HyperGES : The ESA Large Diameter Centrifuge (LDC)

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Committee on the Peaceful Uses of Outer Space (COPUOS) Side Event: Access to Space for All "Path for space technology capacity building.
Wednesday 31 May 2023 13:45-13:55 CEST (On Line)

Background & Motivation

- **HyperGES = Hypergravity Experiment Series**
- The motivation is to make hypergravity environment accessible to countries which do not possess the access to such facilities
- Agreement to collaborate established with a MoU signed 10/2018
- First selection in **2019**
- Second AO in **2022**
- Finally three teams form AO 2019 and AO 2022 were selected and await implementation in September - December 2023

- **Opportunity for (young) professionals to:**
  - build up experience in space / science field
  - experience an international research setting / collaboration
  - exposed to space – related project management / requirements
  - …….

UNITED NATIONS
Office for Outer Space Affairs

ACCESS·TO·SPACE·4·ALL
HyperGES

esa
European Space Agency

1st Round Awardee: Mahidol University, Thailand: Team leader: Dr Tatpong Tulyananda.

Study the effect of hypergravity on watermeal, the smallest and fastest-growing flowering plant on Earth.

Mahidol University

2nd Round Awardee: Universidad Católica Boliviana "San Pablo“: Team leader Dr. Georgina Aurelia Chávez Lizárraga

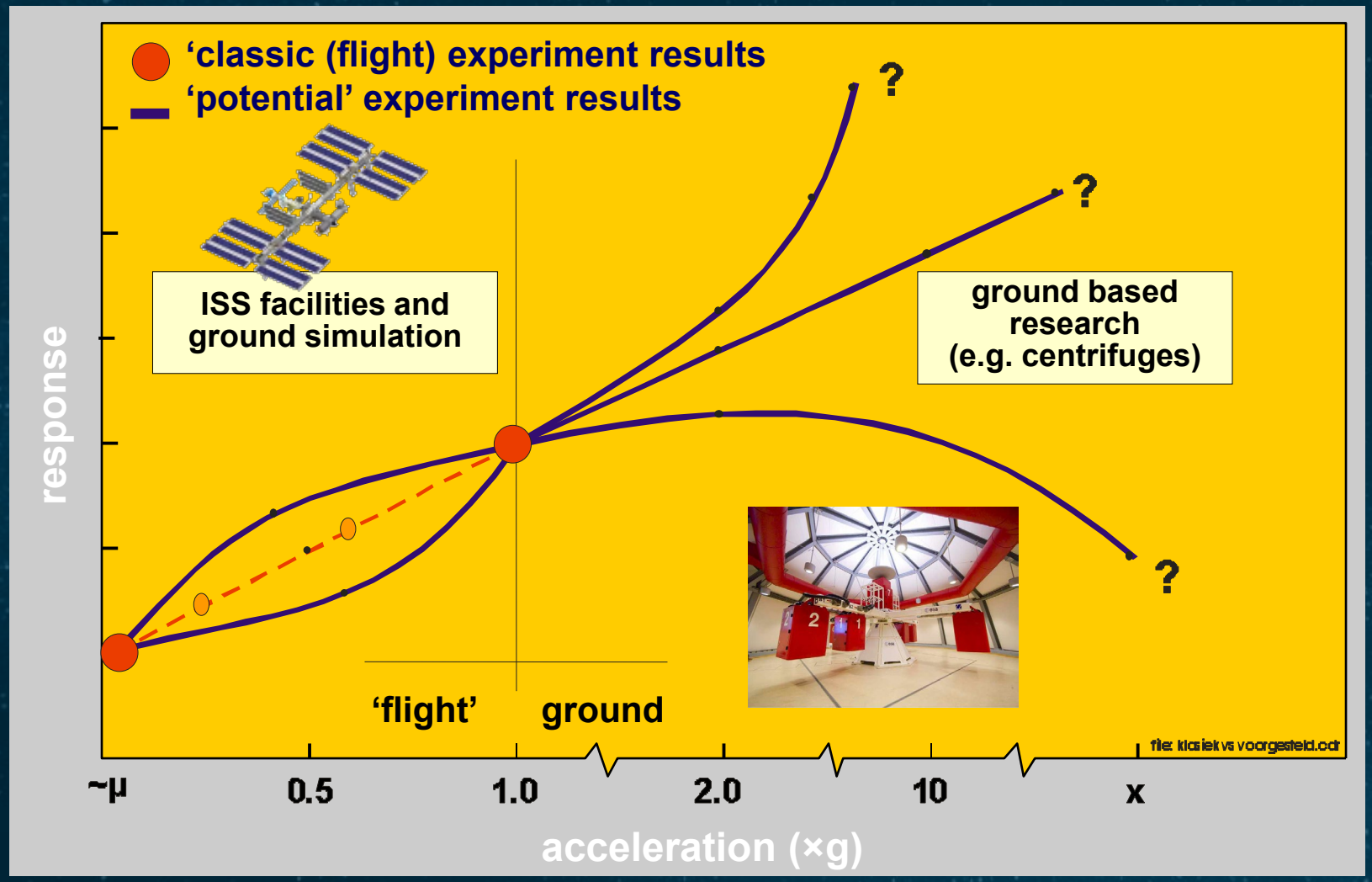
Study, in real time, the effect of hypergravity on erythrocyte membrane and its index of osmotic fragility in order to have a possible explanation of space anemia.

