The COMEX hydrosphere for simulations of future human and robotic missions to the MOON

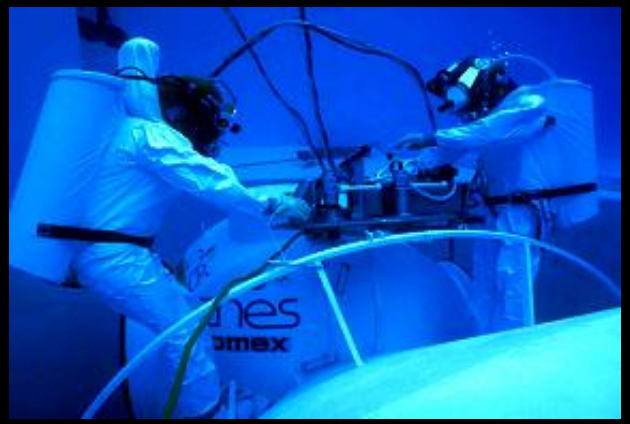
ESTEC
14/12/2015

I – Presentation of Comex

COMEX and its expertise

The *Compagnie Maritime d'Expertise* (COMEX) was founded in 1961 by Henri Germain Delauze (1929-2012). It became a worldwide pioneer in the development of technologies for human and robotic intervention in extreme environments.

Saturation dive 180m under ice (1969)



Astronaut EVA training (1990)

HYDRA-10 deep-diving record (1992)

REMORA2000 submarine (1995)

COMEX and its expertise

Marine Operations

- Research Vessels, ROV and submarines
- Interventions to 2500 m depth
- Activities in
  Survey
  Defence/Archology / Biology
  Subsea mining
  Marine Renewables

Hyperbaric Engineering

- Hyper- and hypobaric chambers for hospitals, research and industry
- Maintenance of hyper- and hypobaric systems
- Test of equipment in various pressure chambers

Robotics and Vision

- Underwater 3D reconstruction
- Camera systems
- Subsea robotics

Space and Innovations

- Underwater simulations of EVA / IVA
- Habitat development
- Life-Support Systems

II – Introduction to Hydrosphere

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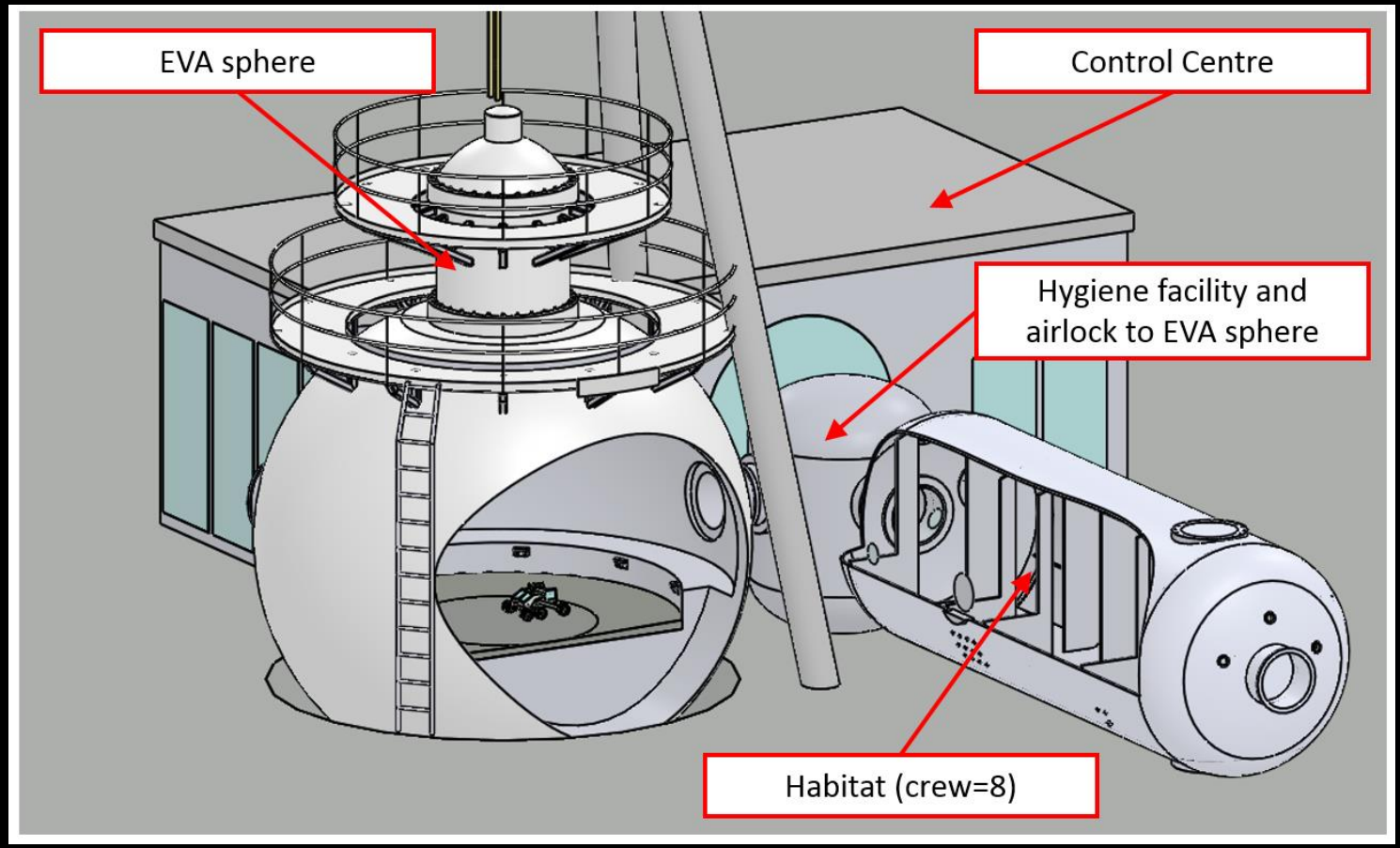
- Facility initially developed for deep-sea offshore diving simulations
- Tried up to 450bar – 4500m and down to 11mbar
- Today dedicated to space mission simulations

