EDEN ISS – The Antarctic Space Greenhouse and its Terrestrial Spin-offs

Institut für Raumfahrtsysteme
Dr. Daniel Schubert

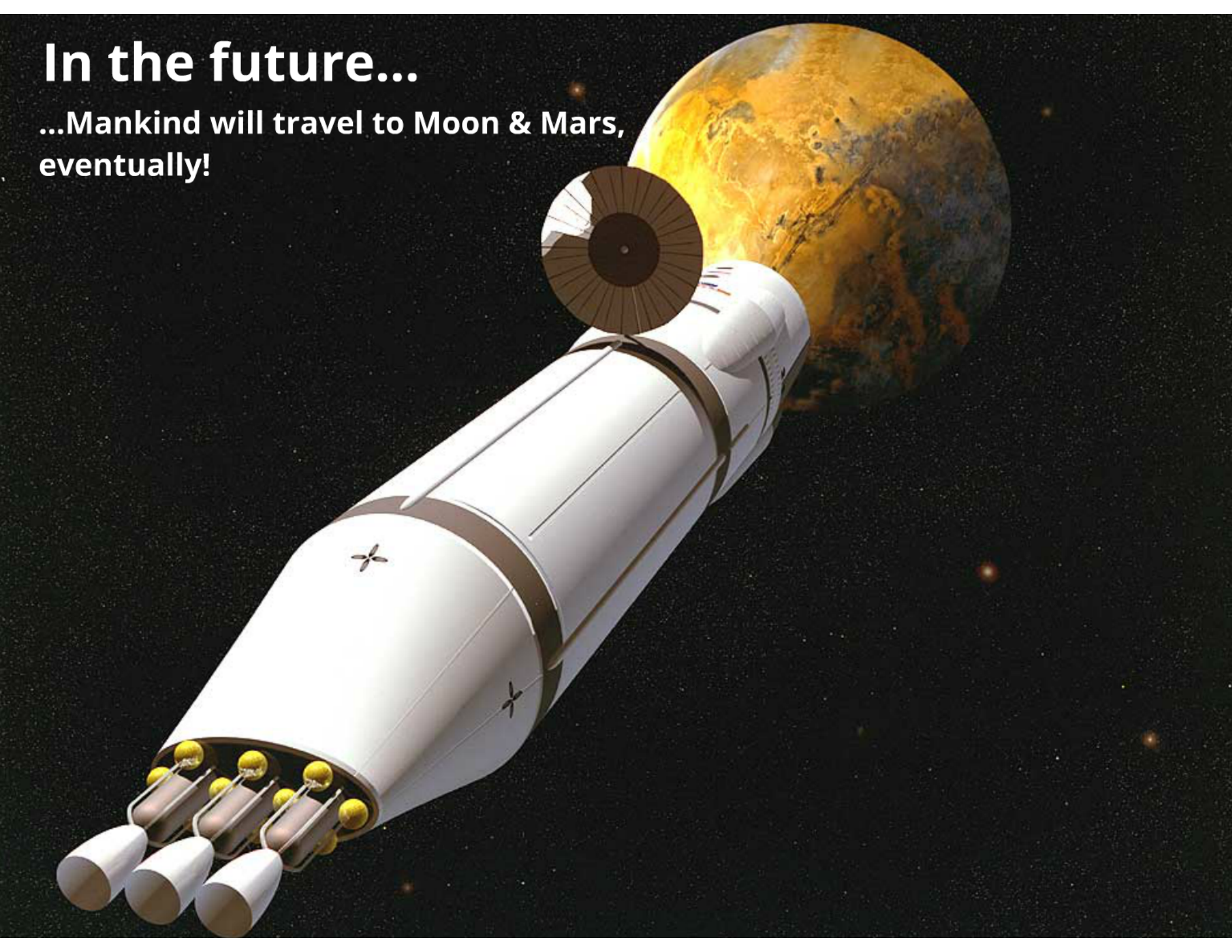
Bremen, 17. Mai 2021

EDEN

