University *of Ljubljana*
Faculty *of Mechanical Engineering*

Experience of cooperation with ESA

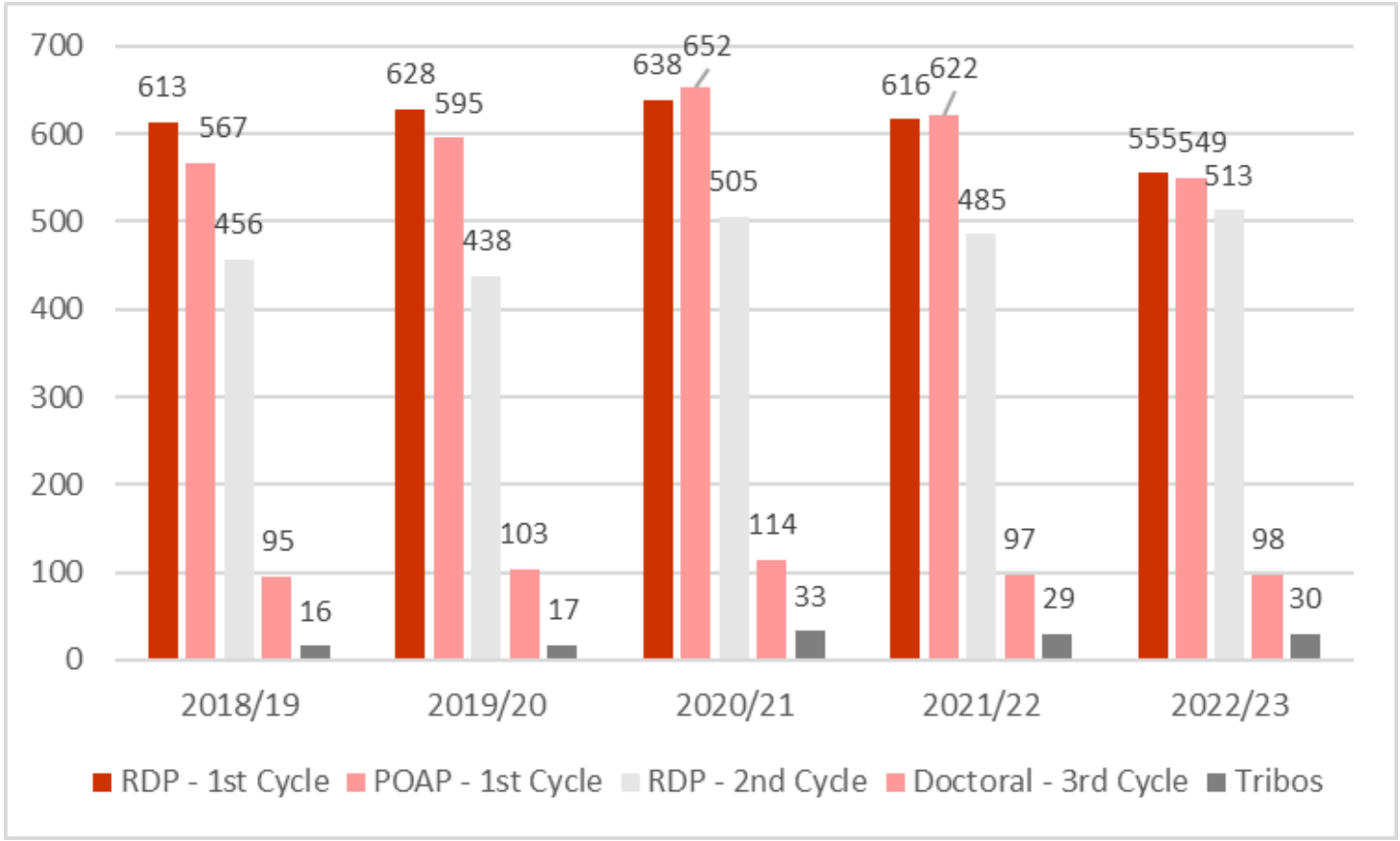
Prof. dr. Janko Slavič,
Vice-Dean for Research and International Relations

