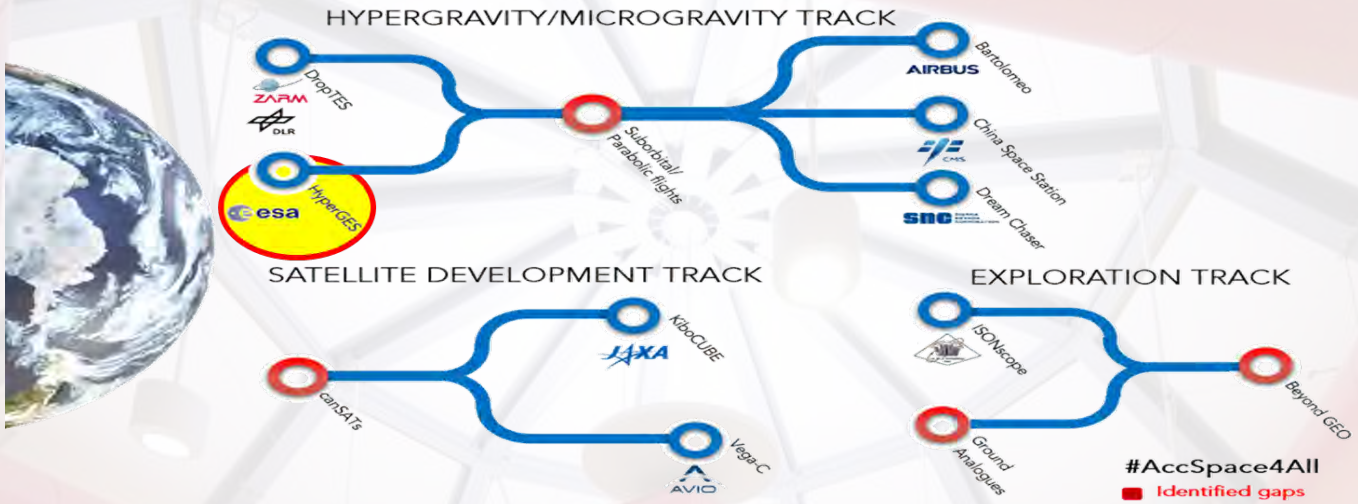



# HyperGES
# The ESA Large Diameter Centrifuge (LDC)

**Dr.ing. Jack J.W.A. van Loon**

Cooperate Scientist @ ESA-ESTEC-TEC-MMG Lab, Noordwijk, The Netherlands
**&**
Dept. Cranial-Facial Surgery, ACTA &
VU University Medical Center, Amsterdam, The Netherlands
Email: j.vanloon@amsterdamumc.nl

# European Space Agency : ESA


# 22

## MEMBER STATES

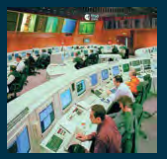
# ESA Establishments *(1)*

**Headquarters**
Located in Paris, home to the main programme directorates that steer and formulate ESA policy.

**ESRIN**
ESA's centre for Earth observation activities, near Rome, Italy, also develops information systems and hosts the Vega launcher project.

**ESTEC**
The European Space Research and Technology Centre, Noordwijk, the Netherlands, is the largest site and the technical heart of ESA.

**ESOC**
The European Space Operations Centre, Darmstadt, Germany, tracks and controls European spacecraft.



**EAC**
The European Astronaut Centre, Cologne, Germany,
trains astronauts for missions to the International Space Station and beyond.

# ESA Establishments *(2)*

**ESAC**
The European Space Astronomy Centre, near Madrid, Spain, hosts the science operation centres and archives for ESA's astronomy and planetary missions.

**Harwell (ECSAT)**
Harwell Centre, in Oxfordshire, UK, is focusing on commercialisation and partnerships in space activities.

**Redu**
Redu Centre in Belgium is part of ESA's ground station network and is also home to ESA's Space Weather Data Centre.

**Guiana Space Centre**
ESA's launchers lift off from Europe's Spaceport in Kourou, French Guiana. It is jointly operated by the French space agency (CNES) and Arianespace with the support of European industry.

