DLR Explorer Initiatives

Enabling technologies for future robotic space exploration

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Purpose of DLR Explorer Initiatives

- Most attractive places for the search for extraterrestrial life, namely the icy water worlds of the outer solar system and still also caves and lava tubes on Mars, are hard to access

- Enabling technologies for such future L-class missions are required
  - Plan:
    - ✓ identification of regions of interest for search for extraterrestrial life
    - ✓ identification of key technologies needed for exploration of these sites
    - ✓ development and field testing in terrestrial analog scenarios
    - ✓ further raising of TRL once suitability is proven
    - ✓ proposal to ESA as a complex L-class mission

- Focus on different degrees of system autonomy → sophisticated AI required!

- DLR Explorer Initiatives: long term strategy for development and demonstration of the required technologies → funding for projects of DLR Explorer Initiatives provided by DLR Space Administration within Germany's national Space Program

VaMEx Initiative

- *VaMEx – Valles Marineris Explorer:* fast moving collaborative heterogeneous robotic swarm (rovers, hominids and VTOL-UAV's) for large area exploration; (slow) mobile carrier module for transfer to Mars, landing in smooth terrain, acting as battery charging station; identification of ROI's by support satellite from orbit; identification of POI's by fast flying scout UAV's

- *Addressed future space application:* highly automated exploration of Martian canyon Valles Marineris

- *Terrestrial analog scenario:* campaigns in discussion (e.g. Canary Islands) for 2021

- *Status:* ongoing development, readiness for ground operations in a space mission assumed for 2035

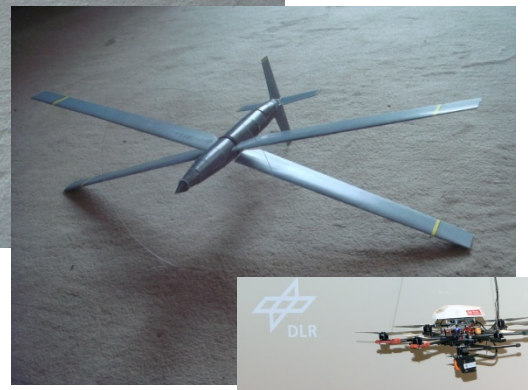
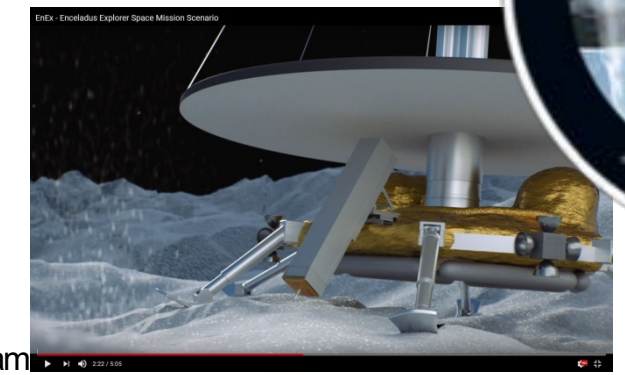


Photo credits (left side): OHB System AG – VaMEx/SKAD team

Photo credit (right side): VaMEx team

EnEx Initiative

- *EnEx-IceMole:* fully maneuverable melting probe equipped with technology for positioning, navigation and clean sampling
- *Addressed future space application:* autonomous in-ice approach towards water filled crevasse on Enceladus for water sampling and analysis (~200 m below surface)
- *Terrestrial analog scenario:* successful demonstration of clean access sampling at Blood Falls, Antarctica, in Nov/Dec 2014 in international collaboration (MIDGE Science Team: J. Mikucki, S. Tulaczyk); further campaigns in discussion (e.g. Mount Erebus, Antarctica)
- *Status:* ongoing development, readiness for ground operations in a space mission assumed for 2045



