SPACE BIOLOGY AND SPACE MEDICINE IN THE LUNARES HABITAT IN POLAND

Dr. Agata Kołodziejczyk

Space Garden, Advanced Concepts Team, ESA, ESTEC, fichbio@gmail.com

EXTREME HABITABLE WORLDS SYMPOSIUM, 2017

AGENDA

1. Lunares Habitat
2. Experiments for Biology
3. Materials and Methods, Results, Conclusions
4. Experiments for Medicine
5. Materials and Methods, Results, Conclusions
6. Summary

LUNARES from LUNA (Moon) and ARES (Mars)

The habitat was opened for use in July 2017 by Space Garden Company in Poland.

It is a unique chronobiological laboratory in Europe,
Specially designed to simulate lunar or martian space missions,
consistent with actual plans of deep space exploration on the world.

Max. 6 analog astronauts can live together during single mission.
Analog simulations can be fully autonomous controlled by astronauts crew,
Or controlled fully remotely from the Mission Control Center located anywhere, from where is access to internet.

The unique feature of this facility is independent operational system
Serving the time and controlling base parameters such temperature, lighting and humidity cycles.

Successful crowdfunding – 7%
Private investment -93%
Space Garden Company,
with other private investors

The first testing lunar mission
Gaining know how

Launching experiments

May 2016

August 2016

July 2017 - present

Lunares for lunar or martian analog missions,
the most automated and remotely controlled habitat in the world.

Objectives:

professional analog simulations,
scientific missions,
educational workshops,
teambuilding,
testing prototypes

All in isolation from sunlight and UTC time!

Lunares Habitat
http://lunares.space

New quality of analogs for future deep space exploration

Equipment:

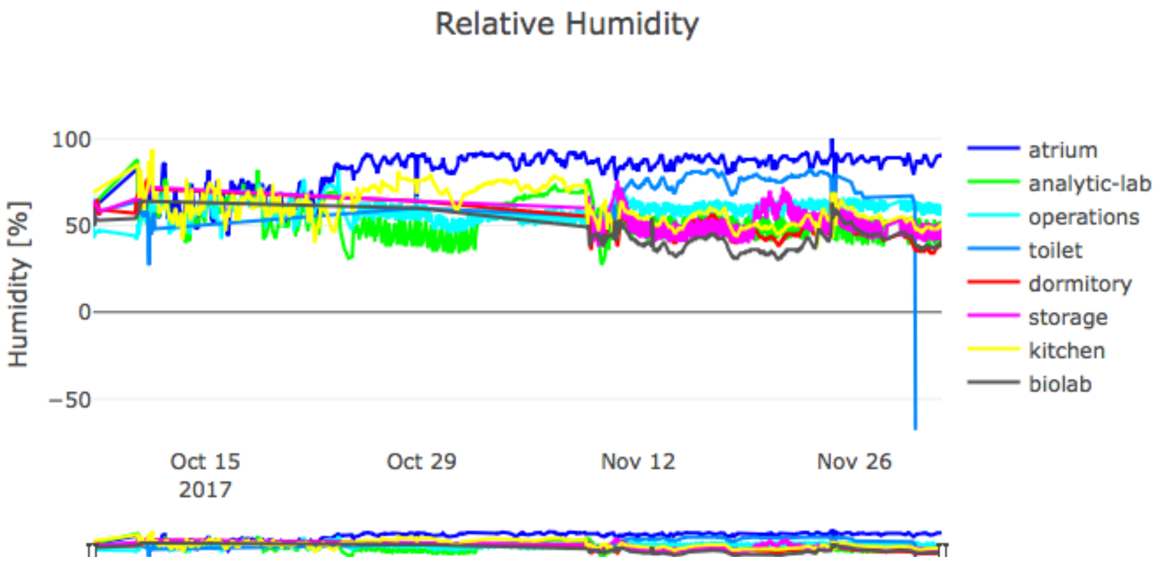
- professional technical workshop,
- biological laboratory,
- hydroponic and life support systems,
- 300 square meters of isolated EVA terrain,
- EVA spacesuits,
- rovers,
- microgravity simulators,
- remote medical devices to monitor astronauts' physiology.

Contact:
office@space.garden
http://space.garden

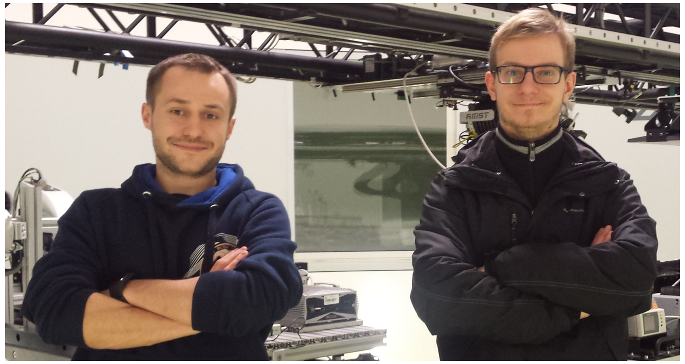
SPACE GARDEN


Dormitory
Hydroponics
Biolab
Airlock
EVA terrain
Atrium
Analytic lab
8 functional modules, more than 100 square meters to live
8 AIRLOCK
3 DORMITORY
2 OPERATIONS
1 BIOLAB
Bioreactors

HABITAT's SENSORY SYSTEM

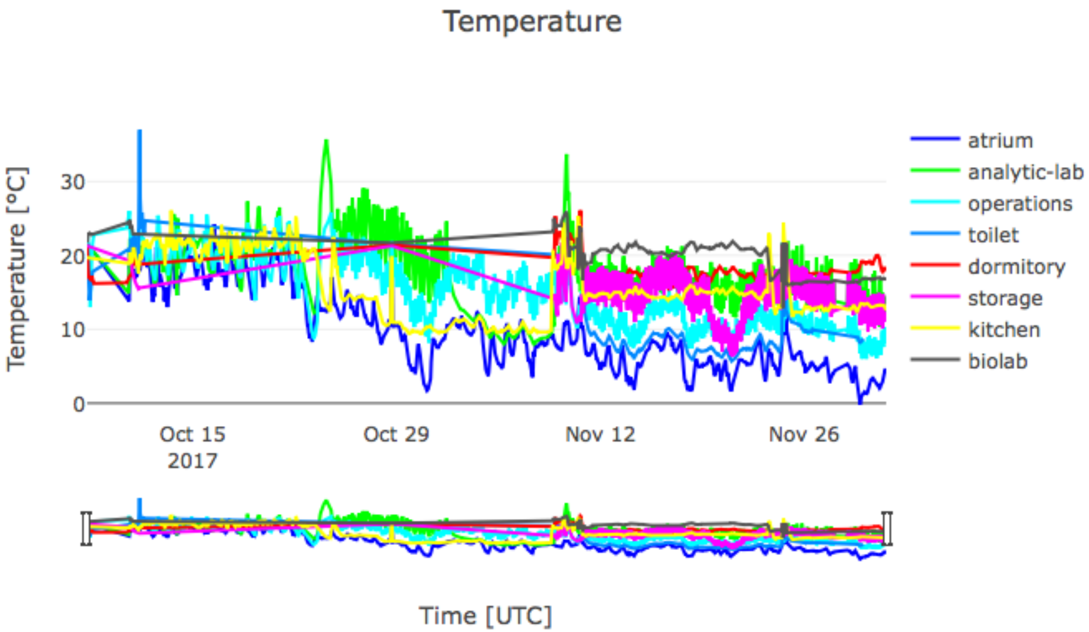


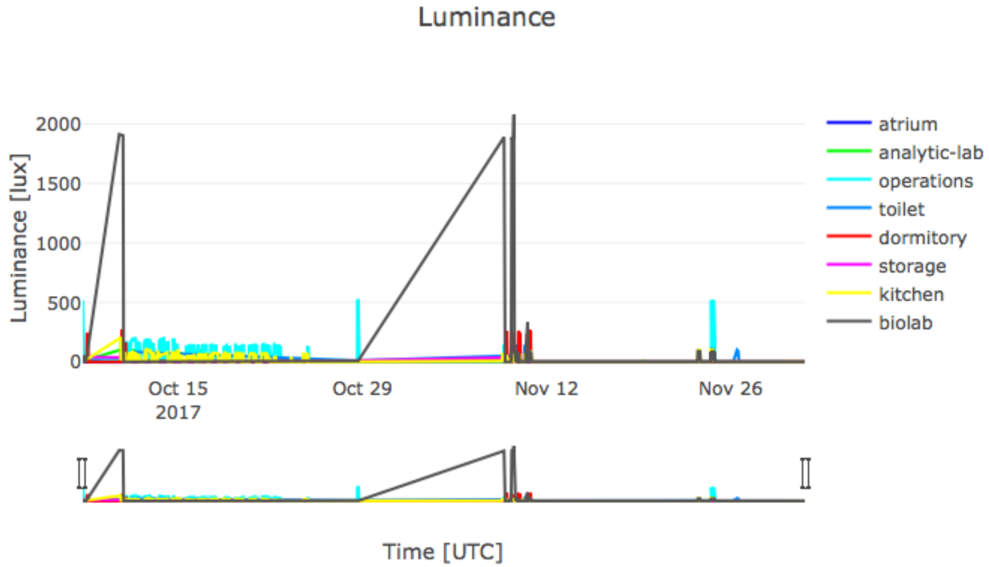
BY AEON LABS



Matt Harasymczuk

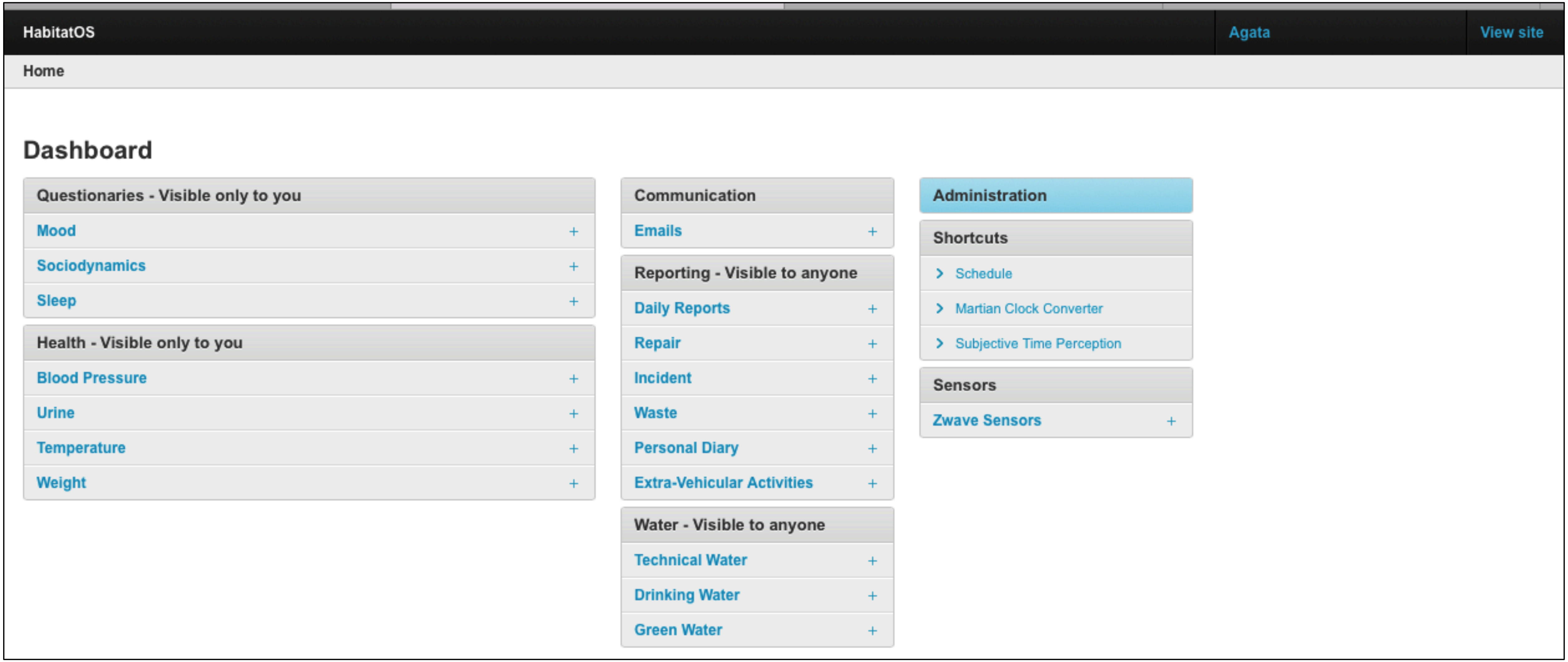
Matt Kraiński





HABITAT's OPERATIONAL SYSTEM

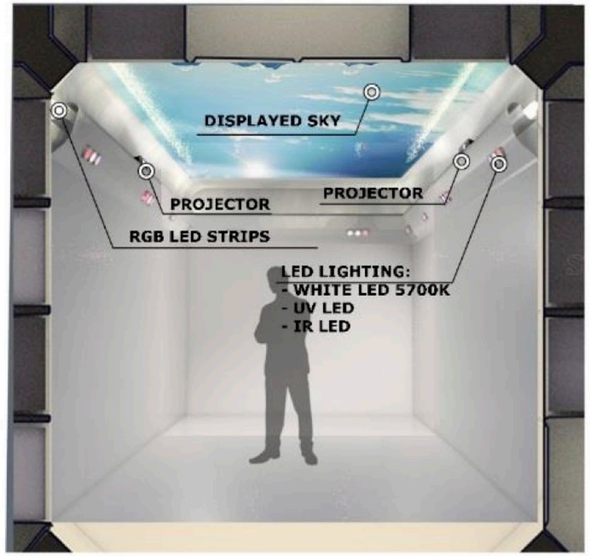
author: Matt Harasymczuk



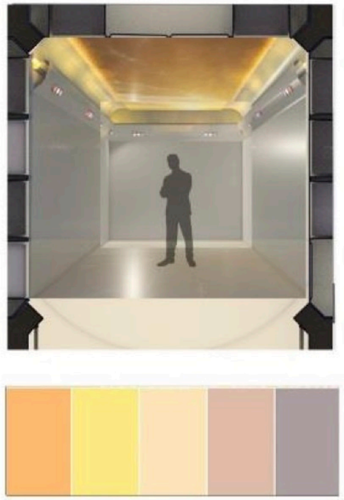
Day-night cycle and physiological lighting systems

