

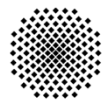
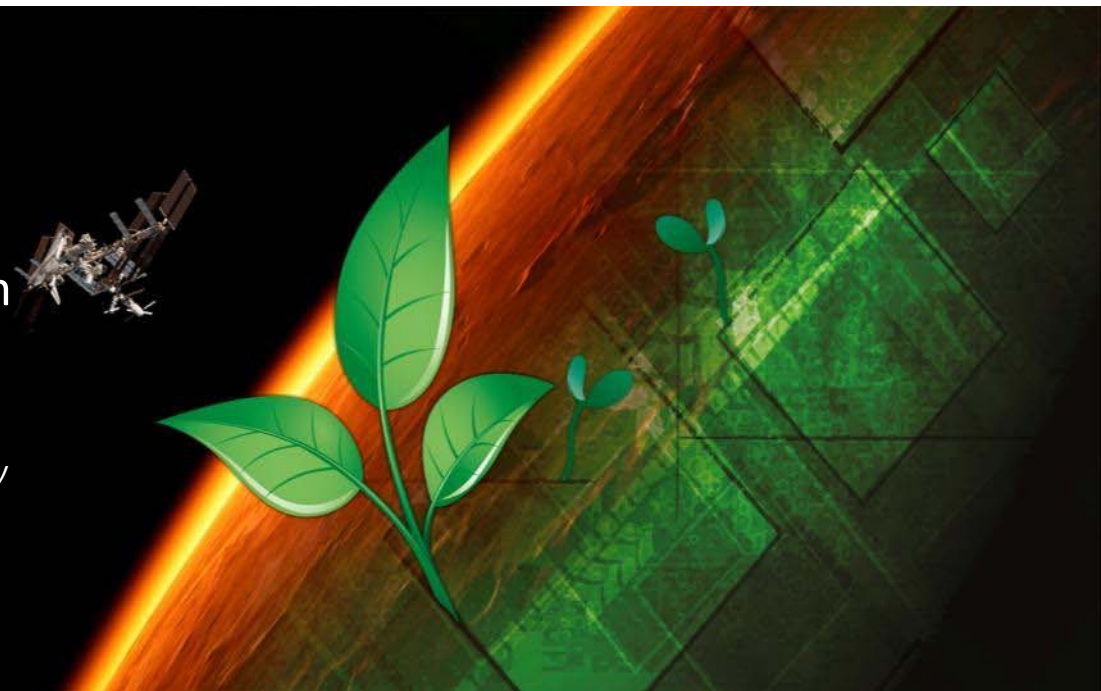


Technology and Innovation for Development of Modular Equipment
in Scalable Advanced Life Support Systems for Space Exploration

MELiSSA Workshop, Lausanne 2016

Closed loop hydroponics
for a novel crop cultivation system
on the EMCS rotor

Sander van Delden, Wageningen Univeristy
Silje A. Wolff, NTNU Social Research
TIME SCALE consortium



University of Stuttgart
Germany



NTNU

Social Research



WAGENINGEN UNIVERSITY
WAGENINGENUR



DTM TECHNOLOGIES



UNIVERSITEIT
GENT



cmr Prototech

Interscience

- Motivation and objectives
- Project tasks and consortium members
- Closed loop hydroponics for ISS
 - Plant cultivation chamber
 - Water and nutrient management (W&NM)
 - Substrate system
 - Sensors for monitoring and control

NTNU Social Research (NO)

- Project coordinator. Crop cultivation system testing, scenario development, water and nutrient supply, dissemination and exploitation

Wageningen University (NL)

- Water, nutrient and oxygen supply

Ghent University (BE)

- Plant health monitoring

University of Stuttgart (DE)

- Algae cultivation chamber concept for the EMCS

DTM (IT)

- Design and realization of ground support equipment and control software

Interscience (BE, NL)

- Plant health monitoring

ProtoTech (NO)

- Crop cultivation system

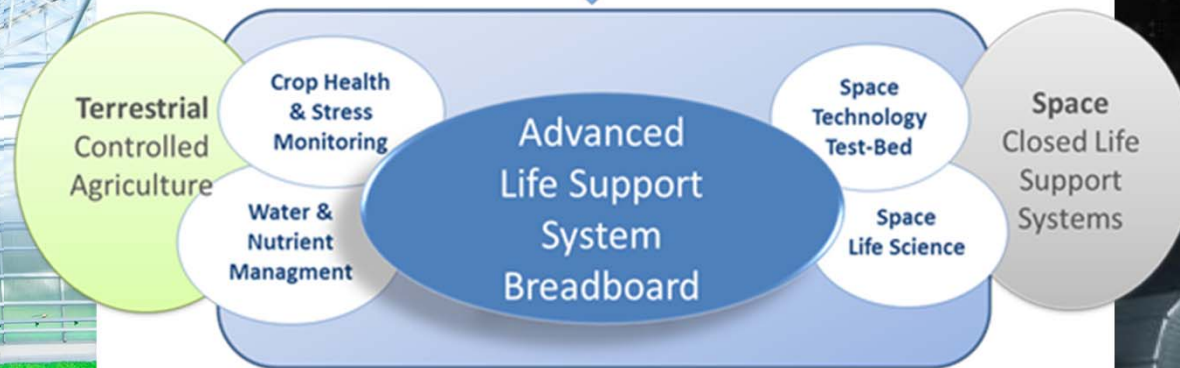
CleanGrow (IR)

