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Developing, testing and commercializing the Hydromars water purification technology for human deep space travels

European Commission
SEAL OF EXCELLENCE

USP: COMPLETE RECOVERY OF WATER IN SPACE

FOLLOW UP: CLOSED CIRCLE OF WATER ON EARTH

Hydromars AB ™
ESA Space Solutions ®

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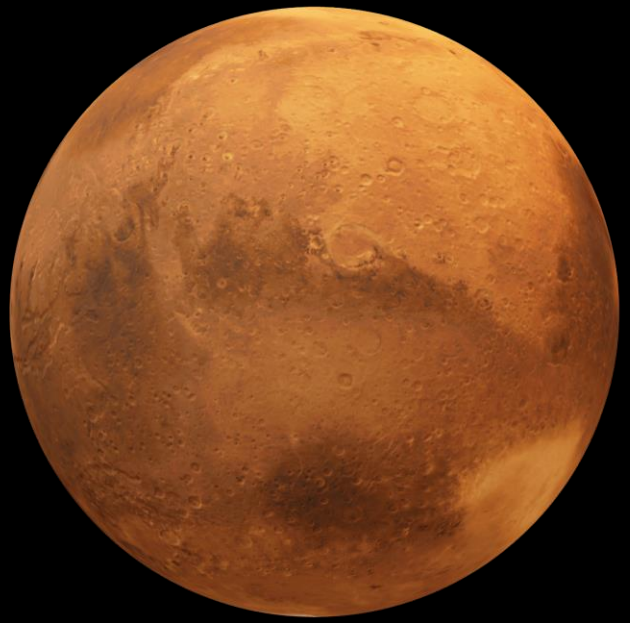
Challenge



3L OF WATER PER DAY AND PERSON (1TON/PERSON/YEAR)

COST OF 1L OF WATER IN SPACE - €35K

CURRENT WATER RECYCLING SYSTEMS RECYCLE 84,7%

97% SALT WATER IN OCEANS

2% FRESH WATER LOCKED IN ICES

1% AVAILABLE FRESH WATER

80% OF WASTEWATER IS NOT TREATED ANYWAY

NEED FOR A TECHNOLOGY ALLOWING COMPLETE WATER CIRCULAR ECONOMY AT A LOW COST!

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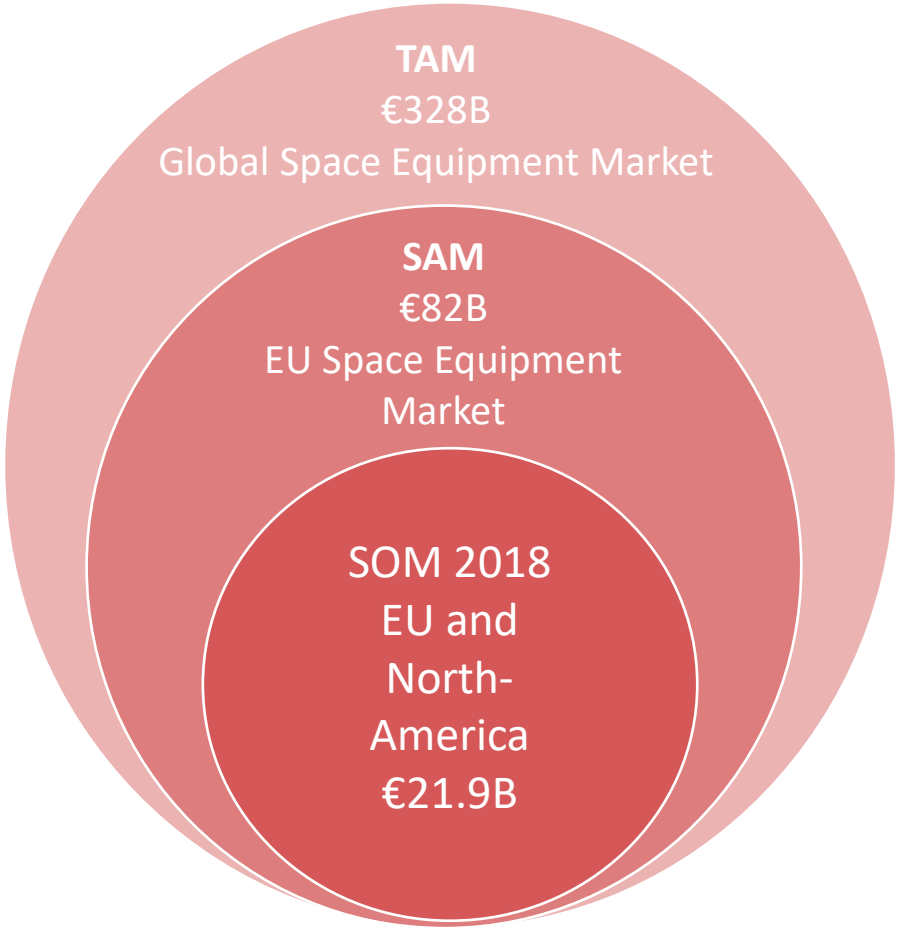
Company purpose

