

# HyperGES : The ESA Large Diameter Centrifuge (LDC)



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MEMBER STATES

1975 Signing of ESA Convention: 10-member states



# ESA Memberstates & Establishments



**Headquarters**  
Located in **Paris**, France

**ESRIN**  
Earth **Rome**, Italy

**ESTEC**  
ESA technical heart, **Noordwijk**, the Netherlands

**ESOC**  
Operations Centre, **Darmstadt**, Germany

**EAC**  
Astronaut Centre, **Cologne**, Germany

**ESAC**  
Astronomy Centre, **Madrid**, Spain

**Harwell (ECSAT)**  
commercialisation and partnerships **Oxfordshire**, UK

**Redu**  
ground stations / Weather Data, **Redu**, Belgium

**Guiana Space Centre**  
Europe's Spaceport, **Kourou**, French Guiana



# ESA-Technology Center ESTEC, Noordwijk, NL



the 'Center of Gravity'

# TEC-MMG Lis Lab @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



Jack van Loon



Alan Dowson



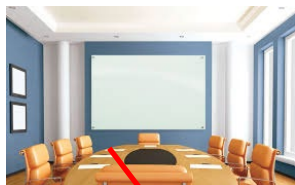
Francois Gaubert



Robert Lindner

flow benches

meeting room



clean room



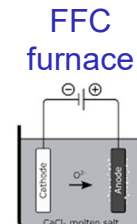
(fluor.) mic.s



plant chamber



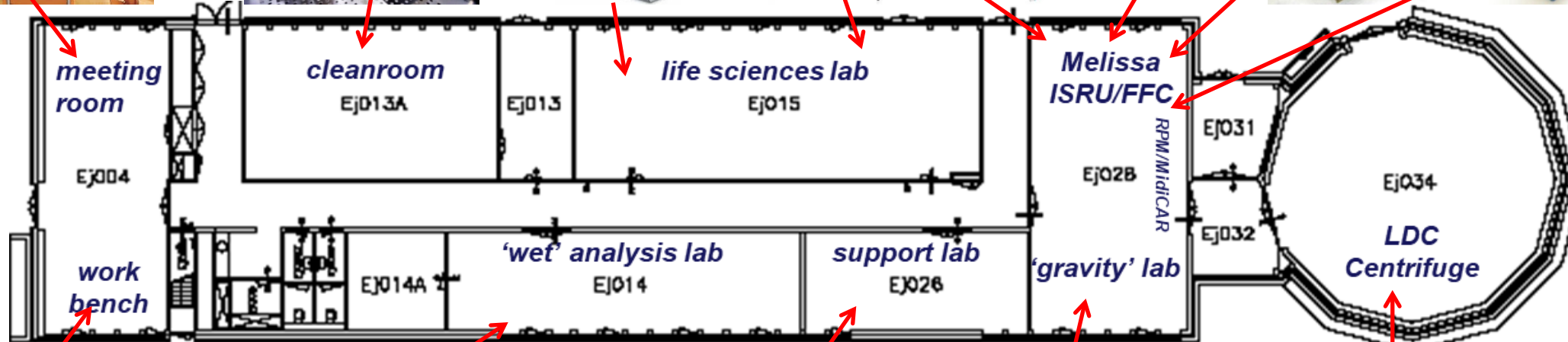
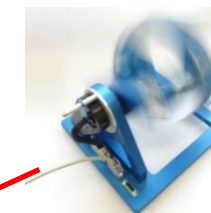
FFC furnace



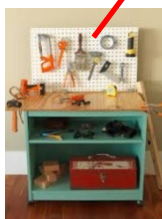
MidiCAR



RPMs



+ other ESTEC labs !!



workbench



LC/MS



e.g. autoclaves



clinostats



LDC

# LisLab – LDC Facilities @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



main lab



support lab



LDC control room



meeting room



'wet lab'