- EVA sphere : 5m-diameter sphere for EVA simulations or robot testbed
- Habitat: 33 cubic meters habitat that can host a crew of 8
- Hygiene facilities: WC and shower for the crew
- Control center for tele-science or remote control
- Inner airlocks: two airlocks between the Habitat and the EVA sphere



	MIN temperature	MAX temperature	**Pressure**	Darkness [yes/no]	Geomorphology [yes/no]	Geochemistry [yes/no]
Moon	- 173 °C	126°C	3 x 10^{-13} mbar	PEL PSC Day/Night	dust, boulders, steep crater borders	Lunar regolith
Mars	- 89°C	- 31°C	6.36 mbar	Day/Night	dust, boulders	Martian regolith
Earth's analogues	- 89°C (Antarctica)	56°C (Death Valley)	382 mbar (Everest)	Yes	Yes (several sites)	Yes (Rio Tinto)
Hydrosphere	-100°C (partly)	+200°C (partly)	11mbar	Yes	Yes (-5m diameter)	Yes (Regolith simulants)

III – Robotics testbed

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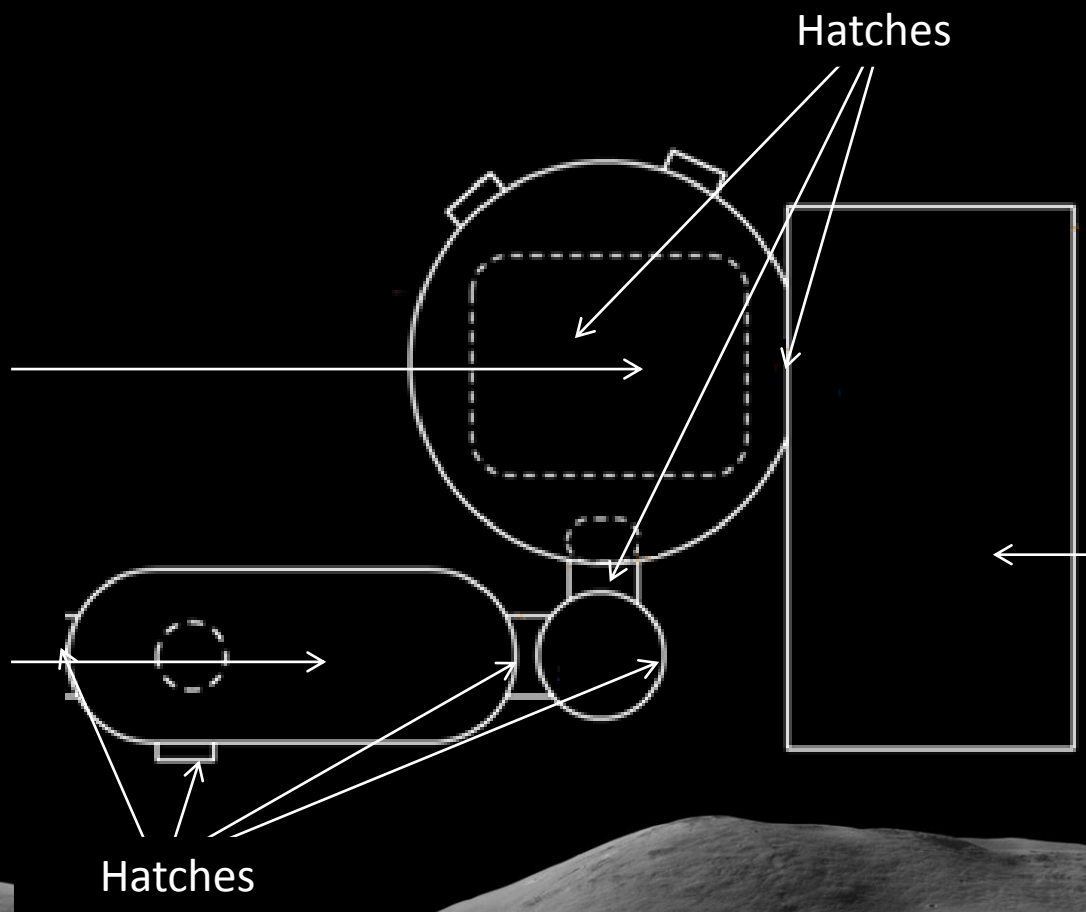
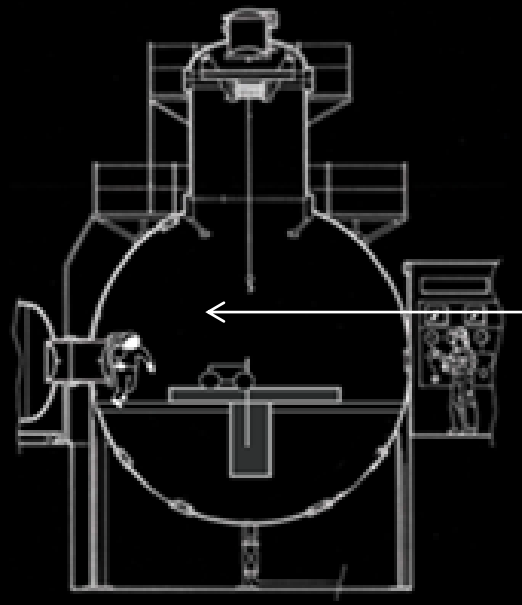