Credits: EnEx team

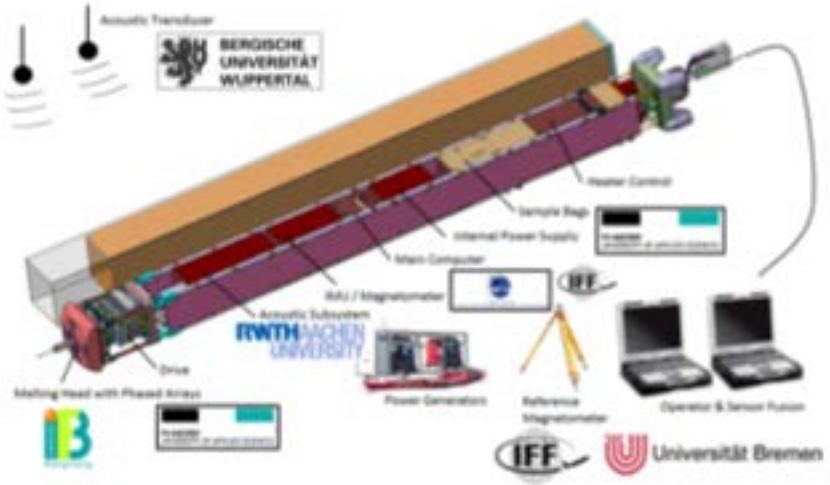
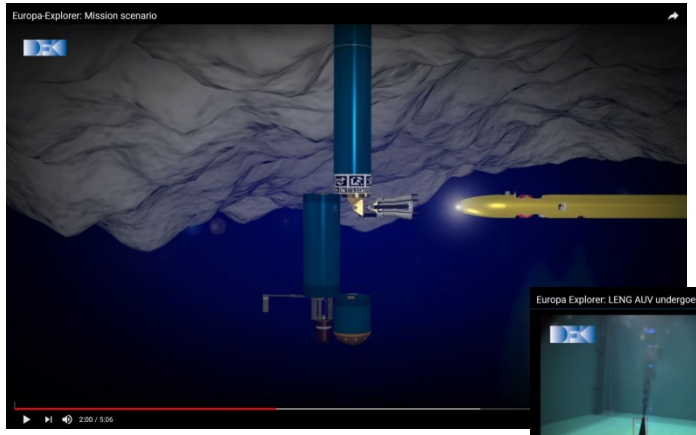
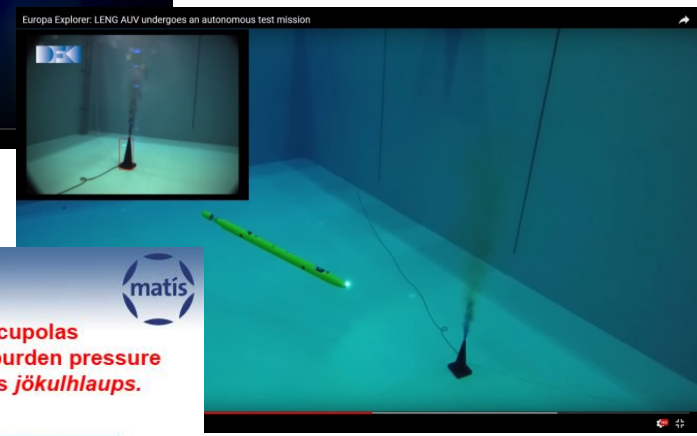