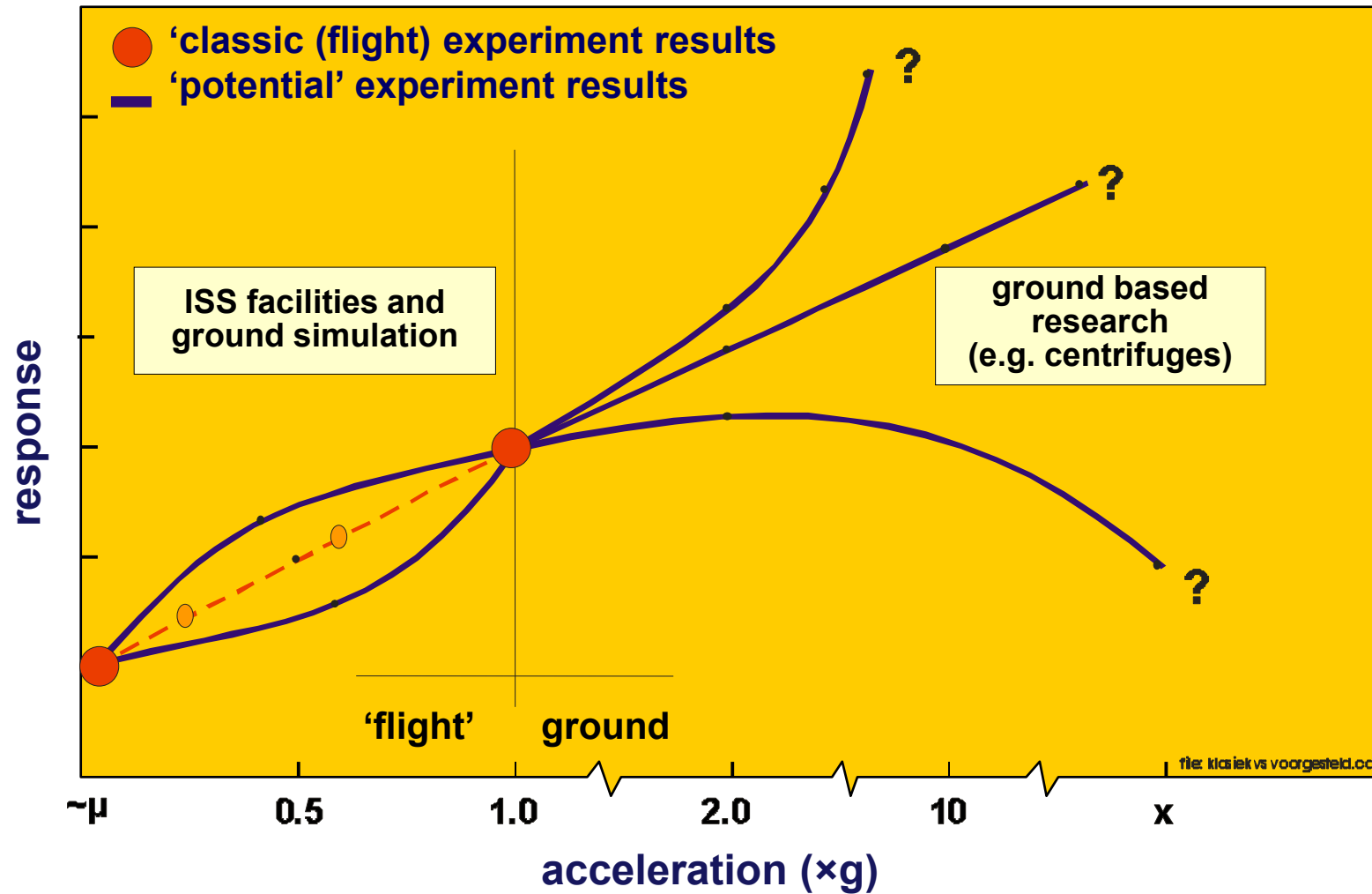


small 'workshop'



LDC prep lab

# Spaceflight vs. Ground-Based Research

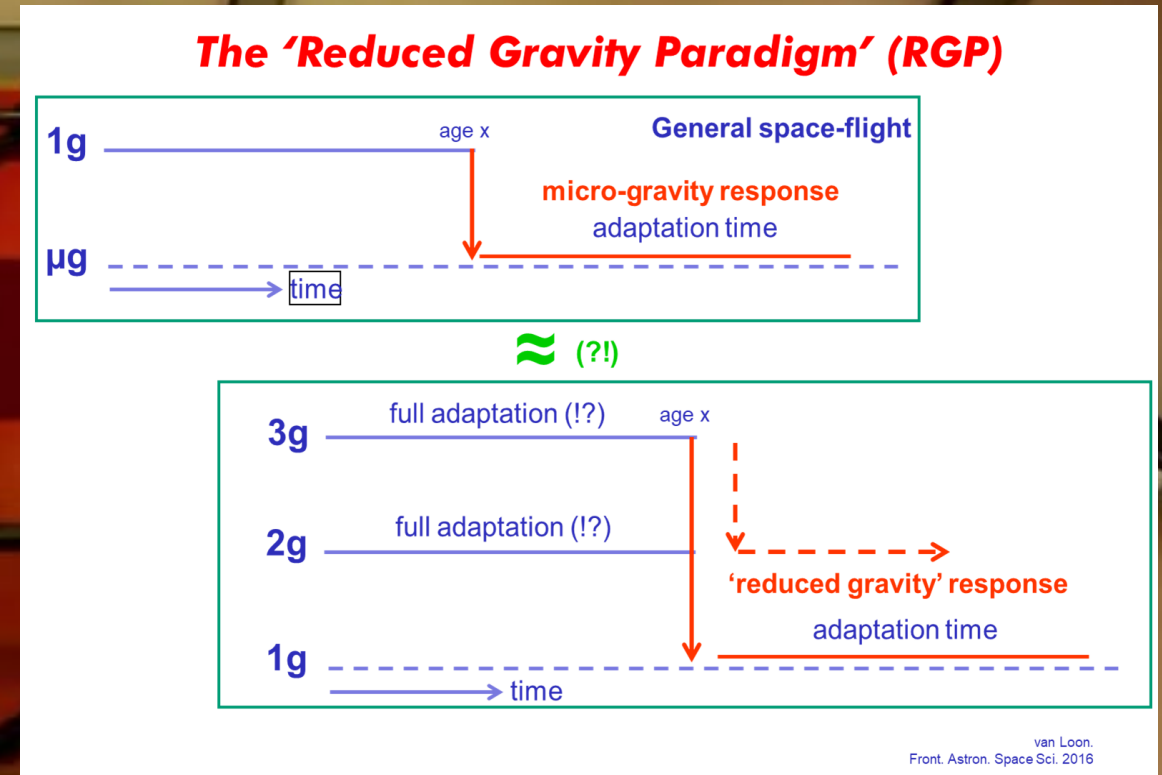
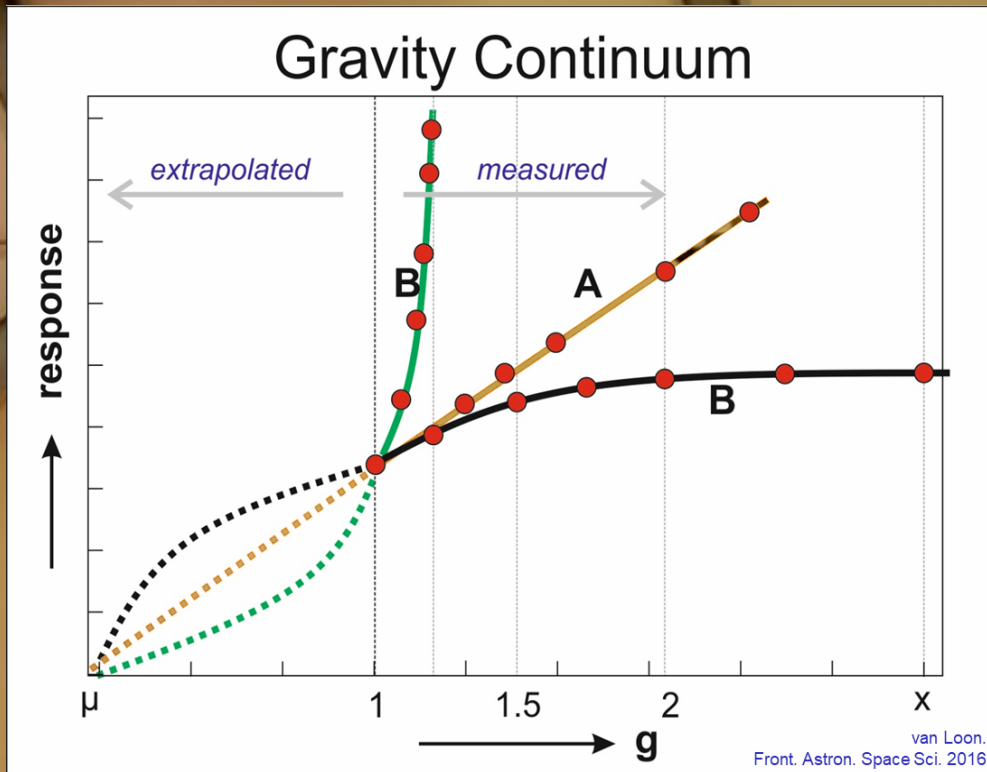


Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.

[See also: van Loon Front. Astron. Space Sci. 2016](#)

# Large Diameter Centrifuge

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





# 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

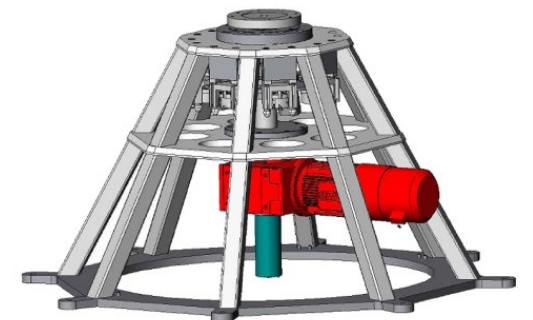
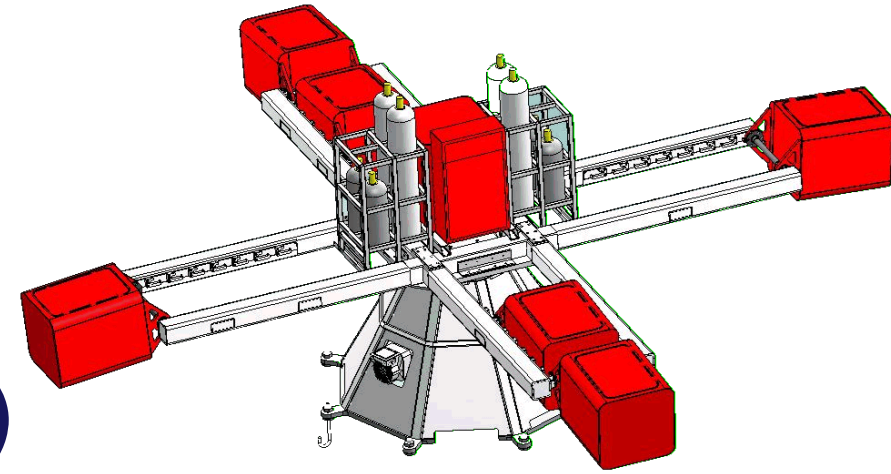
g vector : swing-out: 

payload : 80 kg per gondola (total 210 kg incl. gondola)

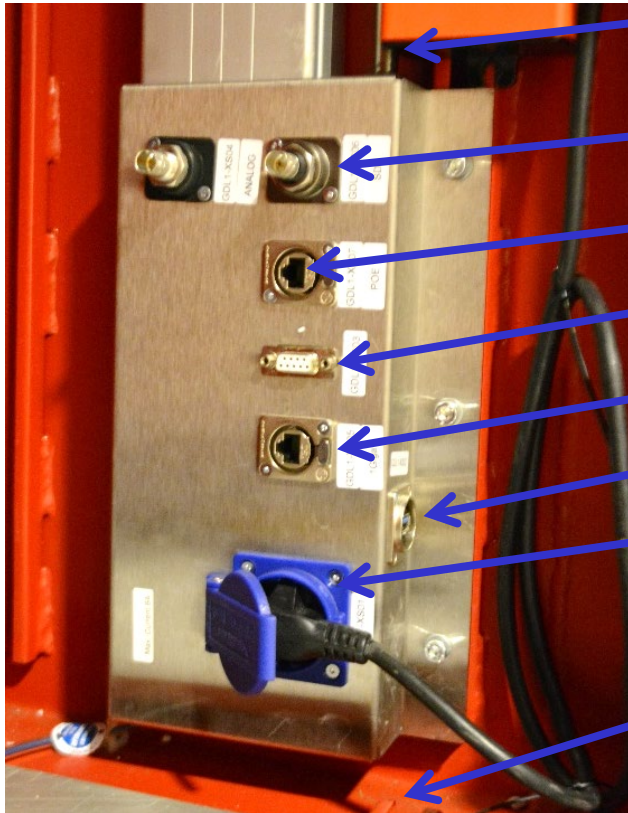
g load : 20×g fully loaded

motor : 22 kW (Siemens)