Ljubljana, 10th October, 2023

Enrollment in the academic year 2022/23

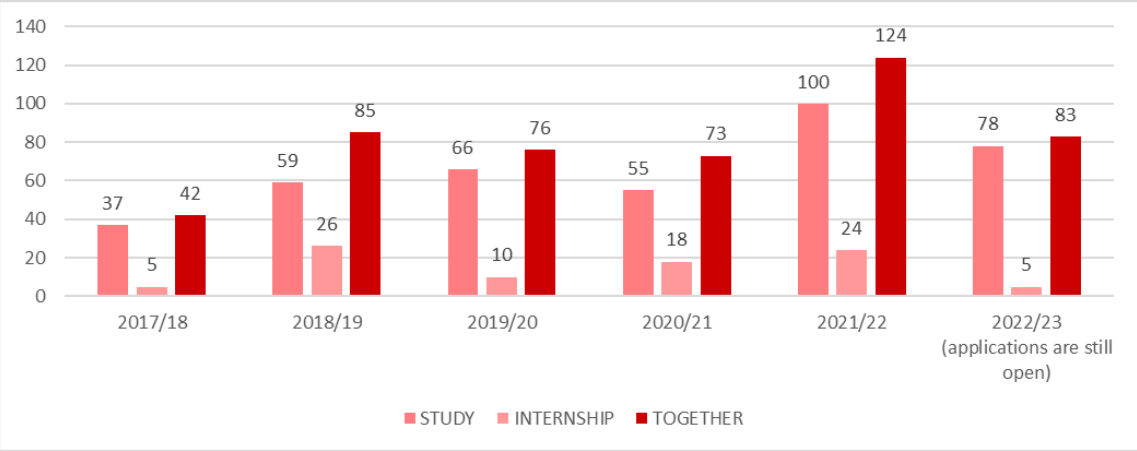
1745

ENROLLED STUDENTS

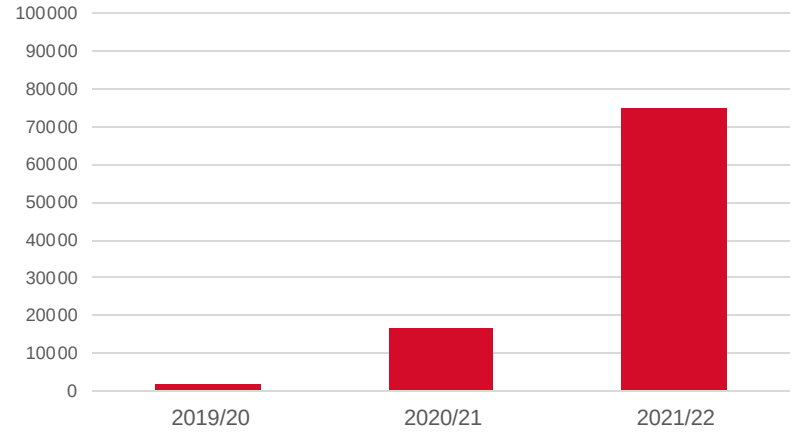


Erasmus+ and exchanges

FOREIGN STUDENTS AT FME

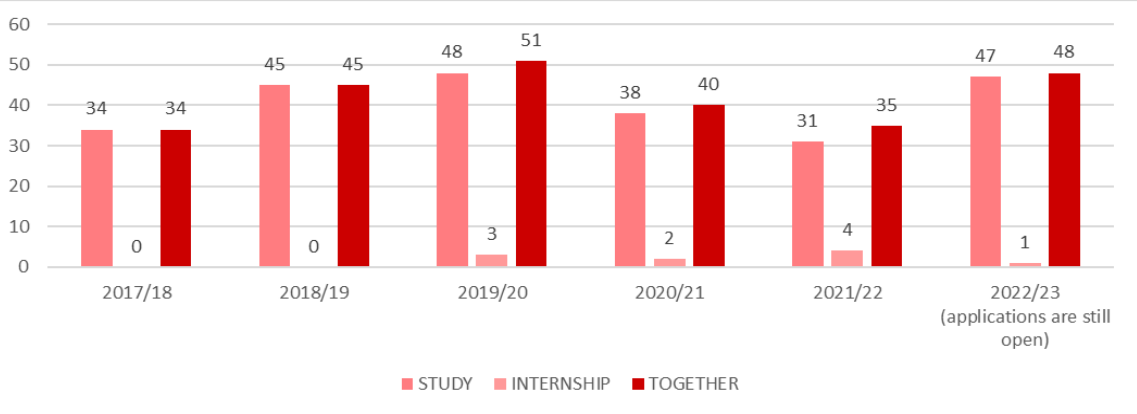


EMPLOYEE EXCHANGES



Financial resources received (UL).

OUR STUDENTS ABROAD



Number of signed Erasmus contracts
124 (+9)

