EDEN LUNA

Science and Technology Demonstration Platform

Vincent Vrakking, German Aerospace Center, 08.10.2025

PLANETARY INFRASTRUCTURES

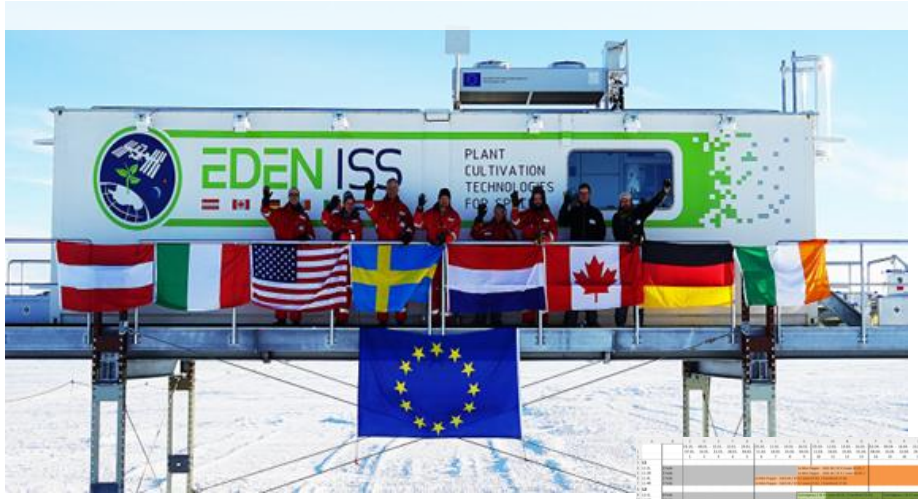
Bioregenerative Life Support Systems (BLSS)	In-Situ Resource Utilization (ISRU)	Space Habitat Design

Source: NASA

Source: ESA

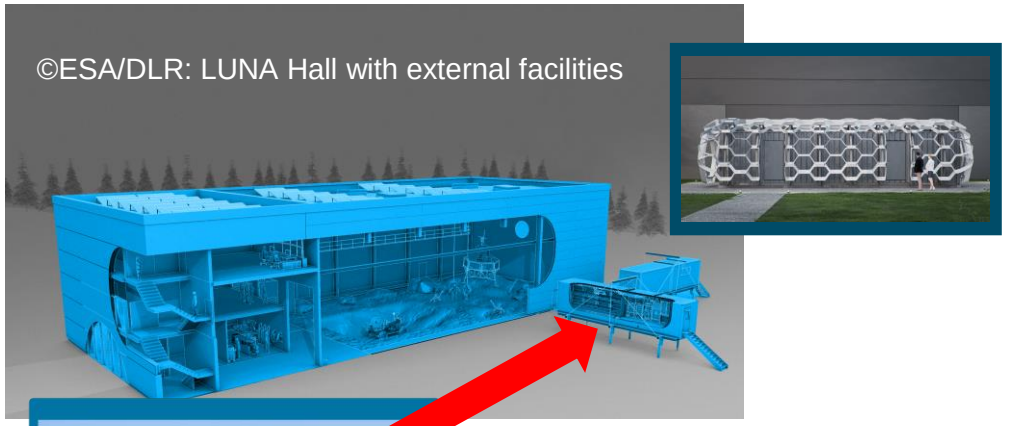
- *System analysis & concurrent engineering studies*
- *Hardware development, design & procurement*
- *Assembly, integration & (analogue field) testing*
- *Operation & technology transfer (e.g. vertical farming)*