Photo courtesy of EnEx field test team, FH / RWTH Aachen

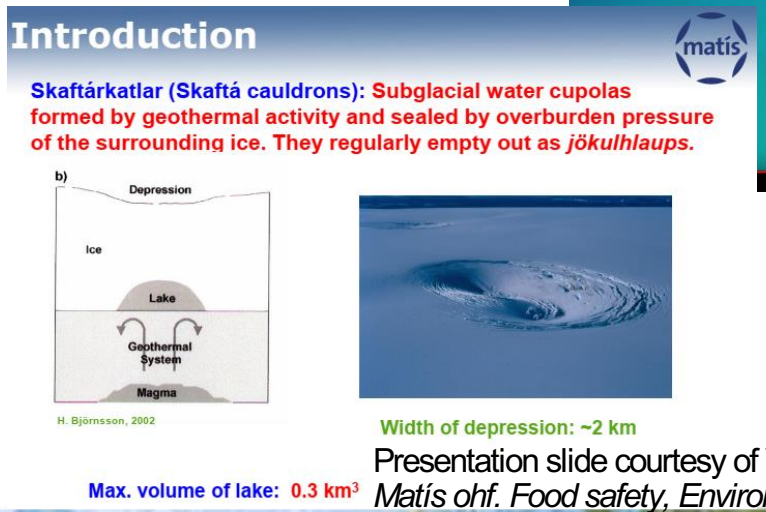
EurEx (part of EnEx Initiative)

- Ice shuttle *"Teredo"* and AUV *"Leng"*: fully autonomous complex exploration system
- *Addressed future space application:* melting through the 15 - 25 km thick ice surface of Jupiter's moon Europa; deployment of AUV for extensive exploration of Europa's ~100 km deep water ocean and seabed; look for hydrothermal vents (black smokers); sample and analysis; communication of results to stationary lander on Europa's surface