Regolith testbed: lunar condition zone for rover experiment

Space habitat simulator for human control team for the rover

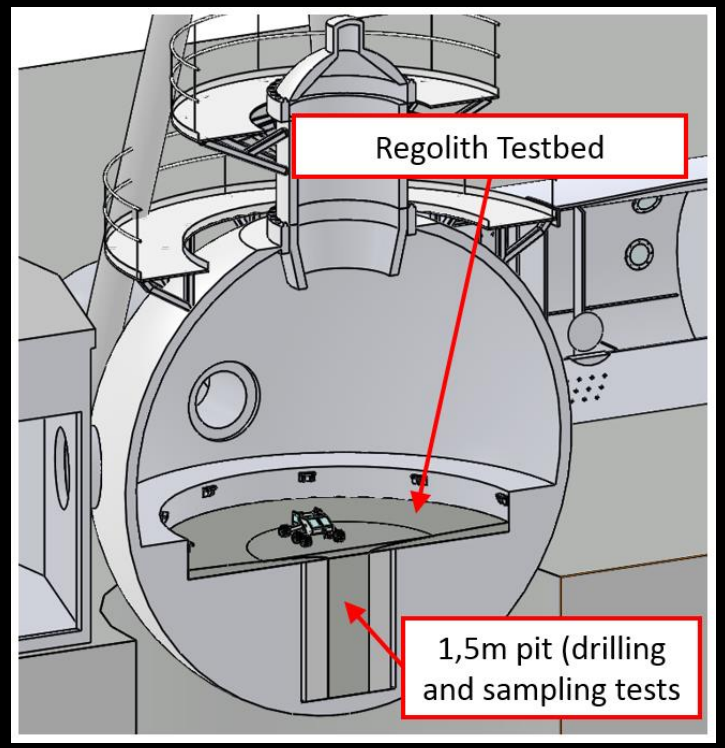


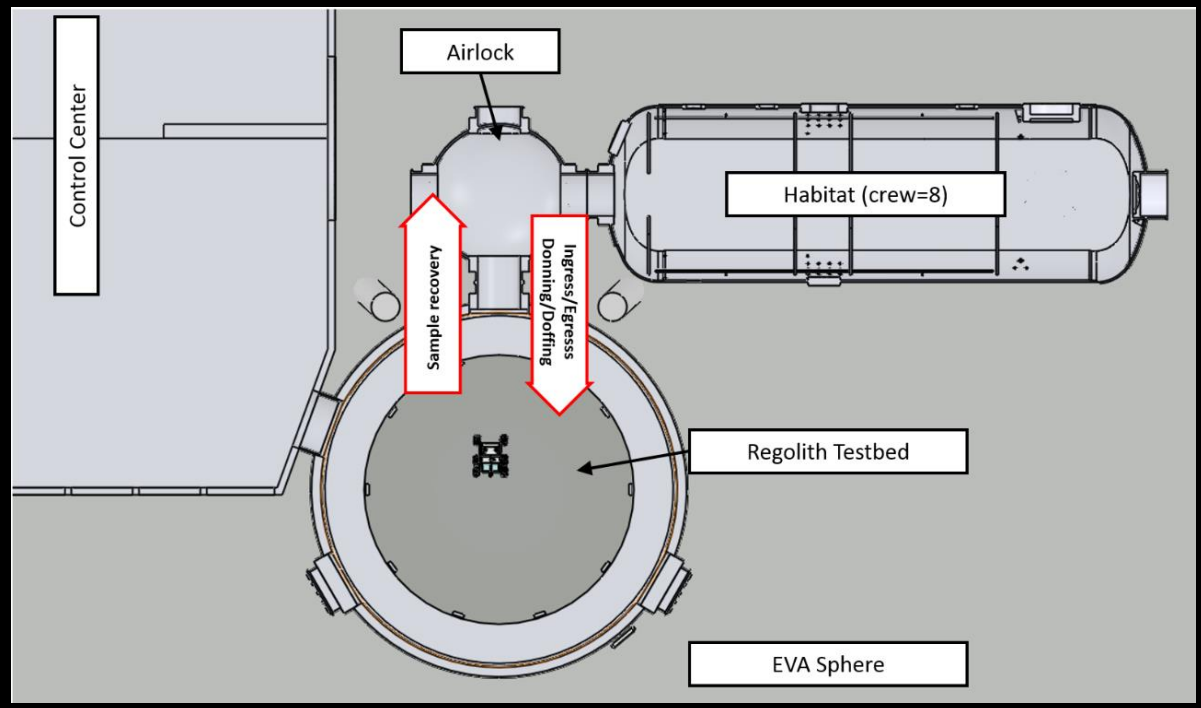
26m3 useable volume for ECLSS/ISRU integration

