

ILEWG LUNEX EMMESI EUROMOONMARS EARTH SPACE INNOVATION: MISSIONS, DATA, INSTRUMENTS, FIELD WORK, ASTRONAUTS, HABITATS, BUSINESS & COLLABORATIONS

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Summary: We describe research and events highlights from ILEWG LUNEX EuroMoonMars Earth Space Innovation EMMESI academy, EuroSpaceHub partners contributing to MoonMars and space missions, Field Research, Astronautics, Entrepreneurship and opportunities for French community,

Organisation of Conferences and Community Events:

As per its terms of reference ILEWG LUNEX EMMESI has co-organised sessions (O), workshops (W), field work campaigns (F), committees meetings (C), community events (E), panels (P) and sessions (S) at International Conferences, and presented reports and talks (T) and Posters/Interactive presentations (IP) there, supported by students YLE Young Explorers grants (Y). This included in 2024: Madrid EuroSpaceHub Board (O,W,E,T), Ahmedabad planetary symposium (O,Y,T), Singapore GSTC (P,E), Leiden EMMESI (F,T), Luxembourg Space Resources (E,Y), LPSC (R,T,IP), IAF spring committees (E, C5,Y), Monterrey Mexico solar eclipse expedition (O,W,W,E,T), EGU (O,C,T,E), Pleaux-Lourdes-Toulouse field campaign (O,W, F, T,Y8), Vienna UN-COPUOS (W,E,T), European Lunar Symposium ELS (T), Vulcano Astrobiology field school and Etna campaign (O,W,F,T,Y6), Nanjing NUAU workshop and opening ILEWG intl laboratory (O,W,E,T), Tokyo Space Tide Summit (P), Busan COSPAR assembly & ILEWG ICEUM (O,C4,E,T, IP, P,Sx5), Beijing CAST/IAA Human Space flight (P,T), Beijing BIT & Hongkong ISSST (W,T,E), Leiden EMMESI (F,W,E,T), Krakow ERC (P,E), Berlin EPSC (S,T), Lausanne CHASM analogue astronauts (W,T), ESTEC industry day (E,W), Padova Science Festival (F,W,E), Grenoble IPAG CSUG Space4All (F,W,T,E), NL Space week and Space explorers (W,E), Milano IAC Intl Astronautical Congress & Space4All (O,Cx5,W,S8,T,E), Toulouse IPSA workshop (T,W,E), Leiden Edibles (W,T), Utrecht Space sustainability (W), Bremen Space Tech (W,E), Mexico-Ibero U Horizontes Cosmicos Space4All (O,W,P,T,E), Luxem-

bourg MVA Moon Village/Space week (O,W,T,E), Hainan Galaxy Forum and IpSpace (P,T,E,F).

Events planned for 2025 include: Macau planetary conf (W,P,T), UN COPUOS SciTech (W,E), Morocco AMES (P, T), Rorkee India STEP/IPSC (P,T), LPSC (W,P), Paris IAF Spring Committees, Vienna EGU, Delhi IAF GLEX, LUX Space Resources, Riga Fotonika workshop, IAA Turin, ISDC Orlando, Seoul Korea ISU SSP Space Studies Programme, Helsinki EPSC, Sydney IAC, Cyprus COSPAR symposium.

Missions, Data, Instruments, Field Work, Astronauts:

EuroMoonMars is an ILEWG programme [1-235] in collaboration with space agencies, academia, universities and research institutions and industries. The programme includes research activities supporting Moon and Mars Missions for data analysis, instruments tests and development, field tests in MoonMars analogue, pilot projects, training and hands-on workshops, technical visits and outreach activities.

Support for Moon, Mars and Space Missions: we have contributed to lunar missions (SMART-1, Kaguya, Chang'E 1-8, LCROSS, LRO, Chandrayaan 1-3, CLPS), as well as Mars missions (Mars Express, MRO, MER, Curiosity, Perseverance, ExoMars TGO 2018 and Rosalind Franklin Rover 2028). LUNEX is participating to future lunar lander missions, including commercial landers, in particular Qosmosys and from CLPS and Artemis programme. LUNEX CEO Prof Foing is now Chief Scientist for Qosmosys lunar lander, and is coordinating possible lunar science and exploration payloads, with LUNEX EMMESI supporting instruments teams.

Data analysis, AI and Machine Learning for Space: we have developed with collaborators advanced analysis of space and astronomy data at EMMESI academy. This included analysis of Earth, Moon, Mars, exoplanet time series

& spectroscopy data . We are developing generic and specialized tools for AI machine learning analysis (Fazel et al).