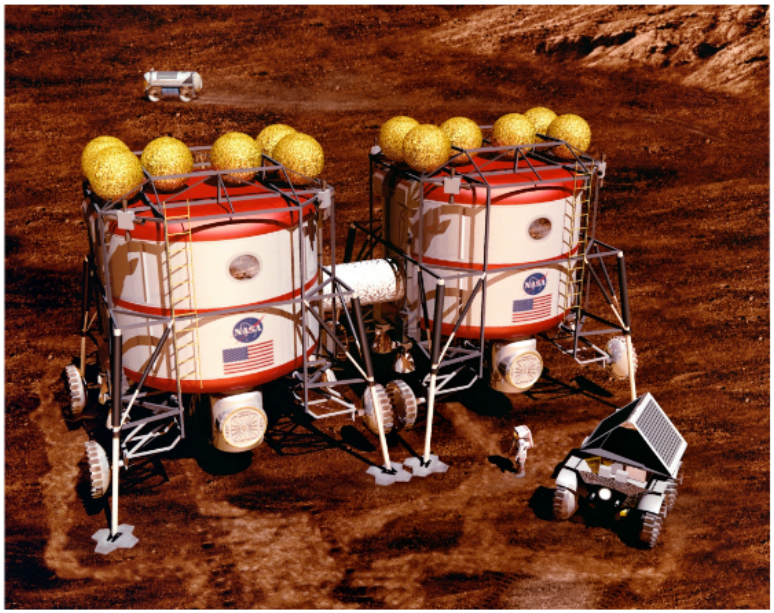
DLR

In the future...

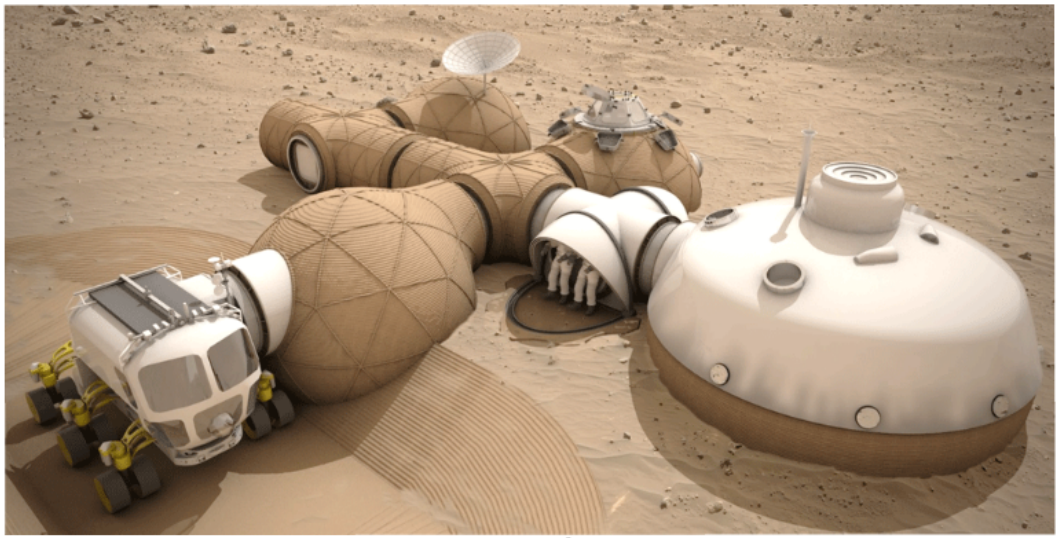
...Mankind will travel to Moon & Mars, eventually!



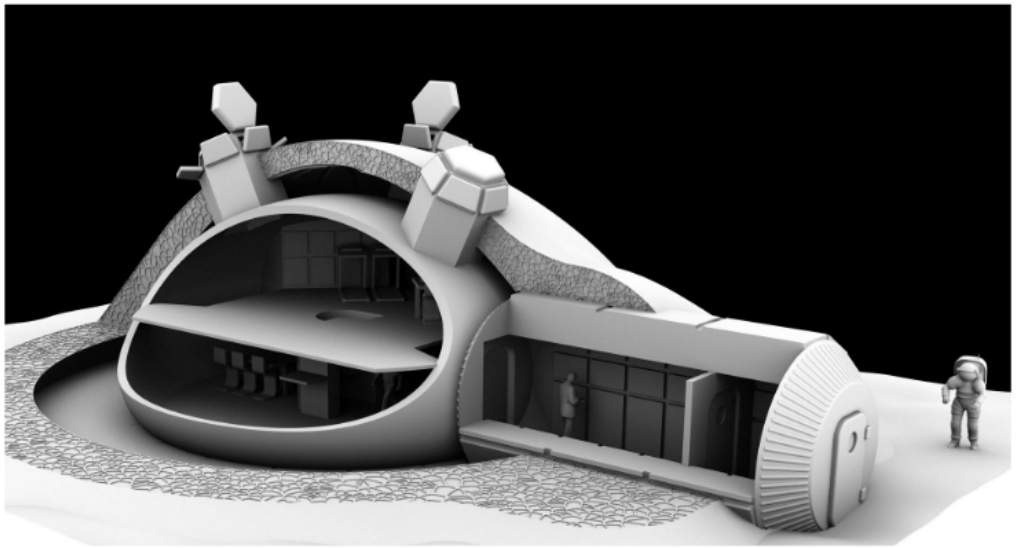
Building a human outpost!



