

ILEWG EUROMOONMARS FIELD CAMPAIGNS: LESSONS FOR ARTEMIS CREW & SCIENCE SUPPORT COLLABORATION. B.H. Foing^{1,2,3}, A. Kołodziejczyk^{1,2,14}, H. Rogers^{11,12}, S. Kerber^{1,2,11}, Marc Heemskerk^{3,11}, M. Musilova^{2,11,12}, R. Perrier^{2,14,15}, H. Castaing^{14,15}, E. Forgues^{14,15}, A. Spilkin^{2,14}, R. Landolina^{2,14}, C. Heinicke^{2,3}, C. Pouwells^{1,2,11}, M. Harasymczuk^{1,2,13}, I. Schlacht^{2,3,6}, S. Hettrich⁷, A. Lillo^{1,2,4}, P. Evellin^{1,2,5}, T. Pacher⁸, A. Decadi^{7,10}, J. Villa-Massone^{2,7}, N. Vermeulen², J. Preusterink², N. Sirikan^{1,11}, H. Boross^{1,11}, P. Radjkakati^{1,11}, A.P. Nunes^{2,11}, A. Wanke^{1,2,11}, A. Beniast^{1,3}, ILEWG EuroMoonMars team, EMMPOL2020 team, EuroMoonMars campaigns Crew & Support Teams; 1 ESA/ESTEC & 2 ILEWG EuroMoonMars (PB 299, 2200 AG Noordwijk, NL, Bernard.Foing@esa.int), 3 VU Amsterdam, 4 Supaero Toulouse, 5 ISU Strasbourg, 6 Extreme Design, 7 SGAC, 8 Puli team, 9 EAC European Astronaut Centre, 10 ESA HQ, 11 EMMIHS (EuroMoonMars - International Moonbase Alliance - HI-SEAS), 12 International Moonbase Alliance (IMA) & Hawai'i Space Exploration Analog and Simulation (HI-SEAS), United States, 13 Analog Astronaut Centre Poland, 14 EMMPOL EuroMoonMars Poland Crew & support team, 15 IPSA

Introduction: The ILEWG EuroMoonMars programme includes research activities for data analysis, instruments tests and development, field tests in MoonMars analogue, pilot projects, training and hands-on workshops, and outreach activities [1-10]. EuroMoonMars field campaigns have been conducted in ESTEC, EAC, at Utah MDRS station, Eifel, Rio Tinto, Iceland, La Reunion, LunAres & AATC bases in Poland, and HISEAs base in Hawaii. In 2019, the EuroMoonMars IMA-HISEAs (EMMIHS) campaigns were launched. Six persons crew spent two weeks at the Moonbase station performing research relevant to both the Moon and Mars there. The EMMIHS campaigns aim to increase the research and technology testing in order to help humans settle on the Moon and Mars. They support the preparation for Artemis and an actual Moon base. We shall discuss the specific lessons on collaboration between crew, mission control and science support

EuroMoonMars campaigns: EuroMoonMars field campaigns have been organised in specific locations of technical, scientific and exploration interest. Field tests have been conducted in ESTEC, EAC, at Utah MDRS station, Eifel, Rio Tinto, Iceland, La Reunion, LunAres base at Pila Poland, and HISEAs base in Hawaii. These were organised by ILEWG in partnership with ESTEC, VU Amsterdam, NASA Ames, GWU in Utah MDRS (EuroGeoMars 2009, and then yearly for EuroMoonMars 2010-2013). Other EuroMoonMars analogue field campaigns using selected instruments from ExoGeoLab suite were conducted in other MoonMars extreme analogues such as Eifel volcano, Rio Tinto, Iceland, La Reunion, Hawaii.

Latest campaigns have been conducted jointly between EuroMoonMars –International MoonBase Alliance –

HiSeas (EMMIHS). EuroMoonMars field campaigns started with EuroGeoMars2009 (Utah MDRS, 24 Jan-1 Mar 2009) with ILEWG, ESA ESTEC, NASA Ames, VU Amsterdam, GWU and continued with yearly EuroMoonMars Field campaigns in Utah (2010-2014), and in other Moon-Mars terrestrial analogues (Eifel volcanic area, Rio Tinto, Iceland, La Reunion, LunAres base & EMMPOL 2020 in Poland, and EMMIHS campaigns at HiSEAS base in Hawaii).

