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SPACE AGENCY

SpaceResources.lu

Recent developments

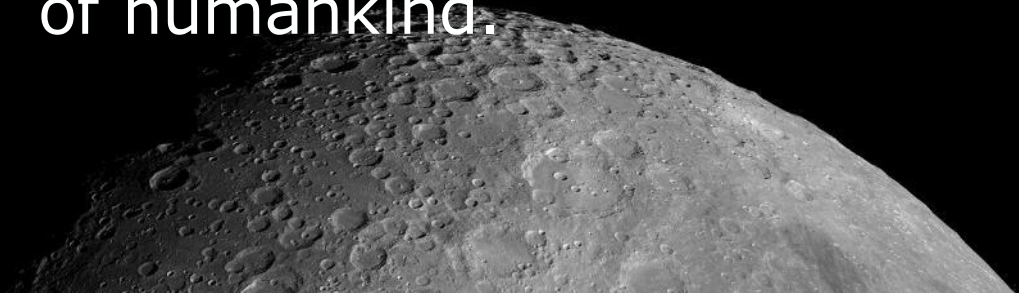
*A Luxembourg Initiative contributing to the
Future of Space Exploration and the Utilisation
of Space Resources*

Bob Lamboray
Senior Project Manager
Luxembourg Space Agency

Golden 6.6.2023 - Space Resources Roundtable



Luxembourg aims to contribute to the peaceful exploration and sustainable utilization of space resources for the benefit of humankind.



④ Key Challenges

Realizing the Potential Benefits of Space Resource Utilization Remains Challenging & Requires Global Partnerships



TECHNICAL

Capabilities necessary to recover, process and utilize resources from space must be developed, tested, and matured



REGULATORY

International & domestic legal frameworks need to be established to protect entrepreneurs, assure investors, and ensure responsible activities



FINANCIAL

Significant **investment** with long-time horizons must be available to enable private firms to develop and deploy critical systems



BUSINESS

Identification of initial capabilities needed for space resources utilisation with near-term applications opening up future **markets**

A Strategy build around 5 Pillars to address the Different Challenges





INTERNATIONAL COOPERATION

Global awareness has rapidly increased and Luxembourg continues its strong international engagement

- **Engagement** at ESA, EU and UN
- **Agreements** with other countries on a governmental level
USA, Japan, Belgium, Poland, Czech Republic, Portugal, Australia/New South Wales
- **Agreements** with other space agencies:
NASA (USA), DLR (DE), CNES (FR), ASI (IT), CNSA (China), UAESA (UAE), ISRO (India), CSA (CA)
- **Membership** at IAF and ISECG
- Creation of an **Advisory Board** on Space Resources
- Promotion activities, in particular key events: "Mining Space Summit", then "**Space Resources Week**"





LEGAL FRAMEWORK

Luxembourg is contributing to progress on further clarifying the legal and regulatory framework

- Adoption of a **Law** on the Exploration and Use of Space Resources (2017)
→ 2nd country worldwide after the US, 1st in Europe
- Strong engagement at the United Nations Committee on the Peaceful Uses of Outer Space (**COPUOS**)
→ Support the creation of a dedicated space resources WG
- One of 8 founding signatories of the **Artemis Accords** addressing operations on the Moon
- Member of the “**The Hague International Space Resources Governance Working Group**” 2016-2019
→ 20 building blocks for a future international framework
- Member of **GEGLA** (Moon Village Association)
Global Expert Group on Sustainable Lunar Activities





FUNDING INSTRUMENTS

Luxembourg engages in various partnerships to provide long-term financial support to companies

- **RDI funding**, mainly through ESA / LuxIMPULSE
- **Orbital Ventures Fund**, investing in early stage space ventures in Luxembourg and worldwide
- Agreement with **European Investment Bank** (EIB)
- Equity investment through **Luxembourg Future Fund** (LFF)
- Equity and loans through **national investment bank** (SNCI)
- Non **dilutive funding** for startups through the start-up support programme at ESRIC dedicated to space resources technologies in partnership with Technoport.





TECHNOLOGY & BUSINESS



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Luxembourg puts a strong emphasis on private and public partnerships to support economic development through R&D

- **R&D contracts** with various companies addressing existing and near-term markets while developing technologies with long-term goals in SRU
- Joined the **European Exploration Envelope Programme** (E3P – Terrae Novae) in ESA and support ESA's space resources strategy
- In-depth **study** on the future value chains to identify most promising domains
- **Challenges & Start-up accelerators**





RESEARCH & EDUCATION



Luxembourg substantially increased its research activities and provides various training opportunities

- Space Resources **Professional Development Course**, in cooperation with ISU, ESA, Colorado School of Mines and ESRIC
- Launch of an “**Interdisciplinary Space Master**” at the University of Luxembourg, with focus on system engineering and entrepreneurship, including classes related to space resources
- The FNR PEARL funding for research programme at Rededicated to “**Solutions for the Sustainable and Responsible use of Space Resources (SolSR)**”
- **European Space Resources Innovation Centre** (ESRIC), a joint initiative of LSA, ESA and LIST





A STRATEGIC PARTNERSHIP



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Luxembourg and ESA established a strategic partnership in ESRIC to contribute to the development of the Space Resources industry in Europe