Hydromars mission is to contribute towards **making life multiplanetary and enable human deep space missions** by:

- Developing, testing and commercializing innovative proprietary **thermal pervaporation technology** which, in **only three steps**, turns water from ***any* water source** into ***high quality* pure water**
- Supporting astronauts with pure water throughout whole long-term space journey and thus, contributing to one of the three components of **NASA Life Support System (LSS)** (**complete recovery by Hydromars VS 84.7% by state-of-the-art**)
- Transferring **knowledge created for space to drive change on Earth** (shipping industry, water purification units in harsh environments)
- Becoming integrated part of the European space ecosystem and major supplier of water purification system for world space contributors/distributors/integrators of Large Space Structures (e.g. DLR, Airbus D&S, ESA)

Earth depends on Space



- Average CAGR: **4.3%** between 2020-2027
- Morgan Stanley estimates that the Global Space Industry could generate **revenue of $1T or more in 2040**, up from ~ $328B currently
- **For every invested Dollar in space, it comes x20 times back into society**

CAGR Luxury Handbags: 7%
CAGR Smartphone: 3.2%
CAGR Social Media: 24%

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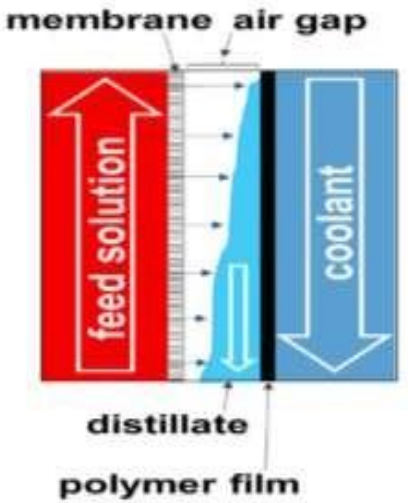
Innovation and Technology

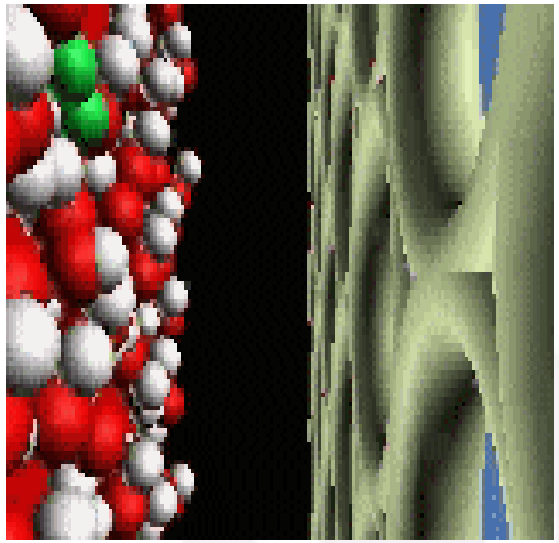
Low Temperature Evaporation (LTE) - turns water from *any* water source into *high quality* pure water

Hydromars is mimicking a natural phenomena: The ability to fully remove EVERYTHING from ANY KIND of water. **Even one carbon atom**

Incoming streams: wastewater from space missions

1. **Heat degassing**: evaporation and elimination of volatile contaminants by heating water (T<100ºC, ambient pressure)
2. **Ultra-pure water separation**: hot feed wastewater flows alongside water repellent (hydrophobic) membrane. The surface tension of the hot feed only allows individual water vapours to pass through to the other side of the membrane. Condensate is completely free from non-volatile components.
3. **Evaporation from the brine**: condensate is evaporated and crystallized by low-temperature heat. Eliminates all residual salts/solids.





