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HIGHLIGHTS 2020

YEARLY STATUS REPORT
EDEN INITIATIVE

DLR

Cover: Young radish plants in the EDEN ISS greenhouse in Antarctica.

Skidoo transport of fresh water to the EDEN ISS MTF

EDEN – THE YEAR 2020

What a year, what a year! Who would have thought this?! The year 2020 marked the beginning of a global pandemic that impacted all areas of social- and professional life. Beginning of mid-March, DLR went into a complete lock-down, followed only by partial reopening during summer, entering a soft lock-down again in winter 2020.

Although these extreme circumstances were not favourable, the operation of the EDEN ISS facility in Antarctica continued successfully, and multiple new research projects were initiated by the group throughout the year.

Most notable is the collaborative science mission of NASA and DLR to jointly operate the EDEN ISS greenhouse. In December 2020, NASA scientist Jess Bunchek travelled to Antarctica. She operates the facility for the isolation campaign in 2021. A multifaceted research programme was worked out between NASA and the EDEN group, which includes e.g. cultivar testing, and crew time measurements.

The year 2020 also marked a milestone for the EDEN group, by outlining the research and development goals for the next decade. The DLR roadmap for the development of bio-regenerative life support systems was officially published. The plan foresees the development of a 1:1 life support module by the year 2025 that will allow to test key cultivation technologies already on space-rated system design level. This will push the courageous ambition to have a flight-ready design by 2030 for a possible Moon deployment scenario.

Dr. Daniel Schubert

Special white strawberries harvested from the EDEN lab during the Botanika project

Main entrance door of the EDEN ISS MTF after light snowfall

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.
EDEN was established within the DLR internal project CROP (Combined Regenerative Organic-Food Production) – a joint research endeavor between the Institute of Aerospace Medicine (ME) and the Institute of Space Systems (RY).
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 Moon and Mars are still several years from coming to fruition, the time to develop 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.
The EDEN Initiative is administered by the Department of System Analysis Space Segment (SARA) at DLR Bremen. The department operates the institute's Concurrent Engineering Facility (CEF) as well as the Space Habitation Plant Laboratory (EDEN Lab). Furthermore, the EDEN group receives support from the institute's Electronic Laboratory (E-Lab), and utilizes the institute's laboratory building (incl. integration hall) in order to foster the development of cutting-edge plant cultivation technologies.

DLR Institute of Space Systems, Bremen (Germany)

Making up hydroponic nutrient solution within the EDEN Lab analytical room

THE EDEN 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 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.

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 since 2012, before joining the team in 2015. Within the EDEN group he investigates the potential use of lightweight inflatable materials and structures that can house Bio-regenerative Life Support Systems and greenhouse systems in particular.

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 team in 2017 as an external consultant and advices the team in horticultural questions. He has evaluated different plant candidates and also developed cultivation methods for fruit trees for use within planetary habitats. He is mainly responsible for the organization of the EDEN plant lab.

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

CONRAD ZEIDLER has been a member of the EDEN research team since January 2011. Within 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 environment parameters.

DR. PAUL ZABEL studied aerospace engineering at the Technical University of Dresden. He joined the EDEN team in 2012. Dr. Zabel is the deputy manager of the EDEN Lab and is working on acquiring funding and projects for EDEN. His research expertise is hybrid Life Support Systems containing greenhouse modules and physical/chemical LSS.

JESS BUNCHEK is a plant scientist at NASA Kennedy Space Center, Florida (USA). She is a visiting guest scientist at DLR, who joint the EDEN team in July 2020. Her visit is part of the larger collaboration agreement between NASA and the EDEN group for advancing the knowledge of plant cultivation in space. She will be the onsite operator of the EDEN ISS research facility at Antarctica for the 2021 isolation campaign.

Preparing to board the airplane to Antarctica in Cape Town

Conrad Zeidler filling the fresh water tank in the EDEN ISS MTF

EDEN ISS MAINTENANCE MISSION

THIRD SUMMER SEASON IN ANTARCTICA

During the Antarctic summer season of 2019/20, the two EDEN members Dr. Paul Zabel and Conrad Zeidler travelled to the Antarctic EDEN ISS research platform in order to carry out essential maintenance and repair work. Although the focus was primarily on routine activities, such as cleaning, sensor calibration and filter exchange, a number of hardware- and software upgrades were conducted as well.

In particular, the Aeroponic misting nozzles in the plant cultivation trays were exchanged with nozzles which have a slightly larger orifice. This replacement will reduce former issues with clogging and resulting cleaning procedures of the nozzles. Additionally, control over the free cooler (the roof-mounted heat rejection unit) was improved by adding a control unit for the fan speed. This measure is expected to reduce the electrical energy demand of the Antarctic greenhouse.

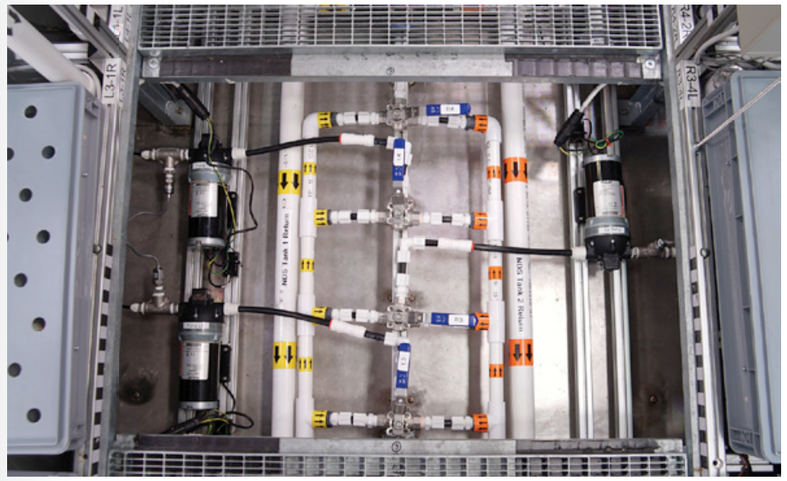
After training- and safety instructions, the EDEN team members handed over the operational activities of the greenhouse to the 40th Neumayer Station III overwintering crew in February 2020.

Conrad Zeidler cleaning a plant cultivation tray in the FEG

Sets of ready-to-use nutrient salts prepared for the EDEN ISS MTF operations phase

Insulated thermal piping connecting to the free cooler on top of the MTF

Replaced filter and acid tank underneath the NDS bulk solution tanks



High pressure pumps and NDS piping in the FEG subfloor after summer season cleaning and maintenance

HIGHLIGHTS 2020

The EDEN ISS greenhouse with Neumayer Station III in the background

The 40th overwintering team in Antarctica (from left to right: Dr. Klaus Guba [Doctor & Base Commander], Roman Ackle [IT], Anna-Marie Jörs [Meteorologist], Wanderson de Almeida Santos [Chef], Julia Loftfield [Air Chemist], Mario Beyer [Technician / Station Engineer], Ina Wehner [Geophysicist], Andreas Oblender [Electrician], Noah Trumpik [Geophysicist])

EDEN ISS WINTER SEASON 2020

THE COLDEST WINTER

In March 2020 third winter season of EDEN ISS in Antarctica started with a fresh crew of nine overwinterers. The first plants of the season were already sown in January by the DLR maintenance crew, which allowed hands-on training of the station crew with crops growing in the greenhouse.
During the isolation phase, all nine crewmembers participated in the operation of the greenhouse, such as water transfer between the station and the greenhouse, treating the plants, and regular checks and maintenance work. Roman Ackle, the station's radio operator, was the main EDEN ISS responsible person on-site. He coordinated the work in Antarctica and was in regular contact with the mission control centre in Bremen.
The year 2020 was an exceptionally cold winter and the coldest winter for the EDEN ISS greenhouse so far. The lowest temperature was recorded on August the 6th with -48.5 °C. While the temperature inside the greenhouse could be kept at the desired level of around 20 °C, the temperature difference between outside and inside resulted in almost 70°C! Nevertheless, during the 334 days long season more than 270 kg fresh food was harvested and eaten by the crew eventually.