- Autonomous sensing through automation and microfluidic platforms



Based on EMCS on ISS, TIME SCALE will develop an advanced life support system concept to allow life science research and technology demonstrations under fractional gravity conditions

Future ISS Utilisation Scenario

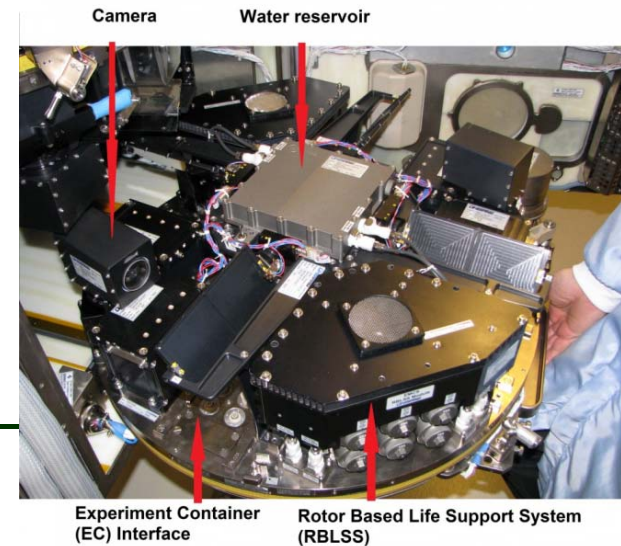
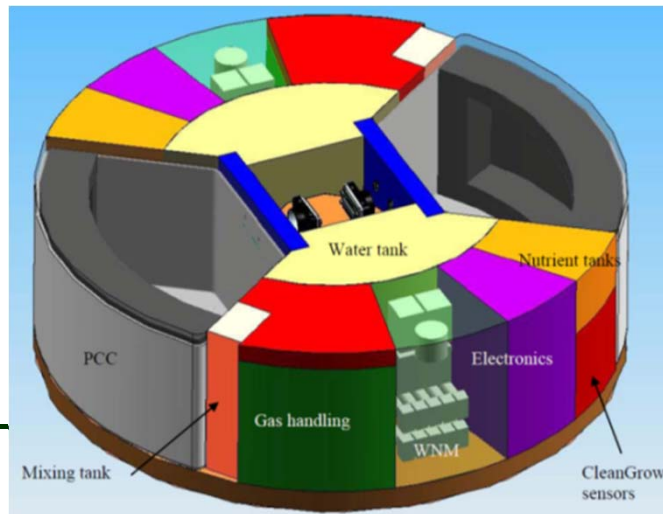
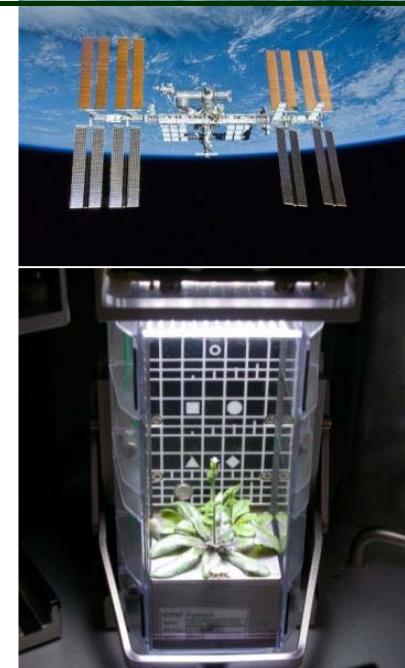
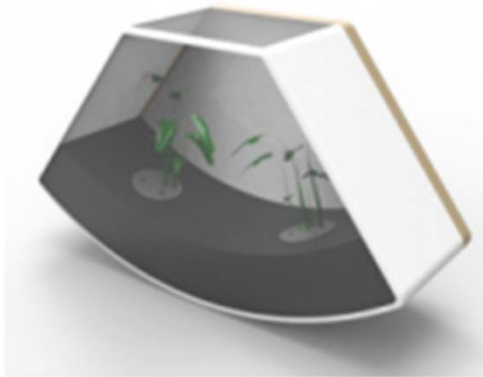


Food Production Solutions for Human Space Flight Exploration and Earth Application



Motivation

- ISS is a fully operational platform for life science research and technology demonstration
- European Modular Cultivation System (EMCS) on ISS allows exposures to microgravity and fractional gravity (Lunar and Martian g)
- The EMCS modular design allows exchanging and improving subsystems



Crop cultivation concept

- Plant cultivation chamber (PCC) or Algae cultivation chamber (ACC)
- Water and nutrient management system (W&NM)
- Plant health monitoring system
- Light system



