



HIGHLIGHTS 2017

YEARLY STATUS REPORT
EDEN INITIATIVE



Several members of the EDEN ISS deployment team soon after their arrival at Neumayer Station III visiting the platform where the EDEN ISS greenhouse would later be installed.

EDEN – THE YEAR 2017

December 17th - CapeTown - South Africa: The EDEN team finishes its last preparations for the upcoming EDEN ISS mission. The next day, the adventure will begin with the inbound flight to the Russian Novo Airbase; Location: Antarctica. From there, the team flies to the German Neumayer Station III, the group's new test ground for the developed closed-loop greenhouse system. Four years of intense planning, hardware development, testing and enhancements finally brought the EDEN team to the eve of the start of the long-awaited Antarctic mission. For the next eight weeks, the team will pick up the EDEN ISS Mobile Test Facility at the shelf ice and then build up the system in the vicinity of the station.

The year 2017 marked an extraordinary year, as all essential controlled environment agriculture subsystems were integrated into the EDEN ISS greenhouse system. Located in the backyard of the DLR Institute of Space Systems in Bremen (Germany), the container was the place of intensive work, where the EDEN team and its consortium partners successfully accomplished all important assembly, integration, and test (AIT) procedures. Then from May until September, the greenhouse system provided suitable conditions for plant growth so that several test grow-outs could be performed.

In June, the successfully organized Flight Readiness Review (FRR) marked an important milestone for the EDEN team. The European Union and the scientific advisory board gave a green light for the planned analogue test mission.

An additional highlight of the year were the kick-offs of the two projects PMARS and GERE, which are both funded through the German Ministry of Research (BmBF). With partners, located in Morocco and Egypt, the projects foresee the adaptation and transfer of EDEN's developed greenhouse technologies into terrestrial systems, in order to provide a closed-loop food production system in desert and arid areas.

The EDEN team looks forward to proceeding with the upcoming research tasks in 2018. Through the Antarctic mission and the implementation of the newly built mission control center in Bremen, the team is confident that they can help contribute to the advancement of knowledge related to plant cultivation in extreme environments, needed for future missions to Moon and Mars.

Dr. Daniel Schubert



Plants growing within custom made 3D printed holders in the EDEN ISS Future Exploration Greenhouse during the assembly, integration and test phase.

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The EDEN ISS containers on the South African Agulhas II Research Vessel en route to the Neumayer Station III.
Photo credit: Will Jelbert (station leader/crew doctor for the 2018 South African overwintering crew).



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 institutes 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)



Matthew Bamsey 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 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 is since then the team leader of this group. His research expertise is set on habitat interface analysis and plant accommodation and dynamic plant production planning.



Dr. MATTHEW BAMSEY holds a M.Sc. in aerospace engineering (University of Colorado, USA) and conducted his Ph.D. in environmental biology with the University of Guelph (Canada). Matthew worked as a postdoctoral researcher at the University of Florida where he supported suborbital plant growth payload developments. He spent over ten years working as an intern at the Canadian Space Agency where he worked with the Arthur Clarke Mars Greenhouse project. Within EDEN, he conducts research related to nutrient delivery systems.



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 external consultant and advises 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.



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 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.



PAUL ZABEL studied aerospace engineering at the Technical University of Dresden. He joined the EDEN team in 2012. Mr. 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. Funded over NPI (ESA) he is doing his Ph.D. on the dynamic behavior of such hybrid systems.



VINCENT VRAKKING studied at the Technical University of Delft in the Netherlands and holds a M.Sc. in aerospace engineering. He has worked 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.



Acid and base dosing pumps within the EDEN ISS Mobile Test Facility.



Paul Zabel installing LEDs during the early phase of the EDEN ISS assembly, integration

and test phase.



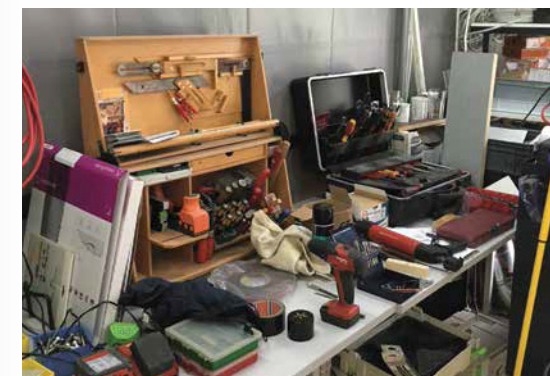
Francesco Iervese and Andres Lüdeke working in the subfloor water tanks within the EDEN ISS cold porch.



A busy view into the EDEN ISS Service Section with concurrent work on various facility subsystems.



The EDEN ISS Mobile Test Facility nearing the end of the EDEN ISS assembly, integration and test phase, with all external hardware installed.



A busy tool bench during the EDEN ISS assembly, integration and testing phase



Giorgio Boscheri and Marco Volponi during Bremen testing of the TASI developed 'RUCOLA' ISS rack-like plant growth system.



A view from the cold porch into the Service Section and towards the Future Exploration Greenhouse, showing the facility following the installation of several subsystems.

ASSEMBLY, INTEGRATION AND TEST – PART ONE

BRINGING THE PIECES TOGETHER...

Although integration of the MTF commenced in 2016 the bulk of the integration activities occurred in the early part of 2017. This included the integration of the thermal system, the air management system (in conjunction with Arescosmo), the bulk of the Service Section structural hardware (in conjunction with Liquifier Systems Group), the nominal camera system, multi wavelength imagers (in conjunction with University of Florida) and the ISPR growth rack (in conjunction with Thales Alenia Space Italy). The respective subsystem partners were heavily involved on the ground in Bremen during the AIT phase and, along with the other project subsystem leads, supported the DLR AIT team in the remote troubleshooting of the installed hardware. Various subsystem level tests were conducted throughout the sequence of installation, followed by full system tests starting in the middle of 2017. The experience from these tests and the initial operations allowed for several hardware and software improvements to be implemented into the MTF, which will further increase system reliability in Antarctica.



The installation of one of the growth chambers within the RUCOLA ISS rack-like growth system.



A view into one of the two RUCOLA ISS rack-like plant growth system growth chambers.



An EDEN ISS Ethernet switch on the ceiling of the Future Exploration Greenhouse.



The Service Section nearing the end of the test phase.





