

HIGHLIGHTS 2022

YEARLY STATUS REPORT
PLANETARY INFRASTRUCTURES



EDEN ISS greenhouse during sunrise after polarnight, Credits: Michael Trautmann

PLANETARY INFRASTRUCTURES - THE YEAR 2022

Another year full of milestones has been completed! The research cluster Planetary Infrastructures has made remarkable progress and has advanced in many areas. We have expanded previous work, gained new team members, partners and projects. 2022 stands for progress, new ideas, and changes.

After successful completion of the fourteen-month Antarctic expedition at Neumayer Station III, NASA guest scientist Jess Buncek returned safely to Germany together with hundreds of plant samples. The EDEN ISS facility remained in hibernation mode for most of 2022, until mid-November when two group members participated in the 2022/23 Antarctic summer season expedition to prepare the research greenhouse for shipment back to Germany. Many new plans are in the pipeline for the greenhouse – EDEN ISS becomes EDEN LUNA! For this the group has established a long-term research plan, including upgrading the facility with new technologies (e.g., robotic arm), and has worked out a fascinating research scenario at the new ESA/DLR LUNA facility in Cologne. But don't worry - future crews in Antarctica will continue to be supplied with fresh food, as the DLR group is already developing the EDEN 2.0 greenhouse system, which will be integrated inside Neumayer Station III (Alfred Wegener Institute, AWI).

In 2022, several milestones have been reached within the space resource utilization ambitions of the group, as the construction of the laboratory-scale multi-stage lunar regolith beneficiation test setup was successfully finalized. The main goal will be to produce an ilmenite-rich feedstock for subsequent oxygen and metal extraction processes. Additionally, the start of the EU-funded LUWEX project marked a major milestone for the group. Essential R&D will be conducted to demonstrate water extraction technologies for the Lunar surface. Many more highlights, such as the humanitarian spin-off project MEPA, multiple laboratory upgrades, and international collaboration agreements were formative for this year. We are motivated and are looking forward to another year of successful work, to enable permanent human presence on Moon and Mars! Stay tuned!

Dr. Daniel Schubert
Research Area Leader -
Planetary Infrastructures



Size of a bean harvested from the EDEN laboratory

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EDEN ISS greenhouse in Antarctic storm, Credits: Michael Trautmann



PLANETARY INFRASTRUCTURES

For a successful human exploration strategy, resources such as water, oxygen, food, and also rocket fuel, energy, habitat building materials, and many different types of consumables will need to be generated and adequately recycled within future extra-terrestrial outposts. Combining the two approaches, reclamation and recycling is the key focus of the Planetary Infrastructures research area. The group is administered by the Department of System Analysis Space Segment (SRS) at DLR Institute of Space Systems in Bremen (Germany). The department operates the Institute's Concurrent Engineering Facility (CEF), as well as the Planetary Infrastructures laboratory, including the Space Habitation Plant Laboratory (EDEN Lab), the ISRU Breadboard (SMU Lab), the 3D Printing Farm, and the EDEN ISS research greenhouse in Antarctica.



DLR Institute of Space Systems, Bremen (Germany)



THE EDEN INITIATIVE

In 2011, the DLR Institute of Space Systems launched its research initiative called EDEN: Evolution & Design of Environmentally-closed Nutrition-Sources. The research initiative focuses on Bio-regenerative Life Support Systems (BLSS), especially greenhouse modules, and how these technologies can be integrated in future space habitats. It is the goal of the EDEN team to further advance the latest cultivation technologies and to adjust these developments into space-related applications. Even though present scenarios for future human missions to the Moon and Mars are still several years from coming to fruition, the development of these technologies needs to start today. Only this way, highly-reliable and resource-efficient BLSS will be ready for implementation into the mission architecture for humanity's journey to the Moon and Mars.



SYNERGETIC MATERIAL UTILIZATION

The Young Investigator Group Synergetic Material Utilization (SMU) was founded in 2021, after winning a DLR internal competition. The group focuses on the development of technologies for in-situ resource utilization (ISRU) on the Moon and Mars and how to establish synergies between ISRU and Life-support systems. The group consists of two PhD candidates, several student assistants, and group leader Dr. Paul Zabel. The current research focus is set on three areas: 1) Regolith Beneficiation and Utilization, 2) In-situ Propellant and Consumables Production, and 3) Development of shared ISRU-LSS infrastructures. In the first area, a beneficiation breadboard is under construction to pre-process lunar regolith before utilization. The goal of the second area is to develop a prototype for extracting water from the lunar surface. The third area focuses on a shared water-hydrogen-oxygen infrastructure for a future space habitat. All three areas are of high near-term importance for space exploration and are high priorities in European and international roadmaps.

THE RESEARCH TEAM



DR. DANIEL SCHUBERT studied at the Technical University of Berlin and has an engineering diploma in industrial engineering with an emphasis on aerospace and production techniques. In 2011, he initiated the EDEN group at the DLR Institute of Space Systems for technology investigations on Bio-regenerative Life Support Systems and has since served as the team leader of this group. His research expertise is set on habitat interface analysis and plant accommodation and dynamic plant production planning.



DR. PAUL ZABEL studied aerospace engineering at the Technical University of Dresden and has a doctorate from the same university. He joined the EDEN team in 2012. Since 2021, he has lead the Synergetic Material Utilization group at the DLR Institute of Space Systems. Dr. Zabel is also the deputy manager of the Planetary Infrastructures Laboratory. His research expertise is in ISRU research and innovation and also in Life-support systems.



RIEKE FREER is a PhD student working in the Synergetic Material Utilization research group. Her research focuses on a shared hydrogen-oxygen-water infrastructure to exploit synergies between the ISRU and LSS effectively. Before undertaking PhD studies, she completed her Master's in process engineering at the Technical University of Hamburg with emphasis on water treatment technologies.



VINCENT VRAKKING studied at the Technical University of Delft in the Netherlands and holds a M.Sc. in aerospace engineering. He began working with the EDEN team on and off in 2012, before joining the team full-time in 2015. Within the EDEN group, he focuses on structure and subsystem design and the development of 3D-printing prototypes.



MARKUS DORN is a horticulture expert and holds a M.Sc. in plant sciences (University of Natural Resources and Life Sciences, Vienna, Austria). He joined the EDEN team in 2017 and consults in horticultural questions. He has evaluated different plant candidates and also developed cultivation methods for fruit trees for use within planetary habitats. His main responsibilities are organizing the EDEN plant laboratory and conducting experiments.



LUCA KIEWIET is a PhD candidate in the Synergetic Material Utilization research group and develops water extraction methods for the Moon and Mars. He holds a 2nd-level Masters degree in Space Systems Engineering from the Politecnico di Torino and a double degree in Space Science and Technology from Luleå University and Université Paul Sabatier Toulouse. He joined DLR in 2021. His expertise is ISRU and space mechanisms.



CONRAD ZEIDLER has been a member of the EDEN research team since January 2011. For his industrial engineering diploma at the Technical University of Braunschweig, he specialized on aerospace engineering and has profound knowledge of trade-off analysis techniques (e.g. AHP). He is an expert in simulation methods and control software. Within EDEN, he is responsible for monitoring and controlling the plant growth and environmental parameters.



JARED STOOCHNOFF is a fourth year PhD candidate from Controlled Environment Systems Research Facility (CESRF) at the University of Guelph in Ontario, Canada. His expertise is in photobiology, plant-environment interactions, and controlled environment agriculture. As a guest scientist (April – July) he, together with the DLR team, built the setup of the nutrient delivers system (NDS) bread-board that will eventually service the NextGen EDEN ISS system.



CHRISTIAN SCHNORR studied Food Technology at the University of Applied Sciences in Fulda and currently holds a M.Sc. in food processing. He is a guest scientist within the EDEN group and is currently working on his PhD thesis investigating the utilization of inedible biomass from plant cultivation by rearing mealworms (*Tenebrio molitor*, L.), including efficient ingestion, digestion, mass gain, and fiber reduction.



KARTHI SAVUNDARARAJAN is a student assistant and studies industrial engineering and production technology at the University of Bremen. He joined the EDEN team in mid-2020 and supports the team in organizing the laboratory and is involved in multiple projects. Karthi is also responsible for the 3D-printing farm, overseeing the production of different prototypes.



CLAUDIA PHILPOT is a Diploma Engineer who studied aerospace engineering at the Technical University of Berlin and joined the EDEN Team in 2022. Her expertise as a satellite operations manager in Industry and Research as well as programmatic experience working with ESA on industry-driven ISS utilization will support her new role as the Project Manager for EDEN LUNA and as Subsystem Engineer for the CEA Technologies developed at DLR.



JESS BUNCHEK is a botanist (B.Sc., Purdue University, 2015), agronomist (M.Sc., The Pennsylvania State University, 2018), and current PhD candidate in space systems engineering at the University of Bremen. Jess previously supported plant production on the International Space Station at NASA Kennedy Space Center (USA) before joining the EDEN team as a DLR-NASA guest scientist in 2020. From late 2020 to early 2022, she overwintered at Neumayer Station III as the EDEN ISS greenhouse operator.



AYLIN BAYLAN studies communication and media at the University of Bremen. She joined the EDEN team in July 2021 as a student assistant and supports the team in tasks regarding PR and outreach. Her daily work routine includes different organizational processes such as contacting interested persons, collaboration partners, and PR teams from other DLR departments. Her area of responsibility also includes supporting several social media accounts and overseeing the yearly report.



ANNIKA FLECHSIG studies Space Engineering at the University Bremen. She joined the EDEN team in January 2022 as a student assistant and supports the team in tasks regarding the optimization of the laboratory. Her responsibilities at DLR Bremen also include supporting the MEPA project. Her tasks include, in addition to helping with harvesting, preparing the cultivation mats for experiments.



DLR-NASA JOINT MISSION UPDATE

MISSION SUCCEEDED: RETURN OF PLANT SCIENTIST JESS BUNCHEK FROM ANTARCTICA

NASA guest scientist Jess Buncek continued her fourteen-month Antarctic expedition at Neumayer Station III into early 2022, concluding crop harvests in the EDEN ISS research platform and also preparing the upcoming Antarctic summer season operations. The overwintering team and summer guests alike enjoyed not only eating the fresh produce grown inside EDEN ISS but also visiting the facility in which the crops were grown.

Once the final crops were harvested in mid-January, operations quickly shifted to cleaning the greenhouse facility and completing required technical work, including raising the EDEN container platform and packing the stored supplies inside the station. The facility was then switched to hibernation mode for the 2022 isolation season in anticipation of the EDEN ISS container take home mission end of the year. Compared to the 2020/21 Antarctic summer seasons, where all guests traveled to Neumayer via the German research vessel Polarstern, the coronavirus pandemic improved enough for the 2021/22 summer season that both ship and air logistics could resume. Jess departed Neumayer on 11 February by plane, stopping over first at Novo Runway and then leaving the Antarctic continent on 15 February for Cape Town. Jess and the other AWI overwinterers from the 2021 season returned to Germany on 19 February and completed medical examinations and debriefs.



Jess Buncek harvesting herbs in the EDEN ISS greenhouse in Antarctica



The 2021 overwintering team departing Neumayer Station III, February 2022. Back row (L to R): Tanguy Doron, Lorenz Marten, Linda Ort, Florian Koch, Paul Ockenfuss, Markus Baden; Front row (L to R): Theresa Thoma, Timo Dornhoefer, Jess Buncek.