Control center

COMEX
Space and Innovations Division
www.comex.fr

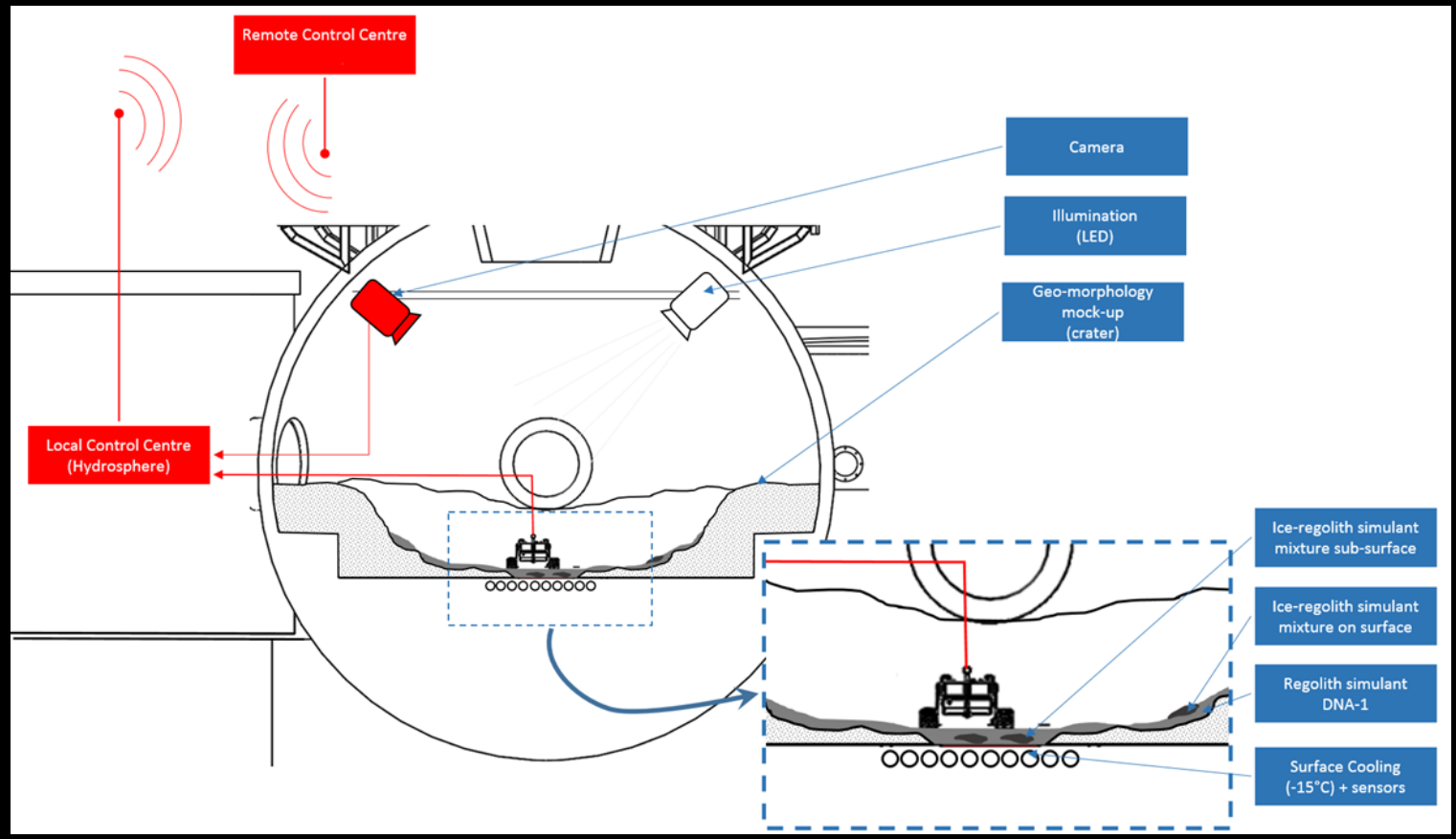
Exemple of test configuration : drilling