FLIGHT READINESS REVIEW

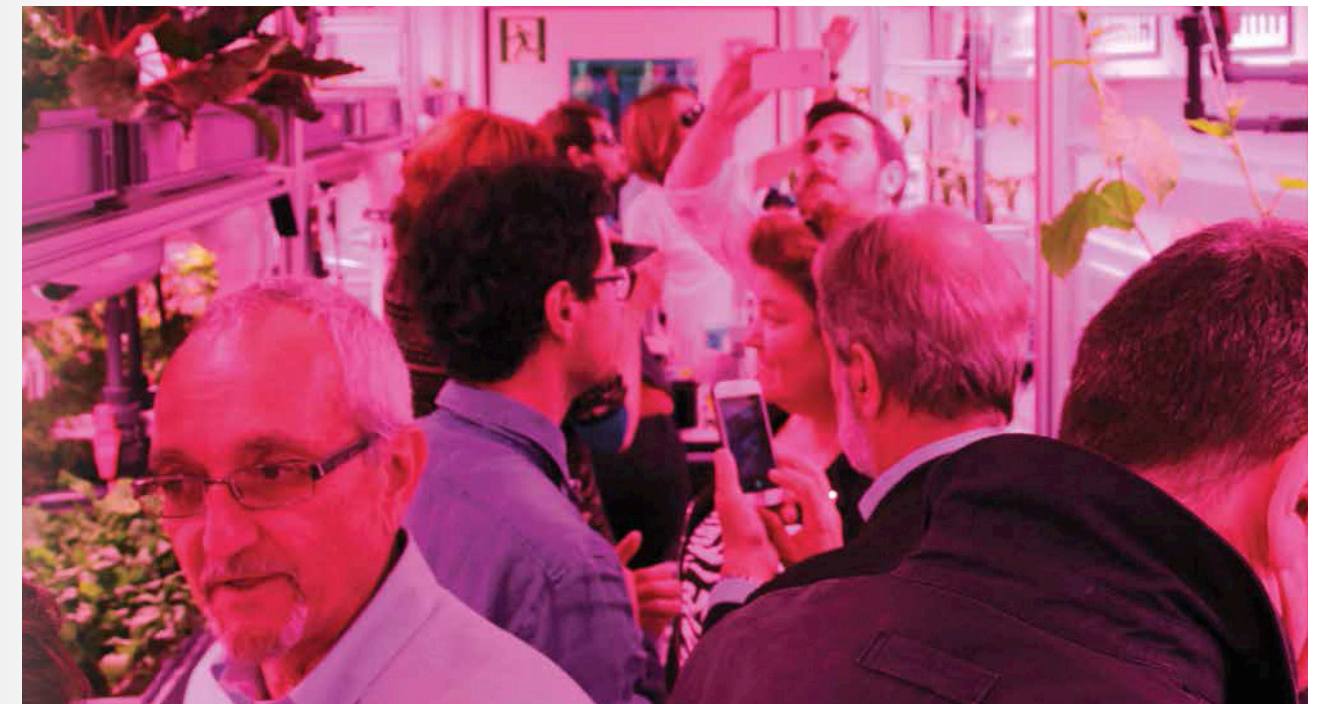
GREEN LIGHT FOR THE MISSION

In June, the EDEN group hosted the final international meeting of all EDEN ISS partner organizations before the commencement of the Antarctic operations phase. Fifty researchers participated in the EDEN ISS 'flight readiness review' (FRR). The three day meeting focused on ensuring the project was ready for deployment from a technical and scientific perspective. It included technical presentations and discussions related to final missions operations, on-going issues with the project and included a tour of the operational Mobile Test Facility. The FRR was the third full EDEN ISS project meeting, following the Critical Design Review in 2016 and the Concurrent Engineering study in 2015. The meeting included the attendance of the EDEN ISS scientific advisory board, the European Commission project reviewers as well as the European Commission project coordinator.

Just over 130 review item discrepancies (RIDs) were raised, covering the spectrum from technical to scientific to operational aspects. Many of these recommendations were incorporated into the project to improve the performance and outcomes of the project.



Participants of the EDEN ISS FRR.



Meeting participants enjoying the fruit of their hard work during a visit within the EDEN ISS FEG.



Frank Kempkes (WR), Cecilia Stanghellini (WR) and Christina Cruz (EC reviewer) in discussion in the EDEN ISS assembly, integration and testing tent.



Ray Wheeler (NASA), Petra Rettberg (DLR-ME), Alexander Tikhomirov (Institute of Biophysics Siberian Branch of RAS) during a tour of the EDEN ISS Service Section.



Eberhard Kohlberg (AWI), Dirk Mengedoht (AWI) and Paul Zabel during the FRR.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 636501





René Waclavicek (LSG) and Connor Kiselchuk observing data and imagery in the DLR EDEN ISS Mission Control Center during the EDEN ISS assembly, integration and test phase.

ASSEMBLY, INTEGRATION AND TEST – PART TWO

THE FIRST TEST GROW-OUTS: ACCOMPLISHED!

With all the major subsystems and components installed, an overall system test of the complete facility was conducted at the DLR Institute of Space Systems between May and September. The purpose of this test was to verify the functionality of the integrated system. During the testing phase, not only the systems were tested, but multiple growth cycles of all selected crops were performed. This allowed for adjustments to be made to the final plant growth conditions. During most of the testing phase, the FEG was completely filled with plants occupying every possible growth tray. All selected crops, except strawberries, were grown for at least one growth cycle. Only minor technical, operational and horticultural issues were identified, all of which could be remedied. The project team was able to harvest several tens of kilograms of edible biomass during the test phase. Furthermore, the scientific and experimental equipment was tested and samples were taken for further analysis. In mid-September the project staff shut down the MTF and began with the preparations for shipment to Antarctica.



Grazyna Bochenek (HS) conducting detailed light measurement during the assembly, integration and test phase.



EDEN students Aditya Pande, Lena Hummel, Maria Rosello Petit and Connor Kiselchuk during the final harvest from the Bremen test phase.



Matthew Bamsey during the Bremen test phase.



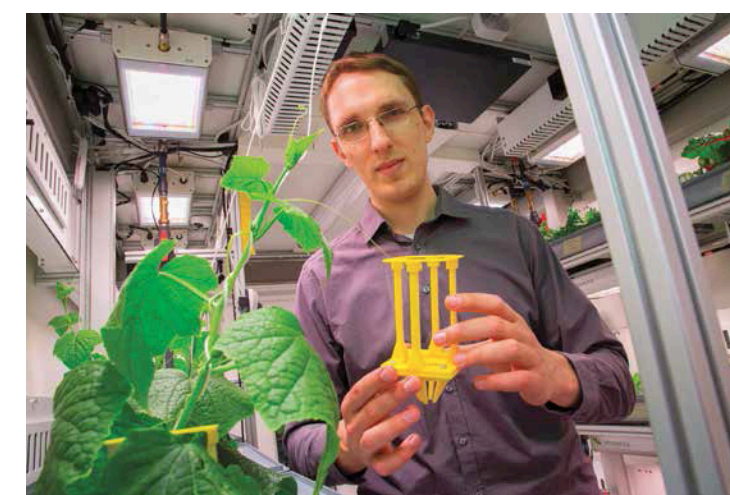
Daniel Schubert observing plant roots within the Future Exploration Greenhouse.



The Future Exploration Greenhouse early in the Bremen growth trials.



EDEN ISS grown Swiss chard.



Vincent Vrakking holding a custom made 3D printed support-structure before its installation within the facility.



A "full" Future Exploration Greenhouse nearing the completion of the Bremen test phase.



KICK-OFF MEETINGS:GERF & PMARS

TRANSFORMING SPACE TECHNOLOGIES INTO TERRESTRIAL APPLICATIONS

The Controlled Environment Agriculture technologies that could one day provide food for astronauts on the Moon or Mars hold significant promise for transforming terrestrial agricultural practices. With reduced resource consumption and independence from climatic or soil conditions, a greenhouse such as the EDEN ISS MTF could allow crop cultivation in regions where traditional field cultivation is not possible.

Within the scope of two bilateral cooperation programs, GERF, between Germany and Egypt, and PMARS, between Germany and Morocco, the EDEN team will adapt CEA technologies into greenhouse designs suitable for the arid regions in the North African countries. A kick-off meeting for the PMARS project was held in Bremen in July with project partners from Desertec University Network (DUN) and the University Ibn ToFail (UIT). The kick-off meeting for the GERF project took place in Cairo, Egypt, at the end of November. Members from the EDEN team met with partners from the Egyptian National Research Center (NRC) to discuss the project planning for 2018.