Fresh, green Dolly Genovese basil from the EDEN ISS greenhouse



Red Robin tomato harvest in EDEN ISS



Weighing Waldmann's Green romaine lettuce in the Service Section



Prepared tubes for microbial sampling on plant roots, shipped to NASA KSC



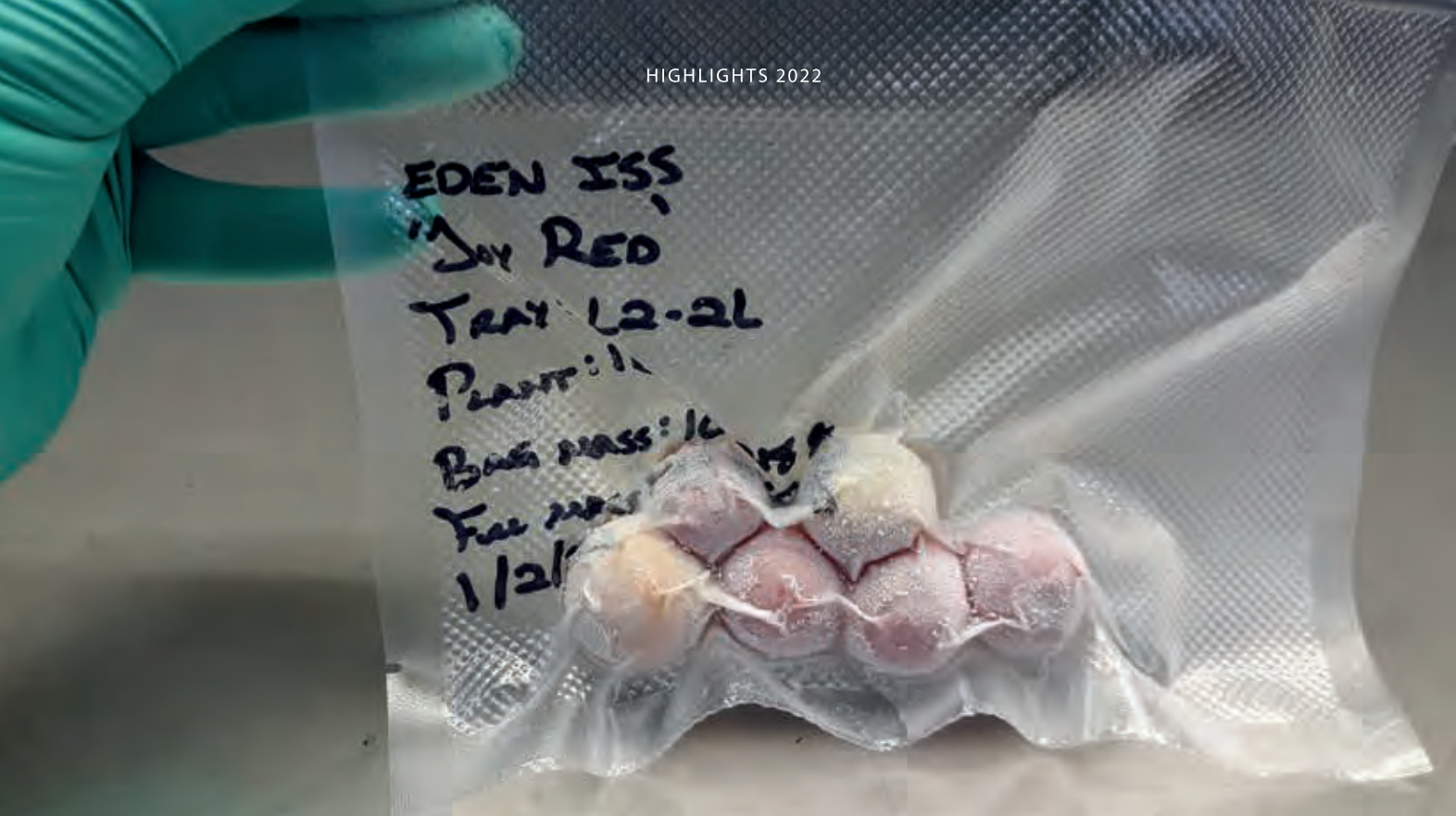
Ilyushin aircraft to transport the 2021 overwintering team from Novo Runway, Antarctica, to South Africa





The full Future Exploration Greenhouse prior to final harvesting in the EDEN ISS greenhouse in Antarctica





Frozen Joy Red tomato fruit, returned to NASA KSC for microbiological and nutrition analyses

EDEN ISS POST-ANALYSIS

NASA-DLR JOINT MISSION SAMPLE ANALYSIS AT KSC

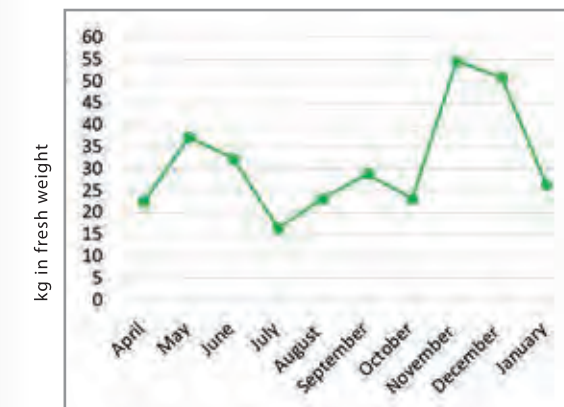
The return freight from the 2021 EDEN ISS isolation campaign quickly arrived in Germany (Spring 2022). Depending on the intended analyses, samples were sent to either DLR Cologne (Institute of Aerospace Medicine) or NASA Kennedy Space Center (KSC). Both institutions have since completed microbiological sample analyses, and NASA KSC plans to analyze the molecular and nutrition samples in 2023.

The 2021 campaign ran from 2 March 2021 to 15 January 2022 for a total of 319 growing days. During this time, 315 kg total fresh edible biomass was produced from 37 different crop cultivars, adding an average of approximately 100 g fresh produce to each overwinterer's diet daily. Preliminary analysis of the crew psychological survey has shown that the overwinterers positively responded to having fresh produce.

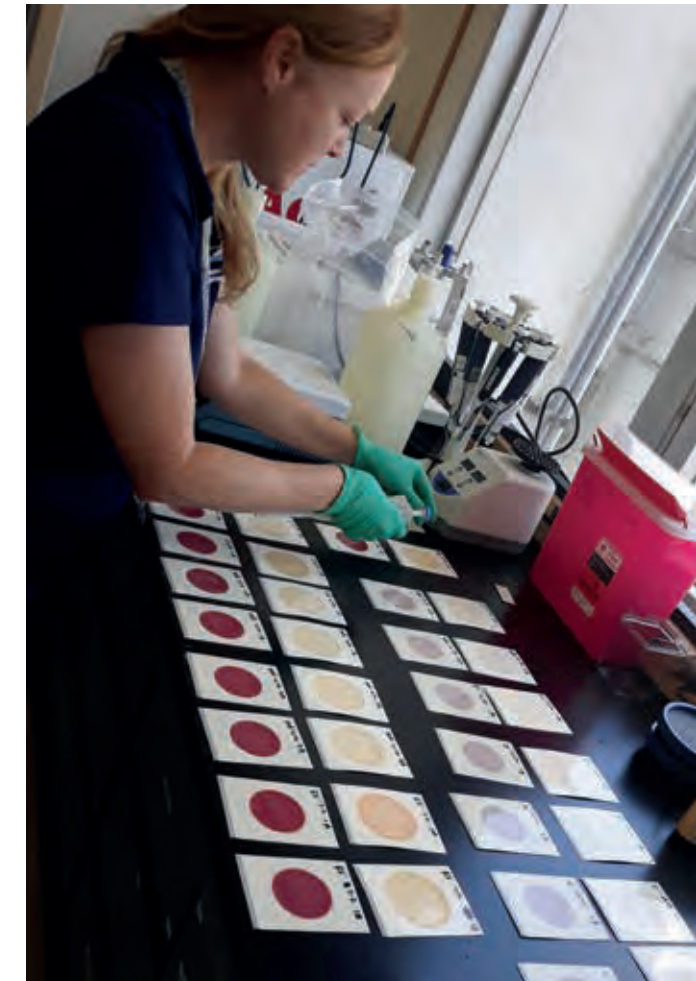
Nutrition samples were collected on 26 of the cultivars, totaling 164 samples across the 2021 campaign. Plant tissue sampling was collected for microbiological and molecular assessments. In total, 139 edible tissue samples and 99 root samples were collected across 17 crops. These crops were selected based on their alignment with previous production on the International Space Station as a method to increase our understanding of the microbiological community of these crops as grown in different locations and systems.



Return samples from the 2021 EDEN ISS Antarctic campaign arriving at NASA KSC. From L to R: Mary Hummerick, Christina Khodadad, Jen Gooden, & Jess Bunchek



Monthly harvested fresh edible biomass (kg) from EDEN ISS during the 2021 overwintering campaign



Scientist Jen Gooden at NASA KSC preparing laboratory tests of the returned samples from the 2021 EDEN ISS Antarctic campaign



Jared Stoochnoff and Vincent Vrakking packing return tissue samples for shipment to DLR Cologne



Jess Bunchek sorting return plant tissue samples from the 2021 EDEN ISS Antarctic campaign at DLR Bremen, before shipping the samples on to DLR Cologne and NASA KSC





Annika Flechsig fixing the AMS



Samples of the Lunar dust simulant dissolution experiments



The two prototypes of the nutrient mixing system in the EDEN laboratory

LABORATORY UPGRADE

THE PROFESSIONAL LAB TAKES SHAPE

In 2022, the new laboratory began to take shape as the multi-purpose laboratory, and the Controlled Environment Agriculture (CEA) control room were outfitted with the technical systems and equipment required for the Planetary Infrastructures group's research and development roadmap.

In the CEA control room, an updated atmosphere management system was installed, which offers improved atmosphere control over the plant cultivation area, and also allows for full recovery and processing of condensate water. This is an important step towards closed-loop greenhouses on the Moon and Mars. Furthermore, through a collaboration with the partner company PRIVA, two custom-developed nutrient mixing systems were installed which allow for precise control of nutrient solution composition.

At the same time, in the multi-purpose laboratory several In-situ resource utilization (ISRU) experiments were set up. In particular, the regolith beneficiation test stand was built-up to concentrate ilmenite-rich feedstock in preparation of further ISRU steps. In addition, the water purification work bench was set up, and several experiment campaigns have been conducted during the year.



Planetary Infrastructures students working on different experiments in the multi-purpose laboratory



Eight cultivation chambers (plant cubes) are newly installed in the laboratory. Comparative plant cultivation experiments can be conducted in future.



The new Atmosphere Management System inside the CEA control room



Victoria Pesch performing a lunar regolith experiment



SCM growth trials carried out in the outdoor integration tent

M.E.P.A.

MOBILE EMERGENCY PLANT-GROWING APPLICATION

Within 2022, the EDEN group has made substantial progress in the further development of the MEPA food production system for humanitarian aid scenarios. As already done in the previous year there were several successful lab-based indoor growth trials carried out, in particular with focus on the durability of the newly designed Seed Cultivation Mat (SCM), and the extension of the range of test plant candidates (e.g., purslane and bush beans). After conducting numerous experiments, the system is now ready to be used. The system follows the plug & grow approach with a bimonthly production mode, followed by a cleaning mode with reduced throughput watering times.