2nd Round Awardee: Macau University of Science and Technology: Team leader: Marta Filipa Simões

Expose several fungi species to hypergravity and study their morphology, genetic stability and metabolism but also the fungal dimorphism and possible relation towards pathogenic transitions during several generations.

ESA-Technology Center ESTEC, Noordwijk, NL

Spaceflight vs. Ground-Based Research

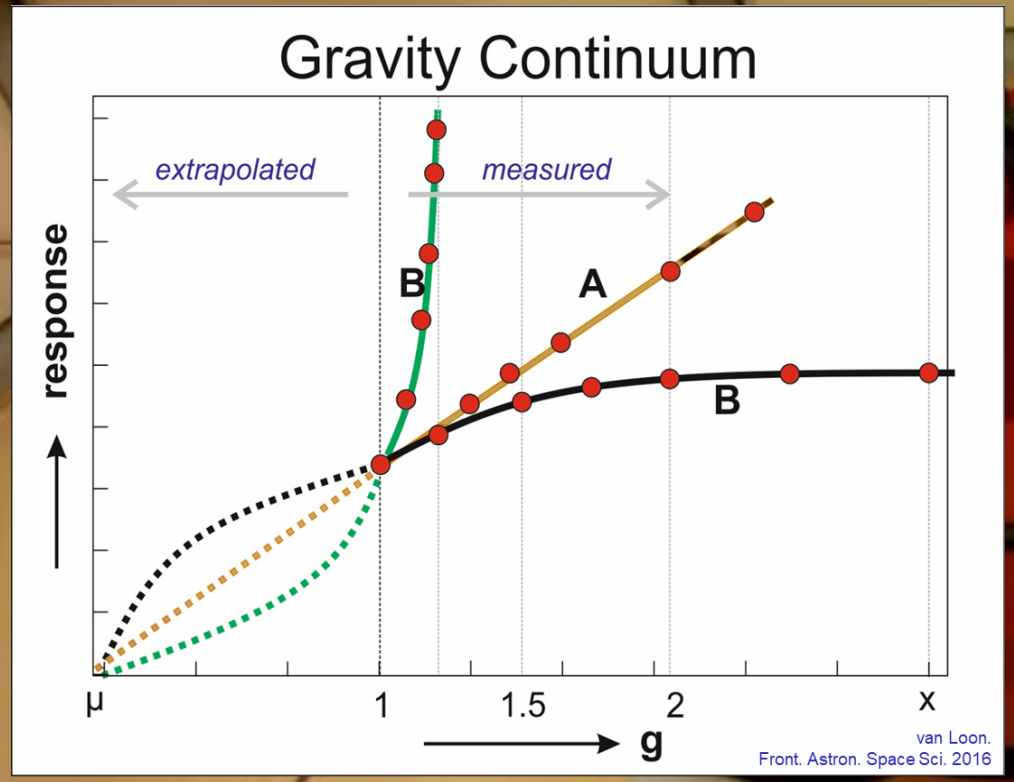


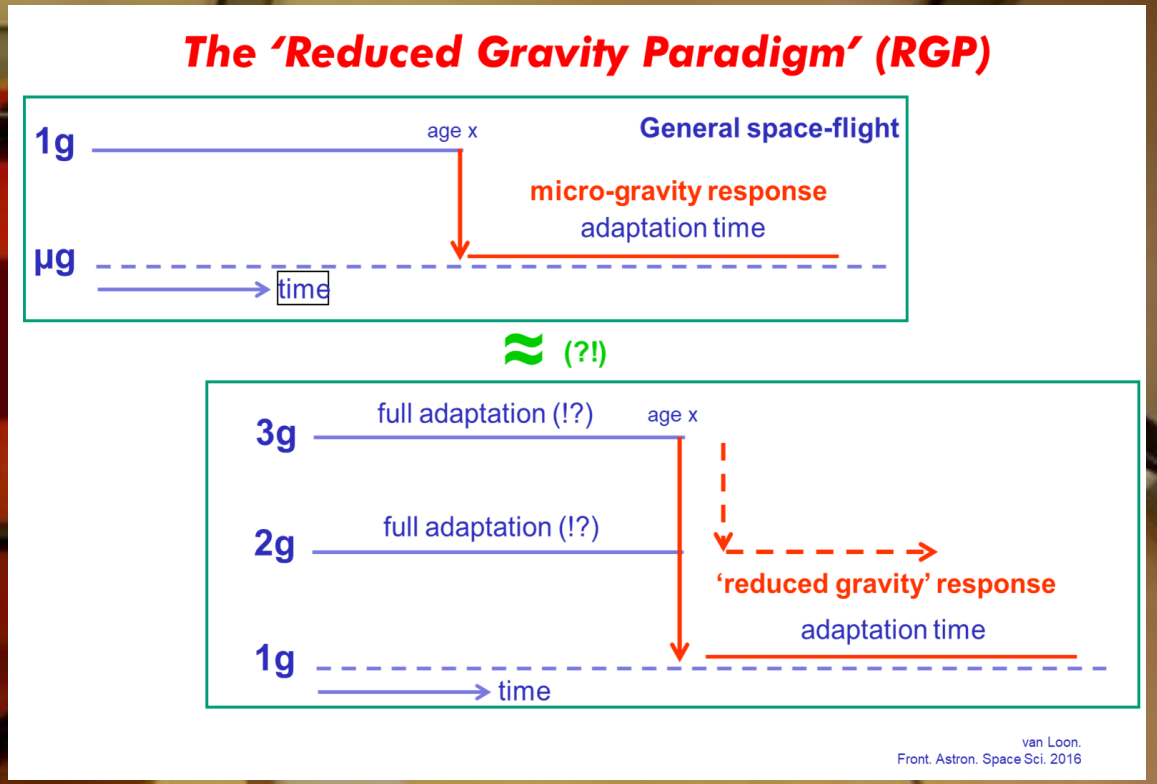
Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.