# ESA-ESTEC, Noordwijk, NL

# 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

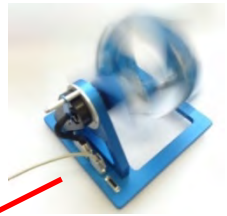
(fluor.) mic.s

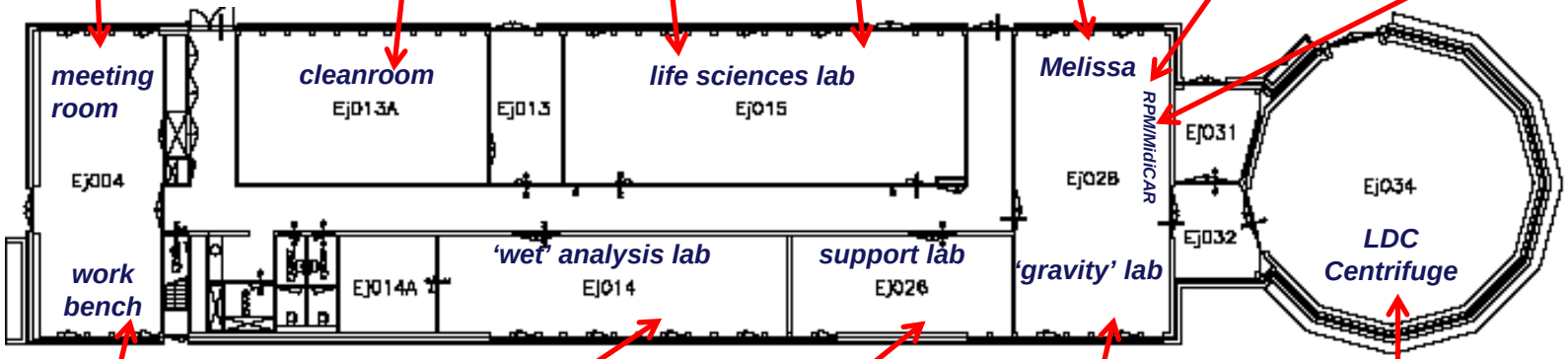
flow benches

plant chamber

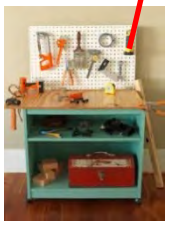
MidiCAR

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

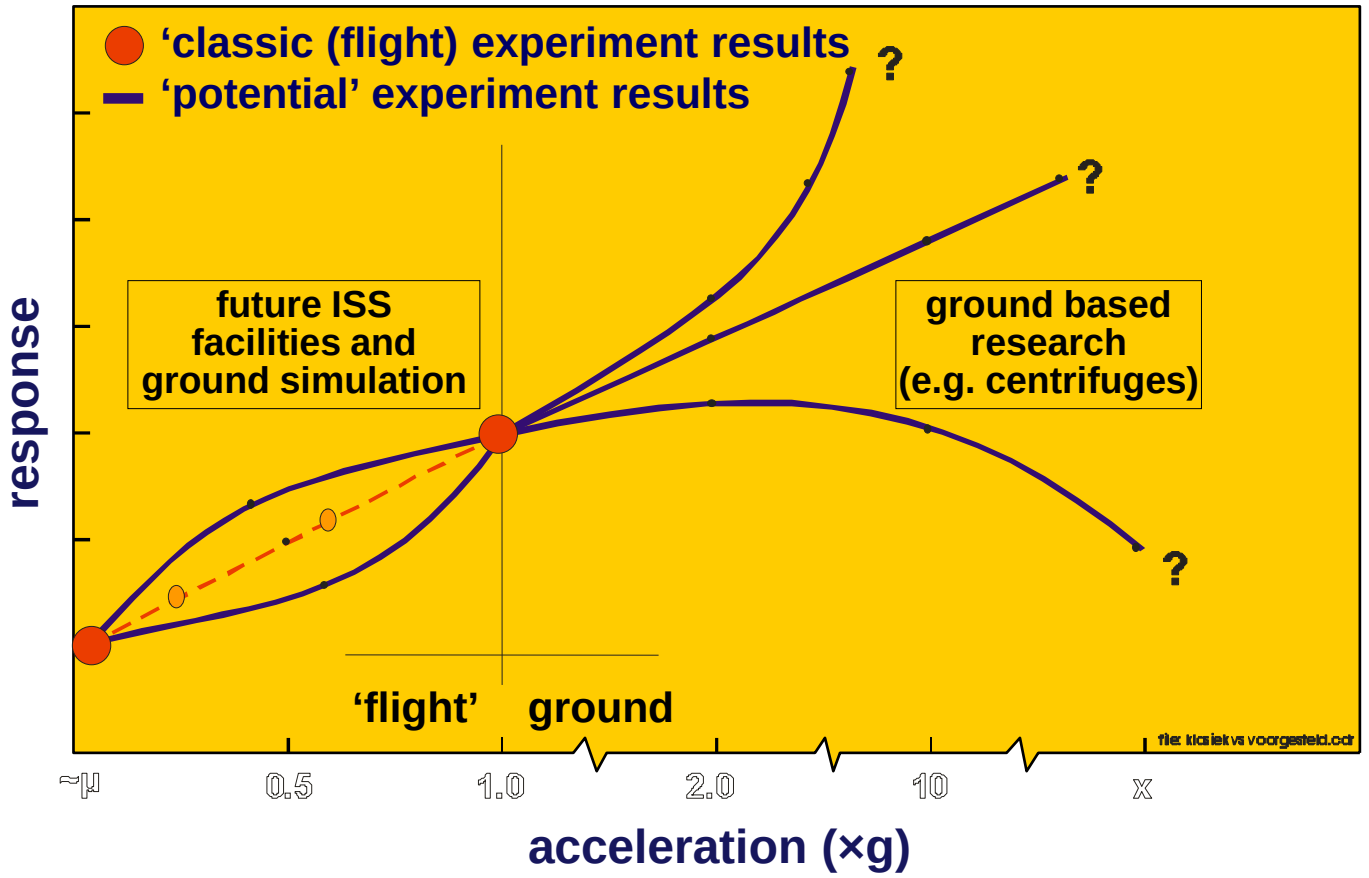
meeting room

small ‘workshop’

LDC prep lab

‘wet lab’

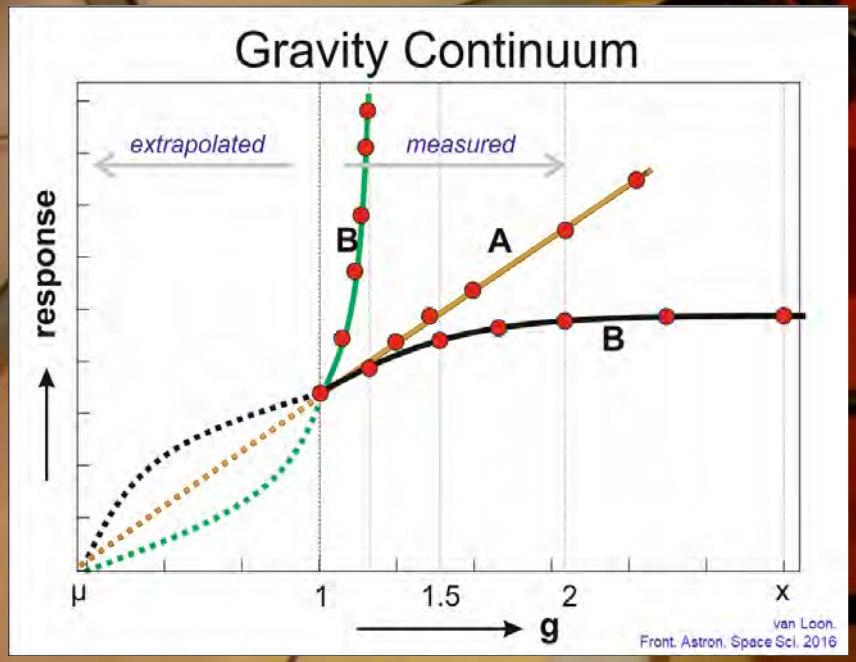
# Current vs. ‘Future’ Spaceflight Research