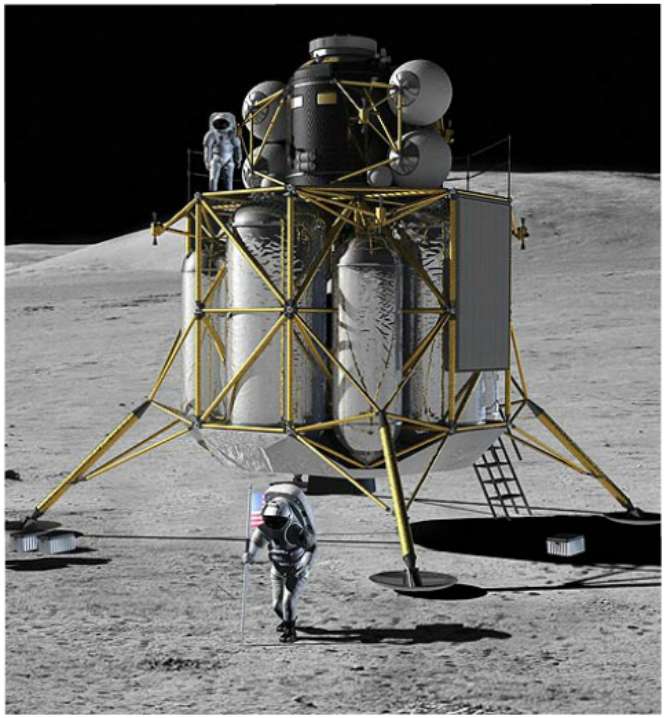
Mars Habitat (NASA)



LavaHive



Sinter Hab for Moon (ESA)



Lunar Mission Concept (NASA)

Greenhouse Modules in future Habitats on Moon and Mars

Fresh Food

Atmosphere Revitalization

Water Recycling

Well-Being

NASA Food Production Facility Concept (2015)

EDEN ISS Built-up Phase and previous Campaigns

Built-up Phase of the system in Jan. 2018

Tomato plant tray inside the FEG

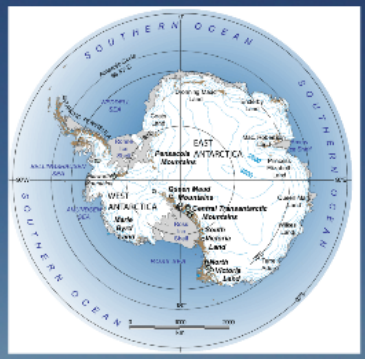
- European research project (14 partners from 8 countries)
- EDEN ISS greenhouse system in Antarctica
- One year analogue mission in 2018
- Two Delta-Missions (DLR/AWI) in 2019 & 2020

Deployment team group picture Feb. 2018

Analogue Testing at Neumayer Station III

Similar Challenges to Moon and Mars

- Crew size
- Isolation & resupply once a year
- Harsh environment
- Technology dependency



