# Programme : Towards the Use of Lunar Resources

| Day 1, Tuesday 3 July: Setting the Scene (Erasmus High Bay) | | | | |
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| **Time** | **Duration** | **Presenter** | **Subject** | **Affiliation** |
| 9:15 | 00:15 | J. Carpenter | Welcome and introduction remarks | ESA |
| 09:30 | 00:05 | J. Woerner Director General | Welcome address (Video Message) | ESA |
| 09:35 | 00:10 | D. Parker Director of Human and Robotic Exploration Programmes | Lunar Exploration in the ESA European Exploration Envelope Programme | ESA |
| 09:45 | 00:15 | J. Carpenter | Towards a Lunar Resources Strategy | ESA |
| 10:00 | 00:15 | G. Sanders | Lunar Resources in NASA | NASA |
| 10:15 | 00:15 | A. Abbud-Madrid | The current status of lunar resources | Colorado School of Mines |
| 10:30 | 00:10 | Clive Neal | Lunar Resources in the LEAG Exploration Roadmap | University of Notre Dame |
| 10:40 | 00:20 | Coffee Break | | |
| **Rationales for Utilising Lunar Resources 1: Use Cases** | | | | |
| 11:00 | 00:15 | M. Landgraf | Products and quantities to close ISRU | ESA |
| 11:15 | 00:05 | R. Gonzalez-Cinca | In-situ resource needs for production of energy in future lunar exploration scenarios | UPC-Barcelona Tech |
| 11:20 | 00:05 | Agata Jozwicka-Perlant | Space Logistics mindset in Ariane Group | Ariane Group |
| 11:25 | 00:05 | R. Buchwald | Airbus vision of sustained lunar exploration architecture based on ISRU | Airbus Defence and Space |
| 11:30 | 00:05 | L. Kiewiet P. Delande | Concept of Operations for harvesting ice in the Lunar south pole to produce rocket propellant | SpacE Exploration and Development Systems (SEEDS) |
| 11:35 | 00:05 | M. Viturro Balufo & S. | Transport architecture based on lunar water". | ISAE-SUPAERO |

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| | | Segura Munoz | | |
| 11:40 | 00:05 | M. Perino | Preliminary Architecture for Lunar ISRU Operations | Thales Alenia Space |

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| 11:45 | 00:50 | **Interactive session: Who are the potential users of lunar resources, what do they need, how much and when?** |

| **Rationales for Utilising Lunar Resources 2: Economics** | | | | |
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| 12:35 | 00:15 | M. Link | The Luxembourg Space Resources Initiative | Luxembourg Ministry of the Economy |
| 12:50 | 00:05 | A. Kapoglou | The application of Mission Orientated Innovation Policy to Lunar Resources | University College London / ESA |
| 12:55 | 00:05 | J. Ocasio-Christian | Current global trends that we are seeing with respect to private and government investments | Caelus Partners |
| 13:00 | 01:00 | Lunch (ESTEC Canteen) | | |
| 14:00 | 00:30 | **Discussion session: What are the economic rationales for investing in lunar resources and ISRU technology in the short medium and long term?** | | |

| **Boundary Conditions 1: Resource Availability** | | | | |
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| 14:30 | 00:15 | E. Sefton Nash | Polar volatiles | ESA |
| 14:45 | 00:15 | K. Joy, M. Anand and I. Crawford | Regolith and pyroclastic deposits | Universty of Manchester, Open University and Birkbeck University of London |
| 15:00 | 00:05 | N. Bowles | Prospecting opportunities from different platforms | University of Oxford |
| 15:05 | 00:05 | T.G. Wasilewski | Extra-terrestrial water resources categorization and evaluation method | Space Research Centre PAS |

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| 15:10 | 00:05 | J. Lamamy | ispace Europe's activities related to lunar exploration and ISRU research | ispace Europe |
| 15:15 | 00:05 | B. Bahov | Water deposits | Space Mining Technologies |
| 15:20 | 00:20 | Coffee Break | | |
| 15:40 | 01:00 | **Interactive session: What do we know about possible resources at the lunar surface, what are the gaps in our knowledge, what needs to be done in advance of resource utilisation and technology demonstration?** | | |

| **Boundary Conditions 2: Legality and Governance** | | | | |
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| 16:40 | 00:05 | A. Salmeri | the legality of Lunar Resources utilisation | University of Leiden |
| 16:45 | 00:15 | T. Masson | Governance of lunar resources | University of Leiden |
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| 17:00 | 00:10 | **Q&A on legal status for lunar resources utilisation, major issues, steps need to be taken and when** | | |

