LIQUIFER is a interdisciplinary research and design group at the intersection of architecture, science, and technology, developing innovative concepts for crew systems, space habitats, and extreme environments on Earth and in space.

This booklet presents a curated overview of LIQUIFER's work in crew systems, highlighting key projects, concepts, and developments since its foundation.

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CREW SYSTEMS

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Content

Company Profile

LIQUIFER is an interdisciplinary group of experts committed to innovative research and product development with space and terrestrial applications. Architecture, science and technology coalesce in the creation of concepts, scenarios, prototypes, systems, and products for future living and working on earth and in space.

LIQUIFER participates in visionary projects as well as focussed investigations, primarily in collaboration with international partners. Research & Development projects carried out by LIQUIFER are typically supported by the European Union Framework Programme, the European Space Agency (ESA) and national space agencies. LIQUIFER's partners include governmental agencies, universities, research institutions, and large and small businesses.

LIQUIFER's mission is the enhancement of our knowledge to bring humankind beyond what is known. Whether the aim is delivering humankind to unknown frontiers within our solar system, or finding strategies for more sustainable living on Earth, LIQUIFER understands that the efforts are connected and focussed towards the same goal – to improve life, and to advance what we know through the synergetic efforts of architecture, science and technology. LIQUIFER refers to this perspective as the earth < > space continuum.

Founded in 2003 as the LIQUIFER Systems Group in Vienna, Austria, LIQUIFER has included a sister company, LIQUIFER Space Systems in Bremen, Germany, since 2019. This enables us to react more flexibly to challenges, and to broaden our participation in future opportunities.

Bringing this knowledge to a wider audience is an imperative to LIQUIFER, achieved by heading dissemination activities in projects, and organizing and participating in public events, seminars, lectures, symposiums, and workshops, for the exchange and transfer of ideas. LIQUIFER management and partners hold teaching positions in leading institutions and continuously engage with students at the educational level.

This is the working principle that distinguishes LIQUIFER, the capacity to take on a challenge, find solutions, and apply gained knowledge to the next challenge at hand. The operative force behind the work by LIQUIFER is the architectural training that enables one to see the interconnectedness of parts on different scales to create a whole.

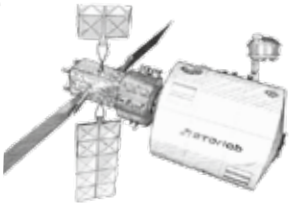
Crew Systems at LIQUIFER

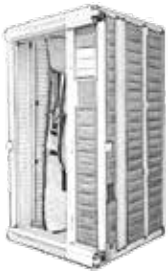
LIQUIFER has amassed substantial heritage achievements in the field of Space Architecture. Our track record within the area of Crew Systems is based on two main fields:

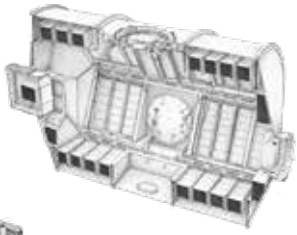
- Design and construction of crew accommodation systems for use in human operated spacecraft (in particular, in space stations);
- Design and construction of habitats for extreme environments (including planetary surface habitats).

Additionally, LIQUIFER has been involved in crew operations simulations.

This booklet provides a comprehensive overview of the relevant concepts and projects created and performed by LIQUIFER since its foundation. The topics are presented in chronological order as far as possible.







DEEP SPACE HABITAT SIMULATOR
2025 - 2026

STARLAB CREW SYSTEMS
2024 -

FLECS
2024 - 2026

LEO POST ISS
2024 - 2026

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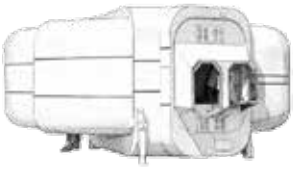
p. 53 p. 49 p. 61 p. 79

DEPLOYABLE GETAWAY
2007 - 2009

MICROGRAVITY SLEEPING BAG
2012 - 2013

SHEE
2013 - 2015

MOONWALK
2013 - 2016



HARMONISE
2022 - 2024

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O-HAB
2022 - 2023

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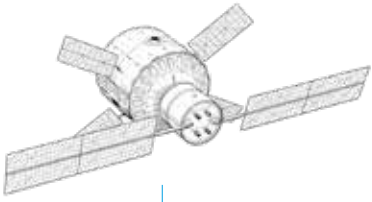

A-LOOP
2021 - 2023

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SPACE HOME MOCK-UP
2020 - 2021

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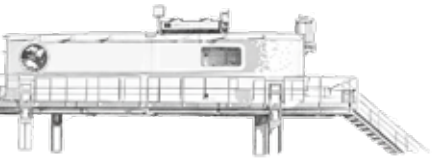
EDEN ISS
2015 - 2019



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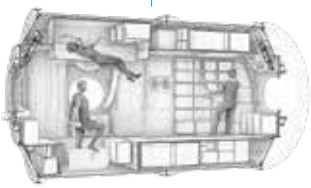
LUNAR GATEWAY I-HAB

(Airbus Defence & Space)
2018 - 2019



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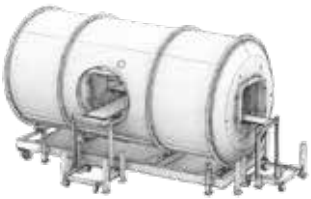
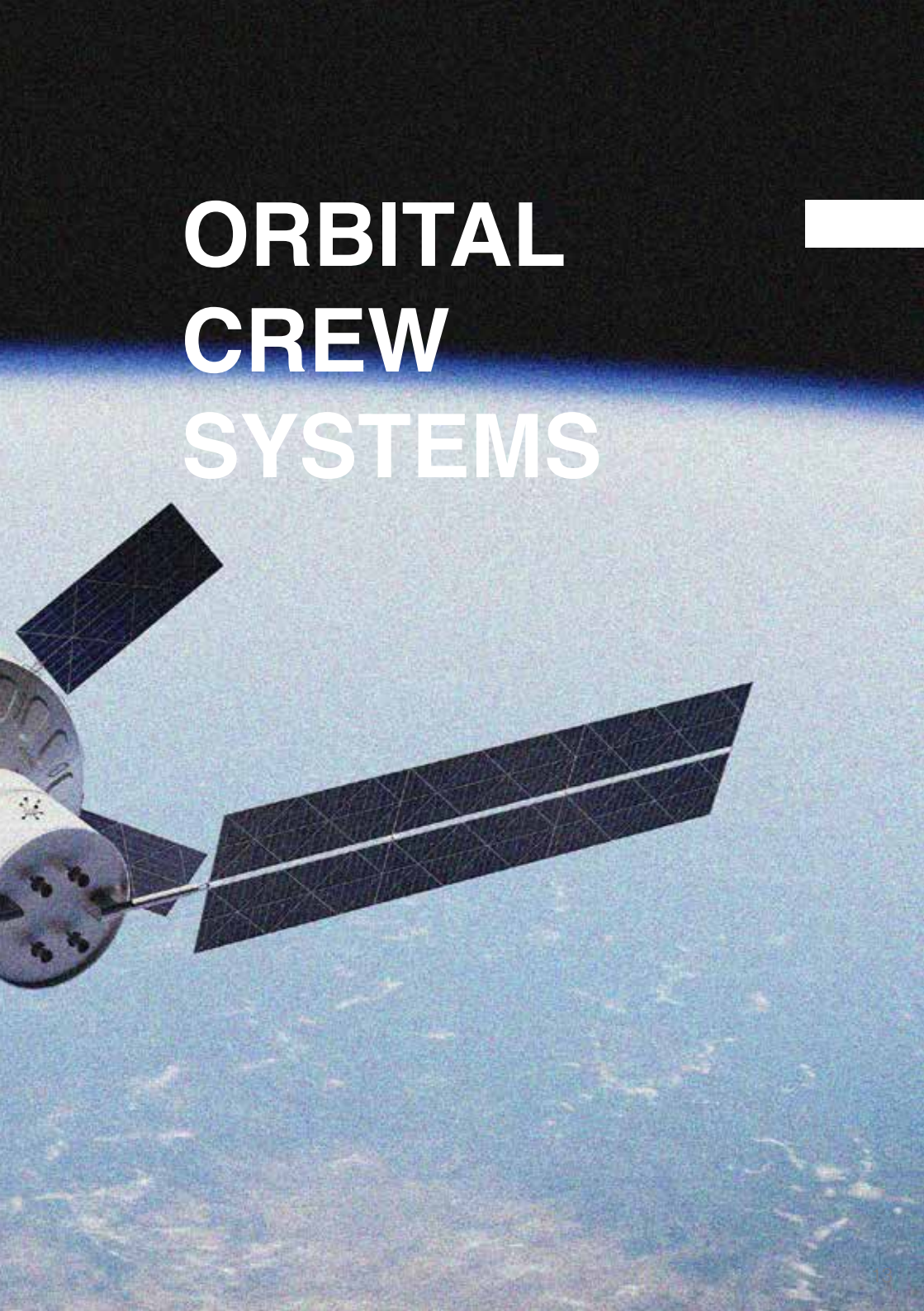
LUNAR GATEWAY I-HAB

(TAS-I)
2020 -



ORBITAL CREW SYSTEMS



FLECS

Foldable Living Environment for Crew Support

OBJECTIVE	Create a foldable private cabin designed for use by astronauts in zero gravity without permanent infrastructure.
CUSTOMER:	In-house development with financial support from ESA-BIC Bremen.
PERIOD OF PERFORMANCE:	05/2024 – 05/2026
PARTNERS:	FAWIC (NL), SABELT (IT)
DESCRIPTION:	The cabin can be easily deployed and stowed away when not in use. Inside, FLECS provides everything for privacy and comfort: ventilation, lighting, storage, work station, and a quiet sleeping space. Modular FLECS can be reconfigured for multiple purposes – as a crew cabin, galley, or hygiene module – offering a versatile solution for the future of human spaceflight.