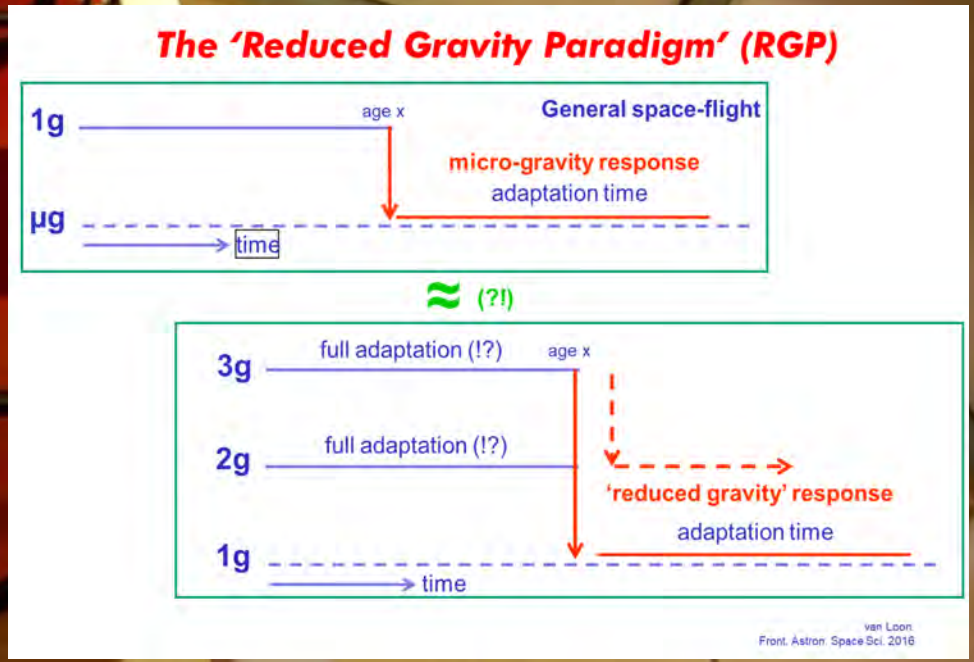



*Schematic presentation of potential experiment opportunities compared to 'classic' experiment setups. Novel space station facilities as well as ground simulations and centrifuges may be applied to study the role of weight (accelerations) on various living and non-living samples.*

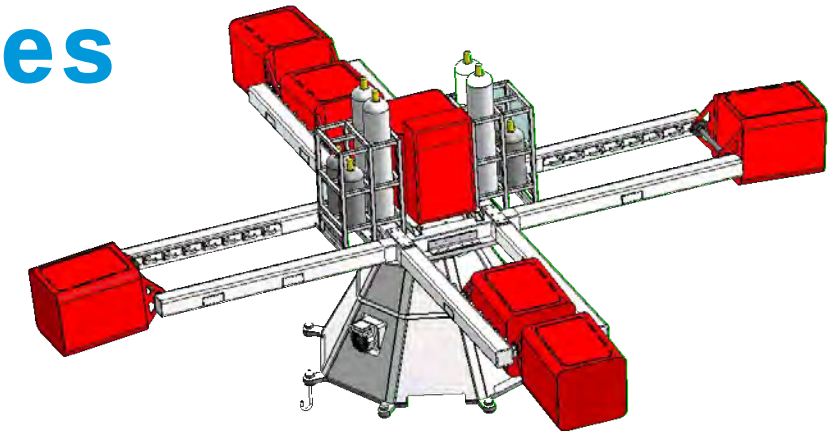
# Large Diameter Centrifuge

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

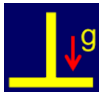


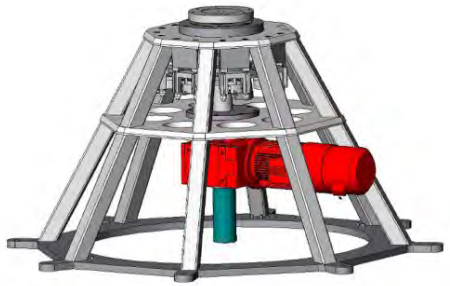
# LDC Main Properties



**diameter :** ~ 8 meter
**arms :** 4
**g levels :** various (8 locations / arm)

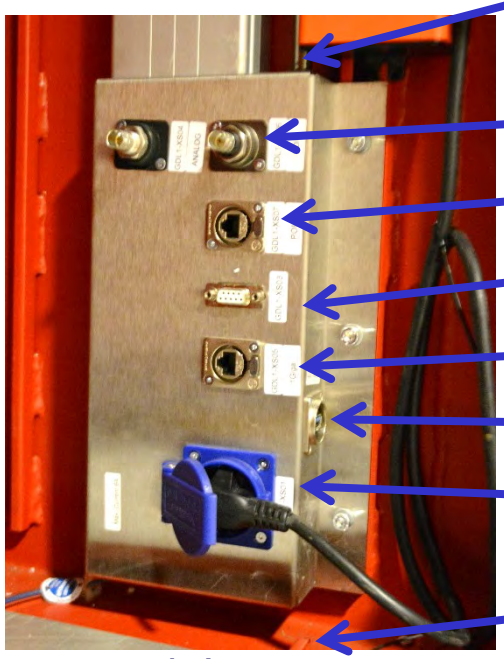



**exp. Volume :** 7 ‘gondolas’ ; 6 rotating (60×60×80 cm)
**center gondola :** control / g-sensitive materials
**g vector :** swing-out:
**payload :** 80 kg per gondola (total 210 kg incl. gondola)
**g load :** 20×g fully loaded
**motor :** 22 kW (Siemens)



