
Łukasiewicz
Institute
of Aviation
SPACE
TECHNOLOGIES

TABLE OF CONTENTS

GENERAL COMPANY INFORMATION

CONTACT

GENERAL COMPANY INFORMATION

Łukasiewicz Research Network - Institute of Aviation is one of the most modern research institutions in Europe, with traditions dating back to 1926. The Institute closely cooperates with the world's tycoons of the aviation industry and institutions from the space industry. The strategic research areas of the Institute are aviation, space and unmanned technologies. Tests and services for domestic and foreign industry in the field of metallic and composite materials, additive, remote sensing, energy and mining technologies are also carried out here. Łukasiewicz Research Network - Institute of Aviation is made up of eight research centers:

- AVIATION TECHNOLOGIES CENTER
  develops technologies dedicated to aircraft design, aerodynamic research and aircraft certification.

- SPACE TECHNOLOGIES CENTER
  conducts research and development in the field of space propulsion, space transportation, satellite testing and remote sensing.

- UNMANNED AERIAL VEHICLE TECHNOLOGIES CENTER
  conducts research and development in the field of drones and anti-drone systems.

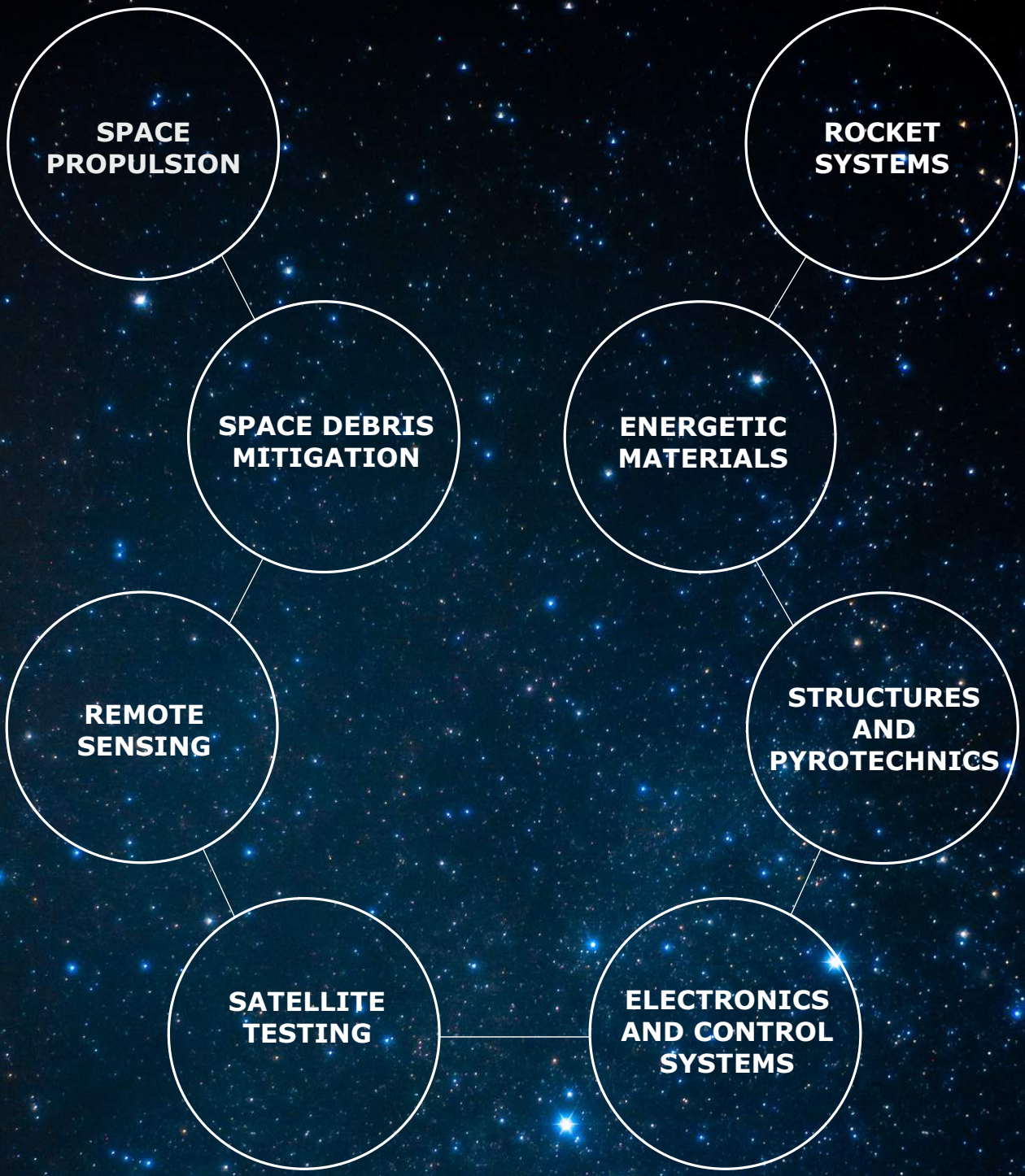
- MATERIALS AND STRUCTURES RESEARCH CENTER
  offers materials and structural components testing in a wide range of loads and temperatures. Thanks to a large number of certified test stands it is a regional leader in fatigue and strength testing.

