

Mars Mission!

Prof. Dr. agr. Prof. h. c. Fritz-Gerald Schröder

HTW-Dresden-Pillnitz, Horticulture Faculty





How to feed the world in the Future?

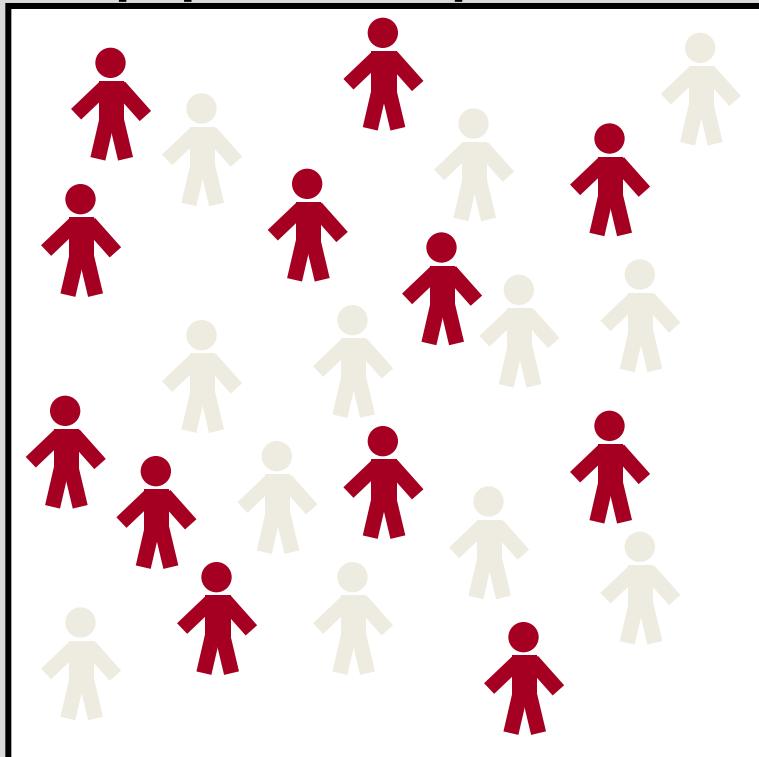
Challanges of 21st century

- Sustainable Agriculture and land use (1,45 Mrd. ha)
 - Water shortage worldwide
- Save food (quality, quantity, pesticides and, price!)
- **Feed the world**
- Global warming
- Environmental pollution (CO₂, water, soil)
- Food crisis (1,4 Mrd. are hungry)
- Economic and political crisis
- International agriculture research and education-shut down up to 30-40 % worldwide!

Population density

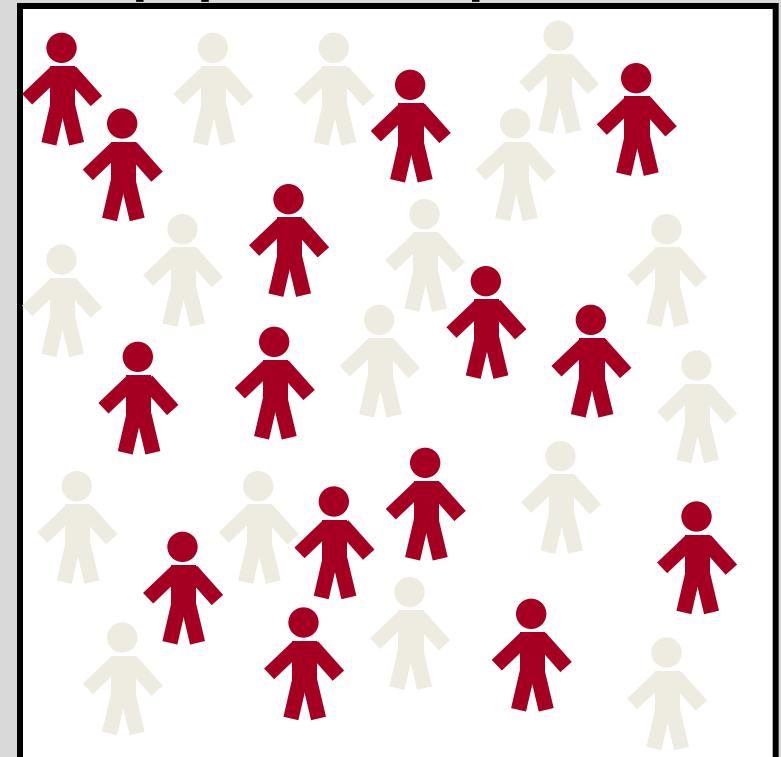
2005

population/sq. km - 48

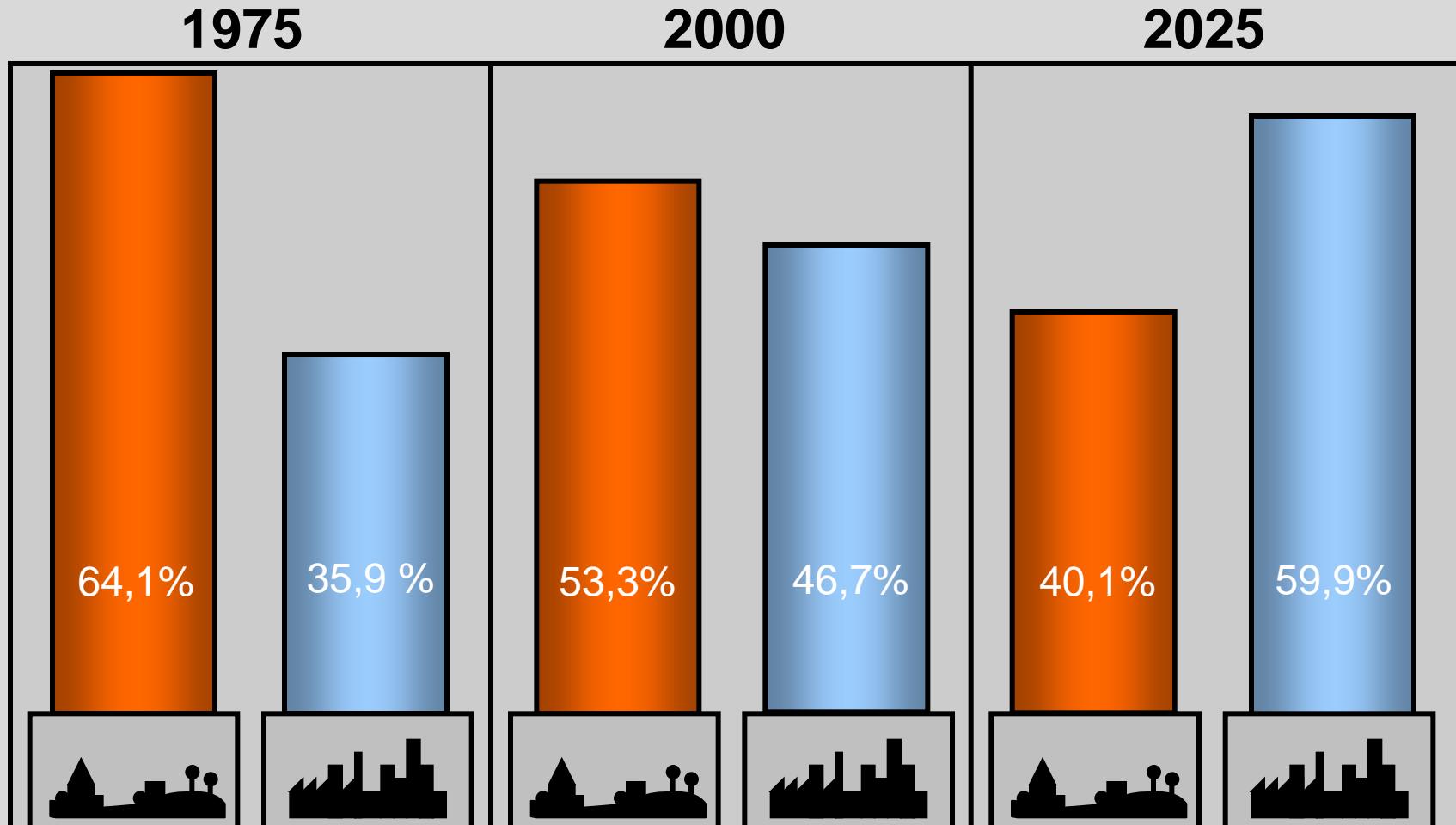


2030

population/sq. km - 61

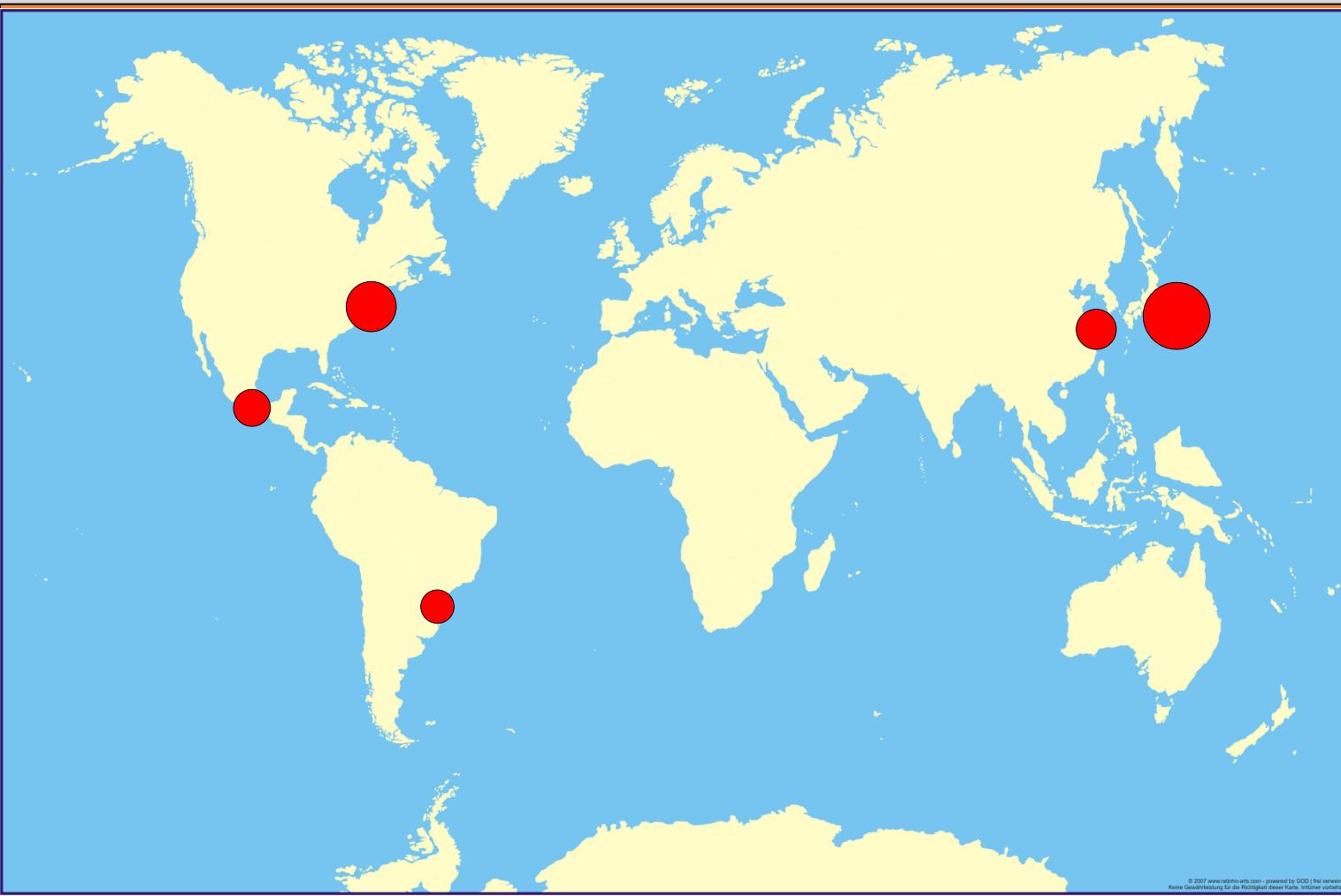


Urbanisation



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision, <http://esa.un.org/unpp>

Worlds Mega Cities 1975



Map: <http://www.ratinho-arts.com/grafik-landkarte-welt.htm>

Source: Deutsche Stiftung Weltbevölkerung (2001): Weltbevölkerungsbericht 2001, Bevölkerung und Umwelt. Stuttgart.