The EDEN team looks forward to the successful continuation of these projects in 2018 and the possible instigation of follow-up projects to promote the widespread use of CEA technologies on Earth.



Mostafa Boshta (NRC), Sayed El Habbasha (NRC) and Vincent Vrakking (DLR) during the GERF project kick-off in November 2017.



Touring the Pyramids near Cairo, Egypt during the GERF project kick-off in November 2017.



Touring the Egyptian Museum



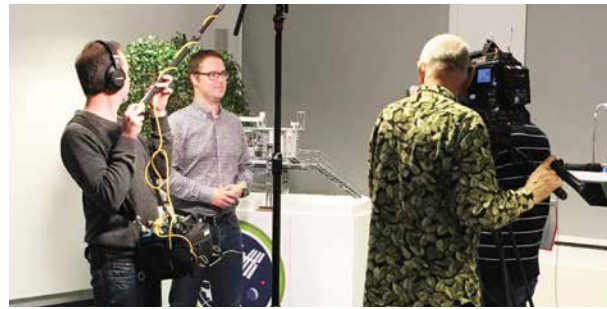
View of the Egyptian Museum



Sayed El Habbasha, Vincent Vrakking and Tarek Samir visiting the Pyramids near Cairo



Celebration of the 10 Year Anniversary of the German Egyptian Science Year 2007



Paul Zabel in front of the cameras.



Conrad Zeider, Dr. Barbara Imhof (LSG) and Prof. Dr. Pascale Ehrenfreund (Chair of the DLR Executive Board) discussing EDEN ISS at the IAC conference in Adelaide, Australia.



One of the two EDEN ISS Mobile Test Facility display models under construction.



Dr. Eberhard Kohlberg (AWI), Paul Zabel, Prof. Dr.-Ing. Andreas Rittweger (Institute Director, DLR Bremen), Daniel Schubert, Prof. Dr. rer. nat. Hansjörg Dittus (Member of the DLR Executive Board), Falk Dambowsky (DLR Media Relations) during one of the 2017 EDEN ISS press conferences.

MEDIA COVERAGE & OUTREACH

COMMUNICATING THE EDEN ISS IDEA TO THE PUBLIC

The curiosity of the press and its media coverage increased during 2017. Together with the public relations department of DLR, the EDEN team organized two press conferences.

Together with Prof. Rittweger (DLR Institute of Space Systems), Prof. Dittus (DLR member of the Executive Board) and Dr. Kohlberg (AWI Coordinator), the EDEN team successfully communicated the research objectives of the EDEN ISS project and its implications towards future human space missions to the public.

Throughout the year, many dedicated interviews, television reports, and radio interviews were conducted with the EDEN team.

The Antarctic greenhouse system and the EDEN laboratory were both focal points of the media coverage, as they perfectly display the group's accomplishments of the last years.

Furthermore, two dedicated EDEN ISS Mock-ups (scale 1:10 and 1:15) were designed and built in 2017. In the future, they will be used for display purposes at conferences, air-shows, conventions, and exhibits. Presented for the first time at the FRR meeting in June, the first mock-up was already on display during the 68th International Astronautical Congress (IAC) in Adelaide, Australia from September 25th to 29th.



Filming of Conrad Zeidler and Matthew Bamsey in the EDEN ISS Mission Control Center.



Daniel Schubert presenting Paul Zabel a gift from the entire DLR Institute of Space Systems before his departure to Antarctica.

MISSION PREPARATION

SPARES, SEEDS, CONSUMABLES, AND A CHESS GAME

Upon the completion of the AIT phase the EDEN ISS Service Section, Future Exploration Greenhouse and separate transport containers were prepared for shipment. Upon the separation of the Service Section and Future Exploration Greenhouse, the containers were cleaned, project supplies (e.g. consumables, spare parts, dangerous goods, etc.) were packed and shipping documentation prepared. The three containers were picked-up by truck on October 2nd. From DLR they were transported to Hamburg where they were loaded onto a container ship (Golden Karoo) and transported to Cape Town where they were later moved onto the South African Agulhas research vessel. From Cape Town the Agulhas traveled to Antarctica and stopped off to drop supplies at the SANAE (South African) Antarctic station before continuing on to drop the EDEN ISS containers and other Alfred Wegener Institute equipment on the ice shelf edge near Neumayer Station III. The containers were then transported ca. 20 km across the ice by tracked vehicle where setup was commenced by the EDEN ISS deployment team.



Markus Dorn, Lena Hummel, Maria Rosello Petit working hard to clean out the Future Exploration Greenhouse before container separation and shipment to Antarctica.



The DLR team in conjunction with employees from CBG Container Bau sealing up the EDEN ISS containers for shipment.



Vincent Vrakking taking inventory of dangerous good destined for Antarctica.

Project equipment during the packing of the EDEN ISS containers for transport to Antarctica.



The removal of the roof-mounted freecooler during de-integration activities in Bremen.

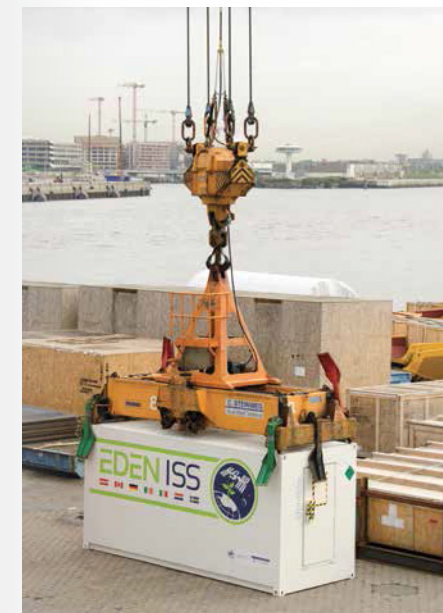


EDEN ISS containers before separation by crane.



The loading of the EDEN ISS containers onto the S.A. Agulhas II in Cape Town South Africa.

Photo credit: Hafen Spedition



The Future Exploration Greenhouse container ready for loading onto the Golden Karoo container ship for transport from Hamburg, Germany to Cape Town, South Africa. *Photo credit: Hafen Spedition*



Truck transport from DLR Bremen to the Hamburg harbour, the first logistics step in the long chain of transport to Antarctica. *Photo credit: Hafen Spedition*



Arrival of the DLR EDEN ISS deployment team at the Neumayer Station III after the ca. 2.5 hour flight from Novo Airbase.

CREW ARRIVAL AT NEUMAYER III

THE ADVENTURE BEGINS, BUT NOT YET...

Several members of the EDEN team were fortunate to be part of the initial EDEN ISS Antarctic deployment team. The four person crew travelled to South Africa where they met up with other Antarctic researchers and boarded a plane that carried them to Novo Airbase situated in close proximity to Russian Antarctic Station Novolazarevskaya. The team spent two nights at this camp before flying to the Neumayer Station III. Upon arrival, the crew was introduced to the station and provided various safety briefings. The crew commenced the preparations for the arrival of the EDEN ISS containers which were unfortunately delayed until the beginning of 2018 due to severe weather and ice conditions. The deployment team will spend a total of approximately seven weeks on-site at Neumayer Station III installing the greenhouse and getting its subsystems operational before leaving Paul to operate the facility while he overwinters at the station.



The DLR EDEN ISS deployment team – Daniel Schubert, Paul Zabel, Matthew Bamsey and Conrad Zeidler at Novo Airbase while awaiting their flight to Neumayer Station III.



