TRANSFORMING EDEN ISS INTO EDEN LUNA

How DLR's plant cultivation system for future deep space exploration missions is being prepared for its next test campaign

Michel Fabien Franke, Institute of Space Systems, 2024/10/17

INTRODUCTION

Our Research Group

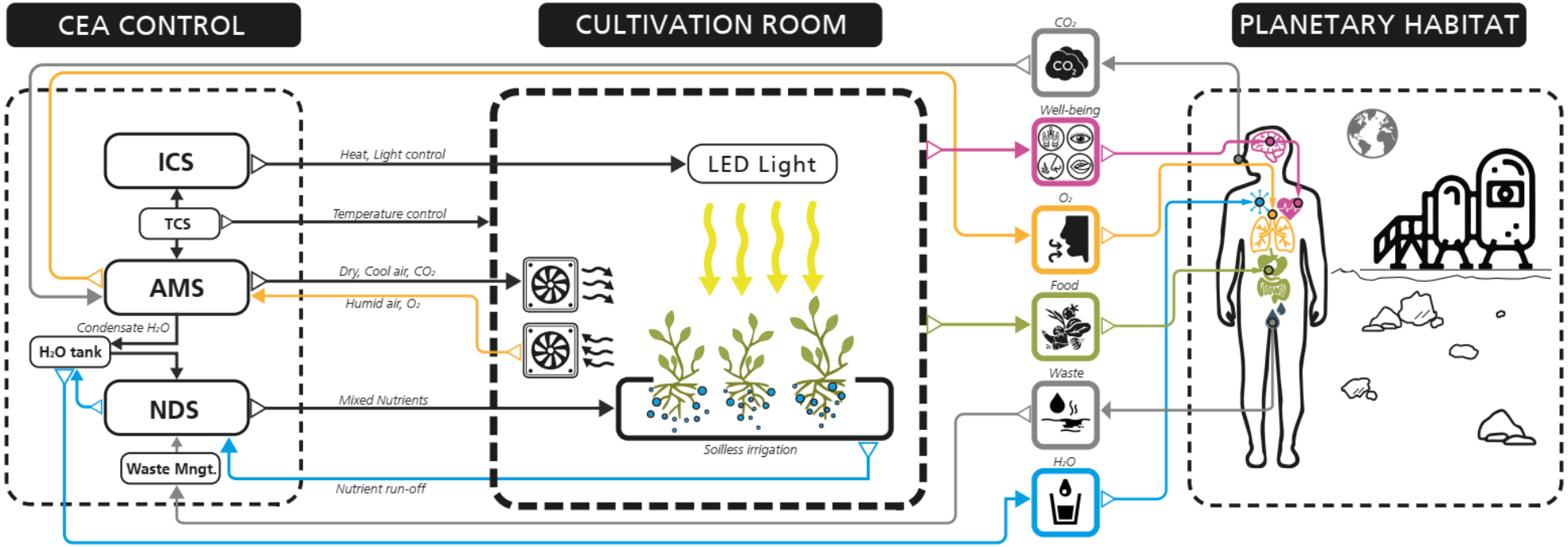
Planetary Infrastructures

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

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

Our Research Topic

Bio-regenerative Life Support Systems



- *Input:* CO2-rich air (respiration), water (recycled grey water), nutrients, light
- *Output:* O2-rich air, water (dissolved in air as RH), nutritious biomass, mental well-being
- *Goal:* Creating a symbiosis between plants and humans

