

ICE-cube

**Investigating Cold adapted organisms as model organisms
for a Europa ocean environment in CubeSat based hardware**

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Knowledge for Tomorrow



ICE-cube

Proposal for ILSRA-2014

International Research Announcement for Research in Space Life Sciences at the International Space Station

“The Proposal received a favourable scientific and technical review and has been selected for the definition phase.”

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Petra Rettberg, D

Lyle Whyte, CA



Recent passive astrobiological space exposure experiments

- **EXPOSE-E, EXPOSE-R, EXPOSE-R2**

- space environment
- Mars environment
- early Earth environment

- **Survival I-III, Marstox I and II on Biopan/ Foton**

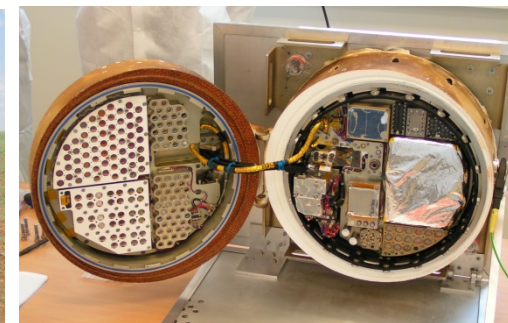
- space environment
- Mars environment

Operations

- pre-flight test program
- flight preparation, integration
- Mission Ground Reference experiment



EXPOSE-E, EuTEF, on the outside of the Columbus Module, ISS. Credit: NASA



EXPOSE MGR in the PSI DLR. Credit: DLR

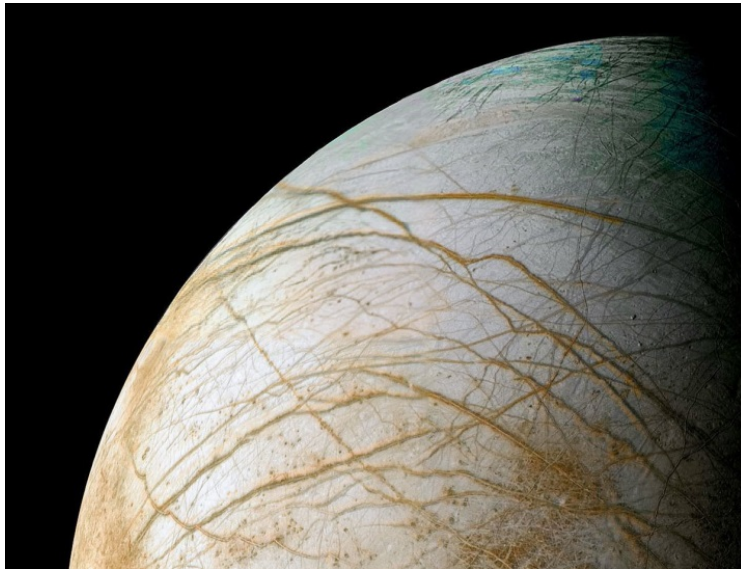
Biopan 5 on Foton, Marstox II, BIOPAN 6. Credit: ESA



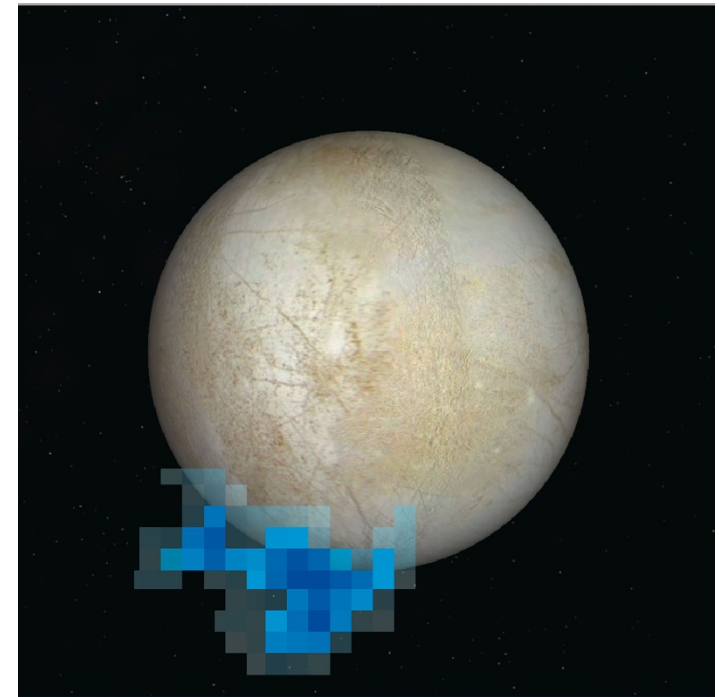
Europa, a possible habitable world

Europa's subsurface ocean is considered a possible habitable niche in our solar system outside of Earth