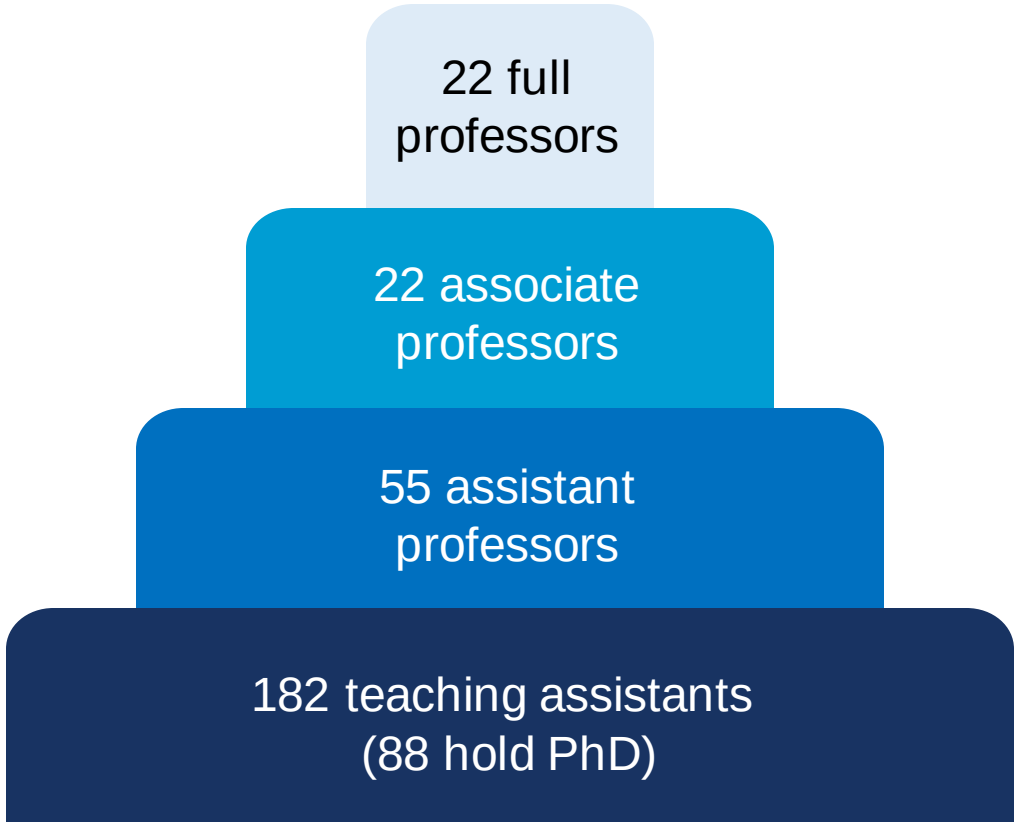
Erasmus+

University *of Ljubljana*
Faculty *of Mechanical Engineering*

Planned for 2027

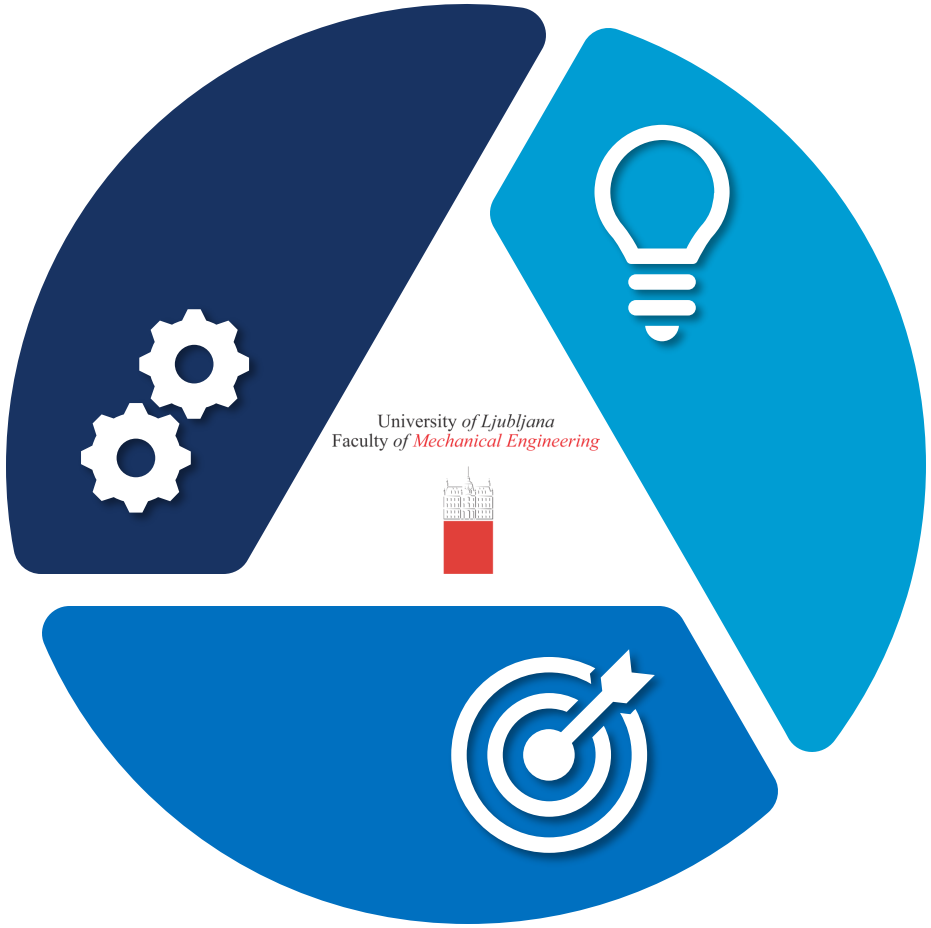
Who are we?

University *of Ljubljana*
Faculty *of Mechanical Engineering*



What is our work?