for HyperGES : max 2 weeks use of LDC



# The Gondola : Main Properties



temp. sensor

anal. / dig. video / PoE channels

RS-232 serial channel

Ethernet channel

USB-2/3 channel

230 V/6 amp line

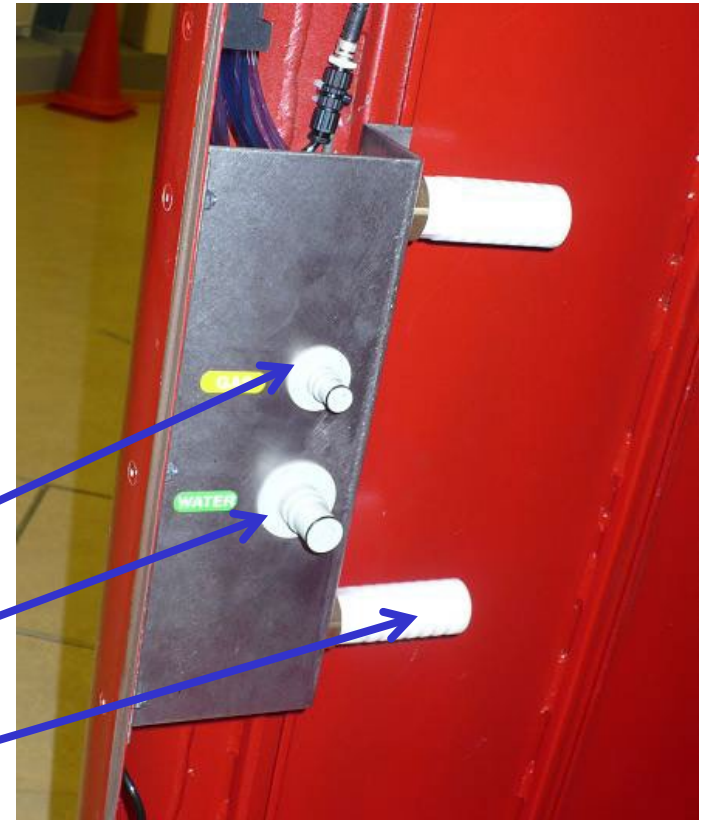
fixation

gas lines (#)

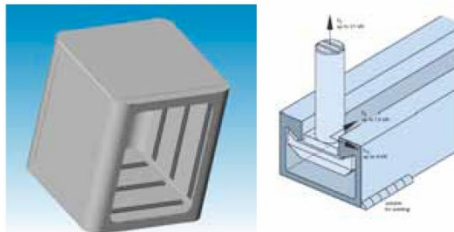
water supply

forced ventilation

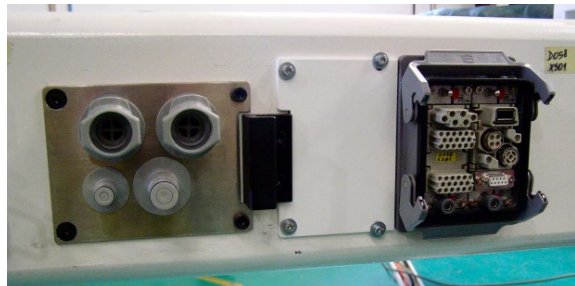
power / data



gas + water lines



experiment fixation



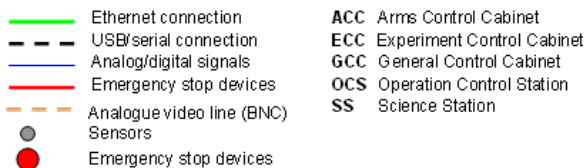
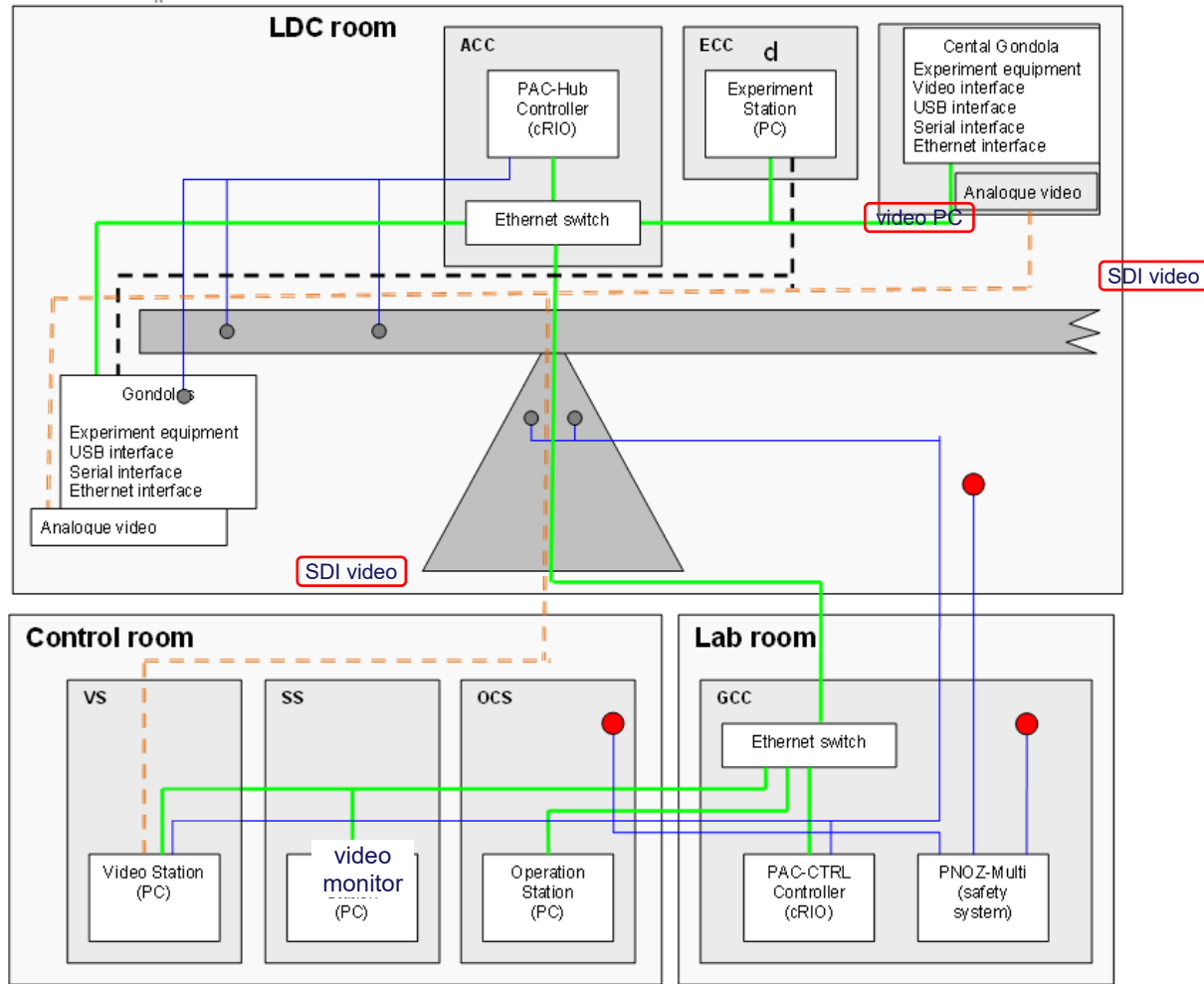
gondola connections