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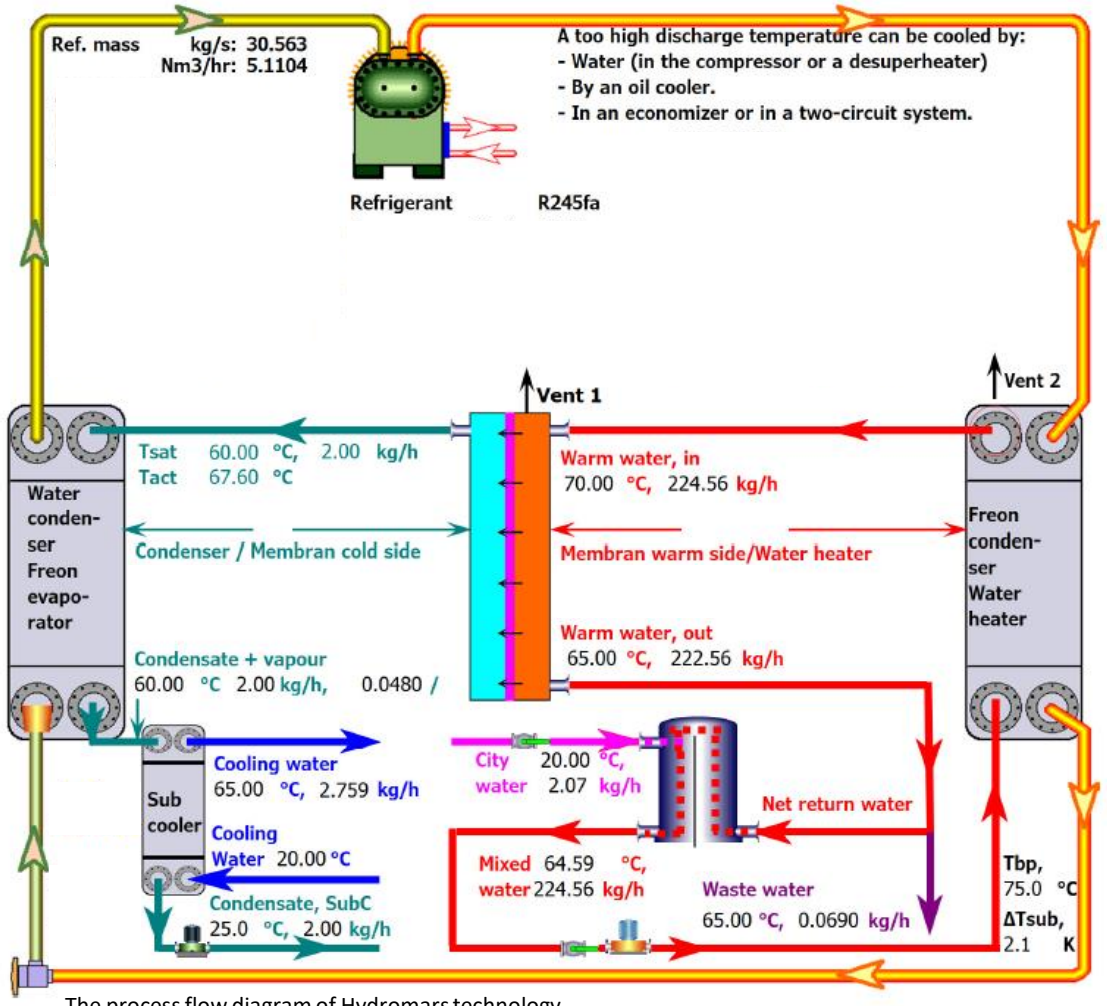
Three basic steps of Hydromars new unit operation

Feed Evaporation → Vapor Permeation → Permeate Condensation

Hydromars makes purification processes circular, ensuring that water and energy is used in an economical way