Pedagogical



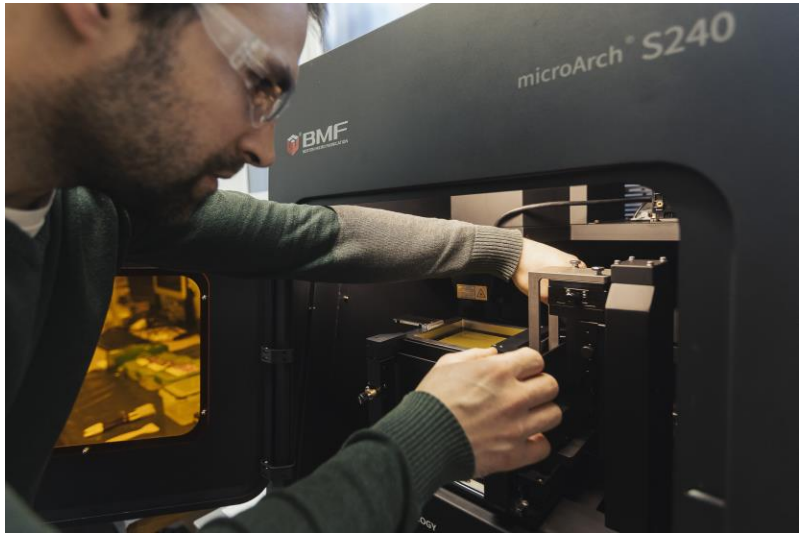
Scientific research

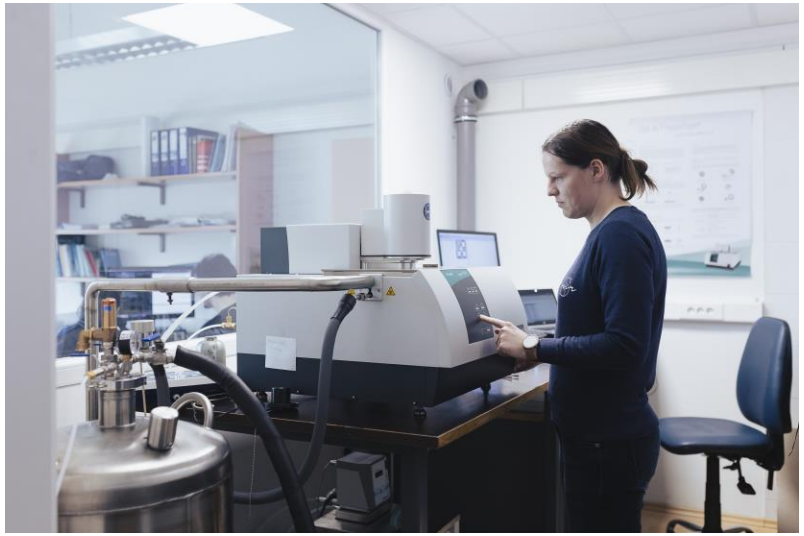
Applied research

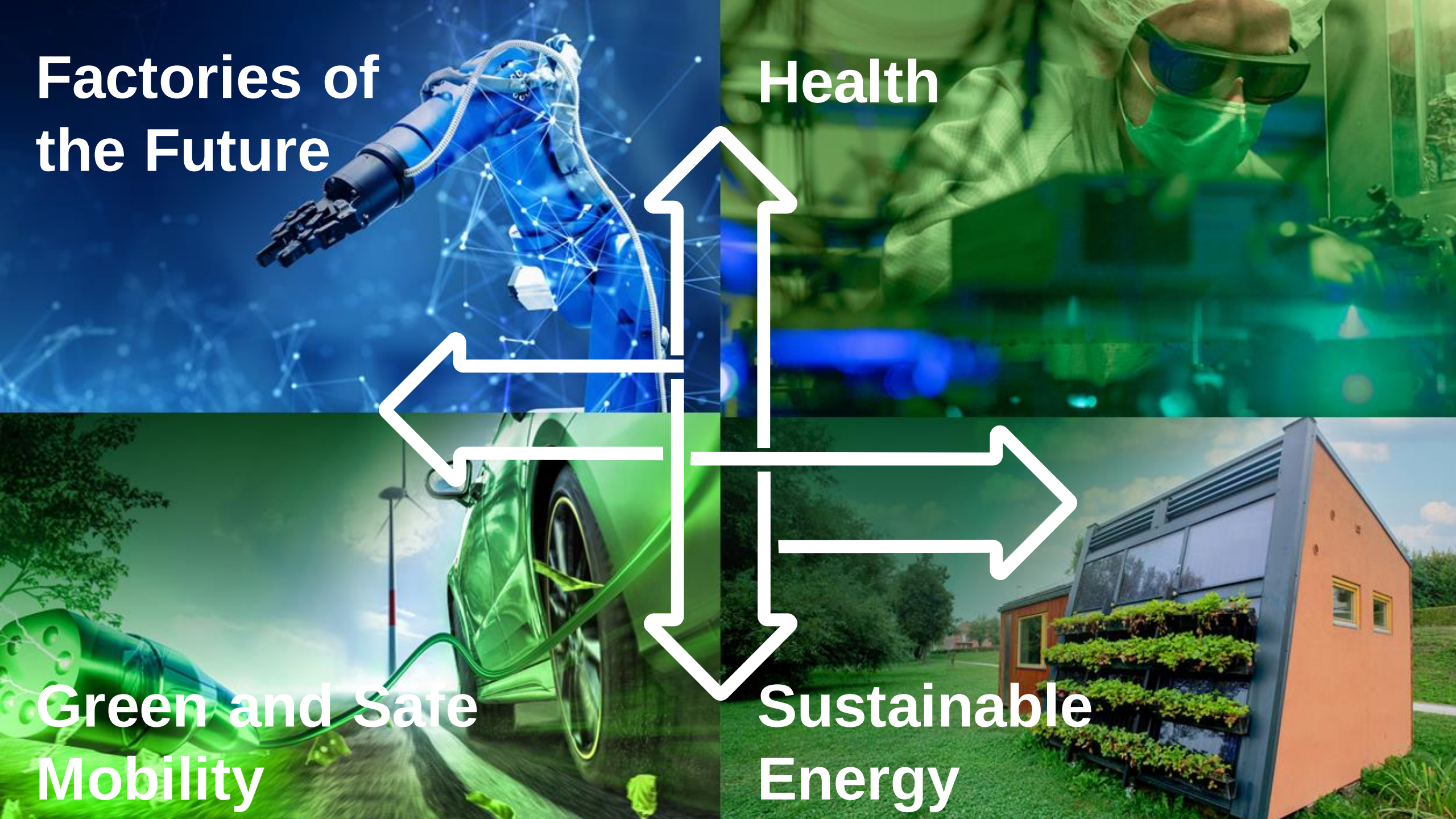
Investment in new equipment

2022: approx. 1.9 mio €

2023: approx. 3.7 mio€






Factories of the Future
Health
Green and Safe Mobility
Sustainable Energy

ESA activities at the UL FS

REPUBLIC OF SLOVENIA MINISTRY OF HIGHER EDUCATION, SCIENCE AND TECHNOLOGY	Javni poziv za zbiranje predlogov projektov za določitev prioritetnih področij, v okviru Načrta za evropske sodelujoče države (PECS)	Ministrstvo za visoko šolstvo znanost in tehnologijo	11.03.2010	20.05.2010