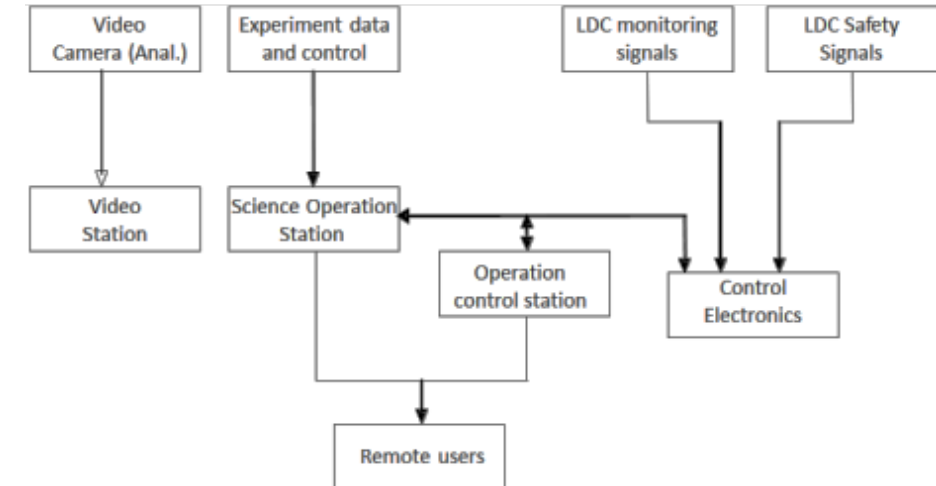
9 analogue video lines /  
8 digital video lines