Cultivation system breadboard

- Modular test-bed for ground testing, validation and demonstration of ISS operational capability
- Emphasis on PCC and W&NM

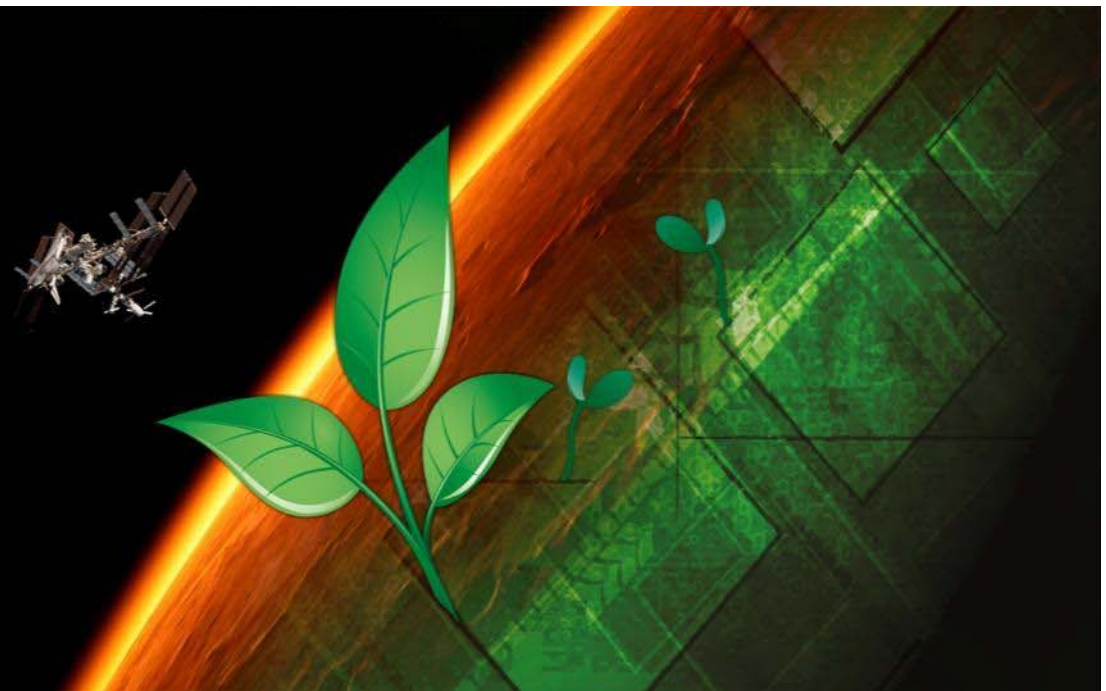


Knowledge and innovation for Space and Earth

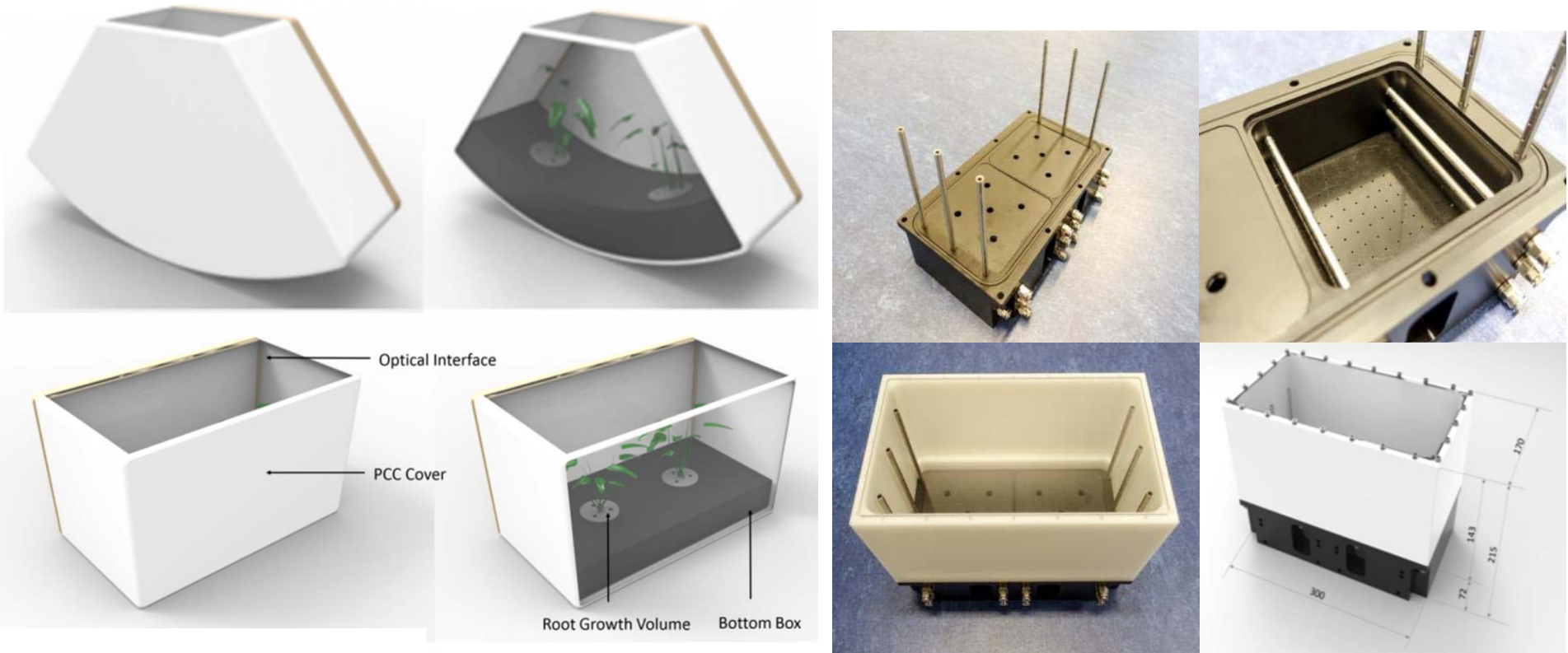
- Mechanistic model simulation of water and nutrient uptake and distribution, transpiration and oxygen consumptions of roots
- Proof of principal for analysis of volatile organic components: SIFT-MS and compact GC-MS
- Early warning system for suboptimal plant conditions
- Ion selective electrode sensors for monitoring of nutrient solutions in cultivation systems