- begins at the very beginning of Slovenia's cooperation with the Agency,
- successfully and efficiently attract researchers from different research fields,
- high success rate for project applications,
- Slovenia's full membership brings new opportunities for our researchers,
- recently, the ESA Academy supported a student project.

Peskovnik
Odprti laboratorij

esa

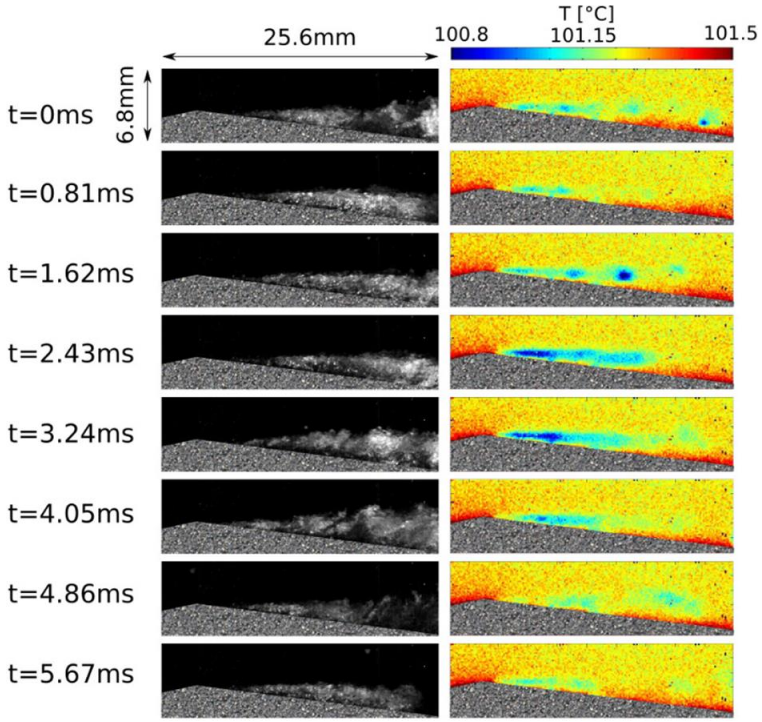
»The first direct measurements of thermodynamic effect«

Problem: Optimal operation of turbopumps is crucial for all liquid fuel rocket engines. To reduce weight, these pumps often operate at critical conditions, where dynamic instability and cavitation are unavoidable.

Purpose: The project purpose is to build the experimental basis containing results of thermodynamic effect in cavitating flow and its influence on the cavity dynamics.

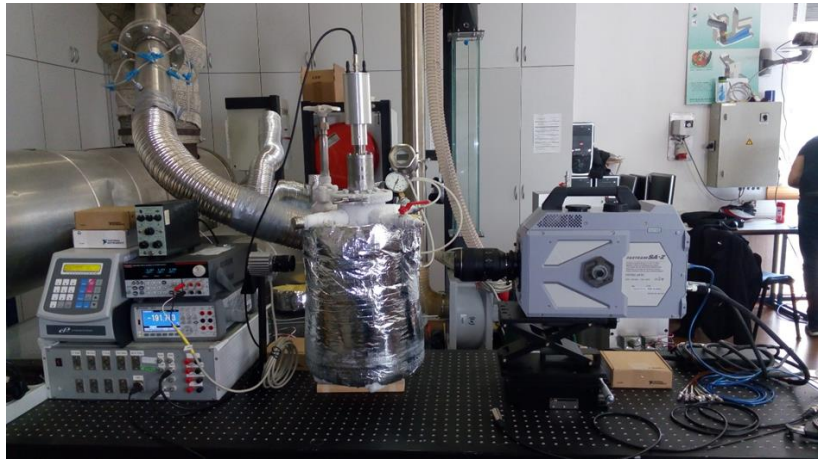
Aims: The equipment and experience we have available, enables to measure the temperature effects directly and thus to construct a better basis for evaluation of the results of numerical predictions.

Project: **Cavitation in Thermosensible Fluids** (CATHEF)
Principal investigator: **prof. dr. Matevž Dular** (Laboratory for Turbine and Water Machines)
Budget: 226.000 EUR
Duration: 2011 – 2015 (52 M)



»Prediction of cavitation damages in cryogenic rocket engine turbopumps«

Problem: Optimal operation of turbopumps is crucial for all liquid fuel rocket engines. To reduce weight, these pumps often operate at critical conditions, where dynamic instability and cavitation are unavoidable.



Purpose: We intended to perform experiments in cryogenic fluids where cavitation will be initiated acoustically – by ultrasound.