Run Time: 8817.9 h
Revolutions: 13938224
(Dec 2017)

# The Gondola : Main Properties



power / data

temp. sensor

anal. / dig. video / PoE channels

RS-232 serial channel

Ethernet channel

USB-2/3 channel

230 V/6 amp line

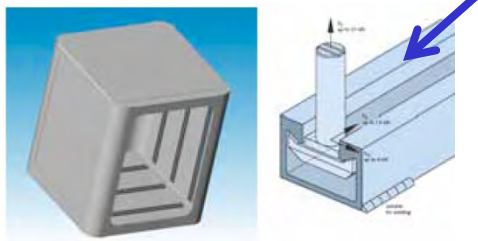
fixation

gas lines (#)

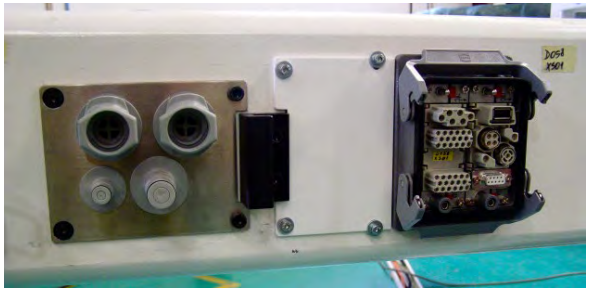
water supply

forced ventilation

gas + water lines



experiment fixation

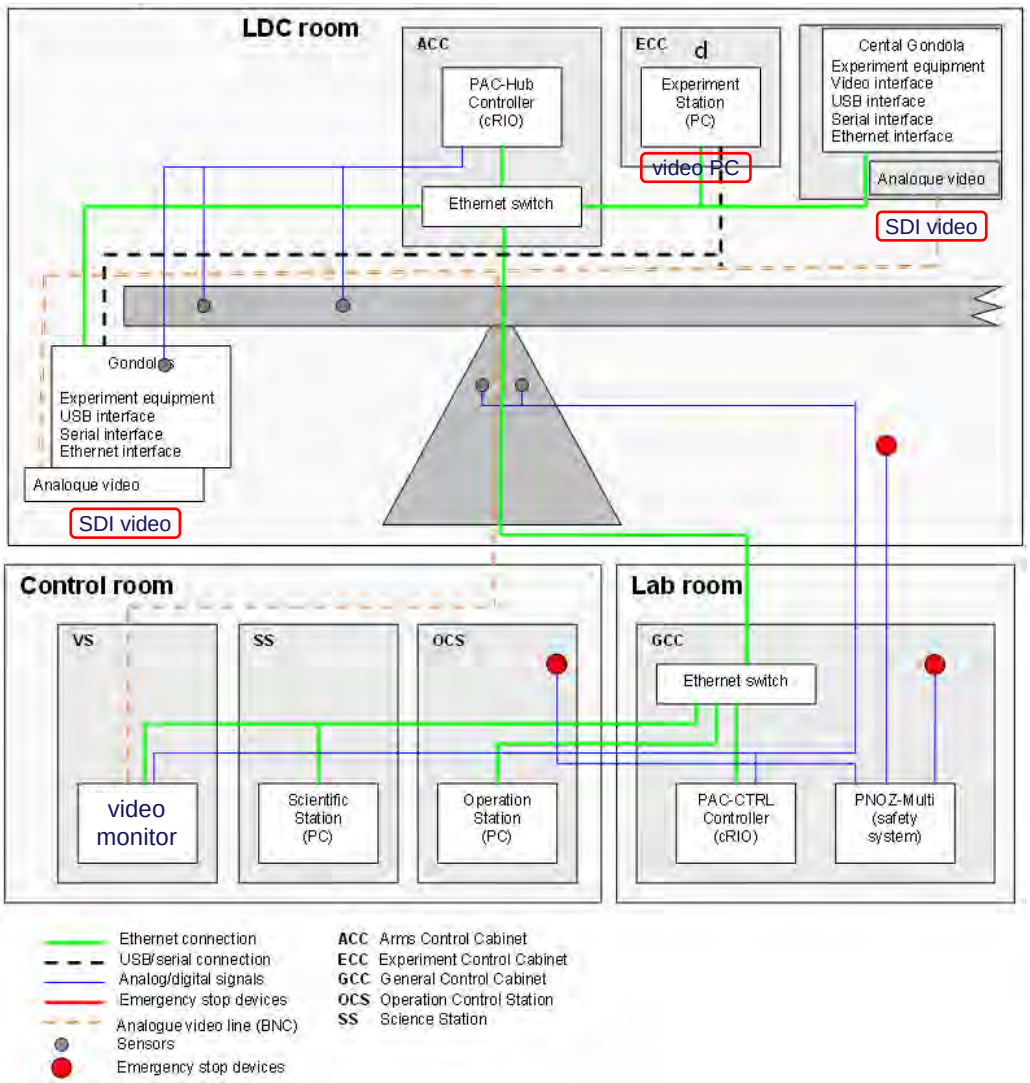


gondola connections

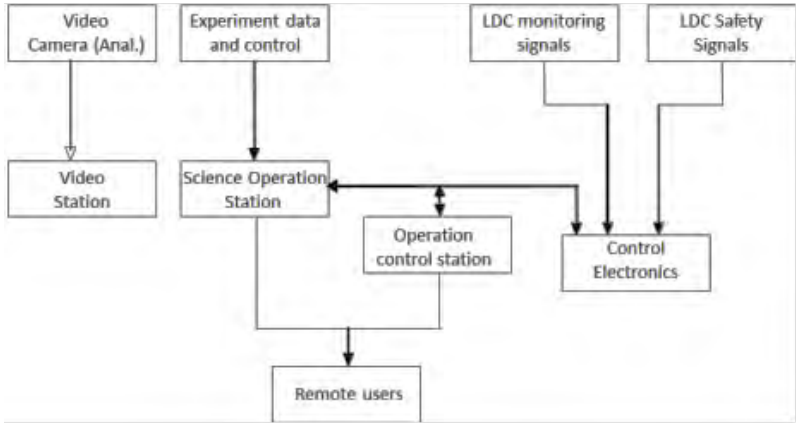