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| 17:10 | Reception and poster session |

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| 19:00 | End Day 1 |

## Day 2, Wednesday 4 July: Technologies (Erasmus High Bay)

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| 09:00 | 00:10 | T. Ghidini | Introduction to the ISRU Technology Day (video message) | ESA |

| **Materials and Construction** | | | | |
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| 09:10 | 00:05 | M. Conti | Potential of The Metalysis FFC Process to Produce Oxygen and Metal Alloys in an Off World Environment. | Metalysis |
| 09:15 | 00:05 | J. Schroeder | The Space Foundry: Refining Metal in Cislunar Space and on the Moon | CisLunar Industries S.A. |
| 09:20 | 00:05 | H. Lakk | Robotic manufacturing of fibrous structure from lunar basalt fibre on the Moon. Fungal based biocomposite material for habitat structure on the Moon and Mars | ESA |
| 09:25 | 00:05 | X. De Kestelier | HASSELL studio's entry to the 3rd Phase of NASA's 3D printed Mars Habitat Centennial Challenge | HASSELL studio |
| 09:30 | 00:05 | C. Ortega | Use of cable robot for Moon habitats 3D printing | AVS |
| 09:35 | 00:05 | E. Dini / P. Carboni | 3D-Printing of Lunar Base using Lunar Soil | Monolite UK \| D-Shape |
| 09:40 | 00:05 | A. Ellery | Building lunar industrial infrastructure from lunar resources using robotic 3D printing | Carleton University |
| 09:45 | 00:05 | K. Doerfler | Robotic In situ Fabrication - The In situ Fabricator IF1 | ETH Zurich |
| 09:50 | 00:05 | P. Weiss | REGOLIGHT project (EC); LUNA (ESA) project: URBAN (ESA): Several finalized DEEP-SEA MINING Projects | COMEX SA |
| 09:55 | 00:05 | B. Imhof | RegoLight - Sintering with Solar Light for building ISRU habitats; | LIQUIFER Systems Group |
| 10:00 | 00:20 | Coffee Break | | |
| 10:20 | 00:05 | A. Markopoulou | Robotic and Additive manufacturing on site | Institute for Advanced Architecture of Catalonia |
| 10:25 | 00:05 | J. Garcia Espinel | Autonomous and teleoperated vehicles for construction and industrial logistics using 5G and Acciona's Large Scale 3D Printing Technology | Advanced and Digital Innovation Hub |

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| 10:30 | 00:05 | M. Dall'Igna | NASA Centenial Challnges: 3D Printed Habitat Challenge and Structural Member Competition | Foster+Partners |
| 10:35 | 00:05 | S. Linke | TUBS-M and TUBS-T regolith simulant development ; "MIRA3D" rover | Institute of Space Systems; TU Braunschweig |
| 10:40 | 00:05 | J. Lee | Building Astronaut Housing on the Moon's Polar Region | LATMOS; University Paris Saclay |
| 10:45 | 00:05 | S. Piesik | Lessons learnt from terrestrial construction in extreme environments | 3 ideas Ltd |
| 10:50 | 00:05 | A. Cowley | Activities of Spaceship EAC relating to ISRU | ESA |
| 10:55 | 00:05 | A. Makaya | Overview of past and ongoing ESA activities in ISRU for Construction and Hardware manufacturing | ESA |
| 11:00 | 00:05 | B. Foing | Smart1 results on lunar sites for resources; Plant growth using lunar soil | ESA |
| 11:05 | 00:10 | Break | | |
| **Oxygen and Water from Regolith and Polar Volatiles** | | | | |
| 11:15 | 00:05 | L. Offermann | Overview of Processes to produce Oxygen from Lunar Regolith | ESA |
| 11:20 | 00:05 | P. Reiss | Lunar ISRU technologies, extraction of volatiles, and handling of regolith at TU Munich | Technical University Munich |
| 11:25 | 00:05 | D. Binns | ISRU payload and Pilot Plant Study outcomes | ESA |
| 11:30 | 00:05 | M. Lavagna | Carbothermal reduction, experiments with ice in vacuum and 3D printing activities | Poli. Di Milano |
| 11:35 | 00:05 | F. Venditti | Carbothermal reduction extraction payload and terrestrial demonstrator | OHB ITALIA |
| 11:40 | 00:05 | T. Denk | (Really) Large Scale and Rather Complete Ilmenite Reduction Demonstrator: Technology and Lessons Learnt | Ciemat - Plataforma Solar de Almera |
| 11:45 | 00:05 | D. Urbina | Alchemist and LUVMI | SAS |
| 11:50 | 00:05 | R. Fisackerly | PROSPECT development and status | ESA |
| 11:55 | 00:05 | A. Morse / S. Barber | ProsPA, derivatives and future incarnations | Open University |