See also: van Loon Front. Astron. Space Sci. 2016

Large Diameter Centrifuge

- Regular hypergravity research
- Launch simulations
- Parabolic Flight hyper-g phase exploration
- …etc.





Centrifuges general topics / background / references:
doi:10.3389/fspas.2016.00021

TEC-MMG Lis Lab @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)


Jack van Loon


Alan Dowson


Francois Gaubert


Robert Lindner

meeting room

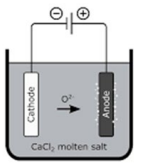
clean room

(fluor.) mic.s

flow benches

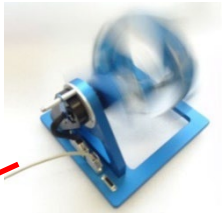
plant chamber

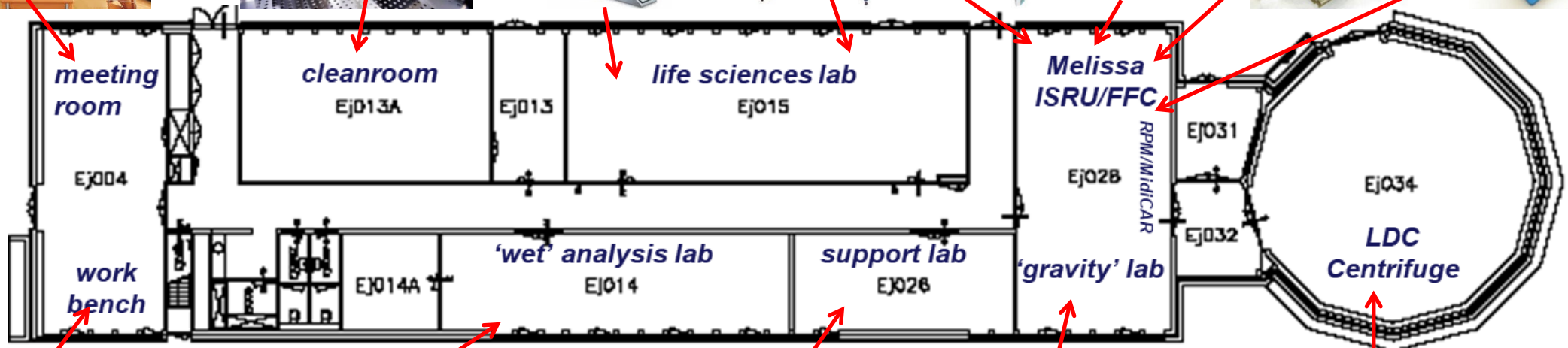
FFC furnace



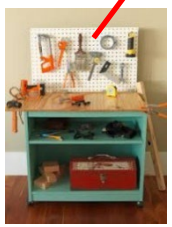
MidiCAR

RPMs





\+ other ESTEC labs !!