9 analogue video lines /
8 digital video lines

# LDC Data / Electronics Interfaces

## Operation Electronics Scheme



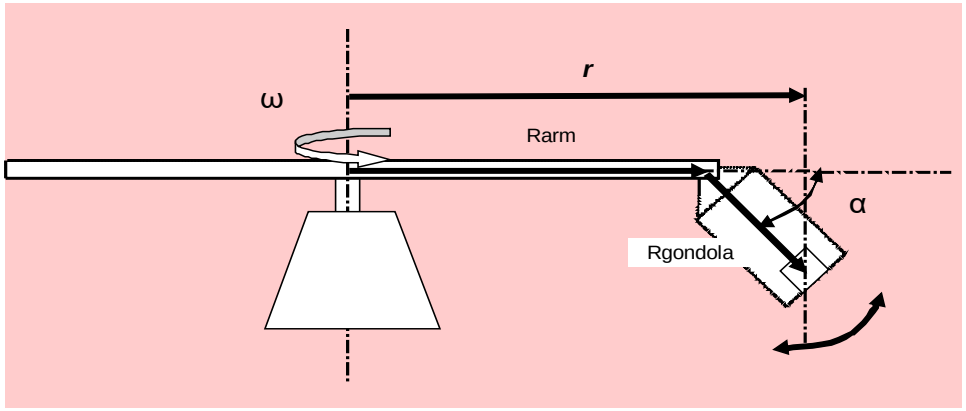

## Operation Data Flow Scheme

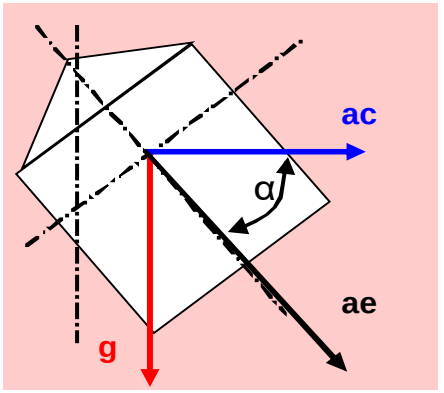


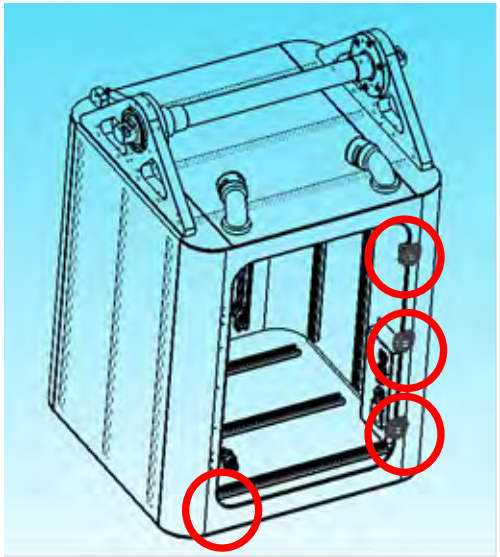

Data / Communication:

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

# LDC Swing-Out / Integration

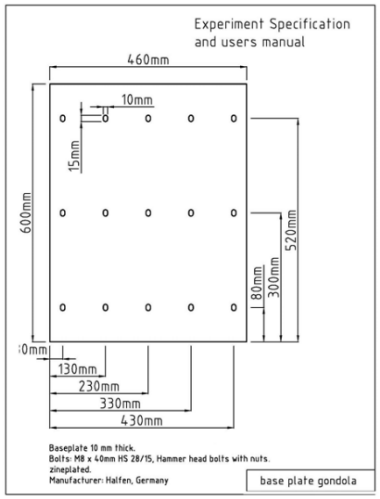


Door clearance: 450× 710 mm (WxH) (max. approximately; round corners, hinges)