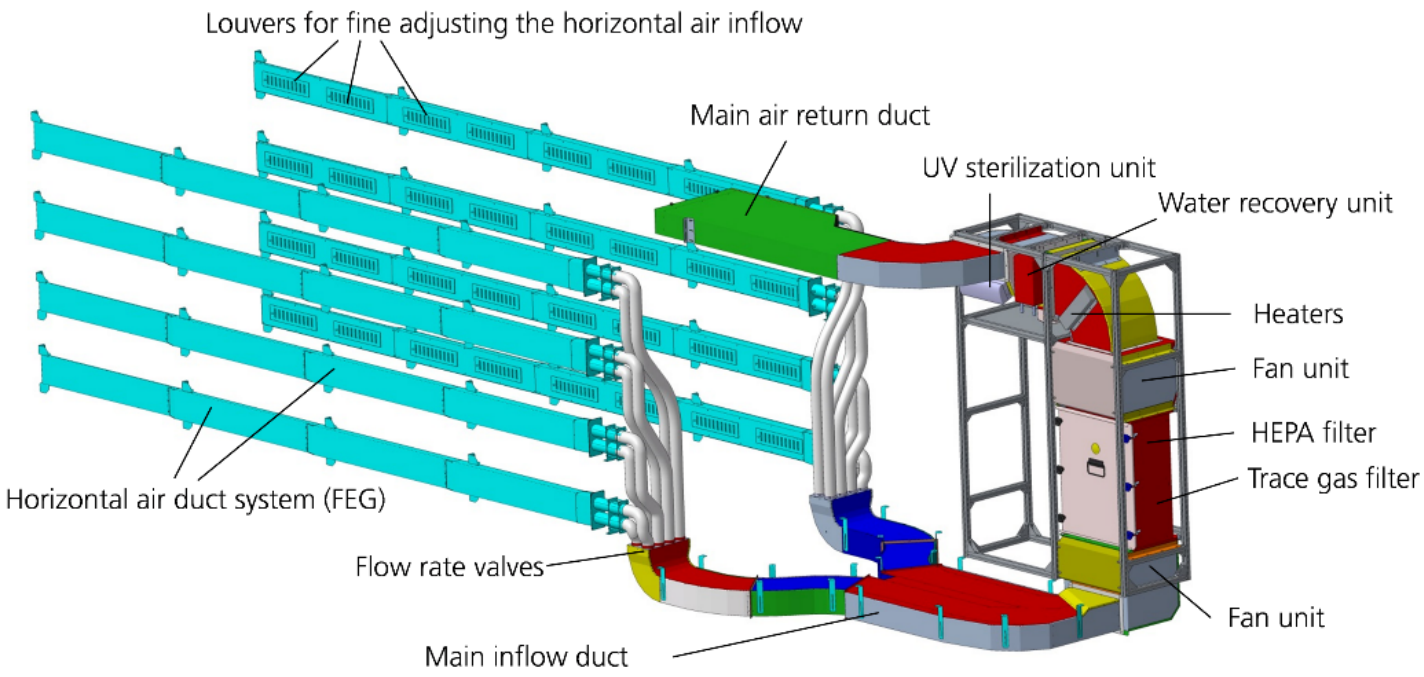
Antarctica

EDEN ISS Facility

Controlled Environment Agriculture

CEA

Air Management System (AMS):



- Exact control of humidity & temperature
- Active CO2 injection
- Complete water recovery
- Air purification (UV & HEPA & Carbon Filters)

Nutrient Delivery System (NDS):

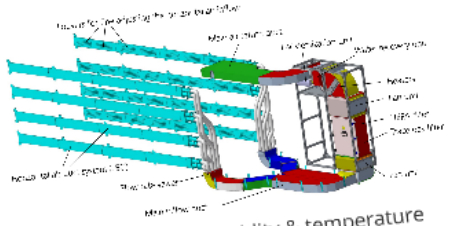
- Exact control of nutrients
- Soiless cultivation (Aeroponics)
- Recirculation => no water loss

Illumination System (ILS):

- Extended day durations (18/6)
- Exact control of light composition (r/b/fr/w)

Controlled Environment Agriculture:

Air Management System (AMS):



- Exact control of humidity & temperature
- Active CO2 injection
- Complete water recovery
- Air purification (UV & HEPA & Carbon Filters)