Worlds Mega Cities 2000



Map: <http://www.ratinho-arts.com/grafik-landkarte-welt.htm>

Source: Deutsche Stiftung Weltbevölkerung (2001): Weltbevölkerungsbericht 2001, Bevölkerung und Umwelt. Stuttgart.

Worlds Mega Cities 2025



Map: <http://www.ratinho-arts.com/grafik-landkarte-welt.htm>

Source: Deutsche Stiftung Weltbevölkerung (2001): Weltbevölkerungsbericht 2001, Bevölkerung und Umwelt. Stuttgart.

Losses of Farmland

Total farmland worldwide 1,45 – 1,6 Mrd. ha

Availability of farmland

1970 = 3800 m² p.p.

2013 = 2500 m² p.p.

2050 = 2000 m² p.p.



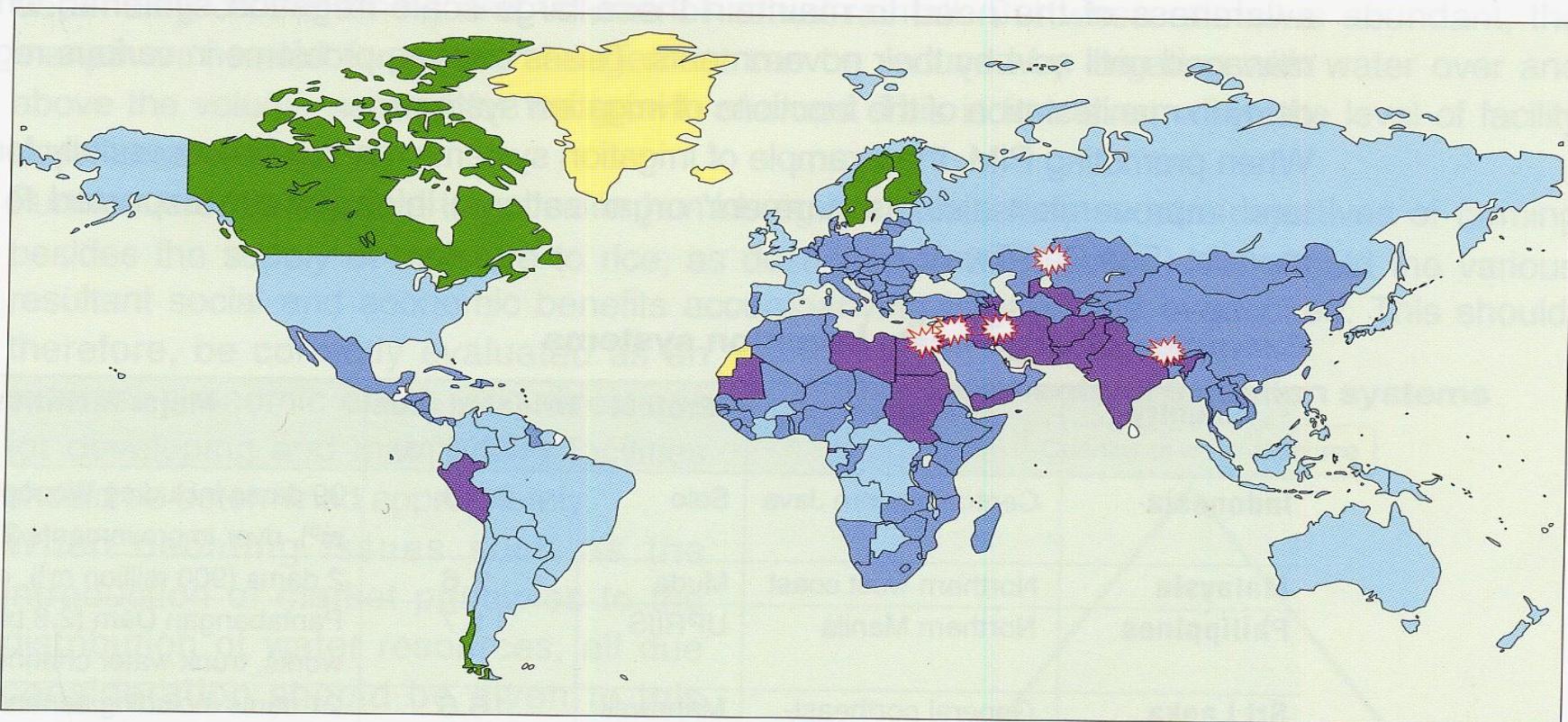
Losses:

Germany: 100 ha every day

- last 25 years ca. 1 Mio ha

Worldwide: 30 ha/min for deserts, erosion, salt

Water crises



Legend: (1) Degree of risk of water shortages :¹⁾ █ No problem █ Low █ Moderate █ High █ No data

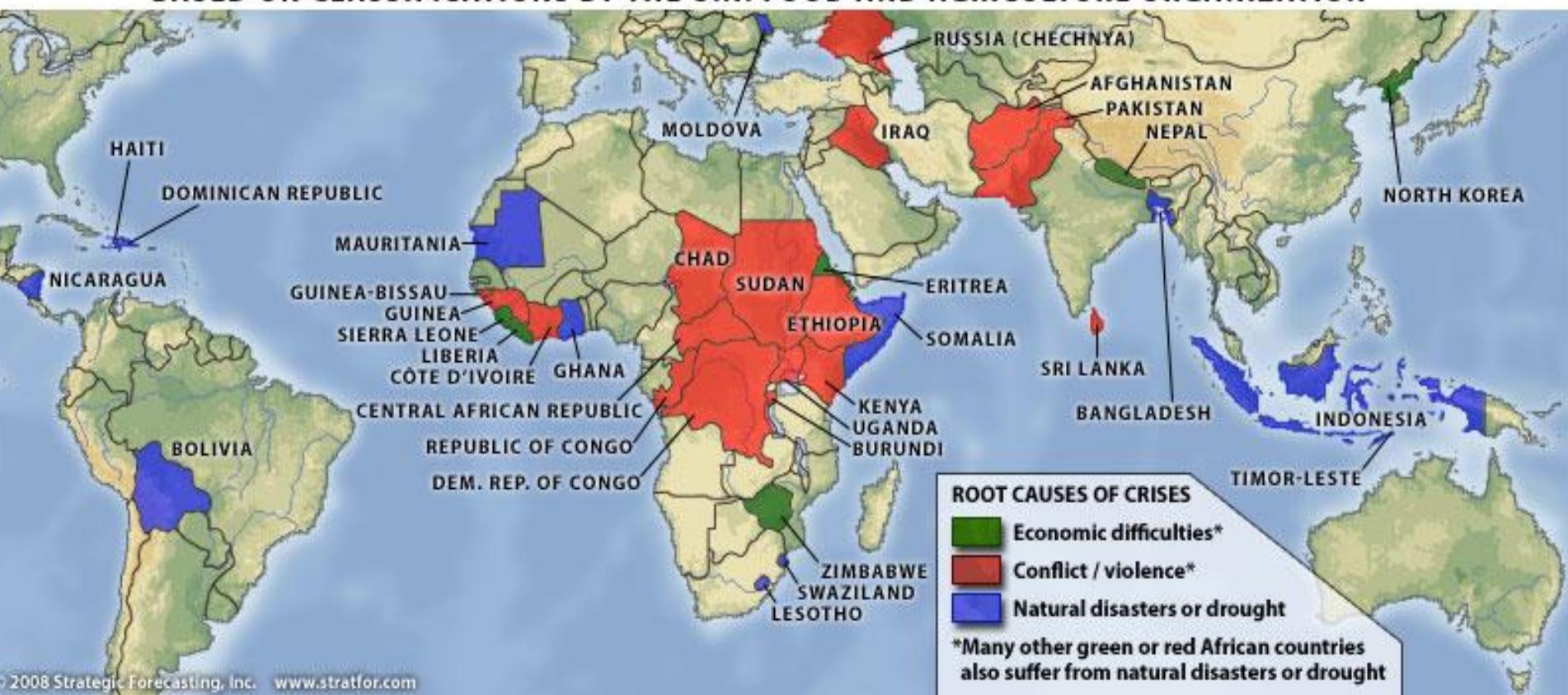
(2) Location of major disputes, etc.²⁾, involving water :

Source: 1) Stockholm Environment Institute, Comprehensive Assessment of the Fresh Water Resources of the World, 1997

2) Lester Brown, ed., State of the world, 1996

Food crisis

**COUNTRIES WITH FOOD CRISES
BASED ON CLASSIFICATIONS BY THE U.N. FOOD AND AGRICULTURE ORGANIZATION**



Food prices in Germany raise up to 43 %



Advanced Greenhouse Modules and Research for use within Planetary Habitat

F.-G. Schroeder¹, D. Brohm¹, N. Domurath¹ and D. Schubert²

1 *University of Applied Sciences Dresden*, Faculty for Agriculture/Landscape Management,
Dresden, Germany

2 *Institute of Space Systems* (DLR), Bremen, Germany



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DLR - Institute of Aerospace