'Rosie F1' plants growing in the FEG

The 2020 overwinterers transplanting rockwool cubes in the FEG (from left to right: Julia Loftfield, Roman Ackle, Wanderson de Almeida Santos)

EDEN ISS cucumbers

EDEN ISS tomatoes

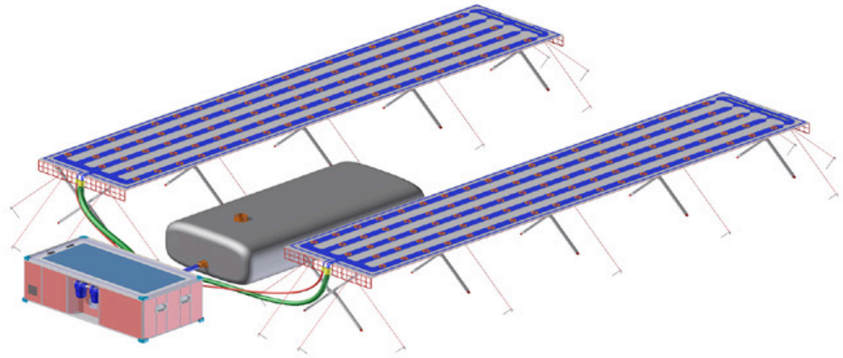
Fresh produce being weighed

Seed inventory in the greenhouse

Anna-Marie Jörss and Noah Trumpik seeding plants in the MTF

HIGHLIGHTS 2020

Young rucola plants growing in the FEG

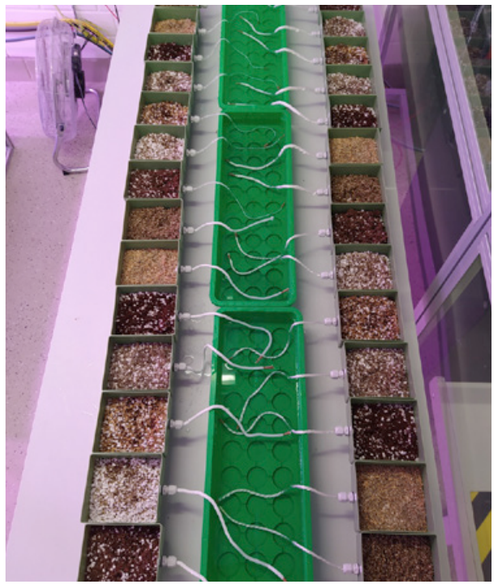


Render of the MEPA plant cultivation prototype system

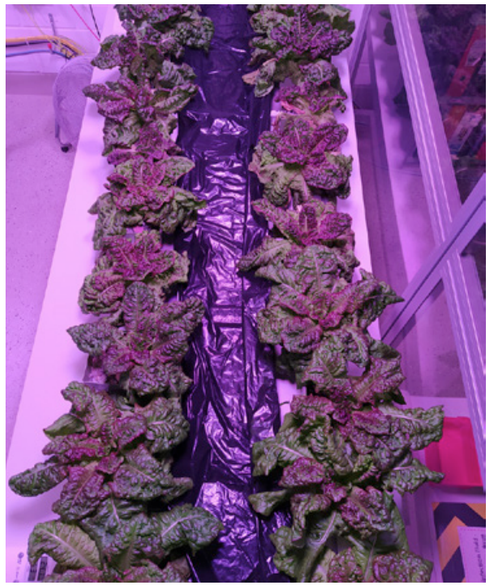
PROJECT MEPA STARTS

HUMANITARIAN TECHNOLOGIES MADE BY THE EDEN GROUP

2020 marked the start of the two-year development project MEPA (German: Mobiles Entfaltbares Pflanzen-Anbausystem), which is funded through DLR's Humanitarian Technology (HumTech) Programme. The project aims to develop a mobile, and fast deployable plant cultivation system which can be easily transported, deployed, and operated at sites around the globe as part of international humanitarian efforts.
Although the Corona pandemic and the resulting DLR-wide lock-down resulted into scheduling and laboratory access challenges, the EDEN team developed a first design for the cultivation system. Initial breadboards and single experiments were created and tested in the laboratory in order to mature the design. For 2021, the assembly, integration and test phase of the first prototype is planned.
The EDEN group also participated in the HumTech days at the end of October 2020. Here, the MEPA design status was presented and fruitful discussion with stakeholders took place.

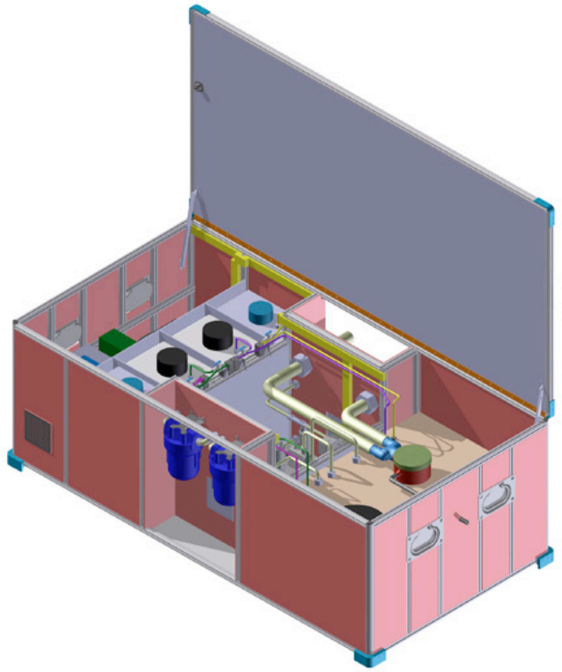


Initial setup of a plant experiment with different cultivation substrates

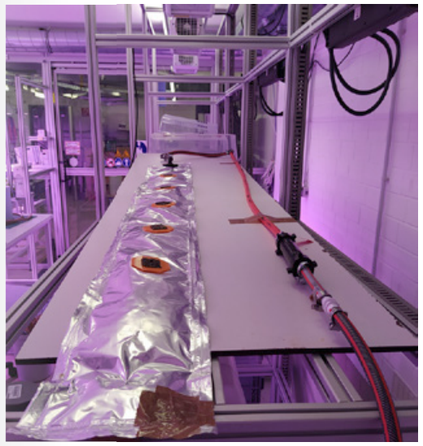


Lettuce growth during a plant cultivation experiment in the EDEN lab

Explosion view of the adapter between the seed cultivation mats and the MEPA support unit



Render of the MEPA Controlled Environment Agriculture support unit



Initial test of a seed cultivation mat prototype

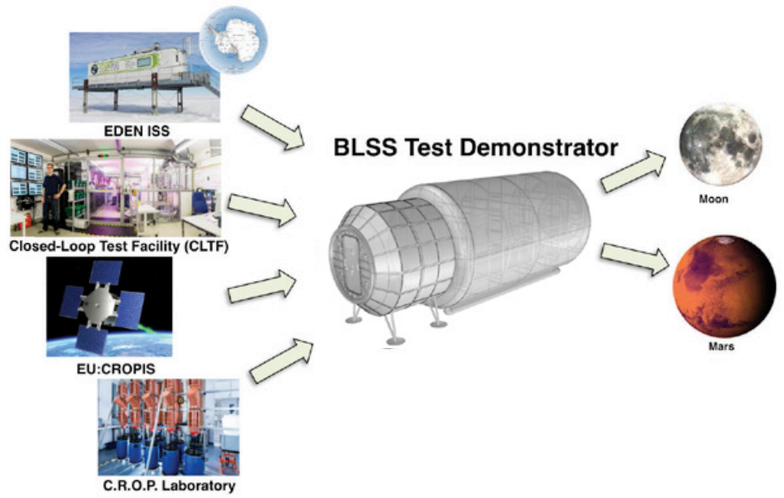
Lettuce growth in a seed cultivation mat prototype after three weeks