Authors: L. Orzechowski, D. Maciejewski, A. Kołodziejczyk

ARTIFICIAL DAY-NIGHT CYCLE CONCEPT

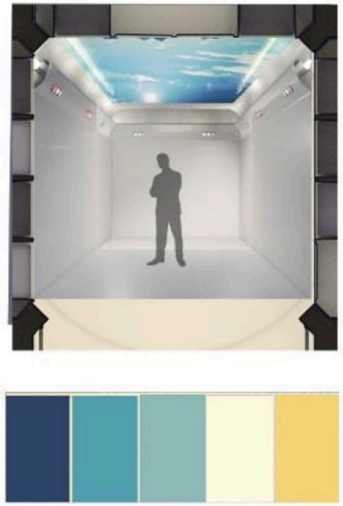


MORNING



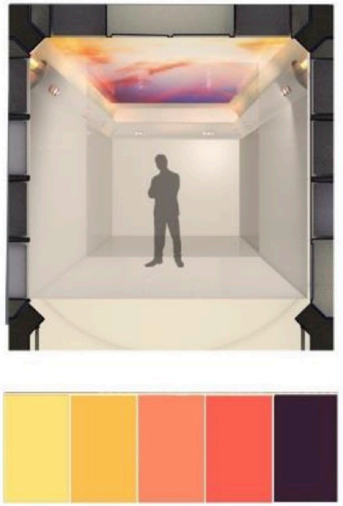
MORNING COLOR SCHEME

NOON

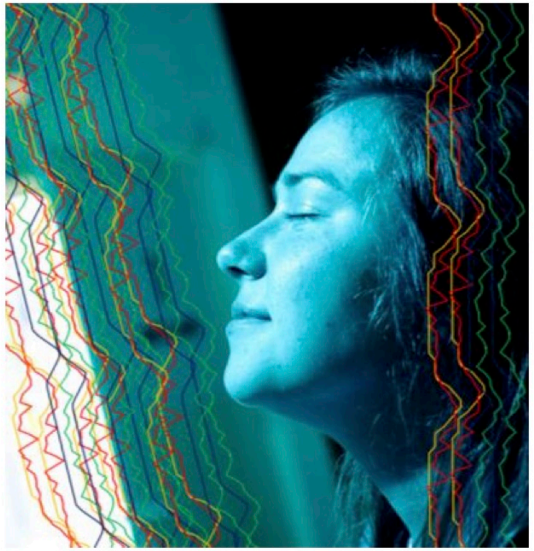


NOON COLOR SCHEME

EVENING



EVENING COLOR SCHEME



RGB Led Control

Turn Off
One Color
Two Color
Three Color
Four Color
Five Color
Six Color
All Color

Reset Color

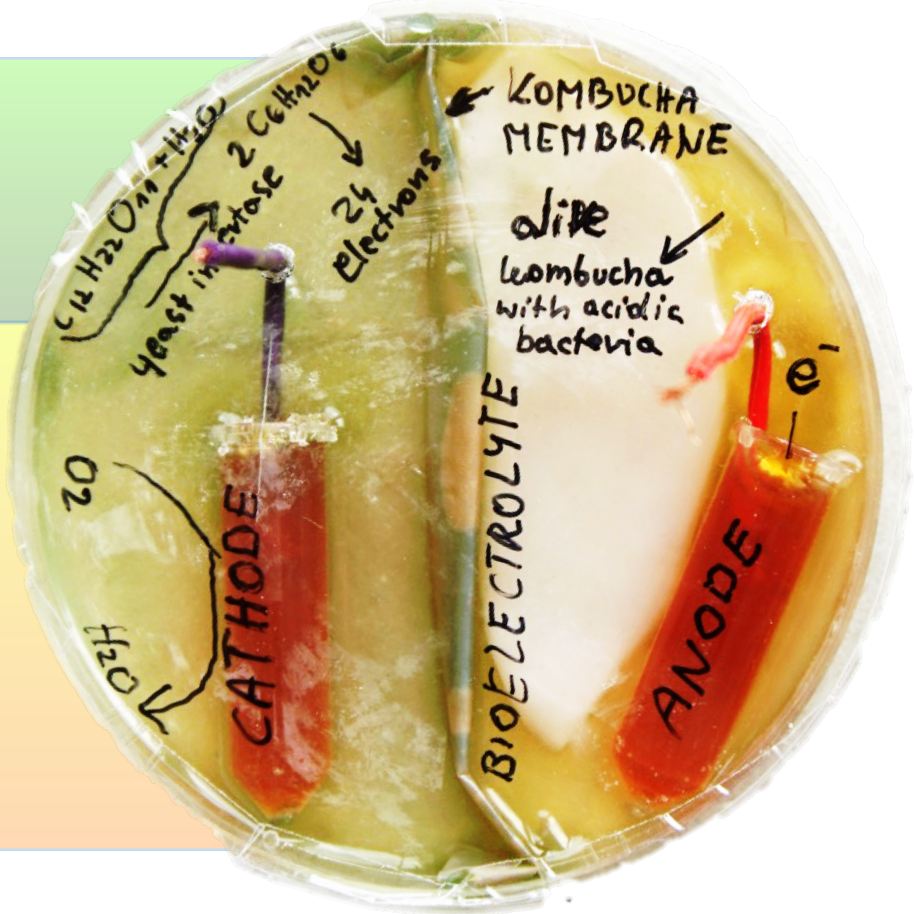
ONGOING PROJECTS IN HABITAT LUNARES

BIOLOGY

1. Photosynthetic biomaterials
2. Alternative bioreactors

MEDICINE:

3. Time architeture: physiological lamps for synchronisation of the biological clock (protein synthesis) – optimisation of artificial Sun in isolated spaces
4. Subjective time perception



CONTROLLED ECOLOGICAL LIFE SUPPORT

Biological Experiments

Experiments concerning Productivity of Artificial Bioreactors Ecosystem

REPORT FROM THE

Lunar Expedition 1.0

PI: Dr Eng. Agata Rudolf

Analog Astronauts: Joanna Kuźma, Dorota Budzyń

Procedure 4.2.1.3. Cockroach growth curve on *Tenebrio molitor* homogenate

Cockroaches were maintained in 10 small plastic boxes, 3 individuals per each box, 5 boxes with males and 5 wit females. Animals were fed with 3 g of Tenebrio homogenate per each box every 3 days. Fresh homogenate was weighed and served to cockroaches. Cockroaches from each box were weighed before serving new portion of food every 3 days, three individuals at once. Animals from each of the boxes were photographed on white paper sheet to monitor aggressive behaviour or morphological changes.


Male Female

Procedure 4.2.7.1. Organic waste production (how much waste organic material, a habitat produces)

A plastic container with a lid was used to collect organic waste produced by the station. The box was first weighed empty, and then each time after the addition of a new amount of collected waste organic material. The box was stored in cold to avoid material deterioration.

Procedure 4.2.8.1 Tenebrio larvae waste utilisation (how much waste material, the larvae can utilise)

Tenebrio larvae were maintained in a large plastic box (2 L volume). Larvae faeces were collected, weighed and stored for plant fertiliser. The box was cleaned and the mass of larvae was weighed. Larvae were fed with some waste organic material. The amount of food eaten by the larvae was checked daily. If all the applied material was eaten by the larvae, a new portion of food was weighed and added to the container.

CONTROLLED ECOLOGICAL LIFE SUPPORT

Procedure 4.2.10.1. Growing plants sprouts in different light conditions

A special type of sprouts culture containers were used (Picture 1). Container, each having 3 levels, were marked as follows: L=light; D=dark; 1.1L, 1.2L, 1.3L; 2.1L, 2.2L, 2.3L; 3.1D, 3.2D, 3.3D; 4.1D, 4.2D, 4.3D. About 30 seeds of Mung Bean were weighed and placed at each level of each container. The plants were water with 200 ml of clean water. For first 24 h, all four containers were stored in light conditions. After 24 h, two containers were (3 and 4) were placed in the dark and left there until the end of experiment. Other two containers (1 and 2) were left in the light conditions. To water the plants, a water gathered at the bottom part of each container was placed back on the top of the same container twice daily. Every 3 days the old water was removed from the container and replaced with 200 ml of fresh water. The plants were weighed (all the plants from each level of each container at once) after first 24 h from sowing the seeds, and then after every 2 days, before the watering. After 5 days of experiment, the plants length was measured, when aligning together all sprouts from each level of each container. Next the fresh sprouts were served to astronauts to eat, and waste organic material (husks, remaining parts of the ruts, etc.) was collected.

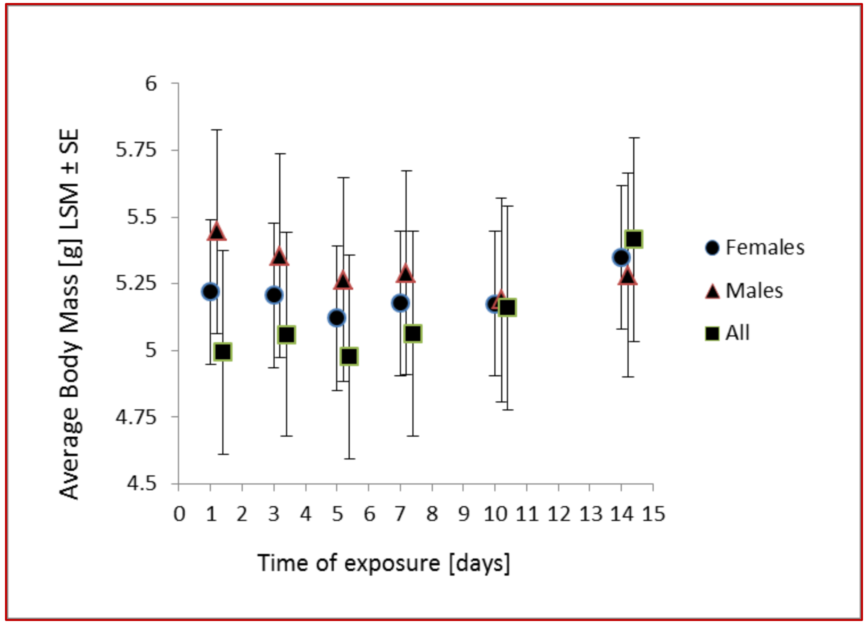
Procedure 4.2.11.1 Growing plants on regolith simulant with Tenebrio fertilizer

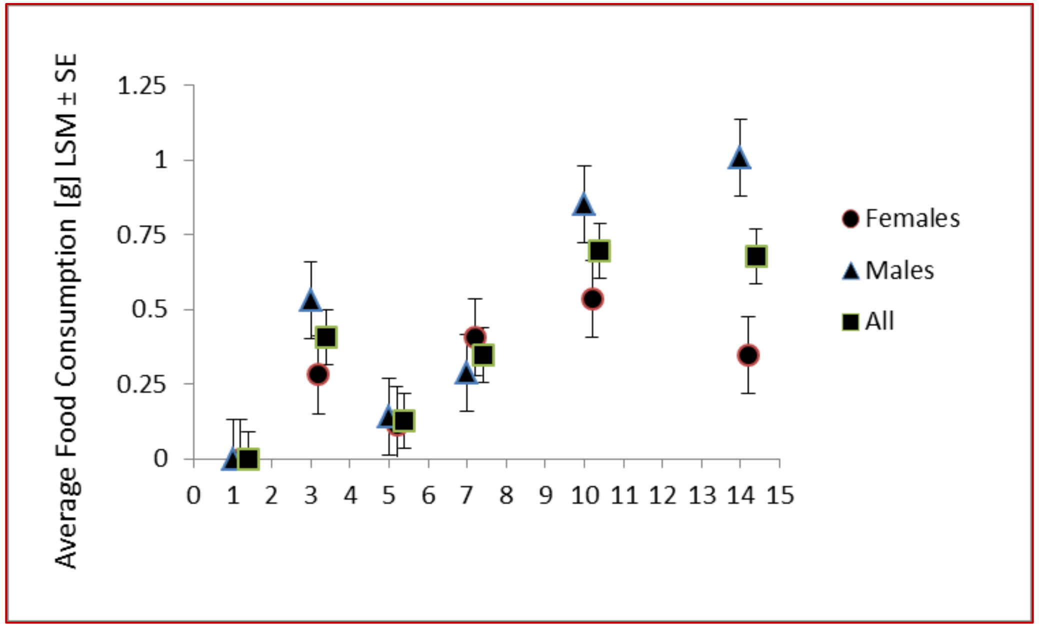
A rock mass simulating moon regolith was placed in 24 small plastic flowerpots. 12 alive chive onions and 12 alive small parsley roots were prepared for the experiment. Green parts of both kinds of plants were cut off. About 4 cm of parsley root was cut and the upper part of the root was used. The regolith simulant was mixed with Tenebrio larvae faeces in proportion of 3:1 and 4:1 (regolith : faeces) and placed in the flowerpots. Onions and ruts were placed/planted, one in each of the flowerpot:6 onions in 3:1 mixture, 6 onions in 4:1 mixture; 6 roots in 3:1 mixture, 6 roots in 4:1 mixture. Each of the pots was weighed with a plant inside, before the watering. The height of green part of each plant was measured. Next, the plants were watered with 2 ml of clean water every two days. Measurements of weight and height were also repeated every two days.

CONTROLLED ECOLOGICAL LIFE SUPPORT

Procedure 4.2.1.3. Cockroach growth curve on Tenebrio molitor homogenate

The results presented below are shown as least square means (LSM) ± SE, F, df and P values at alpha 0.05 in case of ANOVA, and simple means ± SD and P values at alpha 0.05 in case of t-test analysis. In case of some results a simple average or raw values are shown.