- Ocean below ice surface, liquid water, high salt content
- communication between subsurface ocean and ice shell



Cracks in the ice of Europa. Credit: NASA/ESA



Water plumes detected by Hubble,
Credit: NASA/ESA



Europa, a possible habitable world

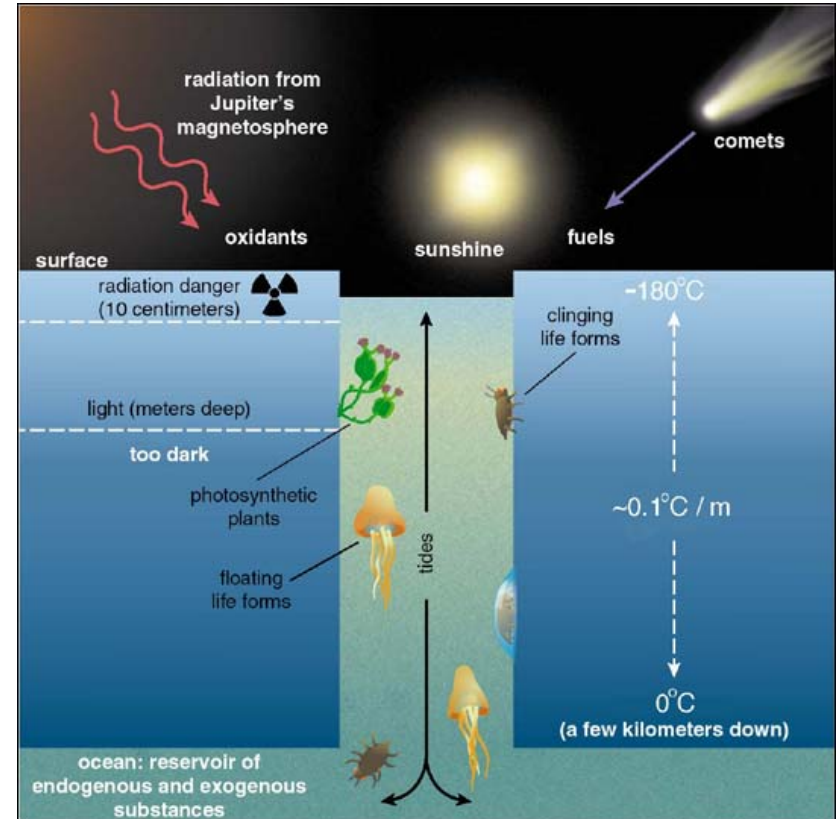
ICE-cube:

to test the hypothesis that for a limited time period selected (terrestrial) extremophile salt and cold adapted organisms from the three domains of life on Earth

can survive and possibly grow in environmental conditions similar to those at the very near subsurface on Europa.

Adverse conditions:

- radiation (Jupiter)
- oxidants
- UV
- low temperature / temperature oscillation
- high salt concentration



Sketch of tidal flow through crack and potentially habitable setting, linking the surface with the ocean.