In addition to the laboratory activities, preparations for the outdoor test phase started. A suitable integration tent was built on the institute's property to assemble and integrate the main subsystems. Despite the cold weather conditions (Nov./ Dec.), the first full system test was successfully accomplished – just before the test campaign had to stop for the winter break. With this milestone, the team is looking forward to the final testing phase in a relevant environment (e.g. refugee camp) in 2023.



Laboratory experiment phase 3 with multiple crops (Overview)



Laboratory experiment phase 3 (Bush Beans)



Markus Dorn showing the progress of the SCM (Seed Cultivation Mat) and ASU (Automated Support Unit) in the MEPA outdoor integration tent



Monitoring the growth of Brassica juncea seedlings (cv. 'Frizzy Joe')



Outdoor Integration tent during winter mode



Experiment setup inside the MEPA integration tent



Control unit and power supply of the ASU



Close up of the ASU



Assisted by F. LAEISZ and the AWI on-site construction team, the two research containers were removed from the raised platform



Claudia Philpot and Vincent Vrakking documenting the disassembly of the EDEN ISS Greenhouse

EDEN ISS TAKE-HOME MISSION

A NEW JOURNEY BEGINS

All good things come to an end eventually! After five years in Antarctica, the EDEN ISS research platform will return to Germany in order to be outfitted for its next mission! From mid-November until mid-December, Claudia Philpot and Vincent Vrakking participated in the 2022/23 Antarctic summer season expedition at Neumayer Station III.

During their stay at the German Antarctic station, the main tasks involved draining the coolant fluid from the thermal system, disconnecting all the interfaces between the Service Section and the Future Exploration Greenhouse, and removing all externally-mounted equipment, such as the roof-mounted free cooler and the CO2 injection system.

Assisted by the AWI on-site construction team, the two research containers were removed from the raised platform and placed on sleds to allow transportation to the edge of the ice shelf for loading onto the research vessel Polarstern. All supporting equipment, spares, and consumables were also packed and stowed for transport back to Germany. The EDEN ISS containers will leave Antarctica on Polarstern in January 2023 and arrive in Bremerhaven in spring 2023, after which the re-outfitting process of the containers will begin as part of the EDEN LUNA project.



Vincent Vrakking clears the EDEN ISS entrance of snow after a stormy night in Antarctica



Containers lifted off the platform – time to go home with Polarstern. Thanks to the Techteam of the Neumayer Station III, Summer Season 2022/2023 (L to R): Claudia Philpot, Benedikt Neuner, Stefan Reich, Michael Trautmann, Christian Mitteregger, Stefanie Bähler, Pitt Eder, Andreas Oblender, Vincent Vrakking.



Claudia Philpot preparing dangerous goods for shipping



Vincent Vrakking cleaning out the service section subfloor



Claudia Philpot disconnects the power and data lines to the FEG equipments



Vincent Vrakking accessing the FEG subfloor area



Vincent Vrakking entering the storage container, with the EDEN ISS greenhouse in the sunny background



EDEN LUNA

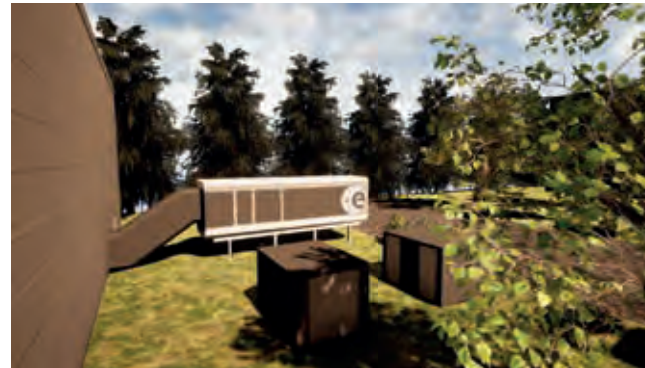
THE NEXT STEP TOWARDS GROWING FOOD ON THE MOON!

As the take-home mission of EDEN ISS at the Antarctic site progresses, it is time to look into the future research goal of this unique platform. With the EDEN LUNA project, the team has found a unique opportunity to provide an adequate second life for the research greenhouse! EDEN ISS becomes EDEN LUNA. The new research platform is planned to be attached to the LUNA facility by 2025. LUNA is a moon analog simulation facility to be located in Cologne – a joint endeavour between DLR and ESA. A habitat connector, called Flexhab, will provide access for the astronauts and scientists to dedicated analog test environments like the EDEN LUNA greenhouse.

EDEN LUNA will provide nearly closed-loop bio-regenerative life support system elements for the moon analog simulation environment to test automated procedures as well as to test working with astronauts-in-the-loop scenarios. The focus for EDEN LUNA will be set on optimizing the nutrient delivery system including the Combined Regenerative Organic food Production (C.R.O.P.) system. Further, a robotic arm will be implemented, automating operational cycles including data analysis and failure detection. The LUNA project Kick-Off meeting took place in September 2022. It is funded by the state of North-Rhine Westphalia and open for cooperation with industrial partners. This third-party funding project will enable the team to test critical technologies that will later be integrated into the envisioned Lunar Agricultural Module (EDEN Next Generation).



LUNA Hall – A moon surface analogue simulation facility



Flexhab attached to LUNA; Flexhab is a planned experiment facility which is expected to connect to EDEN LUNA



LUNA team representatives at the kick off at ESA EAC



EDEN-LUNA as part of the LUNA Analogue Simulation Facility

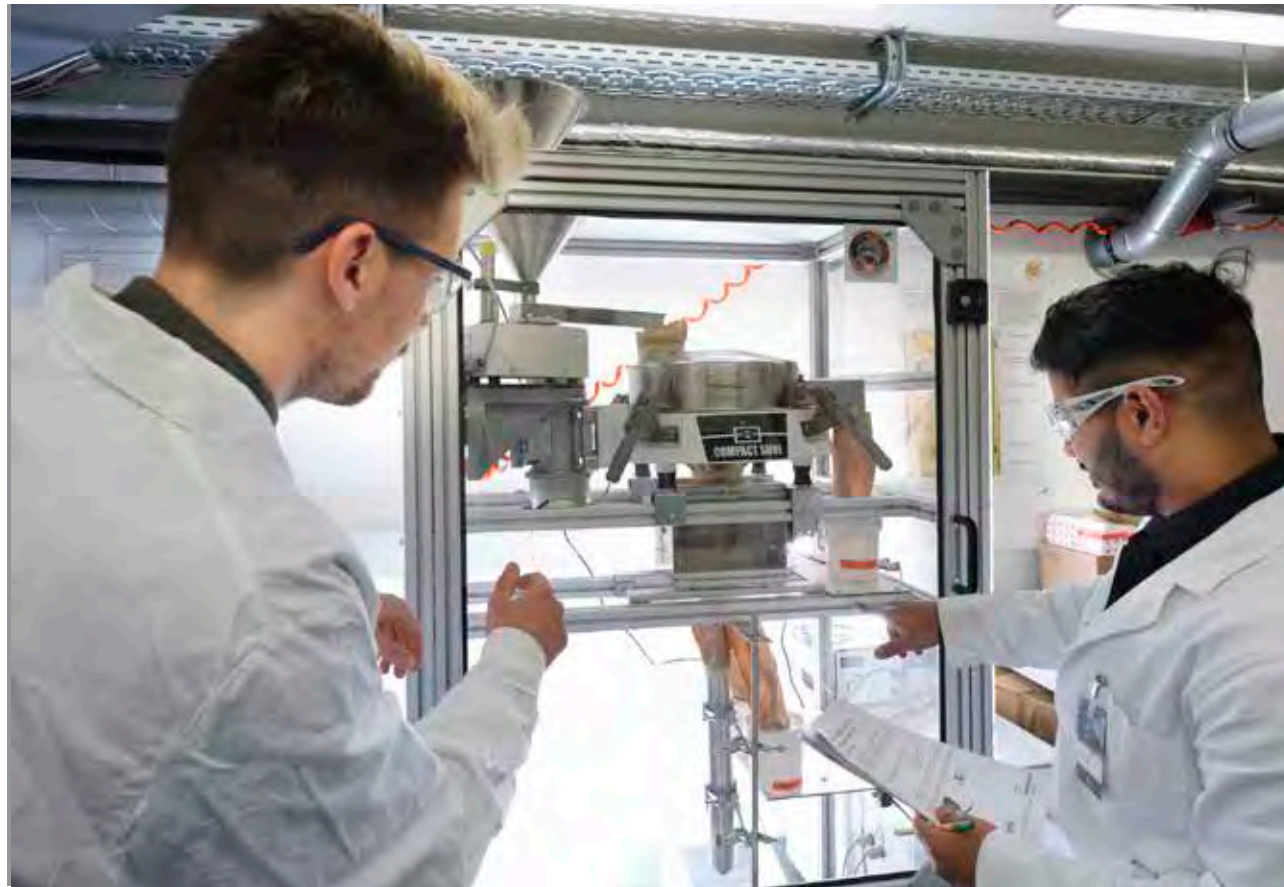


EDEN Mission Control at DLR Bremen

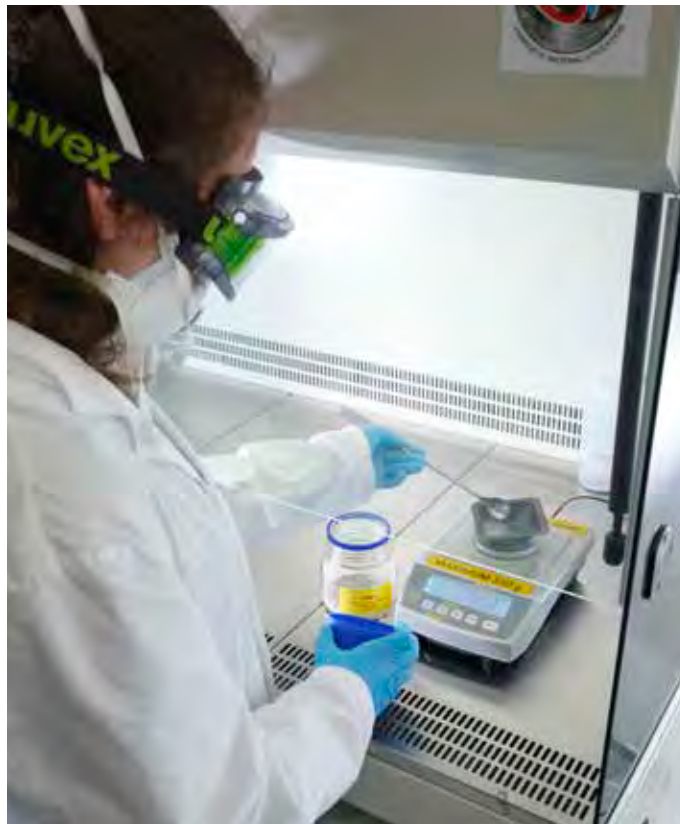
EDEN LUNA will be operated from EDEN Mission Control at DLR Bremen



EDEN LUNA preliminary operations system architecture; mission control center (DLR HB), EDEN LUNA (former EDEN ISS), New EDEN system elements robotic arm and nutrient generation filter system