- COMPOSITE TECHNOLOGIES CENTER
  delivers composite technology solutions and composite material tests for the aerospace industry.

- ENGINEERING DESIGN CENTER
  is an engineering alliance between General Electric Company Polska Sp. z o.o. and Łukasiewicz Research Network – Institute of Aviation. The Center offers design, research and development services in the fields of aviation, gas power and renewable energy.

- ENGINEERING SERVICES CENTER
  provides mechanical and thermal engineering support to strategic research and development projects.

- ENERGY TECHNOLOGIES CENTER
  focuses on engineering areas: designing, manufacturing, analyzing and servicing parts for high-power gas turbines and wind turbines. One of the main tasks of this center is to implement a new energy era that will build a cleaner future.



OFFER

The main area of interest of Łukasiewicz Research Network – Institute of Aviaton within Space Technology is providing research and development services and supporting industry with product development. World-class facilities, experienced staff and young talent ensure quality and allow delivering game-changing solutions to the global market. Certified laboratories and knowledge concerning European Cooperation for Space Standardization (ECSS) make Łukasiewicz Research Network – Institute of Aviaton a strong partner in the domain of Space Technology.

In the year of 2023 in Warsaw a modern research unit – the Laboratory Center for Rocket and Satellite Propulsion - was put into operation, which complements the research offer of the Łukasiewicz – Institute of Aviation in the field of space technologies.

The infrastructure is intended for both qualification and industrial research and development work, including:

- development and qualification of ecological rocket and satellite green propulsion systems,
- development of novel propellants, with emphasis on ecological and hypergolic fuels,
- development of systems for satellite deorbitation,
- development of pyrotechnic components and electronic components systems.

Design and tests of space technologies are carried out in a number of laboratories, including:

1. SPACE PROPULSION RESEARCH LABORATORIES:

- Rocket propulsion test facility - tests in atmospheric conditions, units up to 5 kN of thrust,
- Satellite propulsion test facility - tests in atmospheric conditions, units up to 20 N of thrust,
- Space propulsion test facility - tests in conditions of continuous vacuum, units up to 500 N of thrust,
- Rotating detonation engine test facility (RDE) - for gaseous and liquid fuels.

2. CHEMICAL LABORATORIES:

- Catalyst Laboratory.
- Solid Propellant Laboratory.
- Synthesis Laboratory.
- Liquid Fuels Laboratory.
- Thermal Test Laboratory.
- Analytical Laboratory.

3. ROCKET AND SPACE SUBSYSTEMS TEST LABORATORIES:

- Actuation and Control Systems Laboratory.
- Space Avionics Laboratory.
- Flow Components and Valves Laboratory.
- Injector Test Station.

European Funds
Regional Programme

Republic of Poland

Mazovia.
heart of Poland

European Union
European Regional Development Fund


STA 449
Jupiter
NETZSCH

CHEMICAL LABORATORIES

Expanded in 2023, the Chemical Research Laboratory for space applications enablesa global-scale investigation of physico-chemical properties and chemical compatibility of propellant materials. Łukasiewicz - Institute of Aviation is a leading research and development unit in Poland and worldwide in the field of ecological rocket propulsion. Its primary areas of interest and specialization lie in environmentally friendly liquid and hybrid propulsion systems based on over 98% hydrogen peroxide, as well as innovative hypergolic fuels.

The in-house capabilities of production of hydrogen peroxide with concentrations exceeding 98% are based on a patented method, providing independence in preparations for testing engines and other components utilizing HTP.

THE CHEMICAL LABORATORY PERFORMS THE FOLLOWING TASKS

- Research on fuels for new liquid, hybrid, and gel propulsion systems.
- Research onfuels hypergolic with hydrogen peroxide (production, long-term storage, passivation, and compatibility studies).
- Research on chemical durability of fuels containing catalytic and/or energetic additives.
- Investigation of physicochemical parameters useful for propulsion applications.
- Development of advanced low-smoke solid rocket propellant materials.
- Research on high-performance environmentally friendly fuels and oxidizers of a new generation.
- Development of catalysts for single-component propellant applications.
- Research on the chemical compatibility of different structural materials with working fluids.
- Development of fuel compositions that spontaneously react with hydrogen peroxide (hypergolic).

THE EQUIPMENT OF THE CHEMICAL LABORATORIES INCLUDES, AMONG OTHERS

- Nicolet iS50 FT-IR spectrometer with built-in ATR.
- Vhx 7000 digital microscope.
- Laboratory muffle furnace type FCF 22 SHM.
- Vibratory sieve shaker AS Control.
- Planetary ball mill PM 100.
- Stand for casting solid rocket propellant materials.