workbench


LC/MS

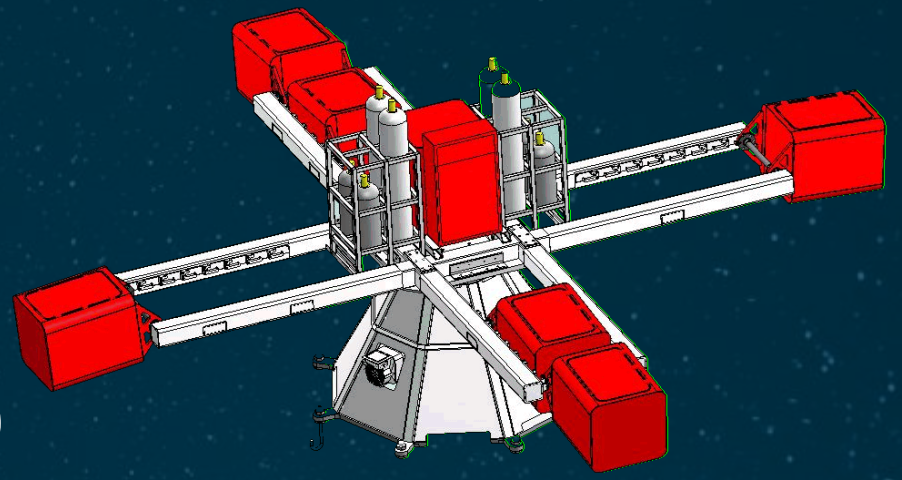

e.g. autoclaves


clinostats

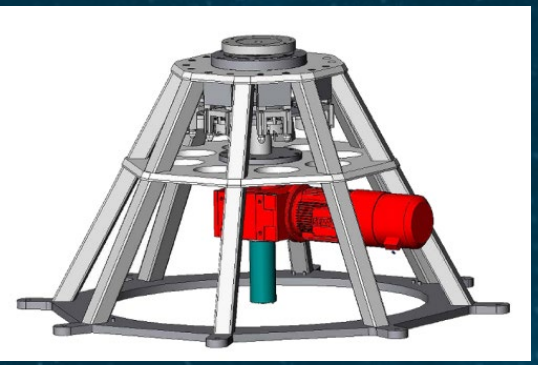

LDC

Link: *ESA TEC-MMG lab*

LDC Main Properties

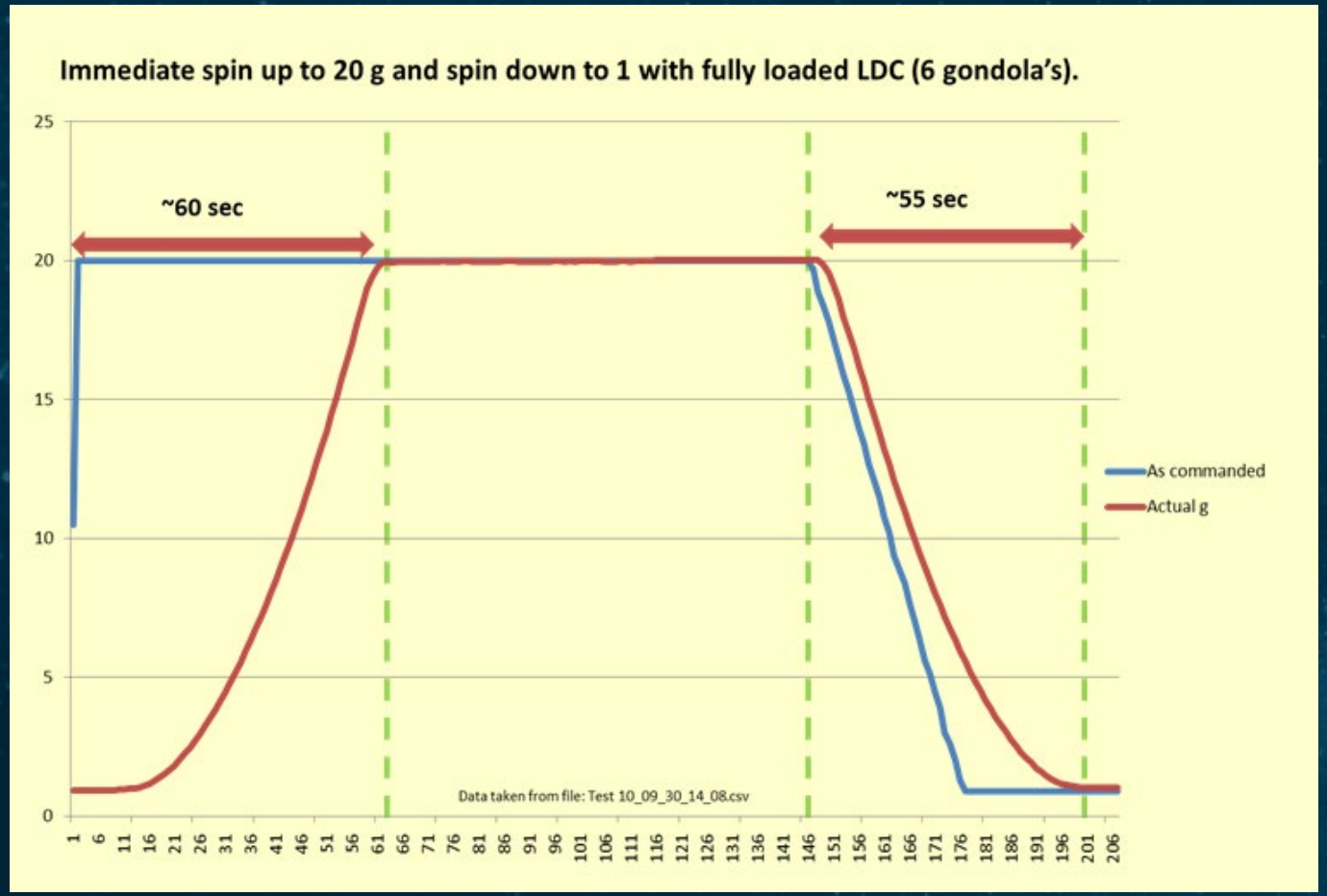


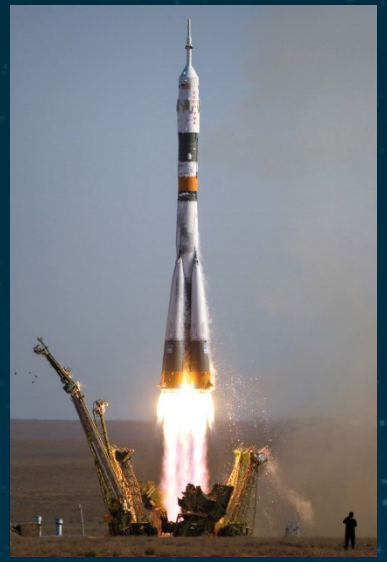
diameter : ~ 8 meter
arms : 4
g levels : various (8 locations / arm)
exp. Volume: 7 ‘gondolas’ ; 6 rotating (60×60×80 cm)
center gondola: control / g-sensitive materials
g vector : swing-out:
payload : 80 kg per gondola (total 210 kg incl. gondola)
g load : 20×g fully loaded
motor : 22 kW (Siemens)