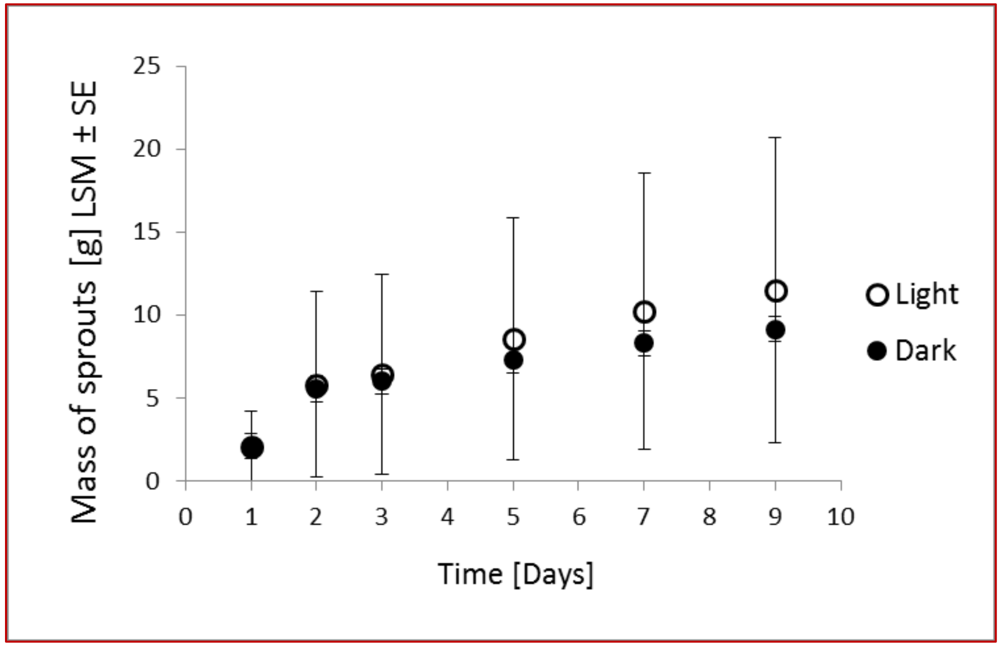




Feeding the Cockroaches with Tenebrio homogenate appeared to be an efficient way of sustaining the Cockroach population in the artificial ecosystem. In the future, the mass of consumed larvae should be scheduled in way to provide about 0.1 g per individual daily.

Procedure 4.2.10.1. Growing plants sprouts in different light conditions

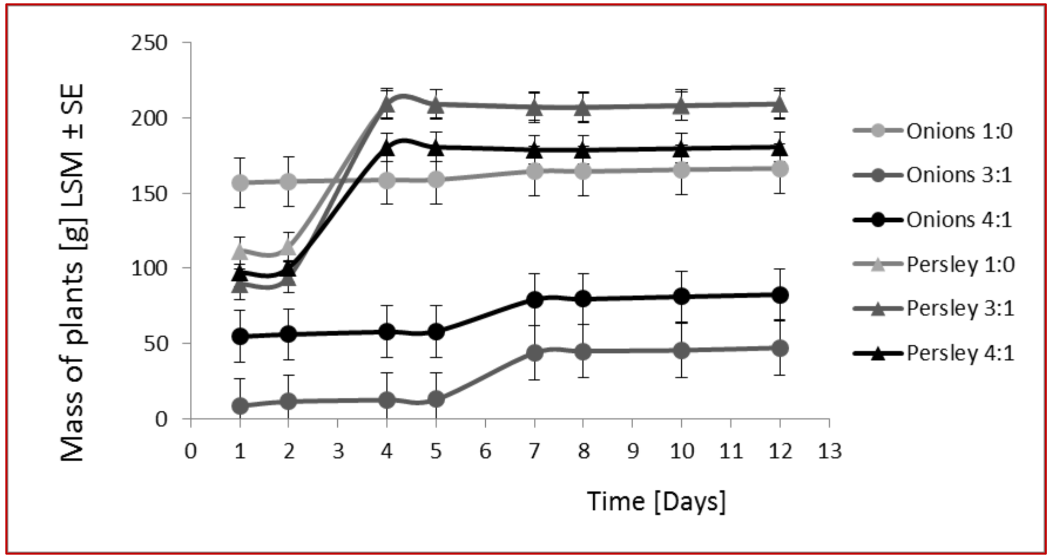
The mass of Mung bean sprouts cultured in Light was higher than those kept in Dark throughout the entire experiment (Effect of the Group: $F_{1,58}$=5.38, P=0.024). Both groups of plants significantly increased their mass (Effect of the measurement Day: $F_{5,58}$=29.24, P<0.001). However, after 9 days of growth in constant light conditions, or in dark conditions with only 24 h light induction, the mass of the sprouts kept in the dark did not increased significantly faster than the mass of the sprouts kept in light (Effect of Day*Group: $F_{5,58}$=0.77, P=0.572).

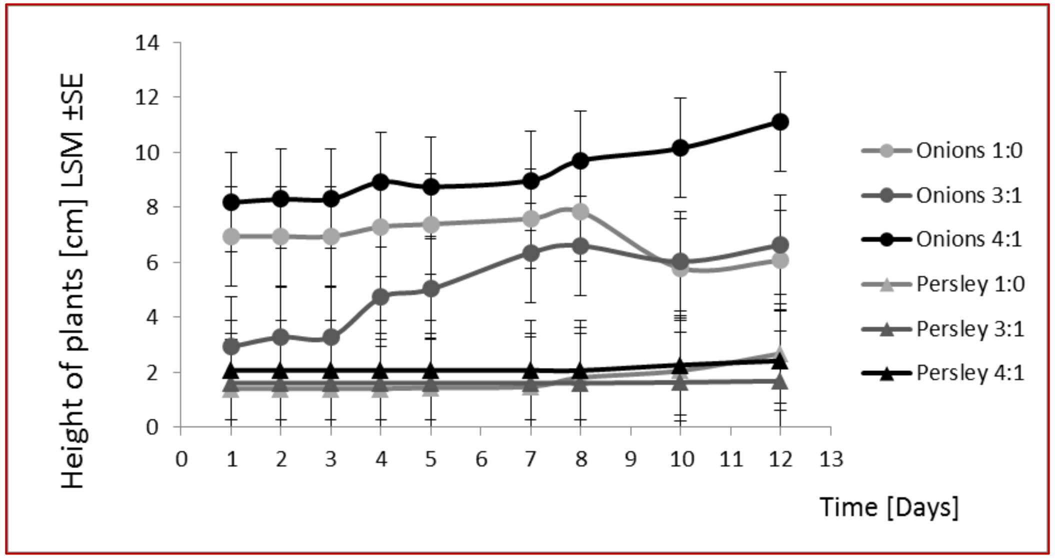


Conclusion: The Mung bean appeared to grow almost as well in mostly dark conditions than in conditions of constant light. The increase of biomass as well as rate of growth was comparable in both light conditions. Therefore, to save energy on lightning at the station, it is possible and most efficient to keep growing sprouts of Mung bean plant in dark conditions with only short light induction.

Procedure 4.2.11.1 Growing plants on regolith simulant with Tenebrio fertilizer

The mass of Onions and Parsley changed during the 12 days-long period of experiment (Effect of measurement Day: $F_{7,138}$=64.88, P<0.001). However, for two species it did not increased in the same rate over the exposure period (Effect of Species*Day: $F_{7,138}$=34.65, P<0.001), or in relation to experimental groups, i.e. fertilizer's concentration (Effect of Species*Group: $F_{2,138}$=15.08, P<0.001). Therefore, the effects of experiment were species-specific, and additional statistical analyzes were performed separately for each of two plant species.



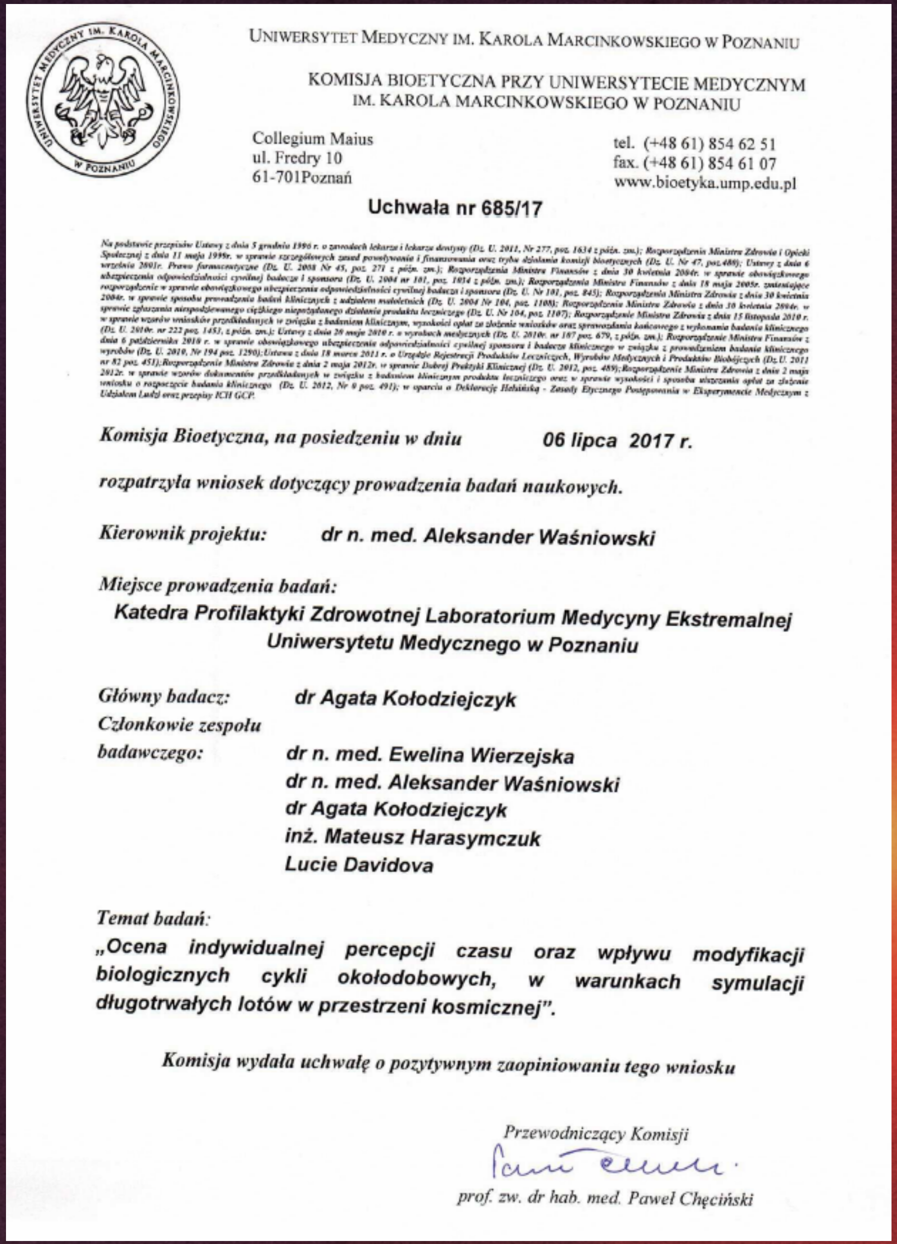


Conclusion: The mixture containing 3:1 proportion of Moon regolith simulant : feaces of Tenebrio larvae appear to be the most beneficial for plant growth among investigated soil compositions. In future experiments, this proportion should be used to maintain healthy plant growth in cultures using moon regolith simulant.

SPACE MEDICINE IN LUNARES MISSIONS

Five missions in 2017:

1. Polish Mars Analog Simulation (PMAS) – 31 July-13 August 2017 - COMPLETED
2. Lunar Expedition I (LunEx I) – 15-30 August 2017 - COMPLETED
3. The first in Europe Educational mission „Youth for Moon” – 11-13 September 2017 - COMPLETED
4. Innovative Concepts Ares (ICAres – I) – 08-22 October 2017 - COMPLETED
5. Hibernity – 10-24 November 2017 - COMPLETED



UNIWERSYTET MEDYCZNY IM. KAROLA MARCINKOWSKIEGO W POZNANIU

KOMISJA BIOETYCZNA PRZY UNIWERSYTECIE MEDYCZNYM
IM. KAROLA MARCINKOWSKIEGO W POZNANIU

Collegium Maius
ul. Fredry 10
61-701Poznań

tel. (+48 61) 854 62 51
fax. (+48 61) 854 61 07
www.bioetyka.ump.edu.pl

Uchwała nr 685/17

Na podstawie przepisów Ustawy z dnia 5 grudnia 1996 r. o zawodach lekarza i lekarza dentysty (Dz. U. 2011, Nr 277, poz. 1634 z późn. zm.); Rozporządzenia Ministra Zdrowia i Opieki Społecznej z dnia 11 maja 1999r. w sprawie szczegółowych zasad powoływania i finansowania oraz trybu działania komisji bioetycznych (Dz. U. Nr 47, poz.480); Ustawy z dnia 6 września 2001r. Prawo farmaceutyczne (Dz. U. 2008 Nr 45, poz. 271 z późn. zm.); Rozporządzenia Ministra Finansów z dnia 30 kwietnia 2004r. w sprawie obowiązkowego ubezpieczenia odpowiedzialności cywilnej badacza i sponsora (Dz. U. 2004 nr 101, poz. 1034 z późn. zm.); Rozporządzenia Ministra Finansów z dnia 18 maja 2005r. zmieniające rozporządzenie w sprawie obowiązkowego ubezpieczenia odpowiedzialności cywilnej badacza i sponsora (Dz. U. Nr 101, poz. 845); Rozporządzenia Ministra Zdrowia z dnia 30 kwietnia 2004r. w sprawie sposobu prowadzenia badań klinicznych z udziałem małoletnich (Dz. U. 2004 Nr 104, poz. 1108); Rozporządzenia Ministra Zdrowia z dnia 30 kwietnia 2004r. w sprawie zgłaszania niespodziewanego ciężkiego niepożądanego działania produktu leczniczego (Dz. U. Nr 104, poz. 1107); Rozporządzenie Ministra Zdrowia z dnia 15 listopada 2010 r. w sprawie wzorów wniosków przedkładanych w związku z badaniem klinicznym, wysokości opłat za złożenie wniosków oraz sprawozdania końcowego z wykonania badania klinicznego (Dz. U. 2010r. nr 222 poz. 1453, z późn. zm.); Ustawy z dnia 20 maja 2010 r. o wyrobach medycznych (Dz. U. 2010r. nr 107 poz. 679, z późn. zm.); Rozporządzenie Ministra Finansów z dnia 6 października 2010 r. w sprawie obowiązkowego ubezpieczenia odpowiedzialności cywilnej sponsora i badacza klinicznego w związku z prowadzeniem badania klinicznego wyrobów (Dz. U. 2010, Nr 194 poz. 1290); Ustawa z dnia 18 marca 2011 r. o Urzędzie Rejestracji Produktów Leczniczych, Wyrobów Medycznych i Produktów Biobójczych (Dz.U. 2011 nr 82 poz. 451); Rozporządzenie Ministra Zdrowia z dnia 2 maja 2012r. w sprawie Dobrej Praktyki Klinicznej (Dz. U. 2012, poz. 489); Rozporządzenie Ministra Zdrowia z dnia 2 maja 2012r. w sprawie wzorów dokumentów przedkładanych w związku z badaniem klinicznym produktu leczniczego oraz w sprawie wysokości i sposobu uiszczania opłat za złożenie wniosku o rozpoczęcie badania klinicznego (Dz. U. 2012, Nr 9 poz. 491); w oparciu o Deklarację Helsińską - Zasady Etycznego Postępowania w Eksperymencie Medycznym z Udziałem Ludzi oraz przepisy ICH GCP.