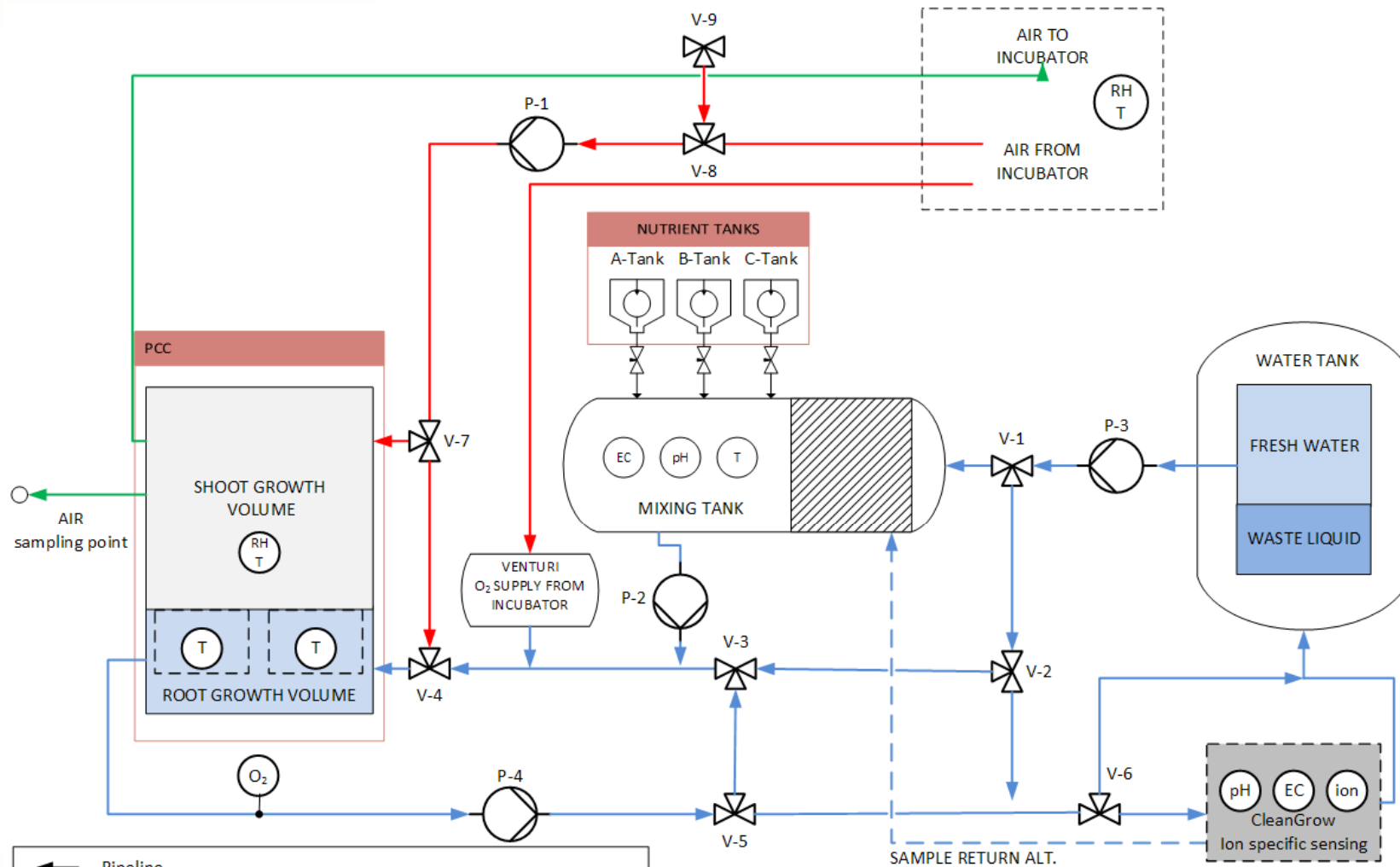
TIME SCALE

Closed loop hydroponics cultivation
system concept and design



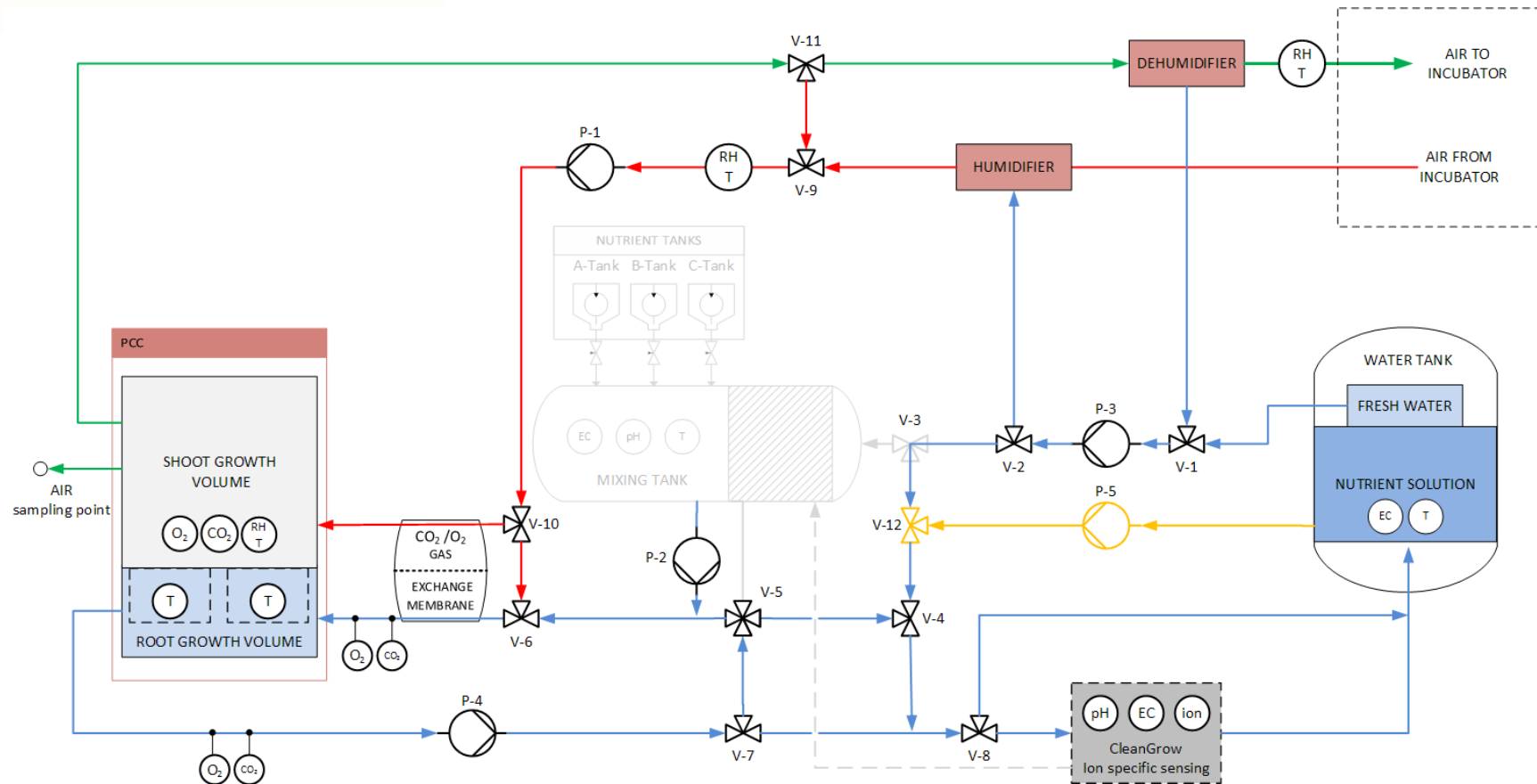
Plant cultivation chamber: Breadboard concept





- ← Pipeline
- P-# Pump (# = number)
- ⊕ Sensor (Letter indicates sensor type: T = temperature; RH = relative humidity; pH = acidity; EC = electronic conductivity; ion = ion specific)
- ⊗ Valve (# = number)

TITLE			
TIMESCALE WP4 - WNM FUNCTIONAL BREADBOARD DIAGRAM			
REV.	DESCRIPTION	DATE	BY
07	UPDATE BASED ON PROTO / USTUTT	25.01.2016	WU