Antarctica on the aircraft display screen!



Novo Airbase containers with luggage prepped for departure to Neumayer Station III.



Your typical (or not) boarding pass.



Daniel Schubert enjoying the tight quarters at Novo Airbase.



The famous "Zebra" toilet at Novo Airbase (interestingly constructed with Canadian wood from Matt's wife's hometown in Northern Quebec!)



Snow vehicles and other infrastructure at Novo Airbase.



Arrival of the DLR deployment team at Novo Airbase.



Arrival of the DLR deployment team and new station overwinterers and their walk from the Neumayer runway to the station.



The DLR Antarctic deployment team Paul Zabel, Conrad Zeidler, Matthew Bamsey and Daniel Schubert in front of the impressive Neumayer Station III.

KEY FIGURES - 2017

JOURNALS

D. Schubert: „Greenhouse production analysis of early mission scenarios for Moon and Mars habitats“, Open Agriculture - Topical Issue: Agriculture in Space, pp. 91-115, 2017

C. Zeidler, V. Vrakking, M. Bamsey, L. Poulet, P. Zabel, D. Schubert, C. Paille, E. Mazzoleni, N. Domurath: „Greenhouse Module for Space Systems: A Lunar Greenhouse Design“, Open Agriculture - Topical Issue: Agriculture in Space, pp. 116-132, 2017

BOOK CONTRIBUTIONS

C. Zeidler: „TERRA Aktionsraum Erde – Landschafts- und Nutzungszonen im Wandel“, Themenband, Klett Verlag, ISBN: 978-3-12-104702-4, 2017

PEER-REVIEWED CONFERENCE PROCEEDINGS

P. Zabel, M. Bamsey, C. Zeidler, V. Vrakking, D. Schubert, O. Romberg: „Future Exploration Greenhouse Design of the EDEN ISS Project“, 47th International Conference on Environmental Systems, Charleston, South Carolina. USA, 16-20 July, 2017

V. Vrakking, M. Bamsey, C. Zeidler, P. Zabel, D. Schubert, O. Romberg: „Service Section Design of the EDEN ISS Project“, 47th International Conference on Environmental Systems, Charleston, South Carolina. USA, 16-20 July, 2017

G. Boscheri, M. Volponi, M. Lamantea, C. Lobascio, D. Schubert, P. Zabel: „Main performance results of the EDEN ISS rack-like plant growth facility“, 47th International Conference on Environmental Systems, Charleston, South Carolina. USA, 16-20 July, 2017

G. Boscheri, V. Guarnieri, S. Chirico, P. Zabel, C. Lasseur: „SCA-LISS: A European tool for automated SCAling of Llife Support Systems“, 47th International Conference on Environmental Systems, Charleston, South Carolina. USA, 16-20 July, 2017

CONFERENCE PROCEEDINGS

C. Zeidler, M. Bamsey, V. Vrakking, P. Zabel, D. Schubert, O. Romberg: „The EDEN ISS Antarctic Greenhouse Project – Final Design and Outcome of the Assembly, Integration and Testing Phase“, International Astronautical Congress, Adelaide, Australia, 25-29 September, 2017

C. Kiselchuk, M. Dixon, C. Thompson, M. Stasiak, M. Bamsey, D. Schubert: „Development of Ion-Selective Optrodes for Interplanetary Food Production and Water Sampling“, American Society for Gravitational and Space Research, Seattle, USA, 25-28 October, 2017

R. Ferl, A.-L. Paul, J. Callaham, N. Beisel, D. Taylor, M. Bamsey, C. Zeidler, D. Schubert: „Spectral Imaging within EDEN ISS for Plant Health and Productivity Assessment“, American Society for Gravitational and Space Research, Seattle, USA, 25-28 October, 2017

DLR, AWI: „EDEN ISS: A Facility to provide Neumayer Station III Overwinterers with Fresh Food while Advancing Space Technology“, Antarctic Treaty Consultative Meeting, ATCM XL CEP, IP043, Beijing, China

INVITED TALKS

„Pflanzenanbau auf dem Mars – und warum ich dafür in die Antarktis gehe“, 13th XLAB Science Festival, Göttingen, 25.01.2017

„Neue Technologien für die Produktion von Nahrungsmitteln in urbanen Ballungsgebieten“, Workshop zum Thema Vertical Farming, Hochschule Bochum, 21.02.2017

„Antarktis-Gewächshaus EDEN ISS – Vorbereitung für zukünftige Habitate auf Mond und Mars“, Haus der Wissenschaft, Braunschweig

„EDEN ISS – Status Report and Mission Overview“, Seminar, Institute of Space Systems, Bremen

POSTERS

V. Vrakking: „“LED-lighted Closed-Loop Greenhouses“, German Egyptian Research Fund Kick-Off Workshop, Cairo, Egypt, 25-28 Nov. 2017

DIPLOM-/ MSC.-/ BSC.-THESIS

K. Birgy: „Storage management and post-harvest considerations of greenhouse systems for planetary habitats“, Bachelor Thesis, FH Aachen, Fachbereich 6: Luft- und Raumfahrttechnik

Dominik von Borell du Vernay: „Analysis of phased implementation strategies of life support systems in a Moon base“, Diplom-Thesis, TU Dresden, Institut für Luft- und Raumfahrtssysteme, 2017

REPORTS (INTERNAL/EXTERNAL)

C. Zeidler, D. Schubert, V. Vrakking, G. Dreyfus, Z. van Acker, O. Rodriguez, A. Gilley, A. Carter, J. den Besten, H. Gorden Smith, P. McBride, M. Loessl, M. Veenstra, M. Hoffmann, E. Wejmo, T.

Zöllner, L. Welker, N. Domurath, G. Schröder, G. van der Feltz, R. Janssen, J. Westra, G. Bochenek: “Vertical Farming 2.0: Designing an Economically Feasible Vertical Farm - A combined European Endeavor for Sustainable Urban Agriculture“, Association for Vertical Farming White Paper, 2017

Lüdeke: “Semi-closed Lettuce Cultivation and Crop Environment Simulation for EDEN ISS“, Praxisprojekt, FH Aachen, Fachbereich 6: Luft- und Raumfahrttechnik