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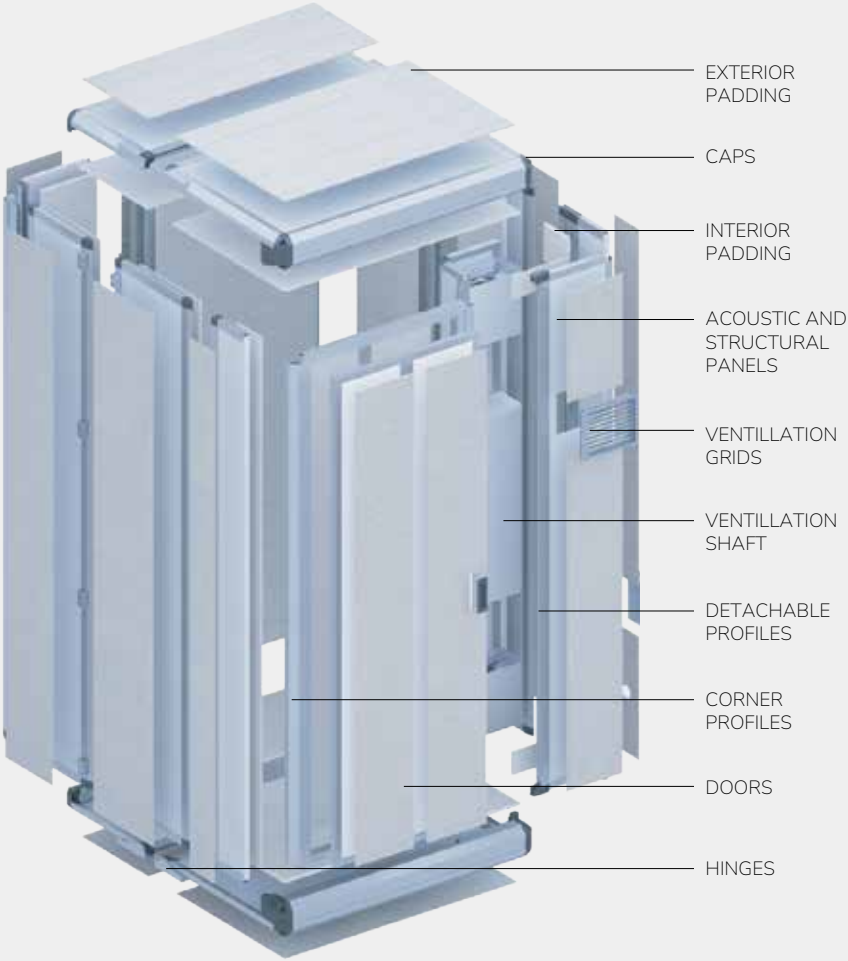

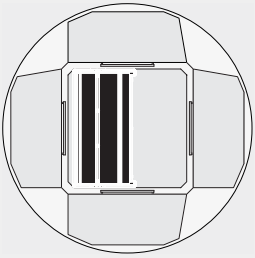

ISS COLUMBUS MODULE

DEPLOYED WIDTH: 1071 mm

FOLDED WIDTH: 463mm (43%)

1. Usability test of the FLECS demonstrator;
2. Details of the FLECS demonstrator - Control panel and private compartment;
3. Details of the FLECS demonstrator - Electricity connector;
4. Details of the FLECS demonstrator - Lighting system;
5. Folding phases of the FLECS demonstrator;
6. Renderign showing FLECS cabins inside the space station.

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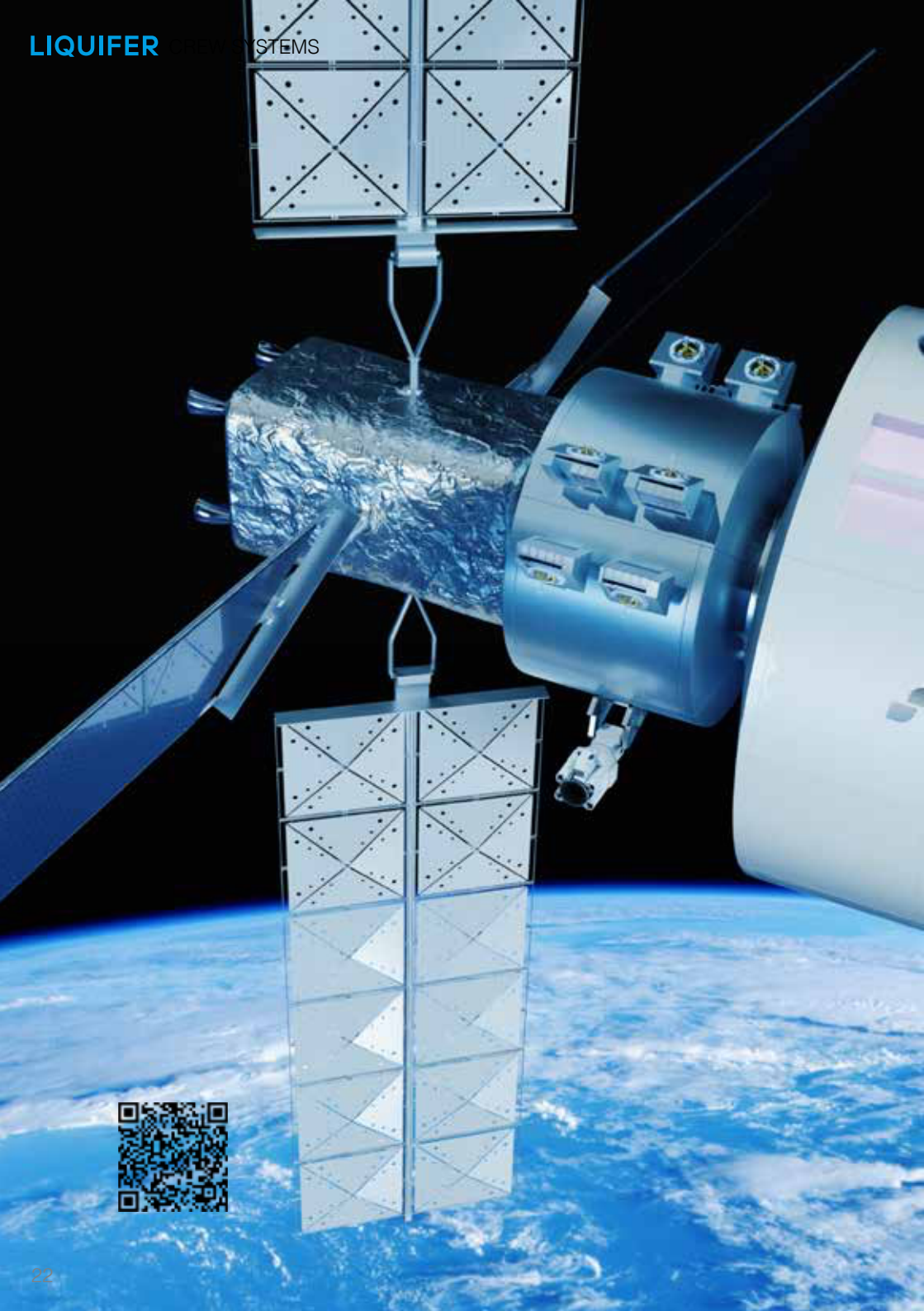
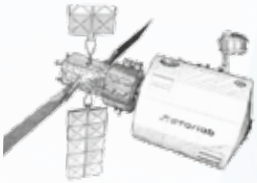


Starlab Crew Systems

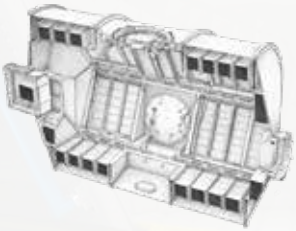
A commercial low Earth orbit space station providing facilities for research and commercial missions



OBJECTIVE	Design the crew quarters, toilet and hygiene compartments through co-engineering activities with the customer.
CUSTOMER:	Airbus Defence & Space for Voyager Space
PERIOD OF PERFORMANCE:	Since 09/2024
DESCRIPTION:	LIQUIFER is part of the Starlab international consortium. Within this project, LIQUIFER is supporting Airbus D&S with the architectural design and co-engineering of the crew quarters, toilet, and hygiene compartments.