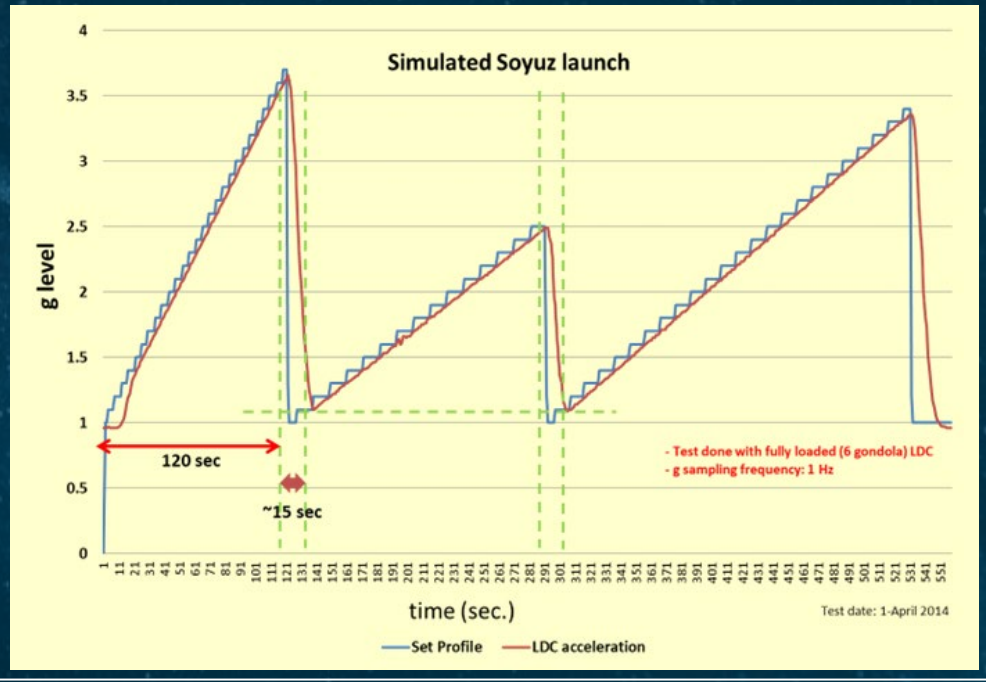


for HyperGES : max 2 weeks use of LDC

LDC Start-up & Profiles

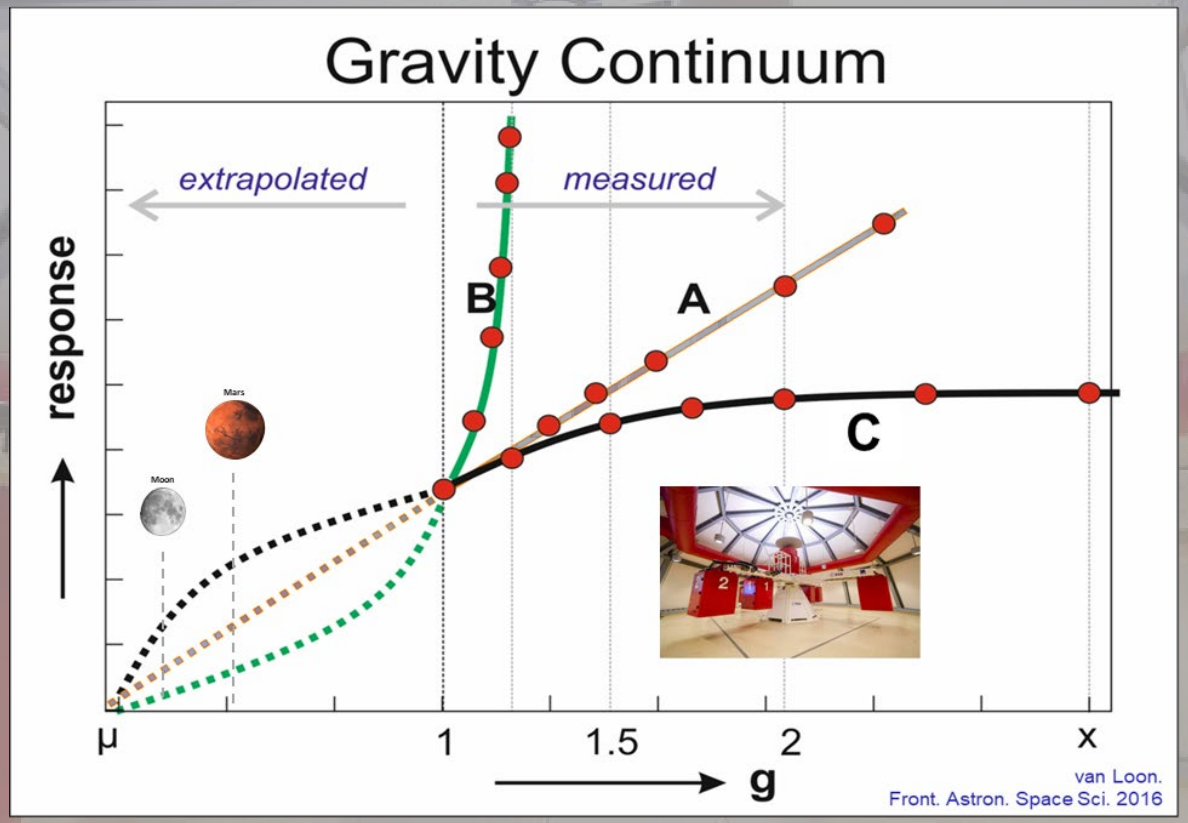


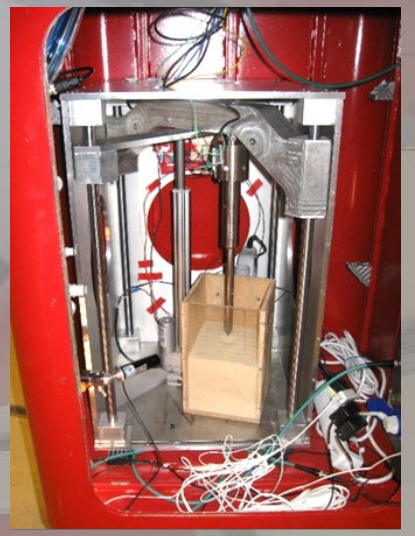




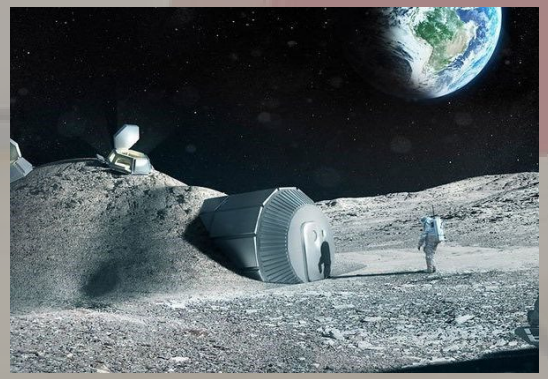
Some ISRU studies in the Large Diameter Centrifuge (LDC) @ TEC-MMG- ESTEC, Noordwijk, NL

Impact
(Glasgow,UK)





Ultrasonic Drill
(Glasgow,UK)

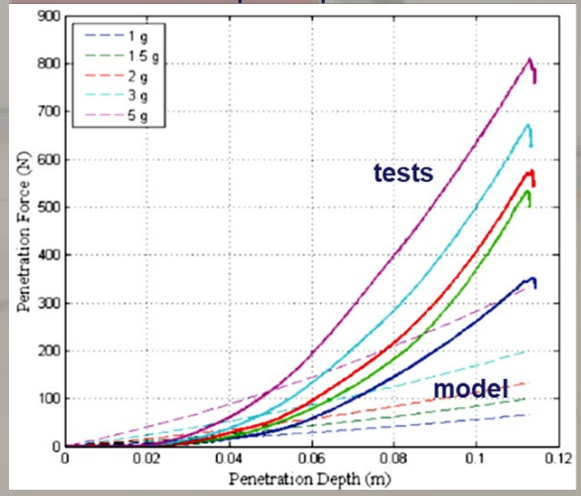


Test Habitat Structures

Scaling effects:

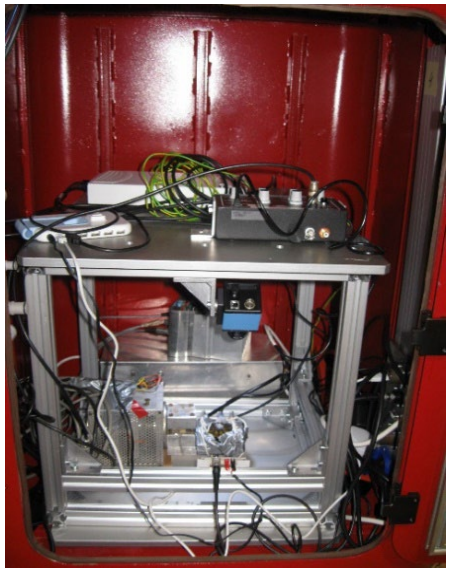
- g = N
- Length: 1/N
- Time : $1/N^2$
- Mass: $1/N^3$

Surface drill peak penetration force

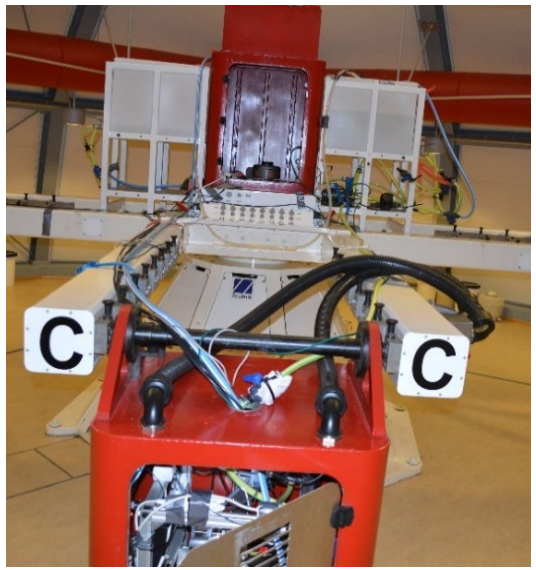


Some Experiment Configurations

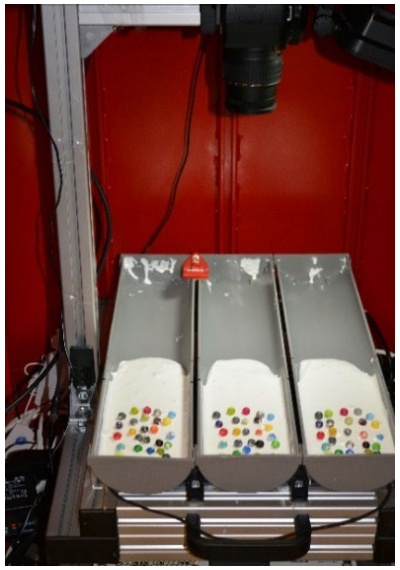
Impact
(Glasgow,UK)



Crab/Neurovestibular
(Aberdeen, UK)

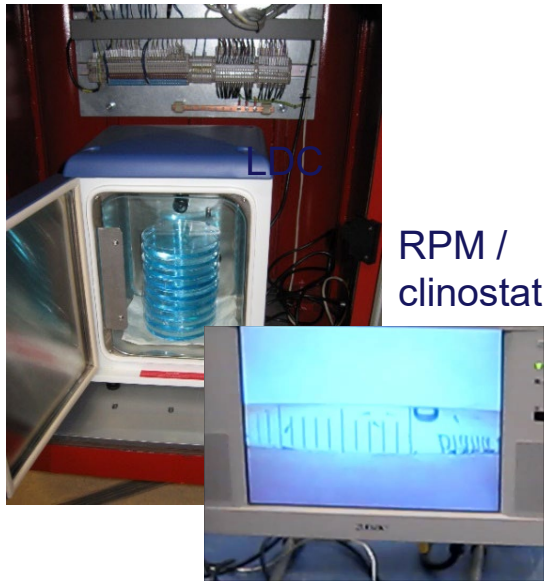


Mass & Heat Transfer
(Thessaloniki, GR)

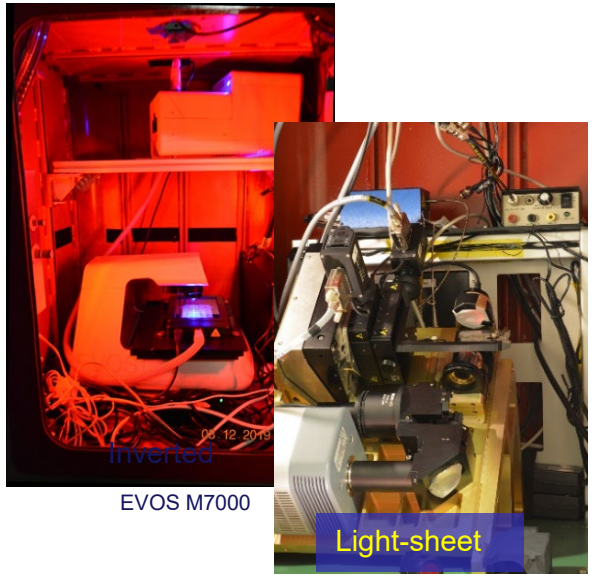


Planetary/Glacier
(Amsterdam, NL)