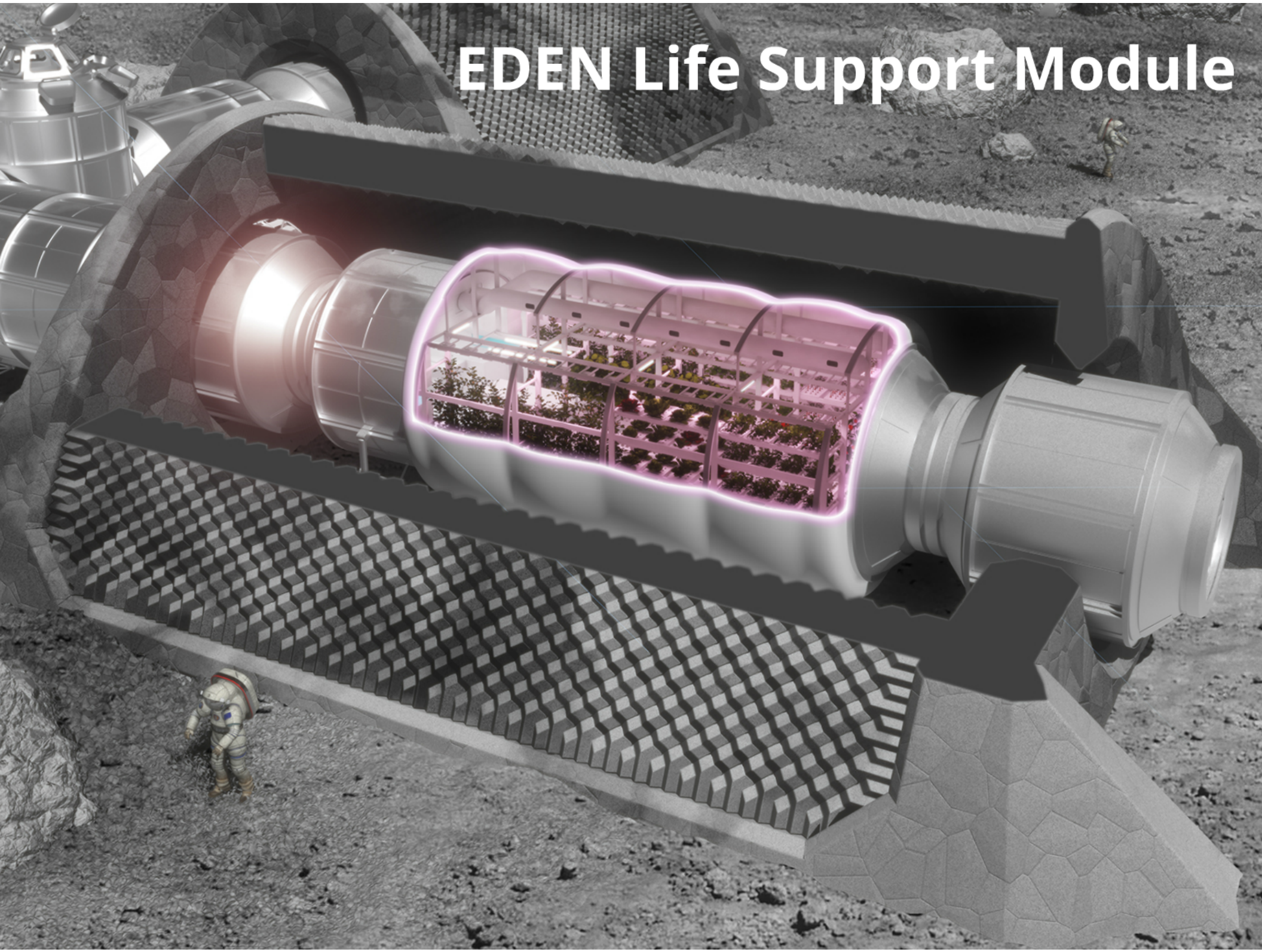
Nutrient Delivery System (NDS):

- Exact control of nutrients
- Soiless cultivation (Aeroponics)
- Recirculation => no water loss

Illumination System (ILS):

- Extended day durations (18/6)
- Exact control of light composition (r/b/fr/w)

- Artificial cultivation independent from outside environment
- Faster production & higher yields than in nature
- Exact control of phenotype, taste and useful substances
- Closed-loop principle


EDEN Life Support Module

Designed for Space - Used on Earth!

Tokyo (source: The Guardian)

Vertical Farming

(Source: Ozu Corporation in Tokyo, Japan, 2009)

(Source: Sky Greens vertical farm, Singapore, 2017)

(Source: Shigeharu Shimamura, Japan)