Students working on the beneficiation test stand



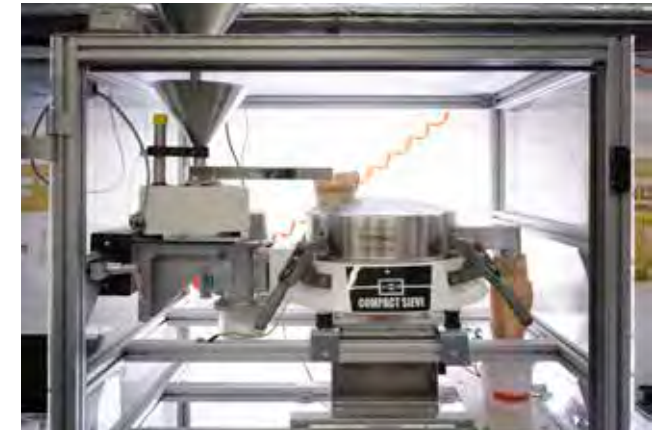
Student preparing the Lunar dust simulant dissolution for experiments



Vibratory feeder of the beneficiation test stand



Students preparing test setup for experiments



Gravitational beneficiation stage



Regolith beneficiation test stand



Tested samples collected for analysis

REGOLITH BENEFICIATION

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Beneficiation constitutes a major intermediate step in the domain of In-Situ Resource Utilization (ISRU). It involves activities such as size sorting or mineral enrichment to create a higher-grade feedstock by separating the target mineral from the residuals. Although an essential part of ISRU, beneficiation as a research area has often been overlooked, while the attention of the scientific community has been mainly focused on the preceding and subsequent steps, i.e., excavation and extraction. In 2022, the laboratory-scale multi-stage lunar regolith beneficiation test setup has been built with the goal of producing an ilmenite-rich feedstock for subsequent oxygen and metal extraction processes. This setup comprises multiple different processes such as vibratory sifting, magnetic separation, and electrostatic separation. By December 2022, the first experiments with the setup have been started with Lunar simulants, developed at the Technical University of Berlin as part of a student Master's Thesis.

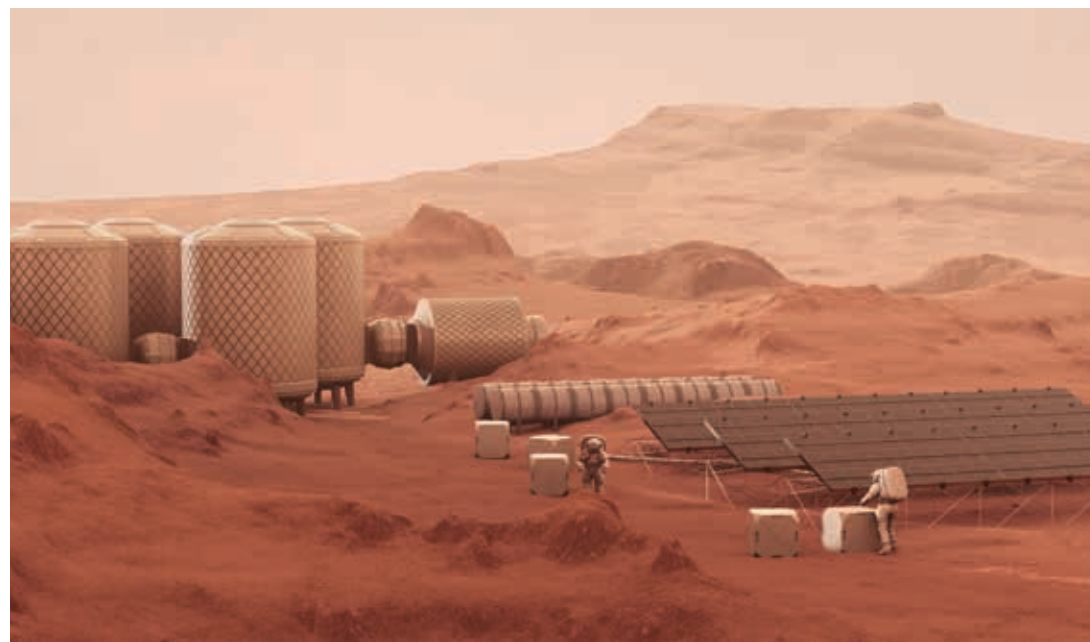


The Humans on Mars Initiative kick-off workshop at the Haus der Wissenschaft (House of Science) in Bremen, June 2022

HUMANS ON MARS

PROJECT TO ENABLE BIOPRODUCTION ON MARS

“Setting the ground for sustainable bio-production in a Martian settlement” is the title of the seed project organized within the University of Bremen Humans on Mars Initiative in collaboration with the Planetary Infrastructures team. The focus of this new three-year project is to analyze different options that combine cyanobacteria, microbial electrochemical systems (MES), and higher plants. After returning from Antarctica, Jess Bunchek began her PhD studies on the project. Proposed experimentation will incorporate the PRIVA Nutribatch system, testing of new irrigation technologies for improved application coverage, and water use efficiency (e.g. advanced Aeroponics), and integrate nutrient stock solution produced by the cyanobacteria and MES in an effort to achieve a more closed-loop crop production system. The project was first presented at the MAPEX “Humans on Mars” kick-off event in July 2022. The initiative comprises several seed projects, all investigating essential aspects of a long-duration presence on Mars. The results of the different seed projects will pave the way for the Excellence Initiative proposal of the University of Bremen in the coming years.



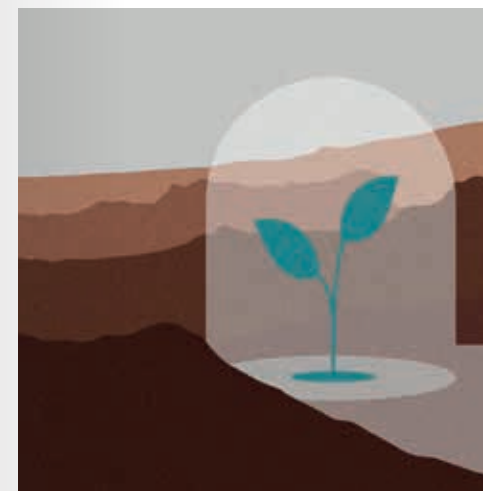
Martian settlement rendering, MAPEX Humans on Mars Initiative



L to R: Dr.-Ing. Bernd Scholz-Reiter, Dr. Claudia Schillig and Kurosch Rezwan at the kick-off Meeting Humans on Mars



Humans on Mars Initiative – Bioproduction on Mars project team; from L to R: Daniel Schubert, Tiago Romalho, Cyprien Verseux, Sven Kerzenmacher, Jess Bunchek, Guillaume Pillot



SUSTAINABLE BIOPRODUCTION ON MARS



MATERIALS TO HARVEST ENERGY FROM SPACE RADIATION



EXTRATERRESTRIAL FABRICATION OF METAL ALLOYS



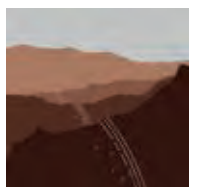
PRODUCTION WITH IMPURE MATERIALS



THE LIVING HABITAT



SHIFTING EXPERIENCES, NEW INTERACTIONS



HUMAN INTEGRATED SWARM EXPLORATION



Humans on Mars Initiative project leader Dr. Christiane Heinicke at the kick-off workshop in June 2022

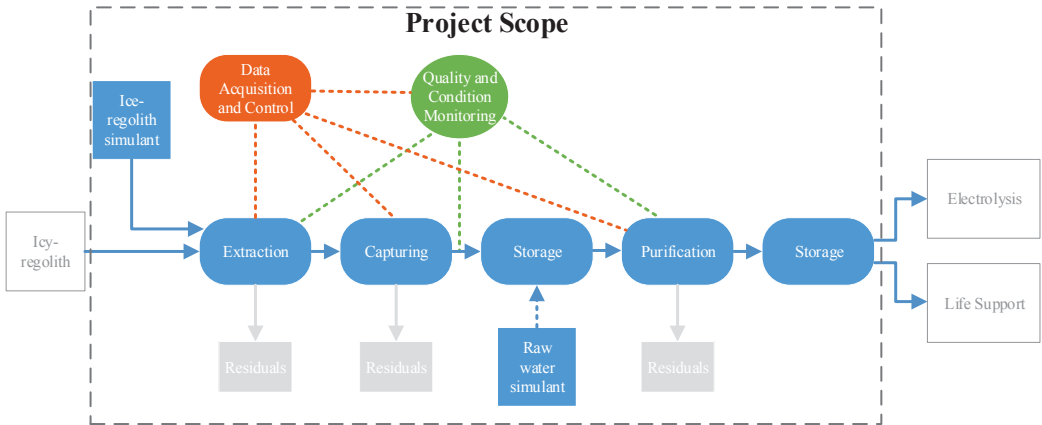


Screenshot of the virtual LUWEX kick-off meeting with the team and all LUWEX partners

LUWEX

ENABLING WATER MINING & PROCESSING ON THE MOON

The project LUWEX (Validation of Lunar Water Extraction and Purification Technologies for In-Situ Propellant and Consumables Production) started in November 2022 with the goal of developing and validating ISRU technologies for the Moon. Among the resources available on the Moon, water is the most versatile and most needed in space exploration. Water can be directly used as consumable for astronauts or electrolyzed to hydrogen and oxygen, a very effective rocket propellant combination. Therefore, LUWEX aims at the development and validation of a complete in-situ water process chain including water extraction, purification and quality monitoring. During the project, an integrated test setup will be built to validate the operational capabilities of these technologies and also of the whole process chain. This setup will deliver a realistic environment analogue to the lunar surface and will use a lunar dust-ice simulant to provide proper validation conditions to raise the TRL of all subsystems and the whole process chain to level 4/5. LUWEX is funded by the European Commission through the Horizon Europe framework program with the grant number 101081937. The Planetary Infrastructure team is leading the consortium. The consortium comprises of large space industry (Thales Alenia Space Italia), SMEs (Liquifer Systems Group, Scanway), and academia (Technical University of Braunschweig, Wroclaw University of Science and Technology), coming from four European countries (Germany, Italy, Austria, Poland).



The project scope of the LUWEX experiment. It includes everything from extraction to purification.



An AI generated concept art, envisioning the idea behind LUWEX (Credits: Monika Brandic Lipinska, LSG)



Paul Zabel, Luca Kiewiet and Rieke Freer celebrating the award of the EU-funding for the LUWEX project

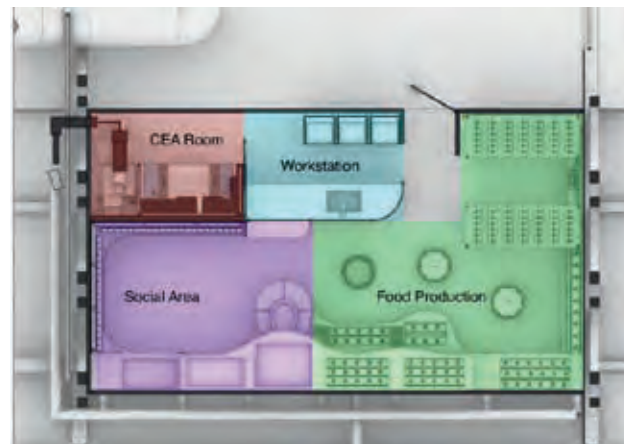




EDEN 2 CE Study Team (L to R): Michael Nacke, Maximilian Botta, Svenja Fälker, Jess Bunchek, Jakob Axthelm, Daniel Schubert, Jan Mattfeld, Vincent Vrakking, Peter Köhler, Thomas Matz, Kyunghwan Kim.