CEF

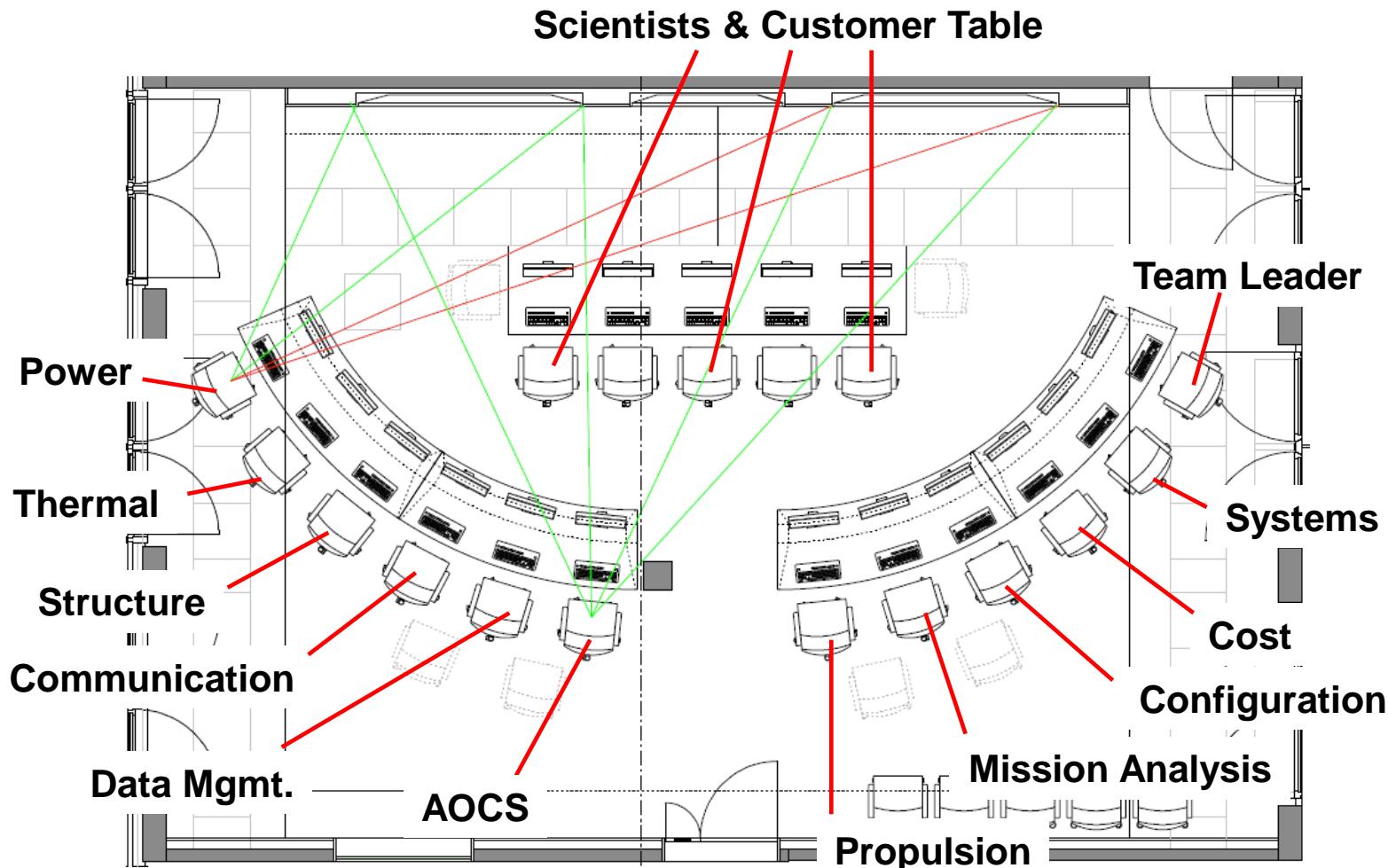


Bremen, founded 2007



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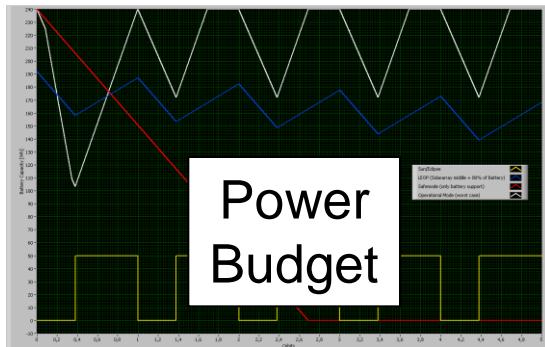
Concurrent Engineering Facility (CEF)



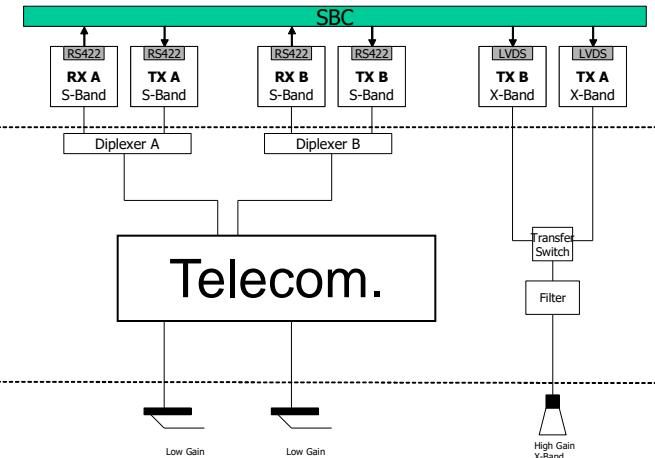
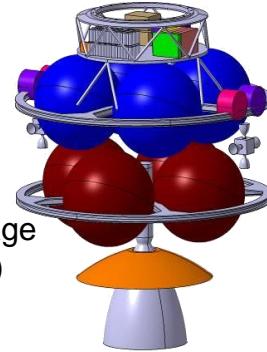
CEF Design Labor



CEF - Results



Cryo-Kick-Stage
(Aldebaran)



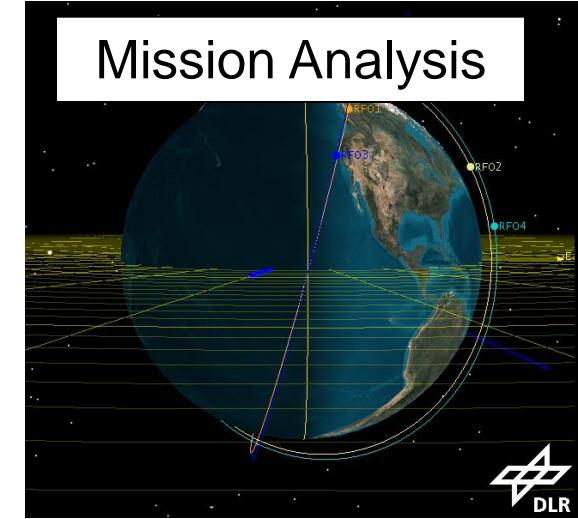
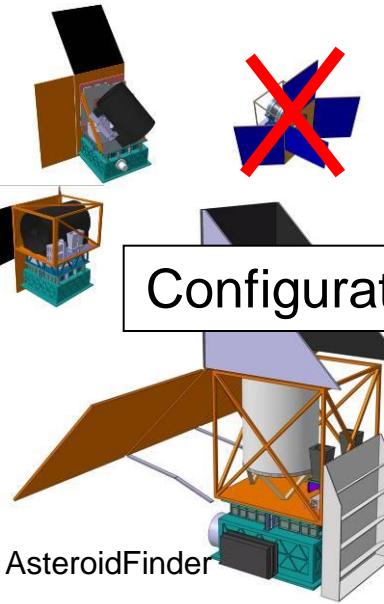
Telecom.

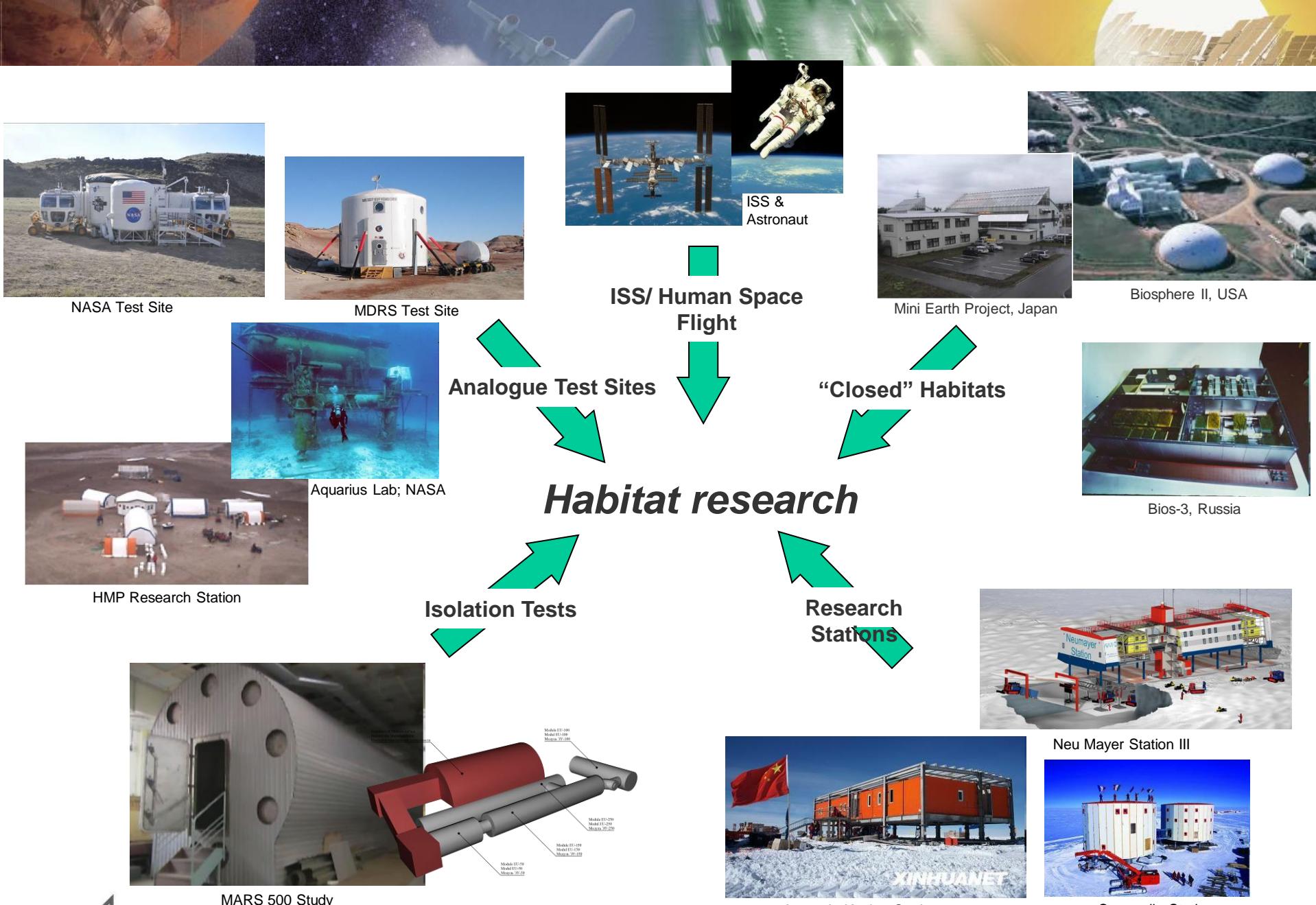
System	Hardware Metrics		Operational (Y1) [h]		Budget (Y1) [h]		Hardware Metrics (Y2) [h]		Operational & Non-Operating Costs		Total Level Metrics (Y1) [h]		Resources	
	Project Management	System Engineering	Instrumentation & Experiment	Operations	Flight	Test	Project Management	System Engineering	Instrumentation & Experiment	Operations	Flight	Test	Total with Resource	Total with Resource per Unit
Project Management	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
System Engineering	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
Instrumentation & Experiment	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
Operations	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
Flight	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
Test	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000
Total with Resource	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	16000	16000
Total with Resource per Unit	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Resources	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	4000	4000

Cost

The table provides a detailed breakdown of costs across various project phases and systems. The total cost for the entire project is 16000 units.