Our Research Projects

EDEN ISS & LUNA, LAM-GTD

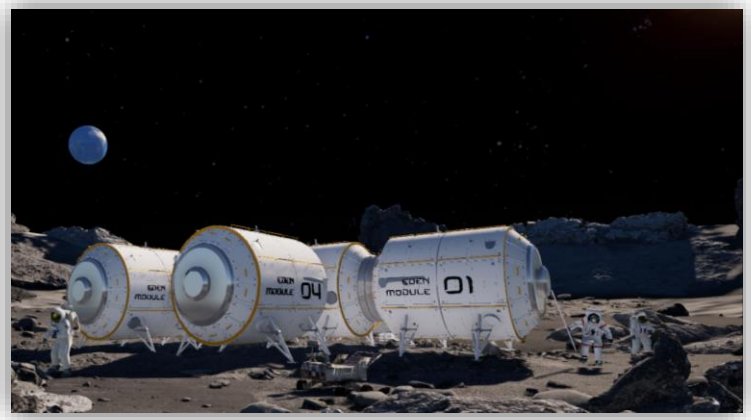
EDEN ISS

A container-sized plant cultivation test facility in Antarctica.
The system was built to demonstrate and validate key technologies and procedures necessary for safe food production within a (semi-) closed system.

EDEN LUNA

Life extension of the EDEN ISS system with fully redesigned subsystems and a refurbished container. Attached to the LUNA analog facility in Cologne, end-to-end operated by and DLR/ESA employees & astronauts.

LAM-GTD



LAM is the attempt to take BLSS one step closer to space. It is a cargo module which turns into a lunar greenhouse once it reaches the Moon. The GTD is developed with space standards and requirements in mind, but operated on Earth.