ROADMAP FOR BIO-REGENERATIVE LIFE SUPPORT

A PLAN FOR THE NEXT DECADE

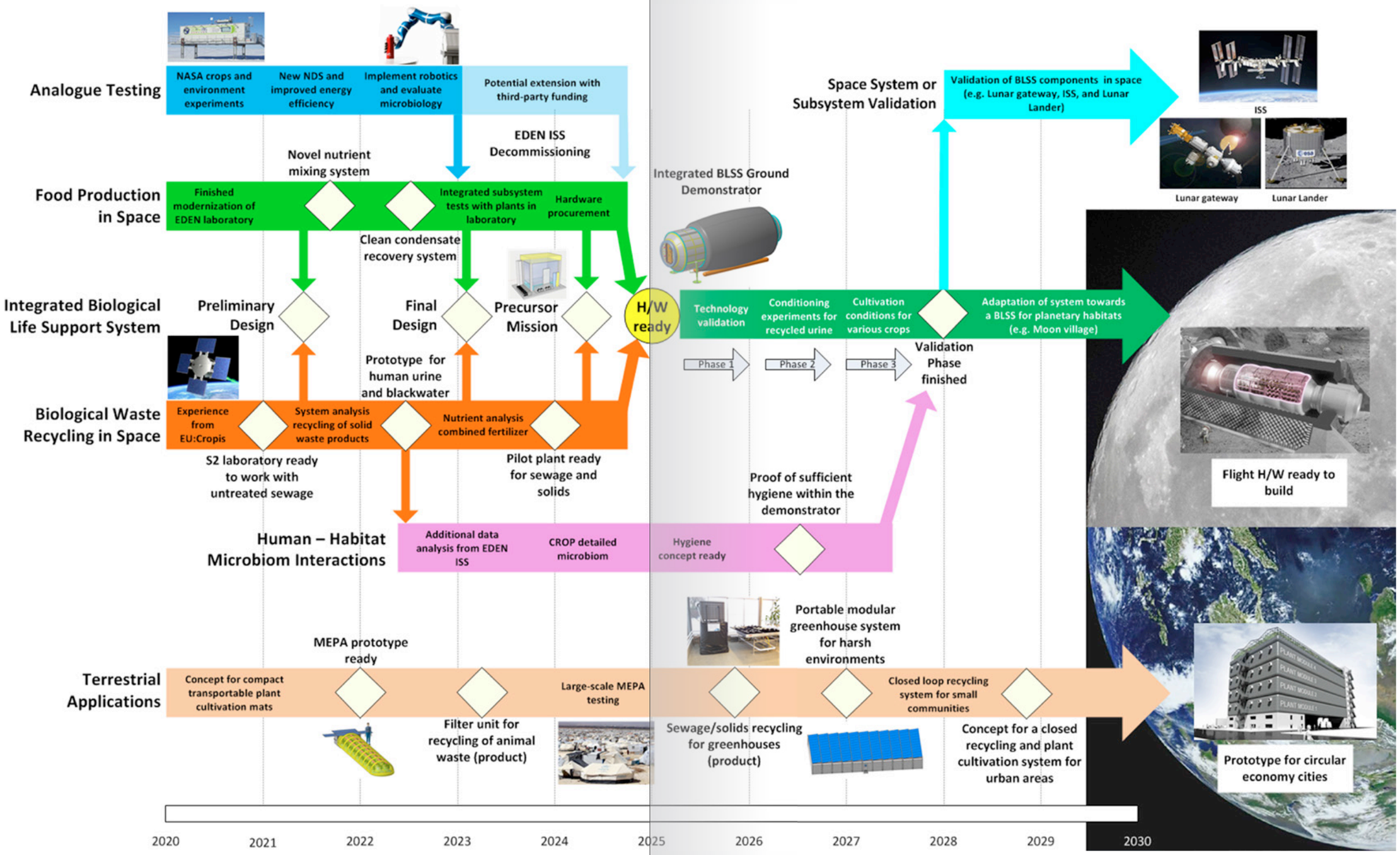
In March 2020 the 'Roadmap for the development of Bio-regenerative Life Support Systems (BLSS)' was officially approved by DLR. Prior to this approval, fruitful coordination meetings between the main partners, the DLR Institute of Space Systems, and the DLR Institute of Aerospace Medicine, took place.
The roadmap foresees the development of a 1:1 test demonstrator, giving scientist and engineers the possibility to test cutting edge cultivations technologies in one space-rated module. This way, the BLSS roadmap lays out the complete R&D agenda of the EDEN group for the next decade (2020 to 2030) for both space- and terrestrial applications. The roadmap states the next logical development step, building upon the knowledge gathered during the EDEN ISS analogue missions.
The first years of the roadmap culminate in 2025 with the construction of the test demonstrator. Following the construction of the system by 2025, focus will be set on validation of the systems and, ultimately, on the adaptation and the qualification of the design towards the use within planetary habitats. In doing so, DLR will have a full consolidated flight design (suitable for Falcon 9 launch system) by 2030.
The roadmap team is proud to announce that further DLR institutes have joined the roadmap. The DLR Institute of Data Science (development of Big Data applications) and the DLR Institute of Robotics and Mechatronics (development of a AI-controlled robotic gardener) will participate in the next steps of the roadmap.

Render of the planned robotic arms operating in the EDEN ISS MTF (Credits DLR-RM)



Schematic of the EDEN NEXT Gen test demonstrator development pathway

HIGHLIGHTS 2020



DLR's Bio-regenerative Life Support System Roadmap (2020-2030)

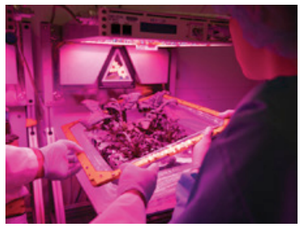
NASA-DLR COLLABORATION

GUEST SCIENTIST JESS BUNCHEK TO BE PART OF EDEN ISS MISSION IV

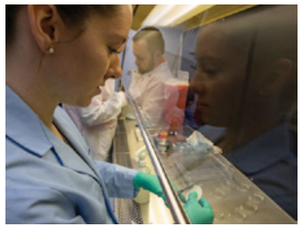
As part of the continued operations of the EDEN ISS greenhouse system in Antarctica, the EDEN team has initiated a collaborative partnership with NASA. Within this collaboration, NASA sent one of their plant scientist, Jess Bunchek, to take part in the 2021 Antarctic winter season at Neumayer Station III. Jess Bunchek will operate the research greenhouse by carrying out the day-to-day tasks, along with a wide-ranging list of scientific activities during this fourth EDEN ISS winter campaign.
Jess Bunchek is a plant scientist working on NASA's VEGGIE plant production system at Kennedy Space Center, Florida (USA). In July 2020, she arrived in Germany to join the 2021 overwintering crew for their intensive training in preparation of the Antarctic deployment, involving e.g. a glacier survival course and firefighting training. In between the training sessions, she worked with the EDEN team to learn the technical- and operational aspects of the EDEN ISS system and prepared the transport of equipment and consumables to Antarctica.