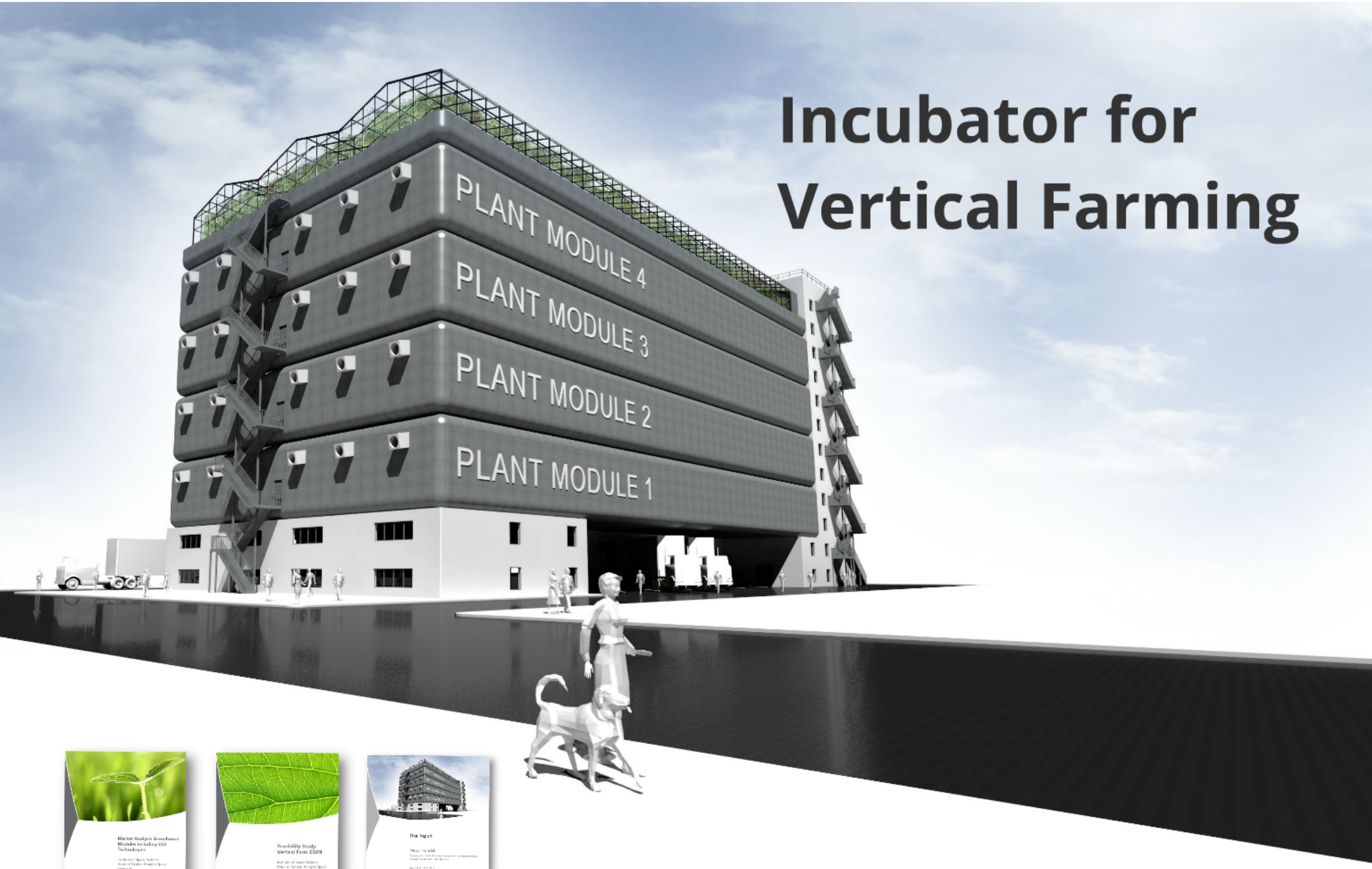
(Source: Innovatus Inc., Japan, 2016)

Benefits

- Extreme high plant density on a small footprint (vertical stacking)
- Faster production and higher crop yields due to CEA
- No use of pesticide/ insecticide (sealed-off system)
- Year-round crop production (even during winter- & dry summer periods)
- Less resource consumption with respect to fertilizer and water (closed-loop principles)
- No weather related crop failures due to hail and heavy rain storms
- Reduction in vehicular transport and food spoilage (in-situ near end consumer)
- Elimination of unwanted discharge (no pollution of soil and ground water)

Vertical farm in Japan (Source: Innovatus Inc., 2016)

Incubator for Vertical Farming



Market Analysis: CEA-Technologies

Feasibility study "Vertical Farming"

Feasibility study "Vertical Farming 2.0"

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

The Situation

- Food provision organized by international organizations
- No- or little fresh food
- Mid-term food source needed
- Hybrid food strategy is envisioned

Refugee camp Zaatari, Jordan; 80.000 inhabitants

Food storage warehouse by WFP

Main R&D Objectives of MEPA

Provide the possibility to produce fresh food within an emergency use case.

- Develop soilless plant cultivation unit
- Compact transport
- Fast deployment
- Reusable system
- Fast production (first harvest after 4-6 weeks)
- Individual & simple usage