Michael Nacke and Jan Mattfeld of the TU Dresden working on the EDEN 2.0 design



Overview of the EDEN 2.0 greenhouse functional areas

EDEN 2.0

DESIGNING THE FUTURE ANTARCTIC GREENHOUSE

While EDEN ISS is scheduled to return to Germany in early 2023, preparations are already underway for the next Antarctic greenhouse. Early discussions between DLR and AWI foresee the possibility to integrate an advanced greenhouse inside Neumayer Station III for food production, psychological investigations, and further technology testing. Lessons learned from the five years of Antarctic greenhouse operation shall be incorporated into the new design.

The early Phase-A design of the greenhouse, called EDEN 2.0, was developed during two design workshops inside the CEF at DLR Bremen in September and October of 2022. Students from the Technical University Dresden, together with the Planetary Infrastructures team and the Neumayer Station III technical coordinators, prepared various concepts. Following a trade-off between the different options, a preliminary design of the subsystems and the overall layout of the greenhouse was developed. The preliminary design not only allows for a large amount of fresh food production during the Antarctic summer seasons but can also be re-configured to provide social and private areas during the winter season to promote the psychological well-being benefits of plants in an isolated, confined, and extreme environment such as Antarctica.



Daniel Schubert presenting during the EDEN 2.0 workshop



The Neumayer-Station III of the Alfred-Wegener-Institut in Antarctica, the future home of EDEN 2.0 greenhouse



One of many splinter meetings carried out during the EDEN 2.0 workshop



A well-deserved lunch break during the EDEN 2.0 workshop



An artist impression of the EDEN 2.0 production area



A rendering of the EDEN 2.0 plant cultivation racks



A view of the EDEN 2.0 Service Section



A relaxing green oasis in the EDEN 2.0 social area



Top view render of the EDEN 2.0 greenhouse



EDEN NEXT Gen CE Study Kick-off presentation



Pizza for everyone to keep energy and spirits high



NRC, CSA and DLR experts during one of many splinter meetings

EDEN NEXT GENERATION

DESIGNING THE LUNAR AGRICULTURAL MODULE

From 12-15 September 2022, the EDEN Next Generation Ground Test Demonstrator design study took place at DLR Institute of Space Systems. The study represented a true kick-off for the new greenhouse test platform. Further, the design study provided a good team-building situation for the entire team and a common understanding of the system and mission goals. Since the team included experts from four DLR institutes – the Canadian Space Agency (CSA), the Canadian National Research Council (NRC), NASA KSC, and the DLR R&D programmatic team – it was crucial to meet in person and via hybrid options in the DLR CEF. During the design study, concept and trade-off analysis were conducted focusing on technologies like the nutrient delivery system, atmosphere management system, illumination control system, plant health monitoring, and data handling & control system. New elements to the EDEN core technology represent the inchworm robotic manipulator, the waste management system C.R.O.P., and the data risk mitigation applications. Further, elements like cost, health & safety risks, and human factors were discussed and captured in the resulting system requirements.



Domain experts working during the EDEN NEXT Gen study

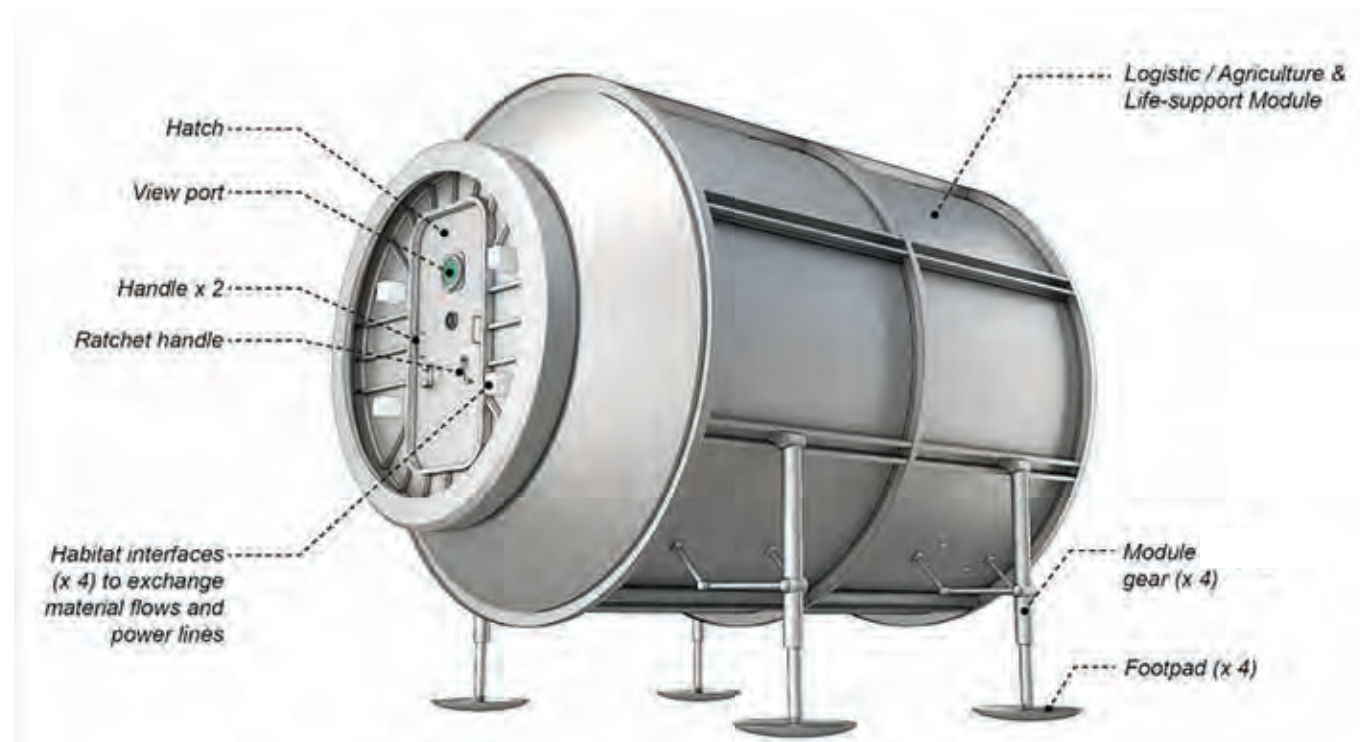


Kim Kyunghwan and Vincent Vrakking discussing the EDEN NEXT Gen design

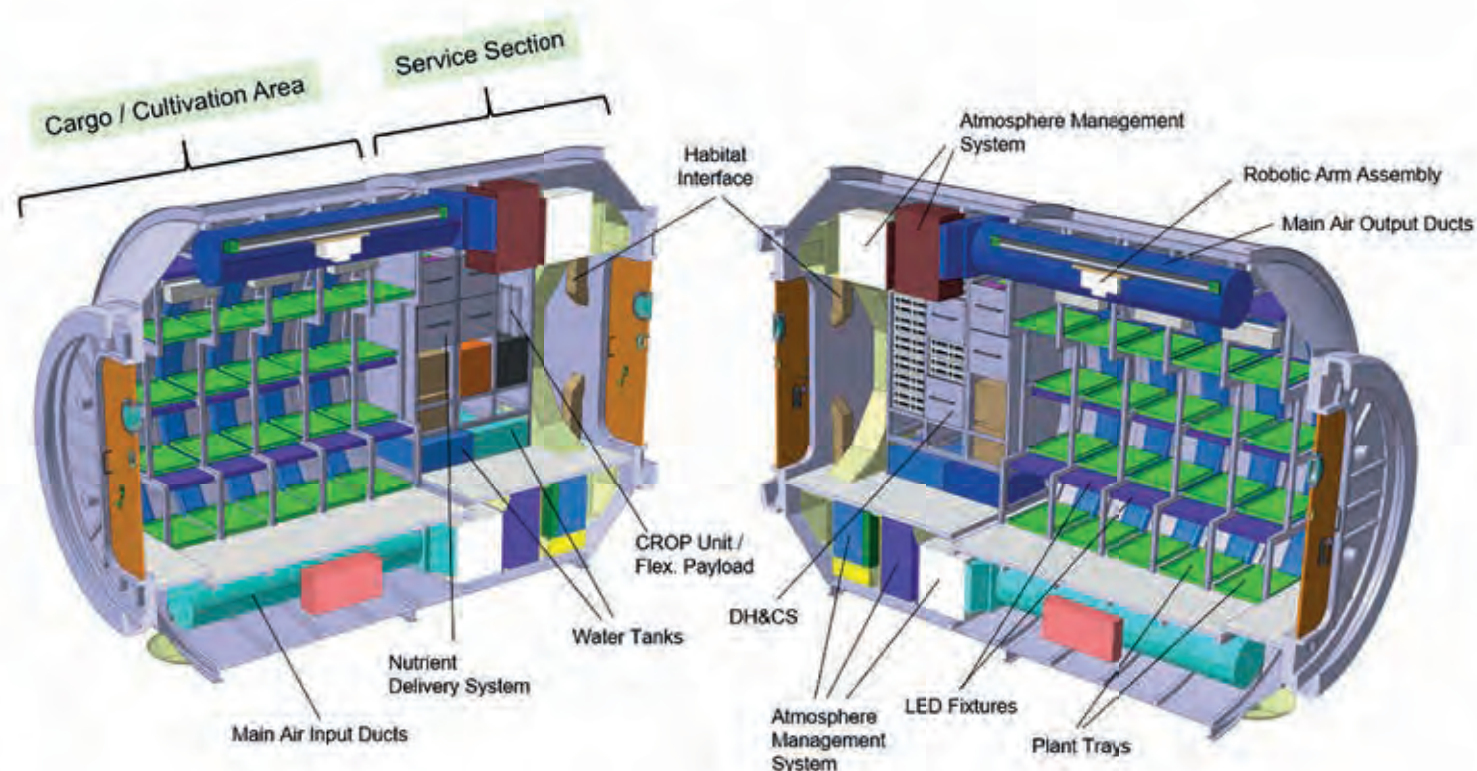


The EDEN NEXT Gen study team





A render of the EDEN NEXT Gen greenhouse structure



Section views of the EDEN NEXT Gen greenhouse CAD model



Signing of the Letter of Intent (LoI) between DLR and CSA at the International Aeronautical Congress (IAC) in Paris. From left to right: Lisa Campbell, Anke Kaysser-Pyzalla, Anke Pagels-Kerp, Andreas Rittweger.



Lisa Campbell, Anke Kaysser-Pyzalla and Anke Pagels-Kerp signing the Letter of Intent between CSA and DLR.

CSA-DLR COLLABORATION

PAVING THE ROAD FOR A FRUITFUL FUTURE

With a long history of collaborative projects with Canadian industry and universities, the argument to tie in the Canadian partners to a combined international development effort for the Lunar Agricultural Module Testbed was obvious! Since 2020, several MOU exchanges, and personnel staff exchanges prepared the partnership along with DLR's and CSA's roadmap on future human exploration activities. Canada's strategic vision on Lunar food production will play a prominent role in the future global R&D program. Canada intends to advance in incremental Lunar missions the science, engineering, and training to develop the mission critical skills, technologies, and design requirements required to contribute to a safe, reliable, and nutritious Lunar food supply by 2035.