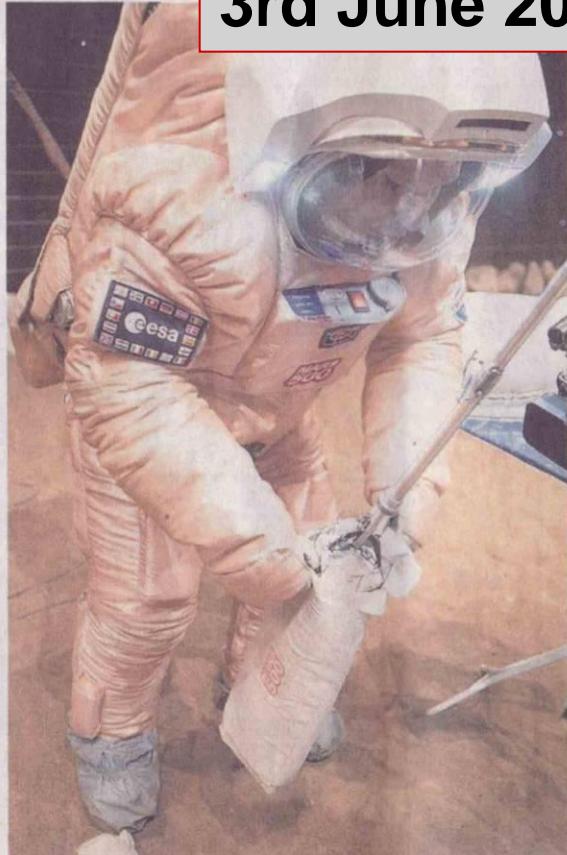
Configuration





ESA: Mars 500 days

3rd June 2010 - Nov. 4th 2011



Ausstieg: Diese sechs Männer haben über 500 Tage in Isolation verbracht. Dabei simulierten sie auch Arbeiten auf dem Mars.

FOTOS: ESA/DPA

Mars-Menschen sind zurück

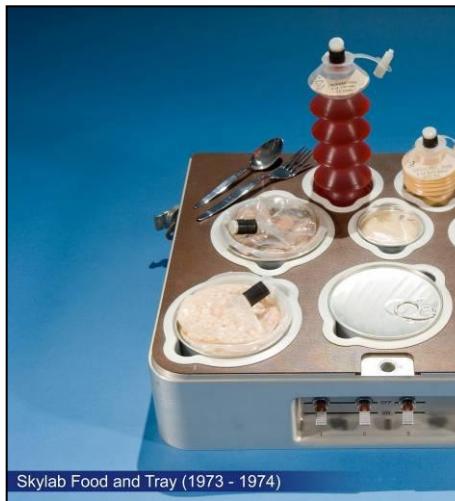


RAUMFAHRT Die Simulation eines 520-Tage-Fluges zum roten Planeten ist beendet. Die internationale Crew hielt trotz Langeweile das Isolations-Experiment durch.

The Martian



Food in space



Skylab Food and Tray (1973 - 1974)



Former investigation with plants

Boing Company ⁷ (1962)	Tibbitts & Alford ⁸ (1982) **	Hoff et al. ⁹ (1982)**	Waters et al. ¹⁰ (2002)**	Vegetable Unit for ISS (NASA, 1998)	Salisbury & Clark ¹¹ (1996)**	Gittelson & Okladnikov ¹² (1994)
Sweet potato	Wheat	Wheat	Wheat	Lettuce	Wheat	Wheat
Tambala	Soybean	Soybean	Soybean	Spinach	Soybean	Salad Spec.
Chinese Gab.	Lettuce	Potato	Lettuce	Radish	Lettuce	Potato
Cabbage	Sweet potato	Carrot	Sweet Potato	Cabbage	Sweet potato	Radish
Cauliflower	Peanut	Peanut	Rice	Green onion	Kale	Beet
Kale	Rice	Rice	Bean	Carrot	Broccoli	Nut Sedge
Collards	Sugar Beet	Tomato	Beet	Tomato	Carrot	Onion
Turnip	Taro	Dry Bean	Cabbage	Pepper	Canola	Cabbage
Swiss Chard	Winged Bean	Chard	Broccoli	Strawberry	Rice	Tomato
Endive	Broccoli	Cabbage	Cauliflower	Differ. Herbs	Peanut	Pea
Dandelion	Onion		Carrot		Chickpea	Dill
Radish	Strawberry		Kale		Lentil	Cucumber
New Zealand Spinach			Spinach		Tomato	Carrot
			Potato		Onion	
			Onion		Chilli Pepper	

* Early missions would use crops to supplement the diet (e.g. vegetables), while later missions might include crops to provide a more complete diet (e.g. significant contribution to carbohydrate, protein and fat requirements)

** Listing do not show the complete range of species suggest for a more complete diet



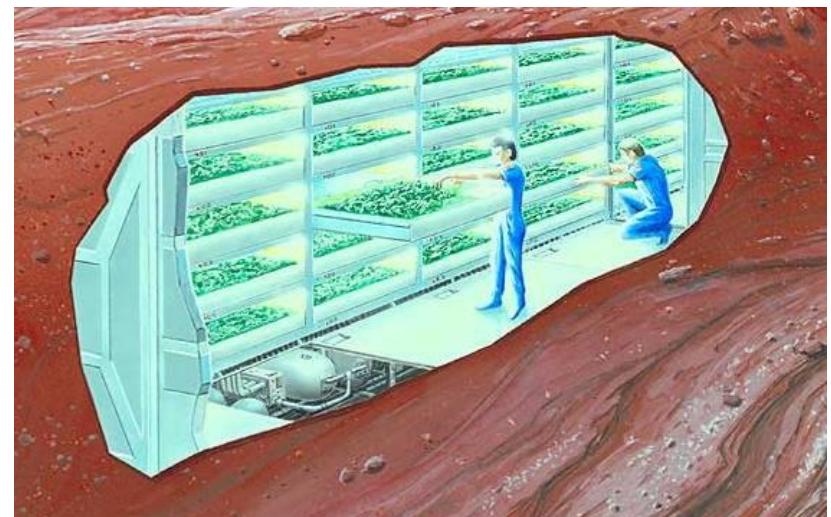
Greenhouse module Preliminary Design

Greenhouse-Module as a Subsystem of Habitats

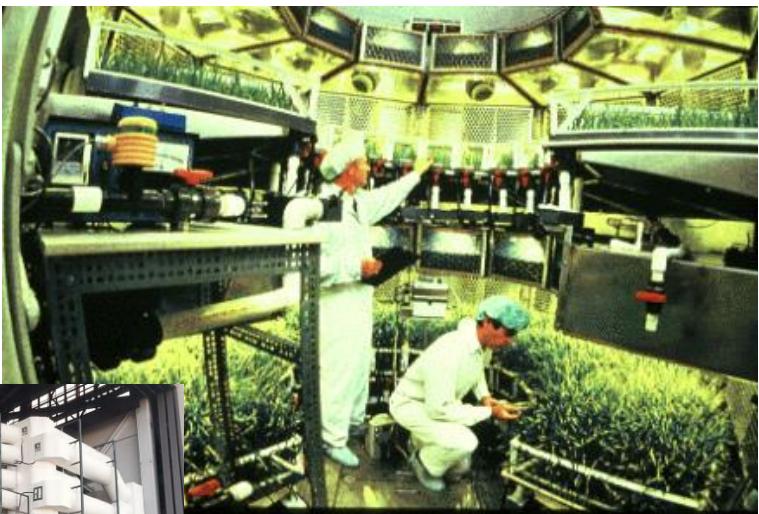


Why 'higher' plants at all?

- Fresh Food
- Raw Material
- H₂O Recycling
- O₂ Recycling
- Psychological Benefits



Greenhouse-Modules



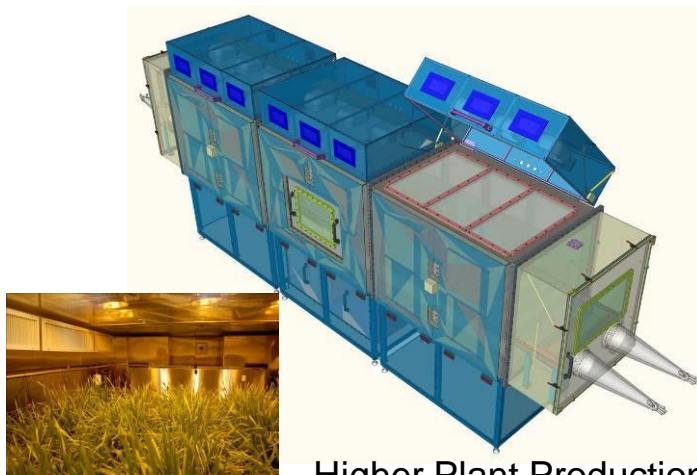
Biomass Production Chamber,
KSC (NASA)