← Pipeline

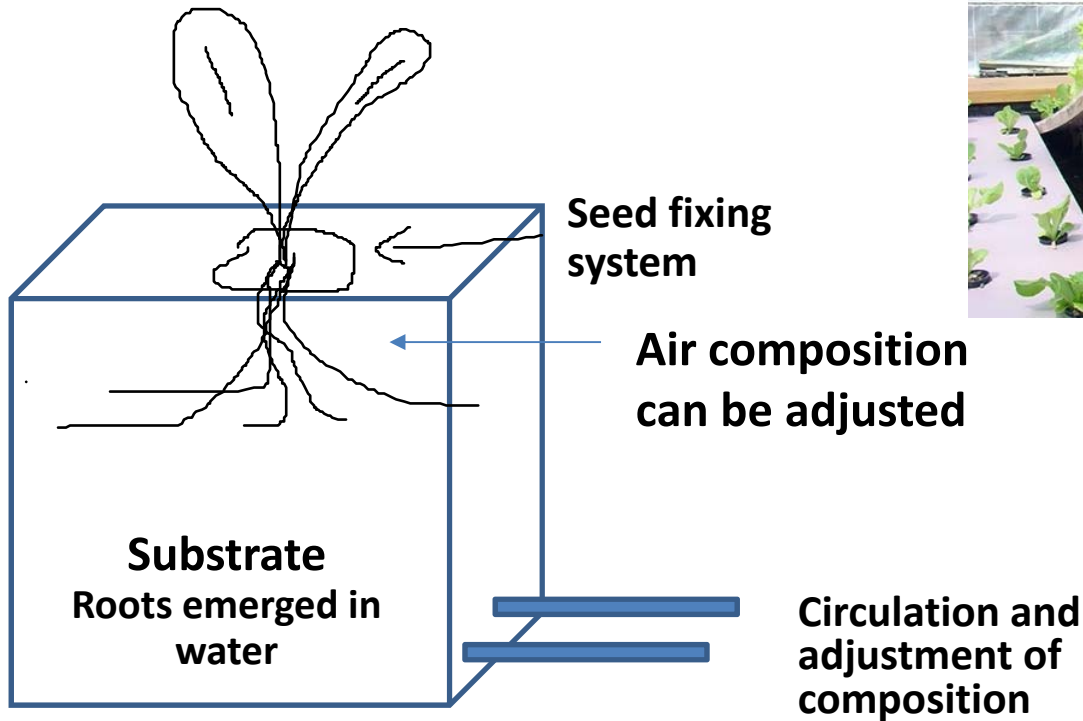
P-#
Pump (# = number)

T
Sensor (Letter indicates sensor type: CO₂= carbondioxide; EC = electronic conductivity; ion = ion specific; O₂= oxygen; pH = acidity; RH = relative humidity; T = temperature)