Aims: Specifically, we intended to investigate a state, which appears somehow intermediate between hydrodynamic and acoustic cavitation, namely a large cavity attached to an ultrasonic horn tip and collapsing with its self-generated subharmonic cycle frequency (the so called "acoustic supercavitation") and which resembles the conditions in the turbopump inducer.

Project: **Experiments and simulations on cavitation and cavitation erosion in cryogenic liquids** (CryoCav)
Principal investigator: **prof. dr. Matevž Dular** (Laboratory for Turbine and Water Machines)
Collaboration: Abelium (industry partner)
Budget: 199.801 EUR
Duration: 2015 – 2017 (24 M)

»Prediction model of LBNP on cardiovascular system response«

Problem: One of the most promising countermeasures to prevent negative effects due to long-term exposure to microgravity conditions is Lower Body Negative Pressure (LBNP).

Purpose: To understand the effect of LBNP on the response of the subject-specific cardiovascular (CV) system and, consequently, to personalize the application of LBNP.

Aims: Measure the CV system response to different levels of LBNP on a large sample of subjects (both males and females). Develop and tune a mathematical model for subject-specific responses.

Project: **Prediction model of countermeasures efficiency on cardiovascular system and fluid shifting in simulated microgravity conditions**
Principal investigator: **assit. prof. dr. Janez Urevc** (Laboratory for Numerical Modelling and Simulation)
Collaboration: Medical University Graz
Budget: 99.717 EUR
Duration: 2022 – 2023 (15 M)

»The internal jugular vein thrombosis is a potentially life-threating disease«

Problem: The impact of microgravity (space travel) on the cardiovascular system is still not well understood.

project started a week ago

Purpose: To understand the deconditioning of blood vessels during long-term exposure to microgravity conditions and to develop a method for detecting deep vein thrombosis that can be used by non-specialized personnel, such as astronauts.

Aims: The aim is to develop a device for non-invasive estimation of jugular vein pressure and rigidity, and for the prediction of jugular vein thrombosis.

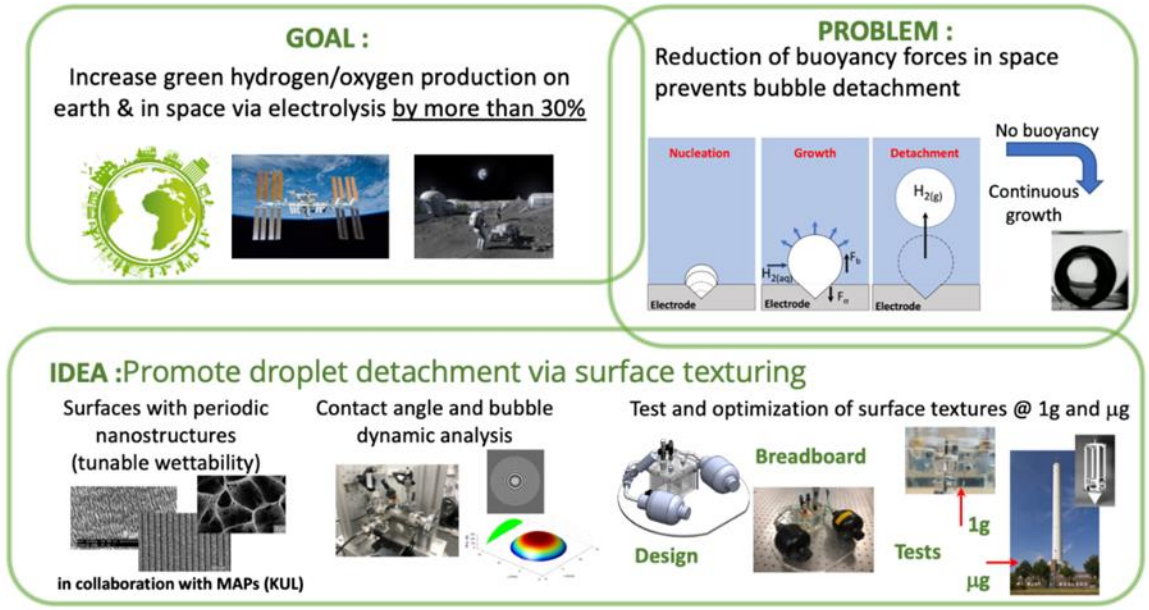
Project: **Device for non-invasive determination of jugular vein pressure and the risk of thrombosis (JVPdevice)**
Principal investigator: **assit. prof. dr. Janez Urevc** (Laboratory for Numerical Modelling and Simulation)
Collaboration: Medical University Graz, University Medical Centre Maribor
Budget: 99.647 EUR
Duration: 2023 – 2024 (15 M)

»Revolutionizing Hydrogen and Oxygen Production in Space with Functionalized Surfaces«

Purpose: Enhance detaching of the hydrogen gas bubbles via the passive technique, namely by texturing the surface of electrodes utilized in electrolyzers.

Aims: To develop techniques able to control and optimize the wettability of PEM electrodes to increase gas bubble formation and release during electrolysis process.