- *Terrestrial analog scenario:* sample return from subglacial lake of geothermal origin on Iceland envisaged for 2021/22 in collaboration with *Matís ohf. Food safety, Environment and Genetics*, Viggó Marteinsson
- *Status:* ongoing development, readiness for exploration activity in a space mission assumed for 2050





Credits: DFKI EurEx team



Presentation slide courtesy of Viggó Þór Marteinsson, *Matís ohf. Food safety, Environment and Genetics*

TRIPLE / nanoAUV (in planning: 2019 – 2024)

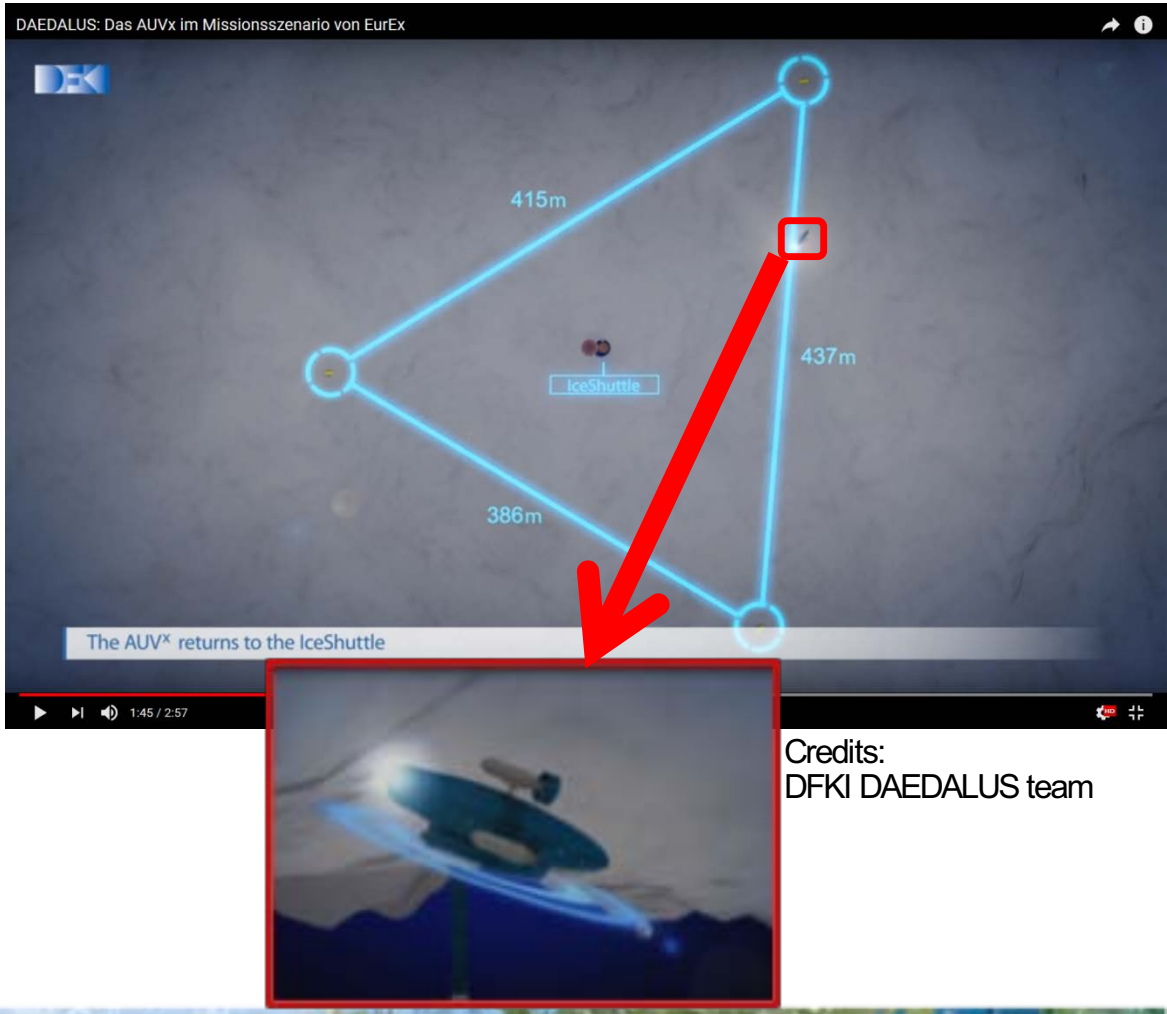
Technologies for Rapid Ice Penetration and subglacial Lake Exploration

