HyperGES: The ESA Large Diameter Centrifuge (LDC)

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European Space Agency : ESA

1975 Signing of ESA Convention

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MEMBER STATES
2020

22 MEMBER STATES
**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.
the ‘Center of Gravity’
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
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)

Meeting room
Clean room
Life sciences lab
Flow benches
Plant chamber
FFC furnace
MidICAR
RPMs

+ other ESTEC labs!!

Workbench
LC/MS
E.g. autoclaves
Clinostats
LDC

Link: ESA TEC-MMG lab
LisLab – LDC Facilities @ ESA-ESTEC
Life- and Physical Science Instrumentation Laboratory (LIS)
LDC Main Properties

diameter : ~ 8 meter
arms : 4

\( g \) levels : various (8 locations / arm)

exp. Volume: 7 ‘gondolas’ ; 6 rotating \((60\times60\times80 \text{ cm})\)

center gondola: control / \( g \)-sensitive materials

\( g \) vector : swing-out: \( \downarrow \)

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

g load : 20\( \times g \) fully loaded

motor : 22 kW (Siemens)

for HyperGES : max 2 weeks use of LDC
The Gondola : Main Properties

- Experiment fixation
- Power / data
- Anal. / dig. video / PoE channels
- RS-232 serial channel
- Ethernet channel
- USB-3 channel
- 230 V/6 amp line
- Fixation
- Gas lines (#)
- Water supply
- Forced ventilation
- Temp. sensor
- Gondola connections
- Gas + water lines
- 9 analogue video lines / 8 digital video lines
LDC Data / Electronics Interfaces

Operation Data Flow Scheme

Data / Communication:
- Remote PC (Win10 / (Win7/XP!), non-Win systems)
  (own PC – have administrator rights!!)
- (TeamViewer)
- Exp. dedicated

Link: LDC User Manual
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
The Gondola: Gravity Profile / Inertial Shear

Total load distribution due to rotation (no Earth 1g)

Bottom of gondola

Place sample @ center!

20g, longest arm total surface area 600x600 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

Reference Link

Best place sample in center of gondola!!
LDC Start-up & Profiles

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

~60 sec

~55 sec

Data taken from file: test_10_09_80_14_0E0.csv

Simulated Soyuz launch

g level

120 sec

~15 sec

time (sec.)

Test date: 1 April 2014

Set Profile

LDC acceleration

THE EUROPEAN SPACE AGENCY
LDC Experiment Accommodation

*Multiple g-levels (~factor 2)*

*Different temperatures (~4-40 °C)*

*Use Multiple Gondolas*

*Lab Pre-integration*

*increase exp. n!*

(Uiniv. Amsterdam, NL)

(Univ. Porto, PT)

(MAP: Aachen et al. DE)

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

Scaling effects:
- $g = N$
- Length: $1/N$
- Time: $1/N^2$
- Mass: $1/N^3$
Some Experiment Configurations

Impact
(Glasgow, UK)

Crab/Neurovestibular
(Aberdeen, UK)

Mass & Heat Transfer
(Thessaloniki, GR)

Planetary/Glacier
(Amsterdam, NL)

5 camera's

Bubble Generation
(Thessaloniki, GR)

RPM / clinostat

Fluorescence Mics

EVOS M7000

Light-sheet
Some peer reviewed papers from previous LDC studies (non-exhaustive list) on general, cell 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: 10.1007/s12217-015-9462-9

Fluid physics
- doi.org/10.1016/j.imultiphaseflow.2019.03.029
- https://doi.org/10.1016/j.fpms.2017.02.001
- https://doi.org/10.1103/PhysRevE.91.053009
- DOI: 10.1209/0295-5075/1/10/24001
- DOI: 10.1007/s10035-013-0403-2
- https://doi.org/10.1016/j.expthermflusci.2015.01.011
- https://doi.org/10.1007/s12217-012-9301-1

Cell biology:
- DOI: 10.1016/j.ejob.2021.03.013
- DOI: 10.1002/jbm.a.37215
- doi: 10.1016/j.bpj.2021.01.021
- https://doi.org/10.1001/j.ij.2019.03.038
- doi: 10.1089/jcd.2017.0206
- DOI: 10.1089/rsf.2016.0688.
- doi: 10.2147/JN.576329
- DOI: 10.1371/journal.pone.0144269.
- DOI: 10.1089/ten.tea.2012.0267

Plasma physics
- doi.org/10.1088/1361-6595/aa6ee8.
- doi.org/10.1088/0963-0252/24/7/022002
- http://dx.doi.org/10.1016/j.materresbull.2014.03.013
- DOI: 10.1140/epjd/e2013-40408-7

Plant biology
- doi:10.1038/s44598-018-24942-7
- 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/jats28-020-00113-7
- DOI: 10.7717/peerj.6055.
- https://doi.org/10.3390/ijms20030720
- DOI: 10.1007/s12217-012-9343-5

Geology/planetary
- doi:10.1098/rspa.2016.0673

Technology
- doi:10.1016/j.bpg.2021.03.021
- DOI: 10.1002/adv.21937
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! …)
- Duration of the experiment (max. 2 weeks)

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

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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=PLaQqa4cng0GGgCeqAwo0bWTPAdB2uHICx&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