

EDEN ISS – growing food for space exploration

EDEN ISS focuses on the ‘**Ground Demonstration of Plant Cultivation Technologies and - Operation in Space**’ and the enhancement of those technologies, ‘**For Safe Food Production on-board the International Space Station (ISS) and Future Human Space Exploration Vehicles and Planetary Outposts.**’

Fresh vegetables for astronauts in space



Vegetables from the EDEN ISS greenhouse, Photo: Paul Rosero, 2017

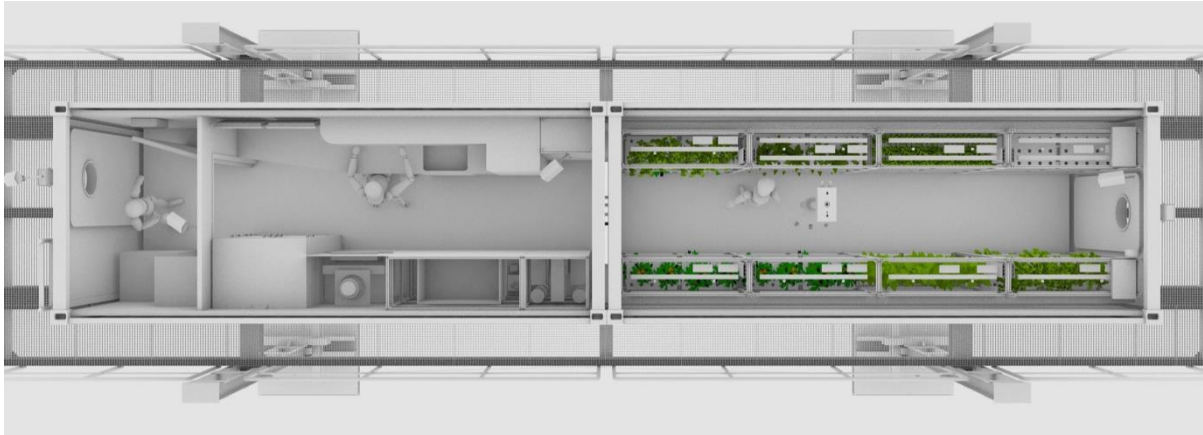
This project is funded by the European Union **Horizon 2020 programme**, under the COMPET-07-2014 topic of **Space exploration / Life support**.

Project Introduction

Sustained human presence in space requires the **development of new technologies** to maintain environmental control, manage waste, provide water, oxygen and food and to keep astronauts healthy and psychologically fit. Space cannot provide these survival-critical elements, found in abundance here on fertile Earth.

A **closed loop system** can be engineered however, to make continuous use of all generated material as feedback material within the same artificial environment. A **bio-regenerative life support system**, using higher plants including vascular (flowering) plants as work horses, can be advantageously employed for the production of food and oxygen, the reduction of carbon dioxide, and for water recycling and waste management. The presence of fresh crops in controlled-environments can also have a positive impact on the psychological well-being of the crew.

A greenhouse as life support system for living on the moon and Mars



Interior of the Mobile Test Facility, Visualization: LIQUIFER Systems Group, 2017

Before use in space, technologies are being tested on Earth under extreme conditions, including the Antarctic



EDEN ISS in Antarctica, Visualization: LIQUIFER Systems Group, 2017

EDEN ISS is developing a **Mobile Test Facility (MTF)** for the **production of food and resources in a closed environment**. The facility is built to provide fresh produce for the crew at the Neumayer III Antarctic station and serves as an analogue environment **for testing plant cultivation under extreme environmental and logistical conditions**; in preparation for **spaceflight-ready systems** and technologies for controlled-plant growth in space and on-board the ISS.

Novel nutrition supply for aeroponic plants, special LED lighting systems, effective mould control, and enhanced-remote-diagnosis through visual monitoring are the innovative developments of project EDEN ISS



Red pepper from EDEN ISS, Photo: Paul Rosero, 2017

EDEN ISS is developing an advanced nutrient delivery system, a high-performance LED lighting system, a bio-detection and decontamination system, imaging systems for monitoring plant health and technologies for ensuring food quality and safety within the MTF. The EDEN ISS consortium has designed and is testing essential **Controlled Environment Agriculture (CEA) technologies** and is using a cultivation strategy that utilises the **International Standard Payload Rack (ISPR)**, with compatible dimensions for spaceflight-ready payloads. A **Future Exploration Greenhouse (FEG)** has been designed and built, to test a large-scale production system.

A greenhouse for planetary space exploration and for preparing a plant-growth experiment on the International Space Station



International Space Station (ISS), Photo: NASA

The EDEN ISS MTF, will be used to study the **mass flow relationships** for the ISPR demonstrator and FEG. In addition to technology development and validation, **food safety and plant handling procedures** are being developed. These are integral aspects of the interaction between the crew and plants within closed environments.

In December 2017, the EDEN ISS Mobile Test Facility will commence a **one-year deployment phase in Antarctica** at the highly-isolated Neumayer Station III, operated by the Alfred Wegener Institute. It is foreseen that the container-sized greenhouse of the EDEN ISS project **will provide year-round fresh food supplementation** for the Neumayer Station III crew.