Plant grow experiments at the
MARS 500 Study, Russia

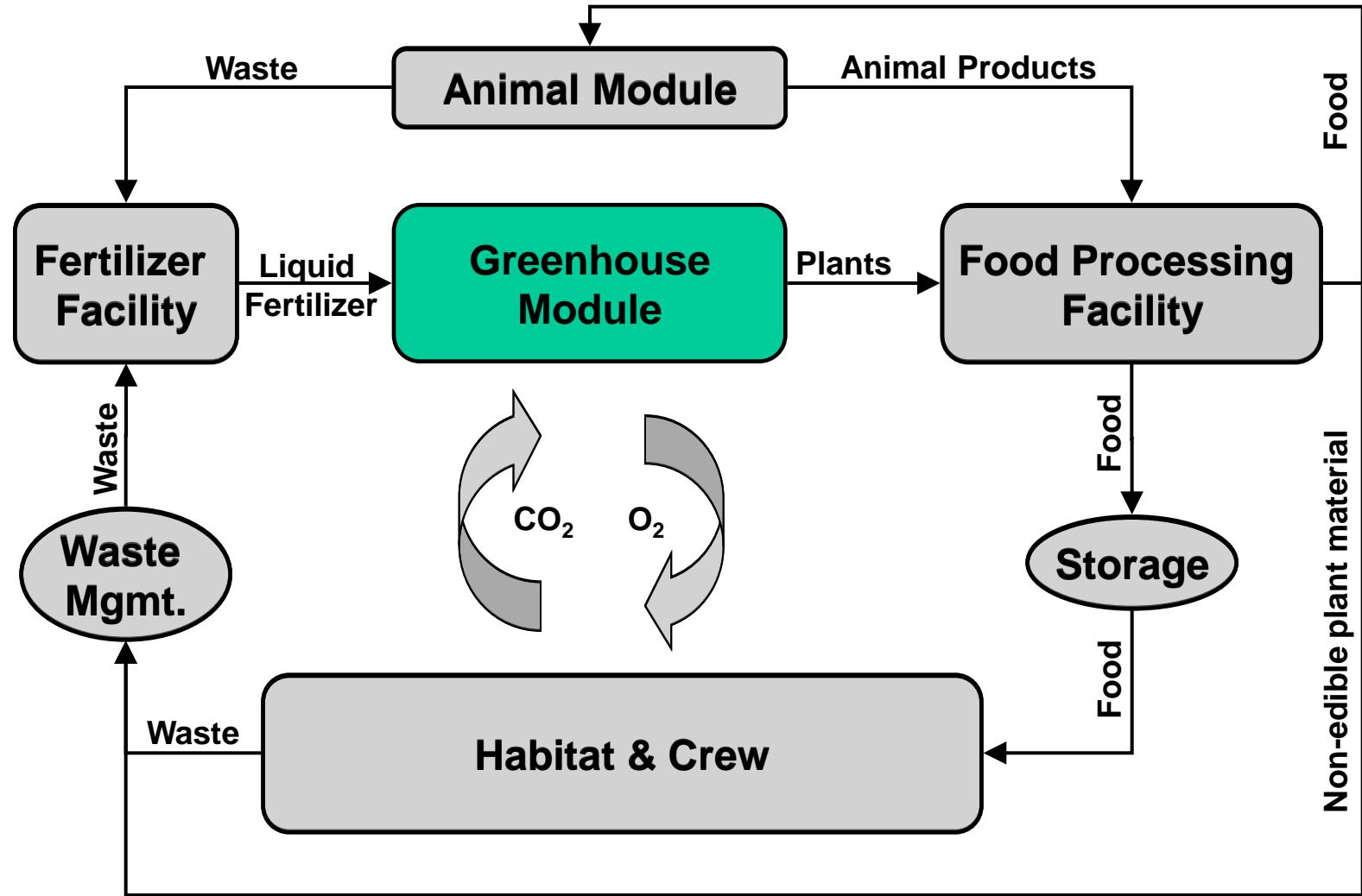


Controlled Environment Agriculture
Center, USA

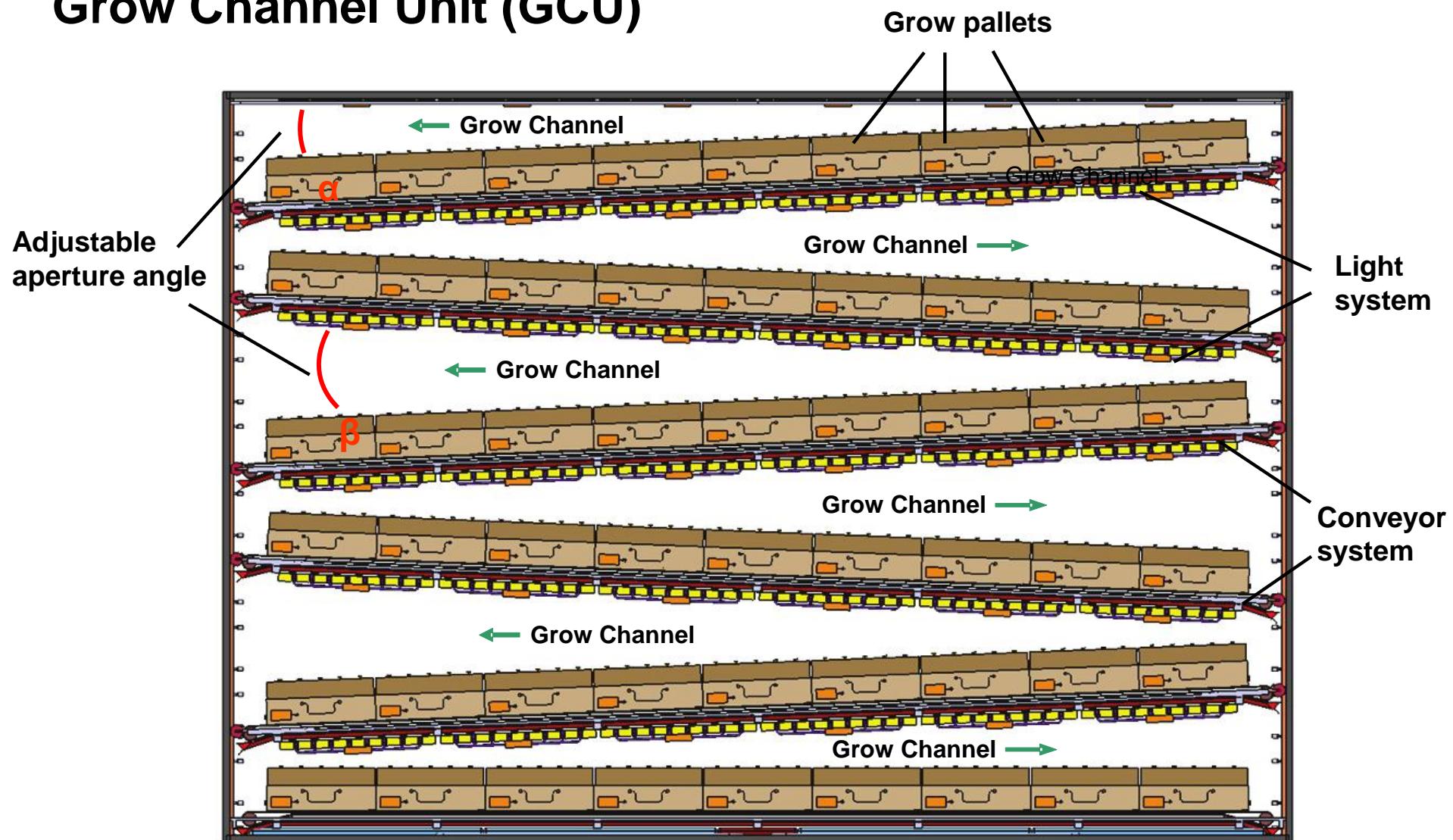


Higher Plant Production
Chamber, Melissa (ESA)

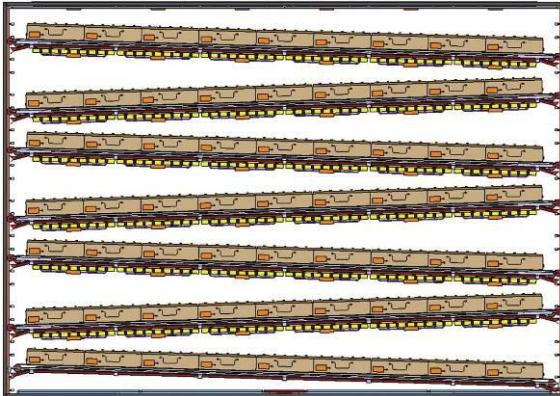
Modules and Interaction



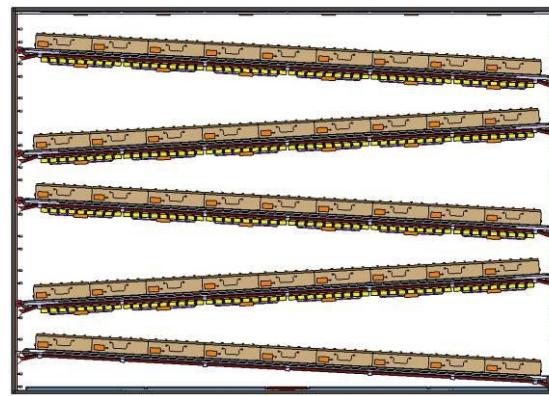
Grow Channel Unit (GCU)



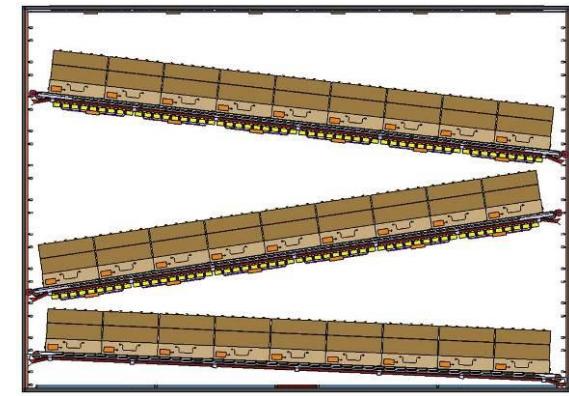
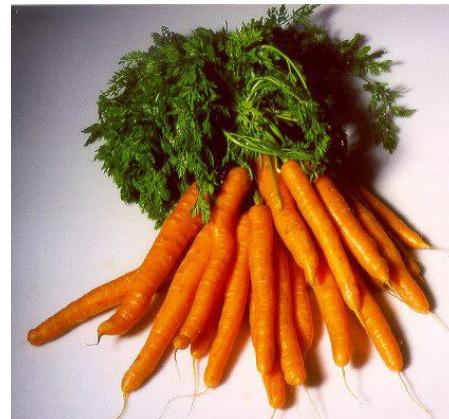
Different GCU configurations



Salad-configuration



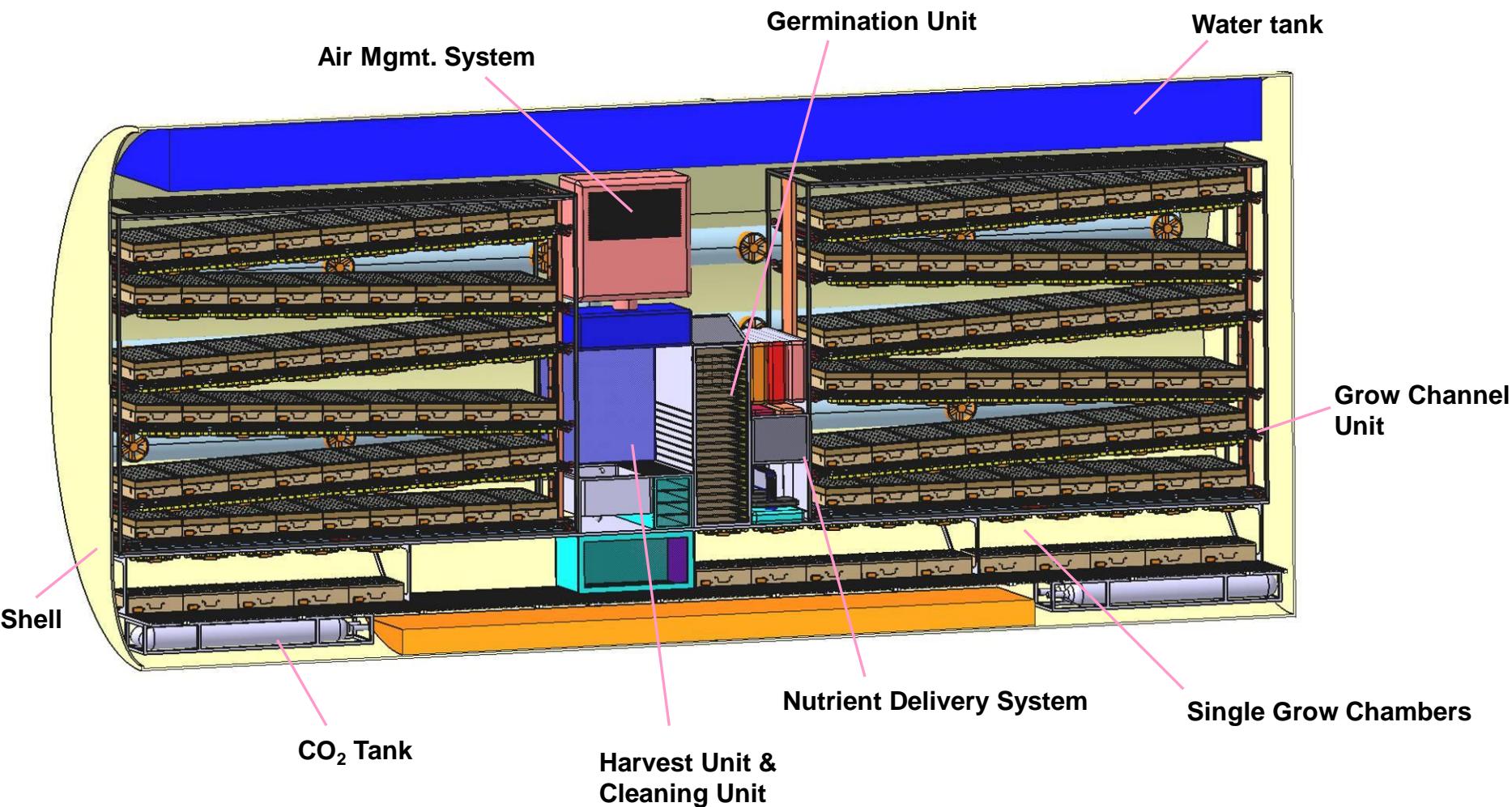
Carrot-configuration



Potato-configuration



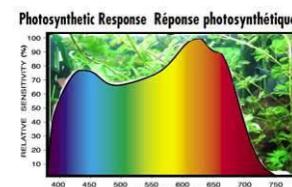
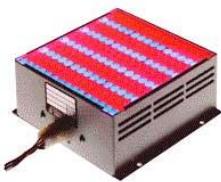
Preliminary Greenhouse Module Design