Komisja Bioetyczna, na posiedzeniu w dniu **06 lipca 2017 r.**

rozpatrzyła wniosek dotyczący prowadzenia badań naukowych.

Kierownik projektu: ***dr n. med. Aleksander Waśniowski***

Miejsce prowadzenia badań:
Katedra Profilaktyki Zdrowotnej Laboratorium Medycyny Ekstremalnej Uniwersytetu Medycznego w Poznaniu

Główny badacz: ***dr Agata Kołodziejczyk***

Członkowie zespołu badawczego:
dr n. med. Ewelina Wierzejska
dr n. med. Aleksander Waśniowski
dr Agata Kołodziejczyk
inż. Mateusz Harasymczuk
Lucie Davidova

Temat badań:
„Ocena indywidualnej percepcji czasu oraz wpływu modyfikacji biologicznych cykli okołodobowych, w warunkach symulacji długotrwałych lotów w przestrzeni kosmicznej”.

Komisja wydała uchwałę o pozytywnym zaopiniowaniu tego wniosku

Przewodniczący Komisji

prof. zw. dr hab. med. Paweł Chęciński

COMPLETED MISSIONS AT LUNARES


INNOVATIVE CONCEPTS ARES
ICAres-1
ICAres-1
October 8-22.2017
@lunares.space

ICAres-1: the first mission addressing disability in space

Aleksander Waśniowski, Laboratory of Extreme Medicine, Poznan University of Medical Sciences
Malgorzata Perycz.,Open Science Foundation

http://lunares.space/pl/icares-1/

© Anna B Gregorczyk

ICAres-1 materials

Rationale:
- People get disabled in space
- Disability on Earth: advantage in space?

Addressing disability
- No eyes, no hands: testing the hab for and by a person with disabilities
- PUMA-1 suit development
- Use of an off-road wheelchair as a roving vehicle for EVA
- Bionic hand 3D printing
- Targeted physical therapy and sports protocols

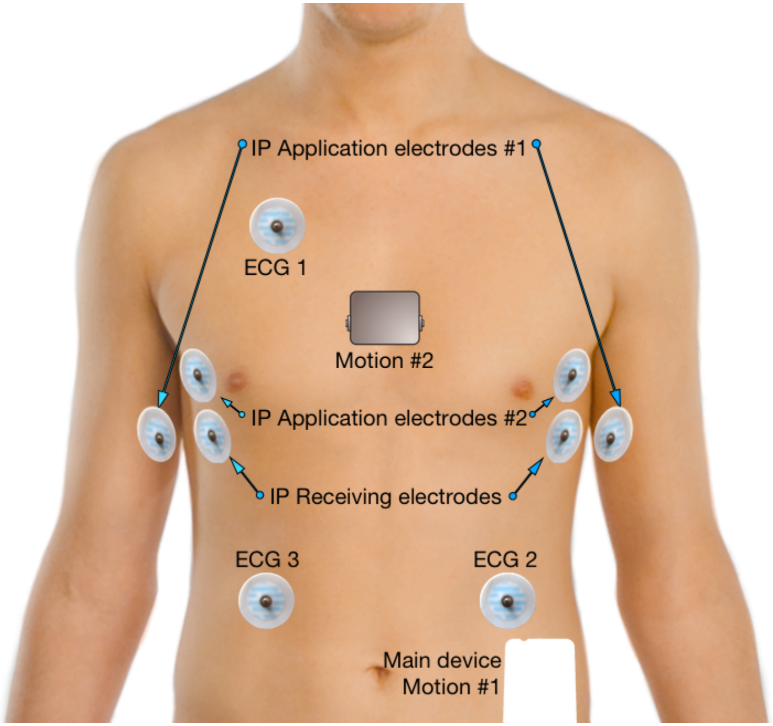
Towards self-sustenance
- How to survive without a drugstore: cultures of leeches and maggots in microgravity simulated conditions
- Terraforming: testing earthworms growth in chondrite
- Plant hydroponics

Living in the hab: continuation of the ongoing projects
- Sociodynamics: SocSenSys
- Time perception

SPACE GARDEN – PLANT IDEAS, GROW TECHNOLOGIES – BIO GEN BLUMIL ARPOL vBionic

Device - Pneumonitor

Pneumonitor uses impedance pneumography technique to estimate breathing activity without a need to use a face mask or mouth piece with nose clip, along with single lead ECG and 3-axis accelerometer. Sample electrode and sensor configurations are shown below.



Materials and Methods

The experiment was performed on a group of 6 analog astronauts over 2 weeks.

4 states were considered:

- at rest,
- doing squats,
- holding breath and
- EVA.

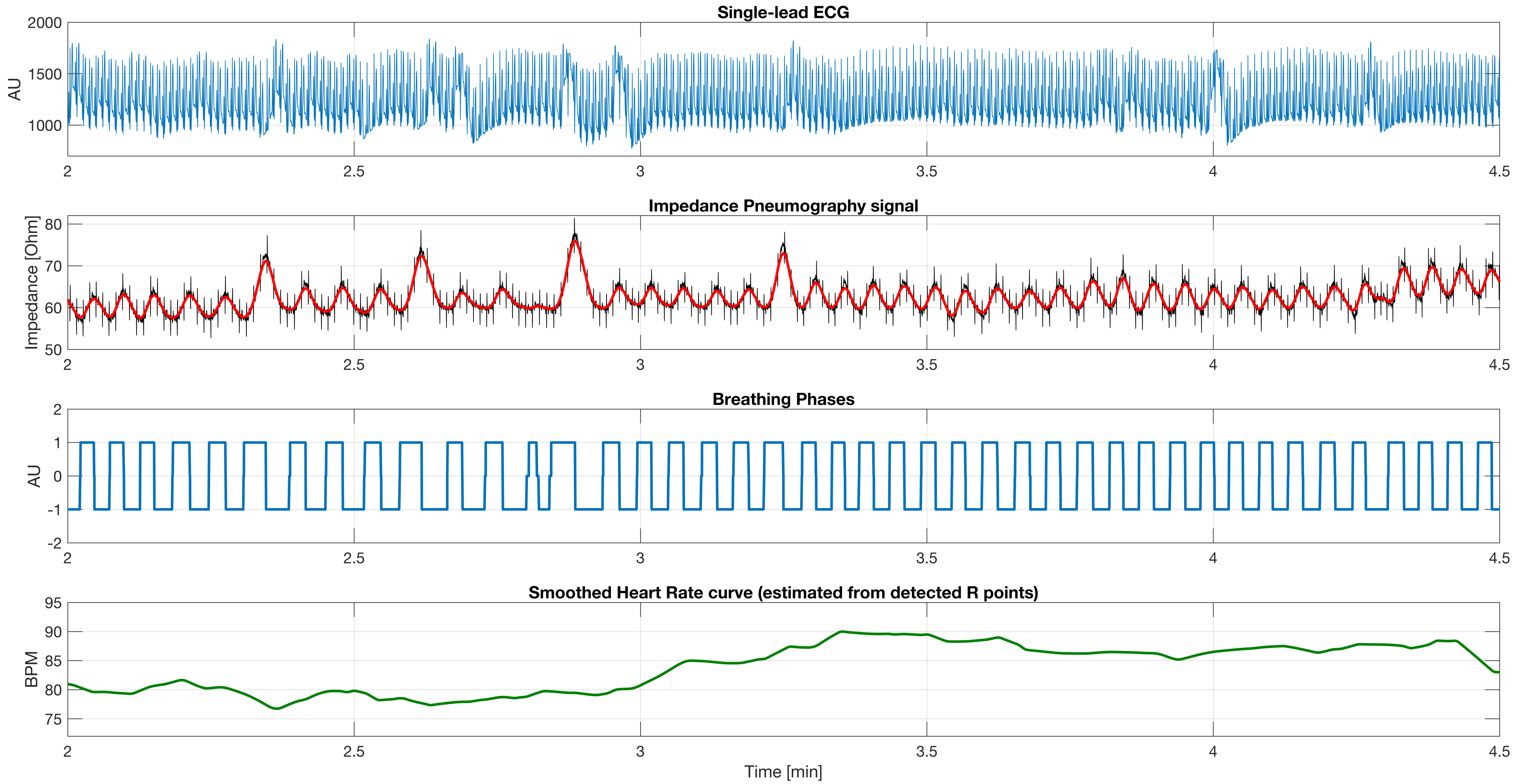
All signals were preprocessed and annotated. The set of cardiorespiratory parameters for the time, frequency and information domains was calculated, e.g.:

- absolute spectral content in the high-frequency band (HF, 0.15 - 0.4 Hz), extracted from the respiration signal

Due to problems with detachment of electrodes, 10 full registrations (out of 15 attempts) were ultimately collected from 5 astronauts (4 males), ages 24-33.

Results (1)

Sample signals for third participant, acquired during staying at rest



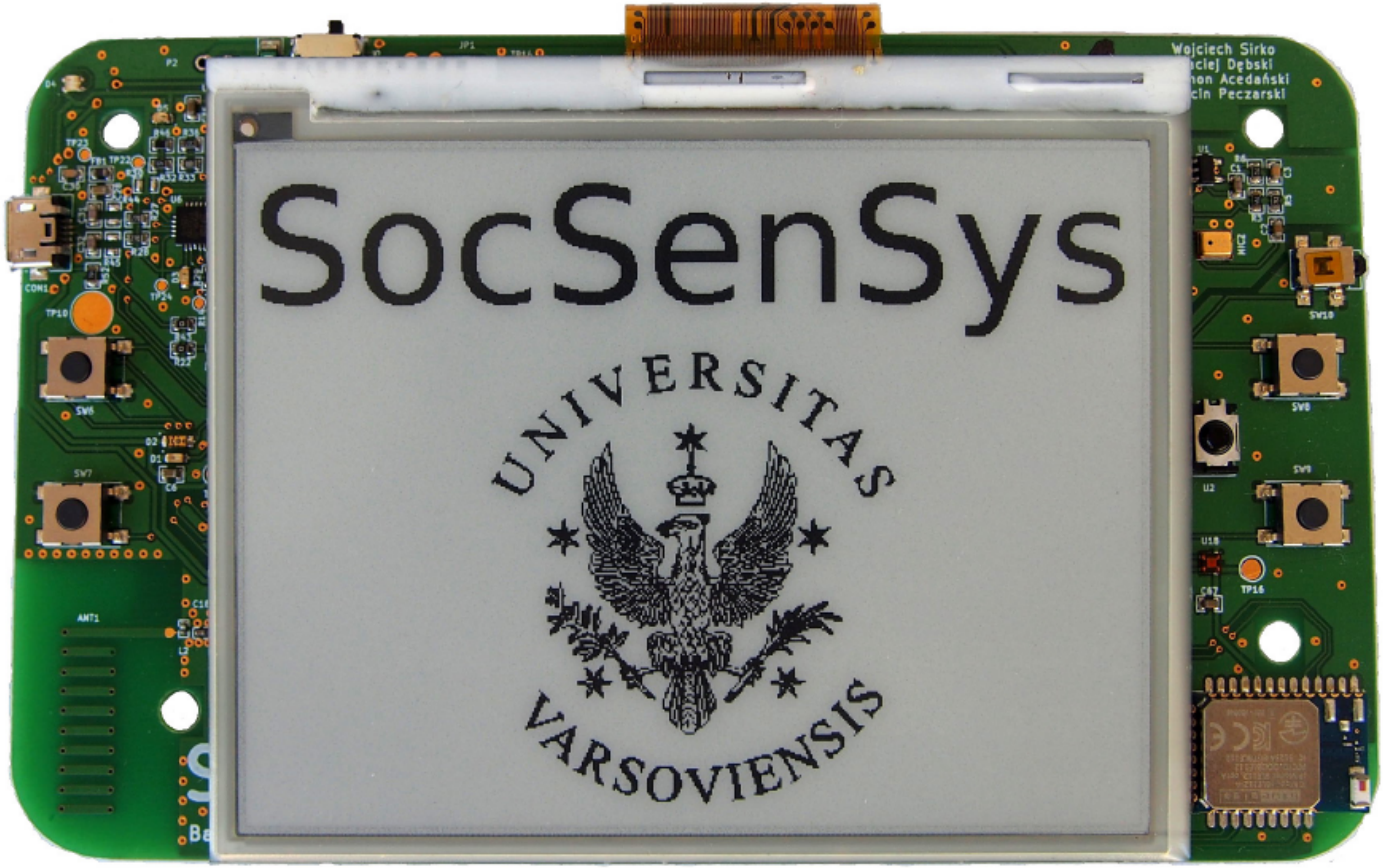
Main conclusions

- Impedance pneumography seems to be the right method to establish an astronaut’s cardiorespiratory profile and adaptation during a mission.