Prototypes of propellant materials obtained through casting process and after thermal conditioning must undergo testing to meet specified parameters, including ballistic, mechanical, thermochemical properties, and safety requirements. Only with a ready and properly characterized propellant material can full thruster tests be conducted, which are performed on site on vacuum or atmospheric test stands. Consolidating the research facilities in one place enables comprehensive research and development of solid propellant materials while increasing their safety.

CHEMICAL SPACECRAFT PROPULSION

Łukasiewicz Research Network – Institute of Aviation is capable of designing, manufacturing and testing rocket propulsion components and systems. Dedicated Propellants, Catalysts and Space Propulsion laboratories are part of the existing infrastructure. The Institute has wide experience in development of monopropellant thrusters, liquid rocket engines, as well as hybrid and solid rocket motors.

MONOPROPELLANT THRUSTERS AND FULL PROPULSION SYSTEMS

- Thrusters and engines for spacecraft with thrust in the range of 1 - 500 N.
- Hydrogen Peroxide Reaction Control Systems for rockets.
- Propulsion for satellite de-orbit.
- Advanced catalyst beds.
- Cutting Edge High Performance Green Propellants.
- Full green propulsion systems for small spacecraft.

Key products under development:

- 1 N low-cost Hydrogen Peroxide Thruster (ESA funding).
- POLON – green propulsion system for microsatellite platforms (NCBiR funding).

LIQUID BIPROPELLANT ENGINES

- Development of bipropellant thrusters for spacecraft and engines for launch vehicle upper-stage propulsion.
- Green storable propulsion for exploration missions, including descent and ascent throttleable propulsion.
- Achievement of significant cost improvements due to use of Additive Layer Manufacturing.
- Development of feeding systems with electric pumps/HTP-powered turbines.
- Capability to design and test engines of thrusts up to 100 kN within national partnerships.
- Liquid rocket engine igniters based on hydrogen peroxide catalytic decomposition and pyrogen igniters based on environmentally-friendly composite propellants.

Key products under development:

- 10 – 20 N bipropellant thruster for Green Space Propulsion (ESA funding).
- 450 N Green Liquid Apogee Engine providing unprecedented performance and capabilities (ESA funding).
- Green upper-stage propulsion for small launch vehicles (reignitable, thrust 5-8 kN)*
- Deep-throttling green propellant engines for landers and reusable rocket stages (ESA funding).

* *Project financed by the National Centre for Research and Developemnt aiding national security and defense activities.*

HYBRID ROCKET MOTORS

- Robust technology for space transportation.
- High performance due to use of 98+% Hydrogen Peroxide.
- Experience with Additive Manufacturing of complex geometry fuel grain.
- Patented hybrid fuel technology.

Key products under development:

- Green propellant hybrid rocket motor with Polyethylene fuel 4 kN thrust version successfully flown during suborbital missions, highly scalable technology.

SOLID ROCKET MOTORS

- Low-cost composite-structure solid rocket motors, tested in-flight.
- High performance composite, as well as double base, propellants.
- Solid rocket motors for microlauncher applications with propellant mass fractions in line with top systems of their size produced worldwide.
- Development of small motors: for stage separation, spin control, ullage solid rocket motors etc.
- Solid propellant gas generators – use of low temperature fuel-rich solid propellant with no solid combustion products, serving as a robust medium for turbine operation.

Key products under development:

- SRM for de-orbit using aluminum-free high-performance propellant (ESA funding in 4 consecutive projects), the only European SRM for de-orbit meeting ESA Clean Space requirements and spacecraft acceleration limits.
- 50 kN solid rocket booster*.
- 6 kN solid rocket motor for rocket-assisted take-off for UAVs.

* *Project financed by the National Centre for Research and Developemnt aiding national security and defense activities.*

PROPULSION SYSTEMS

- Components for use with state-of the-art and green propellants:
  - Propellant tanks,
  - Valves,
  - Tubing,
  - Structures.
- Subsystems.
- Integration and testing.

Key products under development:

- Green Liquid Propulsion system for HYPERSAT platform (NCBiR funding).
- Flow control valves for mono and bipropellant RCS thrusters and apogee engines (ESA funding).
- Latch valves (ESA funding).
- Pyrotechnical valves.
- Demisable propellant tank (ESA funding).
- Throttleable Liquid Propulsion Demonstrator (TLPD), utilizing HTP 98% as oxidizer, aims to provide deep-throttle solution for reusability and increased mission flexibility for European Space Transportation Systems (ESA funding).

GREEN PROPELLANTS

The Institute's crucial achievement is the development and commercialization of the method for preparing hydrogen peroxide, in particular High-Test Peroxide – HTP, which is utilized in a wide range of industries.

THE PROPELLANT LABORATORY REALIZES THE FOLLOWING TASKS:

- Research on propellants for novel liquid, hybrid and gel propulsion systems.
- Research on fuels hypergolic with Hydrogen Peroxide.
- Development of low-smoke advanced solid rocket propellants.
- Research on next-generation high performance green propellants.
- Development of catalysts for monopropellant applications.
- Research on chemical compatibility of various engineering materials with propellants.