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| 12:00 | 00:50 | **Interactive session: What can we learn from terrestrial industries and how can we partner** | | |
| 12:50 | 01:10 | Lunch (ESTEC canteen) | | |
| **Energy and Power** | | | | |
| 14:00 | 00:05 | L. Celotti | Moon Energy Storage and Generation | Sonaca Space GmbH |
| 14:05 | 00:05 | S. Fereres | Overview on terrestrial thermal energy storage systems and possibilities for energy generation and storage in future lunar ISRU habitats | Abengoa Innovacion |
| 14:10 | 00:05 | J. van Oorschot | how an energy grid on the moon should help accelerate the developments towards a lunar village | Maana Electric |
| 14:15 | 00:05 | J. Schleppi | Utilisation of lunar regolith for Power generation on the lunar surface | Heriot-Watt University |
| 14:20 | 00:05 | M. Marigliano | Energy harvesting using reflecting surfaces to concentrate solar energy on celestial bodies. | ALTRAN |
| 14:25 | 00:30 | **Discussion: What are the synergies and feed forward opportunities with resource utilisation on asteroids and Mars** | | |
| 14:55 | 00:20 | Coffee Break | | |

| **Regolith Excavation and Processing** | | | | |
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| 15:15 | 00:05 | J. Cilliers | Estimating the mining scale required to satisfy Lunar oxygen demand | Imperial College London |
| 15:20 | 00:05 | K. Seweryn | Excavation technique dedicated for reduced gravity environments | Space Research Centre PAS (CBK PAN) |
| 15:25 | 00:05 | M. Sperl | Fundamental challenges in materials physics rearding properties of regolith; processed materials; and handling of processed and unprocessed ingredients | DLR |
| 15:30 | 00:05 | G. Cao | Ilmenite enrichment of lunar regolith to extract oxygen and for production of physical assets using lunar regolith | University of Cagliari and Sardinian AeroSpace District (DASS) |
| 15:35 | 00:05 | D. Martin | The ESA Sample Analogue Curation Facility | ESA (ECSAT) |
| 15:40 | 00:05 | A. Risan Borgersen | Regolith beneficiation and comminution | SolSys Mining |
| 15:45 | 00:05 | U.A. Peuker | Effect of reduced gravity along the mechanical Mineral processing chain | TU Bergakademie Freiberg |
| 15:50 | 00:05 | J. Keravala | Developing robotic industrial workforce for space mining and construction | OffWorld |
| 15:55 | 00:05 | H. Otto | Coupled DEM-CFD simulation of a bin flow of lunar regolith simulant JSC-1A in partial vacuum | University Magdeburg |
| 16:00 | 00:05 | S. Shergill | Adaptive ISRU systems | Cranfield University |
| 16:05 | 00:05 | J. Katzer | Harnessing Multivariate Statistics for Assessment of Lunar Soil Simulants | Koszalin University of Technology |
| 16:10 | 00:05 | R. Anyszka | Suitability of Lunar regolith toward high-performace filler synthesis. Application of sulfur-concrete in Lunar environment | University of Twente; Lodz University of Technology; |
| 16:15 | 00:10 | Splitting into sessions | | |
| 16:25 | 01:00 | **Interactive session: What are the most promising technologies in each area, what are the main technical challenges, what has to be demonstrated or tested on the Moon and when?** | | |
| 17:25 | End | | | |