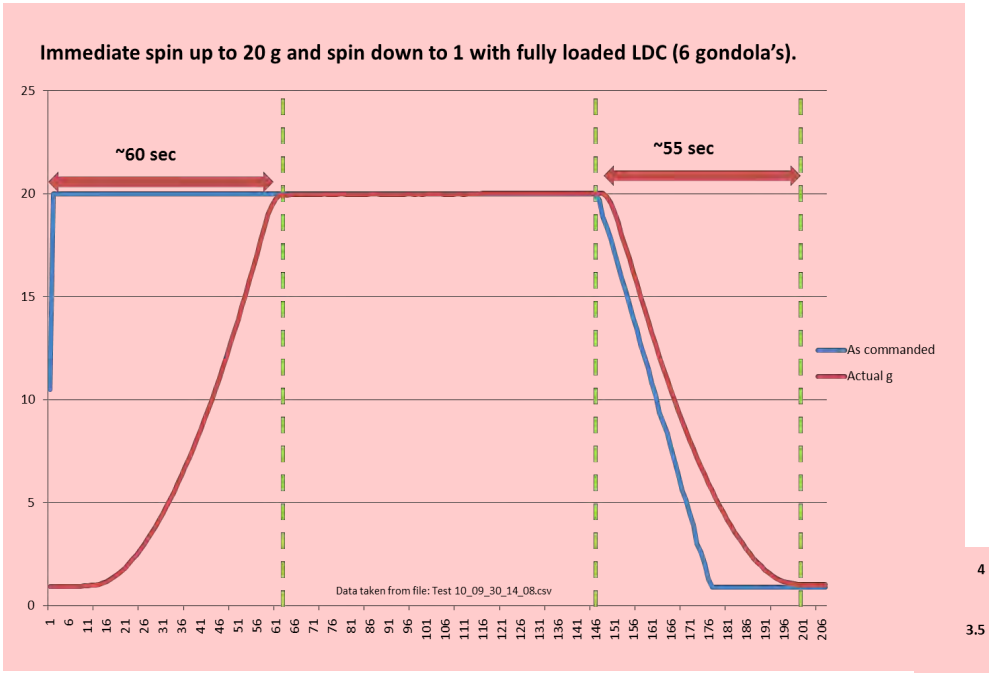
Working space inside: 500×500 × 720 mm

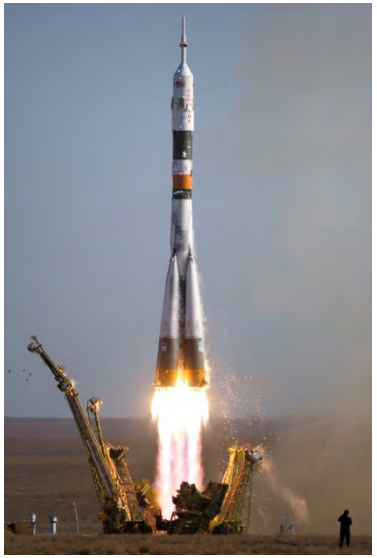


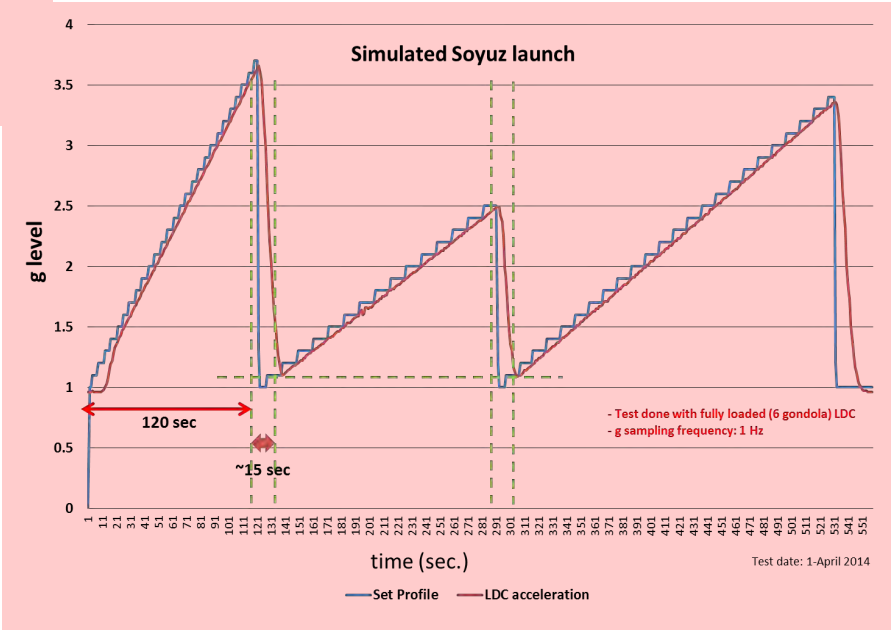

Base plate (mostly not needed)