THE EQUIPMENT WITHIN THE CHEMICAL LABORATORIES INCLUDES INTER ALIA:

- Nicolet iS50 FT-IR Spectrometer with a built-in ATR.
- Vhx 7000 digital microscope.
- Laboratory muffle furnace type FCF 22 SHM.
- Vibratory Sieve Shaker AS Control.
- Planetary Ball Mill PM 100.
- Setup for casting solid rocket propellants equipped with a casting chamber, casting funnel, thermostat, vacuum pump and a vibrating table.

HYDROGEN PEROXIDE

The Space Technology Center has over ten years of experience working with HTP grade hydrogen peroxide. In 2011, scientists and engineers from Lukasiewicz – Institute of Aviation developed a technology for producing hydrogen peroxide with a concentration above 98%. Concentrations up to 99.99% can be obtained. Łukasiewicz Research Network – Institute of Aviation holds several patents for this technology and secured the solution in over 20 countries worldwide.

THE HYDROGEN PEROXIDE LABORATORY FOCUSES ON:

- Development and optimization of modern methods for obtaining HTP.
- Research on HTP storability.
- Analytics e.g. study of trace amounts of metals and determination of trace amounts of ions in accordance with MIL-PRF-16005F, determination of evaporation residue, compatibility tests, organic and inorganic carbon content, microscopical sizing and assessment of the number of particles from aerospace fluids on membrane filters.
- Introducing HTP to the market for the benefit of the European space propulsion community.

THE LABORATORY OFFERS ANALYTICS:

- Study of trace amounts of metals and determination of trace amounts of ions in accordance with MIL-PRF-16005F (Avio 200 ICP Optical Emission Spectrometer).
- Determination of evaporation residue.
- Compatibility tests.
- Organic and inorganic carbon content (Sievers InnovOx ES Laboratory Total Organic Carbon (TOC) Analyzer).
- Microscopical sizing and counting particles from aerospace fluids on membrane filters.


H2O2
H2O2
H2O2
H2O2

ILR-33 AMBER 2K

The ILR-33 AMBER 2K rocket is a suborbital vehicle of Łukasiewicz Research Network – Institute of Aviation. Fully designed in-house, it proves capabilities in terms of larger system development. It is offered as an autonomous product, as well as a platform providing dedicated services. It has been launched three times and demonstrated successful recovery on both: sea and land. The main stage is propelled by a hybrid rocket motor and is assisted by two solid rocket strap-on boosters, which enable adapting the mission to specific payload needs.

ILR-33 AMBER 2K DATA	
Length	4.6 m
Main core diameter	230 mm
Apogee	100 km
Maximum velocity	1300 m/s
Payload	10 kg
Maximum G-force	14 g
Microgravity duration (10^{-3}g, 5 kg)	150 s
BOOSTERS	
Type	Solid rocket motor
Maximum thrust	2 x 16 000 N
Burn duration	6 s
Combustion chamber	Composite structure
MAIN PROPULSION	
Type	Hybrid rocket motor
Oxidizer	Hydrogen peroxide (H_2O_2), concentration 98%+
Fuel	Polyethylene
Maximum thrust	4 000 N
Burn duration	40 s
Combustion chamber	Composite structure

SPACE TRANSPORTATION

Space Technologies Department is capable of launch vehicle design and performance analysis. Mission profiling is within area of Łukasiewicz Research Network – Institute of Aviation's competences. The ILR-33 AMBER 2K rocket is the workhorse in-flight suborbital test platform. Demonstrated competences and validated systems in the area of suborbital rockets can be upscaled and used in microlaunchers.

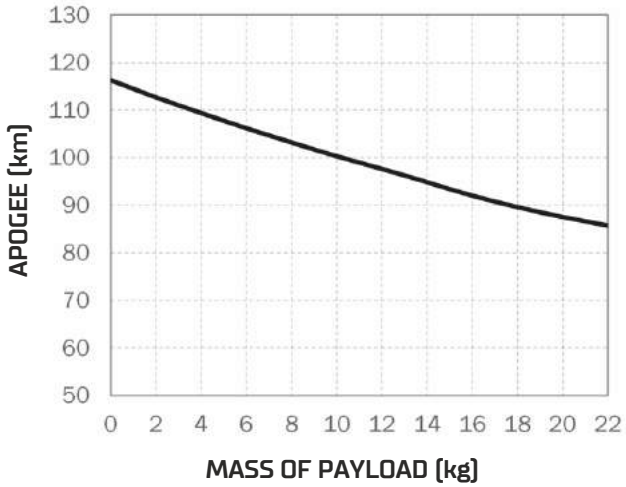
Apart from dedication to suborbital rockets, since 2007 small launch vehicle studies have been on-going. Recent efforts have the goal to enable the development of space transportation systems for launching small satellites to Low Earth Orbits and delivering payloads to Sun-Synchronized Orbits, taking the advantage of international cooperation.