C. Zeidler: “Argus Controls: Aiming for the stars“, EDEN ISS Argus White Paper

SPECIAL

EDEN ISS Press Conference, July 2017

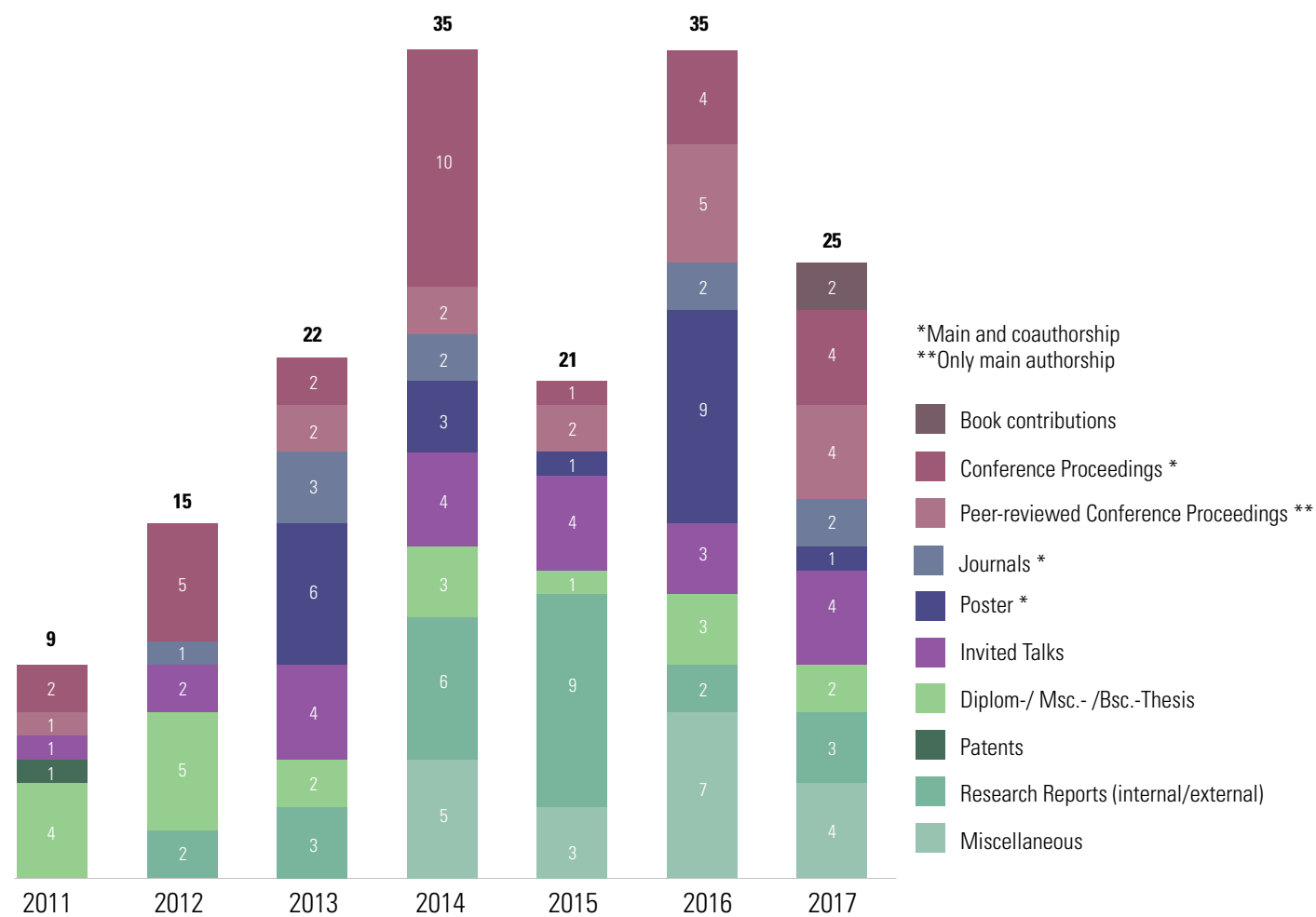
EDEN ISS Press Conference, Nov. 2017

C. Zeidler, V. Vrakking: EDEN ISS exhibit, International Astronautical Congress, Adelaide, Australia, Sep.2017

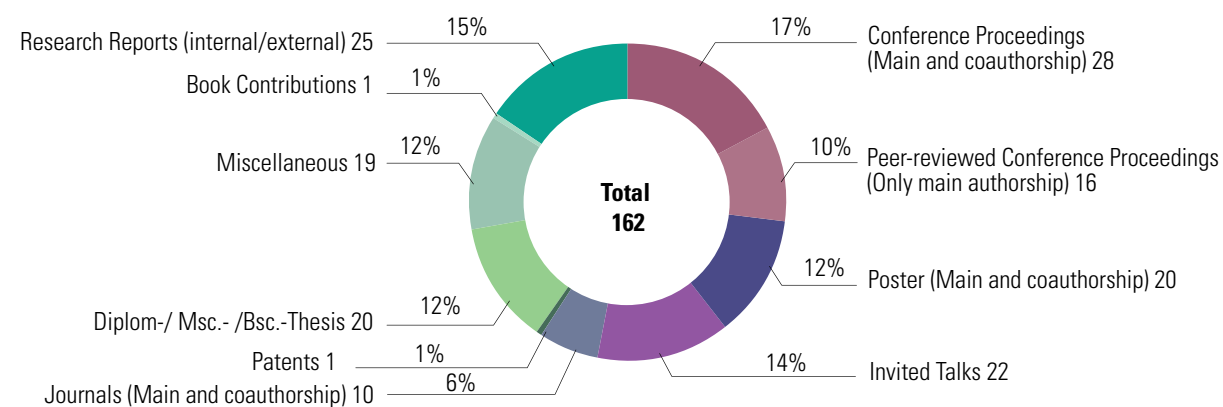
M.T. Bamsey: Membership on the AIAA Life Sciences and Systems Technical Committee.

SUMMARY KEY FIGURES (2011-2020)