LEO Post-ISS

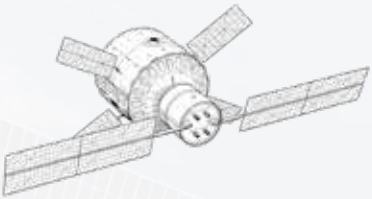
ESA study on flexible interior accommodations for future LEO stations, and de-risking for deep space missions



OBJECTIVE	Enable the safe, efficient, and adaptable deployment of habitat systems for future long-duration missions in LEO post ISS.
CUSTOMER:	TAS-I as Prime Contractor to ESA
PERIOD OF PERFORMANCE:	12/2024 – 12/2026
DESCRIPTION:	LIQUIFER provides support to TAS-I with designs for flexible interior accommodations, and study de-risking measures for deep space missions.

A-Loop

Commercial LEO Space Station Post-ISS



OBJECTIVE	Create a concept for a future commercial space station in low Earth orbit in which advanced crew systems provide enhanced safety and living conditions.
CUSTOMER:	Airbus Defence & Space for ESA
CONSORTIUM:	Airbus (DE); LIQUIFER (DE).
PERIOD OF PERFORMANCE:	12/2021 – 04/2023
DESCRIPTION:	The concept includes all necessary life support systems, a habitation deck with crew quarters and exercise facilities, a science deck with an airlock, payload accommodation, agricutlure modules and a centrifuge to create an artificial gravity environment for the crew.

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1-2. Exterior renderings,
3. Perspective cutaway;
4. Plan view of the habitation deck;
5. Section;
6-7. Science Payload / Shelving System;
8. Science Payload / Rack System;
9. Excersise Bay, Greenhouse and Hygiene Facilities;
10. Galley

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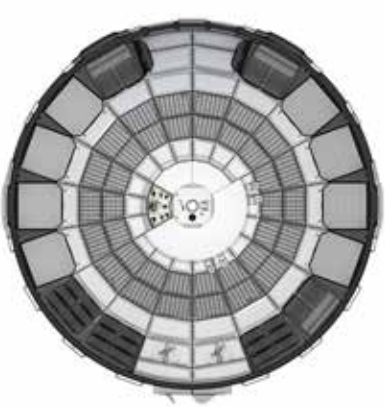

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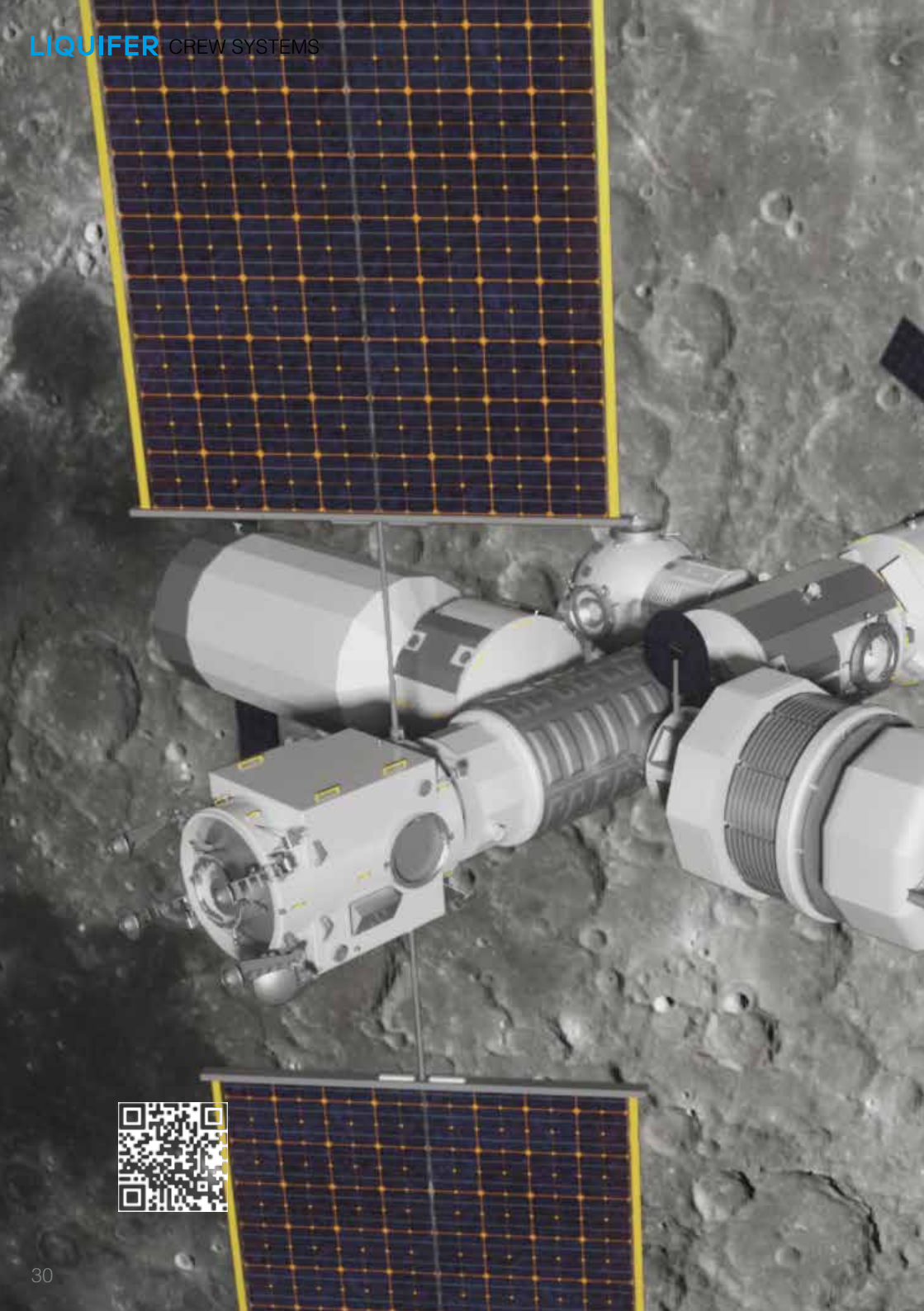
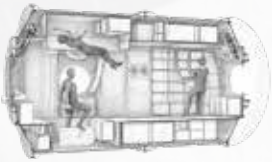


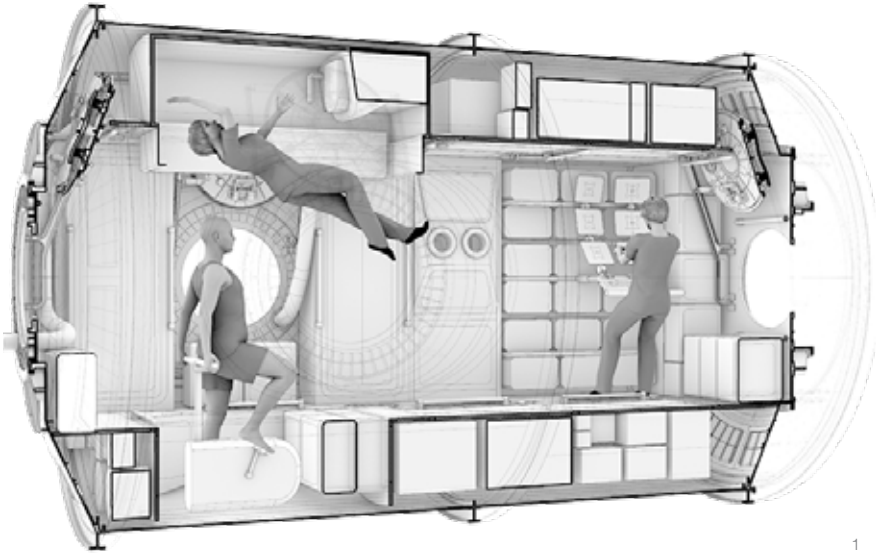
Lunar Gateway I-HAB

International Habitation Module

Prime Contractor: Airbus Defence & Space



OBJECTIVE	Support to ADS for space architecture design, Phase A / B1 study
CUSTOMER:	ESA
CONSORTIUM:	Airbus Defence & Space, TAS-I, Sener, QuinetiQ, SAS, LIQUIFER
PERIOD OF PERFORMANCE:	2018 – 2019
DESCRIPTION:	Under consideration of stringent system requirements, a variety of crew activities were analysed and design solutions proposed for a baseline 30-day mission duration. Architectural models were developed to maximize utilisation of the module. The final design for this phase featured deployable elements, such as sleeping quarters, hygiene facility, galley, and science equipment.