Controlled Environmental Agriculture (CEA) Technologies:

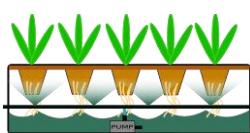
Light Systems

- High performance LEDs
- PAR specific lighting



Nutrient Delivery System

- H₂O delivery
- Fertilizer mix computers,
- Aeroponic/ hydroponic diffusers



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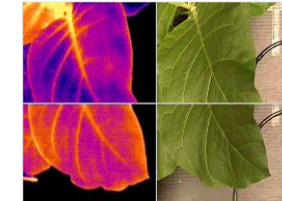
Air Management

- Water recovery
- Temp. & humidity control
- Trace gas separation



Stress and Health Monitoring

- Temp.-, trace gas-, humidity sensors
- Optical sensors



Spin-off 1: *Automated Greenhouse Modules*

- food container for harsh climate conditions
 - ⇒ Desert
 - ⇒ Research station: Neumayer Station South pole
 - ⇒ Ship



Neumayer Station des AWI



Langzeitforschungsschiff Humboldt



Desert

Spin-off 2: Research

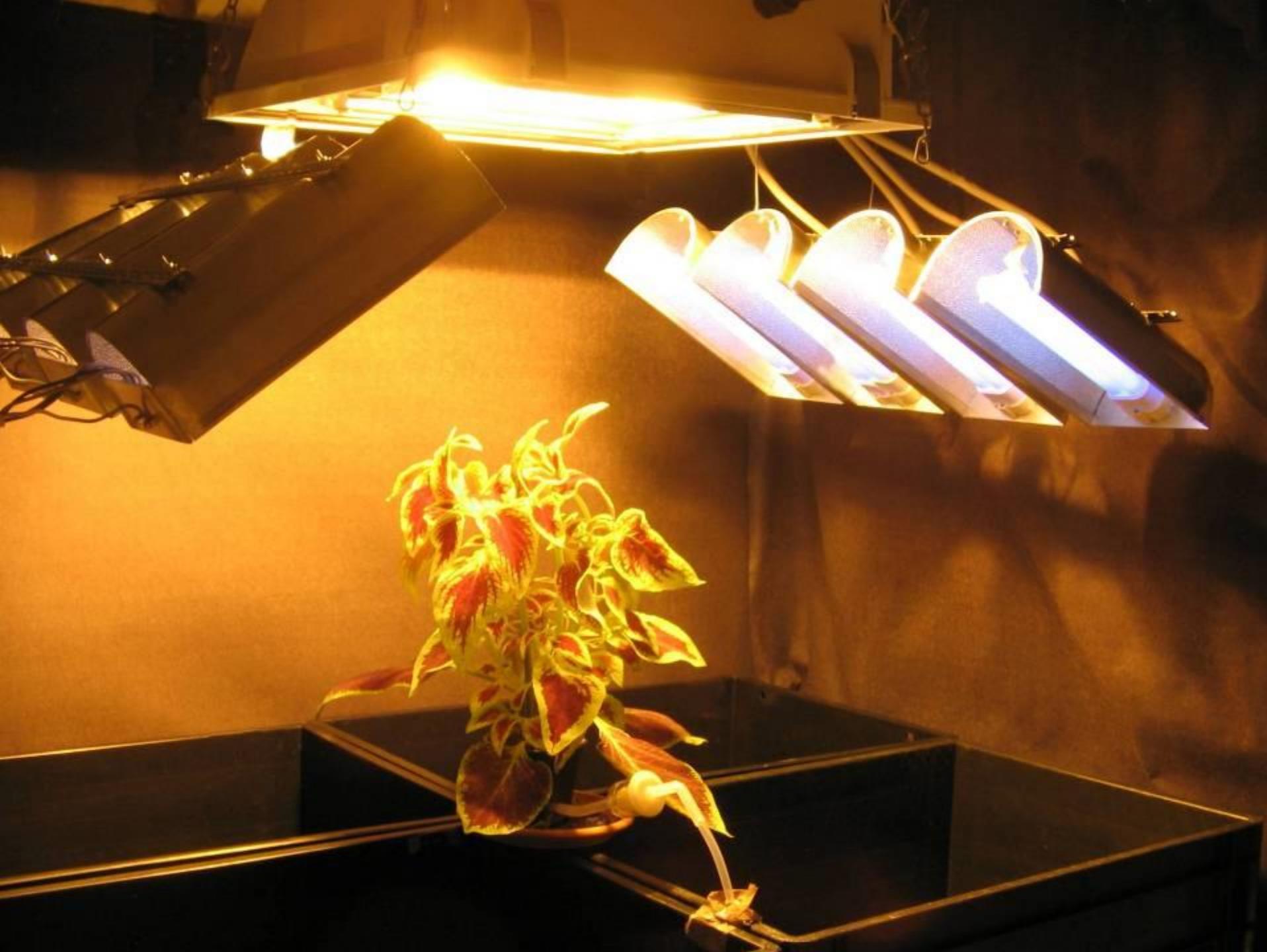
- Biotechnology (*Rapid Grow Chambers*)



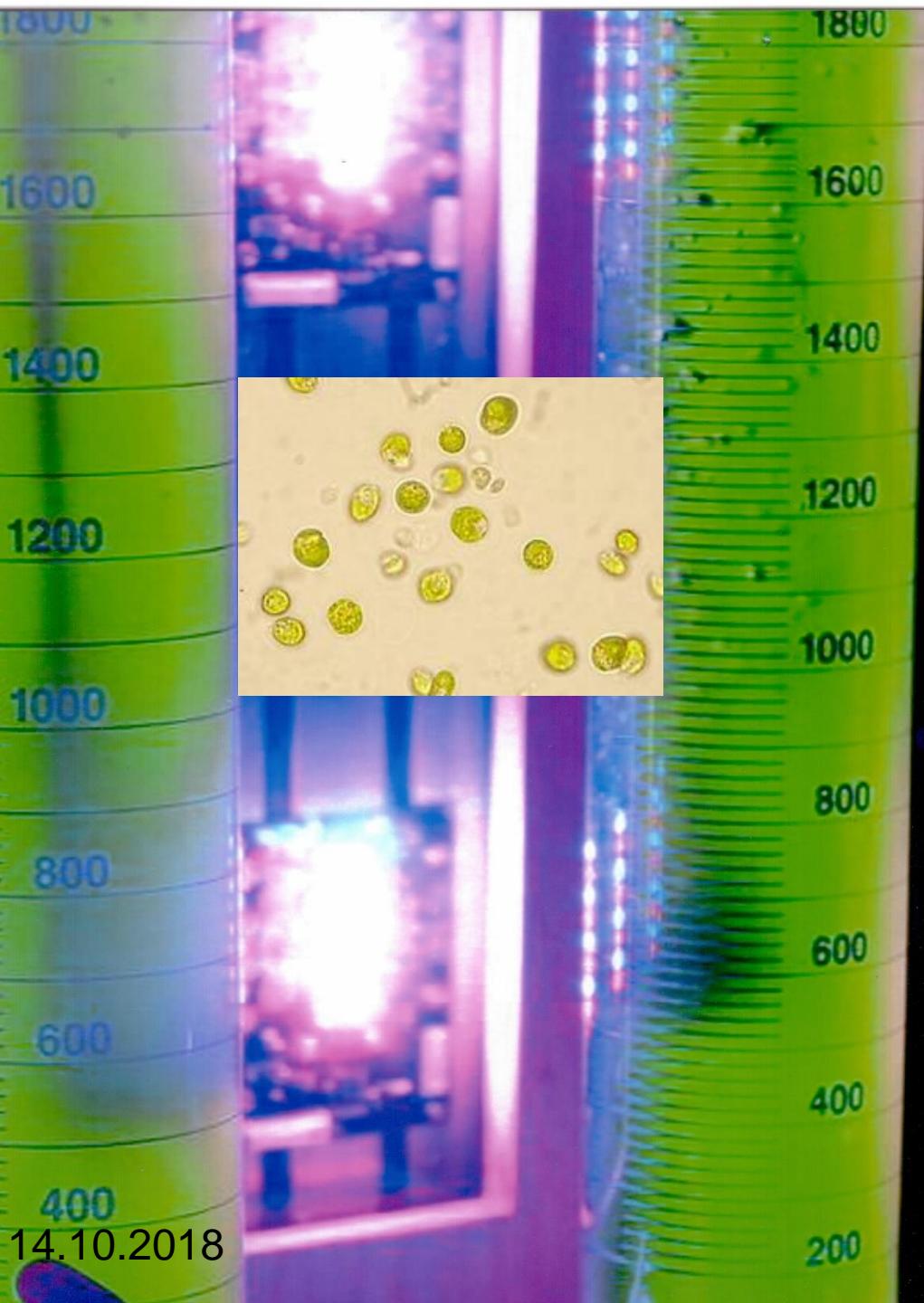
HDVG Methoden innerhalb der Biotechnologie
(z.B. *Rapid Grow Chambers*)

Innovative technology





14.10.2018



Microalgae: Chlorella

Algae bioreactor



A



Alge-house - IBA Hamburg 2013



Food and dietary supplements



Spin-off 3: *Vertical Farming*

- **Controlled Environmental Agriculture (CEA) Technology**
- Production in Megacities Tokio, New York, Beijing
- Vertical farming in high-rise building (High Density Vertical Growth - HDVG)



Vertical Farming Beispiele (Source: Columbia University & Wiki) & High Density Vertical Growth – HDVG Technologien