PUBLICATIONS & KEY FIGURES 2011-2017

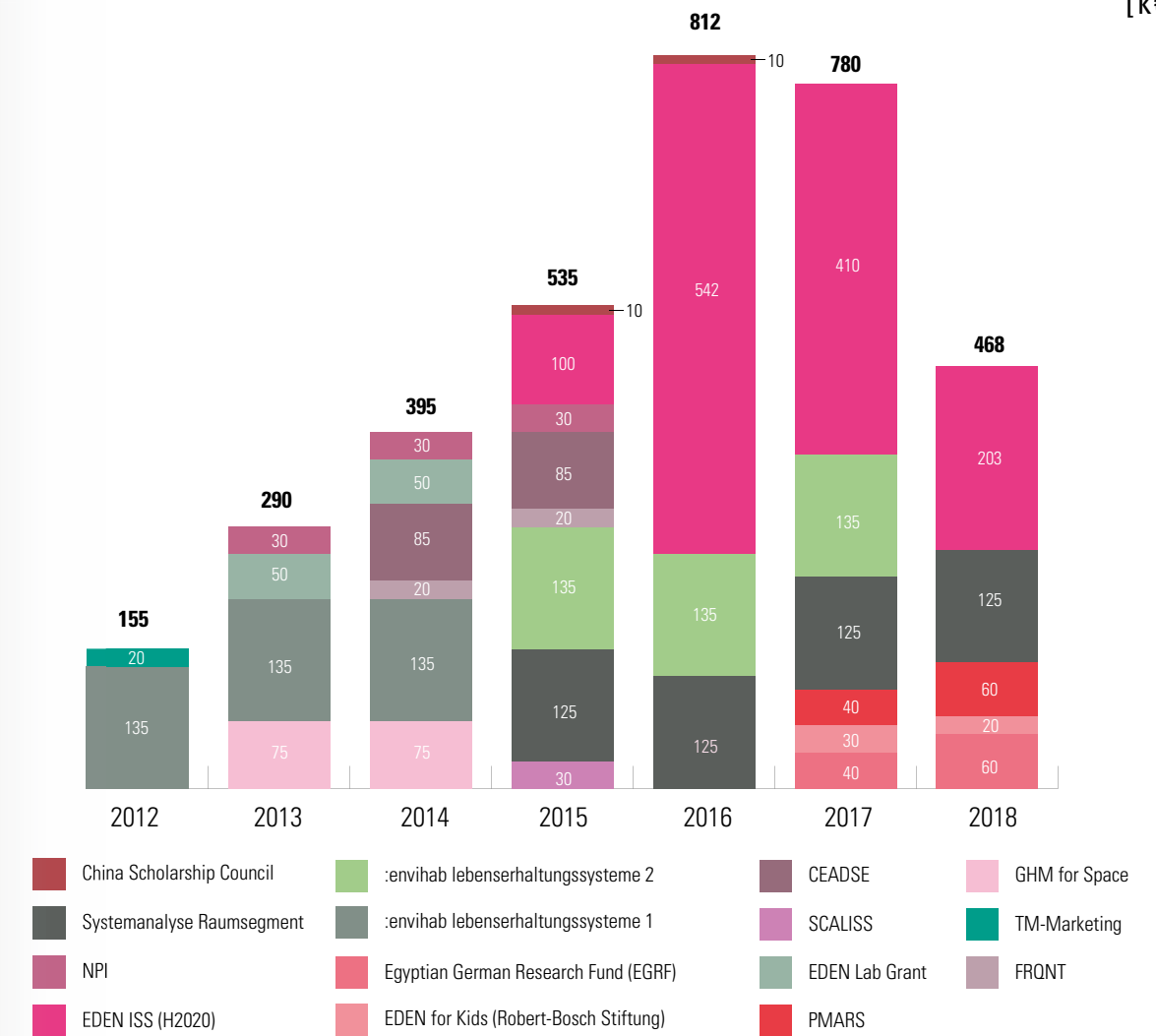


TOTAL PUBLICATIONS & KEY FIGURES 2011-2017

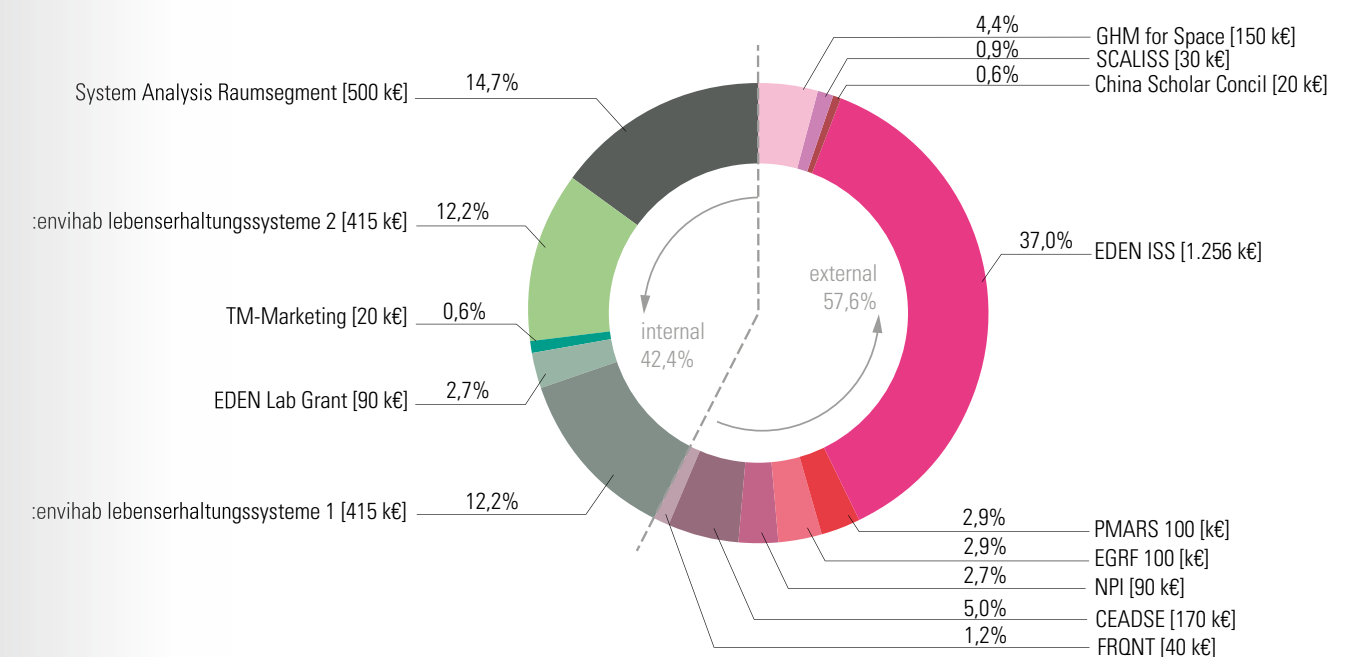


BUDGETS OVERVIEW & FORECAST 2012-2018

[k€]



TOTAL BUDGETS DISTRIBUTION 2012-2018 [in k€]



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:



Lena Hummel is an industrial engineering student from the Ost-bayerischen Technischen Hochschule in Weiden, Bavaria. She did a voluntary internship for six weeks. During her time at DLR she supported the EDEN team with packaging and EDEN ISS shipment preparation. Lena has returned to University to complete her last semester and will start with her bachelor thesis in March 2018.



Francesco Iervese is a M.Sc. space engineering student from Politecnico di Milano, Italy. During his 10 months internship he worked on the integration and test of the EDEN ISS Antarctica greenhouse project. Francesco is finishing his Master in July 2017. In the future he aims to work in the space sector.



Katrin Birgy holds a Bachelor degree in Industrial engineering and management from the University of Bremen. During her time at the DLR in Bremen she worked on her bachelor thesis. In accordance to the EDEN ISS project, her topic outlined the storage management and post-harvest considerations of greenhouse systems for planetary habitats. She started her Master in Production Engineering in October 2017 after finishing her bachelor degree.



Rik van Dommelen is a Mechanical engineering bachelor student at Avans university of applied sciences in Breda, the Netherlands. He had an Internship at DLR with the purpose of writing his bachelor thesis. The topic concerned deployable plant cultivation units. The goal was to look in to different materials and deploying methods for a small rigidizable structure that can hold plants and several subsystems. Operating and maintaining the EDEN team 3D printer was also a part of his tasks.



Jelena Schutowa has a Master of Science in horticulture from the University Geisenheim. During her 7 months internship at EDEN she worked in the EDEN Lab and performed plant-growth experiments in the grow chambers. She also helped with other projects and carried out literature reviews and statistics. Jelena now finished her studies and works in an In Vitro plant Lab.



Connor Kiselchuk is an undergraduate student studying Environmental Science at the University of Guelph, Canada. Connor completed an eight month internship with the EDEN team; where he focused on final subsystem integration, plant growth trials, final MTF assembly and Antarctic mission packaging. He is finishing his degree in December 2018 and plans to do graduate work in the field of bioastronautics.



Dominik von Borell du Vernay was an aerospace engineering student at the Technical University of Dresden. Dominik wrote his Diploma thesis at the EDEN group on life support systems for an evolving lunar outpost. In October 2017, he finished his degree as an aerospace engineer.



Andres Lüdeke is an Aerospace Engineering student with specialization in Space Engineering at the University of Applied Sciences in Aachen. During his seven-month internship at the DLR in Bremen he was part of the team that integrated systems and components into the EDEN ISS container while helping to maintain, install and test new hardware in the EDEN laboratory, like the Saladbox. Andres has since then returned to the university to finish his Bachelor degree.



Thomas Pearson is an aerospace engineering student working on his Master’s degree with a focus in Bioastronautics at the University of Colorado Boulder, USA. During his 6 month internship with EDEN, he helped integrate many components in the Future Exploration Greenhouse including elements of the Nutrient Delivery System, the image acquisition system, and various customized hardware. He is currently a graduate research assistant at the Bioserve Space Technologies Center.