Sample analysis: we analysed various samples including meteorites from Moon, Mars, asteroids, and analogue field samples from campaigns (Vulcano, Etna, Hawaii HI-SEAS) using spectrometry, hyperspectral imaging and Raman .

LUNEX also participates in collaboration with TU Delft in the study of ice, minerals and organics mixture relevant for Moon, Mars and icy Moons.

Payload development: we have developed a test bench for sample analysis using reflectance and transmission spectroscopy, Raman spectroscopy and microscopy. We also adapted an Hyperspectral camera for sample analysis and for telescopic observations of the Moon and other celestial objects.

Space Photonics Lab : this is being developed with in collaboration with Fotonika Latvia, with cubesat synergy .

Shoebox instruments for laboratory tests and analogue were developed for future Moon and Mars missions. We are conceiving a concept of a shoebox module for extracting organics from icy moons of Jupiter and Saturn, with special prototype for Enceladus plumes or surface. LUNEX ExoGeoLab lander is currently adapted with shoebox instruments for supporting future missions to Moon, Mars and icy moons.

Cubesats for education, EarthMoonMars exploration: LUNEX EMMESI has initiated the development of university education cubesats with the support of Leiden University (Observatory, LIACS computer science, Physics and Optics), Leiden Instrument Schools LiS, Delft TU, InHolland Delft, ESA BIC. The development starts with a table top bench & a prototype 3U system, with spacecraft and payload functions. First applications include an Earth and Moon remote sensing cubesat, a 3U adapted on a lunar rover platform, and a 3U shoe-box instrument deployed from surface lander.

Field work and testing of instruments and protocols. Extreme environments on Earth provide similar terrain conditions to sites on the Moon and Mars, in order to rehearse mission operations in the field and through simulations. EuroMoonMars field campaigns were organised in specific locations of technical, scientific and exploration interest. In 2023-24, EuroMoonMars co-sponsored Vulcano 2024 Geo-Astrobiology field school, and a specific EuroMoonMars field tests at Etna, building on the experience of campaigns conducted earlier with DLR and ESA for ROBEX 2019, and ARCHES 2022 campaigns (Wedler et al 2017 & 2022)

EuroMoonMars Analogue astronauts simulations. Lunex EuroMoonMars, has been organizing since 2009 in collaboration with ESA, NASA, European and US universities a programme of data analysis, instrumentation tests, field work

and analog missions for students and researchers in different locations worldwide, including Utah MDRS, IMA Hawaii HI-SEAs, Iceland, Etna/ Vulcano Italy, Atacama, AATC Poland, ESTEC Netherlands, Eifel Germany, etc... Analogue missions provide a practical ground in which researchers can test in a realistic simulation context. During these missions, students have access to special Space instrumentation, laboratories, Facilities, Science Operations, Human Robotic partnerships. In 2023-24, EuroMoonMars co-sponsored EMMPOL Moonbase isolation simulation campaigns in Poland (Hutchison, Laforet, Tataj, Della Guardia) , and at IMA International Moonbase Alliance HI-SEAs (EMMIHS) .

ExoSpaceHab Xpress (ESH-X) is an innovative portable lunar base simulator designed for education, analog missions and public outreach. This habitat has been funded by European consortium EuroSpaceHub and its partner LUNEX EuroMoonMars. After inauguration at Padova Botanical Garden in Italy, ExoSpaceHab-X was shown 20/9-13/10 2023 at the Science week fair of ENS Paris Saclay, and then used at SBIC Space Business Innovation Center Noordwijk in Oct-Dec, then in Leiden with University Jan-April 2024 and 3Aug-18 Sept, Pleaux Auvergne 8 May-1 Aug, Padova Science Festival with 2000 visitors, Grenoble University Space Center in October. t. It is also planned for other locations in Europe in 2025. ESH-X lab-hab module is used to test experiments and investigations for Artemis programme.

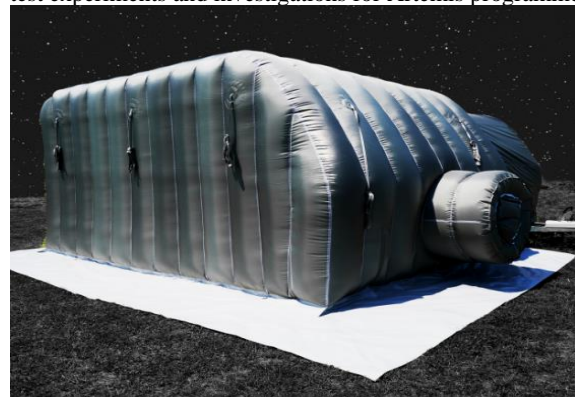


Fig.1: ExoSpaceHab-Xpress Lunar Module developed by LUNEX for research training, astronautics simulations, business innovation & outreach.

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