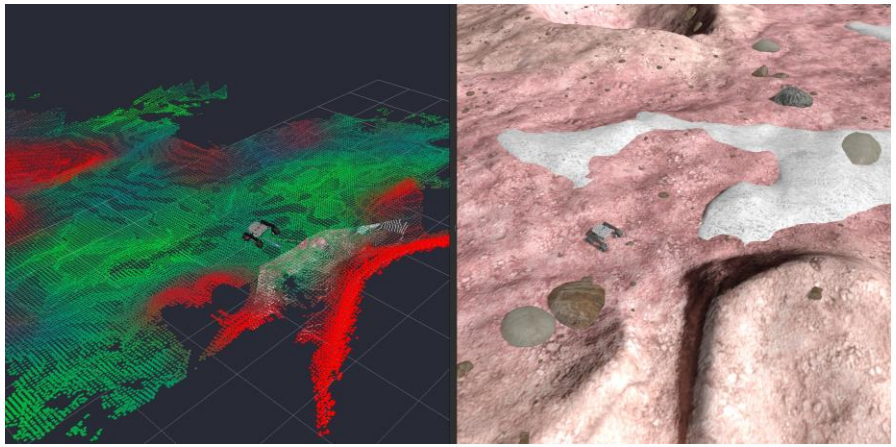
Special achievements: Provide deeper fundamental understanding of hydrogen bubble generation and release on various advanced electrodes.



Project: **Development of tailored surfaces for a more efficient production of Hydrogen and Oxygen in-space via PEM electrolysis**
Principal investigator: **assoc. prof. dr. Maria Rosaria Vetrano (KU Leuven)**
Collaboration: **prof. dr. Iztok Golobič** (UL FS, Laboratory for Heating Technology)
Duration: 2023 – 2025 (18 M)

»Cooperative Terrain Prospecting with Rover Swarms«

Problem: Efficiently mapping the terrain geometry and soil properties is important for robust navigation on Moon and Mars. Given the increasing complexity of future space missions, single rovers will be replaced by multi-rover systems.



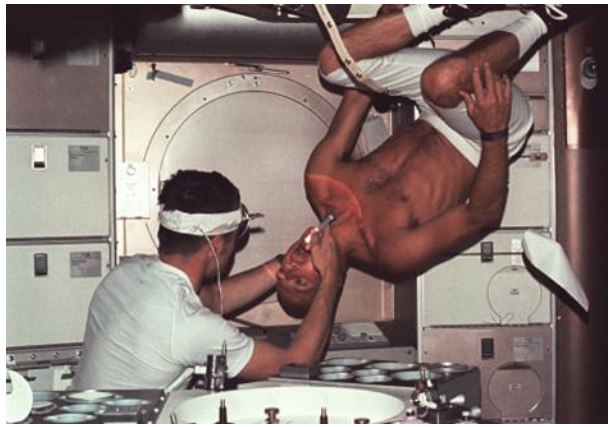
Purpose: To overcome the limitations of individual rover deployments by introducing a cooperative system comprising five small-scale rovers.

Aims: To assemble a fleet of five autonomous small-scale rovers equipped for terrain mapping and navigation; to augment these rovers with devices capable of measuring soil hardness; to test and demonstrate the cooperative capabilities of these rovers under various conditions.

Project: **Self-organizing millirobot swarms for autonomous modification of unknown, granular terrain (SWAM)**
Principal investigator: **assist. prof. dr. Rok Vrabič** (Laboratory for Mechatronics, Production Systems and Automation)
Budget: 68.300 EUR
Duration: to be defined (12 M)

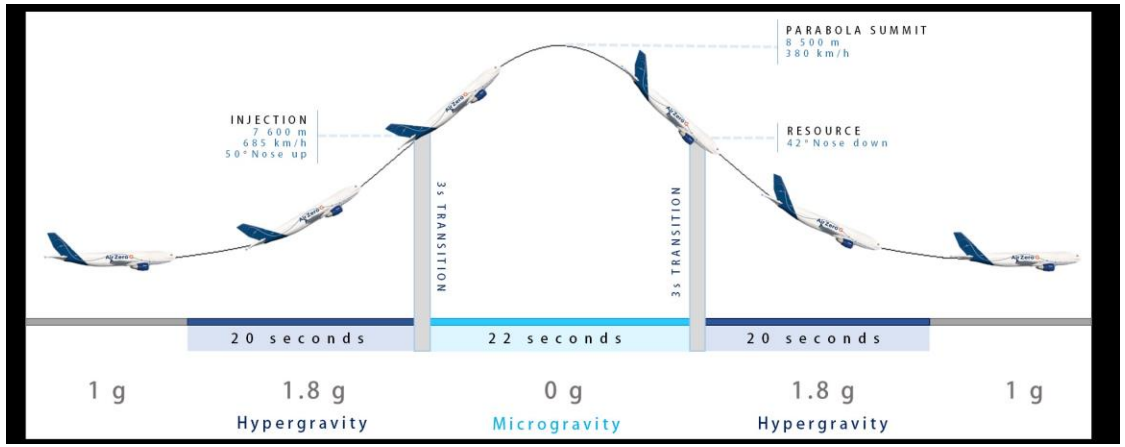
»The first step in preparing dental medicine for long-duration missions to the Moon and Mars«