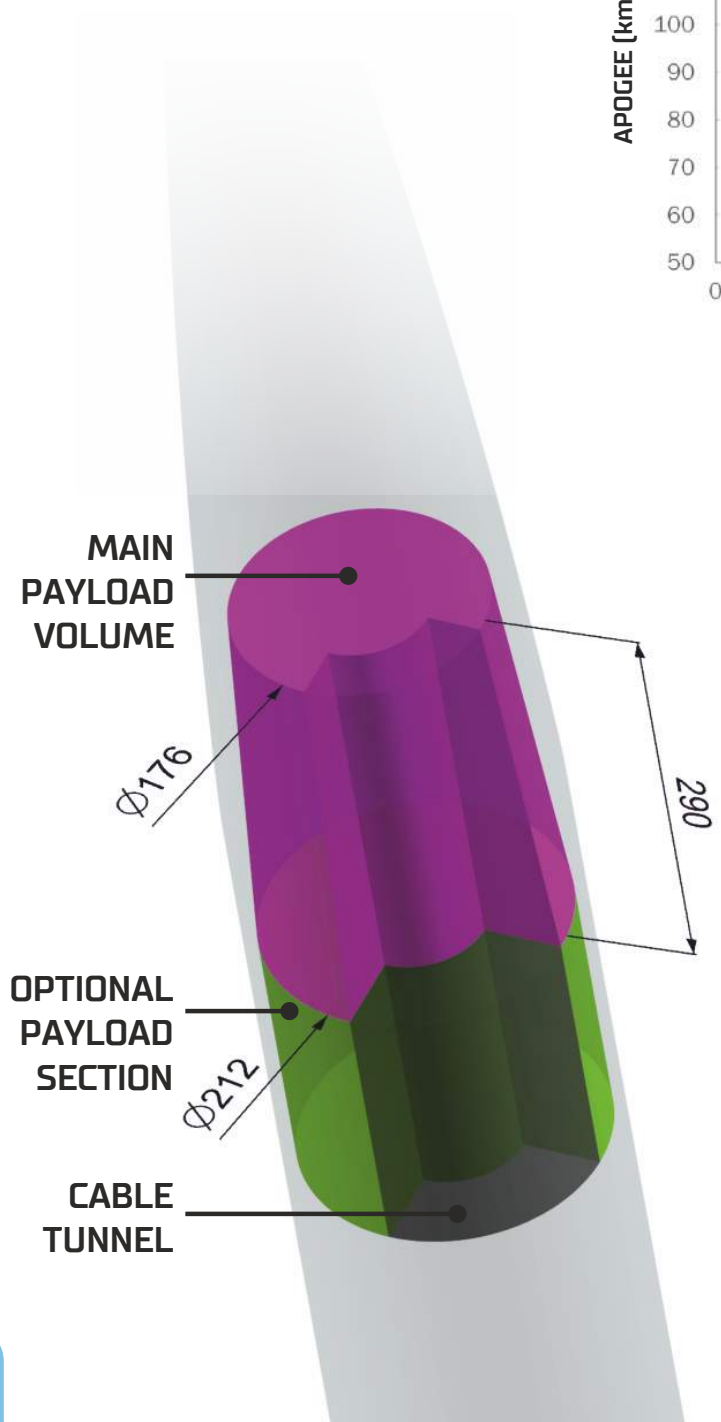
Moreover Łukasiewicz Research Network – Institute of Aviation has also been developing several throttleable rocket engines that will enable reusability of future vehicles, but can be also used for more demanding missions (i.a. lunar, planetary descent and landing). Capabilities of such solutions are verified by the use of different in-flight test platforms (such as FROG, developed in cooperation with ESA and CNES).

NEW SPACE TRANSPORTATION SYSTEMS

SUBORBITAL FLIGHT OPPORTUNITIES

The main goal of the ILR-33 AMBER platform is to validate key technologies developed for use in modern suborbital rockets, satellites and small launch vehicles. AMBER is an affordable, scalable and green vehicle, enabling efficient microgravity experimentation and atmospheric sounding. It can provide up to 150 seconds of microgravity environment for a 10 kg payload. The basic version of the vehicle has been successfully validated in flight.





ROCKET TECHNOLOGY ENGINEERING SERVICES

Łukasiewicz Research Network – Institute of Aviation has over 50 years of experience in space technologies. This includes satellite flight hardware and a wide portfolio of rockets and missiles. Pursuing engineering excellence and supporting global sustainable development, Łukasiewicz Research Network – Institute of Aviation is interested in international cooperation. With a wide range of services dedicated to aerospace vehicle design and optimization, unique development capabilities are offered as services.