Jess Bunchek inspecting plants at NASA KSC

Jess Bunchek in the Mission Control Center at DLR Bremen



Working on the VEGGIE system



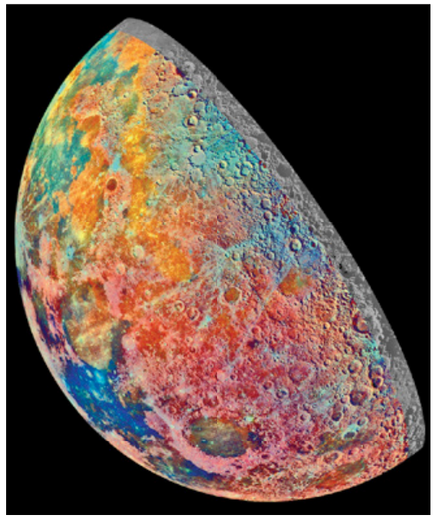
Lab work at NASA KSC

Checking the VEGGIE system

Jess Bunchek during firefighting training

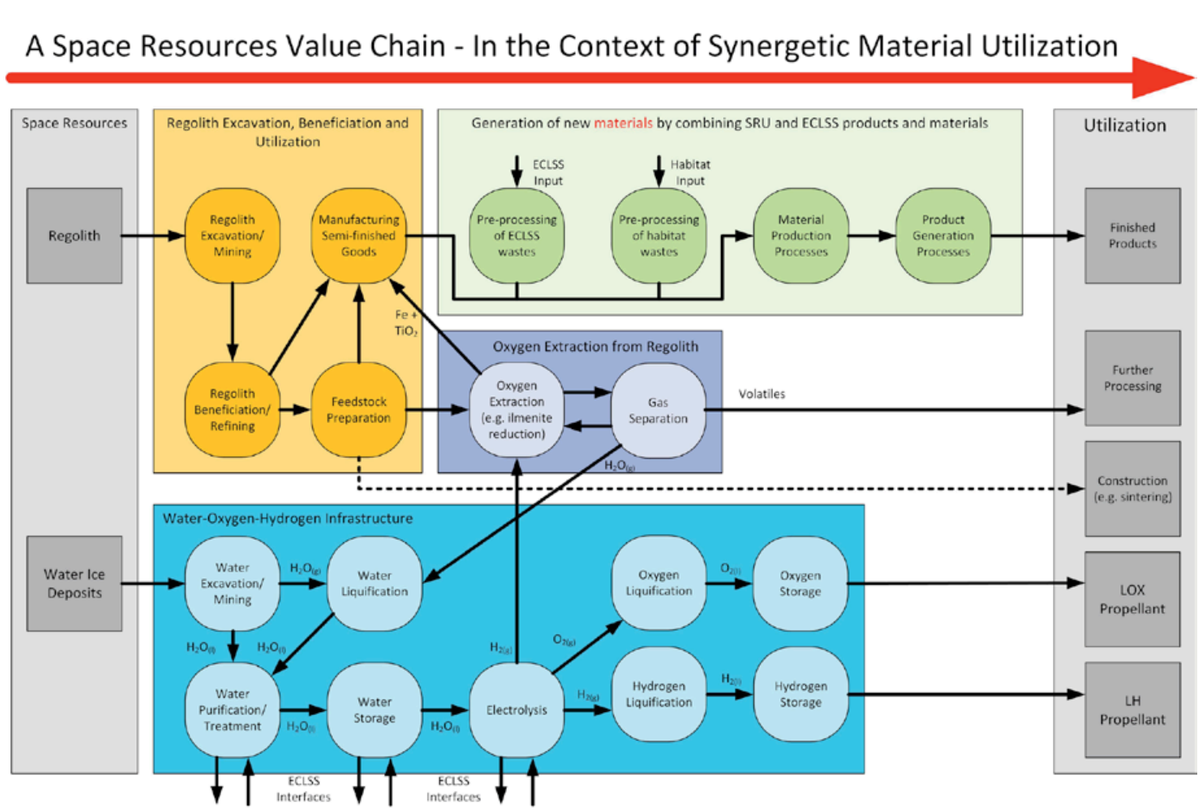
Jess Bunchek with the EDEN ISS mock-up at DLR Bremen

Jess Bunchek during the glacier survival training

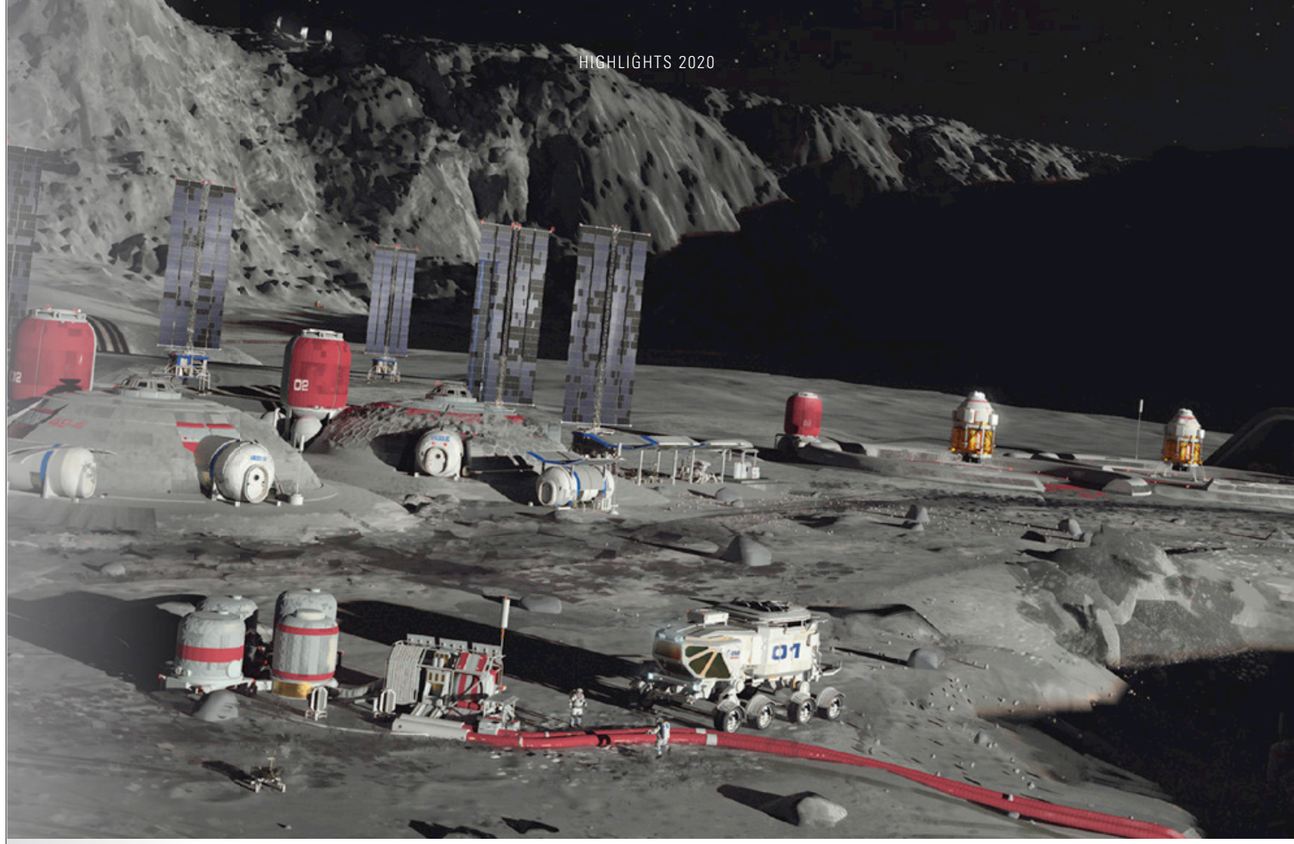


False color depiction of the Moon indicating different types of resources

Dr. Paul Zabel next to a portrait of the Apollo 11 astronauts in the Smithsonian National Gallery in Washington DC during the IAC 2019



Schematic of space resource utilization processes to be investigated in the new Synergetic Material Utilization research group