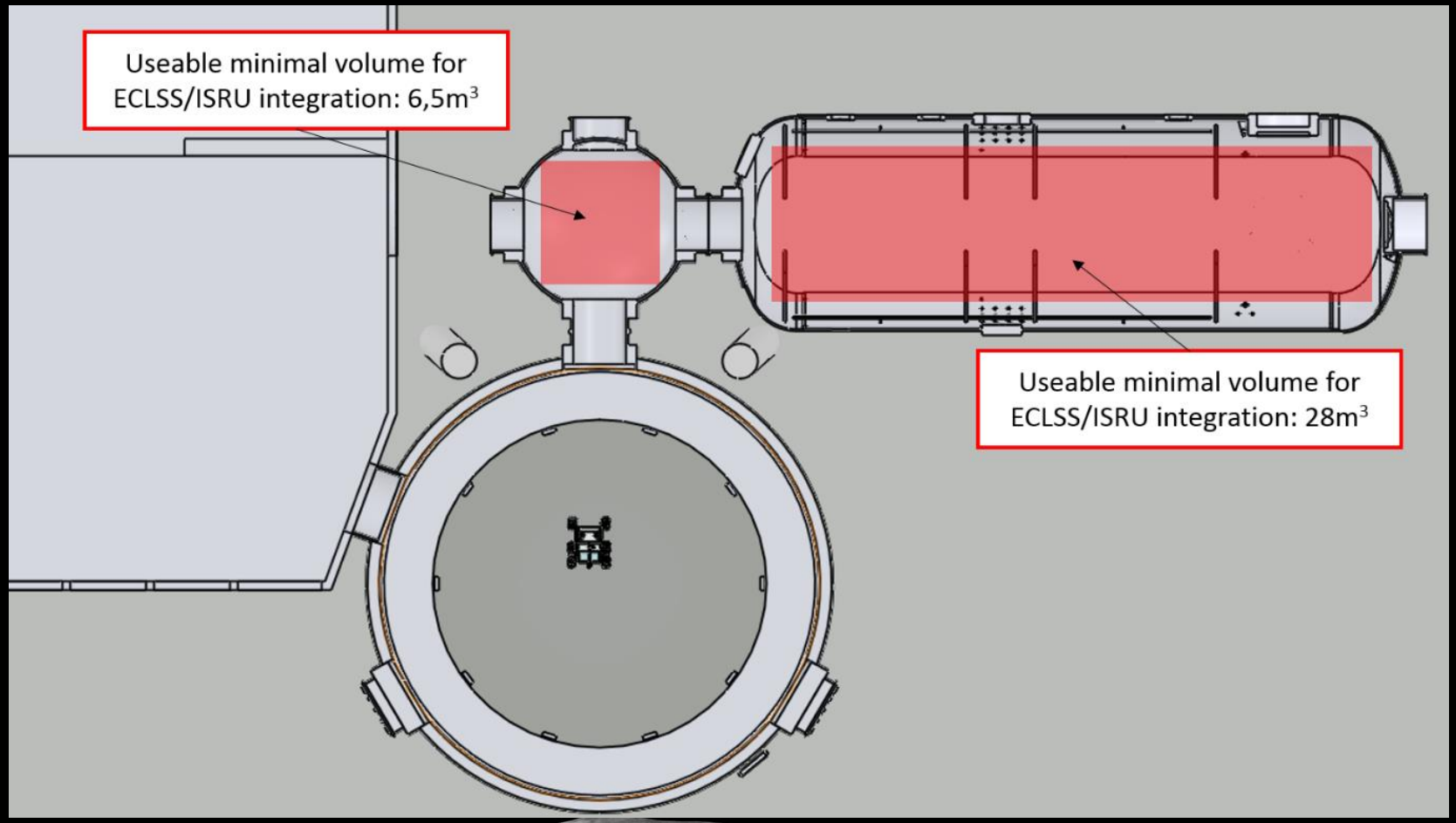


III – Robotics testbed

Exemple of test configuration : crater



IV – Human mission and habitat testbed

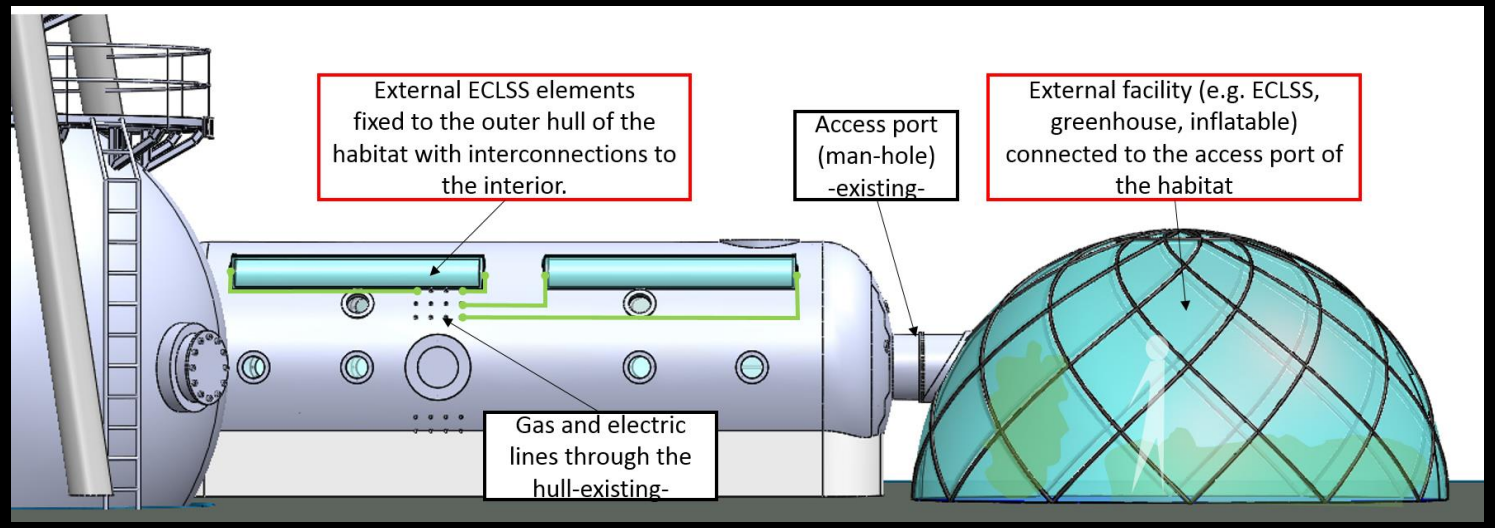

Useable minimal volume for ECLSS/ISRU integration: 6,5m³
Useable minimal volume for ECLSS/ISRU integration: 28m³