Bubble Generation
(Tessaloniki, GR)



RPM / clinostat
(Liege, BE)



EVOS M7000

Fluorescence Mics light sheet

Buoyancy / Coriolis
(Barcelona, ES)

Some peer reviewed papers from previous LDC studies (non-exhaustive list) on general, cell biology, plant biology, animal physiology, fluid physics, plasma physics, geology/planetary, technology, material sciences and other topics: see in LDC user Manual; LINK

Centrifuges general topics / background

- doi:10.3389/fspas.2016.00021
- doi: 10.3389/frspt.2020.00003.
- DOI 10.1007/s12217-015-9462-9

Fluid physics

- https://link.aps.org/doi/10.1103/PhysRevLett.123.244501
- doi:10.1007/s12217-019-09740-8.
- doi.org/10.1016/j.ijmultiphaseflow.2019.03.029.
- DOI: doi.org/10.1016/j.ijheatmasstransfer.2018.12.086
- https://doi.org/10.1016/j.fbp.2017.02.001
- https://doi.org/10.1103/PhysRevE.91.053009
- DOI: 10.1209/0295-5075/110/24001
- DOI 10.1007/s10035-013-0403-2
- https://doi.org/10.1016/j.expthermflusci.2015.01.011
- https://doi.org/10.1016/j.foodres.2013.10.044.
- https://doi.org/10.1007/s12217-012-9323-8

Cell biology:

- DOI: 10.1016/j.ejpb.2021.03.013.
- DOI: 10.1002/jbm.a.37215
- doi: 10.1016/j.bpj.2021.01.021
- doi: 10.3390/ijms21072354.
- https://doi.org/10.1016/j.bpj.2019.03.038
- doi: 10.1089/scd.2017.0206
- DOI: 10.1098/rsif.2016.0688.
- doi:10.2147/IJN.S76329
- DOI: 10.1371/journal.pone.0144269.
- DOI: 10.1089/ten.tea.2012.0267
- https://doi.org/10.1016/j.jbiosc.2011.09.025

Material sciences

- DOI: https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151

Plasma physics

- doi.org/10.1088/1361-6595/aa5ee8.
- doi:10.1088/0963-0252/24/2/022002
- http://dx.doi.org/10.1016/j.materresbull.2014.03.013
- DOI: 10.1140/epjd/e2013-40408-7

Plant biology

- doi:10.1038/s41598-018-24942-7.
- https://doi.org/10.1007/s12217-016-9531-8
- http://dx.doi.org/10.3389/fspas.2016.00002
- doi:10.1038/srep07730
- http://dx.doi.org/10.1155/2014/964203
- doi:10.1371/journal.pone.0058246
- doi:10.1007/s12217-012-9301-1

Animal physiology

- doi: 10.1302/2046-3758.102.BJR-2020-0239.R1
- doi: 10.1038/s41526-020-00115-7
- DOI 10.7717/peerj.6055.
- https://doi.org/10.3390/ijms20030720
- DOI:10.1371/journal.pone.0126928
- DOI: 10.1155/2014/679672.
- DOI 10.1007/s12217-012-9334-5

Geology/planetary

- doi: 10.1098/rspa.2016.0673

Technology

- doi: 10.1016/j.bpj.2021.01.021
- DOI: 10.1002/adv.21937
- ISBN 978-1-68108-499-2

Any question / remarks regarding LDC ?!
Don’t wait asking !!

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LDC User Manual: http://esamultimedia.esa.int/docs/edu/LDC_Experimenter_User_manual_V.3_Rev.0_14-May-2019_ESA-TECMMG-MAN-014129.pdf

TEC-MMG LIS Lab web URL: https://technology.esa.int/lab/life-support-physical-sciences-instrumentation-laboratory

Other general webinar info

SELGRA webinar: Gravity-related research instrumentation applications in life and physical sciences
https://www.youtube.com/watch?v=jejiXxOZt-4

UNOOSA webinar: Introduction to Hypergravity/Microgravity: https://youtu.be/AjmR0syOc-Y?list=PLaOqa4cng0GGgCeqAwo0bWTPAdB2uHICx&t=1263 /
UNOOSA webinar series: https://www.unoosa.org/oosa/en/ourwork/access2space4all/HMTrack_Webinars.html#Tag6

ESA Petri website: https://www.esa.int/Education/PETRI_programme/PETRI_What_is_it