- However, one mayor limitations appeared to be the need to develop a wearable electronic textile solution for the target electrodes, which will enable to decrease the level of detached electrodes and the comfort of the measurements.

Marcel Młyńczak, Msc
Warsaw University of Technology
Faculty of Mechatronics
Institute of Metrology and Biomedical Engineering

Cooperation with University of Warsaw

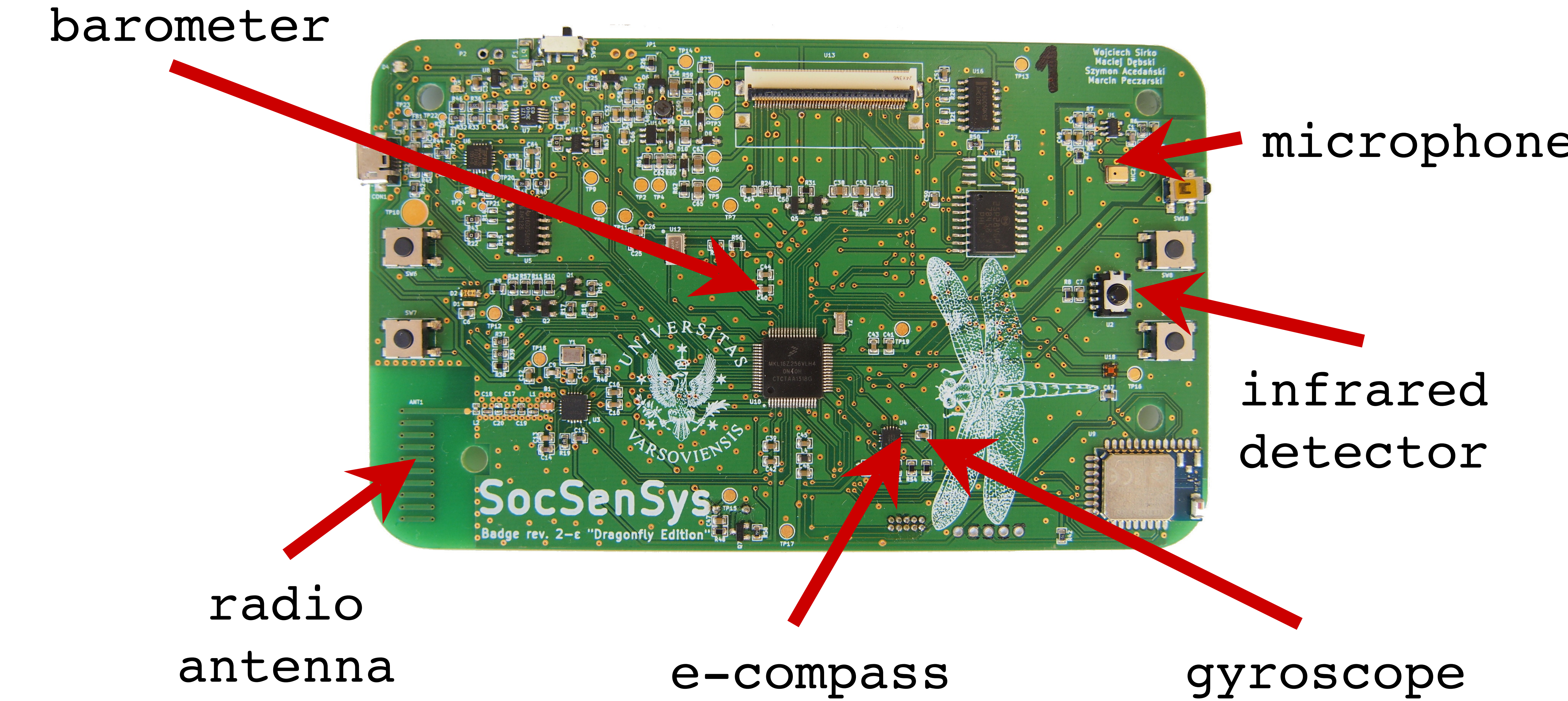


Konrad Iwanicki
iwanicki@mimuw.edu.pl

Maciej Matraszek
m.matraszek@mimuw.edu.pl

Inga Rüb
i.rub@mimuw.edu.pl

A SocSenSys badge: sensors



The experiment

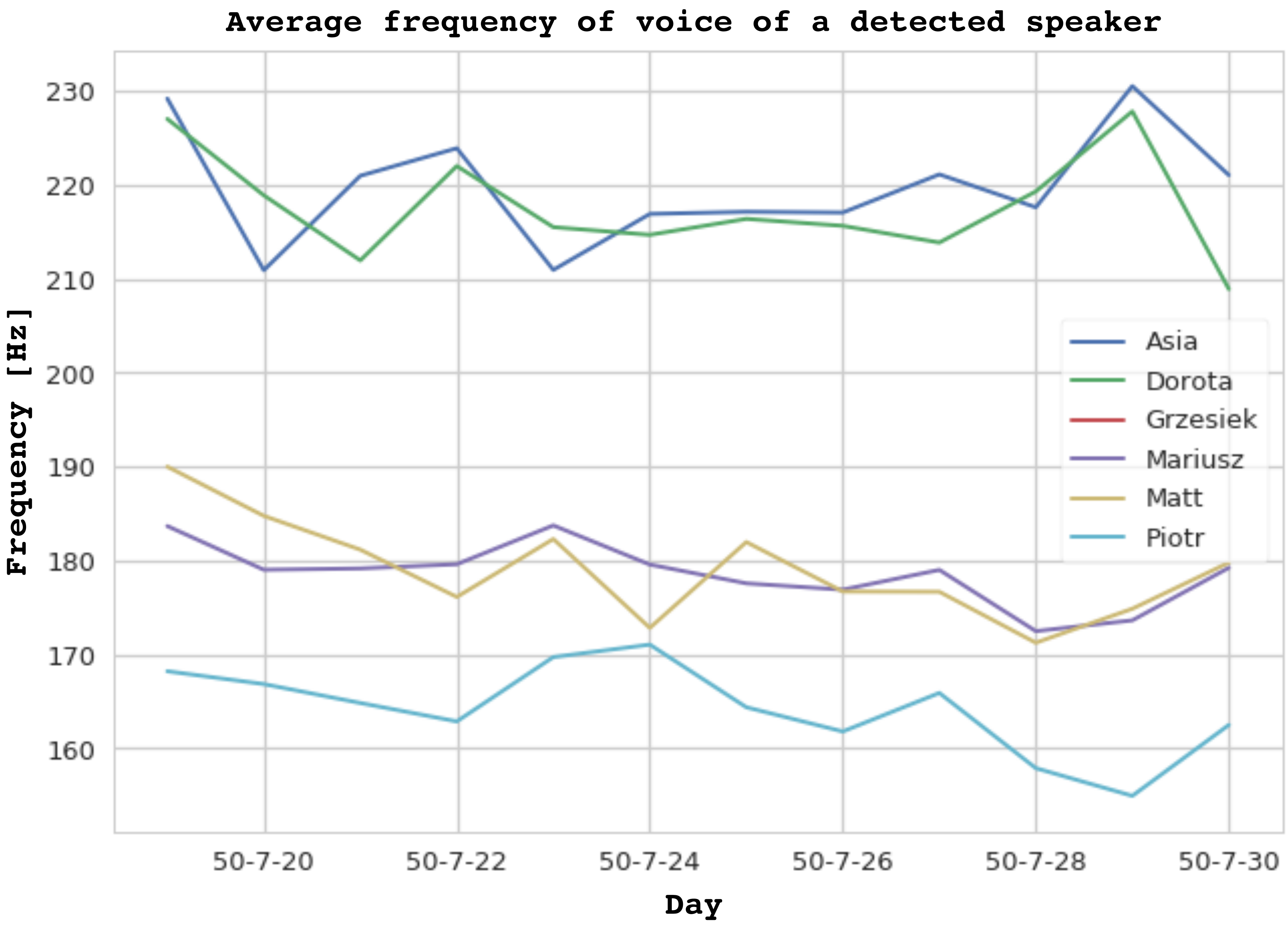
6 participants monitored for **10** days.

sensors

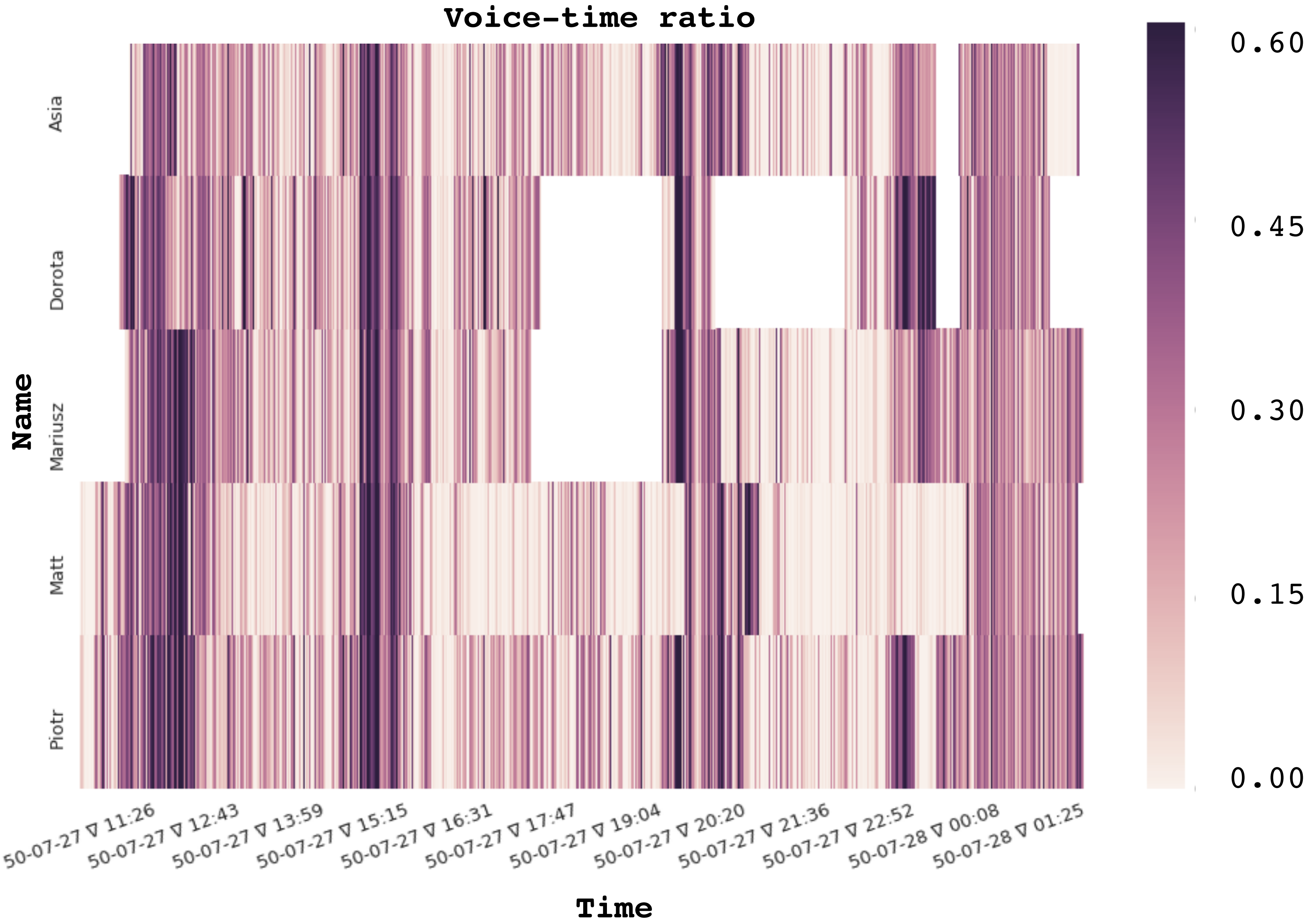
daily surveys

- dynamics of social interactions
- symptoms of stress
- usability of the habitat