Principles of Hydromars Equipment

- Heating of feed using refrigeration cycle
- Vapour transported across hydrophobic membrane
- Condensation of vapours in condenser
- Partial pressure difference using vacuum



The process flow diagram of Hydromars technology

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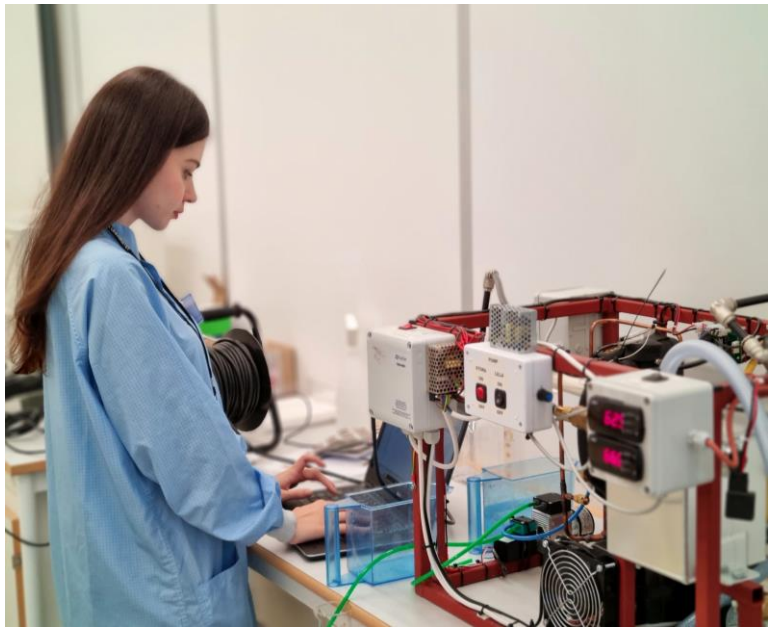
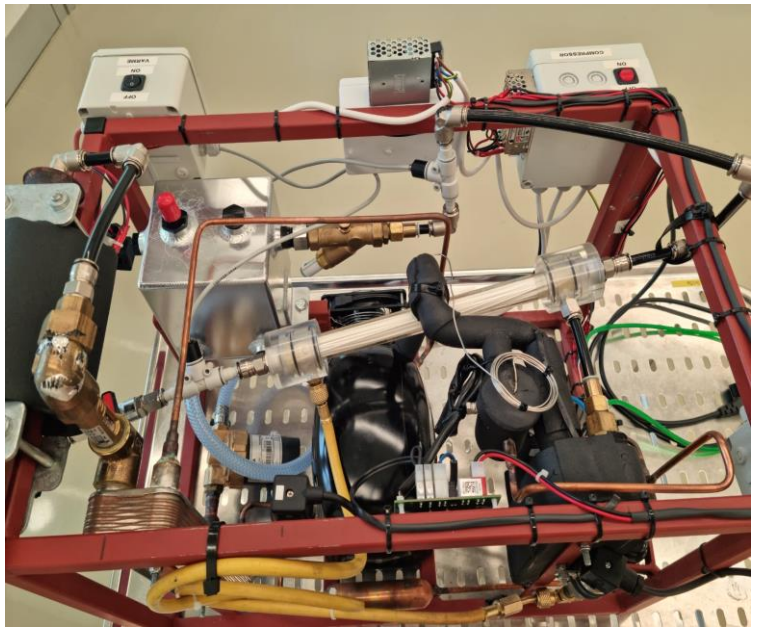
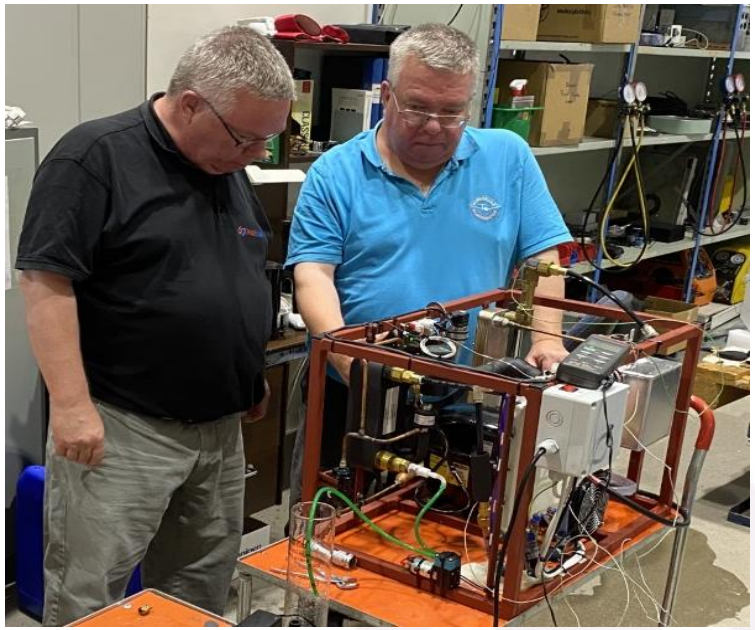
Hydromars Demonstration Unit