# LDC Data / Electronics Interfaces

## Operation Electronics Scheme



## Operation Data Flow Scheme



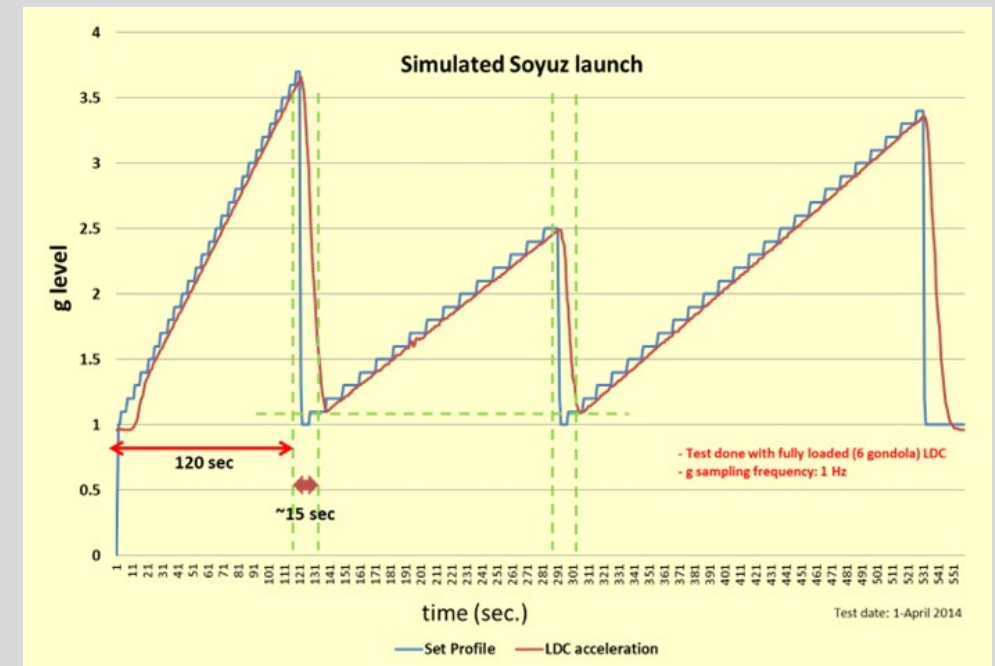
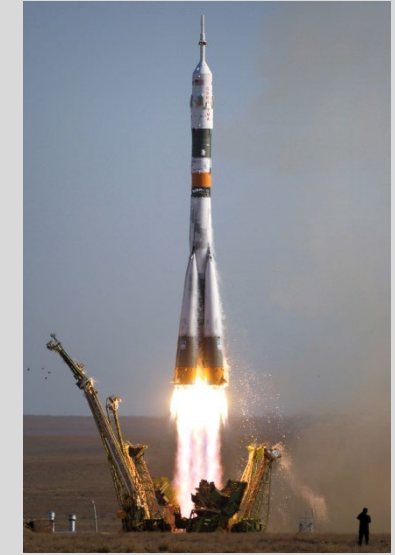
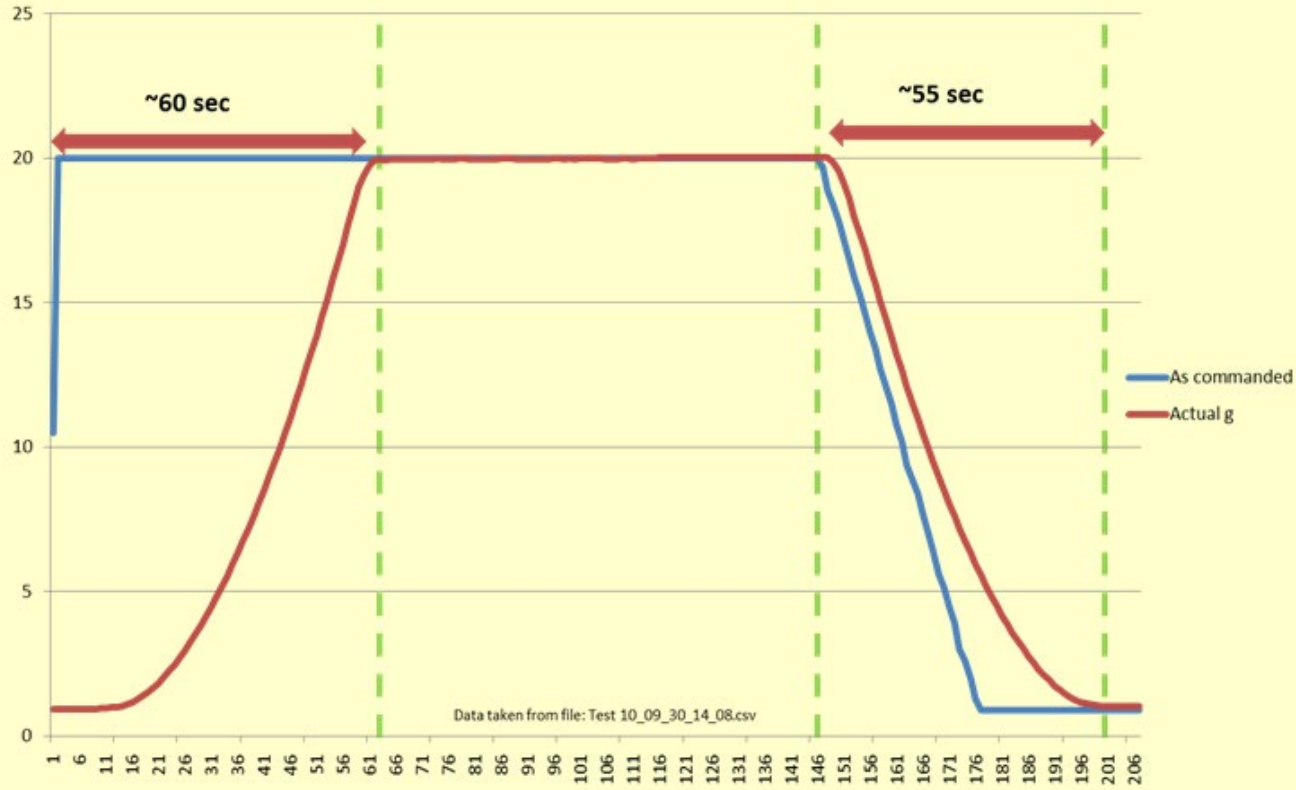
### Data / Communication:

- Remote PC (Win10 / (Win7/XP!), non-Win systems)  
**(administrator rights!!)**
- (TeamViewer)
- Exp. dedicated

See also: [LDC user manual](#)

# LDC Start-up & Profiles

Immediate spin up to 20 g and spin down to 1 with fully loaded LDC (6 gondola's).



