufacturing, energy and power, communication and navigation, life support and even food supply. The potential of space resources for the future of the Hydrogen economy was also addressed.

The session showed that these opportunities for technology transfer and synergies clearly result in mutual benefits for both industries. For space resources, these benefits include the knowledge of the mining industry of large scale production capabilities, as well as minerals and extraction processing. Other domains where space can learn from mining are their experience in high (investment) risk projects, in market development and in project valuation techniques. Unfortunately, there are also many uncertainties to overcome. As mentioned by several speakers, more data on space resources, especially ground truth, is needed. In addition, the necessary technologies for use in space have not yet been showcased in real conditions, if at all. On the terrestrial side, the mining industry is currently undergoing a technological transformation with many uncertainties. Space technology may have some answers. Another topic of discussion is certainly a lack of governance for space resources, that especially hinders any international partnership opportunities.

Terrestrial mining needs a well-established supply chain, something that still needs to be created in space. On Earth, the big mining companies are essentially logistics and administrative companies, compared to most current space mining companies that find their place somewhere along the supply chain. Academia also clearly showed that, for both terrestrial and space mining, highly autonomous and innovative mining concepts and methods are a prerequisite.

To wrap up the session, ESA presented an invitation to tender (ITT) and a new Space Resources Challenge (in collaboration with ESRIC) that were met with great interest, not only by the European, but by the global community. As international partnerships will be key, it is certainly most welcome that non-European entities will be able to partner with European players.

6. Financing & Business Models

The session covered the finance and business models for space resources companies, taking different perspectives from Governmental Institutions, VCs to companies in the space resources arenas. Different points of view and ideas were shared, as well as valuable and inspirational insights on these companies' business models and finances.

One of the topics addressed in the discussion has been the importance of a solid business model. The timeframe for Return of Investment for Space Resources is much longer than what is usually expected by investors, which is 1-2 years. Despite this longer time frame, defining only a Vision Model would not be enough: a Business Model is needed. To enable a vision that lasts, there must be a business that scales and is able to generate return on investment. This means customers (and demand), and it is important to analyse how the business model relates to customers, competitors and other partners. The full supply chain needs to be considered, including the customers of customers, the ultimate customer, and the ultimate motif. For example, is the end goal using resources in space or bringing them back to Earth?

It has been noted that investors are not interested about technology, they are interested in problems, but not the specificity of the solution. They only care about how the business is going to solve that problem and what they will see in return.

One very interesting observation that was made is that space for space is the challenge because there are no current 'problems' in space, only 'problems' on Earth. This brings to the main recommendation: dual terrestrial and space markets. In the session, the panel discussed examples of using space to improve the manufacturing process on Earth, and examples of using the same solution for both the Terrestrial and Space Market ("2 birds 1 stone"). In practice, Terrestrial business provides the financial means for the Space business.

In terms of governments and institutions, we have seen Space Bonds to fund space as critical infrastructure, we have seen infrastructure projects like the ESA Moonlight project building an infrastructure for providing telecommunication and navigation services to other players (including private space resources companies) on the Moon.

One insight is that there will be a space resources ecosystem, which will involve companies whose business cases will be interdependent on one another. It was also observed that it is not expected to have many different players involved in the value chain. It will be more a vertical model in which a same big company will cover a great part of the value chain, like SpaceX for example.

The ESRIC Startup Support programme seems to fit the discussion and recommendations made in the session. ESRIC will offer specialized technical support, Dual Markets are considered, and startups will be introduced to VCs.

7. R&D Needs and Gaps

A session was dedicated to research progress in various technologies and processes needed across the space resources value chain, from extraction and beneficiation to manufacturing and oxygen extraction. Speakers were asked to present the existing needs and gaps specific to their process.

Research on lunar regolith beneficiation has risen the issue of separating grains by size or by mineral concentration. Traditional terrestrial methods like cyclones or wet processes are not suitable for space applications. Techniques based on vibration and electrostatic separation have however shown their potential for future work.

Regarding water extraction on the Moon, more work is needed to know if the water resource at the pole is a viable reserve. New information on the isotope composition would help understanding the origin, renewability, and distribution mechanisms of lunar water. The sublimation rate of water ice and the related isotope fractionation process was highlighted as being poorly understood. The next PROSPECT mission and ground experimental work are expected to provide answers in the next 5-10 years.