Hydromars's latest experimental equipment developed by Peter Nobel and his group of engineers,
Ångström Laboratory, Stockholm, 2022

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Test Results

Hydromars participates with leading Institutes and Multinationals in several European research programs to separate different types of wastewaters into absolutely pure water

Our products are already technically proven at pilot plant setup

- Dealt with relevant complex wastewater streams, for example
  - Flue gas condensate treatment in Power plants
  - Municipal wastewater treatment plants to produce clean water and recover resources
- At TRL 6

Test Results for HYDROMARS's Equipment

Type of contamination	Amount	Method	Detection limit	Test by	Result
Bacteria	14 000 (after 7 days)	Membrane filter count	–	National Bacteriologic Laboratory, Stockholm	BDL
Chlorine	3.4 mg/l	Photometric analysis (Perkin Elmer)	< 0.01 mg/l	Water Protection Association of South West Finland	BDL
Salt water	31 000 ppm	Ion chromatography	< 1 ppm	VBB Viak Stockholm	BDL
Trihalomethanes	1 000 µg/l	Gas chromatography	< 1µg/l	University of Turku, Finland	BDL
Radon	380 Bq/l	Alfa detection	< 4 Bq/l	Swedish Radiation Protection Institute	BDL
Cesium, Strontium, Plutonium, Radium	2.4 Bq	Lithium Drifted Germanium Detector	< 0.1 Bq	Radiation Physics Department, University of Lund	BDL
Arsenic +3	10 mg/l	AAS Graphite	< 0.003 mg/l	Analytica AB, Stockholm	BDL
Arsenic +5	10 mg/l	AAS Graphite	< 0.003 mg/l	Analytica AB, Stockholm	BDL
Ag nanoparticles	3100 µg/l	HPLC	< 2 µg/l	IVL Swedish Environmental Research Institute	BDL
SiO_2	10 000 µg/l	AAS	< 5 µg/l	Vattenfall AB, Stockholm	BDL
Setralin and 20 other pharmaceutical residuals	4 ng/l	HPLC	< 0.8 ng/l	IVL Swedish Environmental Research Institute	BDL

**BDL = below detection limit*

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With Hydromars Solution
Your Ship could be a
Sustainable Zero Waste ship!