For one year, fresh tomato, bell pepper, lettuce and chard will be grown in the EDEN ISS greenhouse for the Neumayer Station III crew in Antarctica

Fourteen international organizations, including universities, research institutes, corporations and small businesses have come together to develop systems that will help to sustain humans in space. The EDEN ISS consortium is comprised of leading European, Canadian and American experts in the domain of human spaceflight and CEA. The EDEN ISS scientific advisory board consists of the top scientists in the field of CEA from Russia, USA, Japan, Italy and Germany.

14 leading European, Canadian and US-American universities, research institutes, corporations and SMEs collaborate to develop project EDEN ISS

The consortium is led by the **German Aerospace Center (DLR)** Institute of Space Systems in Bremen, Germany and includes the following partners:

- DLR Institute of Aerospace Medicine in Cologne, Germany
- LIQUIFER Systems Group, Austria
- National Research Council, Italy
- University of Guelph, Canada
- Alfred Wegener Institute for Polar and Marine Research, Germany
- Enginsoft S.p.A., Italy
- Airbus Defense and Space, Germany
- Thales Alenia Space Italia S.p.A., Italy
- Arescosmo S.p.A., Italy
- Wageningen University and Research, the Netherlands
- Heliospectra AB, Sweden
- Limerick Institute of Technology, Ireland
- Telespazio S.p.A., Italy
- University of Florida, United States of America

Design Overview

EDEN ISS MTF consists of two shipping containers that are subdivided into three distinct sections.

- **Future Exploration Greenhouse (FEG)**
- **Service section**
- **Cold porch/airlock**

The facility will be operated by a crewmember, with a large emphasis on remote monitoring and operations.

The EDEN ISS double-container comprises 3 parts: the future exploration greenhouse, the service section and the airlock



Left: Interior of the Service Area, right: View into the EDEN ISS greenhouse,
Visualizations: LIQUIFER Systems Group, 2017

The **Future Exploration Greenhouse (FEG)** is the main plant growth area of the Mobile Test Facility and consists of a highly adaptable multi-shelf growth system and is capable of maintaining a number of different environmental settings.

The **service section** houses the main support subsystems, including; thermal, power, air management and nutrient/water subsystems and provides working space for pre- and post-harvest procedures. The full rack ISPR plant growth demonstrator is integrated within the service section.

The **cold porch/airlock** is a small buffer room to limit the entry of cold air into the FEG when the main access door of the facility is in use. This section is also used for storage purposes.

Objectives

Six objectives are defined for the validation of key technologies for space greenhouses under mission relevant conditions, with representative mass flows:

- 1. Manufacture of a space analogue mobile test facility*
- 2. Integration and test of an International Standard Payload Rack plant cultivation system and Future Exploration Greenhouse*
- 3. Adaptation, integration, fine-tuning and demonstration of key plant cultivation technologies*
- 4. Development and demonstration of operational techniques and processes for higher plant cultivation to provide safe, high-quality food*
- 5. Study of microbial behaviour and countermeasures within plant cultivation chambers*
- 6. Actively advance knowledge related to human spaceflight and transform research results into terrestrial applications*

Project Status

The critical design review of the EDEN ISS MTF was completed in March 2016 and was followed by hardware development and testing phases. Between late 2016 and early 2017, subsystems were installed and tested in the MTF. The greenhouse has been powered-up to support Heliospectra plant-growth LED lamps to be tested in different wavelengths; blue, red, red+blue (pink), and white; and the thermal rack and atmosphere management rack have been integrated and used to control the greenhouse climate.

Also, late last year, was the test campaign at Wageningen University and Research in the Netherlands to investigate the decontamination system intended for use in the container. Afterwards, an initial microbiological analysis of the decontamination system performance was provided by partners Airbus Defense and Space in Ottobrunn, Germany based on a small-scale experiment using the equipment. A large-scale experiment was completed in November 2016 at the Wageningen University and Research. In all, nearly 300 test plants and 300 samples were inoculated with microorganisms for these tests.

Currently, the long-term integrated testing campaign is underway at DLR in Bremen.

In October, the facility will be transported to Antarctica by ship via Cape Town, South Africa. The MTF will be placed on top of an external platform located approximately 400 m south from Neumayer Station III. The Alfred-Wegener-Institute for Polar and Marine Research, has already built the platform in Antarctica in preparation for the arrival of the EDEN ISS MTF. A detailed scientific campaign will be conducted throughout the expedition and numerous samples will be returned to European laboratories for further research.

EDEN ISS is a 4-year project extending from March 2015 to December 2018.

The EDEN ISS Press Kit – May 2017 includes:

1. Information Letter (project introduction / design overview / project status)
2. Introduction to Project Partners
3. Press & Publications
4. Frequently Asked Questions (FAQ)
5. EDEN ISS project images
6. EDEN ISS project logo
7. EDEN ISS project flyer

Please contact project representatives for more information.



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