IMPRESSIONS 2017

THE YEAR THE JOURNEY BEGAN



DLR students Maria Rosello Petit, Lena Hummel and Connor Kiselchuk taking a short break during the packing of the EDEN ISS transport container.



Matthew Bamsey, Paul Zabel showing their happiness following the arrival of the TASI built RUCOLA ISS rack-like plant growth system.



Employees from HART Kälte- und Klimatechnik visiting the EDEN ISS Mobile Test Facility during the Bremen test phase to take a look at their colleague's work on the thermal control system.



Giorgio Boscheri (TASI) and Marco Volponi (TASI) hard at work 'in' RUCOLA.



DLR student Thomas Peterson making adjustments to the Mobile Test Facility camera system.



Cucumber plants in the Future Exploration Greenhouse wound up within their growth rack during the Bremen test phase.



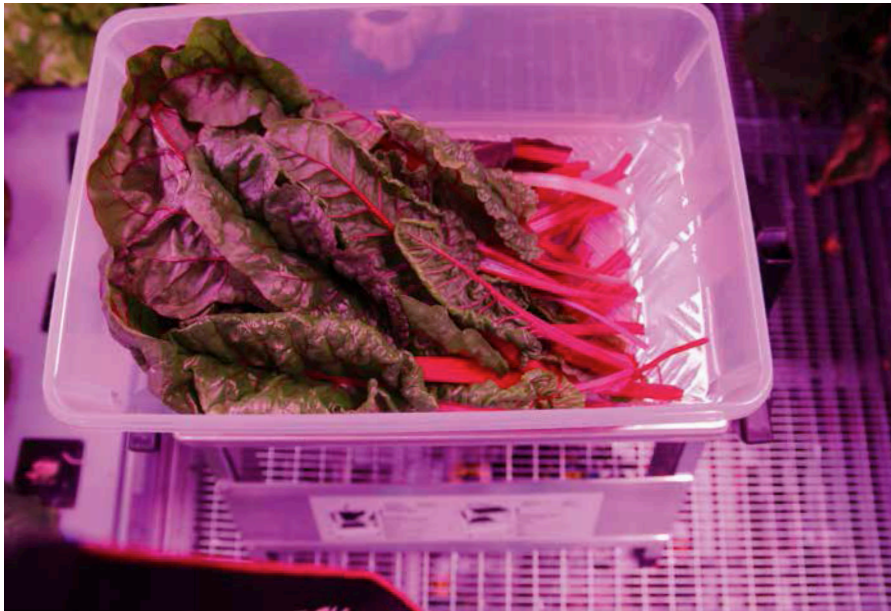
The DLR 'Salad Box' under laboratory test in Bremen following modifications before deployment to Neumayer Station III.



Dr. Tom Dueck (WR) passing on horticultural management knowledge to Paul Zabel in the months leading up to his overwintering in Antarctica.



Ewald Meister (HART Kälte- und Klimatechnik) installing LED cooling lines.



Swiss chard during one of many EDEN ISS harvest events during the assembly, integration and test phase.



A year in the EDEN laboratory wouldn't be the same without at least one good leak.



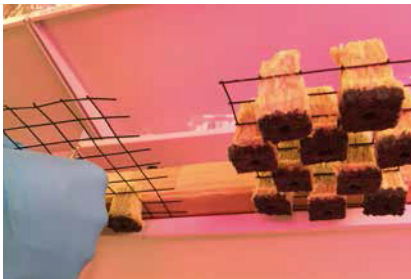
Organizing the wide variety of EDEN ISS seeds prior to shipment to Antarctica.



DLR student Connor Kiselchuk coating the rockwool cubes with cheese wax.



Maria Rosello Petit and Connor Kiselchuk taking care of EDEN ISS harvest activities.



Rockwool cubes with their freshly coated cheese wax left out to dry.



Matthew Bamsey on a mission to keep the Future Exploration Greenhouse clean.



Inedible biomass during final harvesting activities getting sent to the trash.



It wouldn't have been possible without them: Aditya Pande, Maria Rosello Petit, Markus Dorn and Lena Hummel in the final preparation of the EDEN ISS container for shipment.



Aditya Pande and Connor Kiselchuk transporting EDEN ISS cooling fluid from the EDEN laboratory to the blue Antarctic transport container while getting a good leg workout.



That's it! The blue transport container is locked and ready for transport to Antarctica.



The large Service Section window cover with well wishes from all EDEN ISS team members to Paul Zabel for his overwintering phase and for project success in general.



Maria Rosello Petit demonstrating that cleaning can indeed be fun.



Daniel Schubert demonstrating that packing can indeed be fun.



The large number of EDEN ISS growth trays before shipment to Antarctica.



Maria Rosello and Aditya Pande illustrating true EDEN teamwork.

The EDEN team with several members of their family on the day of the pick-up of the EDEN ISS containers.



Dedicated survival training in the Alps for the Antarctic overwintering crew in order to be prepared for the eight month lasting isolation phase at Neumayer Station III.



Paul Zabel eating his survival outdoor food during his survival training on a glacier in the Alps.



Chainsaw training for the overwintering team.



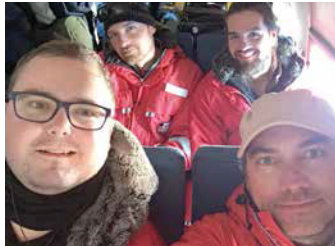
Daniel Schubert trying on his Antarctic gear in Bremerhaven.



The AWI overwintering crew during their firefighting course in Germany.



Dr. Mark Kliss (NASA Ames), Paul Zabel, Dr. Ray Wheeler (NASA KSC) and Dr. Dave Klaus (UColorado) at the 2017 ICES Conference in Charleston, South Carolina.