An important milestone was reached at the International Astronautical Congress (IAC) in Paris when the Letter of Intent (LoI) was signed between DLR and CSA on the combined development of Lunar Agricultural Module – Ground Test Demonstrator. Lisa Campbell (President of CSA), and Anke Kaysser-Pyzalla (Chair of the DLR Executive Board), signed the agreement. With this strong bi-national partnership both teams (CSA & DLR) are now prepared to move forward by working on the technical and organizational aspects of the combined work distribution.



FURTHER HIGHLIGHTS

MORE HAPPENED DURING THE YEAR – FIND OUT WHAT:



Botanika exhibition “plants in space”

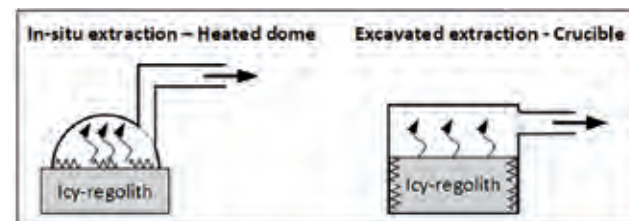
WATER EXTRACTION EXPERIMENT

In preparation of the LUWEX water extraction and purification experiment, a trade-off analysis was performed in order to select the most promising concept for future water extraction. Two interns, Niklas and Franco, performed a study and found that excavating icy-regolith and placing it into a reaction chamber yielded better results than extracting the water in-situ. This result will pave the way for the future design of Lunar water resource utilization.



BOTANIKA FINAL PRESENTATION

In spring 2022, the official final presentation of the outreach project Orbital Fruits was conducted. The team of DLR, Botanika, and Bock BioScience presented their final results and project evaluations. Although the third-party funded project comes to an end, the joint-organized exhibition at the Botanika remains open to the public, displaying the overall topic of “Plants in Space”.



Designs for water extraction methods which are investigated in the trade-off study



Rieke Freer experimenting in the laboratory with the glovebox of the department of Radiation Biology at the DLR Cologne

GLOVE BOX EXPERIMENT

The leaching experiments to study the behavior of the Lunar regolith simulants in aqueous solutions were repeated in a nitrogen glovebox to mimic the lack of atmosphere on the Moon. Moreover, the dissolved oxygen in the solution was removed by bubbling the solution with nitrogen and carbon dioxide. The department of Radiation Biology at the DLR Cologne (Institute of Aerospace Medicine) provided their laboratory with the glovebox and their expertise.



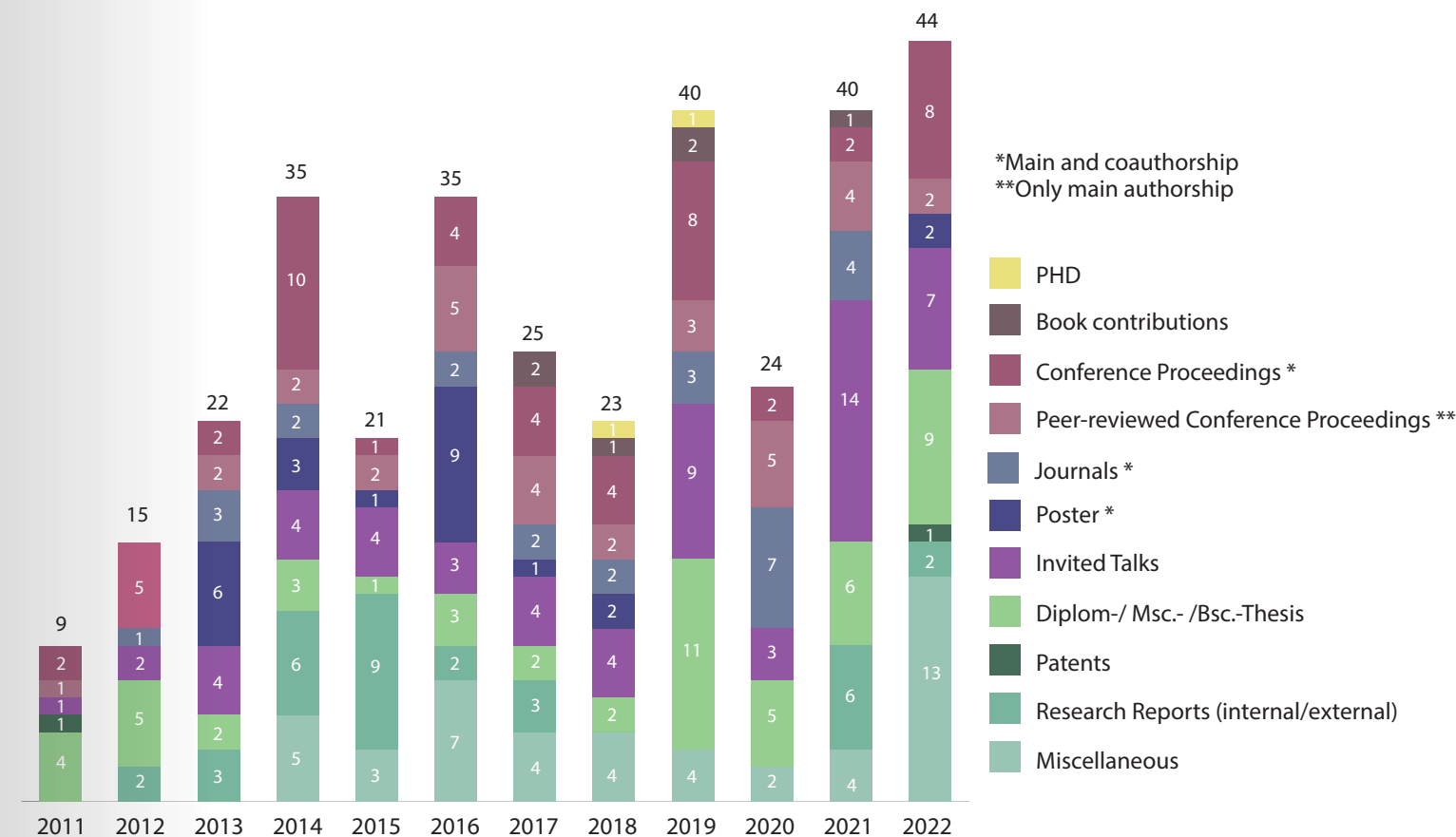
Experiment regarding the use of mealworms within future life support systems

MEALWORMS IN SPACE

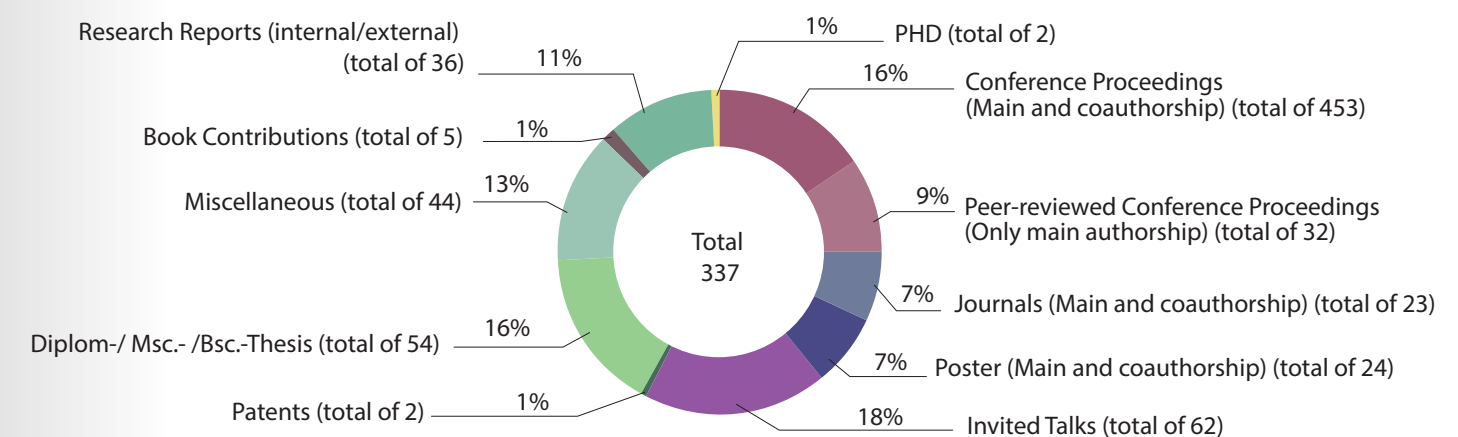
Guest scientist Christian Schnorr continued his investigations regarding use of mealworms within future life support systems. Studies with different proportions of root mass have been concluded, showing that low proportions of root mass are optimal for growth as well as feed utilization. In order to fully substitute wheat bran, other side streams that occur in current BLSS are identified and will be used to formulate a diet for future cultivation of mealworms in space.

SUMMARY KEY FIGURES

PUBLICATIONS & KEY FIGURES 2011-2022



TOTAL PUBLICATIONS & KEY FIGURES 2011-2022



KEY FIGURES - 2022

NORMAL CONFERENCE PROCEEDINGS/ PRESENTATION

Zabel, P., Freer, R., Kiewiet, L.: „Synergetic Material Utilization - ISRU developments at the DLR Institute of Space Systems“, Space Resources Week, Luxembourg, 03-05 May, 2022.

Verseux, C., Ramalho, T.P., Bunchek, J., Schubert, D., Pillot, G., Kerzenmacher, S.: Setting the ground for sustainable bioproduction in a Martian settlement, 44th COSPAR Scientific Assembly, 16.07.- 24.07. 2022, Athens Greece Session: F4.1-0012-22

Bunchek, J., Schubert, D., CEA in Space (and Time), 13. HEF Symposium - DAFA-Platform Controlled Environment Agriculture, 29.9.2022, Hans-Eisenmann-Forum, Technical University Munich, Munich

Schubert, D.: Ground-based Demonstrator for the first space-ready Lunar Agricultural Module, MELiSSA Conference, Toulouse, France, 8.11- 9.11. 2022

Kiewiet, L., Hab, N.M., Marchese, F.M., Freer, R., Zabel, P.: „Trade-off and optimization for thermal lunar water extractor“ IAC, Paris, 18-22 September 2022.

Hummerick, M., Gooden, J., Spencer, L., Bunchek, J., Torres, J., Khodadad, C., Spern, C., Schubert, D., Zabel, P., Vrakking, V., Dorn, M., Fritsche, R., Wheeler, R., (2022) Microbiology of the EDEN ISS Greenhouse and crops during the 2021 overwintering season. 38th ASGSR, 9-12 November 2022, Houston, Texas, USA

Schubert, D., Maiwald, V, Vrakking, V., Philpot, C., Dorn, M., Kyunghwan, K.: „Ground-based Demonstrator for the first Space-ready Lunar Agricultural Module“, MELiSSA Workshop, 8.11.-10..11.2022, Toulouse, France

Schubert, D.: „EDEN ISS: Analogue Testing of Plant Cultivation for Space“, Session Functional Foods and Bioactive Compounds, 22nd IUNS-ICN, International Congress of Nutrition, 6.-11. 12 2022, Tokyo, Japan

PEER-REVIEWED CONFERENCE PROCEEDINGS

Vrakking, V., Zabel, P., Schubert, D., Dorn, M., Bunchek, J., „Summary of Research and Outreach Activities during the 2021 Season of the EDEN ISS Antarctic Greenhouse“, 51st International Conference on Environmental Systems, St. Paul, Minnesota, USA, July, 2022

Zabel, P., Vrakking, V., Zeidler, C., Schubert, D.: „Energy and Power Demand of Food Production in Space based on Results of the EDEN ISS Antarctic Greenhouse“, 51st International Conference on Environmental Systems, St. Paul, Minnesota, 10-14 July, 2022.