Possible Areas of Deployment

Refugee camps

Earthquakes

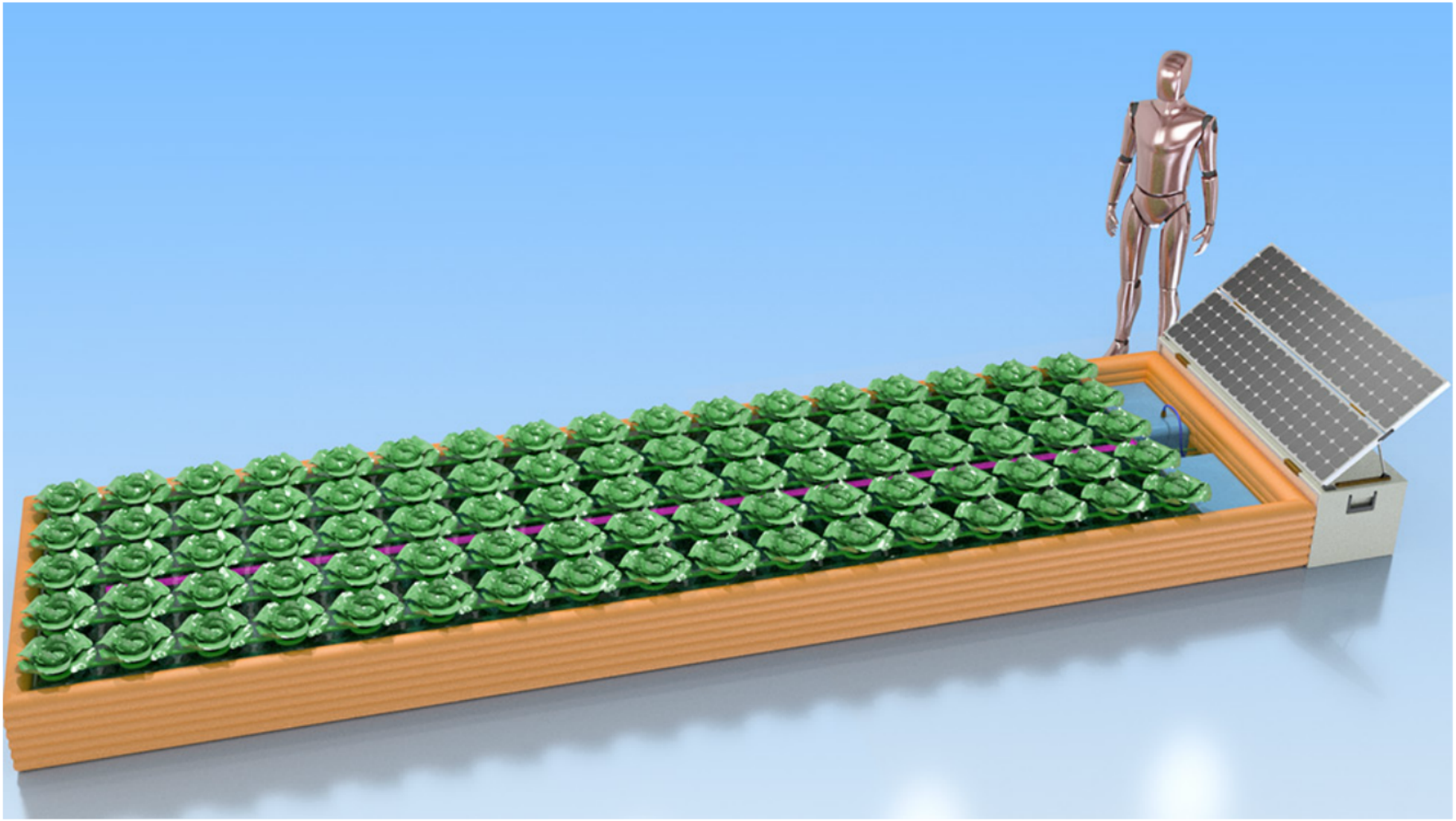
Floods

M.E.P.A.