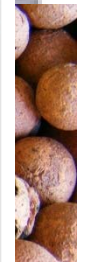
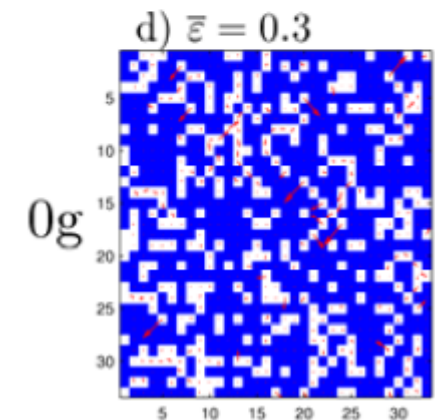
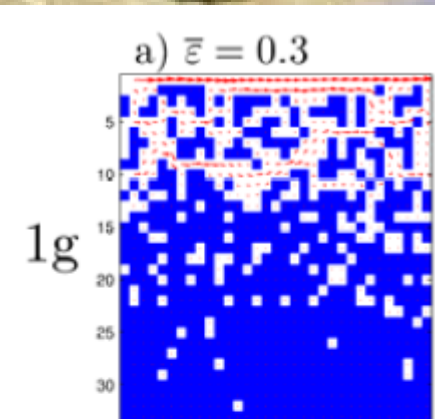
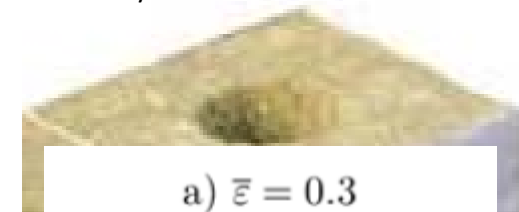
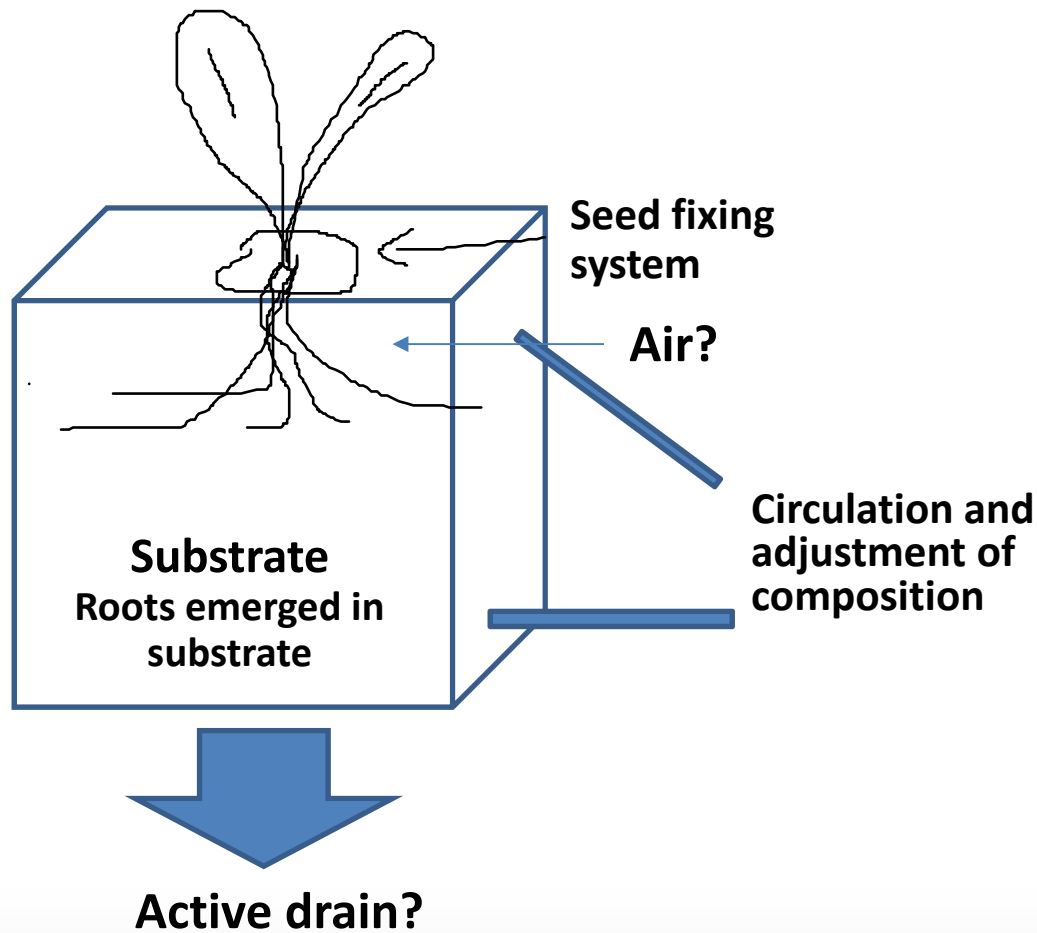
V-#
Valve (# = number)