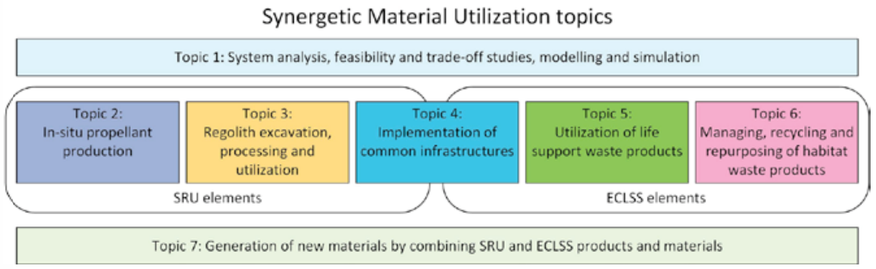


Render of a potential lunar base infrastructure (Credits: ESA)

SYNERGETIC MATERIAL UTILIZATION

COMBINING LIFE SUPPORT AND SPACE RESOURCES UTILIZATION

The concept of Synergetic Material Utilization (SMU) combines Space Resources Utilization (SRU) and Environmental Control and Life Support System (ECLSS) engineering approaches to lower the material supply required from Earth. Both R&D fields utilize similar resources, technologies and processes. Each field also greatly benefits from the resources provided by the other. Consequently, there is high potential for synergies between ECLSS and SRU. Among these synergies is a common water infrastructure, in-situ propellant production and the generation of new materials by combining SRU and ECLSS products and materials.
Dr. Paul Zabel proposed SMU to the DLR directorate for space sciences as a topic for a young investigator research group in summer 2020 and was approved in December. Led by Dr. Paul Zabel, the new research group will initially consist of three PhD candidates. By starting this new research topic, a holistic resource usage scenario for future planetary infrastructures can be created.