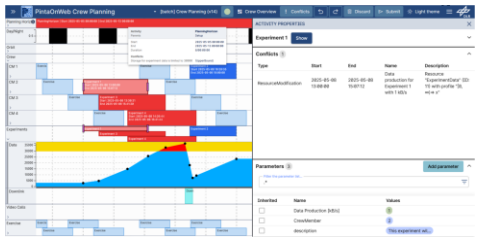
EDEN LUNA – SYSTEM



©DLR: EDEN ISS, Antarctica 2018

©DLR: Crop planning tool, 2018



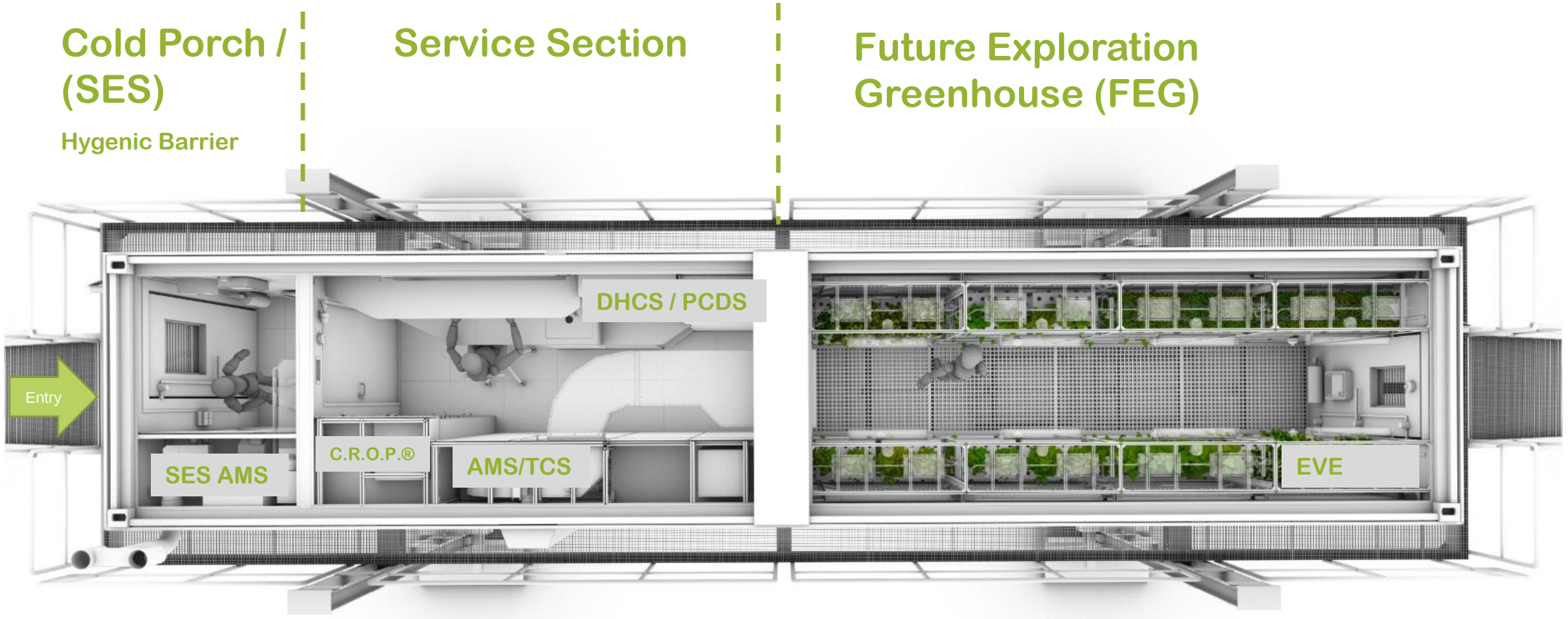


©DLR: PintaOnWeb Demo, 2025

- *Refurbished container structure with updated interfaces*
- *New payloads and updated subsystems*
- *Improved operational procedures*

- *Investigate system in- and outputs*
- *Test and improve new operations planning tools*
- *Implement improved inventory management system(s)*
- *Investigate use of AR/XR in crew operations and training*
- *Test and improve FDIR methods by simulating failures*

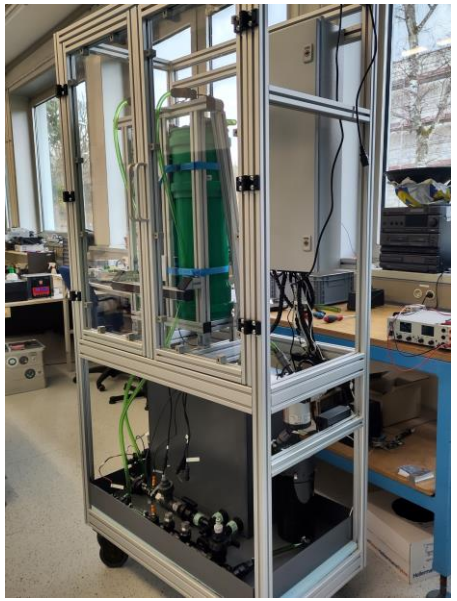
EDEN LUNA - LAYOUT



- 40ft container including approx. 12m^2 growth area
- Complex interactive System, controlled by MCC in Bremen & Cologne (MUSC)