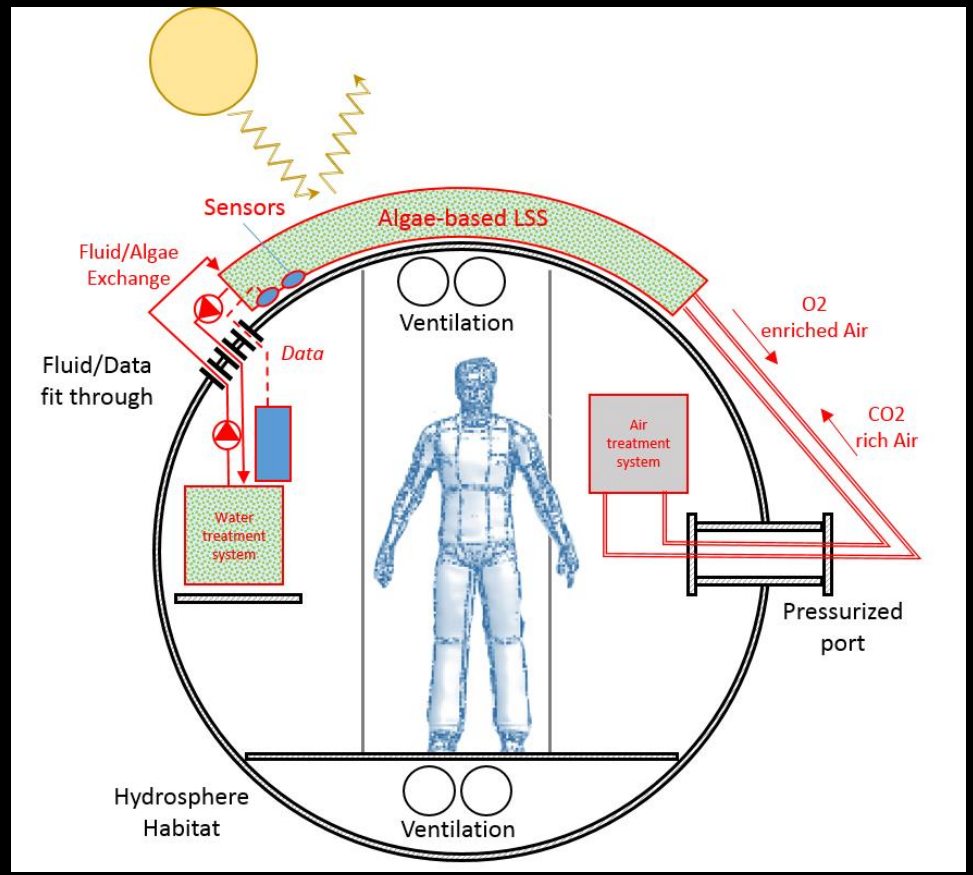
Variable light spectra

Forward hatch of the habitat

Exterior view of the habitat

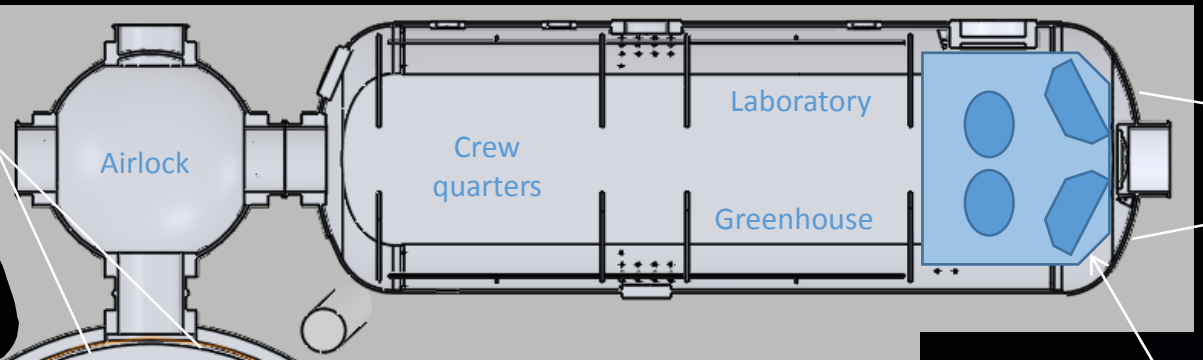
IV – Human mission and habitat testbed

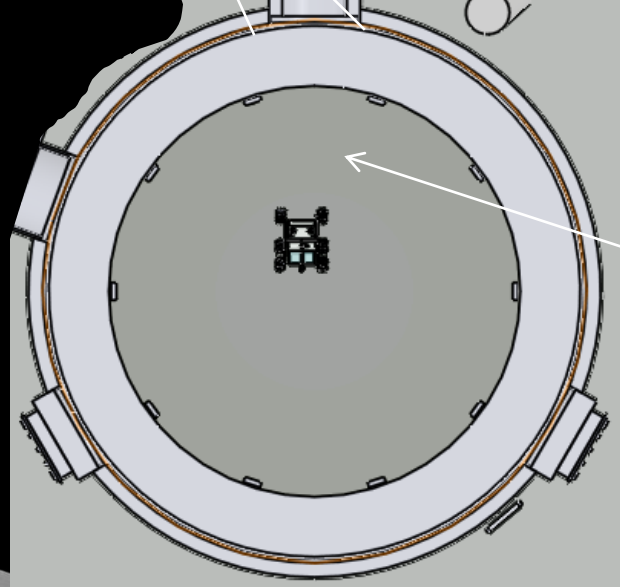




IV – Human mission and habitat testbed

Pressurized Rover simulation test-bed





EVA/robotics simulations

Image: NASA / Luna study

Pressurized Rover Cockpit simulator

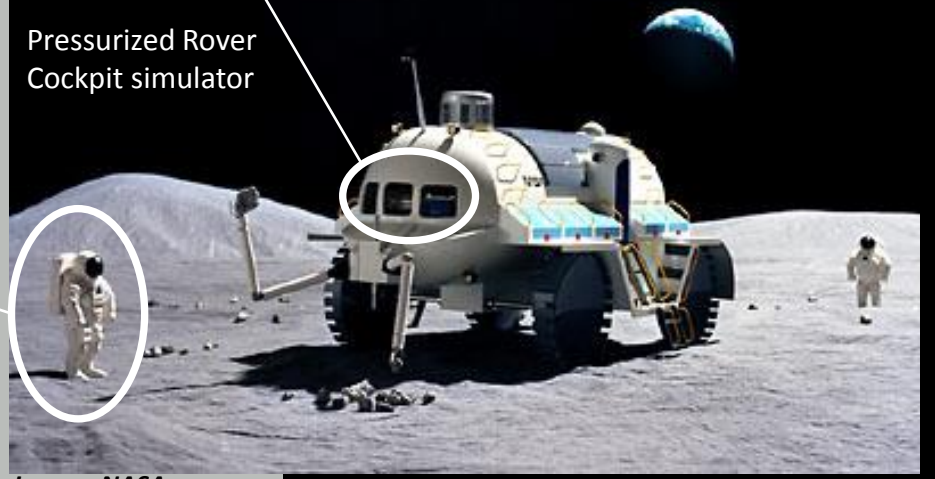
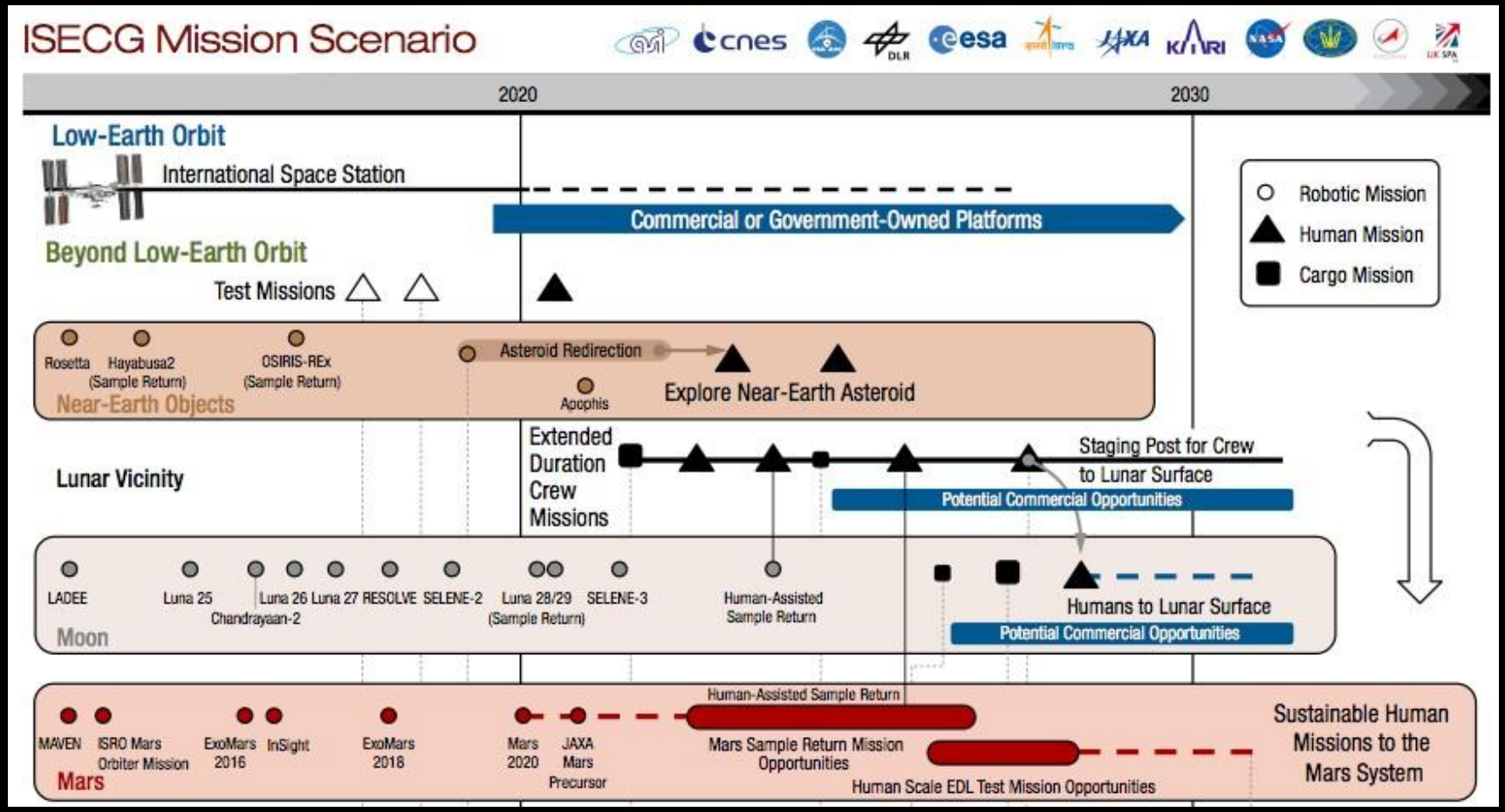


Image: NASA

V – Integration in a European simulation architecture


ISECG Mission Scenario
2020
2030
Low-Earth Orbit
International Space Station
Commercial or Government-Owned Platforms
Beyond Low-Earth Orbit
Test Missions
Robotic Mission
Human Mission
Cargo Mission
Rosetta
Hayabusa2 (Sample Return)
OSIRIS-REx (Sample Return)
Asteroid Redirection
Apophis
Explore Near-Earth Asteroid
Near-Earth Objects
Lunar Vicinity
Extended Duration Crew Missions
Staging Post for Crew to Lunar Surface
Potential Commercial Opportunities
LADEE
Luna 25
Chandrayaan-2
Luna 26
Luna 27
RESOLVE
SELENE-2
Luna 28/29 (Sample Return)
SELENE-3
Human-Assisted Sample Return
Humans to Lunar Surface
Potential Commercial Opportunities
Moon
Human-Assisted Sample Return
MAVEN
ISRO Mars Orbiter Mission
ExoMars 2016
InSight
ExoMars 2018
Mars 2020
JAXA Mars Precursor
Mars Sample Return Mission Opportunities
Human Scale EDL Test Mission Opportunities
Sustainable Human Missions to the Mars System
Mars