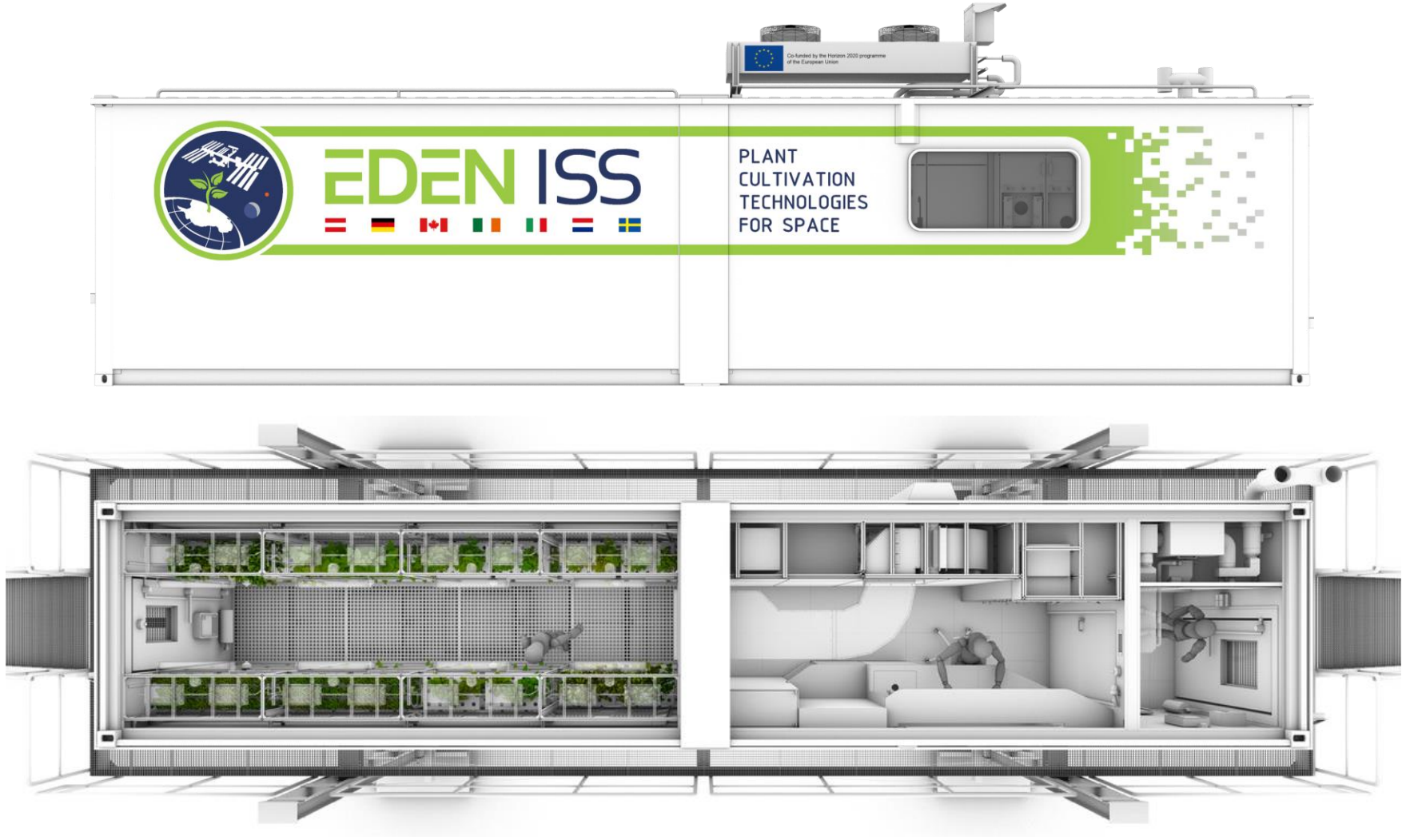
EDEN ISS

Project

- First complex greenhouse analogue mission in Antarctica
- Tested at German Neumayer Station III
- Supplied *9+1* crew members
- *14* partners from different backgrounds (industry, universities, institutes)
- *8* countries involved
- Started in *2015*, ended in *2022*

- Test of critical plant cultivation technologies in relevant environment
- Humans-in-the-loop investigations
- Controlled by Mission Control Center (MCC) at DLR Bremen

System



- Independent biomass production under a semi-closed-loop environment
- Fast production cycles, high yields, low resource consumption

Subsystems

Controlled Environment Agriculture (CEA)

Nutrient Delivery System (NDS)	Illumination Control System (ICS)	Atmosphere Management System (AMS)

- *NDS* mixes macro- and micro-nutrients, dissolves them in water, delivers nutrients to plants
- *ICS* irradiates light in wanted parts of the electromagnetic spectrum
- *AMS* induces airflow, filters contaminants, recaptures water, measures & controls air conditions

Arrival in Antarctica

Operation in Antarctica













EDEN LUNA

Image source: ESA/DLR

Project

Ideas

- Refurbishing & upgrading EDEN ISS
- Astronauts-in-the-loop testing
- Preparatory step for the LAM-GTD

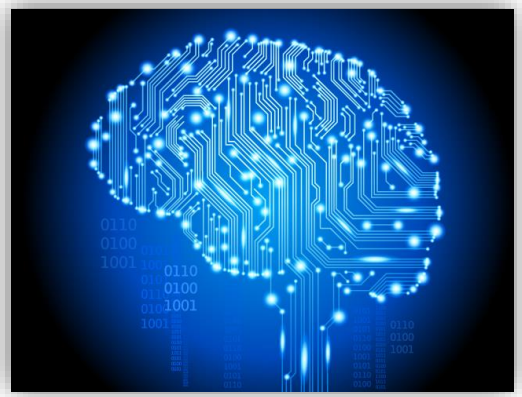
Advancement

- Improved CEA Technologies
- New command and data handling system
- EDEN Versatile End-Effector (EVE) Robotic System
- The C.R.O.P.® Bio-filter for urine processing
- A novel Machine Learning / Artificial Intelligence system for Anomaly Detection And Monitoring (ADAM)