EDEN LUNA – PAYLOADS

©TASI/DLR: RUCOLA crop cultivation system, Antarctica, 2018



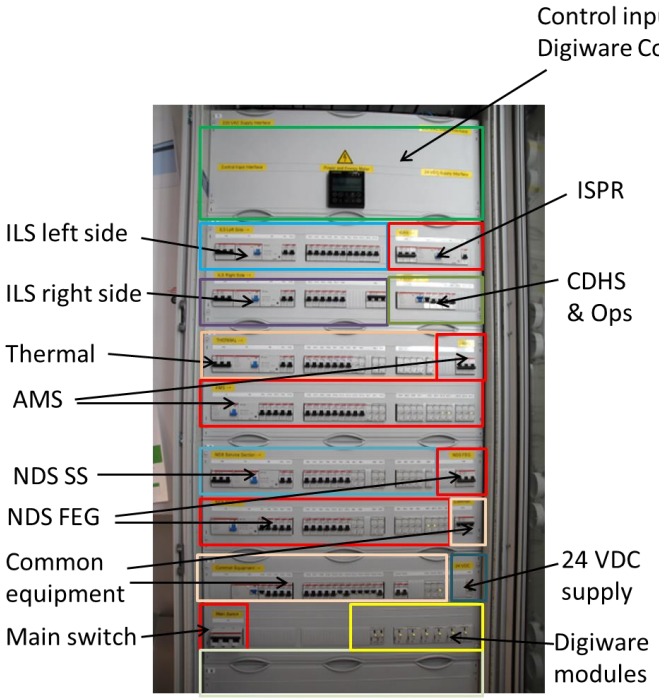
©DLR: C.R.O.P. Biofilter, Cologne, Germany, 2025

©DLR: EVE Robotic system, Oberpfaffenhofen, Germany, 2025

- *Original payload from TASI returned to Italy in 2019*
- *New C.R.O.P. Biofilter*
- *New Robotic System – EDEN Versatile End-Effector (EVE)*

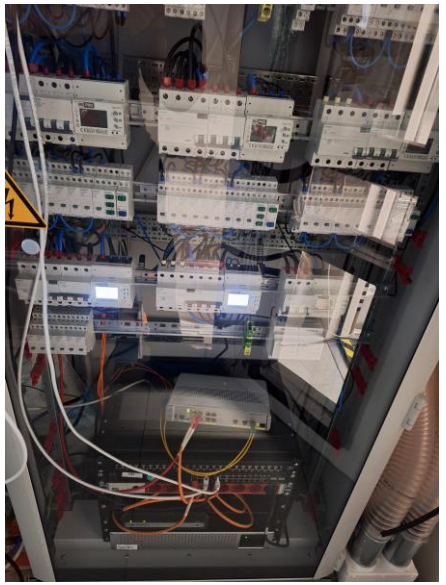
- *Investigate (semi-autonomous) robotic operations*
- *Enhance robotic system capabilities*
- *Investigate urine processing and post-processing*
- *Investigate crop cultivation using C.R.O.P.-modified nutrient solution*
- *Implement additional payloads in the future (e.g. bio-reactors)*

EDEN LUNA – DHCS & PCDS



©DLR: EDEN ISS PCDS, Bremen, Germany, 2017

©DLR: EDEN ISS ARGUS DHCS, Bremen, Germany, 2017



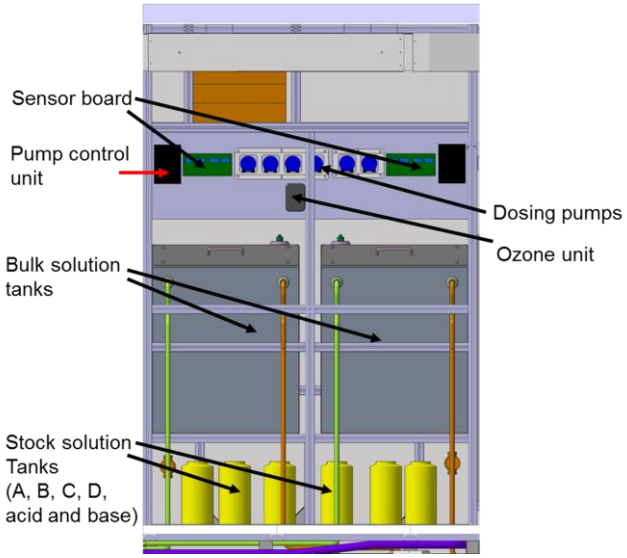
©DLR: EDEN LUNA DHCS & PCDS, Bremen, Germany, 2025