The TRIPLE project requires three main HW parts:

I. nanoAUV
- DFKI's AUVx concept as starting point for development of miniaturized autonomous underwater vehicle as payload for a shuttle melting probe
- Tasks:
  - ➢ basic exploration capability
  - ➢ acquisition of fundamental scientific data (e.g. temperature profile, salinity, pH, ...)
  - ➢ sample return (water, lakebed soil, ...)

II. Shuttle melting probe (contamination-free access to a subglacial lake in Antarctica)

III. AstroBioLab (automatized sample analysis lab)

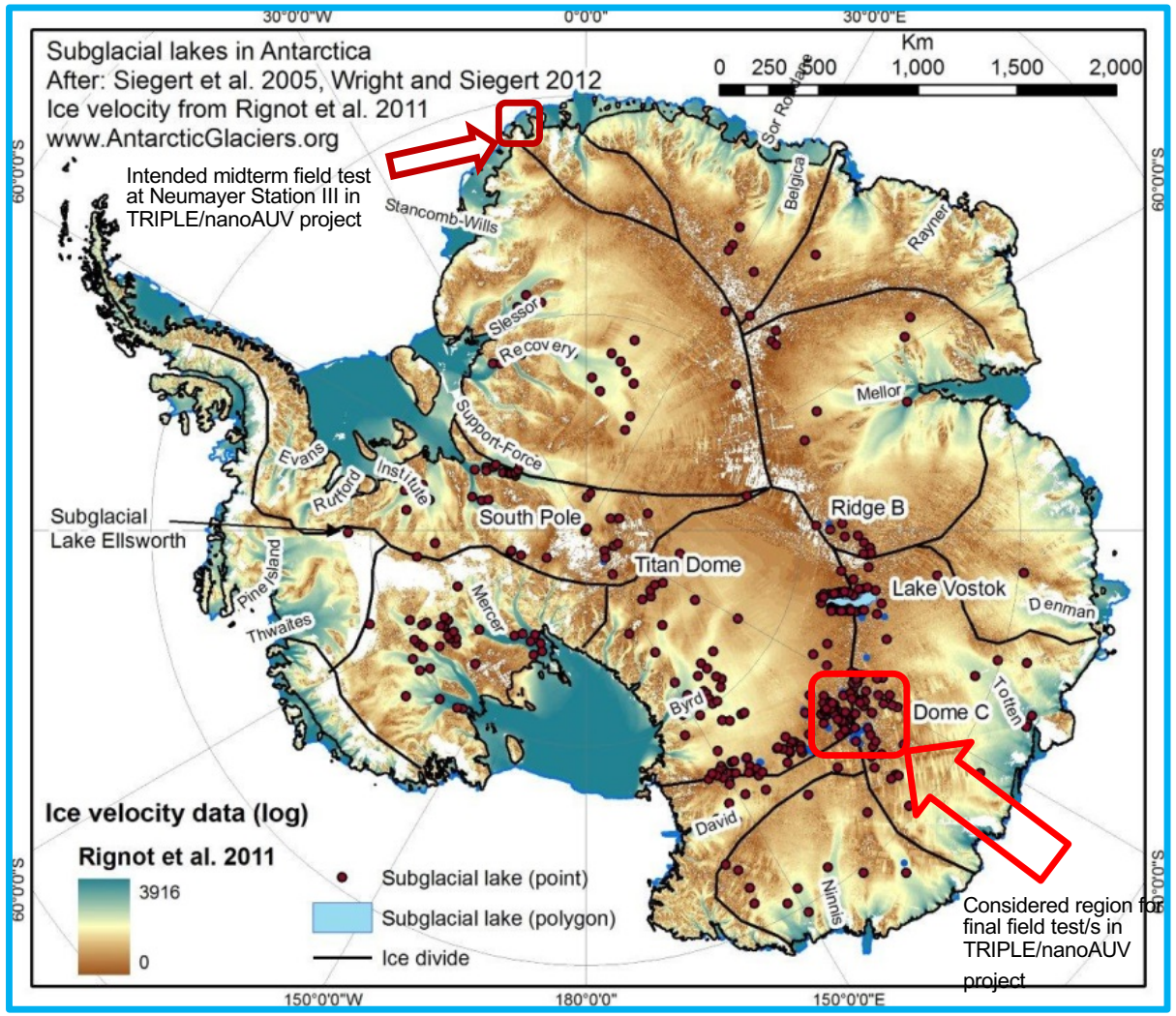


Credits:
DFKI DAEDALUS team

TRIPLE / nanoAUV (in planning: 2019 – 2024)

- Nov/Dec 2022: Field test campaign at *Neumayer III* station, located on the ~200 metres (660 ft) thick Ekstrom Ice Shelf, Antarctica

- Nov/Dec 2024: Demonstration of an Europa-similar scenario with fast melting IceShuttle through ~3.3 km thick ice sheet in Dome-C-region, Antarctica. Base camp: Concordia Research Station. Intended objectives:
  - ❖ contamination-free access to a subglacial lake with exploration and sample return (sample analysis foreseen in AstroBioLab on surface)
  - ❖ repeat demonstration at another Dome-C subglacial lake



Summary and Conclusions

✓ The space exploration scenarios addressed in DLR Explorer Initiatives are ambitious: development of several different key technologies is required.

✓ DLR Explorer Initiatives offer German engineers an attractive *„playground“* for inventions, development and testing of new technologies, that shall enable future robotic space exploration missions.

✓ Field test campaigns in terrestrial analog scenarios are envisaged.

✓ Once all needed new technologies are available and have proven their suitability, it is declared objective of DLR Space Administration to submit a proposal for an appropriate L-class mission to ESA

✓ International collaboration in the development of technologies as well as in field test campaigns is appreciated:

Open minded discussions on possible collaborations are welcome anytime!