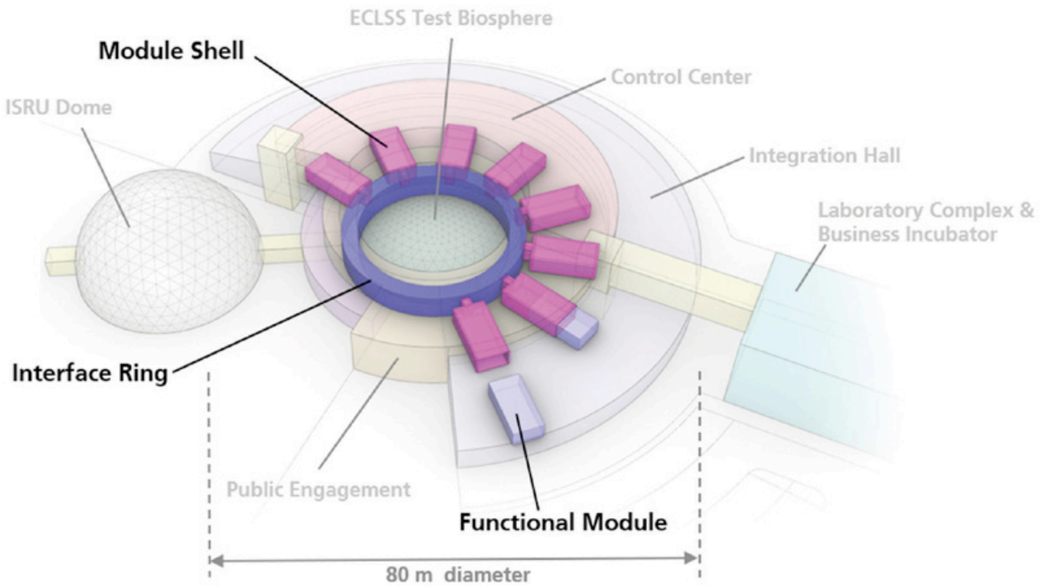


Overview of research topics of the new SMU research group

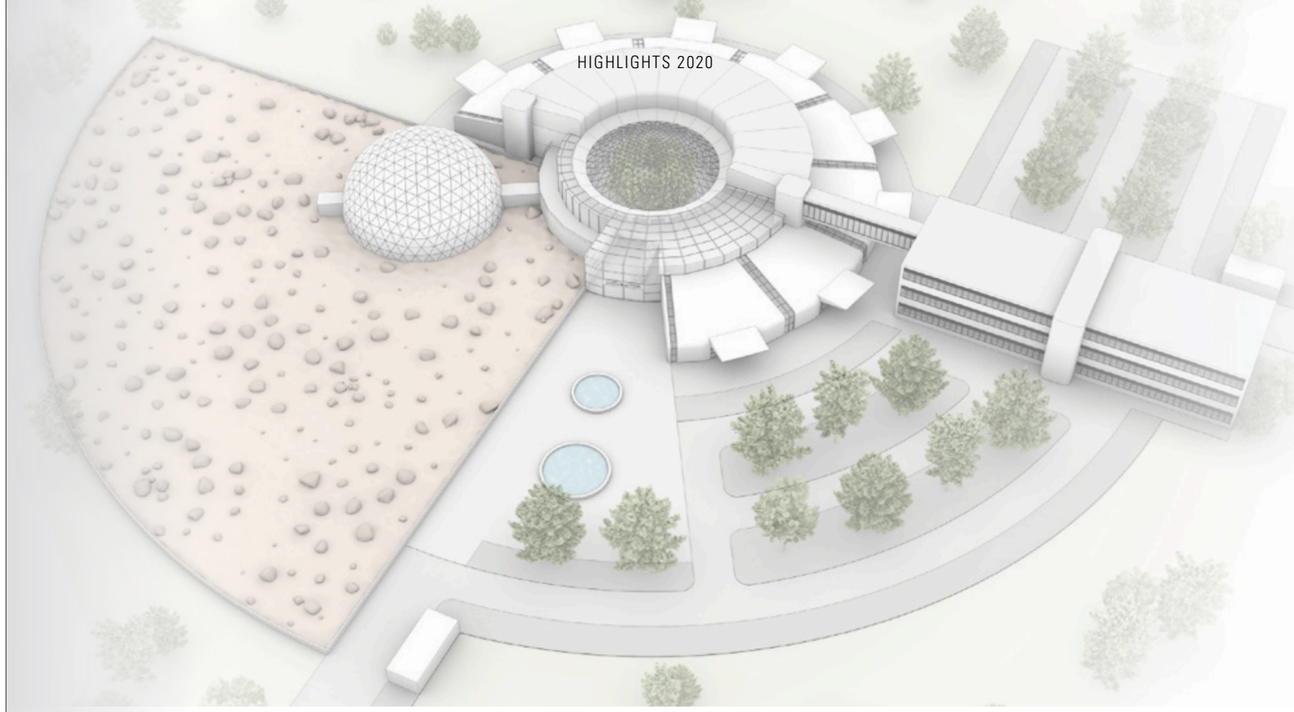
INCUBATOR FOR HABITAT- AND SUSTAINABILITY TECHNOLOGIES

A TEST HABITAT FOR HUMANITY'S FUTURE

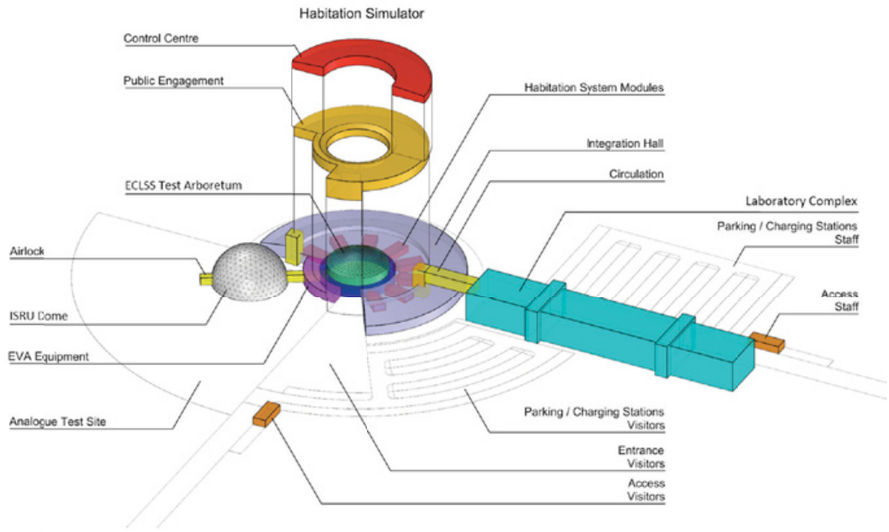
With the concept paper 'Incubator for Habitat- and Sustainability Technologies – IHST', the EDEN team reinitiated the long-envisioned endeavor to establish a new research facility for human exploration and habitation on Moon and Mars. The planned research infrastructure will allow a multidisciplinary research community to conduct R&D on cutting-edge planetary habitat technologies and processes. The nucleus of this incubator is the modular test habitat, linking all functional habitat tasks (e.g. air management, water management, food production) together into one combined habitat. Self-reliance of such an infrastructure is achieved by recycling and conditioning of air, water and waste, high-tech farming (agriculture, animal husbandry), in-situ resource utilization and advanced manufacturing (e.g. 3D printing). At the same time, a practicable and comfortable environment for the crew has to be provided (e.g. living areas, food processing, and medical care). Within the test habitat extended testing periods with humans-in-the-loop can be conducted. Furthermore, sustainability is an increasingly, urgent task for human existence on Earth. Therefore, main objective of the incubator is to transfer the developed habitat technologies towards terrestrial applications via a dedicated business incubator.



Functional layout of the habitat simulator inside the IHST (credits:Rene Waclavicek, Liquifer Systems Group)

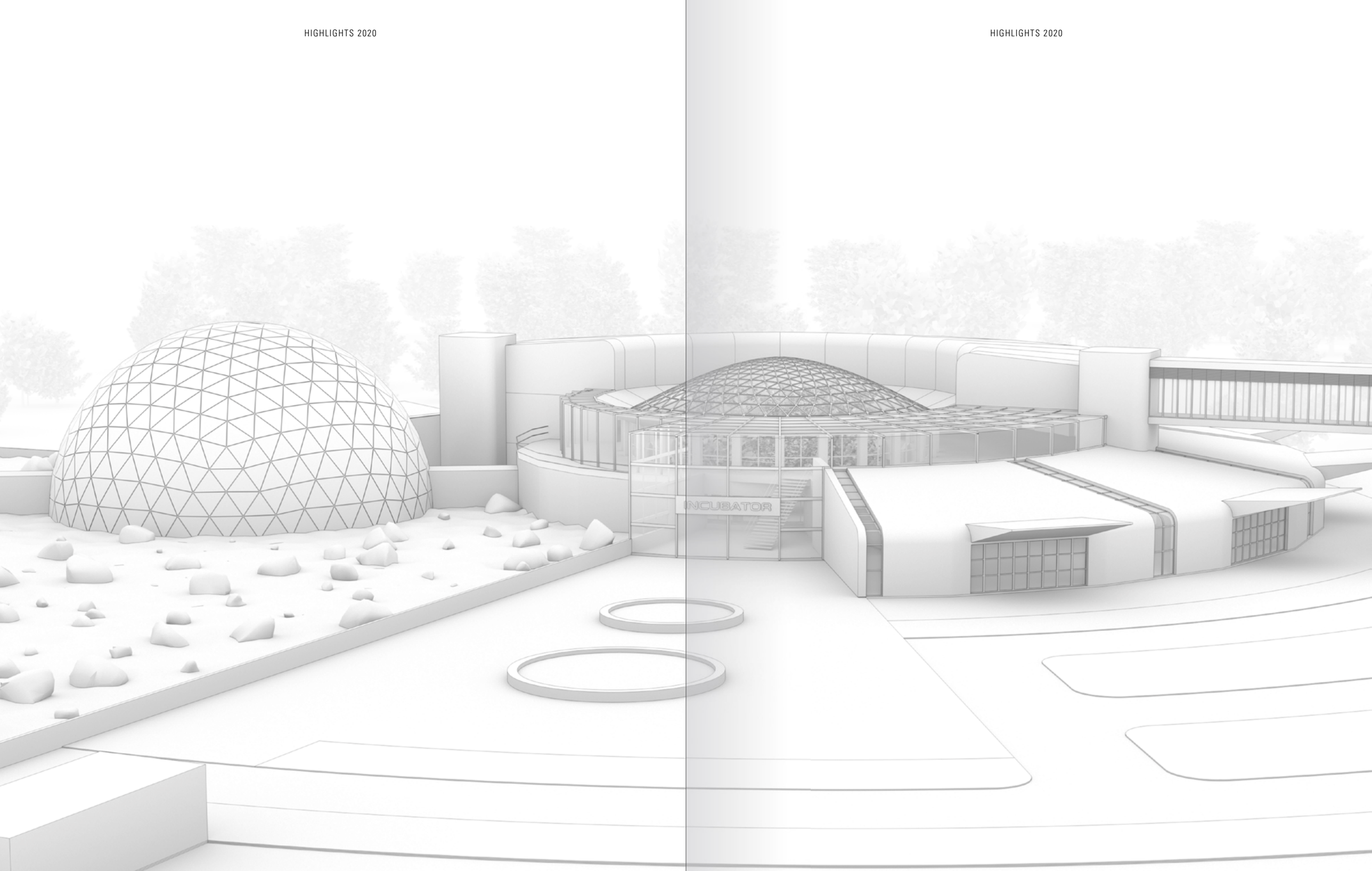


Render of the Incubator for Habitat- and Sustainability Technologies (IHST) facilities (Analogue test site, ISRU dome, habitat simulator, and laboratory & business incubator building) (credits:Rene Waclavicek, Liquifer Systems Group)



Overview of the Incubator for Habitat- and Sustainability Technologies (IHST) design (credits:Rene Waclavicek, Liquifer Systems Group)

HIGHLIGHTS 2020



Front view of the Incubator for Habitat- and Sustainability Technologies (IHST) facility, (credits:Rene Waclavicek, Liquifer Systems Group)

FURTHER HIGHLIGHTS

MORE HAPPENED DURING THE YEAR – FIND OUT WHAT:

Depiction of potential Augmented Reality implementation in the EDEN ISS greenhouse

Augmented Reality in the FEG

In June 2020, EDEN team member Conrad Zeidler started his PhD work with the title "Augmented Reality in a Planetary Surface Greenhouse for Crew Time Optimization". Conrad Zeidler is supervised by Prof. Dr. Johannes Schöning, head of the Human-Computer Interaction (HCI) research group at the University of Bremen.

Dr. Paul Zabel harvesting fresh food from the Agrilution PlantCube system during the 2019/2020 Antarctic summer season

The EDEN team transported the Plantcube system to Antarctica in order to test the device during the 2020 isolation phase. This autonomous home farming device was developed by the start-up company Agrilution. The system ran for several cultivation cycles and added a variety of different microgreens and herbs to the menu of the overwinter team.

Plants growing in the Agrilution PlantCube system at Neumayer Station III

3D-printed rockwool holder

Agrilution PlantCube system operating at Neumayer Station III

Dr. Paul Zabel joined the ICES International Committee in September 2020. This committee is responsible for organizing various sessions within the conference program. Furthermore, Dr. Paul Zabel was also appointed co-chair of the session ICES204: Bio-regenerative Life Support.