Oxygen extraction from lunar regolith was demonstrated to be possible by carbothermal reduction and the FFC Cambridge process, based on a molten salt electrolysis. Carbothermal reduction uses hydrogen and methane to extract the oxygen from lunar minerals. Water is formed and can then be electrolysed to recycle the hydrogen and store or reuse the oxygen. A demonstration below the melting point of the regolith was shown but how much oxygen from the regolith was extracted remains to be quantified. The FFC Cambridge process is, to this date, the only one which has shown the full reduction of lunar regolith simulant, leaving as a by-product only a metallic powder. The research was focused on lowering the process temperature from 950°C to a minimum. Various salt eutectics were used and at least 40% of the oxygen in the regolith was extracted at 660°C in $CaCl_2$-LiCl. Open research questions relate to the impact of the regolith on the salt contamination, the minimum salt to regolith ratio, the choice of inert anode and if a partially reduced regolith holds value as a product. Other work on resource extraction have shown progress status on cobalt extraction from asteroids.

Additive manufacturing, or 3D printing, was a prominent research topic among abstracts. Work on laser sintering of lunar regolith has shown new proof of concept with an engineering model of a payload. Environment elements such as vacuum and reduced gravity were tested for printing in 1D. The next steps should generate 2D and 3D structures and better understand the temperature dependence of the process, key ground demonstrations before developing a flight model and scaling up the technology. 3D printing from molten regolith was also part of the presented research works. Although an early demonstration was shown, additional research is expected in order to understand the melt viscosity and emissivity, measure mechanical properties of the 3D printed parts, and develop new means for continuous 3D printing operations. The last presentation showed the advantage of using wet regolith mixture for manufacturing on the Moon and Mars.

8. ESA Space Resources Strategy

In 2019, ESA has published its first Space Resources Strategy [5]. The strategy defines up to 2030 a list of priorities and objectives based on underlying assumptions. With the creation of the Artemis programme, China's interests in developing an international lunar robotic station, and the multitude of international initiative to the Moon, ESA works on a first revision of the strategy.

The community present at the workshop confirmed that ESA should keep promoting such strategy as it helps to focus European national and private investments, while securing the position of Europe in the global endeavour. All stakeholders wish however to be proactively engaged in the strategy development.

The first version of the ESA Space Resources Strategy is focused on the Moon and the community highlighted that space resources has not only a critical role to sustain operations on the Moon, but also on Mars. It could even be the enabler for first human Mars mission. The impact on innovation for circular economy in space is also expected to be significant. All these elements, together with the lessons learned across the various sessions of the Space Resources Week, will be integrated in the revision of the strategy which will be published in 2022.

9. References

[1] European Space Agency - European Space Research and Technology Centre, "Workshop: Towards the Use of Lunar Resources," 2018. [Online]. Available: http://exploration.esa.int/moon/59878-workshop-towards-the-use-of-lunar-resources/.

[2] A. L. Graps *et al.*, "ASIME 2016 White Paper : IN-SPACE UTILISATION OF ASTEROIDS : ' Answers to Questions from the Asteroid Miners ' by Amara Graps + 30 Co-Authors Outcome from the ASIME 2016 : Asteroid Intersections with Mine Questions were provided by the Companies : Planeta," *arXiv Prepr. arXiv1612.00709*, pp. 1–85, 2016.

[3] Luxembourg Space Agency, "MAJOR TAKEAWAYS of the MINING SPACE SUMMIT 2018" [Online]. Available: https://space-agency.public.lu/dam-assets/publications/2018/MINING-SPACE-SUMMIT-2018-Whitepaper.pdf

[4] Luxembourg Space Agency, "MAJOR TAKEAWAYS of the MINING SPACE SUMMIT 2019" [Online]. Available: https://space-agency.public.lu/dam-assets/publications/2020/MINING-SPACE-SUMMIT-2019-Paper.pdf

[5] European Space Agency, "ESA Space Resources Strategy," 2019. [Online]. Available: https://sci.esa.int/documents/34161/35992/1567260390250-ESA_Space_Resources_Strategy.pdf.

LUXEMBOURG SPACE AGENCY

esa

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY | LIST

SPACE RESOURCES.LU
AN INITIATIVE BY THE LUXEMBOURG SPACE AGENCY

www.spaceresourcesweek.lu