Gas / fluid containers

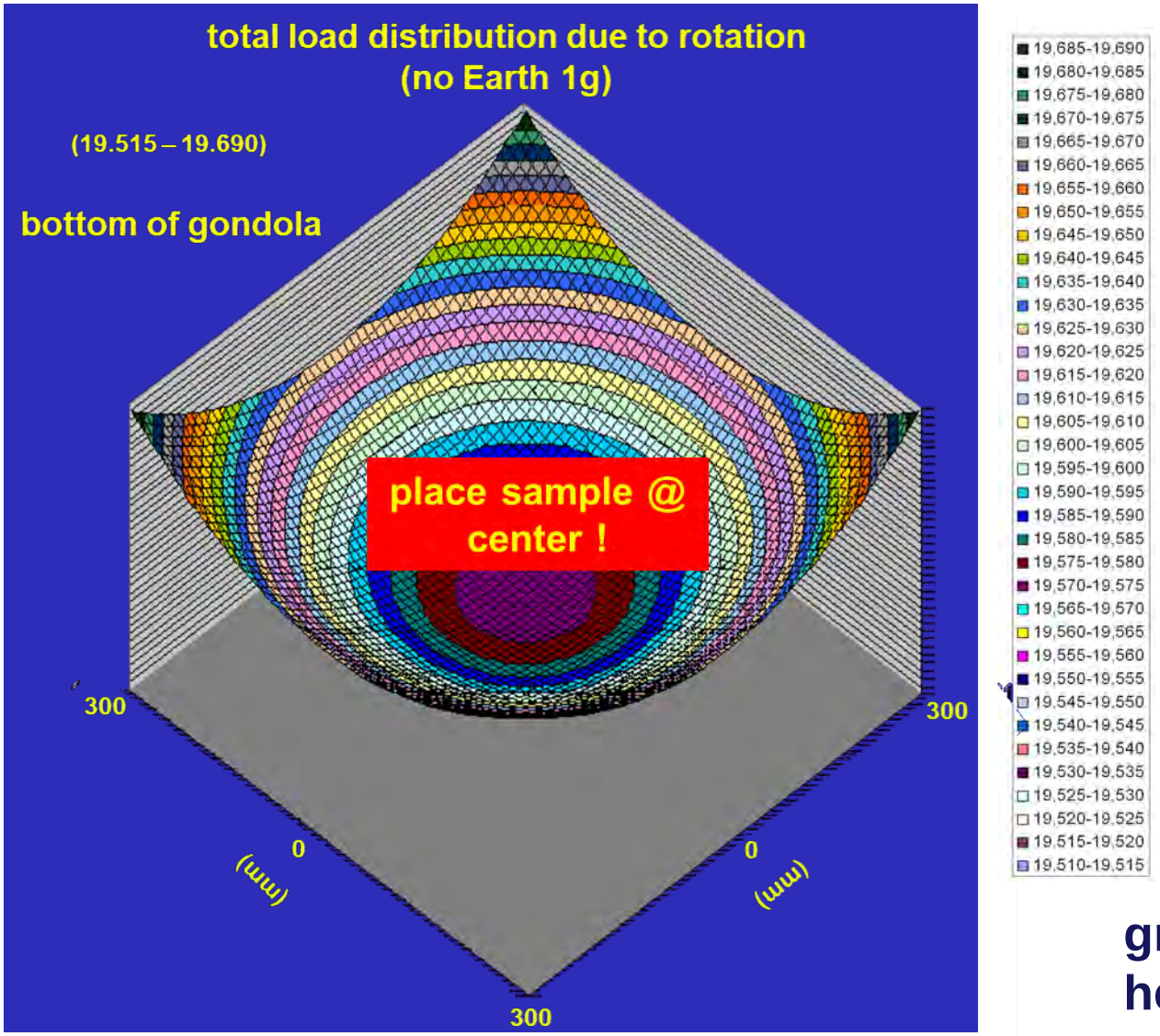
# LDC Start-up & Profiles





# The Gondola : Gravity Profile / Inertial Shear




**20g, longest arm**
**total surface area**
**600×600 mm**

**max. gradient / inertial shear over full surface area:**
**@ 80 cm: 0.6%**
**@ 40 cm: 0.7%**
**@ 0 cm: 0.9%**

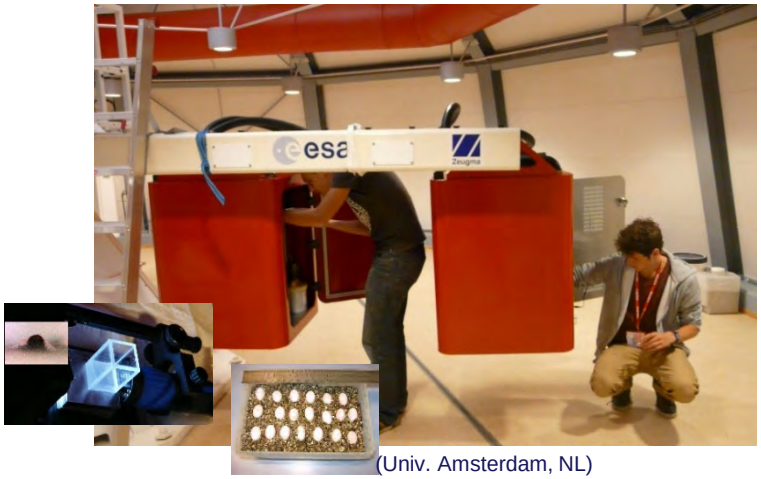
**gradient over gondola height: 10.3%**

**Place sample in center of gondola !!**

*See also:*
*van Loon et al. J Biomechan Eng 2003*

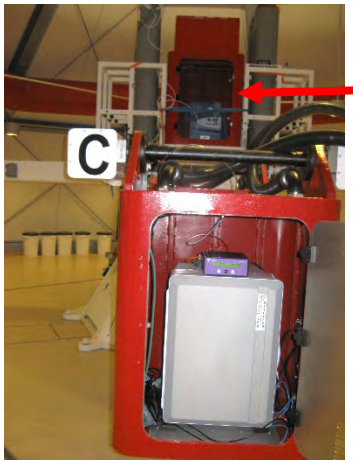
# LDC Experiment Capacity

Multiple g-levels (~factor 2)




(Univ. Amsterdam, NL)

Different temperatures (~4-40 °C)

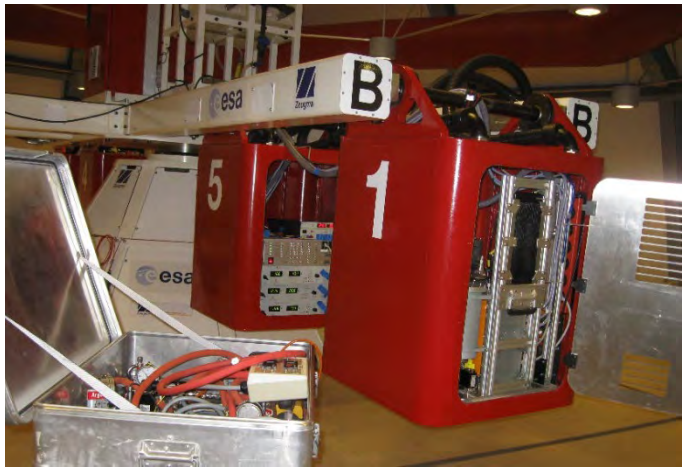



also in center

(Univ. Porto, PT)

increase exp. n !