Expo 2000 Germany – Potential of buildings

*Pavillon of
Netherlands*





EXPO 2015
Milano, Italy

UNITED STATES OF AMERICA
STATI UNITI D'AMERICA



AMERICAN FOOD 2.0

YOU'RE STANDING ON
THE CONEY ISLAND BOARDWALK

DET SULLA
PIATTIERA DI CONEY ISLAND

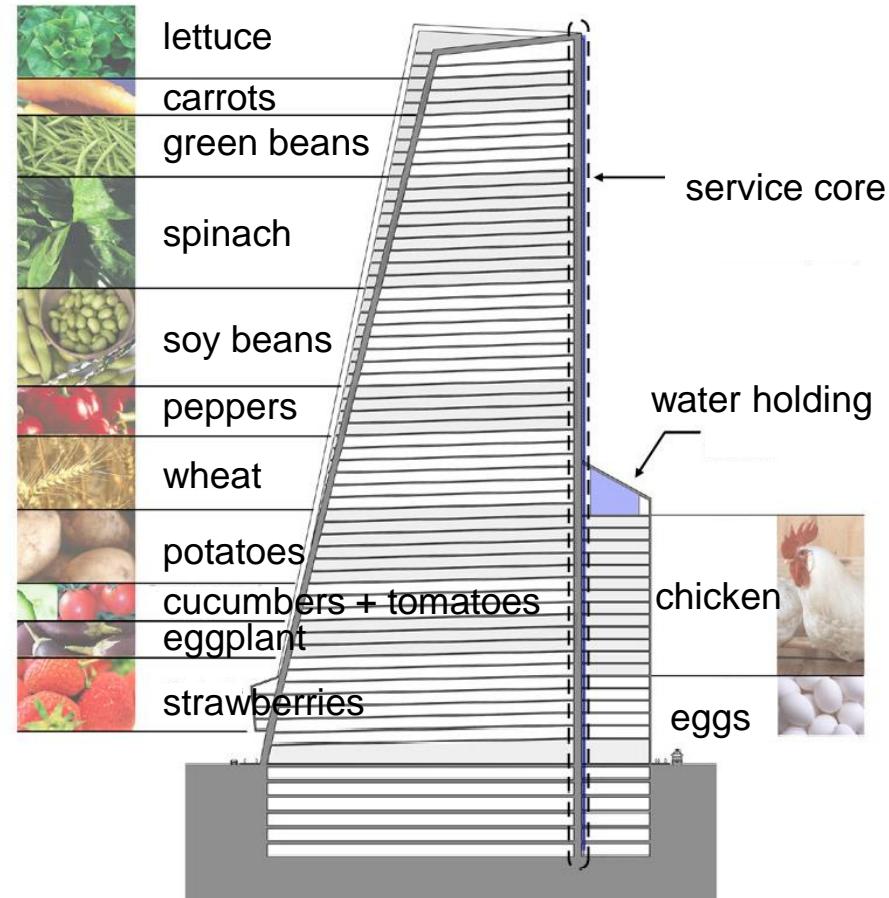
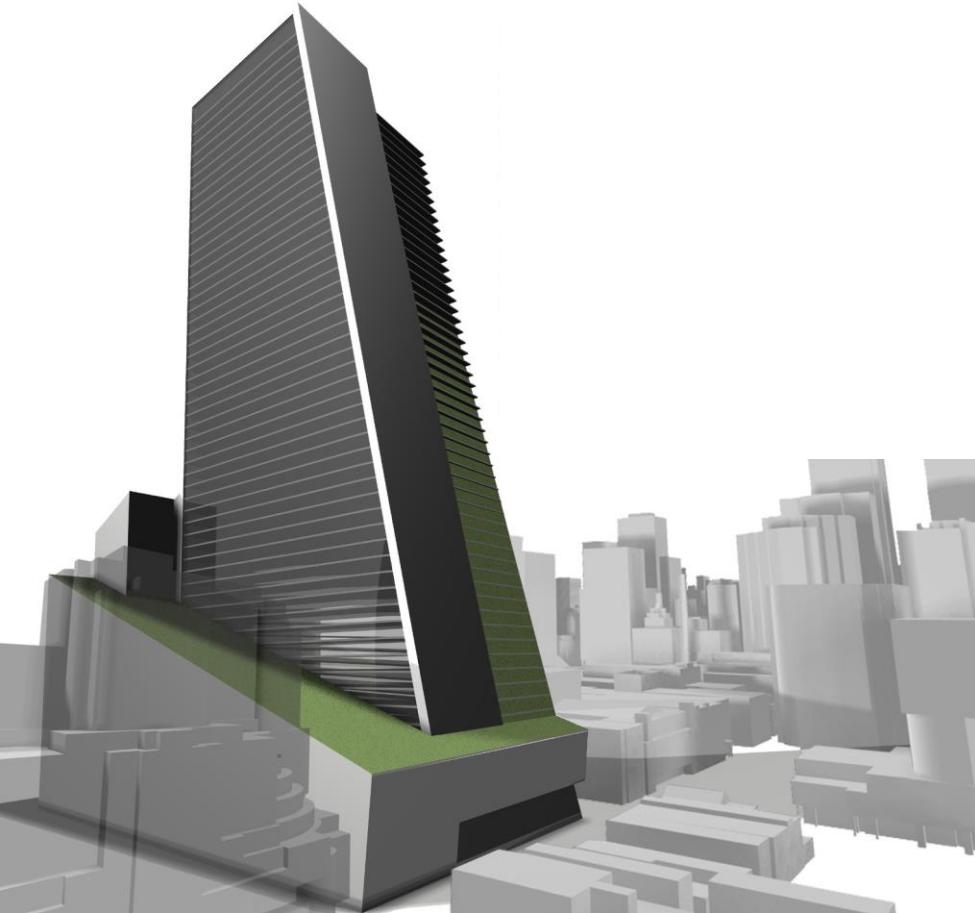
FDN
EM 3

FDN
EM 3

TRACCIE

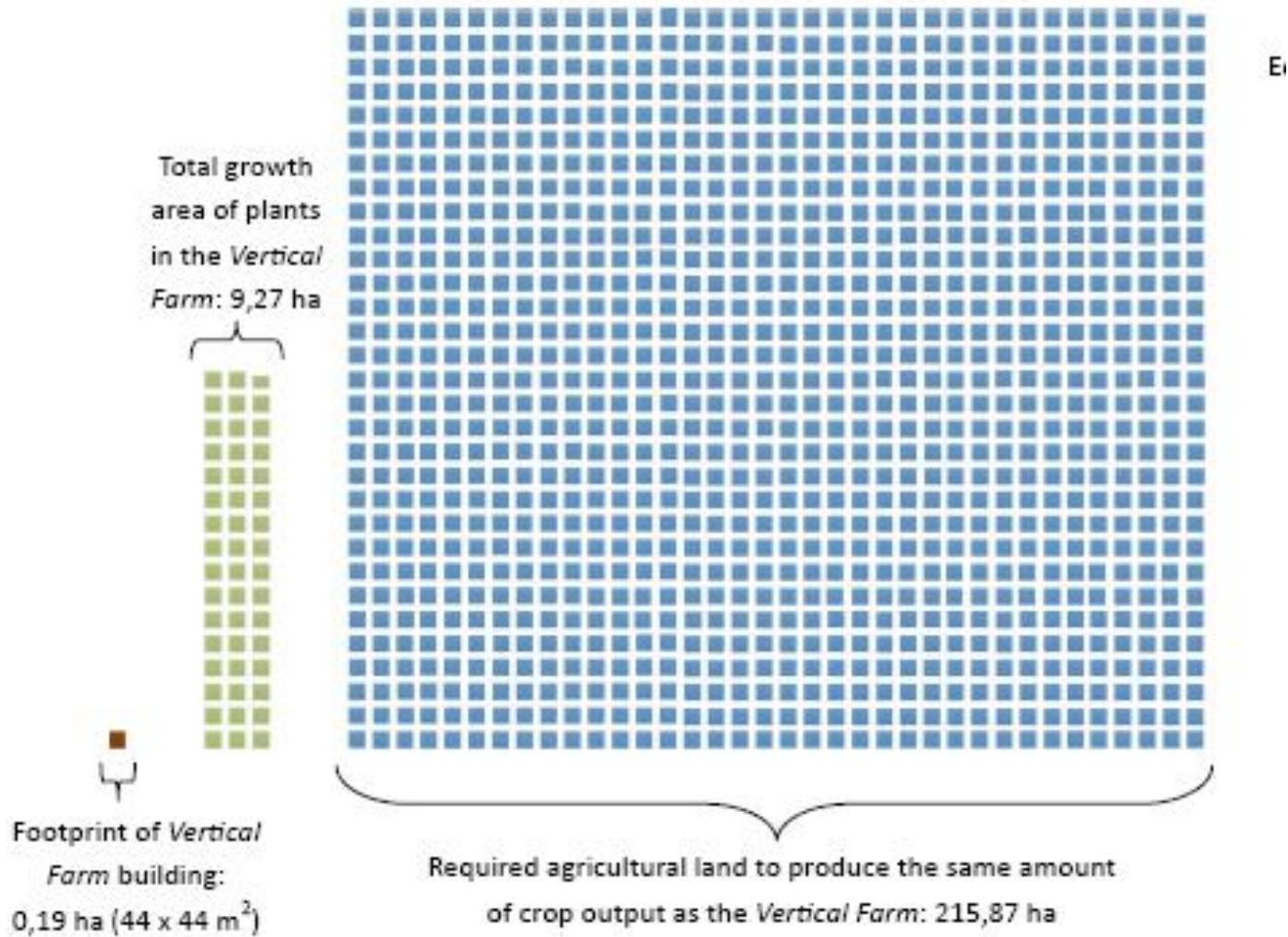


Vertical Farming



Vertical Farm compared to Traditional Agriculture

One square = 0,19 ha



Potential of cities

- Industrial facilities
- Processing facilities
- Store houses
- Military facilities
- High rise buildings



Objectives

- Sustainable and most innovative food production
- Save food production for local city market
- Stability of prices for food = political stability
- Resources use efficiency
- CO-2 food print
- Cycle of materials and energy
- Create jobs and income within the cities
- Psychological effects for humans

Sustainable Plant factories in Japan



(Marcelis & Dueck
2010)

Food Marketing?

- What's next after eco, bio, local und seasonal food?

- **Clean?**

- Clean food

- Clean products



- Clean...pure...without any other supplements

-***for a pure life***



GreenSys 2015



INTERNATIONAL ST.MARY'S HOSPITAL (Plant Factory)

Smart City – Kashiwa-na-ho, Japan (Population 3 mio.)