VEHICLE AND PROPULSION DESIGN

- Solid, hybrid and liquid rocket propulsion systems.
- Mechanisms, valves, bearings.
- Composite structures.
- Navigation and control systems.
- Flight-computers and other electronic systems.
- Structures and simulations (Finite Element Method).
- Aerothermodynamics analysis including rarefaction effects, combustion modelling (Computational Fluid Dynamics).
- System-level studies.

SOFTWARE

- Computational Fluid Dynamics tools.
- 3D solvers for solid and hybrid rocket motor internal ballistics, compatible with CAD software.
- 6-degree-of-freedom simulations of rocket and spacecraft dynamics.
- Cost engineering tools - state-of-the-art parametric and bottom-up methods.

SYSTEM VALIDATION AND TESTING

- Rocket propulsion system and component characterization.
- Non-Destructive Testing.
- Environmental testing.
- Wind tunnel testing.
- Material testing - strength, fatigue etc.
- Chemical characterization.


TRUMPF

ROCKET AND SPACE SUBSYSTEMS TESTING LABORATORY

The development of rocket and satellite engine components using low-toxicity liquid, solid, gaseous, and gel propellant materials is a natural extension of the Institute's offerings. Alongside the development of rocket engine families, work is planned on other components of propulsion systems, including propellant tanks, valves, filters, pipelines, structures, interfaces, inert gas pressurization subsystems, and control systems. In addition to our own R&D work, we offer testing, design services, and engineering consulting for external clients and within project consortia.

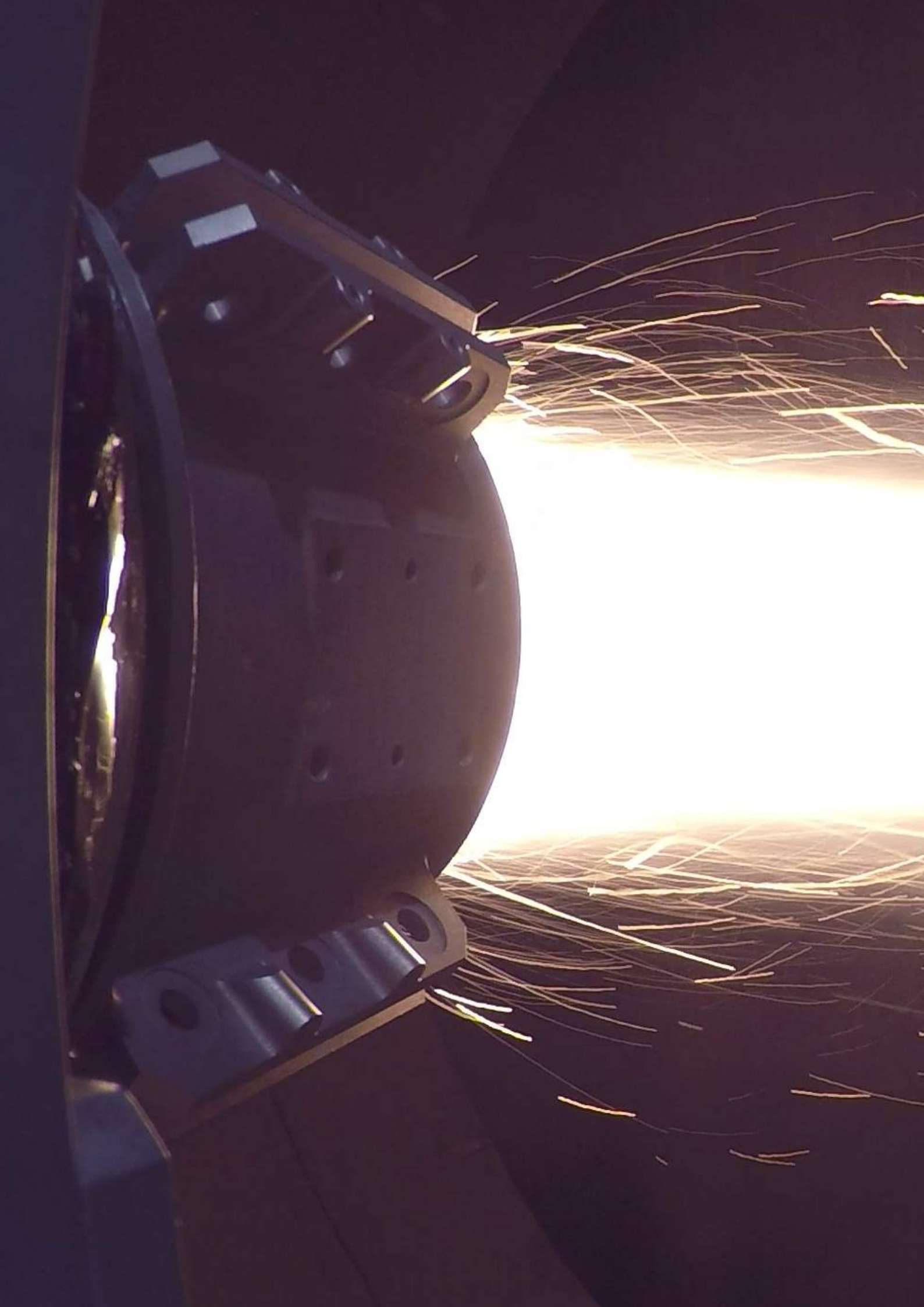
The design and testing of space subsystems take place in:

- Actuation and Control Systems Laboratory.
- Space Avionics Laboratory.
- Flow Components and Valves Laboratory.
- Injector Test Station.
- Cleanrooms of ISO 7 and ISO 8 classes.