INVITED TALKS

Zeidler, Conrad (2022) Controlled Environment Agriculture in Space. Seminar zum Thema Technologies in Space, University - St. Gallen; 05.10.2022, Online.

Schubert, D.: EDEN ISS - Analogue Testing of Plant Cultivation Technologies for Space, Institute of Space Systems, University of Stuttgart, 01.06.2022

Schubert, D.: EDEN ISS - Analogue Testing of Plant Cultivation Technologies for Space, Space Architecture Workshop, International Space University (ISU), Strassbourg, France, 27.04.2022 (online)

Schubert, D.: EDEN ISS - Analogue Testing of Plant Cultivation Technologies for Space, Association for Vertical Farming, Vertifair 2022, Dortmund 27.-28.09.2022

Schubert, D.: „EDEN ISS: Analogue Testing of Plant Cultivation for Space“, Carl Schurz Auditorium, German Embassy Washington, 6.12. 2022, Washington, USA

Schubert, D.: „EDEN ISS: Analogue Testing of Plant Cultivation for Space“, Canadian Museum of Nature, Space Event – German Embassy, 7.12.2022, Ottawa, Canada

Bunchek, J.: „Summary of Research Activities during the 2021 Season of the EDEN ISS Antarctic Greenhouse“, University of Arizona, Controlled Environment Agriculture Center (CEAC), 30.11.2022, Tucson, Arizona, USA

DIPLOM-/ MSC.-/ BSC.-THESIS

Kuhr, L.: „Implementation of in-situ Plant Health Visualization for Controlled Environment Agriculture using Microsoft HoloLens 2“ Masterarbeit, Technische Universität Braunschweig, 2022

Baylan, A.: „International Project EDEN ISS - Eine Fallstudie über Organisation, Chancen und Herausforderungen der strategischen Wissenschaftskommunikation in DLR – NASA Kooperation“, University of Bremen, 2022.

Klug, M.: „Nutzung der HoloLens 2 für die Pflanzenerkennung und Augmentierung im Kontext des EDEN ISS Weltraumgewächshauses.“, University of Bremen, 2022.

Korth, T.: „Redesign of the Condensate Water Recovery Subsystem of the EDEN ISS greenhouse based on operating experiences.“ Technical University Dresden, 2022.

Bellido Rosas, A.: „Design of the Command and Data Handling System for a Controlled Environment Agriculture System“, University of Applied Sciences Fulda, 2022.

Hab, N.M: „Modelling and Simulation of a Lunar Water Extractor for ISRU. Diplomarbeit“, Technical University Munich, 2022.

Hansonis, M.: „Concept study on the potential extraction of nutrients for algae and plants on the surface of Mars“, University of Stuttgart, 2022.

Franke, M.: „Development of a Testbed for the Beneficiation of Lunar Regolith - Concentrating an Ilmenite-Rich Feedstock for In-Situ Oxygen Production on the Moon“, University of Bremen, 2022.

Blomqvist, T. A.: „Possible nutritional output of rapid-deployable CEA greenhouses for Emergency Scenarios.“, Swedish University of Agricultural Sciences, 2022.

INTERNAL/ EXTERNAL RESEARCH REPORTS

Vrakking, V., Bunchek, J., Schubert, D., Zabel, P., Zeidler, C., Dorn, M., Ferl, R., Paul, A. (2022) EDEN ISS. Chapter in Expeditions to Antarctica: ANT-Land 2021 / 22 Neumayer Station III, Kohnen Station, Flight Operations and Field Campaigns Reports on Polar and Marine Research

Bunchek, J., Hummerick, M. (2022) 2022 EDEN ISS Antarctic Greenhouse Project Report. NASA Environmental Controls and Life Support-Crew Health and Performance System Capabilities Leadership Team (ECLSS-CHP SCLT)

MISCELLANEOUS

Kiewiet, L.: Scientific Advisory Board member of MIRAGE-project about Martian water extraction and methane production together with Astronika, 2022

Kiewiet, L.: Review activitiies for CEAS Space Journal article, 2022

Schubert, D.: Member of the Scientific Advisory Board, Association for Vertical Farming (AFV)

Philpot, C.: Member of the Technical Reviewer Committee of the International Space Station RD Conference

Vrakking, V.: Review activities for paper submission of the 51st International Conference on Environmental Systems (2022)

Zeidler, C.: Review activities for paper submission of the 51st International Conference on Environmental Systems (2022)

Dorn, M.: Review acitivities for paper submission of the 51st International Conference on Environmental Systems (2022)

Zabel, P.: „Member of the ICES International Committee and co-chair of session 204 ‚Bioregenerative Life Support‘.

Zabel, P.: Reviewer for Frontiers in Physiology, 2022.

Zabel, P.: Reviewer for CEAS Space Journal, 2022.

Schubert, D., Zabel, P.: „Human Space Exploration & Habitation“,

Lecture, Elective module, Space Master, SoSe2022, University of Bremen

Schubert, D.: „Bemannte Weltraumexploration & Habitate“, Training couse, Concurrent engineering study, Studium Generale, SoSe2022, Technical University of Dresden

Schubert, D.: „Astronautische Weltraumexploration & Habitate“, Lecture, Studium Generale, WiSe2022/ 23, Technical University of Dresden

POSTER

Freer, R., Kiewiet, L., Zabel, P.: „System Analysis of a shared water-hydrogen-oxygen infrastructure for future space habitats“, Space Resources Week, Luxembourg, 03-05 May, 2022.

Kiewiet, L., Freer, R., Zabel, P.: ‚Trade-off and optimization for Lunar water extraction“, Space Resources Week, Luxembourg, 03-05 May, 2022.

PATENTS

Schubert, D.: „Mobile entfaltbare Pflanzenanbaueinheit und Verfahren zum Betreiben dieser Pflanzenanbaueinheit“, Patent no.: DE 10 2018 008 772.8, (supplement from 2018)

THE STUDENTS OF PLANETARY INFRASTRUCTURES

Without the assistance and help of highly-motivated students, the success of Planetary Infrastructures group would not have been possible! See below what the student's tasks were and what they are doing now:



NIKLAS HAB has studied aerospace engineering at the TU Munich. During his Master's Thesis at DLR within the SMU group he designed and modelled several thermal water extraction methods on the moon for ISRU. With the help of the simulation results, he also conducted a trade-off to assess and optimize different methods in regard to certain water mining scenarios.



TOM KNIJNENBURG is studying "Sustainable energies and environmental technologies" with a focus on water treatment in Bremerhaven. He joined the "Synergetic Material Utilization" (SMU) group in Bremen on the 16.05.22 for his study internship. Therefore, he can use his knowledge of water treatment for the moon now.



TOR BLOMQVIST studied Agronomy - Food Science at the Swedish University of Agricultural Sciences. During his Master's thesis at the EDEN group, he worked on the potential of MEPA as a food production system for humanitarian food aid scenarios. The research investigated the application of MEPA and involved a proposal of new metrics measuring the nutritional quality of the potential output.



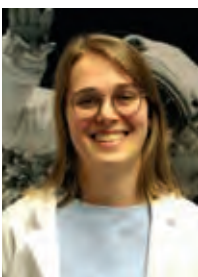
TOBIAS KORTH studied mechanical engineering at the TU Dresden. In his Diplom thesis, he developed a redesign of the condensate water recovery system of EDEN ISS based on the lessons learned from past operation. Featured are a new antimicrobial concept and better redundancy and accessibility. The redesigned system is planned to be integrated into the updated EDEN LUNA greenhouse.



KIM KYUNGHWAN is a space architect and student in the Master of Space Studies program (MSS) at the International Space University (ISU) in France. During his internship at DLR, he carried out designs for the lunar greenhouse system and the EDEN NEXT GENERATION project. For the EDEN 2.0 project, he investigated the human factors, including the psychological aspect of an adaptable greenhouse system.



AYLIN BAYLAN studied Media and Communications at the University of Bremen. In the course of her Bachelor's thesis with the EDEN Team, she analyzed the organization, opportunities and challenges of the strategic science communication in the EDEN ISS project within the DLR-NA-SA cooperation. The thesis examines the internal, international team-communication regarding the external, strategic PR work of the project.



ISABELL WITTEKIND is a student pursuing a Master's degree in space engineering at the University of Bremen. After finishing her one-year master project in 2022, she started her thesis on an analysis and design of a logistic-to-green approach for a lunar greenhouse module within the EDEN Next Generation Ground Test Demonstrator project.



ANNIKA FLECHSIG studies Space Engineering at the University Bremen. She joined the EDEN team as a student assistant in January 2022 and is currently writing her Master thesis on the EDEN Next Gen greenhouse module. The focus of her thesis is set on the further development of the Atmosphere Management System of the module.



VICTORIA PESCH joined in October 2022 and is experimenting with lunar regolith simulant at the DLR Bremen Synergetic Material Utilization (SMU) group to complete her Master's degree in Aerospace Technologies at the City University of Applied Sciences in Bremen. She programs a measurement and control system for a lunar water purification system as part of her thesis "Experimental Development of a Lunar Water Simulant and System Control of a Related Lunar Water Purification System".



KUNAL KULKARNI is a Space Engineering student at the Technical University of Berlin. He joined the Synergetic Material Utilization team at DLR Bremen as a student assistant in October 2022 and is working on the lunar regolith beneficiation test stand developed earlier. He is writing his Master's thesis on the topic of "Optimization of lunar regolith beneficiation for the production of an Ilmenite-rich feedstock."



CHRISTOPH KALIS studies aerospace engineering with the focus on spaceflight at Delft University of Technology. In November, he joined the SMU group and started his literature study about the state and extraction methods of Lunar water. This serves as a preparation for his Master's thesis "Modelling and Simulation of a Lunar Water Capturing Device" with the aim to build a prototype in summer 2023, as part of the LUWEX project.



MART HEITKAMP is an intern within the Luwex project. At the University of Twente, located in Enschede, Mart is pursuing a Master's degree in Mechanical Engineering. Regarding the Luwex project, his responsibility is to further develop the actual design. Moreover, designing an experiment and testing the prototype will be one of the challenges during his six-monthly period at DLR.



ANURAG MOHANAN THEVAR PARAMBIL is pursuing his master's in Control Microelectronics and Microsystem (CMM) at the University of Bremen. In the EDEN team, he is working on his Master's thesis - 'Control and Data Handling System for MEPA plant cultivation unit'. He is involved in setting up the prototype, testing and further development of the MEPA project.



FRANCO MARIA MARCHESE studies Space Systems Engineering at TU Delft. He joined the Synergetic Material Utilization group, where he worked on Lunar In-Situ Resource Utilization. Focus of his analysis was the trade-off and optimization of thermal water extraction systems, the objective being production of a compelling preliminary design that could serve as baseline for prototype testing.

IMPRESSIONS 2022

SEE WHAT ELSE HAPPENED DURING THE YEAR...