©DLR: EDEN LUNA Subsystem PDU Assembly, Bremen, Germany, 2025

- *New decentralized DHCS architecture*
- *New in-house software development*
- *Streamlined, more compact, PCDS*
- *Improved harness*
- *Machine Learning & AI-based Anomaly Detection And Monitoring (ADAM)*

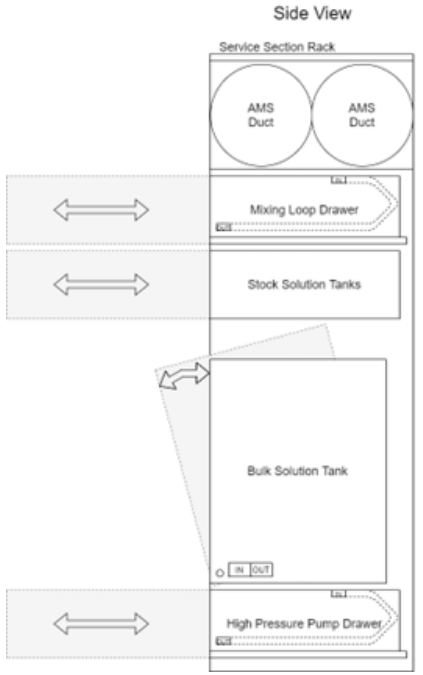
- *Monitoring (and optimization) of power and energy demand*
- *Ongoing optimization of software*
- *(Future) replacement of COTS hardware with custom (space-ready) hardware*
- *Generate databases for machine learning and AI-training (e.g. telemetry, telecommands)*

EDEN LUNA – NDS



©DLR: EDEN ISS NDS CAD design

©DLR: EDEN ISS NDS, Bremen, Germany, 2017



©DLR: EDEN LUNA NDS design

©DLR: EDEN LUNA NDS rack, Bremen, Germany, 2025

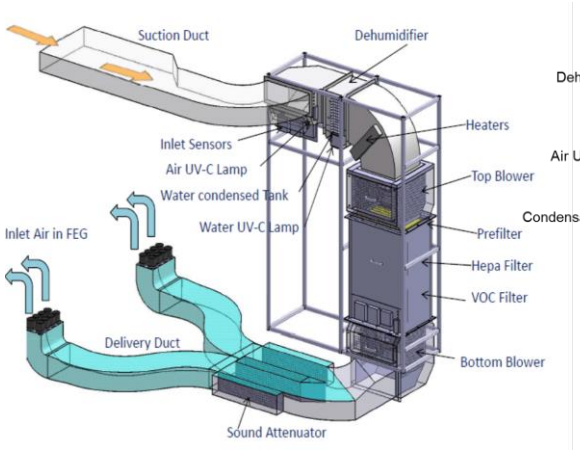
- *New component selection and subsystem layout*
- *Subsystem architecture focused on improved reliability and redundancy*
- *Configuration focused on improved accessibility and maintainability*

- *Investigate system performance and reliability*
  Continuous pumping with distribution valve manifold to control irrigation schedule
- *Investigate microbial growth & countermeasures*
- *Test new cleaning procedure(s)*
  Heating mats applied to tank exterior to enable hot water cleaning cycle