The Electromagnetic Valves Laboratory allows for comprehensive testing of space flow components during static and flow tests. The laboratory is equipped with a helium detector for precise leakage measurements and a flow station where the test object performance can be evaluated under operating flow conditions. With two hydraulic lines, the facility allows for simultaneous testing of a pair of single-flow and single dual-flow valves, where, in the latter case, fuel and oxidizer flows are controlled by a common actuator.

THE LABORATORY ALLOWS FOR:

- Flow tests with flow rates ranging from 0.2 to 50 g/s (for water) and pressures up to 40 bar.
- Evaluation of internal and external leakage.
- Evaluation of back-pressure relief characteristics.
- Determination of valve response time (opening/closing).
- Determination of pressure drop characteristics.
- Burst pressure tests.
- Valve cleanliness assessment.
- Water hammer resistance evaluation.
- Life assessment through high-cycle testing in operating flow conditions.
- Determination of electrical parameters such as power consumption, insulation resistance, coil resistance, electrical bonding, pull-in/drop-out voltages etc.



ROCKET AND SPACECRAFT PROPULSION TESTING SERVICES

ROCKET PROPULSION TEST FACILITY - TESTS IN ATMOSPHERIC CONDITIONS UP TO 5 KN

Advanced laboratory infrastructure allows for testing within a range of 1 Newton (N) to 5,000 N, making the Institute a perfect hub for the aerospace industry. Within the laboratory we develop and examine propulsion systems for:

- Orbit correction,
- Spacecraft orientation control,
- Long-distance space missions,
- Planetary landings.

Testing rocket propulsion systems under atmospheric conditions is an essential step in the development of any propulsion technology. This process verifies the engine's performance in an environment safe for both the propulsion system and its surroundings, thanks to extensive instrumentation.

Our institute conducts research on liquid propellant engines and hybrid propulsion systems. With well-equipped testing facilities and an experienced engineering team, we provide precise and indispensable data for the design, development, and optimization of rocket engines. Our test facility is adapted for both early-stage experimental propulsion research and qualification tests for the final stages of technological readiness.

1. THRUST RANGE: 1 N - 5,000 N

2. EQUIPMENT:

- Dedicated facility: The laboratory, control room, and workshop are housed in a fully enclosed test chamber, allowing year-round testing regardless of atmospheric conditions. The building is additionally equipped with acoustic insulation and a noise suppressor extending approximately 50 meters. Specially reinforced walls and safety systems ensure the safety of the testing personnel and the surrounding area, ensuring that daily operations on campus do not interfere with ongoing tests.

- Test stand: The test stand is constructed with a test frame equipped with two vertically movable plates, enabling the assembly of test objects in both vertical and horizontal configurations. The materials used in the test stand are selected to ensure compatibility with hydrogen peroxide and chemical resistance to fuels and combustion products. Its design allows for easy and rapid adaptation of the test object's mounting interface to the existing infrastructure through standard mechanical interfaces. The test stand is mechanized to facilitate operation and expedite testing procedures.

- Power supply facilities: The testing facility possesses three pairs of oxidizer-fuel supply installations of different sizes, with capacities of respectively 52, 20, and 8 liters of propellants. These installations can be utilized at various pressures and flow rates, up to 60 barA.

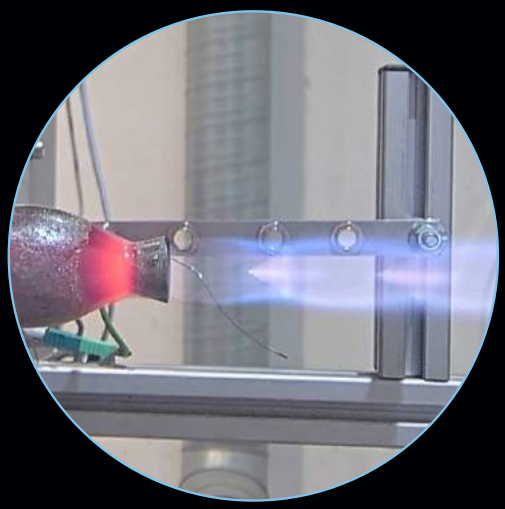
Pneumatic supply to the installations is achieved through the use of automatic, remotely controlled pressure regulators, utilizing high-pressure nitrogen and helium tanks. The facility also has a direct access to a liquid nitrogen storage, eliminating concerns regarding even the largest nitrogen requirements.