Credit: R. Greenberg



Biological samples

Test organisms:

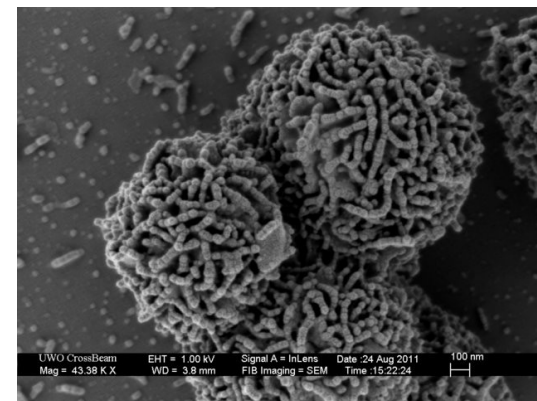
The bacterium *Planococcus halocryophilus* Or1

- isolated from high arctic permafrost,
- grows and divides at -15°C
- laboratory culture established
- cold adaptation responses thoroughly investigated (physiological, genomic and transcriptomic analyses)

The eukaryotic yeast *Rhodotorula sp. strain JG-1b*

- isolated from Antarctica
- grows at temperature below -10°C
- grows at salinity of 15% NaCl, 12% perchlorate

Lyle White, Canada



Planococcus halocryophilus SEM image. Credit: Lyle Whyte



Rhodotorula colonies. Credit: Lyle Whyte



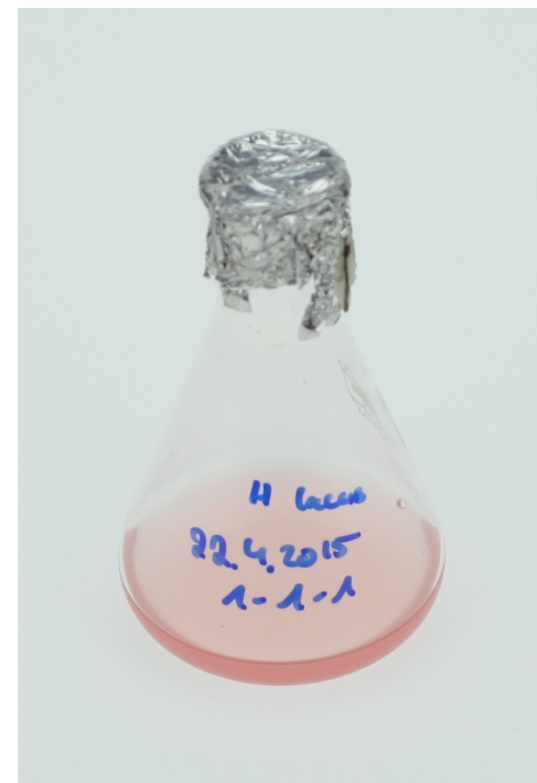
Biological samples

The Archaea *Halorubrum lacusprofundi*

- isolated from Deep Lake with salinity of 10 times concentrated sea water
- grows at temperatures of -14 °C to -18 °C,
- culture currently established at DLR
Elke Rabbow, Germany

Methanogenes tbd
proposed by reviewer

Halorubrum lacusprofundi
Credit: DLR



Model organisms:

Halobacterium salinarum

- grows at 20% NaCl

Deinococcus radiodurans

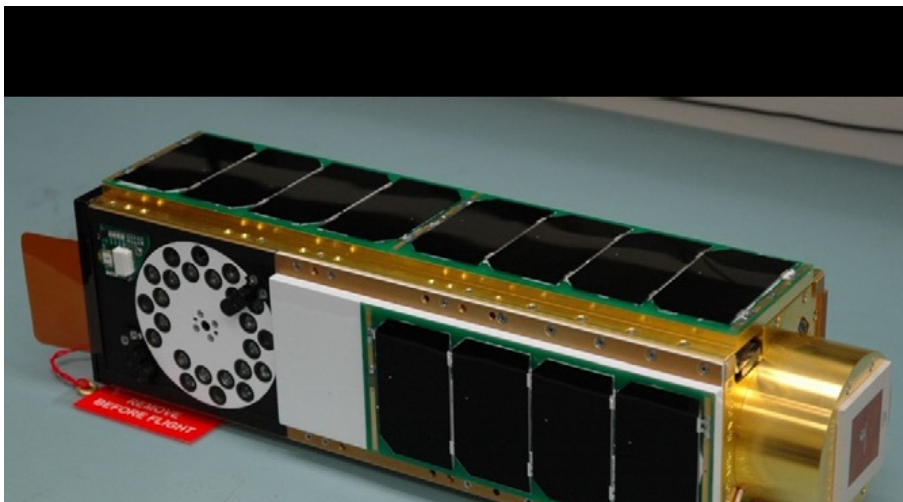
- high radiation resistance
- Stefan Leuko, Germany