TITLE			
TIMESCALE WP4 - WNM & RH FUNCTIONAL DIAGRAM (REDUCED COMPLEXITY)			
REV.	DESCRIPTION	DATE	BY
07	UPDATE FROM PROTIQ / USTUTT	25.01.2016	WU

Substrate system: Deepflow



Heinse R, Jones SB, Tuller M, Bingham GE, Podolski IG, Or D. 2009. Providing Optimal Root-Zone Fluid Fluxes: Effects of Hysteresis on Capillary-Dominated Water Distributions in Reduced Gravity. *SAE Technical Paper 2009-01-2360 4970*.



- Nutrient solution should fit the plants need (species specific)
 - A customised commercial nutrient recipe will be used (and tested) for lettuce
 - Several nutrients solutions from literature will be tested/ developed for Arabidopsis



Sensors

- pH, DO, EC
- Specific ions



Ions:

NH₄

NO₃

Ca

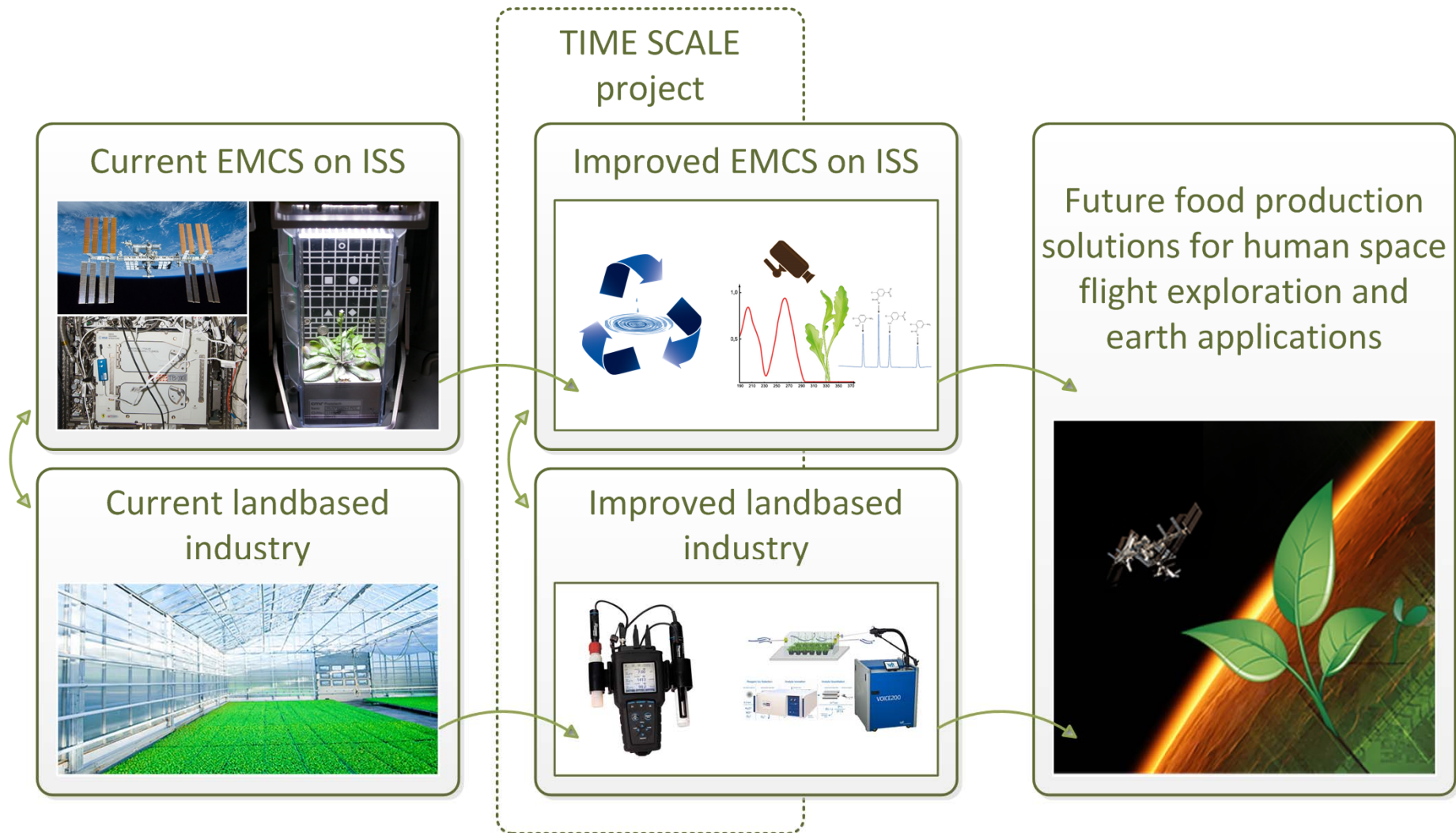
K

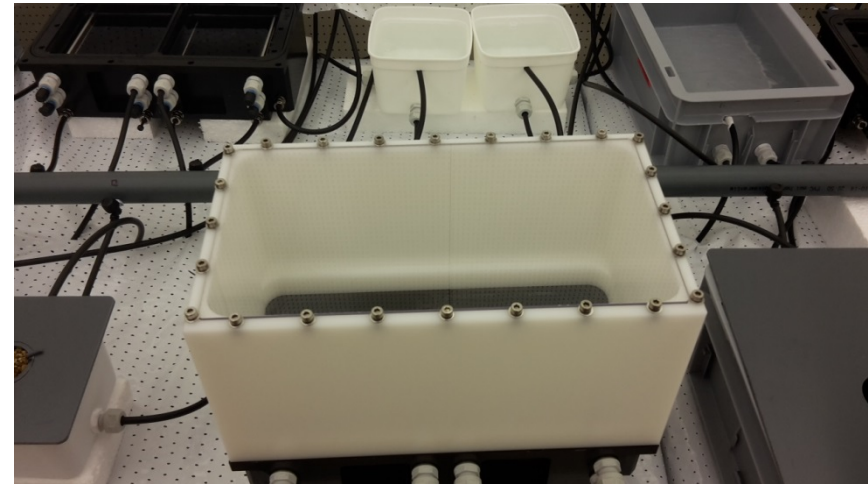
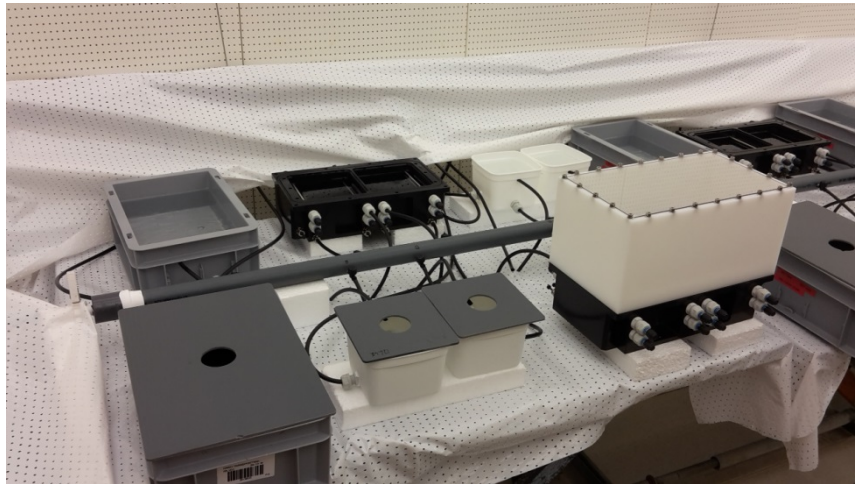
Na

Cl



Inline sensor BOX







Thanks for your attention!