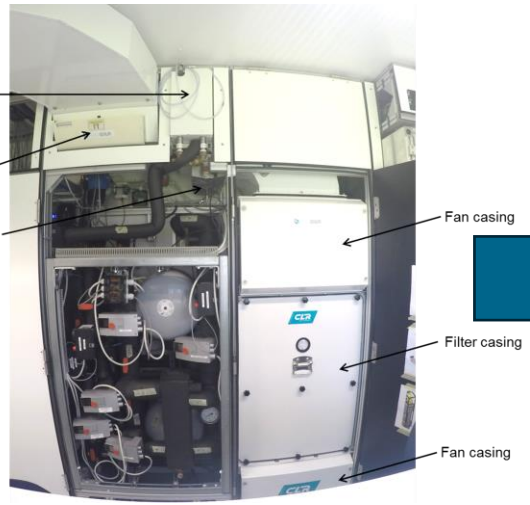
EDEN LUNA – ECS

ATMOSPHERE MANAGEMENT SYSTEM & THERMAL CONTROL SYSTEM

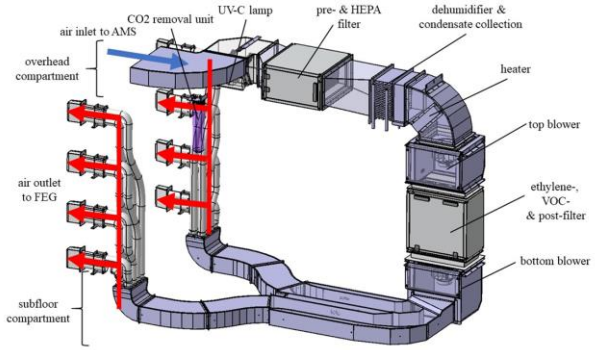
Korth et al., 'Environmental Control Systems for EDEN LUNA Plant Production Module',
54th International Conference on Environmental Systems, 13-17 July 2025, Prague, Czech Republic



©DLR: EDEN ISS AMS CAD image



©DLR: EDEN ISS AMS,
Bremen, Germany, 2017



©DLR: EDEN LUNA AMS CAD image

©DLR: EDEN LUNA TCS rack,
Bremen, Germany, 2025

©DLR: EDEN LUNA AMS,
Bremen, Germany, 2025

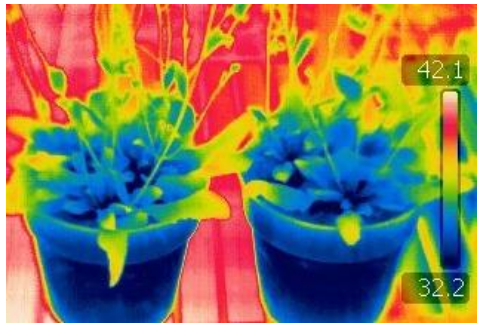
- *(Re-)use of EDEN ISS Hardware where possible*
- *New dehumidifier – Increased capacity*
- *New filter layout –to prevent microbial build-up on dehumidifier*
- *New sensors – Particulate matter, VOC,*
- *New CO2 scrubber – to remove (potential) excess crew emissions*
- *New SES AMS & TCS*

- *Investigate optimal air filtration and purification architecture*
  Baseline (rough filter, UV-C, pre- & HEPA filter, VOC filter, rough filter)
- *Investigate condensate water quality & post-processing needs*
- *(Future) Implement additional sensor & monitoring capabilities*
  ((Near) real-time microbial monitoring, enhanced trace gas monitoring)
- *(Future) Reduce waste heat and investigate waste heat valorization options*

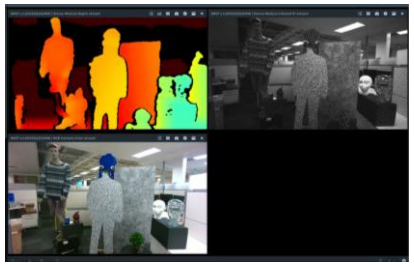
EDEN LUNA – PHM

©DLR: EDEN ISS Top View Camera Image, Antarctica, 2018

©DLR: EDEN ISS Side View Camera Image, Antarctica, 2018



Thermal image of potted plants
source: https://qubitsystems.com/thermal-imaging/



Intel RealSense D457 2D view: Depth, IR, RGB
(source: https://www.intelrealsense.com/)

FLIR A50 Camera
(source: https://www.topa.de/flir-waermebildkamera-a50/)

Intel RealSense D435i Camera
(source: https://www.intelrealsense.com/)

- *(Re-)use of EDEN ISS cameras (after testing)*
- *New FLIR thermal imaging camera*
- *Mobile imaging system on EVE – Intel RealSense depth camera*