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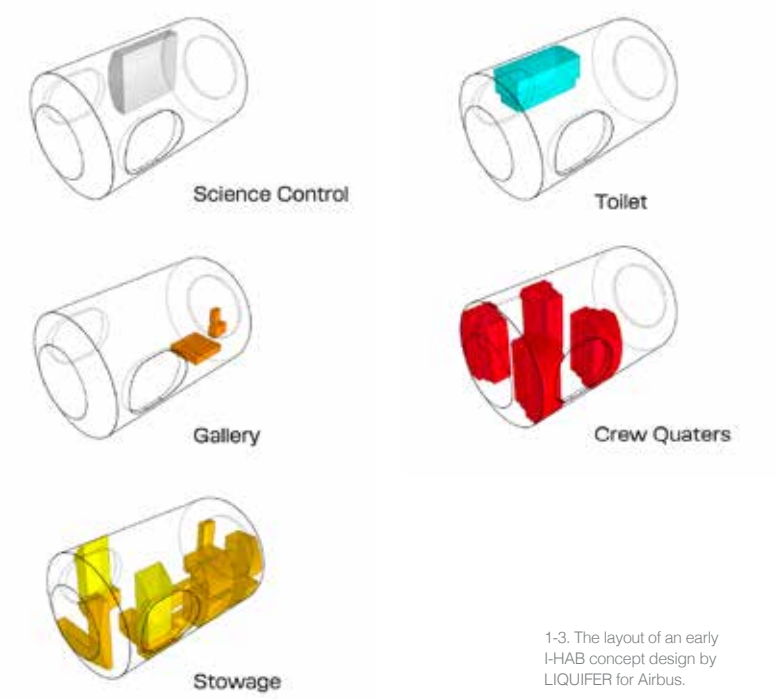
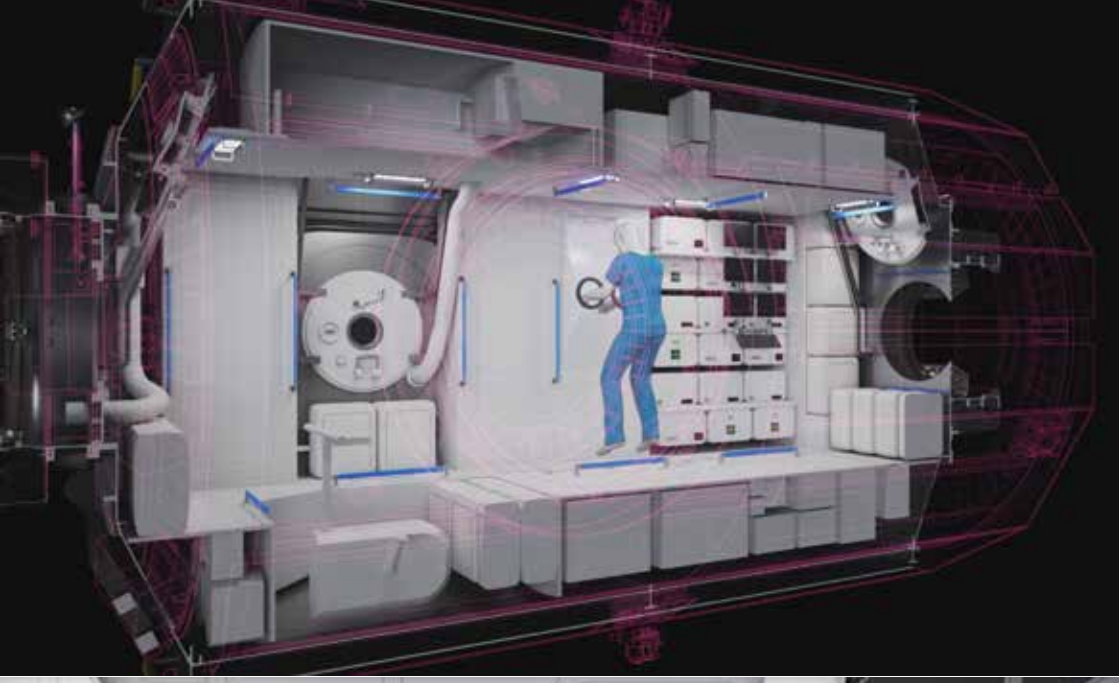


1-3. The layout of an early I-HAB concept design by LIQUIFER for Airbus.



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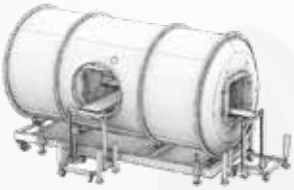
4. Full-size mock-up built by LIQUIFER at the Airbus premises in Bremen, Germany
5-7. Interior of the full-size mock-up.

photo credits: Airbus D & S

Lunar Gateway I-HAB

International Habitation Module

Prime Contractor: TAS-I



OBJECTIVE	Interior configuration until PDR, Design and manufacture a full-size mock-up to support human-in-the-loop (HITL) tests.
CUSTOMER:	TAS-I, as Prime Contractor to ESA
CONSORTIUM:	LIQUIFER with SPARTAN Space
PERIOD OF PERFORMANCE:	Since 2020
DESCRIPTION:	The mock-up is equipped initially with low fidelity outfitting and later with medium fidelity equipment. Mechanisms to simulate crew activities in zero gravity are included. The results of the HITL tests support I-HAB system design.

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1. Stanley G. Love and the Lunar I-Hab, credits: ESA
2. Interior of the Lunar I-Hab Mock-up, credit: SPARTAN SPACE

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3. ESA astronaut Luca Parmitano inside the Lunar I-Hab mock-up with engineers from Thales Alenia Space, credits: ESA
4. Rosemary Coogan takes a look at Lunar I-Hab, credits: ESA

Space Home Mock-Up

A conceptual test-bed for the future Gateway I-HAB

OBJECTIVE	Design and implement the interior architecture for the Space Home Mock-Up in Turin.
CUSTOMER:	Thales Alenia Space Italia (IT).
CONSORTIUM:	LIQUIFER (DE); subcontractors: Comex (FR); Sabelt (IT)
PERIOD OF PERFORMANCE:	2020 – 2021
DESCRIPTION:	The interior configuration includes two types of crew-quarters, one of which is deployable, a transformable galley table, a greenhouse, stowage provisions and a control station

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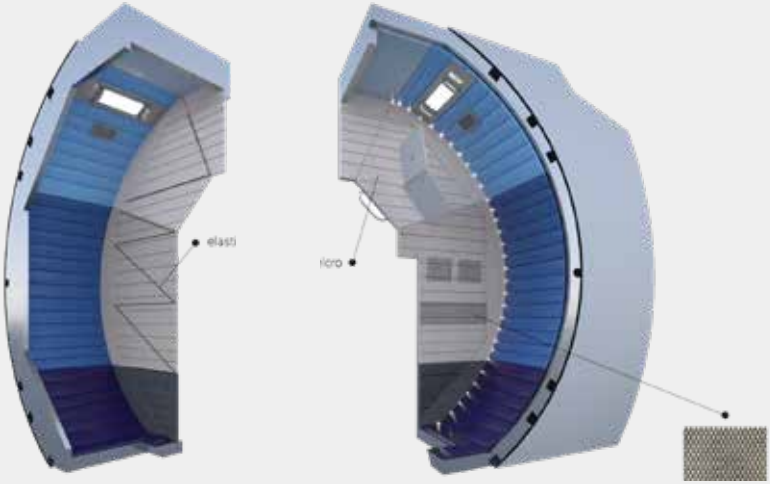

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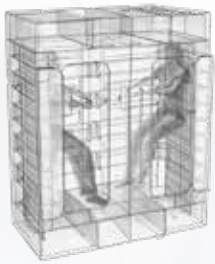
1. Interior of the Space Home Mock-up;
2. Design of the foldable Crew quarter;
3. Design of the crew quarter with a window.
4. Control / payload installation
5. Gas tanks, galley, cargo net
6. Alexander Gerst inside the Space Home Mock-Up, courtesy of ESA

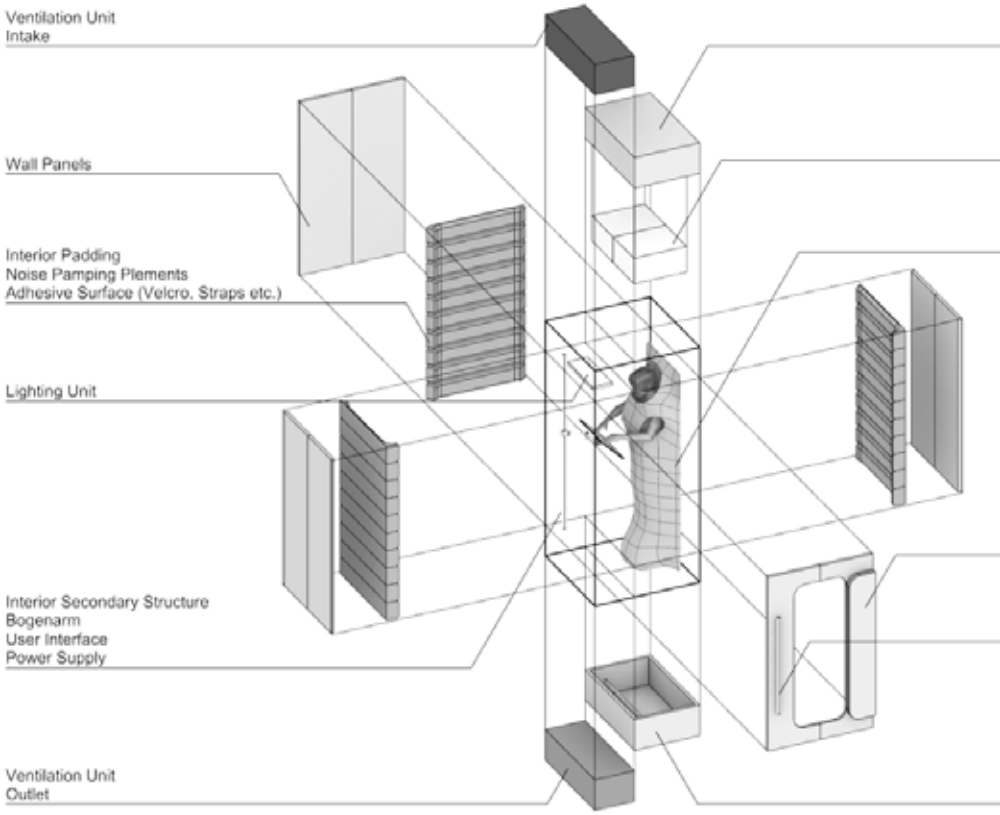
6

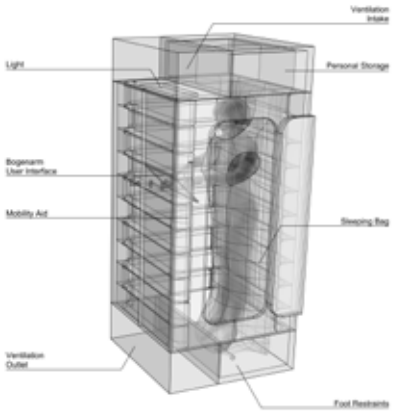
Orbital EURO-HAB (O-HAB)

