The EDEN Initiative

Abstract

In 2011, the DLR Institute of Space Systems launched a research initiative called EDEN – Evolution & Growth of Environmentally-closed Nutrition Sources. The research initiative focuses on bio-regenerative life support systems, especially greenhouse modules, and technologies for future human-made space habitats.

The EDEN initiative comprises several projects with respect to space research, ground testing and spin-offs, which are performed by a small team of enthusiastic researchers. The EDEN team has established cooperation with other European and international research groups to share research results and to work on mutual projects.

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EDEN Scope

- Design of Greenhouse Modules (GHM) for future space habitats
- Development of Controlled Environment Agriculture (CEA) technologies
- GHM ground testing at Earth-analogue test sites
- Investigations in post-processing procedures
- Interface evaluations GHM << Habitat
- Terrestrial spin-offs, benefiting citizen on Earth

ESA GHM for Space System

The goal of the EDEN Greenhouse Module for Space System project is to design an automated production facility for higher plants, utilizing mass production principles to minimise mass and volume as well as power demands. The project is performed for the European Space Agency (ESA MUSCA group).

The project will combine the different disciplines, associated with higher plant cultivation research into a solid space-proven concept taking all systems engineering aspects into account. The EDEN GHM project is one part of European activities focused on developing a regenerative life support system (LSS). The cultivation of higher plants can make an essential role within a bio-regenerative LSS since it can contribute to all major functional aspects in closing different loops within a habitat.

DLR C.R.O.P.

The research project C.R.O.P. (Combined Regenerative Organic-food Production) is a combined DLR project of the Institute of Aerospace Medicine and the Institute of Space Systems. The goal is to develop a bio-regenerative LSS with the main focal point on urine degradation, solid waste recycling and food production. Possible areas where C.R.O.P. systems can be implemented are agriculture processes and in households. The C.R.O.P. project will research the following areas:

- Nitrification: the conversion of ammonia from urine to a more manageable nitrate solution
- Detoxification of complete molecules, such as hormones, antibodies and harmful degradation products
- Cultivation of beneficial microorganisms to improve plant growth

EDEN - Space Research

ESA National Partnership Initiative (NPI)

ESA NPI (Networking/Partnership Initiative) supports work carried out by Universities and research institutes on advanced technologies with potential space applications. A DLR-affiliated topic for the ESA NPI is the Combination of Physicochemical Life Support Systems with Space Greenhouse Modules for higher loop closure at different internal pressure levels. It will focus on the following areas:

- Improve readiness of greenhouse modules as part of LSS by taking advantage of the experience and reliability of current physico-chemical (PFC) LSS.
- Analyse proper interfaces and buffer methodologies between the greenhouse module and other habitat systems, and also between different internal atmospheric pressure levels.
- Investigate current analytical and mathematical models of PFC/LSS, develop new models when necessary.

EDEN - Ground Testing

Analogue Testing @ Antarctica

ASS Antarctic Greenhouse

The Antarctic GHM (performed by the DLR Advanced Study Group) comprised all necessary systems and subsystems needed for the cultivation of different crops for a remote research station at the South Pole. The focus of this investigation was the estimation of mass flows and output of an container GHM

EDEN C.R.O.P. - Proposal

The EDEN C.R.O.P. aims at validating plant cultivation technologies at multiple analogue test sites (Recrevatar Station at Antarctica, Atacama Desert, Chile) to support bio-regenerative life support systems for future human space exploration. These technologies in clude:

- Structures, Mechanics & Plant Compartment
- Nutrient Delivery System
- Environmental Control
- Lighting System

GHM Subsystem & Infrastructure Development

EDEN Laboratory

The EDEN laboratory, established in spring 2011, allows the DLR staff to experimentally investigate plant cultivation under closed environments. The research objectives are the development of customised LED panels, the creation of light recipes for different plant species and preparatory activities (e.g., plant compartment design) for a future container-shaped greenhouse module.

Food Processing Facility (FPF)

The Food Processing Facility (FPF) is the general interface between a future habitat and the greenhouse module. Analyzing the post-processing procedure is an essential aspect considering the overall production cycle for generating food within a closed habitat on future Mars. Within the EDEN laboratory a broadband FPF enables certain experiments considering all aspects of the different food production steps in an innovative manner (e.g., harvesting, cleaning, cutting, extracting, disinfecting, sterilizing, drying, dehydrating, packing and storing).

CEADE

The Controlled Environment Agriculture Development for Space and Earth (CEADE) project intends to utilise the pull of space technology by advancing the readiness of CEA technologies within GHMs. CEADE is funded by an International Incoming Fellowship as part of the European Marie Curie Actions.

Habitation Simulation

Flash

The Flash (Facility for Laboratories for Sustainable Habitats) study focused on the concept development of a closed loop habitat for technology testing, with different recycling applications and In-Situ Resource Utilisation (ISRU) processes. The facility consists of an EVS terral hall, control center, public engagement area and 12 functional modules (e.g., Air, Water, Greenhouse, Storage, Living, FVF Module). The main study points were the overall configuration, equipment-level subsystem description and the mass flow relationships between the modules.

Flash 2

During the Flash 2 study, the design results of the first Flash will be further investigated and enhanced to achieve a detailed level-ready for publication, finding of partners and acquiring of funding for additional studies and first mock-ups and modules.

EDEN - Spin-offs

Vertical Farming

Vertical Farms are poised as a potential solution to the global food demand by allowing increased crop growth per unit area. During a CE study a semi closed loop Vertical Farm focusing on input/output flow analysis, power demand estimations and detailed cost calculations was designed. The study’s objective was to determine the technical and economic feasibility of such a cultivation system. The Vertical Farm is a 37 floor building harvesting staples food and 10 varieties of fruit and vegetables. The CE study found that the Vertical Farm produces a high plant yield. In order for crops grown on agricultural land to match this yield, an area 1,300 times that of the Vertical Farm footprint would be required.

EDEN - Partners