- *Generate images for crop growth databases*
- *Investigate microbial contamination & countermeasures*
- *Investigate biomass quantity & quality output*
- *Investigate plant stresses (e.g. drought, heat)*
- *Investigate new crops & cultivars*
- *Future implementation of root-zone sensors*

EDEN LUNA – RESEARCH PLATFORM

Food Production

Controlled Environment Agriculture

Photobioreactors

Crop Modeling & Production Planning

Insect production

Cell cultivation (cultured meat, cellular agriculture)

Waste Valorization

Fertilizer recovery

Bioplastics

Water recovery & Zero-liquid waste

Food Storage & Food Processing

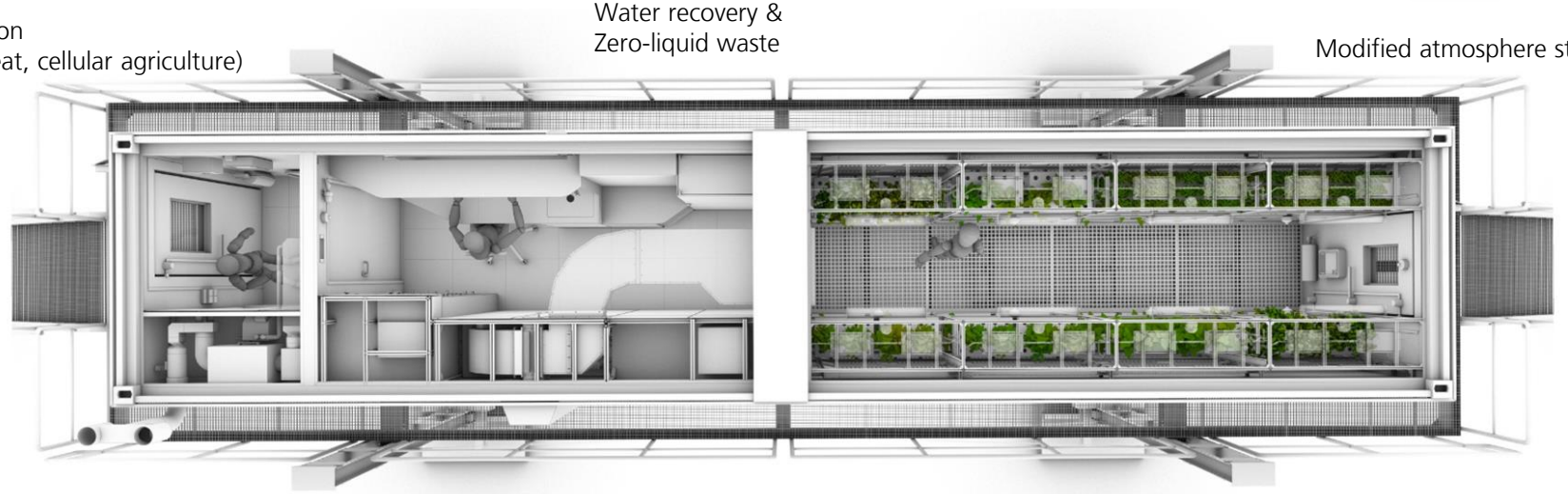
Shelf-life extension

Advanced Oil Extraction

Novel food packaging

Advanced and optimized food processing equipment

Modified atmosphere storage



Food Safety and Quality

Microbial Analysis

Nutritional Analysis

Mitigation Strategies

Acceptability, Palatability, Sensory Analysis

Decontamination

Growth Recipes

Human Factors

Operations & Procedures

Work Load

Crew Time

Crew Training

Psychological Well-being

EDEN LUNA – USER WORKSHOP

- **EDEN Mobile Test Facility as internationally recognized greenhouse test facility for:**
  - **CEA-breadboard testing – closing loops in BLSS**
  - **Astronauts-in-the-loop testing, procedure developments,**
  - **Increasing automation for system and plant health analysis to reduce crew time demand**

EDEN LUNA Workshop – specifically for plant growth facility technologies / BLSS –

2nd December 2025

Hybrid

9 am – 5 pm

Overview on current Research and open/new aspects

Extended utilisation of current systems

New user integration options

(Univ., industry, intern. Partners)

- https://www.dlr.de/de/irs/forschung-und-transfer/projekte/eden-luna

Imprint

Topic:	**EDEN LUNA** Science and Technology Demonstration Platform
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