Young plants growing as part of plant cultivation experiments of the Botanika project

Universität Bremen

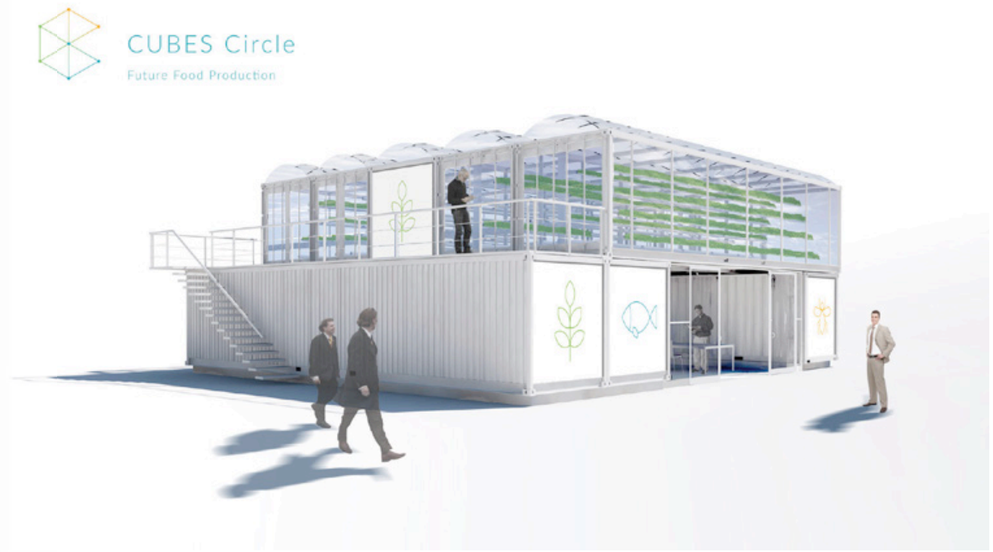
The EDEN group initiated a dedicated lecture at the University of Bremen within the Master degree course Space Engineering. Organized by Dr. Paul Zabel and Dr. Daniel Schubert, the lecture Human Space Exploration & Habitation teaches the basics of life support systems, ISRU techniques, and human habitation designs for Moon and Mars. Over 70 students participated during the first semester in 2020.

'Botanika' strawberry plants flowering in the EDEN lab

On December 20th the non-stop voyage from Bremerhaven directly to the shelf ice of Antarctica started, following to a 10-day quarantine of all mission personnel due to the Corona pandemic. Using the AWI research vessel Polarstern, Jess Bunchek (NASA) and Vincent Vrakking (DLR) were on a 4-5 week voyage around the globe in order to reach Antarctica mid-January 2021.

After the successful opening of the exhibition Plants in Space at the Botanika Bremen in 2019, the work within the BAB-funded project continued in 2020. Although the Corona situation did not allow the use of the EDEN lab to its full capacity, some experiments on the hydroponic cultivation on strawberry, blackberry, and raspberry had been performed nevertheless.

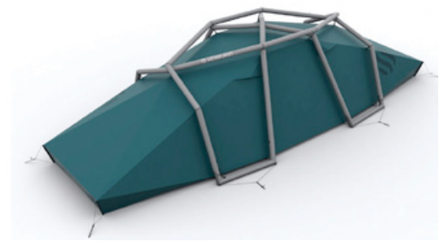
Tomato crops growing in the exhibition at Botanika Bremen



Render of the CUBES Circle design (credits: cubescircle.de)

The EDEN team started its collaboration with the CUBES Circle consortium – a research project funded by BMBF. The project foresees to develop a closed cultivation method by integrating fish-, insect- and plant cultivation into a new process chain, where the individual elements of the chain are intelligently connected and regulated. Here the EDEN team developed a 3D printed plant holding system for the greenhouse CUBE.

Heimplanet 'Mavericks' shelter design (credits: Heimplanet)



Heimplanet 'Nias – Classic' shelter design (credits: Heimplanet)

Heimplanet 'Backdoor – Classic' shelter design (credits: Heimplanet)

Together with its partners, the EDEN team won the BMBF-funded Tunisian-German collaboration call. With a total budget of 0.6 M€, the project team will develop a unique inflatable greenhouse system for emergency purposes by further enhancing the MEPA design. EDEN team will further strengthen its collaboration with its Tunisian partners and also initiate new collaborations on German side, such as INTEGAR GmbH und Heimplanet GmbH.

KEY FIGURES - 2020

JOURNALS

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PEER-REVIEWED CONFERENCE PROCEEDINGS

Zabel, P., Zeidler, C., Vrakking, V., Schubert, D., Imhof, B., Hogle, M., *„Summary and Evaluation of the EDEN ISS Public Outreach Activities"*, International Conference on Environmental Systems, 2020.

Zabel, P., Zeidler, C., Vrakking, V., Schubert, D., *„Implications of different plant cultivation techniques for food production in space based on experiments in EDEN ISS"*, International Conference on Environmental Systems, 2020.

Zabel, P., *„Effects on ECLSS Behavior caused by the Start-up of a Food Production Facility"*, International Conference on Environmental Systems, 2020.

Zeidler, C., Vrakking, V., Zabel, P., Bamsey, M., Schubert, D., *„Resource Consumption and Waste Production of the EDEN ISS Space Greenhouse Analogue during the 2018 Experiment Phase in Antarctica"*, International Conference on Environmental Systems, 2020.

Vrakking, V., Zeidler, C., Zabel, P., Dorn, M., Schubert, D., *„Status and Future of the EDEN ISS Mobile Test Facility"*, International Conference on Environmental Systems, 2020.

CONFERENCE PROCEEDINGS

Zabel, P., *„Overview of experiment results from the first research campaign of the EDEN ISS greenhouse facility in Antarctica in 2018."*, MELiSSA Conference, 3-5 November, 2020.

Schlacht, I.; Schubert, D., Foing, B.: *„Human Factors and Habitability Impact of Plants on Isolation"*, International Astronautical Congress (IAC), 12-14 October 2020, Cyberspace Edition, IAC-20.E5.VP.13

INVITED TALKS

Zabel, P., „Mein Antarktisgemüsegarten", 15. Freie Gartenakademie Münster, 06.80.2020, Münster, Germany.
Zeidler, C., *NASA's Autonomy and Robotics to Space-based Crop Production Systems Workshop*; Kennedy Space Center (Florida); 06.-07.08.2019.

Schubert, D.: *„GRÜNE LUNGE IM EWIGEN EIS - Ein Gewächshaus in der Antarktis liefert Erkenntnisse für die zukünftige Pflanzenzucht auf Mond und Mars"*, Humboldt University of Berlin; FG Biosystemtechnik, 03.02.2020

Schubert, D.: *„EDEN ISS: Analogue Testing of Plant Cultivation for Space"*, 18.02.2020, Institute of Aerospace Medicine, German Aerospace Center

DIPLOM-/ MSC.-/ BSC.-THESIS

Woeckner, Gerrit (2020) *System Analysis of Integration Paths for Augmented Reality Technology in Greenhouses as Part of Future Extraterrestrial Habitats,* Master Thesis, Technical University of Braunschweig

Sojati, Esti (2020) *Picture Collage & Time-Lapse Web Application for EDEN ISS,* Bachelor Thesis, Jacobs University Bremen

Paudel, Rohit (2020) *Automated sensor data extraction pipeline and Subsystems visualization for EDEN ISS Project,* Bachelor Thesis, Jacobs University Bremen

Marvin Lipps (2020) *Systems analysis for the advancement of the MEPA-system for plant cultivation in extraterrestrial habitats and terrestrial emergency situations,* Master Thesis, University of Bremen

Jana Fahrion (2020) *Microbial Monitoring in the EDEN-ISS Greenhouse, a Mobile Test Facility in Antarctica,* Master Tesis, University of Ulm