Instrument science support and experiments: *Goals of EuroMoonMars & ExoGeoLab:* We integrated instruments integrated in an ExoGeoLab test bench, along a methodic hands-on research: 1) We procured and adapted instruments to equip a small ExoGeoLab demo lander. Some instruments can also be used on a small or mid-size Rover. some instruments can be brought for field site campaigns. 2) This terrestrial payload (instruments, sensors, data handling) has been deployed, operated and used as collaborative research pilot facility (ExoGeoLab, fig.1), first tested and operated at ESTEC & transportable 4) We have implemented the possibility of remote control of instruments from an adjacent mobile laboratory, and a remote science desk. 5) The suite of measurements includes a comprehensive set with telescopic imaging reconnaissance and monitoring, geophysical studies, general geology and morphology context, geochemistry (minerals, volatiles, organics), subsurface probe, sample extraction and retrieval, sample spectroscopy analysis. 6) We have reproduced some simulation of diverse soil and rocks conditions (mixture of minerals, organics, ice, penetrations of water, oxydant, organics, living organisms & plants) and diagnostics 7) We used these instrument packages to characterise geological context, soil and rock properties 8) Science investigations in-

clude geology, geochemistry, mineral, oxydant, organics, volatiles & biomarker diagnostics. 9) After first validations we started to exploit the facility for collaboration with partners that have provided some additional guest instruments, and performed specific investigations. From this test bench and kit of ExoGeoLab instruments, we have operated comprehensive instruments packages either installed and deployed by analogue astronauts and then teleoperated from the control room or from remote science investigators.

Crew simulations and science support. We made use of the mobile lab habitat ExoHab to simulate logistics support, local operations and research that can be performed from a lunar Landed module. An additional ExoBiology Laboratory module (ExoLab) has been equipped to support related technical research, and a new version ExoLab 2.0 was developed.

EuroGeoMars 2009 was the first EuroMoonMars field research campaign dedicated to the demonstration of astrobiology instruments and a specific methodology of comprehensive measurements from selected sampling sites (Utah MDRS) with ILEWG, ESA ESTEC, NASA Ames, VU Amsterdam, GWU. Crew 1 included: Foing, Stoker, Zavaleta, Ehrenfreund; Crew 2: Pletser, Borst, Peters, Wills, Sarrazin, Hendrikse, Monaghan; Crew 3: Foing, Ehrenfreund, Boche-Sauvan, Gross, Wendt, Thiel; Crew visiting media: Marabella, Gronendaal, Derks; Mission Control & Science Support: Westenberg, Mahapatra, Blake, Page, Kotler, Martins, Orzechowska, Direito, Kotler, Clarke, Wilhelm, Slob, Petitfils

EuroMoonMars Field campaigns were conducted from 2009, with following partners:

2009 Sept EuroMoonMars-Eifel 2009 with ILEWG, ESA ESTEC, VU Amsterdam, Austrian Space Forum OEWf, GWU, Ecole de l'Air

2010 EuroMoonMars-DOMMEX 2010 (Utah MDRS) with ILEWG, ESA ESTEC, NASA Ames, VU Amsterdam, GWU, Ecole de l'Air, FloridaTec, UCL Louvain

2010 EuroMoonMars SALM La Réunion

2011 EuroMoonMars2011 (Utah MDRS)

2012 EuroMoonMars2012 (Utah MDRS) with ILEWG, ESA ESTEC, NASA Ames, VU Amsterdam, GWU, Ecole de l'Air, FloridaTec;

Crew: Stoker, Battler, v't Houd, Bruneau, Cross, Maiwald, Svendsen, Oltheten, Nebergall, Orgel; Support: Foing, Ehrenfreund, Elsaesser, Rammos, Rodrigues, Direito, Roling

EuroMoonMars 2018-20 at IMA HISEAS base on Mauna Loa volcano in Hawaii (EMMIHS). The Hawaii - Space Exploration Analog and Simulation (HISEAS) Hawaii habitat on Mauna Loa, on the Big Is-

land of Hawai'i is owned and operated by the International Moonbase Alliance (IMA). A Mission control center has been installed, also with remote science support from co-investigators worldwide. A number of science investigations in geology, exploration of lava-tubes, sample collection, astrobiology, and human factors study were conducted, in collaboration with remote science support. Latest EMMIHS campaigns included:

2018 EMMIHS0 EMM-IMA-HISEAS scouting campaign May 2018 (Crew: Rogers H&A, Foing, Wilhite, Machida; support@ BluePlanet: Ponthieux, Cox et al)

2019 EMMIHS1 February (crew: Musilova, Sirikan, Mulder, Weert, Burstein, Pothier; support@ BluePlanet: Foing, Ponthieux, Cox, Rogers)

2019 EMMIHS2 8-22 December in Moonbase, (crew: Musilova, Kerber, Castro, Wanske, Pouwels, d'Angelo; support@ BluePlanet: Cox et al, support@ESTEC/VUA: Ageli, Foing, Heemskerk, Beniest, Sitnikova, Preusterink)

2020 EMMIHS3 18 Jan- 1 Feb in Moonbase, (crew: Heemskerk M&H, Rajkakati, Musilova, Brasileiro, Edison; support: BluePlanet & ESTEC/VUA)

2020 EMMIHS4 1-15 Feb in MoonbaseEMMIHS0, (crew: Boross, Dehler, Musilova, Neidlinger, Pantazidis, Sheini; support: BluePlanet & ESTEC/VUA).

Acknowledgments: we thank participants, partners and supporters of ILEWG EuroMoonMars activities.

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EuroMoonMars astronaut operating ExoGeoLab Lander