A concept for an inflatable habitation module in low Earth orbit

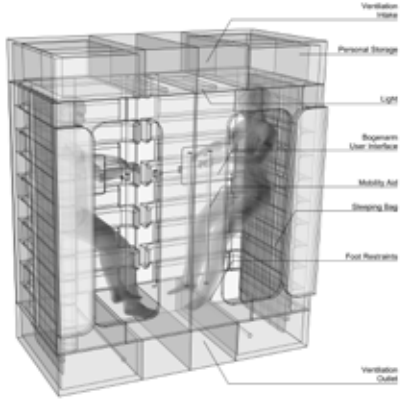


OBJECTIVE	Perform a feasibility study and design for an inflatable orbital habitat with reconfigurable interior crew systems.
CUSTOMER:	SPARTAN Space as Prime Contractor to ESA.
PERIOD OF PERFORMANCE:	2022 – 2023
DESCRIPTION:	LIQUIFER's solution included crew quarters, multi-purpose storage, preparation and dispensing system, hygiene cabin, toilet cabin and a multi-purpose workstation.





SINGLE CABIN

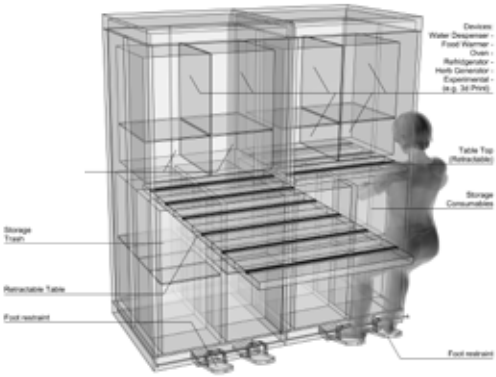


DOUBLE CABIN

Top Case
Personal Storage

Cargo Bags

Sleeping bag

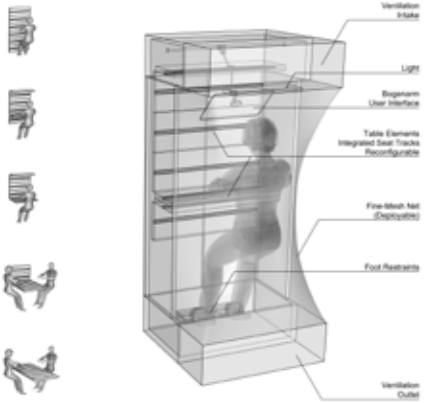


GALLEY

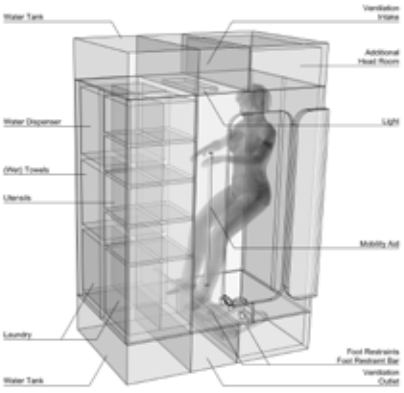
Door elements

Mobility Aid

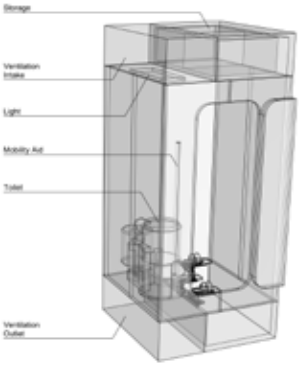
Top Case
Foot restraint bar



WORK STATION



HYGIENE



TOILET

Microgravity Sleeping Bag

OBJECTIVE:	Develop a micro-g sleeping bag as part of a demonstrator project.
SPONSOR:	Austrian Space Agency
PERIOD OF PERFORMANCE:	2010 - 2012
DESCRIPTION:	The sleeping bag is designed specifically for use in microgravity. It provides in-space countermeasures to combat physical and mental fatigue, improving both sleep quality and the in-orbit space experience.

1 - 100% silk hood inlay attached to Nomex exterior with velcro.
2 - 100% silk sleeping bag inlay attached to Nomex exterior with velcro.
3 - Velcro closure for inverted pleat.
4 - Exterior sleeping bag made from Nomex. Expanded area at knees accommodates neutral body position.
5 - Inverted pleat added to allow for more movement possibilities.
6 - Inlay from 100% silk, lower part attached with velcro.

Deployable Getaway

A deployable crew cabin to improve living conditions on board the ISS

OBJECTIVE:	Create a deployable crew cabin to reduce crew fatigue and improve crew performance on the ISS.
CUSTOMER:	LIQUIFER in-house project co-funded by the Austrian Space Agency
PERIOD OF PERFORMANCE:	2007 - 2009
DESCRIPTION:	The Deployable Getaway is a three-dimensional countermeasure for stress and fatigue, in particular in human space missions. The project included design and breadboard development for a deployable crew cabin, providing a privacy for relaxation, reflection, and power naps that can promote better crew health, performance, and safety.

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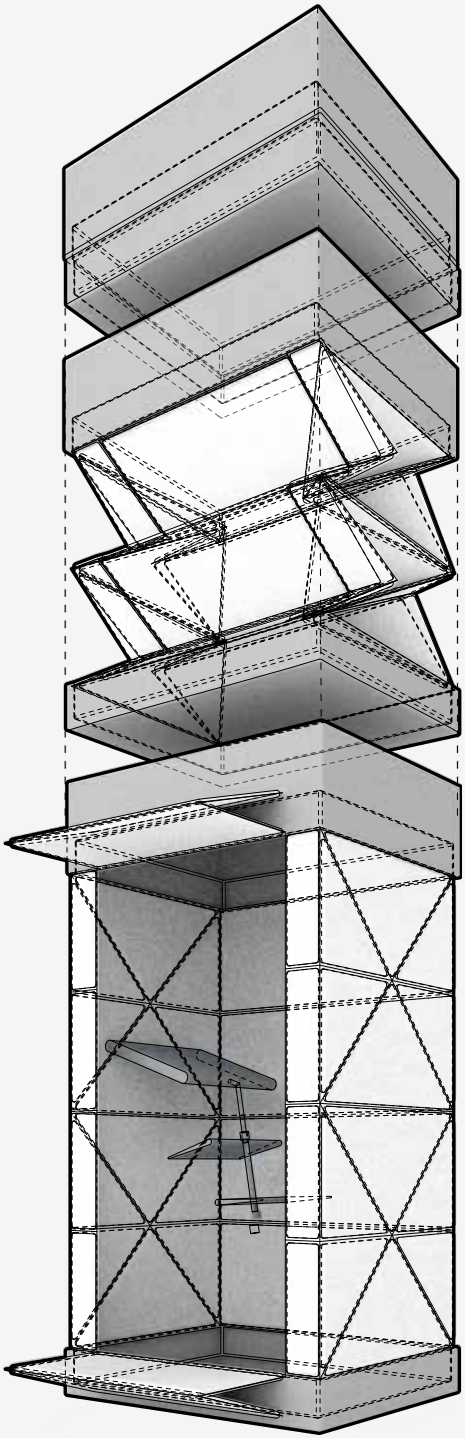
1-2. Unfolding of the Deployable Getaway prototype;
3-5. Details of the Deployable Getaway, which provides a temporary private retreat for working, relaxing and sleeping on orbital space stations.