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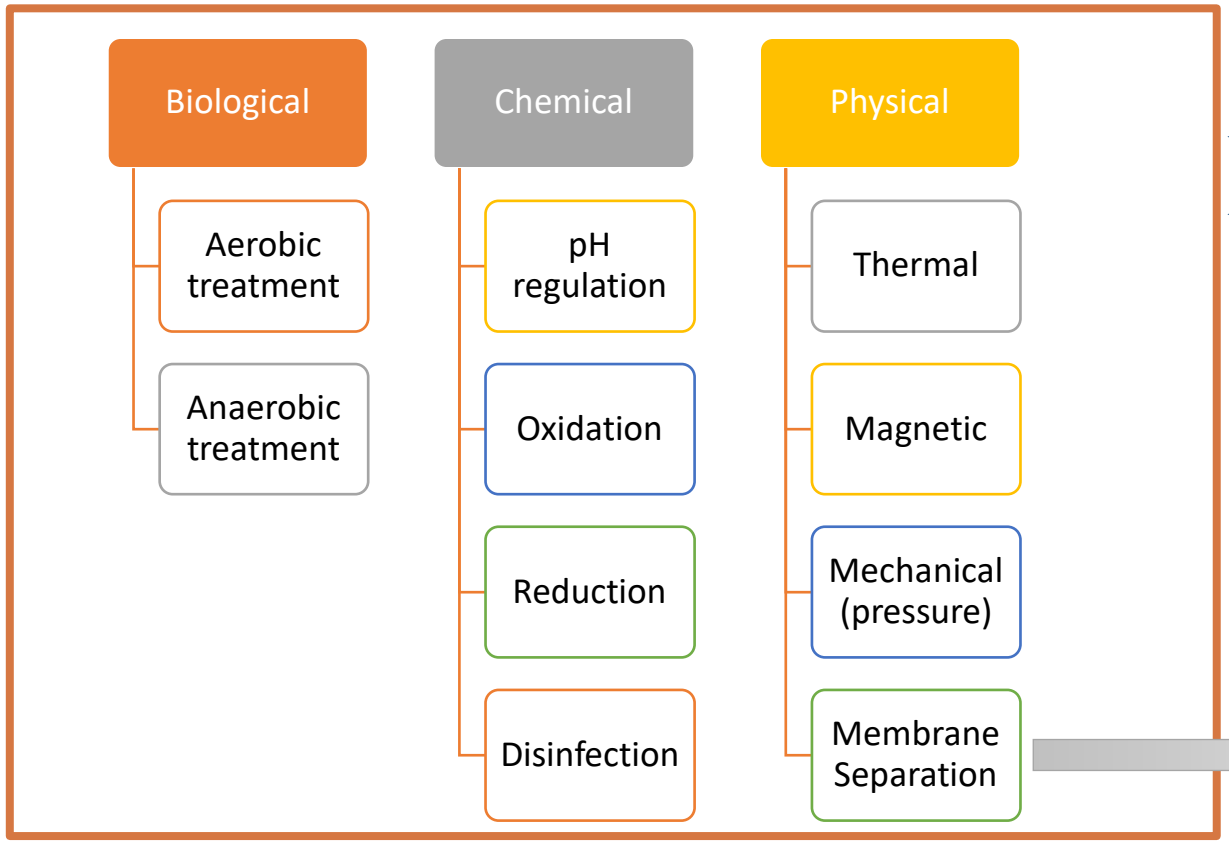
Existing Treatment Methods in Shipping



Combination of technologies for water treatment to recover, reuse and release water

- ✓ Reverse osmosis (RO)
- ✓ Micro-filtration (MF)
- ✓ Nano-filtration (NF)
- ✓ Ultra-filtration (UF)

Issues associated with aerobic treatment

- Difficult and time-consuming process
- Generates noxious N_2O gas which contributes to the greenhouse effect
- Highly restrictive treatment conditions

Issues associated with RO

- Bio-fouling and scaling
- Sludge disposal issues
- Upper pressurization limits
- High electricity demand

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Transforming waste into value

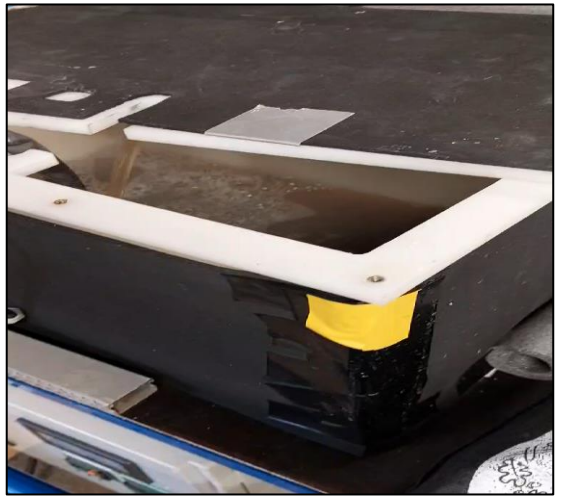
Waste heat Available

- Upwards of 64% of the primary energy input into ships is lost to the environment (MARPOL)
- **The industry needs a system which utilizes waste heat**