## Day 3, Thursday 5 July: Missions and implementation (ERASMUS Centre)

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| 09:00 | 01:20 | **Briefing on the ESA Lunar Resource Utilisation Mission and Industrial Activities** | | |
| 10:20 | 00:10 | Group Photo | | |
| 10:30 | 00:20 | Coffee Break | | |
| **Missions, supporting technologies and commercial activities** | | | | |
| 10:50 | 00:05 | K. Acierno | ispace's updated M1 and M2 plans | ispace Europe |
| 10:55 | 00:05 | A. Berinstain | The Moon Express MX family of robotic explorers | Moon Express Inc. |
| 11:00 | 00:05 | C. Sallaberger | Canadian Technology status; missions & system definition activities; Collaboration opportunities | Canadensys Aerospace |
| 11:05 | 00:05 | A. Zuniga | Developing and building lunar infrastructure for robotic missions and approaches to establishing sustainable business models using the COTS acquisition model. | NASA Ames Research Center |
| 11:10 | 00:05 | M. Haeming | Overview on know-how; goals; and partnerships for moon exploration and ISRU with particular focus on ISRU payload development. | Airbus Defence and Space |
| 11:15 | 00:05 | A. Jaime Albalat & L. Richter | OHB activities in support of ISRU | OHB System AG |
| 11:20 | 00:10 | Q&A | | |
| 11:30 | 00:05 | M. Hazadi | Commercial exploration of the Moon - How commercial missions can support lunar resource exploration | Puli Space Technologies |
| 11:35 | 00:05 | G. Martucci di Scarfizzi | Logistic and operational approaches and constraints | ALTEC S.p.A. |
| 11:40 | 00:05 | K. Yoshida | Robotics technology for lunar surface mobility and exploration of resources | Tohoku University |
| 11:45 | 00:05 | J. Vrublevskis | Stirling nuclear and cryocooling systems for the Moon & lunar communication data relay and future navigation system. | Thales Alenia Space, UK |
| 11:50 | 00:05 | J. Jaworski | Highlights from Rover Speed Characterisation for Lunar Exploration project and PIAP terrestrial mobile robots for lunar ISRU plant operations | PIAP Space |
| 11:55 | 00:05 | L. Feruglio | Artificial Intelligence for Mission Autonomy Autonomous Operations for Lunar ISRU | AIKO S.r.l. |

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| 12:00 | 00:10 | Q&A |
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| 12:10 | 01:00 | **Reporting from technology splinters and identification of in situ technology demonstration needs** |
| 13:10 | 01:00 | Lunch |
| **What next?** | | |
| 14:10 | 00:15 | A community vision for lunar resources |
| 14:25 | 00:15 | The roles of ESA and other actors |
| 14:40 | 00:15 | Future community building and support |
| 14:55 | 00:15 | Next steps |
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| 15:10 | Closing Reception and Networking Opportunity | |
| 17:00 | Close | |

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| **Posters** | | |
| D. Lucsanyi | Challenges and simulations of the lunar surface radiation and plasma environments and effects | Puli Space Technologies; ESA/ESTEC |
| R. Bamford | radiaiton risk and active shielding approaches | RAL Spsce; Rutherford Appleton Laboratory |
| L. Herrera & F. Ruiz | Moon Village Labs: a knowledge-sharing platform designed to actively interconnect Moon Villager students with Moon Villager professors and companies. | Somethingg |
| L. Overmeyer | Einstein-Elevator | Leibniz University Hannover |
| M. Johnson | CubeSat scale in-situ spacecraft/lander/rover printer | Imperial College London / PocketSpacecraft.com |
| M. Verma | Design and integration of: Lunar (Nano) Rovers ISRU payloads Swarming | Stellar Space Industries |
| A. Gregorio | A lunar rover system including the BRICSAT actuator and lunar science with microwaves | University of Trieste; PICOSATS SRL |
| H. Mátyás | "Preparing a Lunar Rover Mission in the Framework of Analog Planetary Research" | Puli Space Technologies |
| Jarosław JAWORSKI | | PIAP Space Sp. z o.o., Warsaw Office |
| M. Mokthari<br>P. Sossi<br>F. Moynier | Experimental determination of the Zinc isotopic fractionation factor during evaporation | Institut de Physique du Globe de Paris |
| Luca Celotti | MESG – MOON ENERGY STORAGE AND GENERATION Concept design and analysis | Sonaca |