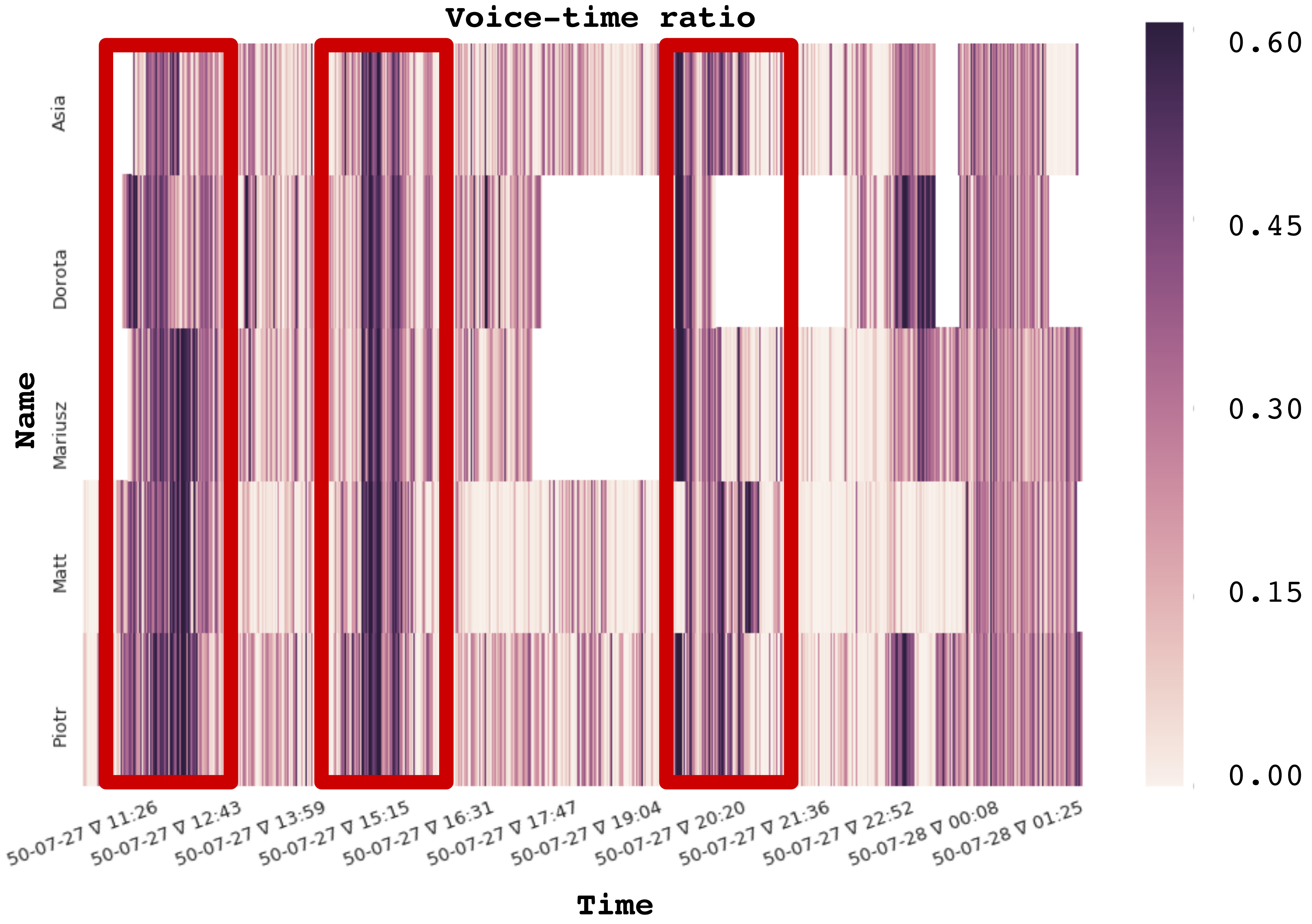
Example: voice frequency



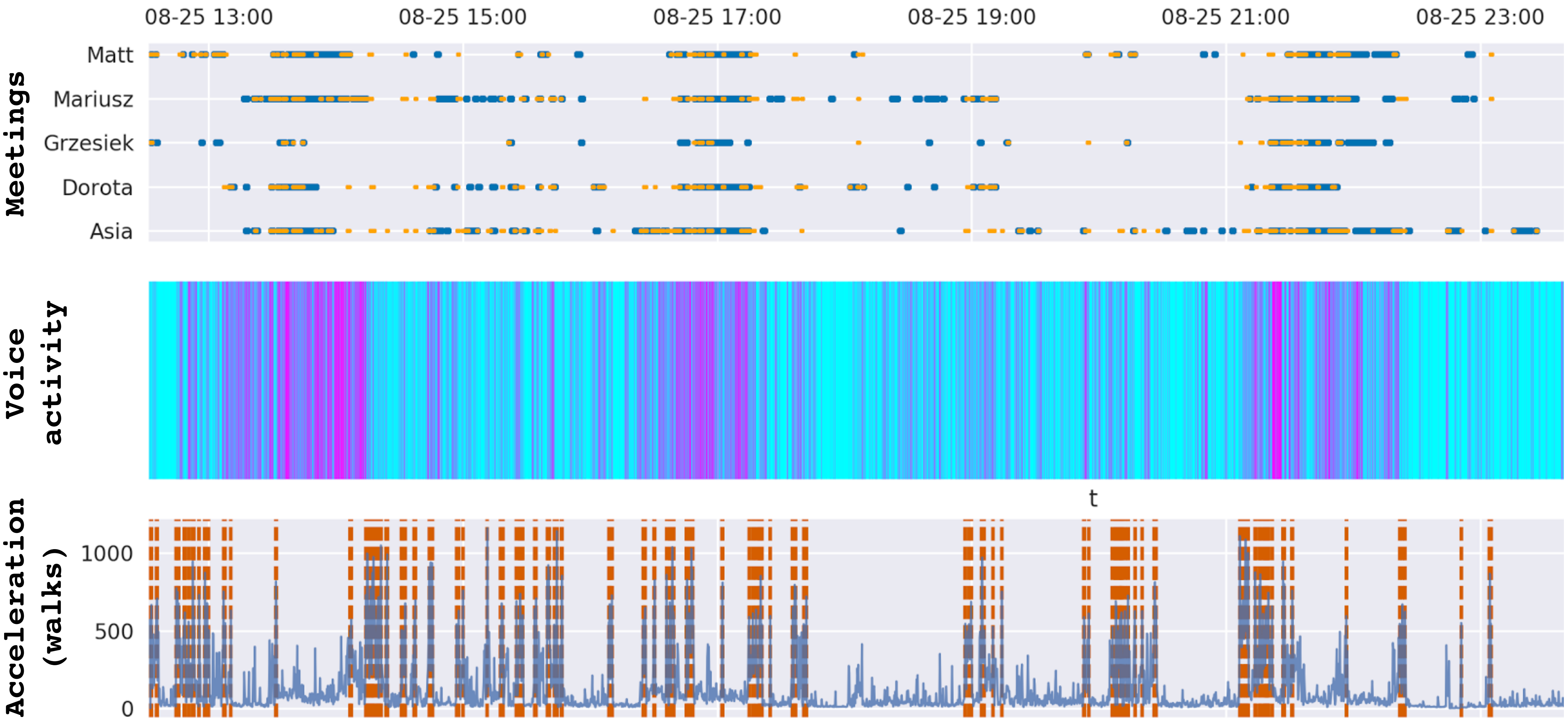
Example: detected meetings



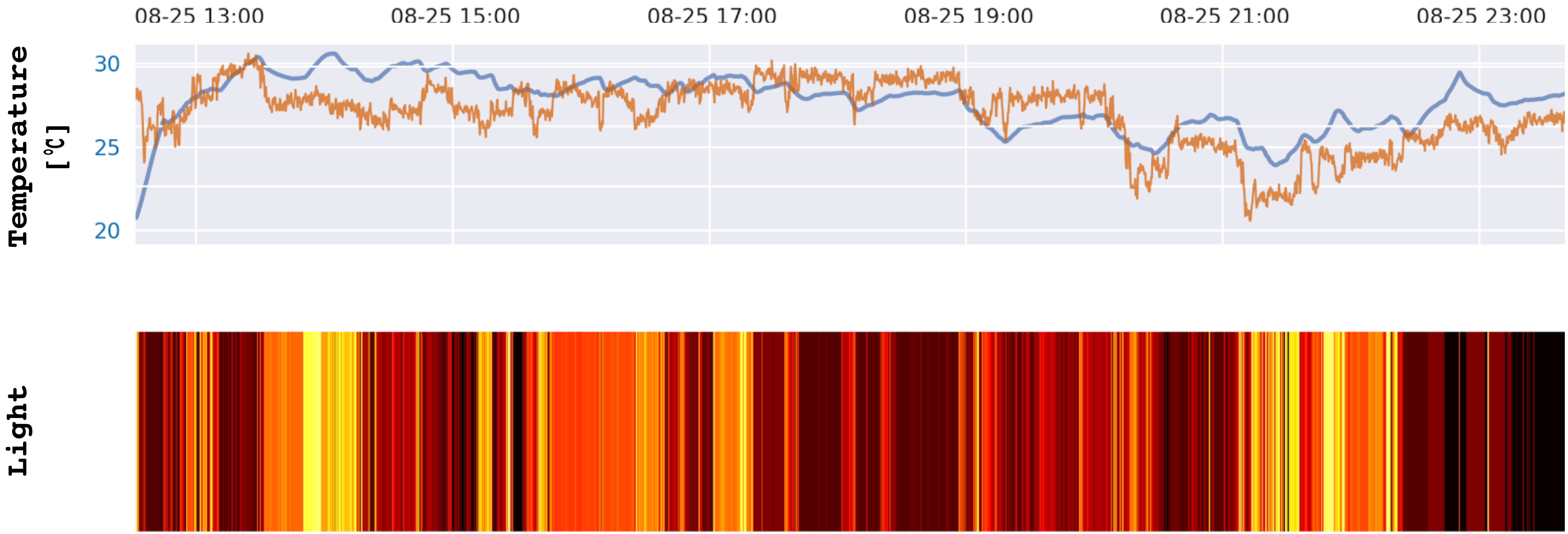
Example: detected meetings



Example: a recorded timeline



Example: a recorded timeline



SocSenSys

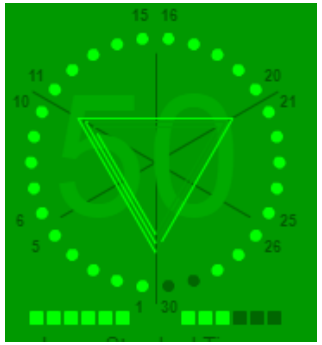
Supported by the (Polish) National Science Centre (NCN) within the SONATA programme under grant no. DEC-2012/05/D/ST6/03582.

NATIONAL SCIENCE CENTRE
POLAND

For further information see:

https://www.mimuw.edu.pl/~iwanicki/projects/SocSenSys/

TIME ILLUSIONS



8h shift

8h shift

3 days 24h	4 days 26h	4 days 22h	3 days 24h

Phase I

Phase II

Phase III

Phase IV

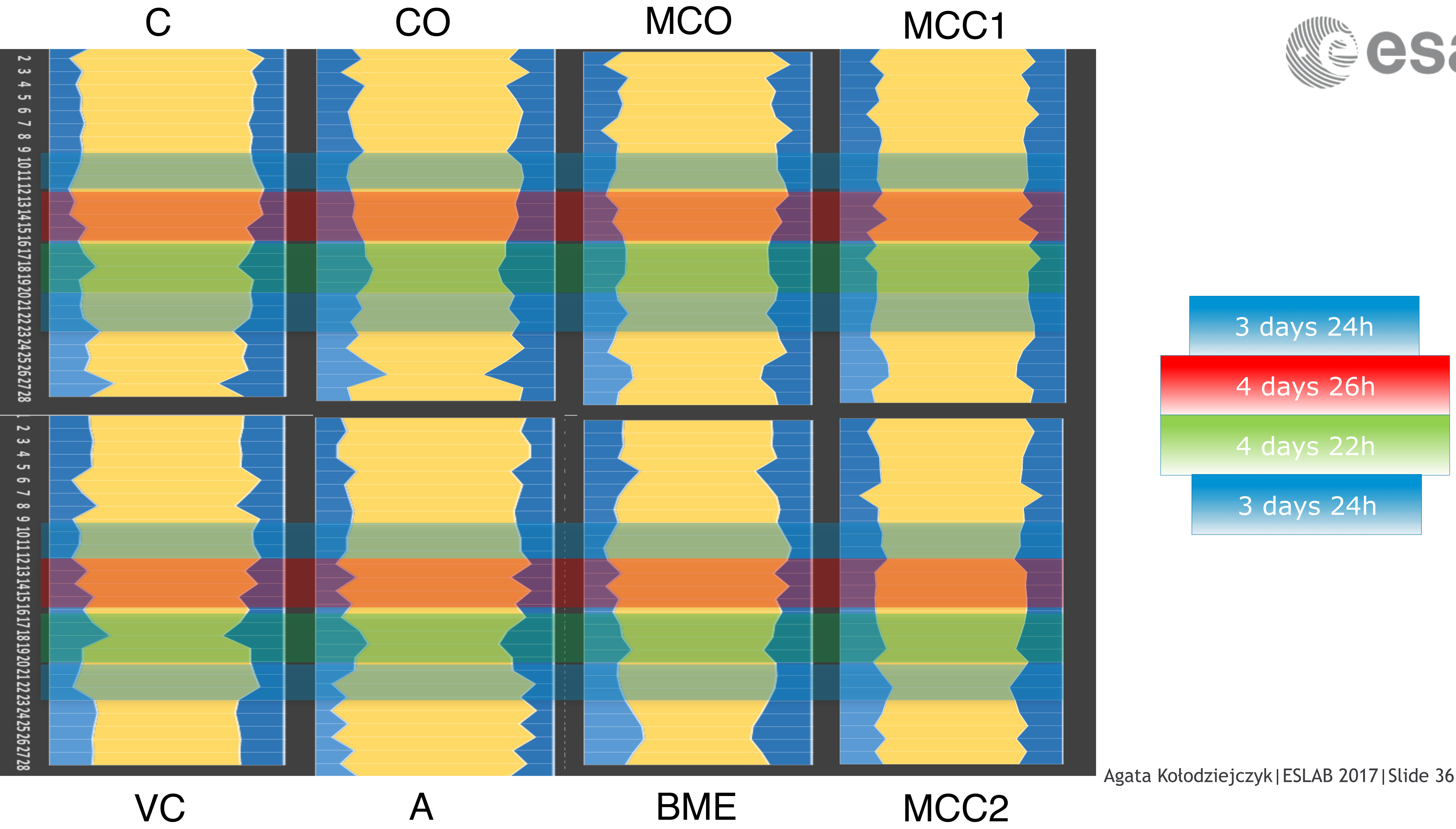
LUNAR EXPEDITION 1

Lunar Standard Time (LST)
50-07-24 ∇ 19:16:51
http://www.LunarClock.org

ASTRONAUT SCHEDULE - LEX1

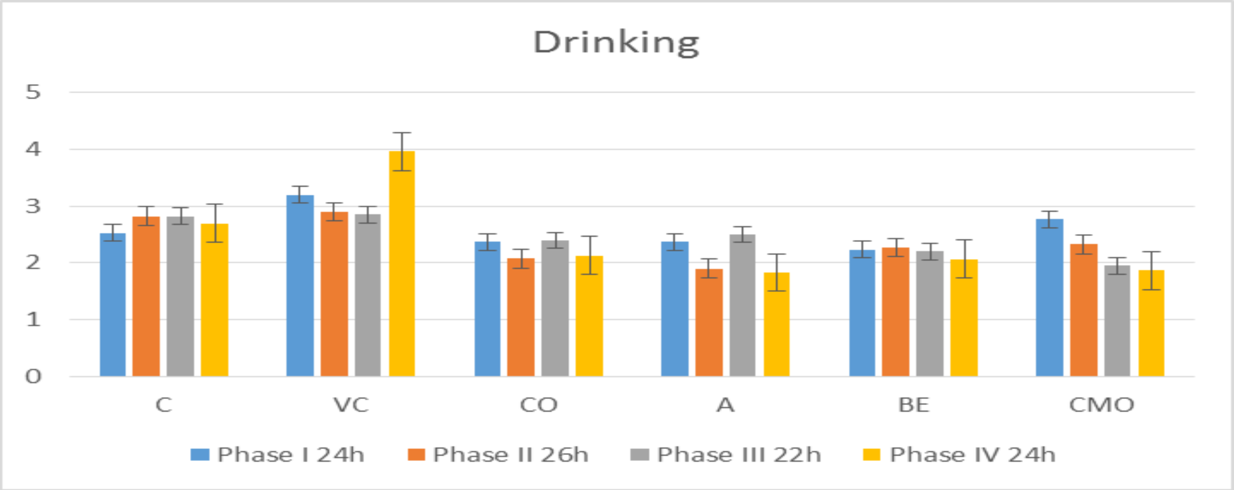
LUNARES	Piotr Konorski **Commander**	Mariusz Słonina **V-ce Commander**	Matt Harasymczuk **Crew Medical Officer**	Asia Kuźma **Astrobiologist**	Dorota Budzyń **Communication officer**	Grzegorz Ambroszkiewicz **Biomedical Engineer**	Twardowsky **Witcher**
	Biometry	Biometry	Biometry	Biometry	Biometry	Biometry	Meditation
	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
	Crew Briefing	Crew Briefing	Crew Briefing	Crew Briefing	Crew Briefing	Crew Briefing	Crew Briefing
50-07-24 ∇ 16:43:04	Switch on physiological lighting in the habitat	Preparation for EVA, put on suit and medical checkup	SPORT = 1h	Preparation for EVA, put on suit and medical checkup	Briefing with Capcom	4.2.10.1	Takes care of Myntha spirit in biosphere bottles
	SPORT = 1h	EVA: Type : Operational[O]: Search for a mine and transport it using a rover, map a communication range of EVA terrain in scale 1-5	Procedure 4.8.11	EVA: Type : Operational[O]: Search for a mine and transport it using a rover, map a communication range of EVA terrain in scale 1-5	Controls EVA from the base	4.2.7.1	
	Elaborate video for Embry-Riddle					SPORT = 1h	
	4.2.7.1					4.6.2.1	Makes Astronaut Positive Energy
		Take out suit and post-EVA medical checkup	4.2.7.1	Take out suit and post-EVA medical checkup	SPORT = 1h		
	Lunch !	Lunch !	Lunch !	Lunch !	Lunch !	Lunch !	Lunch !
	Prepare video for Embry-Riddle	Prepare video for Embry-Riddle	Prepare video for Embry-Riddle	Prepare video for Embry-Riddle	Prepare video for Embry-Riddle	Prepare video for Embry-Riddle	Takes care of Myntha spirit in biosphere bottles
	Preparation for EVA, put on suit and medical checkup	4.2.3.2: Photograph samples	Controls EVA from the base	4.2.8.1	4.2.4.2	Preparation for EVA, put on suit and medical checkup	
	EVA: Type : Operational[O]: 4.5.3. preparing the lunar terrain for the Lunarthlon			SPORT = 1h	4.2.7.1	EVA: Type : Operational[O]: 4.5.3. preparing the lunar terrain for the Lunarthlon	
50-07-25 ∇ 01:31:20		Daily Diary			Debriefing with Capcom		
	Take out suit and post-EVA medical checkup	SPORT = 1h		4.2.1.3	Switch off physiological lighting in the habitat	Take out suit and post-EVA medical checkup	
	Procedure 4.1.3	Procedure 4.1.3	Procedure 4.1.3	Procedure 4.1.3	Procedure 4.1.3	Procedure 4.1.3	
	YOGA	YOGA	YOGA	YOGA	YOGA	YOGA	
	Dinner Preparation	Dinner Preparation	Dinner Preparation	Dinner Preparation	Dinner Preparation	Dinner Preparation	
	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner
	Report	Report	Report	Report	Report	Report	Protecting the base from bad energy
	Goodnight!	Goodnight!	Goodnight!	Goodnight!	Goodnight!	Goodnight!	

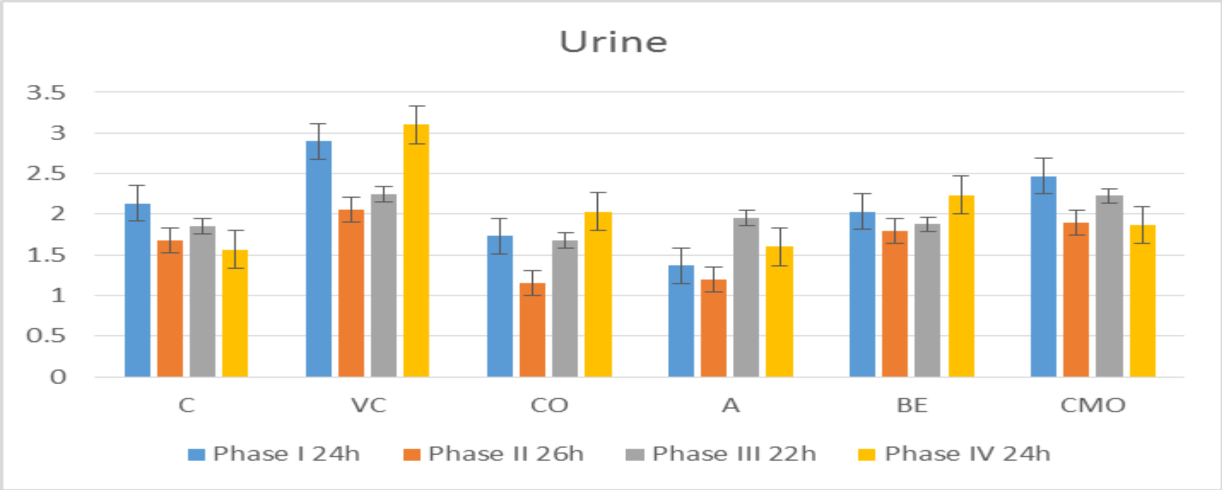
Day7 Arkusz8 Legend Day1 Day2 Day3 Day4 Day5 Day6

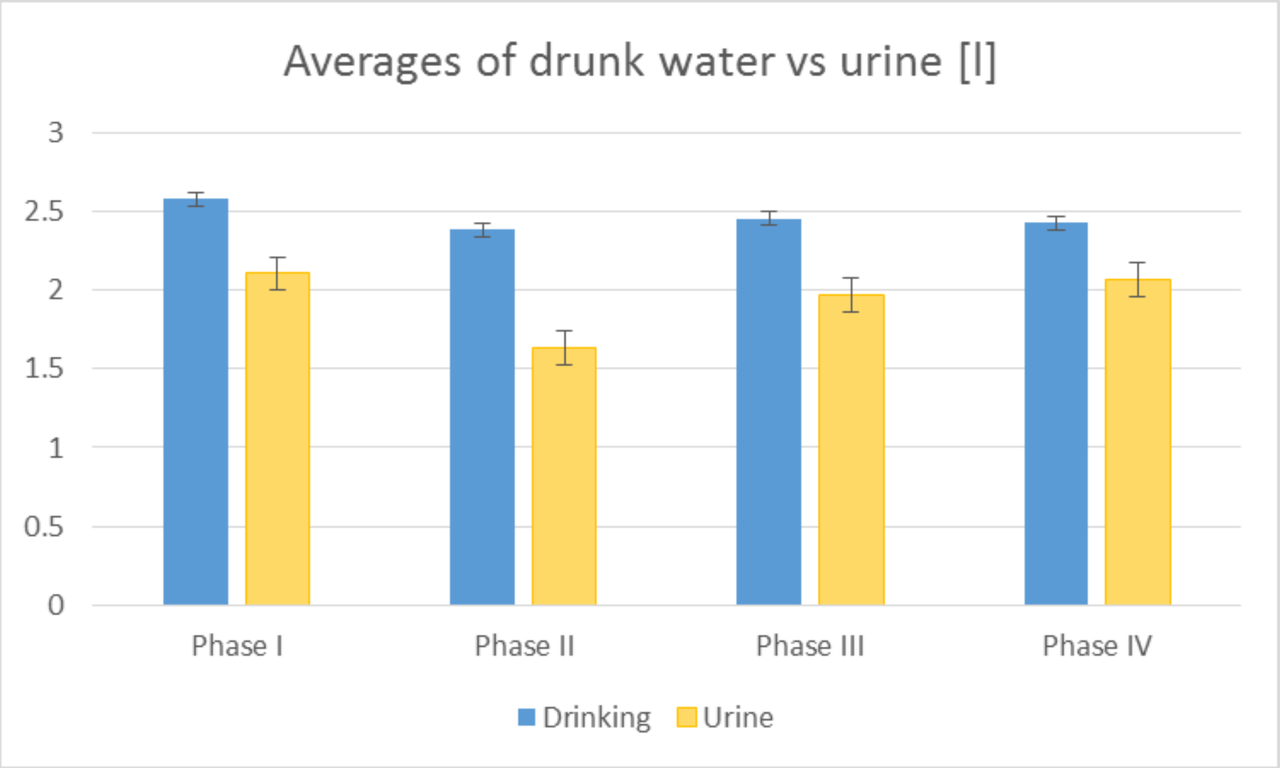

C
CO
MCO
MCC1
VC
A
BME
MCC2
3 days 24h
4 days 26h
4 days 22h
3 days 24h

WATER

		C			VC			CO			A			BE			CMO			Everyone	
Missioan Day	Lunar Day	Drinking [l]	Urine [l]	Shower [min]	Drinking [l]	Urine [l]	Shower [min]	Drinking [l]	Urine [l]	Shower [min]	Drinking [l]	Urine [l]	Shower [min]	Drinking [l]	Urine [l]	Shower [min]	Drinking [l]	Urine [l]	Shower [min]	Technical Water	Biolab Water
1	50-07-18	2,2	2,3	Nd	2,7	2,4	Nd	2,3	2,3	Nd	2,5	1,7	Nd	2,3	2,0	Nd	1,5	3,2	Nd	0,8	-
2	50-07-19	2,9	1,8	Nd	3,3	3,7	Nd	2,3	0,8	Nd	2,5	0,9	Nd	2,3	1,7	Nd	3,3	2,2	Nd	3,4	-
3	50-07-20	2,5	2,3	Nd	3,6	2,6	Nd	2,5	2,1	Nd	2,1	1,5	Nd	2,1	2,4	Nd	3,5	2,0	Nd	1,7	-
4	50-07-21	2,9	1,1	Nd	2,9	2,3	Nd	1,7	1,0	Nd	2,0	0,9	Nd	2,5	2,5	Nd	2,9	3,3	Nd	84,2	-
5	50-07-22	2,8	1,6	Nd	2,3	0,8	Nd	2,5	1,6	Nd	1,6	0,7	Nd	2,5	1,3	Nd	3,9	0,8	Nd	4,6	-
6	50-07-23	2,9	2,3	0,5	2,7	2,3	1,0	2,1	1,0	2,0	2,0	2,2	2,5	2,3	1,3	1,5	1,5	1,8	1,8	1,1	1,5
7	50-07-24	2,7	1,7	3,5	3,7	2,8	1,0	2,0	1,0	-	2,0	1,0	-	1,8	2,1	-	1,0	1,7	1,0	13,6	1,5
8	50-07-25	2,8	1,6	1,0	3,7	2,4	-	2,7	1,9	2,5	2,4	1,1	-	2,4	2,4	1,2	1,5	1,4	-	7,0	-
9	50-07-26	2,8	2,6	1,5	3,2	3,4	1,0	2,1	2,0	2,5	2,5	1,9	2,5	1,7	1,2	-	2,2	1,3	-	-	-
10	50-07-27	2,9	1,1	2,0	2,3	1,7	1,5	2,3	1,1	-	2,5	2,3	-	2,3	2,4	1,5	2,1	3,3	-	-	1,5
11	50-07-28	2,8	2,1	1,5	2,2	1,5	-	2,5	1,7	2,5	2,6	2,5	1,3	2,4	1,5	1,2	2,0	2,9	1,5	-	-
12	50-07-29	2,6	2,0	1,0	3,2	2,9	1,2	1,9	2,1	2,5	2,0	1,7		2,1	2,8	1,2	2,5	2,5	-	-	0,5
13	50-07-30	2,9	1,2	1,5	4,5	5,0	1,85	2,3	2,5	-	1,5	2,5		2,0	2,8	1,0	2,1	2,3	2,8	9,0	-
14	50-08-01	2,6	1,5	1,8	4,2	1,4		2,2	1,5	2,8	2,0	0,6	2,0	2,1	1,1	1,5	1,0	0,8	-	-	-
	Total:	38,1	25,2	14,3	44,5	35,0	7,6	31,3	22,5	14,8	30,2	21,6	8,3	30,8	27,3	9,1	31,0	29,3	7,1	125,2	5,0
	Average:	2,7	1,8	1,6	3,2	2,5	1,3	2,2	1,6	2,5	2,2	1,5	2,1	2,2	2,0	1,3	2,2	2,1	1,8	13,9	1,3
	Min:	2,2	1,1	0,5	2,2	0,8	1,0	1,7	0,8	2,0	1,5	0,6	1,3	1,7	1,1	1,0	1,0	0,8	1,0	0,8	0,5
	Max:	2,9	2,6	3,5	4,5	5,0	1,9	2,7	2,5	2,8	2,6	2,5	2,5	2,5	2,8	1,5	3,9	3,3	2,8	84,2	1,5