Inner city areas

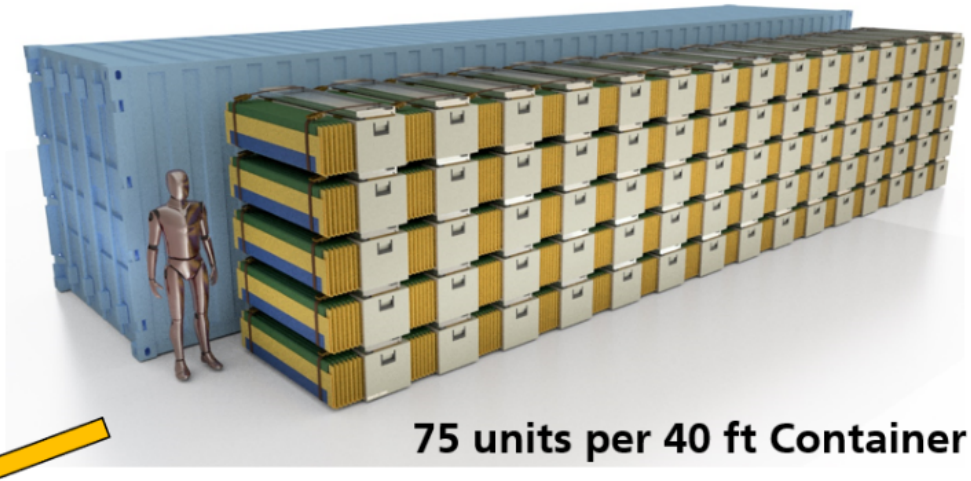
Droughts

Mobile Cultivation System

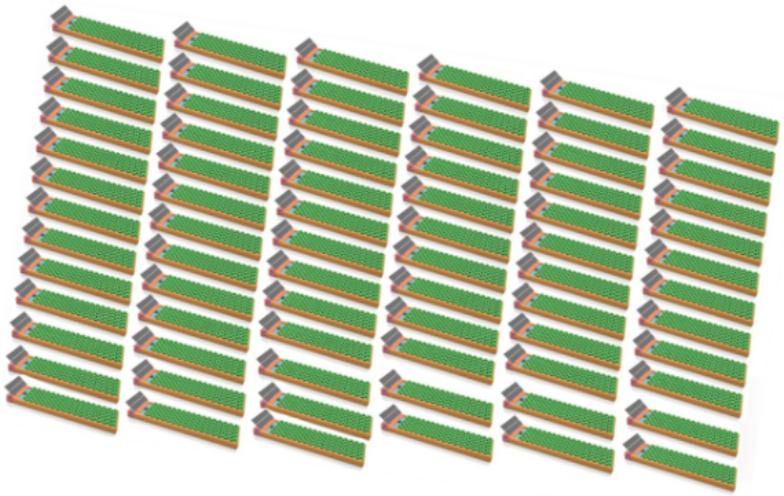


Deployment Scenario

International Aid Organisation



75 units per 40 ft Container



~530 m² of total grow area

ca. 3,5 tons of lettuce every ~4-6 weeks

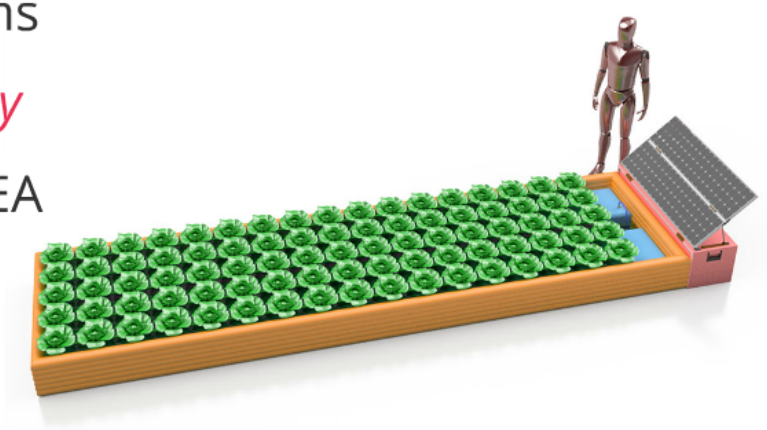
Summary & Cost

Designed for space - used on Earth!

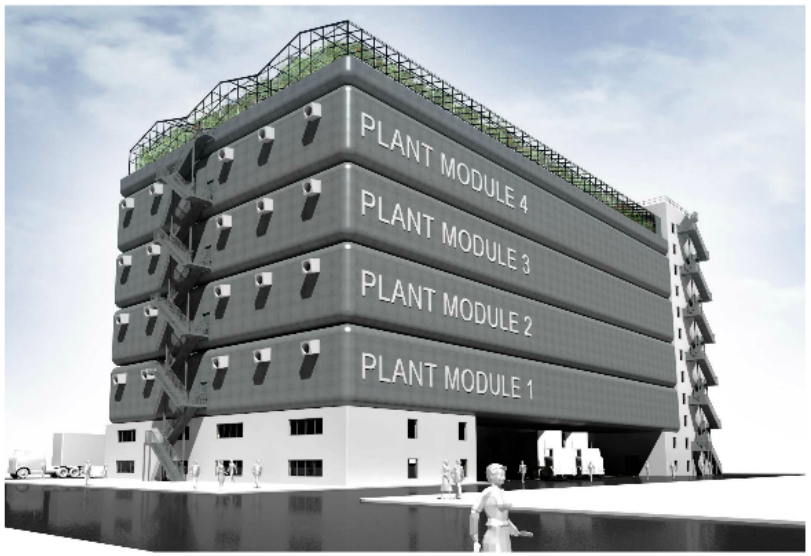
Thank you for your Attention!

EDEN

- Using Controlled Environment Agriculture (CEA) for independent & faster food production
- In-situ production in mega cities and arid regions
- Key step towards a sustainable *Circular Economy*
- DLR EDEN group has profound knowledge in CEA



Mega City Tokyo, source: The Guardian



DLR Vertical farm incubator

Designed for space - used on Earth!

Thank you for your Attention!