CEA Technologies


Robotic System


Urine Filters


AI / ML Risk Mitigation

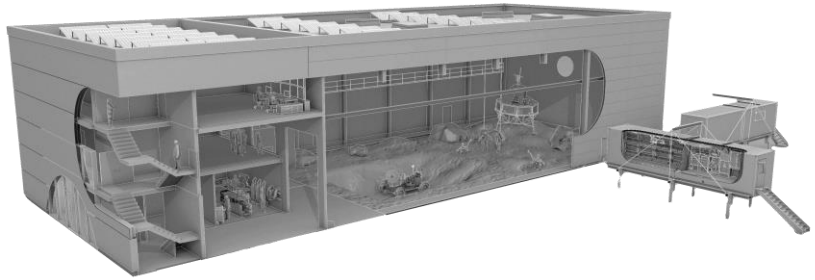
Infrastructure

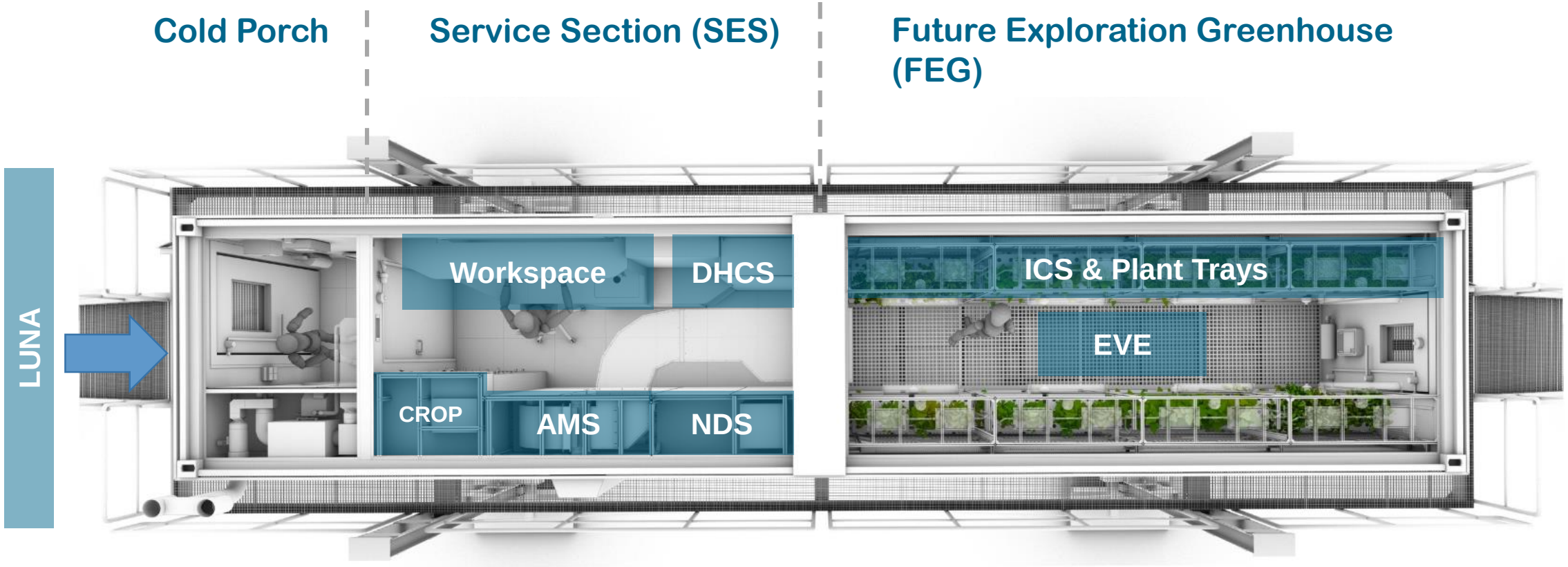
LUNA Analog Facility

- An analogue facility for the preparation of future human and robotic missions to the Moon at DLR/ESA-EAC in Cologne
- Includes functional integration of external modules (i.e. EDEN LUNA, space suits, lander)
- Allows complex simulations for lunar surface activities (tools, processes, crew training, etc.)