Multiple Gondolas



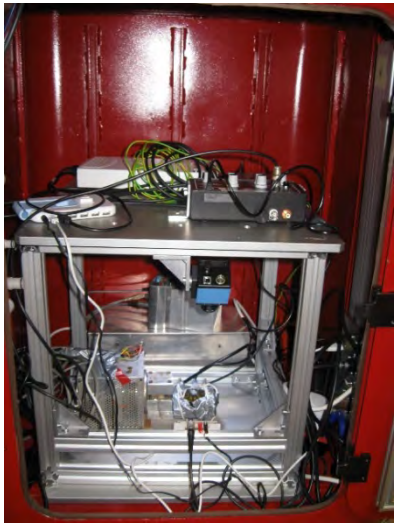

(MAP: Aachen et al. DE)

Lab Pre-integration

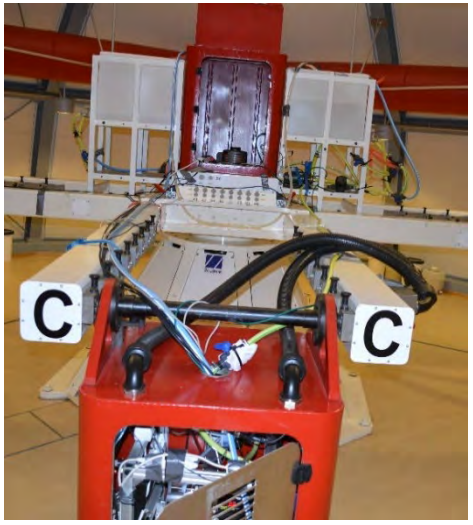
(ASML/TU/e, NL)

# Some Experiment Configurations

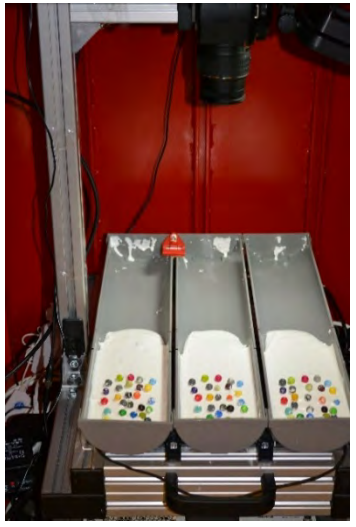
Impact
(Glasgow,UK)



Crab/Neurovestibular
(Aberdeen, UK)

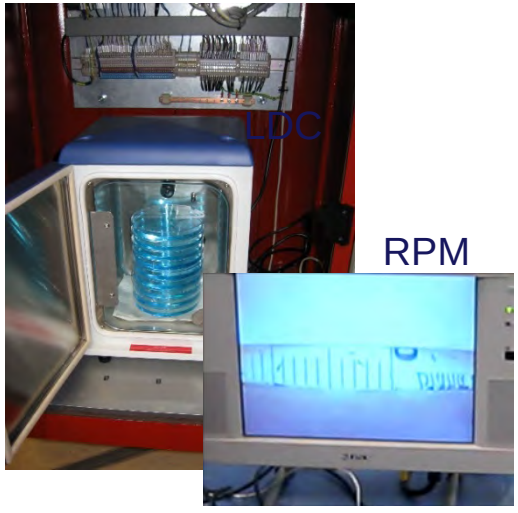



Mass & Heat Transfer
(Thessaloniki, GR)

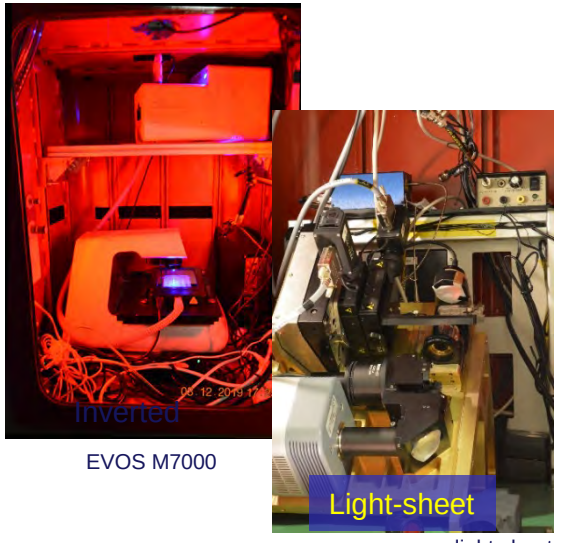


Planetary/Glacier
(Amsterdam, NL)


Bubble Generation
(Tessaloniki, GR)




(Liege, BE)




EVOS M7000

Fluorescence Mics

light sheet

Buoyancy / Coriolis
(Barcelona, ES)

# The HyperGES Proposal : what should be clearly addressed?!

**Why to use the LDC?**

- Use LDC for ‘regular’ hypergravity studies / launch simulations / low gravity extrapolations / microgravity simulations (Reduced Gravity Paradigm)
- Science / application background / rationale (Preliminary data (own / from literature) / References! …)

**How to use the LDC?**

- Identify what parameters to measure and how (either on-line or post exposure) – Expected outcome
- Show a (preliminary) hardware configuration
- Think about schedule / logistics
- How to communicate your results (report / peer reviewed science paper / conference presentation, local and social media …….)

**Before upload…..**

- (re-)Check if ALL parts of the proposal are completed
- ……

**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:**

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

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

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

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

material sciences

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

Other topics / background

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

# Any question / remarks ?!
# Don’t wait asking !!

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j.vanloon@amsterdamumc.nl
+ 31 653700944 (mobile)

TEC-MMG LIS Lab web URL:
http://m.esa.int/Our_Activities/Space_Engineering_Technology/Life_Physical_Sciences_and_Life_Support_Laboratory