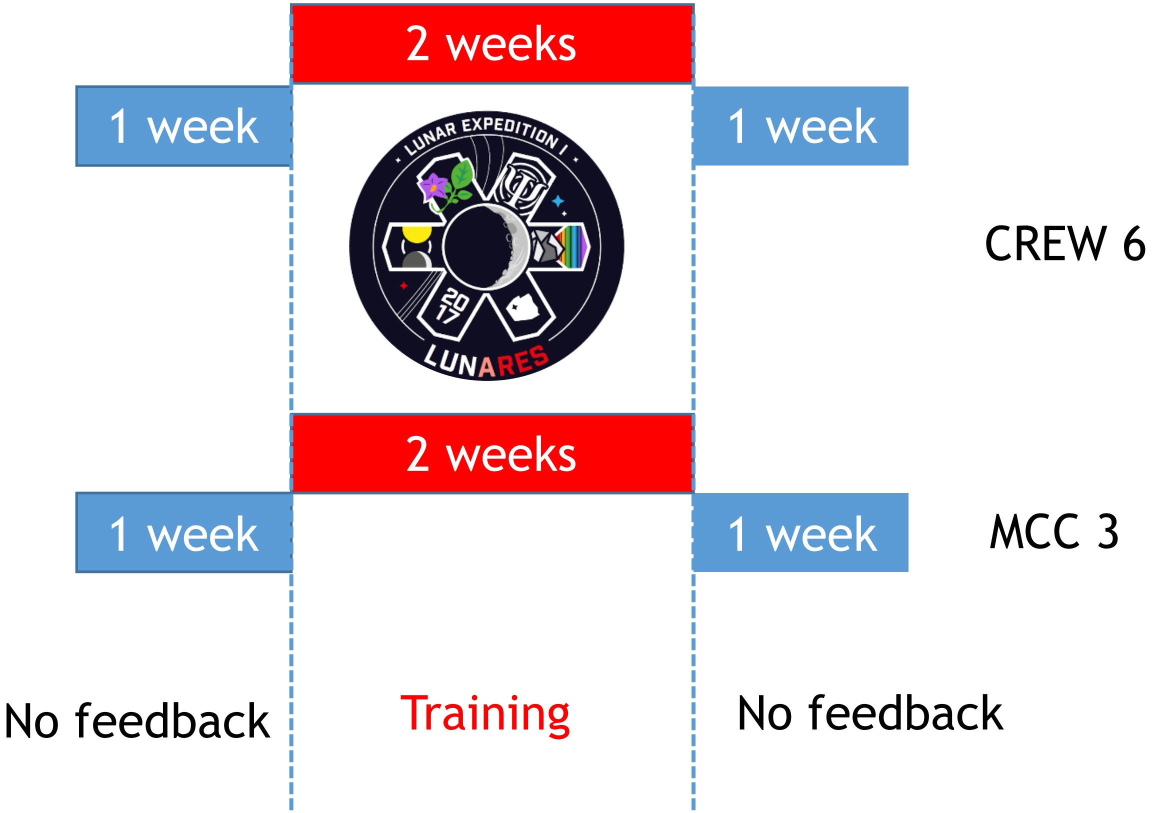


1. Astronauts seem to release less water during jetlag phases

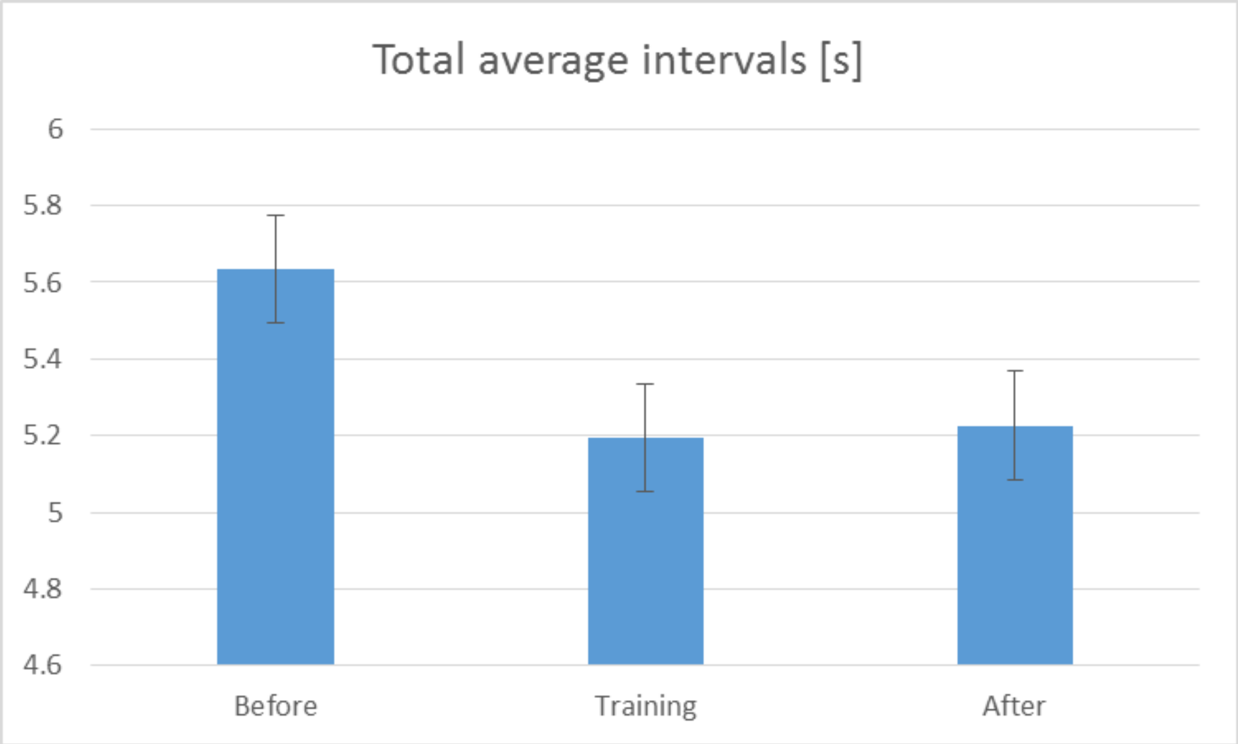
COMBINED EXPERIMENTS

- 1. Monitoring of sleep and activity cycles, body temp, HR, body weight
- 2. Subjective time perception training

Parameter	All	Red	White	Blue
Count	28	10	9	9
Tempo	77.78	83.33	75	75
Regularity	0.5735	0.2835	0.4893	0.4147
Interval	6.1807	5.624	6.5231	6.4645
Time Between Clicks		1. 5.797	1. 6.257	1. 7.109
		2. 5.929	2. 6.003	2. 6.147
		3. 5.839	3. 5.973	3. 6.45
		4. 5.683	4. 6.476	4. 5.979
		5. 5.867	5. 6.494	5. 6.047
		6. 5.605	6. 7.383	6. 6.465
		7. 5.05	7. 7.061	7. 6.987
		8. 5.44	8. 6.538	8. 6.532
		9. 5.406		

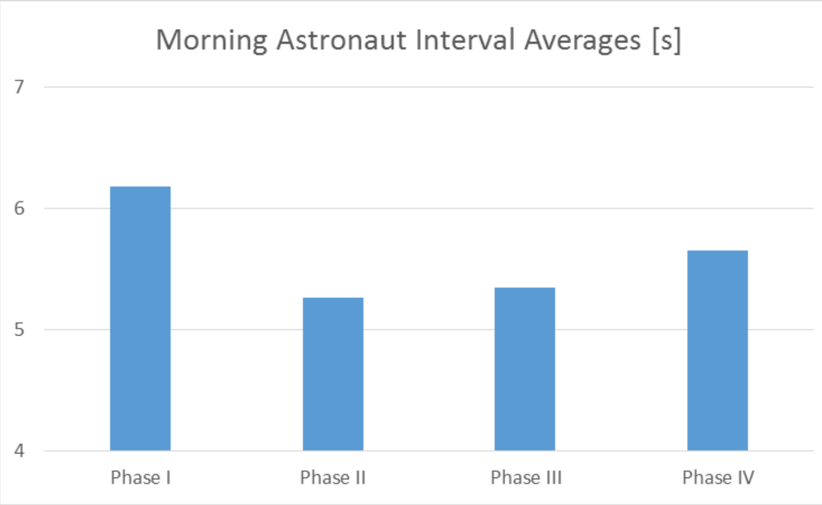


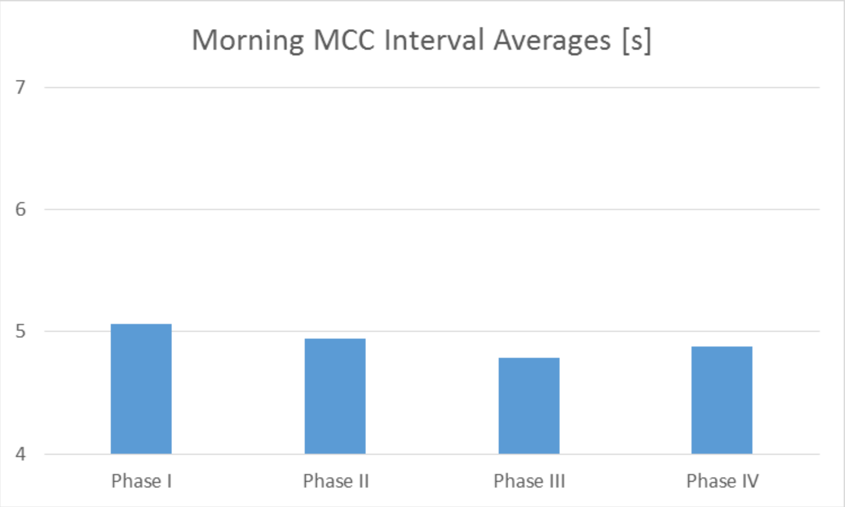
EFFECT OF TRAINING

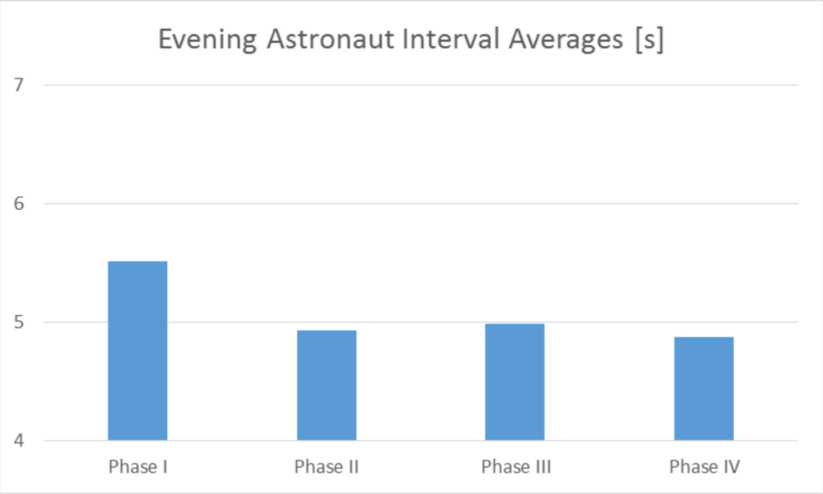


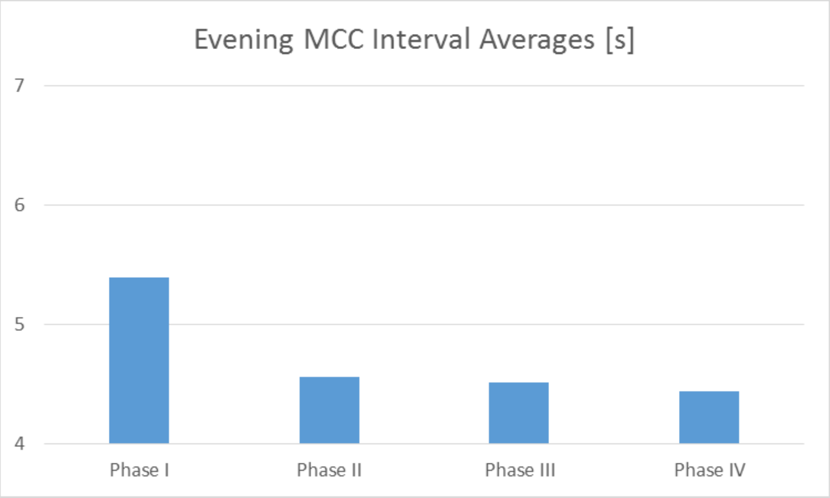
1. Two weeks of training influenced subjective time perception.
2. Induced time perception is connected with memory and learning processing in the brain

MORNING VS EVENING TRAINING









1. Acceleration is natural for subjective time perception
2. Astronauts had tendency to extend 5s intervals, especially in the morning

CONCLUSION

Performing same experiments in consecutive missions allows:

- To achieve comparing results, increasing the statistical power,
- To obtain optimal manuals and procedures,
- To gain lesson learned for future crewed deep space missions.

Organized simulations in Lunares base deliver information to create an open source platform for analog missions, which main aim will be to increase the efficiency of analog human experiments for scientific, educational and other space sector communities.

But it is not the end … more missions are planned….

Any ape can reach for a banana,
but only humans can reach for the stars. V.S. Ramachandran

THANK YOU :)

https://www.youtube.com/watch?v=NA1oURgOon0&feature=youtu.be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