System

Mobile Test Facility

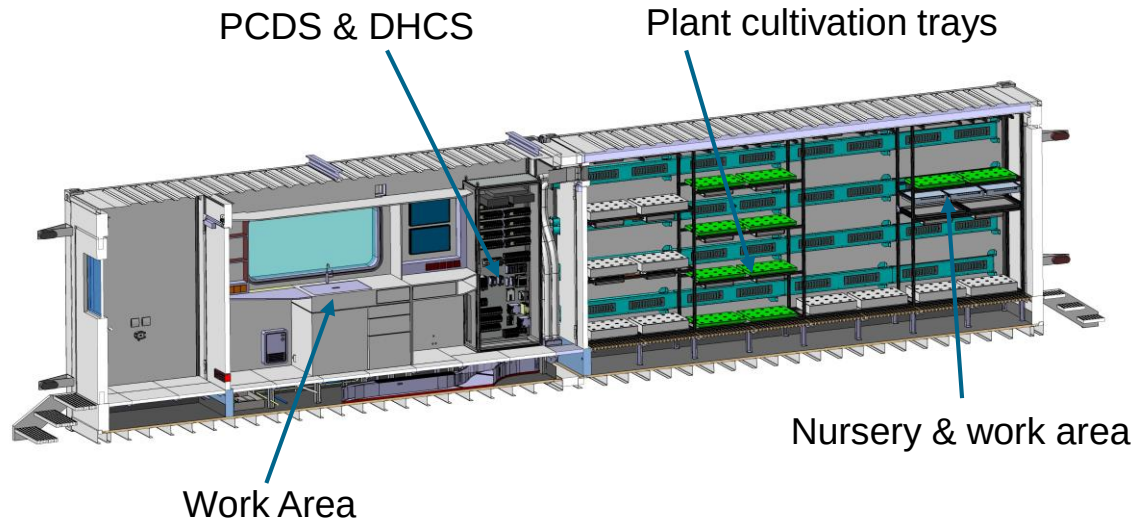


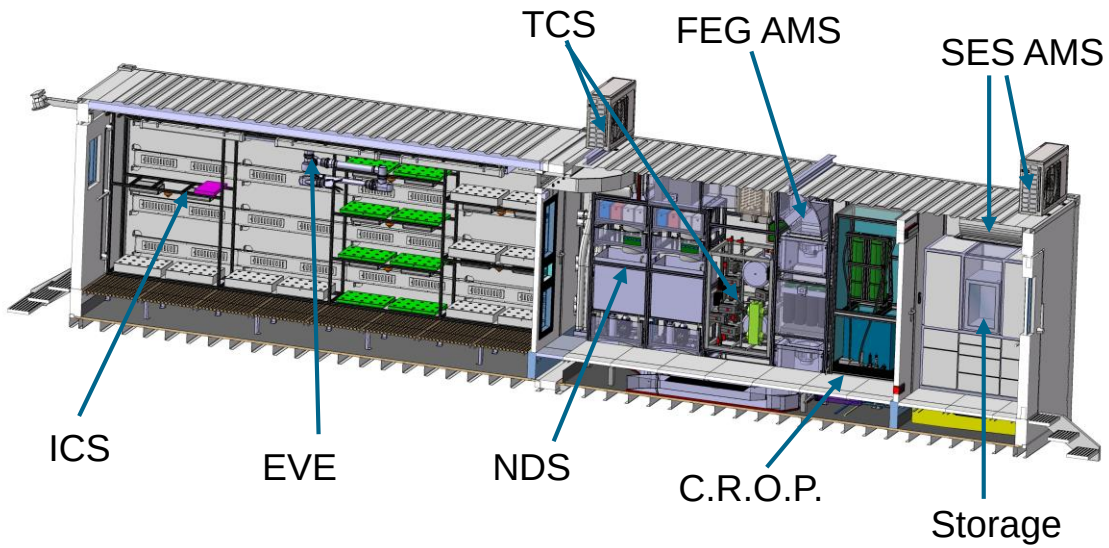


Subsystems

Controlled Environment Agriculture (CEA)

- Simplified Structure & Mechanisms
  - Merging containers to facilitate transport and installation
- Upgraded Atmosphere Management System
  - New sensors to monitor particulate matter, VOCs and ethylene
  - CO2 scrubber to remove excess CO2
  - New dehumidifier & condensate water recovery system
  - New Service Section air conditioning unit
- New Thermal Control System
  - Avoiding leakages
- New PCDS & DHCS designs
- Modified Nutrient Delivery System
  - More robust high pressure pumps
  - Simplified piping architecture
  - Integrated heating elements for cleaning mode
- New work areas & storage cabinet





Progress

EDEN LUNA

Thank you!

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