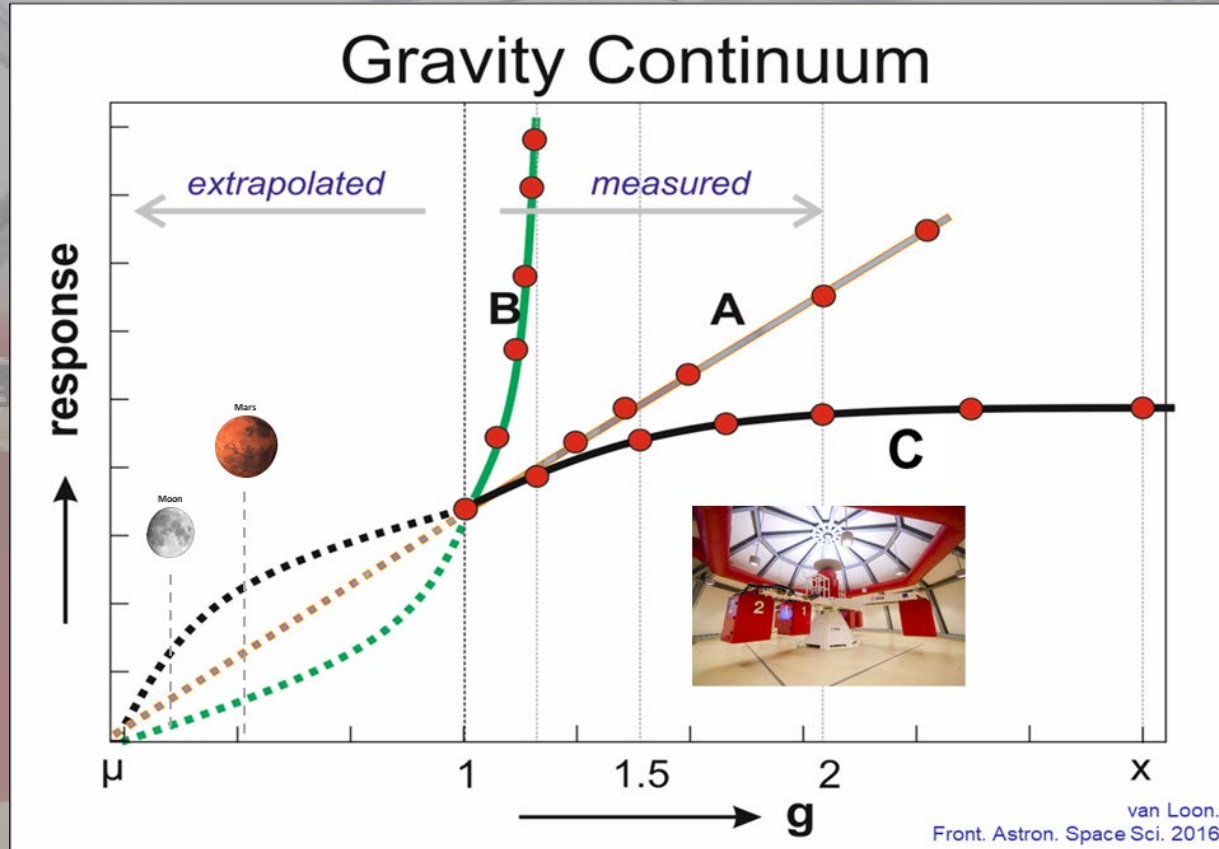
# Some ISRU studies in the Large Diameter Centrifuge (LDC) @ TEC-MMG- ESTEC, Noordwijk, NL



Impact  
(Glasgow, UK)

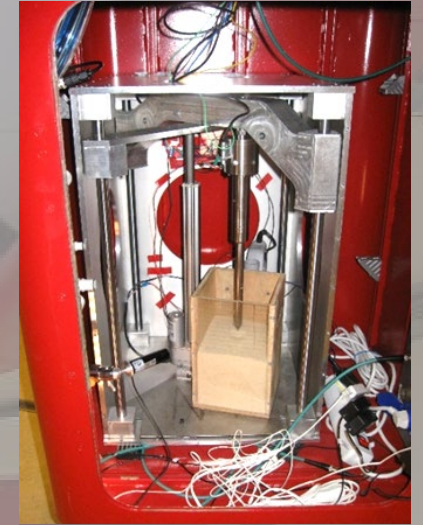


Test Habitat Structures



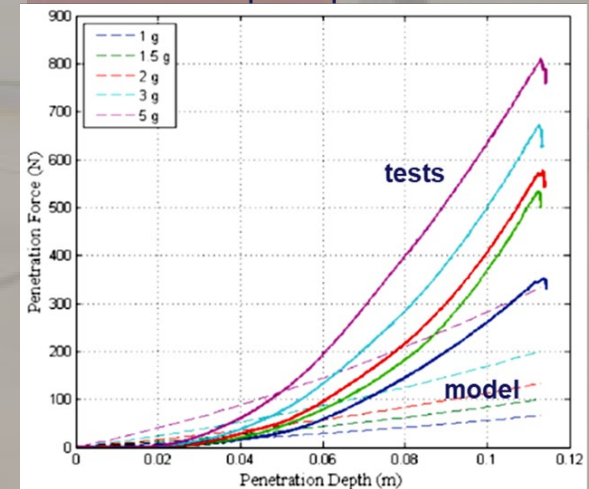
### Scaling effects:

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



Ultrasonic Drill  
(Glasgow, UK)

### Surface drill peak penetration force



# Some Experiment Configurations



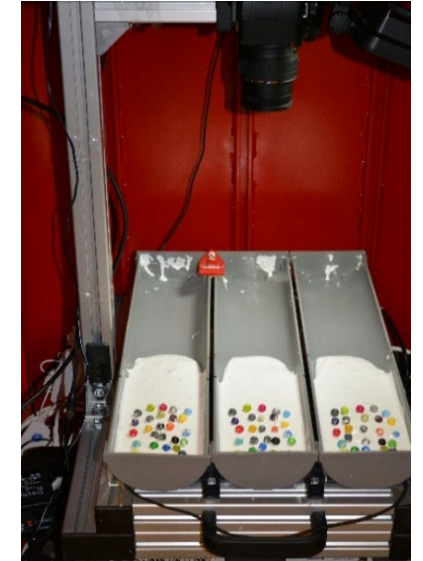
**Impact**  
(Glasgow, UK)