Spores of *Bacillus subtilis*

- vacuum resistant, space experiments
- Corinna Panitz, Germany



Cube based HW - Idea



Credit: NASA Ames Research Center

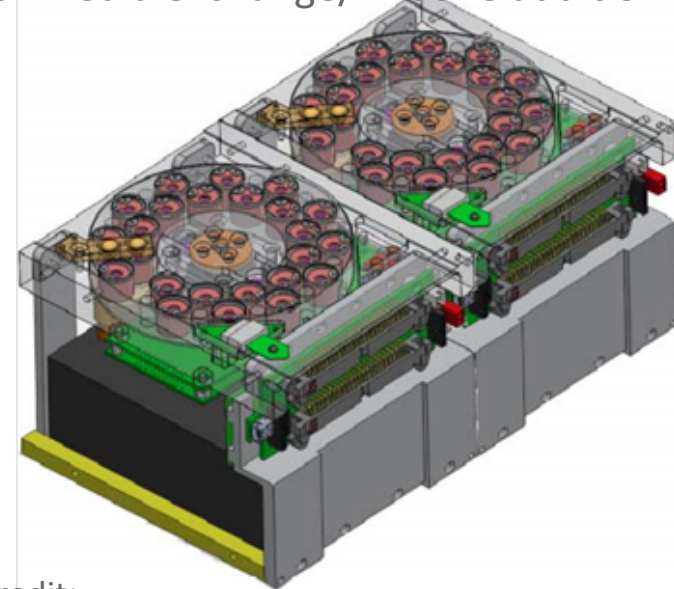
NASA Ames O/OREOS 3U satellite

- two independent payload instruments (1U each) + 1U bus
- one circular array of sample cells at the left end of the satellite is exposed to space

For ICE-cube: 2 sample wheels in 2 units are foreseen

Similar to OREOCube payload:

- Two independent sample wheels for 24-sample cell carrier (+24 dark) each
- integrated UV/Vis/NIR spectrometer
- transparent windows for UV-exposure
- fixative reservoir, media reservoir, tubing, pumping tbd
- for media exchange/ fixative addition



Credit:

<http://www.lpi.usra.edu/meetings/lpsc2013/pdf/2498.pdf>



The space experiment

Upload

- fully equipped ICE-cube facility (for ISS: accommodation on external exposure platform)

Start of experiment

- *start sample growth by medium addition tbd*
- OD measurement of all samples at t_0 (start conditions, baseline)

Experiment performance

- regular measurement of position with respect to sun
- regular sample positioning for UV irradiation below MgF_2 window
- regular OD measurements at tbd times for growth determination
- *addition / exchange of growth medium at tbd times*
- data acquisition and download for analysis and optional experiment adaptations

Experiment termination

- positioning of all samples in dark position
- *addition of fixative tbd*
- download of sample wheels *or hole ICE-cube tbd* for analysis



Data download

Science data:

- extraterrestrial LEO solar UV spectrum underneath MgF2 window (spectroradiometer)
- OD measurement of sample for growth determination (spectroradiometer)
- active dosimeter for flux of protons, electrons and heavy charged particles at the sample location

Environmental data:

- extraterrestrial LEO solar UV spectrum (spectroradiometer)
- ionizing radiation (active dosimeter)
- temperature oscillations at sample site (temperature sensors)
- solar insolation angle (photo sensor)

Housekeeping data:

- health
- status parameter including
- sample wheel position

Telecommand for adjustments of automatic experiment schedule, e.g. UV irradiation times



General Missions (requirements)

Space exposure :

- duration > 6 months tbd, measure as long as possible
- return to ground for post flight sample analysis desired (ISS foreseen)
- any orbit (ISS foreseen)
 - high inclination, i.e. higher ionizing radiation beneficial but not necessary (internal radiation source)
- “cold” position (tbd for ISS)
- any other mission
 - Moon
 - interplanetary
 -

MGR requirements

Parallel ground based experiment mandatory for analysis

- flight identical H/W for MGR experiment and for preflight test
- flight parameter data for MGR experiment
- access to simulation facilities (available at DLR)



PSI DLR. Credit: DLR



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Thank you for your attention



PSI DLR. Credit: DLR