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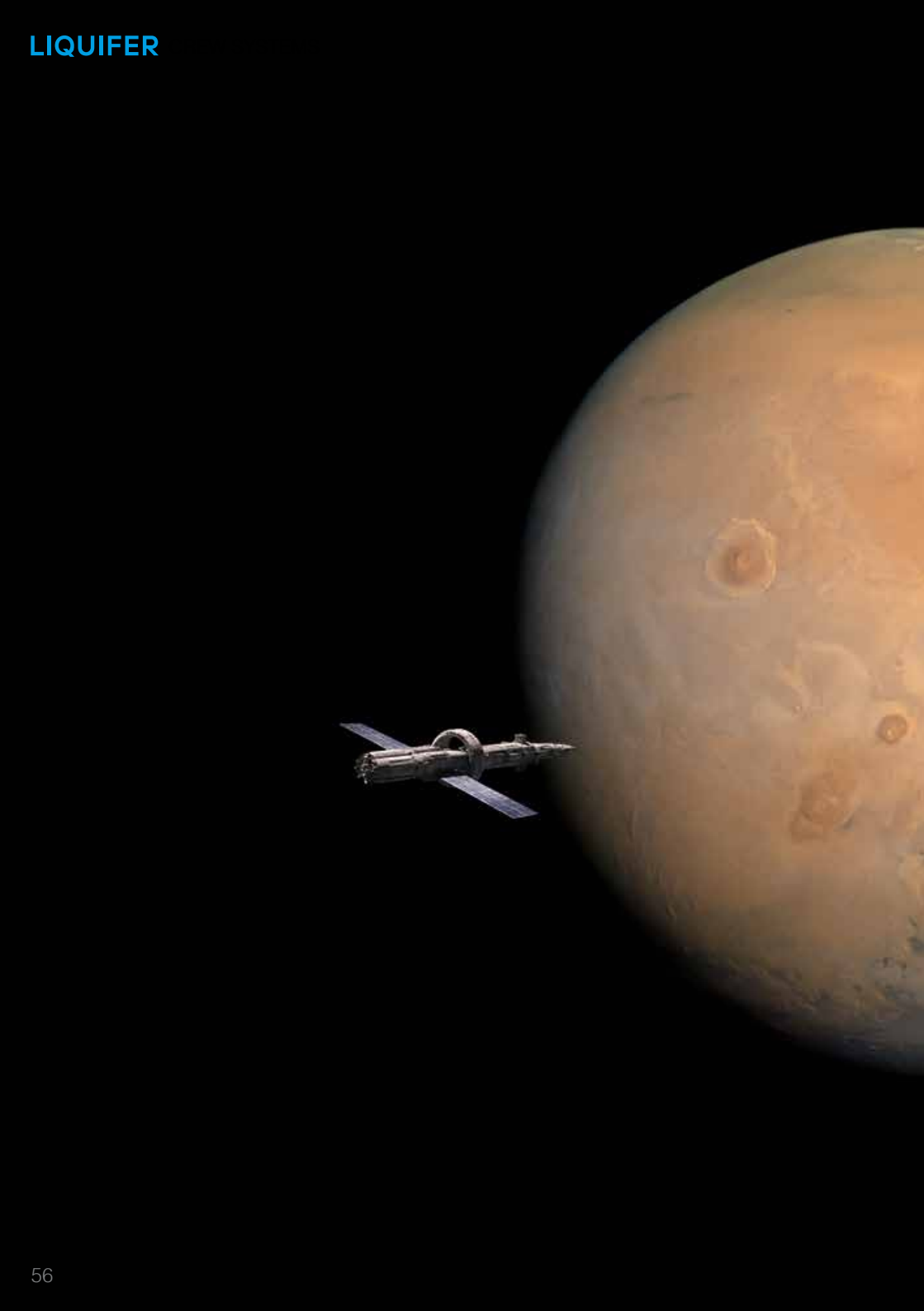
LIQUIFER



DSHS

Deep Space Habitat Simulator

OBJECTIVE: To provide support in establishing concept baseline and relevant requirements for a future (European) simulator for Deep Space Transfer Habitats.

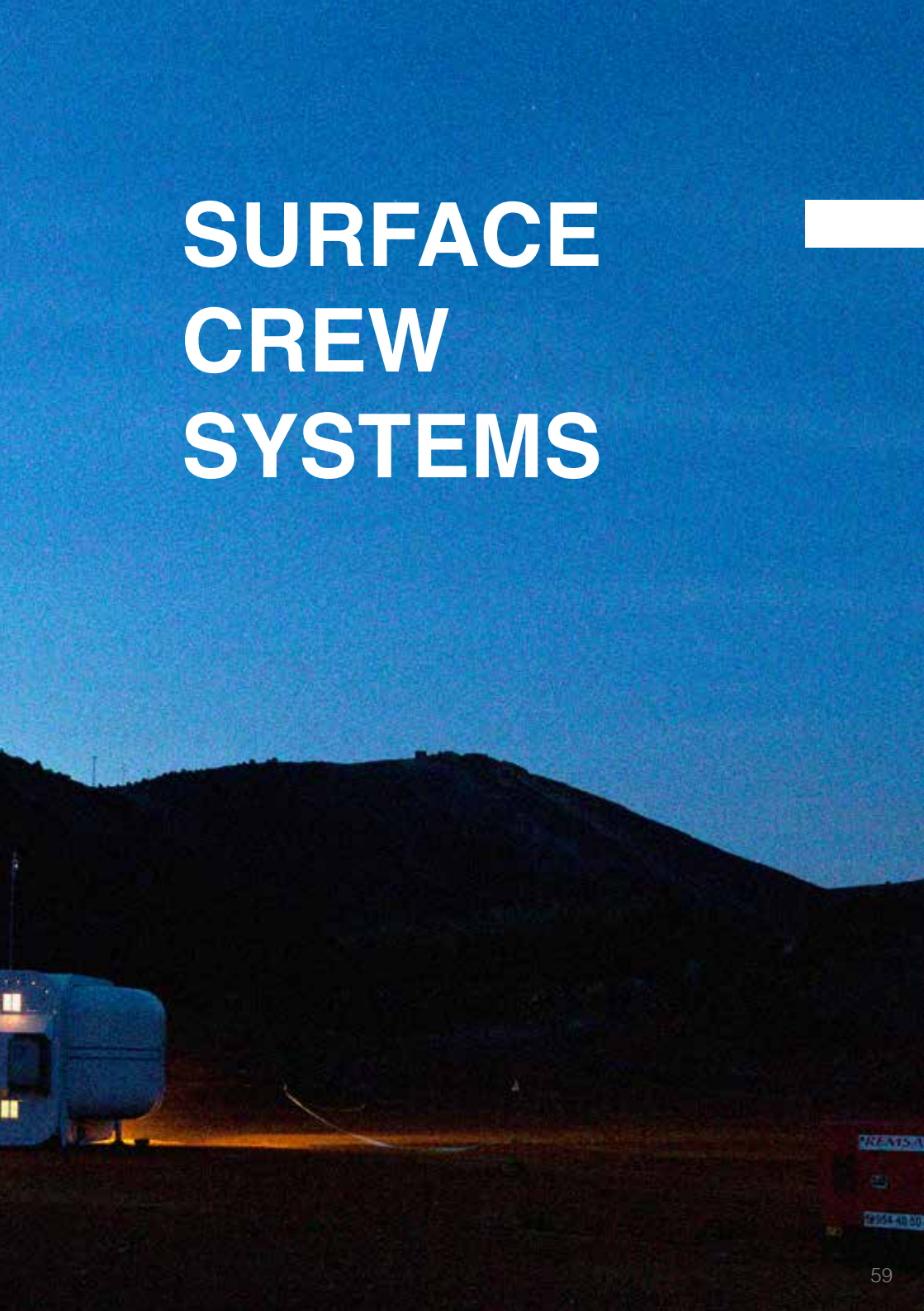
PRIME/CUSTOMER: Spartan Space (FR) as Prime Contractor to ESA

CONSORTIUM: LIQUIFER (DE); DLR (DE); OHB (DE); DFKI (DE); MEDES (FR)

PERIOD OF PERFORMANCE: 06/2025 – 03/2026

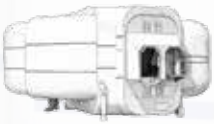
DESCRIPTION: A comprehensive system view and robust data management will leverage existing platforms while integrating future capabilities. It will incorporate novel Conops, closed-loop ECLSS, and AI to enhance autonomy and robustness, with a strong focus on crew health and performance—particularly through a deployable crew cabin that enables privacy for rest and recovery, improving safety and effectiveness.

SURFACE CREW SYSTEMS



SHEE

Self-deployable Habitat for Extreme Environments



OBJECTIVE:	To develop a self-deployable, autonomous planetary habitat test bed for terrestrial analogue simulations.
SPONSOR:	European Union (EU-FP7)
CONSORTIUM:	ISU (FR); LIQUIFER (AT); SAS (BE); COMEX (FR); University of Tartu (EST), Sobriety, SPIN (Czech Republic)
PERIOD OF PERFORMANCE:	01/2013 – 12/2015
DESCRIPTION:	LIQUIFER led the technical development and was responsible for the overall design. SHEE accommodates a crew of two for a mission length of two weeks, and includes two crew cabins, kitchen, hygiene facility, workspace and laboratory. SHEE is fitted with an environmental control and monitoring system, and enclosed storage for waste and wastewater.