Claudia Philpot and Isabell Wittekind at the VertiFarm trade fair 2022



Daniel Schubert presenting at the VertiFarm trade fair 2022



Daniel Schubert during VertiFarm at panel discussion



Team at the VertiFarm trade fair 2022 (L to R): Isabell Wittekind, Kim Kyunghwan, Daniel Schubert, Karthi Savundarajan, Claudia Philpot



Daniel Schubert presenting at the MELISSA conference in Toulouse



Meeting old friends at MELISSA conference



Live Herzberg Network Event "Space Talk", hosted by the Embassy of the Federal Republic of Germany in Ottawa: (L to R) Volker Schmid (German Space Agency at DLR, Mission Manager Cosmic Kiss), Aram Kerkonian (Adjunct Professor, University of Ottawa), Daniel Schubert (Research Cluster Leader, Planetary Infrastructures, DLR), Sabine Sparwasser (Ambassador to Canada of the Federal Republic of Germany), Isabelle Tremblay (CSA Director, Astronauts, Life Sciences & Space Medicine), Marc Jochemich (Head Washington Office of the DLR), Mary Preville (Vice-President, Director Space Program Policy, CSA), Ian McLeod (MDA, Vice President, Corporate Development), Éric Laliberté (Associate Director General, Vice-President Science & Technology Office), Renée Filiatrault (Fellow Canadian Global Affairs Institute).



Students and PhD candidate at the International Astronautical Congress 2022 in Paris



Freezers with the return science samples from the 2021 EDEN ISS Antarctic campaign packed and prepared for transport from Neumayer Station III to the ship for transit to Bremen



From L to R: Timo Dornhoefer, Linda Ort, and Jess Bunchek harvesting Mizuna mustard during their overwintering campaign



Jess Bunchek back at DLR Bremen after completing her 14-month Antarctic overwintering campaign



Kim Kyunghwan and Luca Kiewiet harvesting cucumbers in the EDEN Laboratory



Karthi Savundararajan and Markus Dorn preparing the MEPA outdoor integration tent



Karthi Savundararajan and Markus Dorn unpacking components for the MEPA tent



Karthi Savundararajan and Markus Dorn assembling the MEPA tent



Priva colleagues helping out in the CEA control room

IMPRESSIONS



Harvest tray with purslane plants grown on MEPA's SCM



Tor Blomqvist monitoring growth experiments in the laboratory



Kids from the School Lab visiting the EDEN Lab

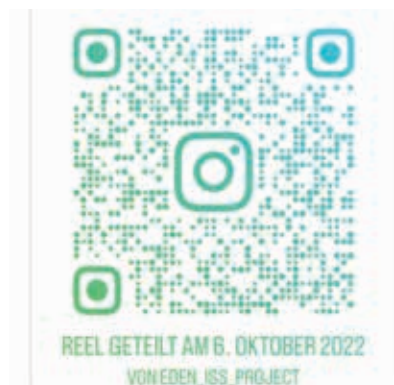
IMPRESSIONS



Thermal vacuum chamber which will be used for the LUWEX water extraction and capture experiment



MEPA integration tent under construction



Scan QR codes to find our social media content!



Barbecue event with the Planetary Infrastructures team at the DLR institute in Bremen

IMPRESSIONS



Planetary Infrastructures students preparing the barbecue for lunch



Vincent Vrakking and Kim Kyunghwan toasting at dinner afterwork



Office selfie of guest scientist Jared Stoochnoff with Vincent Vrakking and Daniel Schubert



Planetary Infrastructures team event after work



Michael Trautmann was member of the 42. overwintering mission at the Neumayer-Station III of the AWI in Antarctica. Besides his profession as an electrical engineer, he is a passionate photographer. During his 12-month stay he took advantage the overwhelming nature of Antarctica for new inspiration and photo projects. We sincerely thank Michael for the stunning photographs he took during his overwintering of EDEN ISS. On the following pages you can see some of many impressive shots Michael sent us. For more impressions of his work in Antarctica please find his Instagram: [_michaeltr.](#)



View of EDEN ISS and the stunning Milky Way during new moon in blue light



View of EDEN ISS and the stunning Milky Way during new moon in rose light

Overwinterer during Antarctic storm on his way from EDEN ISS to Neumayer III



EDEN ISS greenhouse in sunset light before polarnight

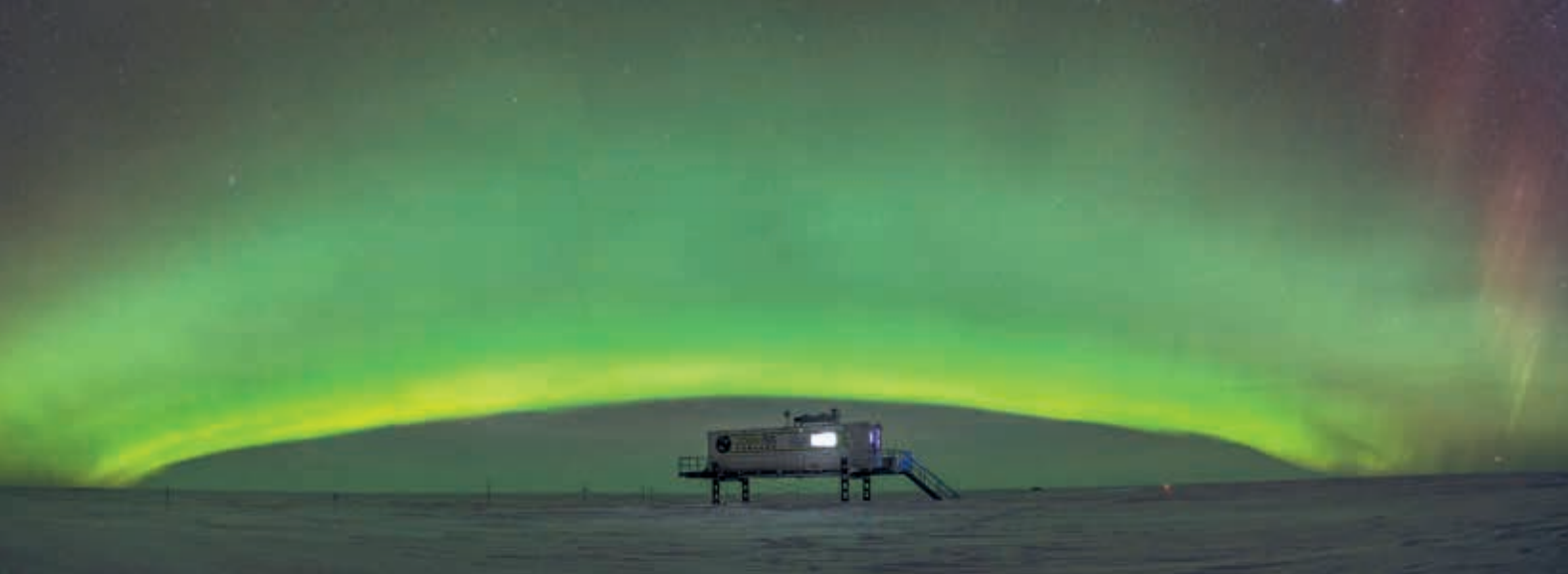


Polarnight ends in Antarctica





EDEN ISS in bright, full moonshine during Polarnight in August



Panoramic view of the EDEN ISS greenhouse in green polar light



EDEN ISS with Neumayer Station III in the background



View of the ice layers on which EDEN ISS is placed



Artistic Illustration of the EDEN ISS greenhouse in sunlight



EDEN ISS in colorful polar lights during Polarnight in Antarctica



Buffet at the Planetary Infrastructures christmas party in December 2022



Colleagues chatting at the christmas party in the laboratory



Cooling the juice for the christmas party

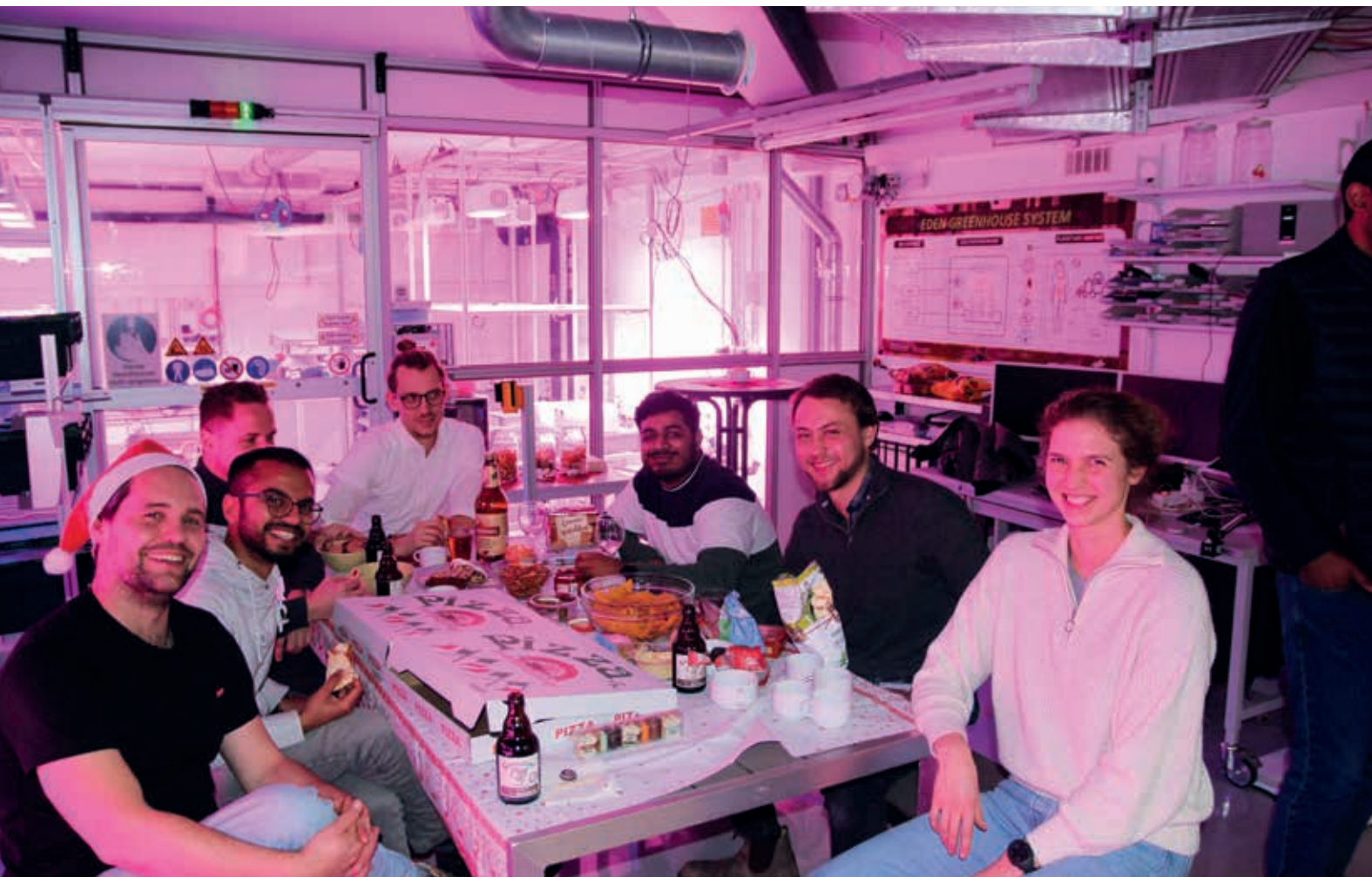


Student chat at the buffet of the christmas party



Students preparing drinks for the get-together

Team gathering at the christmas party in the EDEN Laboratory, December 2022



DLR at a glance

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

DLR has approximately 8000 employees at 20 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Bremerhaven, Dresden, Goettingen, Hamburg, Jena, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Oldenburg, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

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