Chiba University



Mitsui Garden Hotel



Front

Conference Center

Smart Center





ロメインレタス



YERISU

GREEN ROOM

中家村

みらい畑



Fresh
Eco



◆ Healthy
◆ Safety

生産場所と取り組み

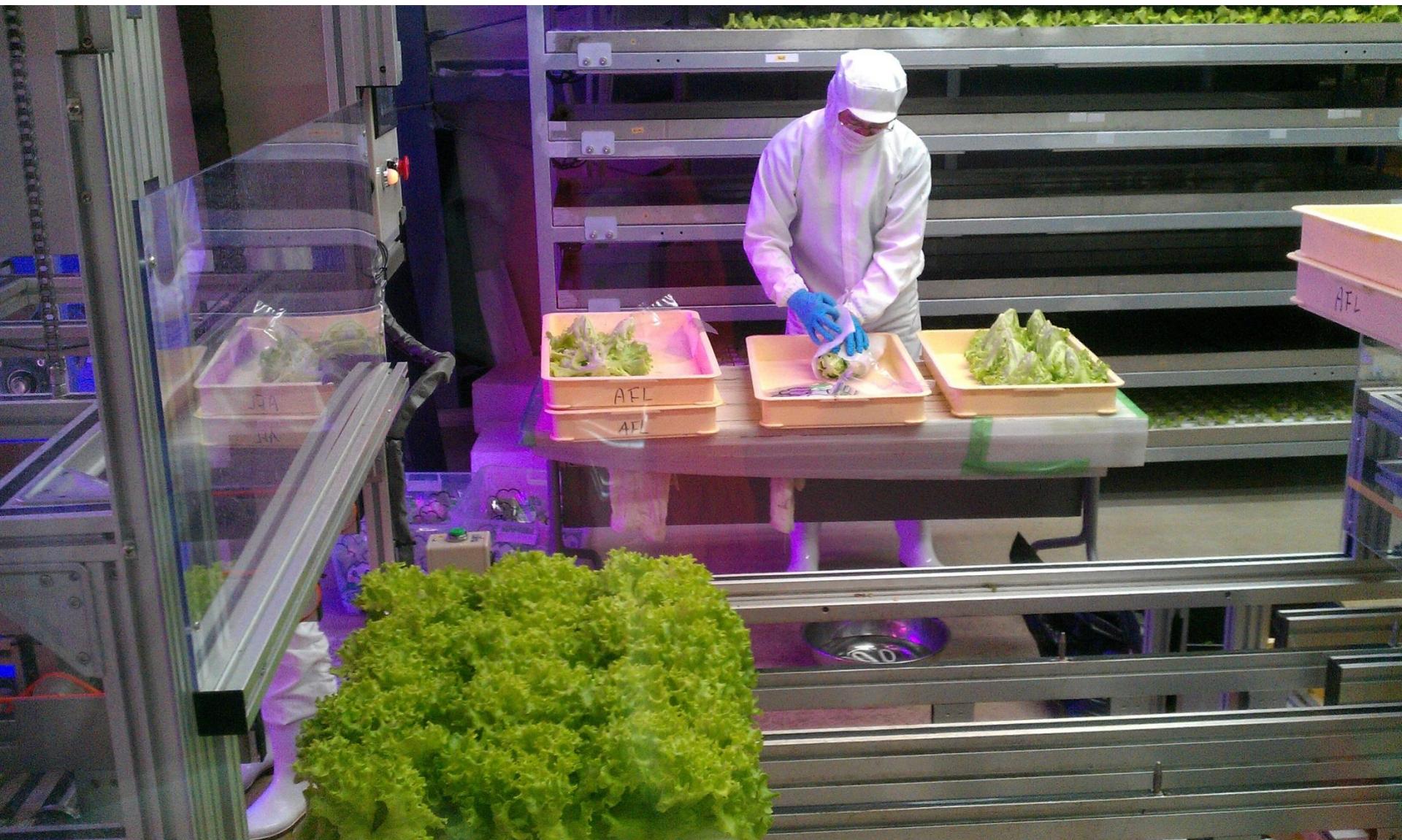


Plant Factories

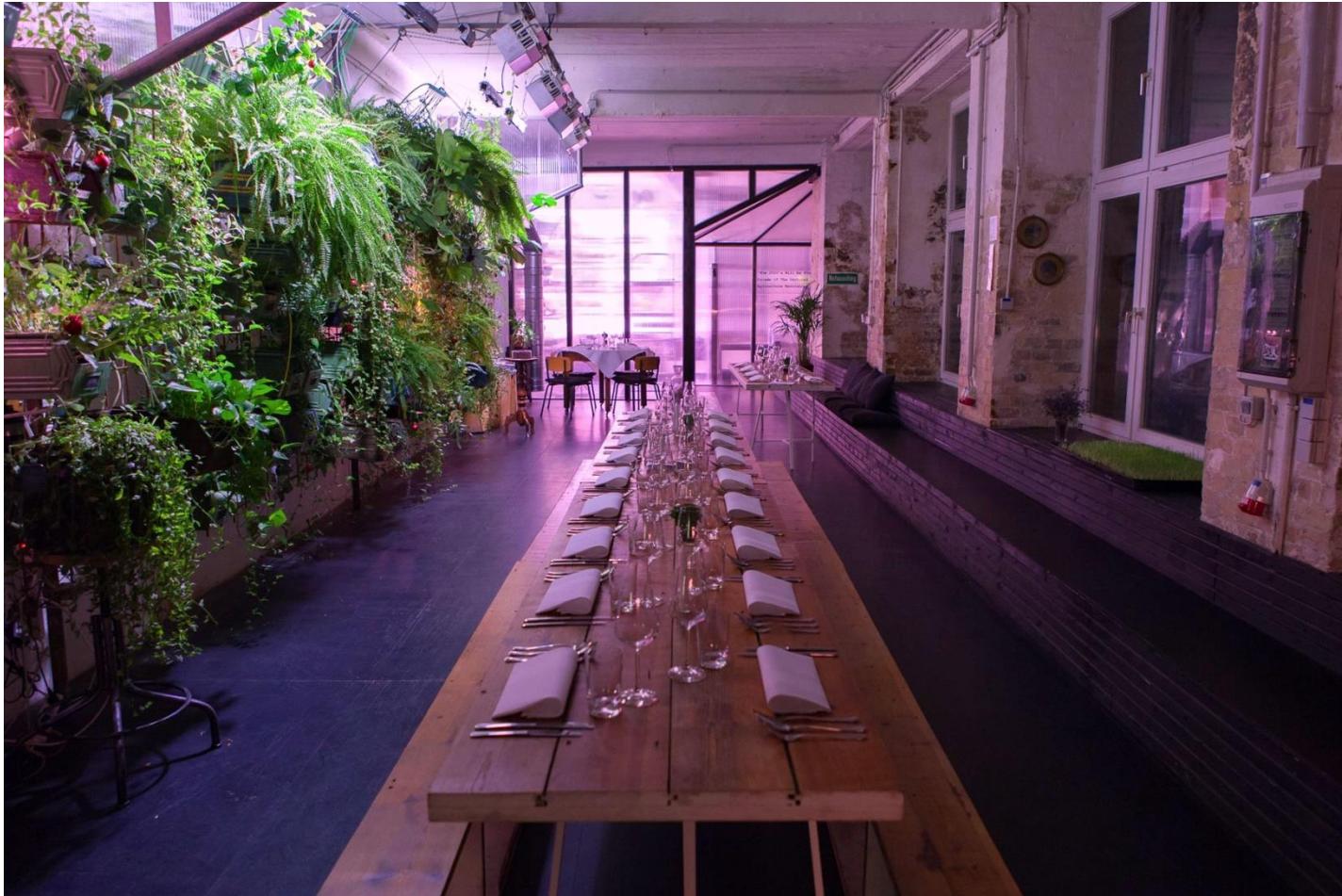








Infarm Berlin



INFARM's Berlin headquarters is a hybrid research lab, vertical farm and culinary event space. It is our field test area for new models of food consumption.

Production facility of Infarm



Show case in Berlin



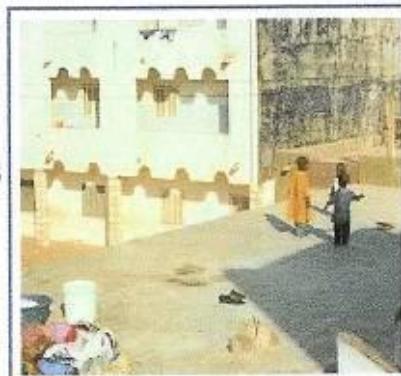
FAO Micro garden Low-Tec !!!

Micro gardens

Beneficiaries: **landless poor people in urban areas**

Actors: **women & children**

Purpose: **daily availability of fresh vegetables for home consumption and neighbourhood marketing**

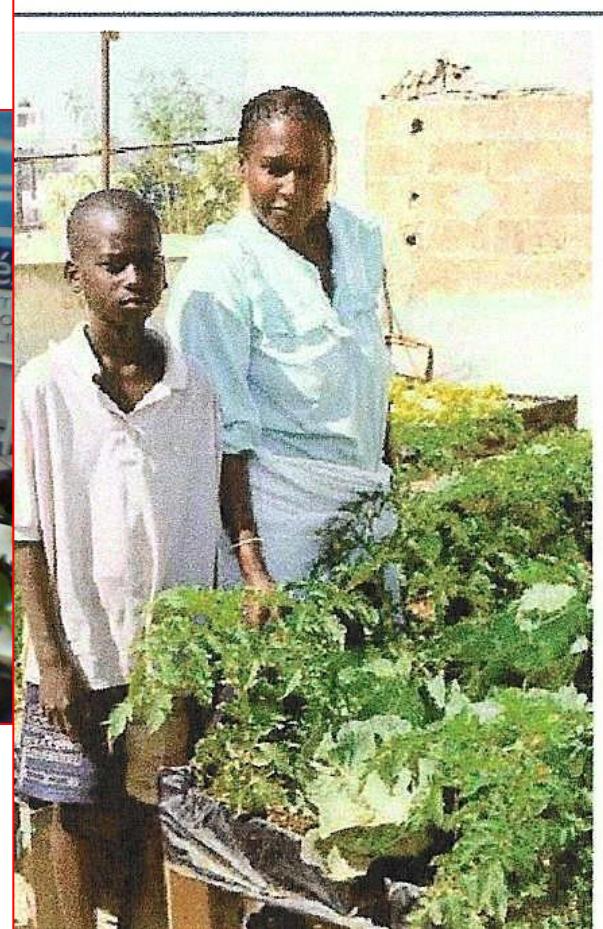
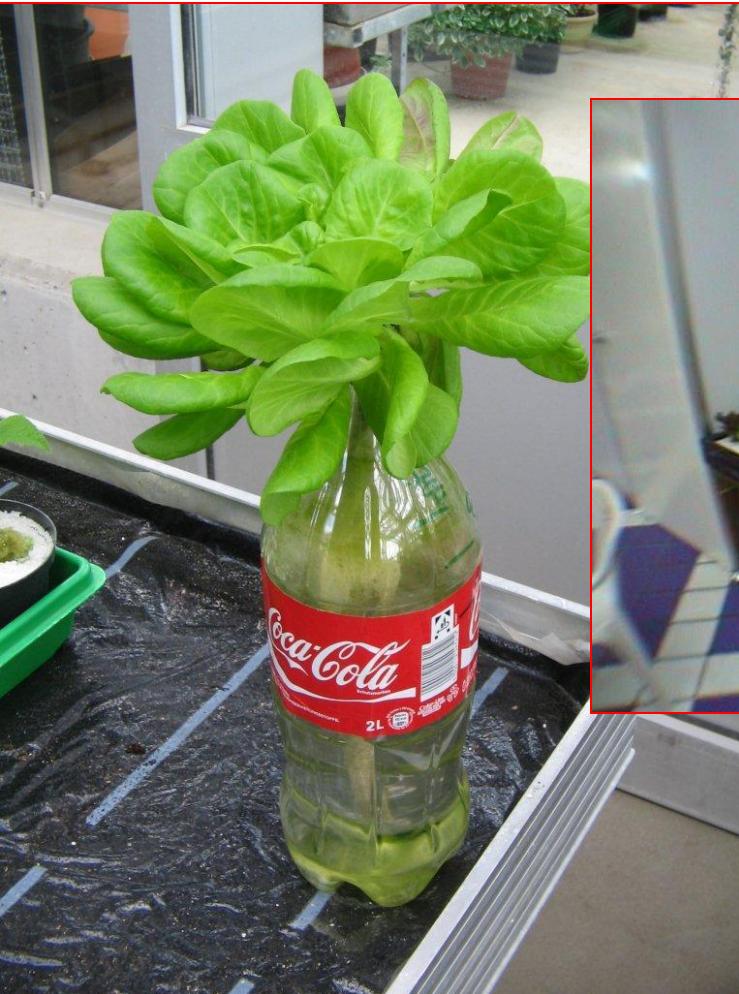


before



after

Low-Tec Hydroponic: FAO-Micro gardens



Conclusion

The diversity of hydroponic systems are increasing greatly.

- High and low-tec systems are available
 - most innovative crop production can be used for Planetary Habitats

The basic question is:

What is the most suitable hydroponic system for a given situation?

- sustainable production of food and energy
- safe food
- saving resources

It's a long way to go to the Mars!

Network



Projektleitung,
Systemanalyse,
Konzeption



Testkunden, Anforderungs-
Mgmt.



ITT-Vergabe,
Europäisches
Forschungsnetzwerk,
Expertise in PGC



Prozessoptimierung,
Verfahrenstechnik,
IMVT



tbd



Spezial-LEDs für die
Pflanzenzucht



PFP, MMS, Ergonomie



(Sensortechnik)



Biologischen Aspekte,
Bemannte Raumfahrt, Mars
500 Erfahrung, Testanlagen



Produktionstechnik,
Concurrent Engineering,
Produktentwicklung,
Marktanalysen



Product- & Cooperate
Design

Thank you and see you next time at the Mars