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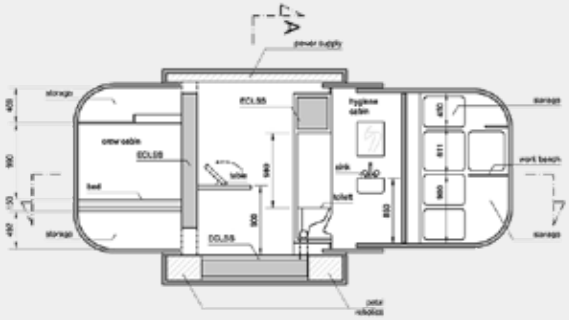
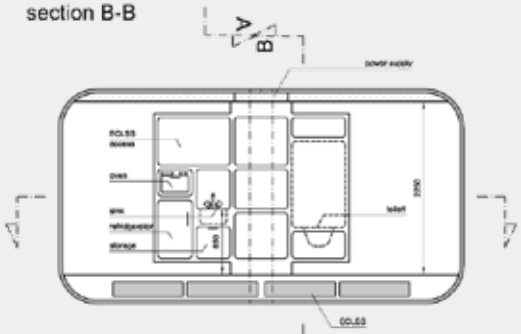
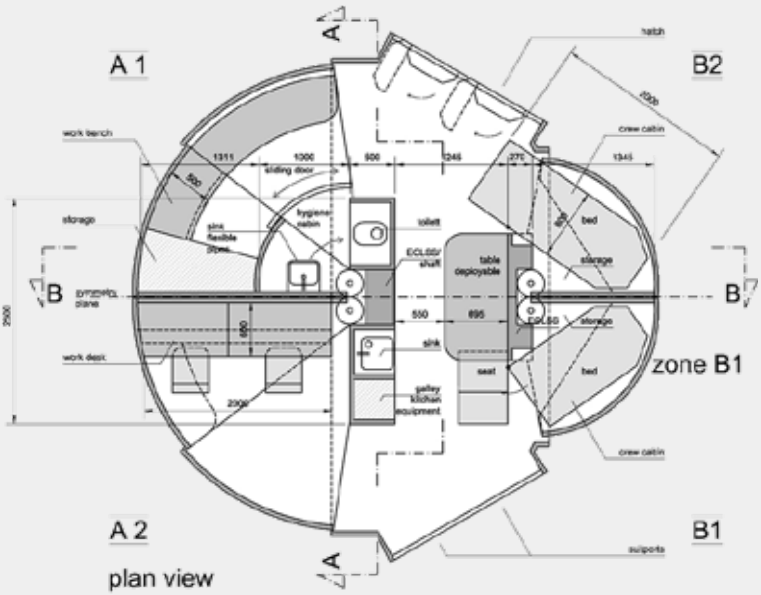
1. SHEE habitat during the demonstration mission.
2. Demonstration of the deployment of the SHEE habitat.
3. Rendering of the deployment of the SHEE habitat on Mars.
4-7. Interior of the SHEE habitat



section B-B



section A-A
elevation ECLSS rack A




LIQUIFER

Harmonise

OBJECTIVE:	To assess the feasibility of recycling in-situ resources and unused hardware for Moon and Mars settlements, and to demonstrate viable reuse concepts.
SPONSOR:	ESA Express Procurement Plus – EXPRO+
CONSORTIUM:	OHB (DE) Azimut Space GmbH (DE), LIQUIFER Systems Group (AT)
PERIOD OF PERFORMANCE:	09/2022 – 08/2024
DESCRIPTION:	In order to establish sustainable settlements on the Moon and Mars, we must reduce our dependence on payloads by utilising in-situ resources and obsolete hardware. Techniques such as 3D printing enable the conversion of recycled materials into useful items. LIQUIFER designed and built a simple chair for a future lunar base using close-out panels to demonstrate the reuse of spacecraft parts for habitat elements.

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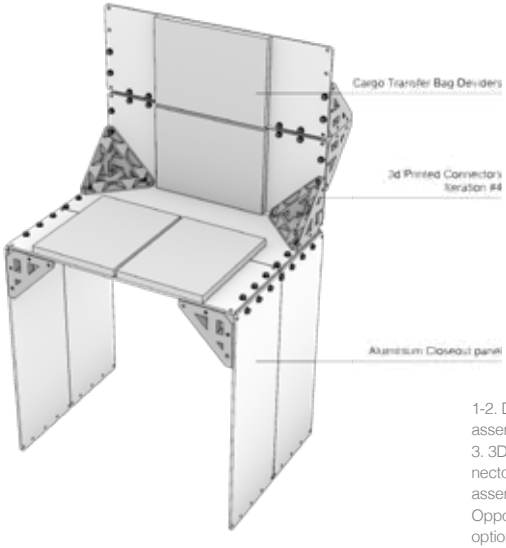
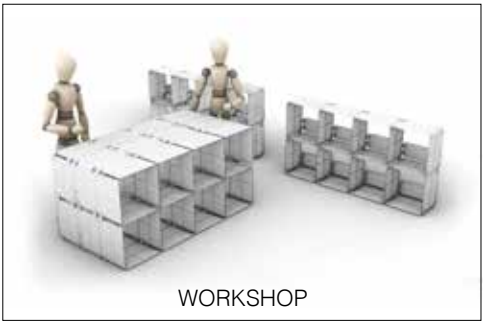


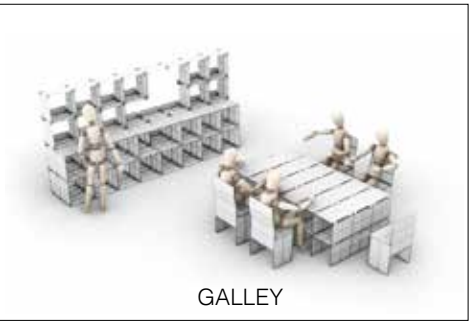
1-2. Details of the chair assembly.
3. 3D-printed connectors for the chair assembly.
Opposite side: design options for furniture using close-out panels



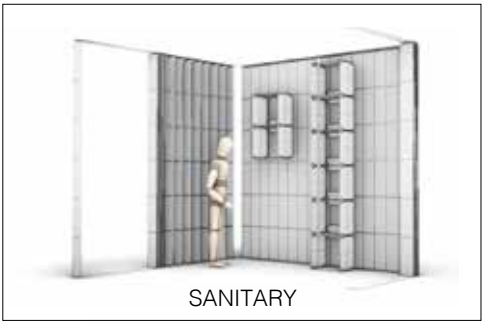
WORKSHOP

GREENHOUSE

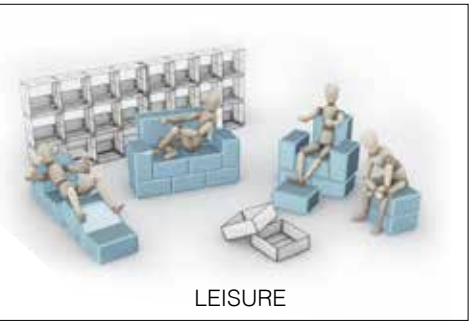
LABORATORY



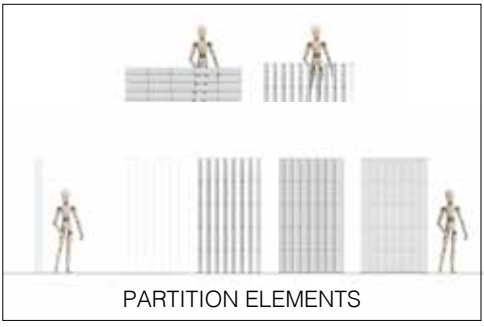
GALLEY



SANITARY



LEISURE



PARTITION ELEMENTS

PRIVATE QUARTERS


EDEN ISS

EDEN ISS

OBJECTIVE: To advance controlled environment agriculture and develop ground-based demonstration of plant cultivation technologies enabling long-term human presence in space. It requires integrated systems for environmental control, waste management, provision of water, oxygen, and food, while supporting astronaut health and well-being.

SPONSOR: EU – Horizon 2020 (EU-H2020), Space exploration / Life support

CONSORTIUM: DLR Institute for Space Systems, LIQUIFER Systems Group (Service section/airlock design and implementation, requirements and interface management); National Research Council (IT); University of Guelph (CA); Alfred Wegener Institute for Polar and Marine Research (DE); Enginsoft (IT); Airbus D&S (DE); Thales Alenia Space, Turin (IT); Aero Sekur (IT); Wageningen University and Research (NL); Heliospectra (SW); Limerick Institute of Technology (EI); Telespazio (IT).