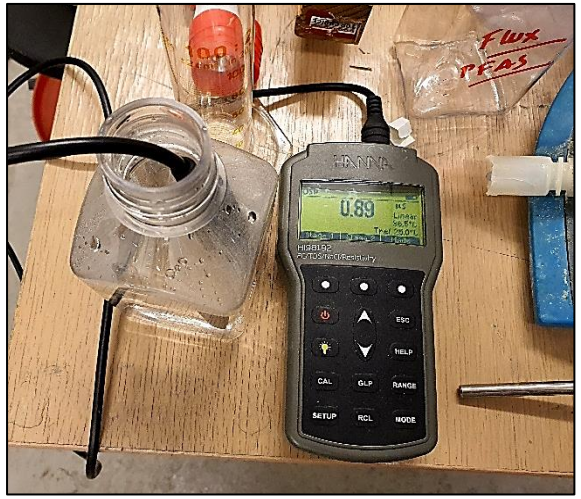
Hydromars technology utilizes ***waste heat*** for ***desalination, wastewater & flue-gas treatment*** **as well as for clean water production & recovery of** ***valuable resources (elements, nutrients)***

Transforming waste into value

Energy	Resource recovery	Manufacturing Processes
Green Hydrogen	Nutrients recovery	Process Water
	Metals recovery	Brine Solution



Treatment of domestic waste where among others, there are human made nutrients. Stockholm, 2022



Conductivity of 0,89 µS/cm means that the water is absolutely pure, and we have to add minerals for health and taste

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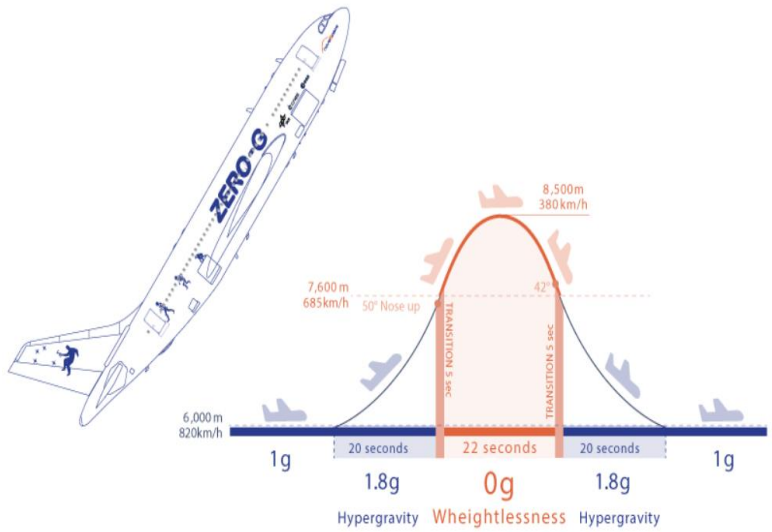
Next Steps



- Parabolic Flights
- Test urine as the next feed
- Test run at ISS
- Implementation of learnings on Earth (Shipping)

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Team

Aapo Sääsk

Founder & Chairman

- 50 years managing SCARAB Development AB
- Inventor of several water-treatment and energy-efficient technologies

Shorena Tsindeliani

CEO and Co-Founder

- Roles as CEO with focus on business development

Miriam Åslin

Operational Director

- Project Leader, for 18 years managing and developing water purification system projects
- Expert on ecotoxicology and deep-tech prototype engineering and design

Dr. Ala's Kullab

CTO

- Product and production development
- PhD in Energy Technology
- Expert on water management and purification

Peter Nobel

Technology Expert

- 25+ years successfully navigating long sales cycles for industrial components
- Expert on sales, marketing, R&D and manufacturing
- Worked for Alfa Laval and SWEP

- **Entrepreneurs**, **scientists** and space **industry experts** from chemical, mechanical engineering, product development, production, product commercialization, and management
- **Scientific validation**: ESA, *imec*, Royal Institute of Technology (KTH), Swedish Environmental Research Institute, Clarkson University, Manta Inc.
- **Established network of Institutes**: Cooperation with **Andrew Martin, Professor at KTH**, Department of Energy Technology and **Frank Holsteyns, Doctor of Engineering**, Head of Department at ***imec***.

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