- The Luxembourg Government launched the **SpaceResources.lu** initiative in 2016
Luxembourg aims to contribute to the peaceful exploration and sustainable utilization of space resources for the benefit of humankind
- ESA published the **space resources strategy** in 2019
The strategy is addressing the challenge of a Sustained and Sustainable Human Presence in Space through the utilisation of local resources
- Luxembourg and ESA signed a **Memorandum of cooperation** in the field of space resources in 2019
- Luxembourg established the **European Space Resources Innovation Centre** (ESRIC) in 2020
- ESA joined ESRIC as a **strategic partner** in November 2020



esric



- ESRIC is a national **innovation centre** in the field of **Space Resources**
- is built around **3 pillars**
 - Research
 - Commercialisation
 - Community Management
- is led by its Director Dr Kathryn Hadler and has a team of **17 people** (47% female) and **12 nationalities**

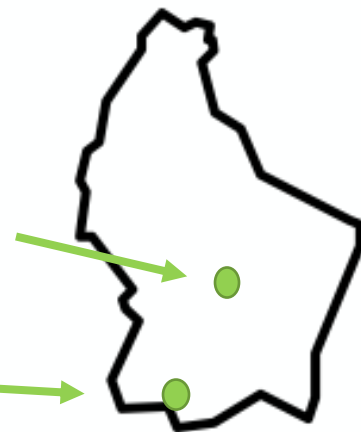


- is located in the south of Luxembourg in **Belvaux**

ESRIC Labs
41, Rue du Brill
4422 Sanem
info@esric.lu

Luxembourg city

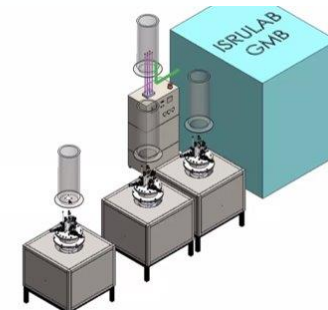
Belvaux



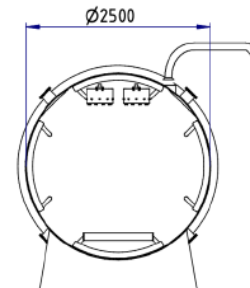
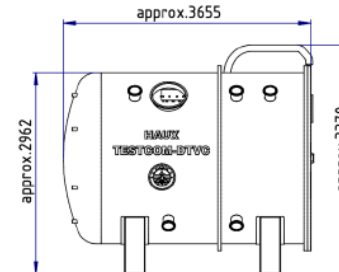
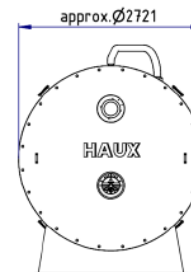
- ESRIC space resources specific research **infrastructure** currently consists of
 - Hydrogen reduction demonstrator
 - Molten Salt Electrolysis demonstrator (FFC) – *in procurement -> 2024*
 - Dusty Thermal Vacuum Chamber (DTVC) – *in procurement -> 2025*
- ESRIC research infrastructure is **open** for external users
- ESRIC will develop in collaboration with ESA a **Ground Based Pilot Plant**.



Alchemist Hydrogen Reduction Prototyp



Molten Salt Electrolysis Cells



Dusty Thermal Vacuum Chamber and Terrestrial Pilot Plant



ESRIC is conducting research projects in many different areas



1. Regolith beneficiation
2. Process Optimisation
3. Recycling of end-of-life equipment
4. Environmental impact and legacy



5. Geology and prospecting of lunar ilmenite deposits
6. Plasma-enhanced hydrogen reduction of regolith (2 projects)
7. Advanced treatment of regolith for manufacturing
8. Optimisation of reversible fuel cells
9. Ceramic additive manufacturing using regolith

10. Purification of oxygen and water for ISRU processes



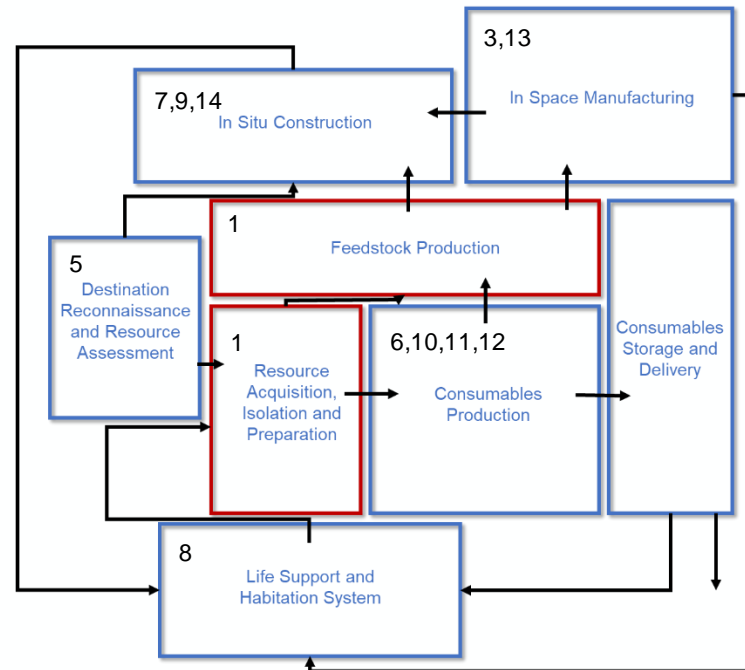
11. Fluidized-bed hydrogen reduction of regolith
12. FFC molten salt electrolysis of regolith



13. End-to-end processing from oxygen production to metal 3D printing



14. Microwave sintering of regolith



(simplified) Integrated ISRU Functional Flow Diagram
(ISECG – ISRU gap assessment)



OTHER ACTIVITIES



Space Resources Week



ESA ESRIC Space Resources Challenge



ESRIC Startup Support Programme (SSP)



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Thank You !

www.space-agency.lu

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