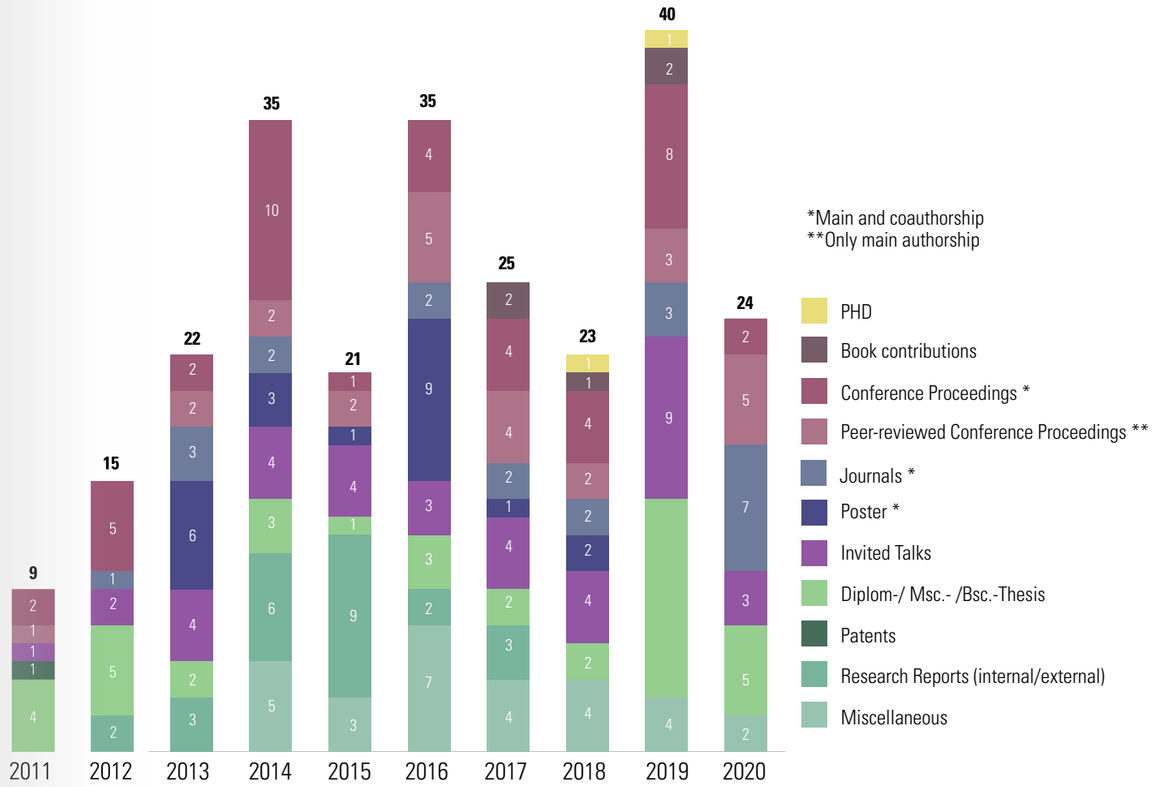
MISCELLANEOUS

Zabel, P. became *‚Member of the ICES International Committee and co-chair of session 204 ‚Bioregenerative Life Support'*

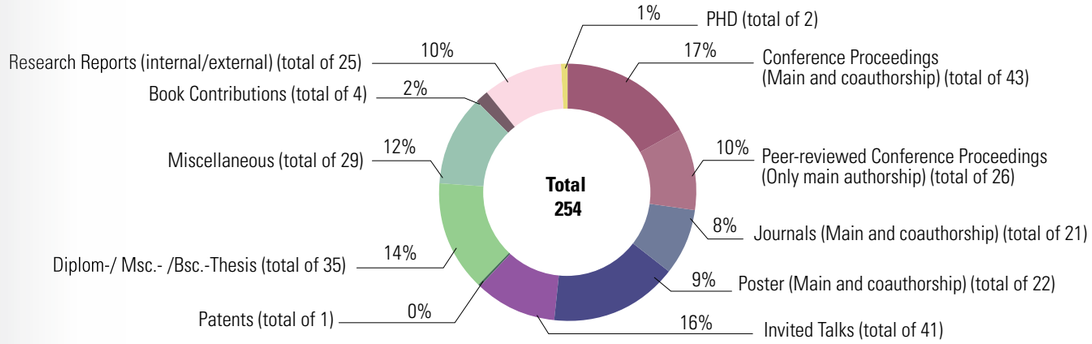
Schubert, D., Zabel, P.: *„Human Space Exploration & Habitation"*, lecture, Elective module, Space Master, SS2020, University of Bremen

SUMMARY KEY FIGURES (2011-2020)

PUBLICATIONS & KEY FIGURES 2011-2020

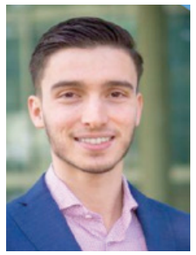


TOTAL PUBLICATIONS & KEY FIGURES 2011–2020



THE EDEN STUDENTS

Without the assistance and help of highly-motivated students, the success of the EDEN Initiative would not have been possible! Therefore the entire EDEN team would like to say thank you. See below what the student's tasks were and what they are doing now:



Esti Sojati is in his third year of studying computer science at Jacobs University in Bremen. During his Bachelor work for the EDEN team, he compiled a visualization software for organizing the vast stream of daily pictures, sent from the EDEN ISS greenhouse system to DLR's mission control center.

Gerrit Woeckner studied aerospace engineering from the TU Braunschweig. During his Master thesis at the EDEN group he incorporated a system analysis for possible integration paths regarding Augmented Reality (AR) applications for greenhouses in future extraterrestrial habitats on Moon and Mars. The EDEN ISS greenhouse in Antarctica served as a basis for the underlying research.

Jana Fahrion has studied biology at the University of Ulm. In her master thesis at DLR-ME she analyzed the microbiome of the EDEN-ISS greenhouse. She investigated microbial samples from greenhouse surfaces, from the nutrient solutions and from the plants grown therein in comparison to commercial produce. The results were summarized in a publication in Frontiers in Microbiology.

Marvin Lipps was enrolled within the space engineering course at the University of Bremen when he joined the EDEN team from September 2019 till June 2020. Marvin was engaged in the MEPA project, where he complied his Master thesis with the title "Systems analysis for the advancement of the MEPA system for plant cultivation in extraterrestrial habitats and terrestrial emergency situations".

Nora Volling studies aerospace engineering at the Bremen University of applied science. During her 5-month internship within the EDEN Team she helped with the preparations for the EDEN ISS Summer Season 20/21. She was also included in the further development and construction of the MEPA design. After her internship she will stay in the EDEN group to work on her Bachelor thesis in the MEPA Project.

IMPRESSIONS 2020

A FULL YEAR OF WORK...

Conrad Zeidler cleaning the FEG subfloor

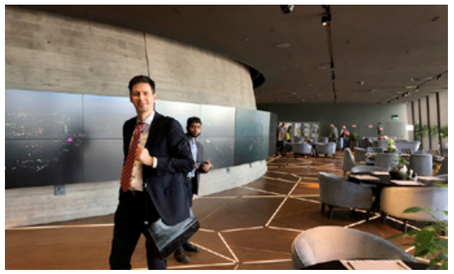
Noah Trumpik harvesting cucumbers from the EDEN ISS greenhouse

Roman Ackle, Julia Loftfield and Wanderson de Almeida Santos (front to back) during harvest inside the FEG

Lettuce head – fresh harvest from the FEG

Basil plants in the EDEN ISS MTF

EDEN grow system with four tomato plants at the Botanika exhibition



Dr. Robert Axmann during collaboration meeting at the Skoltech University in Moscow

Sputnik mock-up at the Moscow institute for space systems

View of Moscow skyline at night during the 'Helmholtz Wintergespräche' in February

Jess Bunchek during the glacier survival training

Jess Bunchek during firefighting training

Jess Bunchek during firefighting training

Jess Bunchek and the 2021 overwintering team during firefighting training

The EDEN team during a barbeque social event

Initial sketches of the EDEN ISS NASA-DLR mission logo

Equipment to be sent to Antarctic for the 2020/21 summer maintenance mission

A young penguin visiting the EDEN ISS greenhouse

YR-ED-2020–issue1

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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German Aerospace Center

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