PERIOD OF PERFORMANCE: 03/2015 – 02/2023

1-3. EDEN ISS, 400 m south from the Neumayer-Station III on the Antarctica, credits: DLR;
4. EDEN-ISS during the polar night which began at the end of May and ended in July. Outside temperatures dropped below -42 °C and created extreme challenges for the greenhouse system, credits: DLR,
photo bottom right: AWI / Michael Trautmann for EDEN ISS

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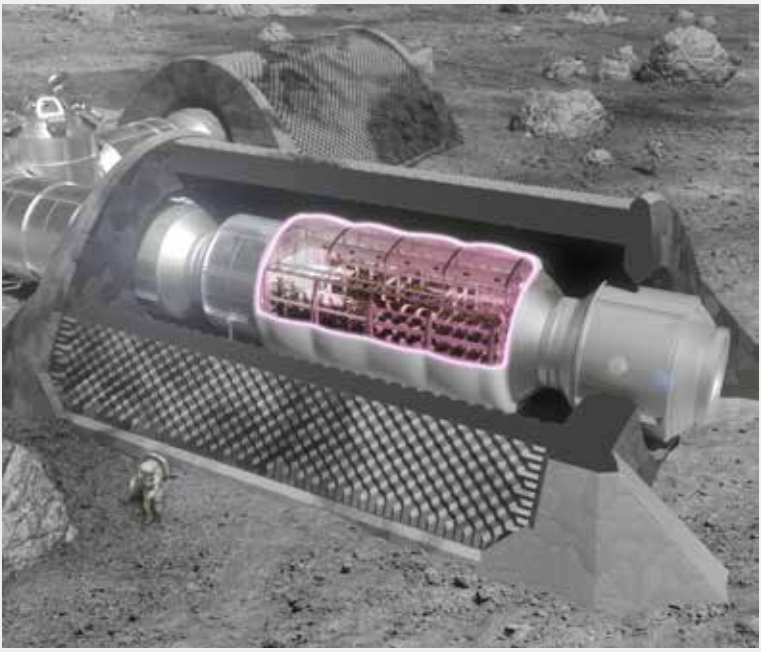

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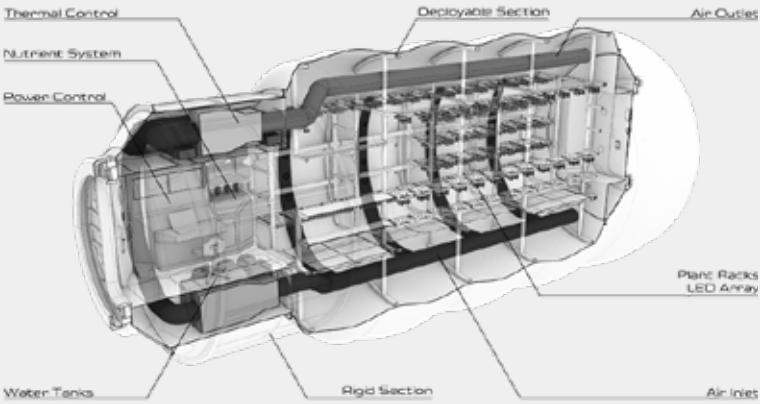

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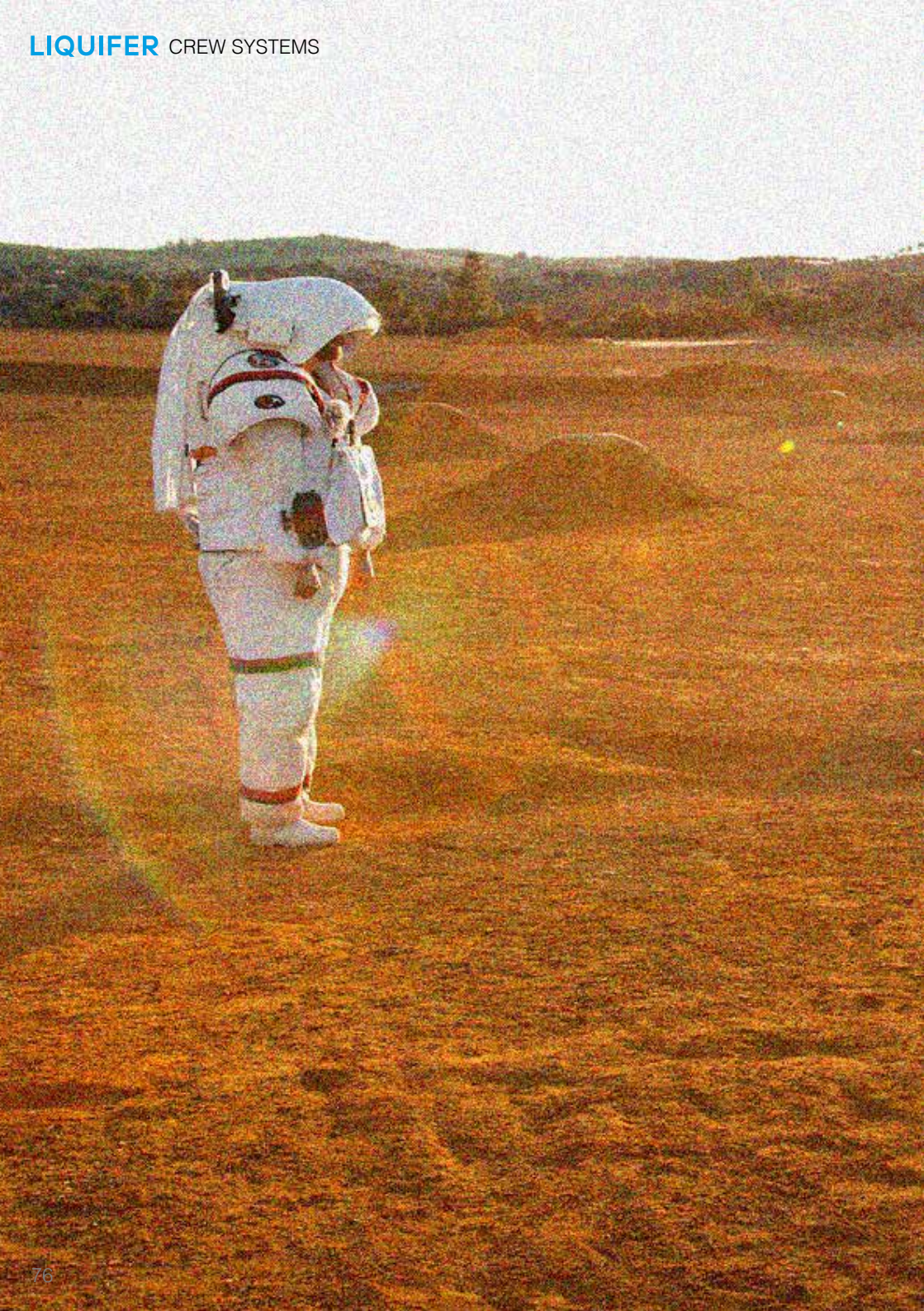
5. DLR scientist, Paul Zabel, tasked with maintaining and harvesting the plants at the EDEN ISS, credits: DLR
6-7. Interior of the EDEN ISS greenhouse. The aeroponic irrigation technique used a mist environment within the light protected root zone of the plant growth trays. Early plant growth was supported by 3D-printed structures. Over 20 plant varieties were cultivated including lettuce, cucumber, radishes, dwarf tomatoes and strawberries. Photo credits: DLR;
8. Rendering of a future greenhouse on the Moon or Mars, based on the EDEN ISS.



CREW OPERATIONS SIMULATIONS

MOONWALK

Human-Robot collaboration for planetary surface exploration

OBJECTIVE:	To develop and test technologies for cooperative human-robot space exploration and extravehicular activity.
SPONSOR:	European Union (EU-FP7)
CONSORTIUM:	DFKI Robotics Innovation Center (DE); COMEX (FR); Airbus (UK); LIQUIFER Systems Group (AT); Space Applications Services (BE); NTNU Centre for Interdisciplinary Research in Space (NO); INTA Instituto Nacional de Técnica Aeroespacial (ES).
PERIOD OF PERFORMANCE:	11/2013 – 10/2016
DESCRIPTION:	Moonwalk developed and validated European technologies under simulated extraterrestrial conditions. Low-gravity conditions were simulated at subsea Marseilles, while environmental and exobiological conditions were replicated at Rio Tinto, Spain. LIQUIFER developed astronaut tools, the rover payload box, a dissemination programme and procedures for the simulations in Rio Tinto and underwater.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1-6. Simulation of extreme environmental conditions and specific exobiological conditions found on Mars. The robot-astronaut team tests MOONWALK systems and technologies at Rio Tinto in Spain. credits: COMEX

7-11. The underwater environment allows the testing of space exploration scenarios under simulated low-gravity conditions. Pool tests at the COMEX premises in Marseille preceded the simulations in natural underwater envi-ronment, both involved a lander mock-up fragment equipped with a suitport, two simulation spacesuits and a robotic rover. credits: COMEX.

Partners

Academic & Research Institutions

Alfred Wegener Institute for Polar and Marine Research (Germany)
DFKI Deutsches Forschungszentrum f. künstliche Intelligenz (Germany)
DLR Institute for Space Systems (Germany)
INTA Instituto Nacional de Técnica Aeroespacial (ES)
International Space University (France)
Limerick Institute of Technology (Ireland)
MEDES (France)
National Research Council (Italy)
NTNU Centre for Interdisciplinary Research in Space (NO)
University of Guelph (Canada)
University of Tartu (Estonia)
Wageningen University and Research (Netherlands)

Space Agencies

Austrian Space Agency
European Space Agency

Industry

Aero Sekur (Italy)

Airbus Defence and Space (Germany)

Azimut (Germany)

COMEX (France)

Enginsoft (Italy)

FAWIC (Netherlands)

Heliospectra (Sweden)

OHB (Germany)

QinetiQ (United Kingdom)

SABELT (Italy)

SENER (Spain)

Sobriety (Czech Republic)

Spartan Space (France)

Space Applications Services (Belgium)

SPIN (Czech Republic)

Telespazio (Italy)

Thales Alenia Space (Italy)

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Creating next-generation crew systems
for enhanced crew performance