HyperGES
The ESA Large Diameter Centrifuge (LDC)

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1975 Signing of ESA Convention

10 MEMBER STATES
MEMBER STATES

22
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.
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

the ‘Center of Gravity’
TEC-MMG Lis Lab @ ESA-ESTEC
Life- and Physical Science Instrumentation Laboratory (LIS)

Meeting room
Clean room
Life sciences lab
Support lab
Plant chamber
Flow benches
MidiCAR
RPMs

+ other ESTEC labs!!

Ej013A
Ej013
Ej015
Ej026
Ej02B
Ej031
Ej032
Ej034

Workbench
LC/MS
E.g. autoclaves
Clinostats
LDC

Jack van Loon
Alan Dowson
Francois Gaubert
Robert Lindner
LisLab – LDC Facilities @ ESA-ESTEC
Life- and Physical Science Instrumentation Laboratory (LIS)

- main lab
- support lab
- meeting room
- ‘wet lab’
- small ‘workshop’
- LDC control room
- LDC prep lab
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
- ....

**Gravity Continuum**

**The ‘Reduced Gravity Paradigm’ (RGP)**

- 1g
  - General space-flight
  - micro-gravity response
  - adaptation time
- μg
  - time
- 3g
  - full adaptation (?!)
  - age x
- 2g
  - full adaptation (?!)
- 1g
  - ‘reduced gravity’ response
  - adaptation time
LDC Main Properties

diameter : ~ 8 meter
arms : 4

\[ \text{g levels} : \text{various (8 locations / arm)} \]

\[ \text{exp. Volume} : 7 \text{ 'gondolas'} ; 6 \text{ rotating} \ (60 \times 60 \times 80 \text{ cm}) \]

center gondola : control / g-sensitive materials

\[ \text{g vector} : \text{swing-out} : \]

\[ \text{payload} : 80 \text{ kg per gondola} \ (\text{total 210 kg incl. gondola}) \]

\[ \text{g load} : 20 \times g \text{ fully loaded} \]

\[ \text{motor} : 22 \text{ kW} \ (\text{Siemens}) \]

Run Time: 8817.9 h
Revolutions: 13938224
(Dec 2017)
The Gondola: Main Properties

- Temperature sensor
- Analogue/digital 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 connections
- Gondola connections
- 9 analogue video lines / 8 digital video lines
- Experiment fixation
- Gas + water 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
Immediate spin up to 20 g and spin down to 1 with fully loaded LDC (6 gondola's).
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%

See also: van Loon et al. J Biomechan Eng 2003
LDC Experiment Capacity

Multiple g-levels (~factor 2)

Different temperatures (~4-40 °C)

also in center

Multiple Gondolas

increase exp. n !

Lab Pre-integration

(Univ. Amsterdam, NL)

(Univ. Porto, PT)

(MAP: Aachen et al. DE)

(ASML/TU/e, NL)
Some Experiment Configurations

- **Impact** (Glasgow, UK)
- **Crab/Neurovestibular** (Aberdeen, UK)
- **Mass & Heat Transfer** (Thessaloniki, GR)
- **Planetary/Glacier** (Amsterdam, NL)

- **Buoyancy / Coriolis** (Barcelona, ES)
- **Bubble Generation** (Tessaloniki, GR)
- **Fluorescence Mics**

- **5 camera’s**
- **RPM**
- **Inverted**
- **EVOS M7000**
- **Light-sheet**
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://doi.org/10.1016/j.ijmultiphaseflow.2019.03.029](https://doi.org/10.1016/j.ijmultiphaseflow.2019.03.029)
- [DOI: https://doi.org/10.1103/PhysRevE.91.053009](https://doi.org/10.1103/PhysRevE.91.053009)
- [DOI: 10.1209/0295-5075/110/24001](https://doi.org/10.1209/0295-5075/110/24001)
- [https://doi.org/10.1016/j.fbp.2017.02.001](https://doi.org/10.1016/j.fbp.2017.02.001)
- [https://doi.org/10.1103/PhysRevE.91.053009](https://doi.org/10.1103/PhysRevE.91.053009)

**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](https://doi.org/10.1016/j.materresbull.2014.03.013)
- [DOI: 10.1140/epjd/e2013-40408-7](https://doi.org/10.1140/epjd/e2013-40408-7)

**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: 10.1038/s41598-018-24942-7](https://doi.org/10.1038/s41598-018-24942-7)
- [https://doi.org/10.7717/peerj.6055](https://doi.org/10.7717/peerj.6055)
- [http://dx.doi.org/10.3390/ijms20030720](https://doi.org/10.3390/ijms20030720)
- [https://doi.org/10.1007/s12217-012-9301-1](https://doi.org/10.1007/s12217-012-9301-1)

**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](https://doi.org/10.1007/s12217-016-9531-8)
- [http://dx.doi.org/10.3389/fspsa.2016.00002](https://doi.org/10.3389/fspsa.2016.00002)
- [doi:10.1038/srep07730](https://doi.org/10.1038/srep07730)
- [http://dx.doi.org/10.1155/2014/964203](https://doi.org/10.1155/2014/964203)
- [doi:10.1007/s12217-012-9334-5](https://doi.org/10.1007/s12217-012-9334-5)

**Animal physiology**
- [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/10.1007/s12217-012-9334-5](https://doi.org/10.1007/s12217-012-9334-5)
- [doi:10.1038/srep07730](https://doi.org/10.1038/srep07730)
- [http://dx.doi.org/10.3390/ijms20030720](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: 10.1016/j.ijheatmasstransfer.2018.05.151](https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151)

**Technology**
- [DOI: 10.1002/adv.21937](https://doi.org/10.1002/adv.21937)

**Material sciences**
- [DOI: https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151](https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151)

**Other topics / background**
- [DOI 10.1007/s12217-015-9462-9](https://doi.org/10.1007/s12217-015-9462-9)
Any question / remarks ?!
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