**Crab/Neurovestibular**  
(Aberdeen, UK)



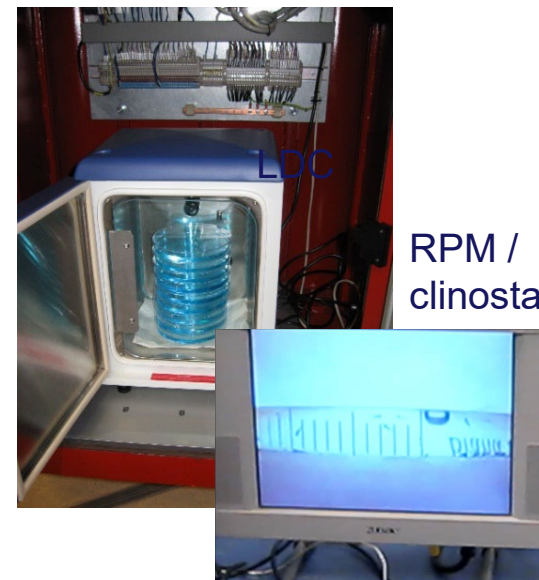
**Mass & Heat Transfer**  
(Thessaloniki, GR)



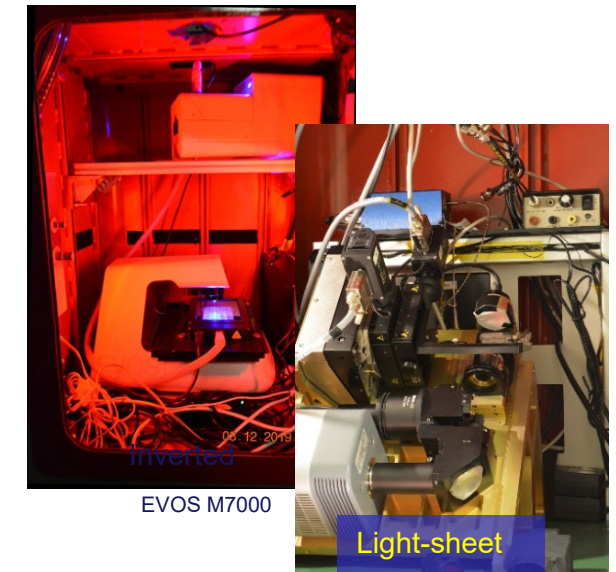
**Planetary/Glacier**  
(Amsterdam, NL)



**Bubble Generation**  
(Thessaloniki, GR)



(Liege, BE)



**Fluorescence Mics** light sheet

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](https://doi.org/10.3389/fspas.2016.00021)
- [doi: 10.3389/frspt.2020.00003](https://doi.org/10.3389/frspt.2020.00003).
- [DOI 10.1007/s12217-015-9462-9](https://doi.org/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](https://doi.org/10.1007/s12217-019-09740-8).
- [doi.org/10.1016/j.ijmultiphaseflow.2019.03.029](https://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.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](https://doi.org/10.1209/0295-5075/110/24001)
- [DOI 10.1007/s10035-013-0403-2](https://doi.org/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](https://doi.org/10.1016/j.ejpb.2021.03.013).
- [DOI: 10.1002/jbm.a.37215](https://doi.org/10.1002/jbm.a.37215)
- [doi: 10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- [doi: 10.3390/ijms21072354](https://doi.org/10.3390/ijms21072354).
- <https://doi.org/10.1016/j.bpj.2019.03.038>
- [doi: 10.1089/scd.2017.0206](https://doi.org/10.1089/scd.2017.0206)
- [DOI: 10.1098/rsif.2016.0688](https://doi.org/10.1098/rsif.2016.0688).
- [doi:10.2147/IJN.S76329](https://doi.org/10.2147/IJN.S76329)
- [DOI: 10.1371/journal.pone.0144269](https://doi.org/10.1371/journal.pone.0144269).
- [DOI: 10.1089/ten.tea.2012.0267](https://doi.org/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](https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151)

#### Plasma physics

- [doi.org/10.1088/1361-6595/aa5ee8](https://doi.org/10.1088/1361-6595/aa5ee8).
- [doi:10.1088/0963-0252/24/2/022002](https://doi.org/10.1088/0963-0252/24/2/022002)
- <http://dx.doi.org/10.1016/j.materresbull.2014.03.013>
- [DOI: 10.1140/epid/e2013-40408-7](https://doi.org/10.1140/epid/e2013-40408-7)

#### Plant biology

- [doi:10.1038/s41598-018-24942-7](https://doi.org/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](https://doi.org/10.1038/srep07730)
- <http://dx.doi.org/10.1155/2014/964203>
- [doi:10.1371/journal.pone.0058246](https://doi.org/10.1371/journal.pone.0058246)
- [doi:10.1007/s12217-012-9301-1](https://doi.org/10.1007/s12217-012-9301-1)

#### Animal physiology

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

#### Geology/planetary

- [doi: 10.1098/rspa.2016.0673](https://doi.org/10.1098/rspa.2016.0673)

#### Technology

- [doi: 10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- [DOI: 10.1002/adv.21937](https://doi.org/10.1002/adv.21937)
- [ISBN 978-1-68108-499-2](https://doi.org/10.1007/978-1-68108-499-2)

# Any question / remarks regarding LDC ?!

## Don't wait asking !!

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**TEC-MMG LIS Lab web URL:**

[http://m.esa.int/Our\\_Activities/Space\\_Engineering\\_Technology/Life\\_Physical\\_Sciences\\_and\\_Life\\_Support\\_Laboratory](http://m.esa.int/Our_Activities/Space_Engineering_Technology/Life_Physical_Sciences_and_Life_Support_Laboratory)

**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](http://esamultimedia.esa.int/docs/edu/LDC_Experimenter_User_manual_V.3_Rev.0_14-May-2019_ESA-TECMMG-MAN-014129.pdf)