A terrestrial lunar village to prepare a Moon village on the far side of the moon

" A Moon village shouldn't just mean some houses, a church and a town hall
– Johann-Dietrich Woerner

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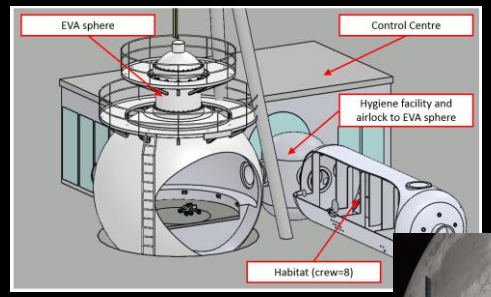
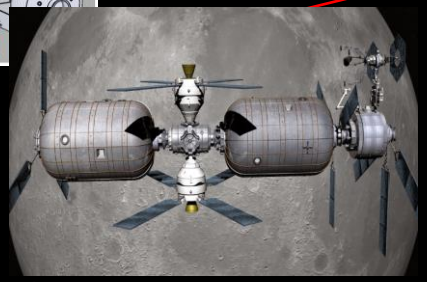
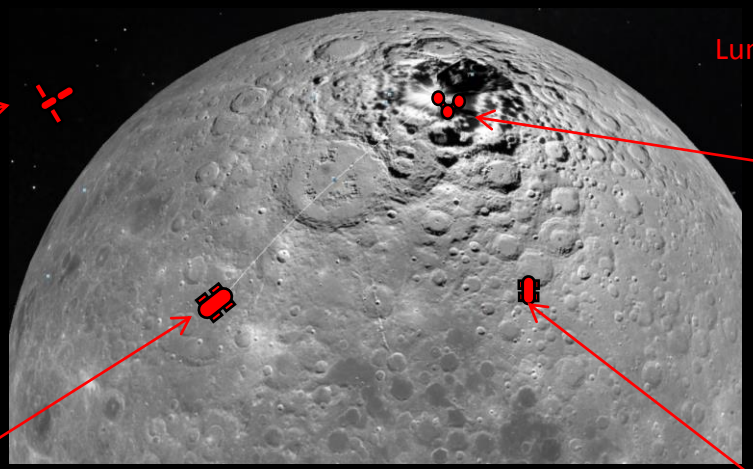


Cis-lunar space station





Lunar Pole Station

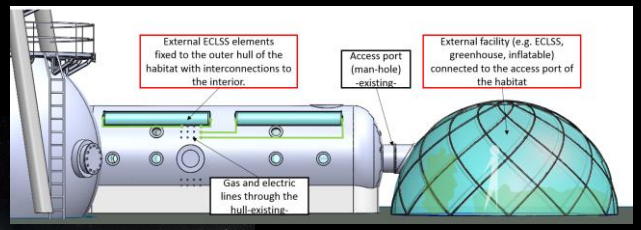
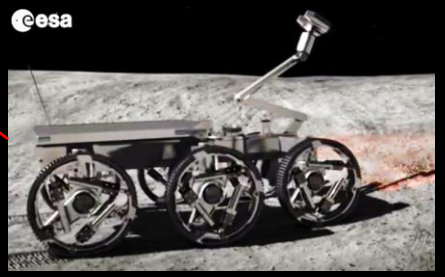
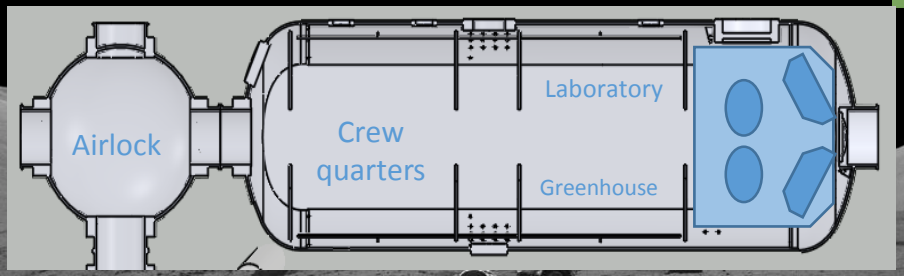


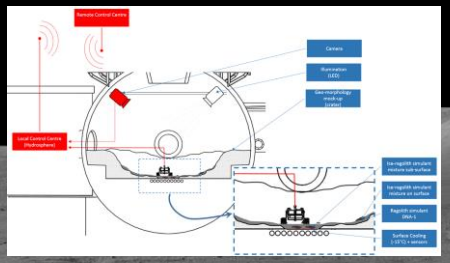
Image: NASA

Pressurized Rover





Robot teleoperation



VI – Conclusion

Collaborative projects opportunities

Two current European Commission Calls on robotics

COMPET-4-2016: SRC Space Robotics Technologies
http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2241-compet-4-2016.html

COMPET-5-2016: Scientific Instrumentation
http://ec.europa.eu/research/participants/portal4/desktop/en/opportunities/h2020/topics/2240-compet-5-2016.html

Thank you !

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