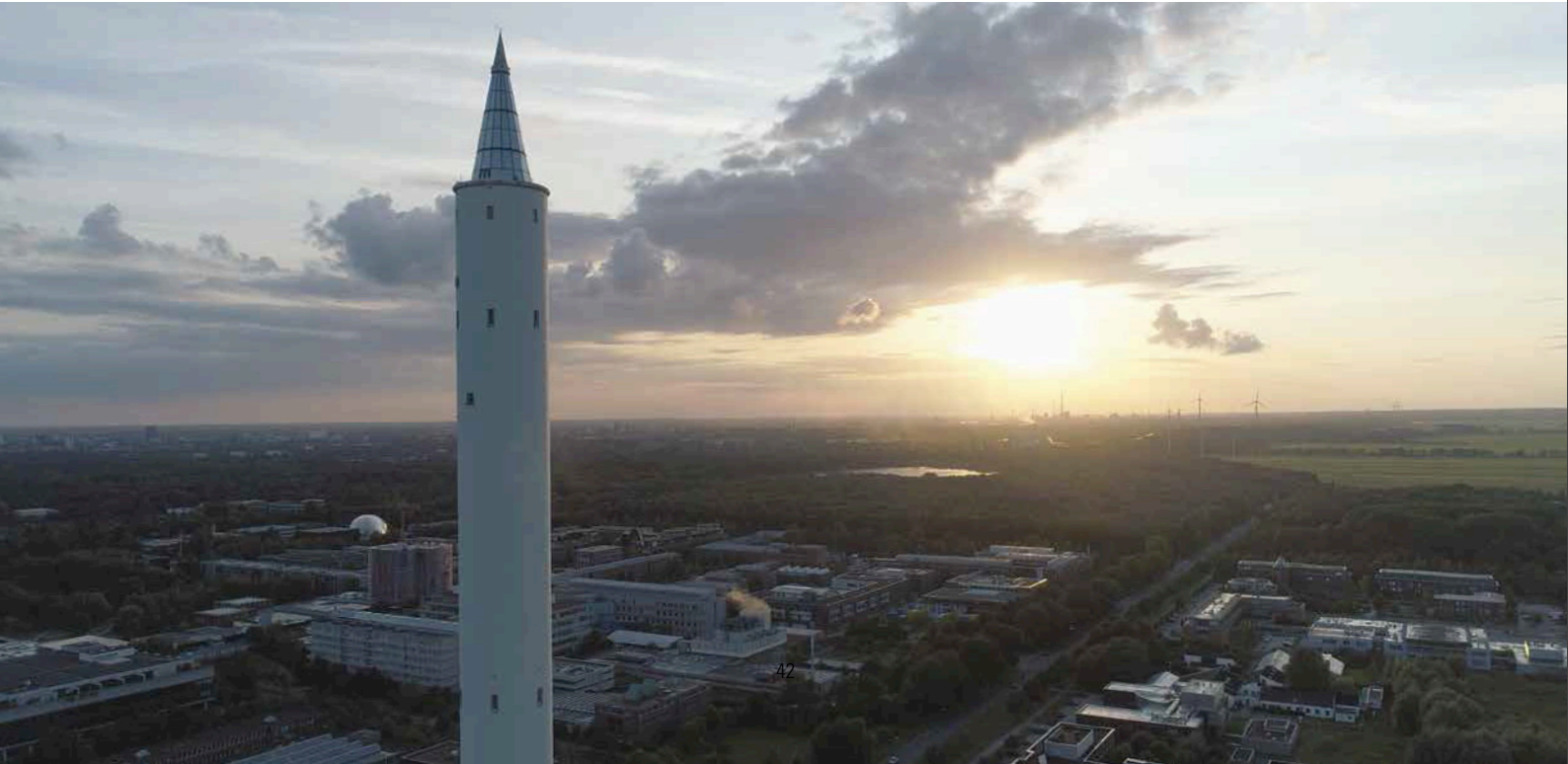


DLR EDEN ISS deployment team on the flight from Novo Airbase to Neumayer.



Vincent Vrakking making the Great Pyramids look small.

University of Bremen and the technology park, location of the DLR Institute of Space Systems.



The DLR team with several EDEN ISS partners enjoying a summer BBQ while taking a break from assembly, integration and test activities.



Backyard grilling.



Giuseppe Bonzano (Arescosmo) integrating the air management system.



Markus Dorn enjoying a BBQ break



A mid-mission surprise box for Paul in the early stage of preparation.



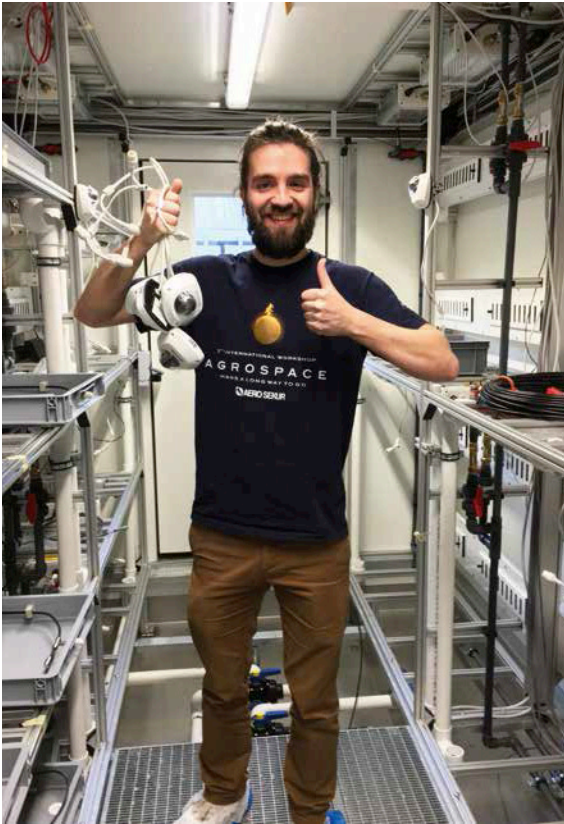
An example of the media attention that the EDEN ISS project generated in 2017.



Sandra Müller (DLR) and Maria Rosello Petit preparing one of the EDEN ISS display models.



FEG camera view of Matthew Bamsey.



Conrad feeling good about progress in the installation of the Mobile Test Facility camera system.



An AWI visit from Eberhard Kohlberg, Dirk Mengedoh and Bernhard Gropp the station leader for 2018 Neumayer Station III overwintering.



Making some 'final' adjustments to the air management system.



Playing Tetris with the installation of RUCOLA into the Service Section.

The EDEN Team saying goodbye to Paul before his Antarctic overwintering.





Loading the Service Section container onto the Golden Karoo container ship in Hamburg. *Photo Credit: Hafen Spedition*



The EDEN ISS containers in the Hamburg harbour. *Photo Credit: Hafen Spedition*



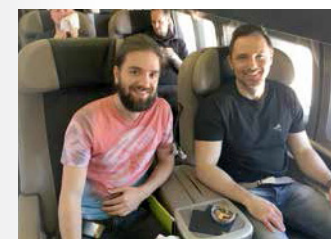
EDEN ISS containers en route between Bremen and Hamburg. *Photo Credit: Hafen Spedition*



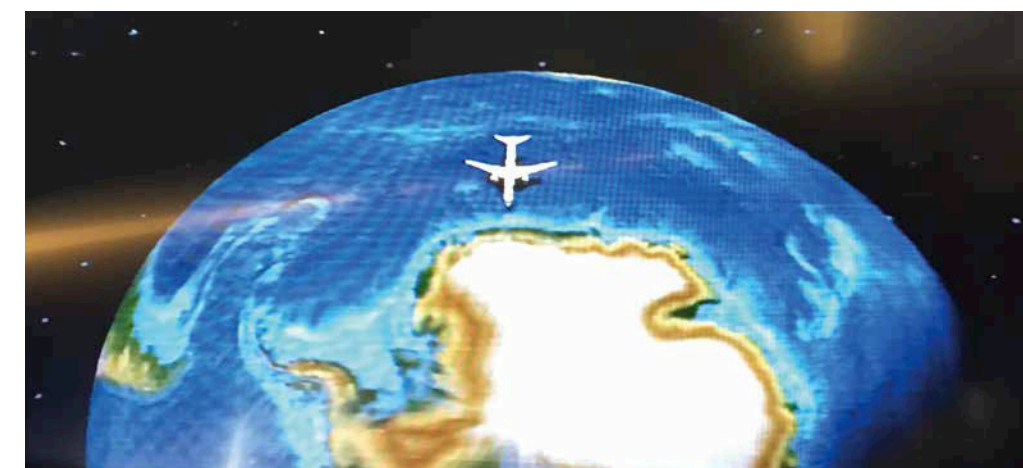
DLR deployment team ready for departure to from Cape Town to Antarctica.



Conrad Zeidler, Daniel Schubert and Matthew Bamsey spending time outside at Novo Airbase.



Conrad Zeidler and Matthew Bamsey en route to Antarctica.



Getting closer to arrival during the 5.5 to 6 hour flight from Cape Town to Antarctica.



Paul Zabel, Conrad Zeidler, Matthew Bamsey and Daniel Schubert on the EDEN ISS platform wishing a Happy New Year to all.

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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