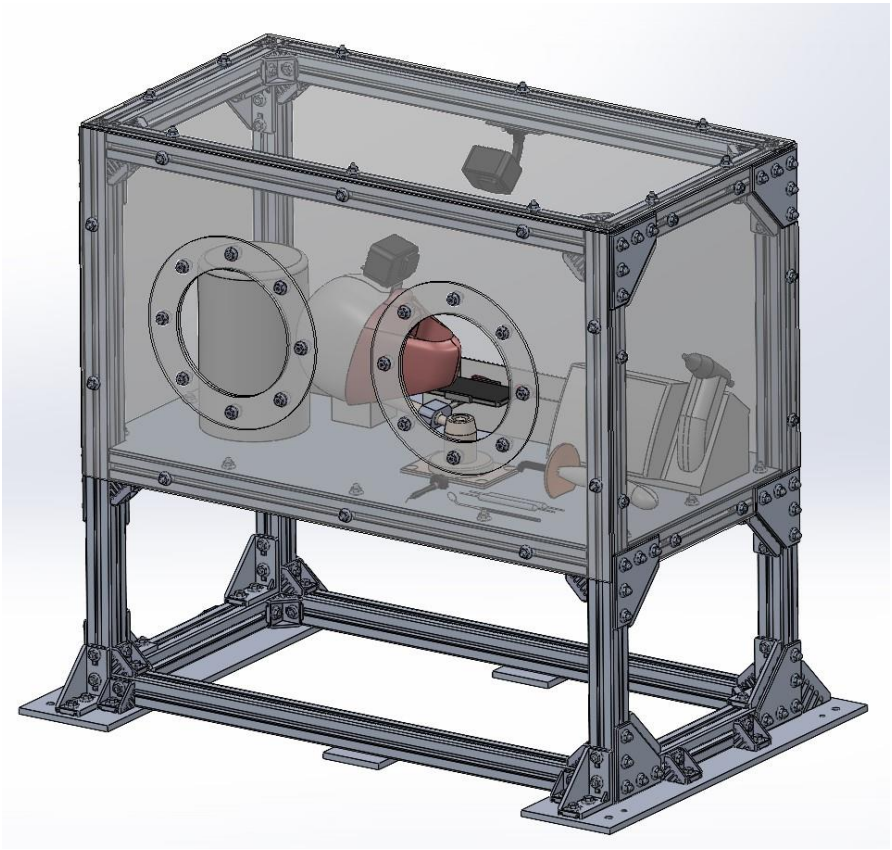
SpaceDent is an European space agency (**ESA Academy**) supported **student project**, which is, as **first of its kind**, preparing **dental medicine** for long-term missions to the **Moon and Mars**. The experiment, performed by two dentistry students during parabolic flight, aims to determine whether the accuracy of dental drilling and filling placement in micro-gravity is controlled enough to provide a safe and reliable astronaut treatment in space.



Multidisciplinary collaboration
Dental Medicine
Mechanical Engineering
Electrical Engineering

»The first step in preparing dental medicine for long-duration missions to the Moon and Mars«





Peskovnik
Odprti laboratorij

Catalogue of Slovenian Space industry 2023

University of Ljubljana, Faculty of Mechanical Engineering

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1000 Ljubljana, Slovenia

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University *of Ljubljana*
Faculty of *Mechanical Engineering*

SHORT DESCRIPTION OF THE INSTITUTION

Scientific research work of UL FS is carried out in the fields of power and process engineering, design, mechanics and maintenance of machines, production engineering, mechatronics, micromechanic systems and automatization.

SPACE SEGMENTS THAT ARE MOST RELEVANT FOR YOUR INSTITUTION

- Ground systems
- Life in space
- Space settlement

MAIN ACTIVITIES RELEVANT FOR THE SPACE SECTOR

- Accelerated vibration fatigue testing and research,
- Ice properties at cryogenic temperatures and high velocities,
- Boiling heat transfer phenomena,
- Surface and interface nanotechnology, boundary lubrication and tribochemistry,
- Extreme mechanics of light-weight structures,
- High fidelity multi-scale and multi-domain models for batteries and fuel cells,
- Physicochemically consistently high fidelity and computationally efficient system level models,
- Physicochemically consistent observer models of batteries.

VALUE PROPOSITION/OFFERING

- Development of different custom mechanical componentsand equipment,
- Vibration fatigue research,
- Prototype machine for testing the properties of ice particlesin air stream and water jet,
- Additive manufacturing services,
- Tribologically-optimised mechanical systems and maintenance-free lubrication of mechanical assemblies,
- Analysis of load bearing capacity, functionality and stability of these structure,
- Custom sensors,
- Services on production and joining of components.

REFERENCES IN SPACE INDUSTRY

ESA projects

- Prediction model of countermeasures efficiency on cardiovascular system and fluid shifting in simulated microgravity conditions
- Experiments and simulations on cavitation and cavitation erosion in cryogenic liquids (CryoCav); 2015 – 2017
- Cavitation in Thermosensible Fluids (CATHEF); 2011–2015
- ESA-funded boiling research p roject (AO-2004-111: BOILING)
- Scientific manuscripts
- Additive Manufacturing: Hybrid additive manufacturing of Inconel 718 for future space applications (Materials Characterisation, 2021)
- Numerical algorithms: Multiple Wrinkling Mode Transitions in Axially Compressed Cylindrical Shell-Substrate in Dynamics (Thin-Walled Structures, 2020)
- Structures: Wrinkling crystallography on spherical surfaces (PNAS, 2015)
- Aerodynamic Drag Control: Smart Morphable Surfaces for Aerodynamic Drag Control (Advanced Materials, 2014)

Scientific monograph

- Vibration Fatigue by Spectral Methods: From Structural Dynamics to Fatigue Damage–Theory and Experiments, Elsevier 2021

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Faculty *of Mechanical Engineering*

We propel the future