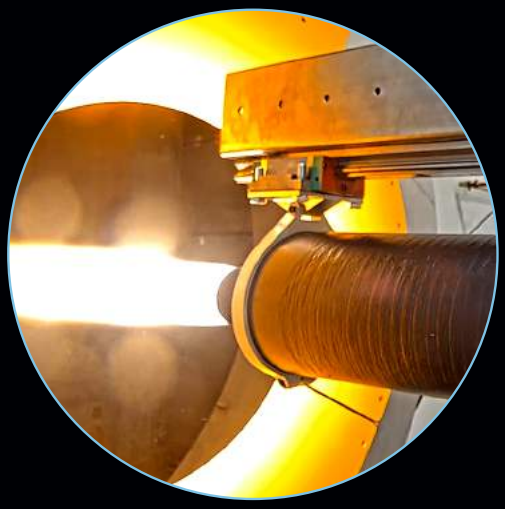
- Exhaust gas deflector: This component allows rocket engine testing in a vertical configuration. The exhaust gas plume is cooled using an automated water injection system, after which it is redirected horizontally and vented into a silencer.

- Water cooling system: The facility is equipped with a water cooling system that provides a continuous regulated flow of coolant to dissipate heat from the test object, protecting it from overheating. The test duration using the cooling system varies according to project requirements. At maximum efficiency (2 L/s), a test lasts approximately 450 seconds, with an increased duration based on decreasing cooling intensity. The system is controlled from the main test control computer.

- Integration workshop: The onsite integration workshop allows for integration of test objects and test infrastructure. The workshop contains basic tools, personal protective equipment for working with hydrogen peroxide and fuels, and quality control equipment (boroscope, microscope, metrological tools) for assessing the tightness of test objects using helium. The workshop is equipped with standard hydraulic and mechanical fittings. It also includes an electronic station with a wide range of devices for electrical and electronic device integration and diagnostics (soldering station with fume extraction, oscilloscope, laboratory power supplies, workshop microscope, etc.).

- Control and measurement system: The control and measurement infrastructure is based on a real-time system implemented on the National Instruments PXI platform. The software is developed by a team of specialized engineer-programmers. Thanks to proprietary software development, the test procedure can be precisely tailored to customer requirements, allowing for quick integration with provided non-standard solutions.





3. MEASUREMENT CAPABILITIES:

- Measurements of Basic Physical Quantities: The laboratory is capable of performing measurements of fundamental physical quantities, such as pressure, temperature, flow rate, force, and vibrations. The system is equipped with measurement cards that allow data collection from nearly 200 independent measurement channels at frequencies reaching up to 2 MS/s.

- Control Signals: Control over the test object and other devices used during the test is also managed by a real-time system. It can control nearly 100 independent digital outputs, which can switch devices requiring various signal values: 5VDC, 24VDC, 28VDC, 230VAC.

Additionally, it can generate analog signals within the range of (-10, 10) VDC with 16-bit resolution. The maximum achievable frequency for control line changes during the test is 1 kHz.

- Vision System: Enables test progress recording. Standard visual cameras are available, recording Full HD images at frequencies of up to 60 Hz. At the crew's disposal there are also thermal imaging cameras and high-speed cameras for rapidly changing processes (recording frequencies under suitable conditions up to 1 MHz).

- Measurement Device Inventory: In the absence of client's own sensors, our inventory is supplemented with proprietary ones. Devices from various manufacturers like Kistler, Keller, ZEPWN, HBM, PCB, Czaki, and many others are at the client's disposal.

4. SAFETY:

- The laboratory and test stands are designed with focus on minimizing risk and negative environmental impact. Materials used for the construction of measurement stands are selected to ensure compatibility with commonly used propellant materials.

- The real-time-based test software has the capability to define limits and analyze them in real-time during testing. In case of irregularities, the system can respond within timescales unattainable by personnel (1 ms) and autonomously implement programmed safety procedures.

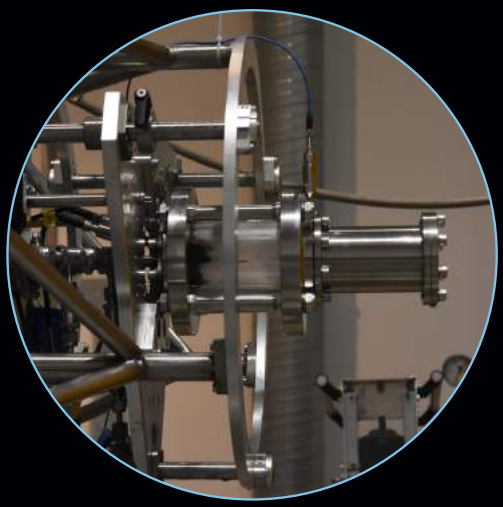
- A fire suppression system that can be activated from the control room in the event of test anomalies. In case of threats beyond the system's capabilities, the control room is equipped with an alert system to notify specialized units.

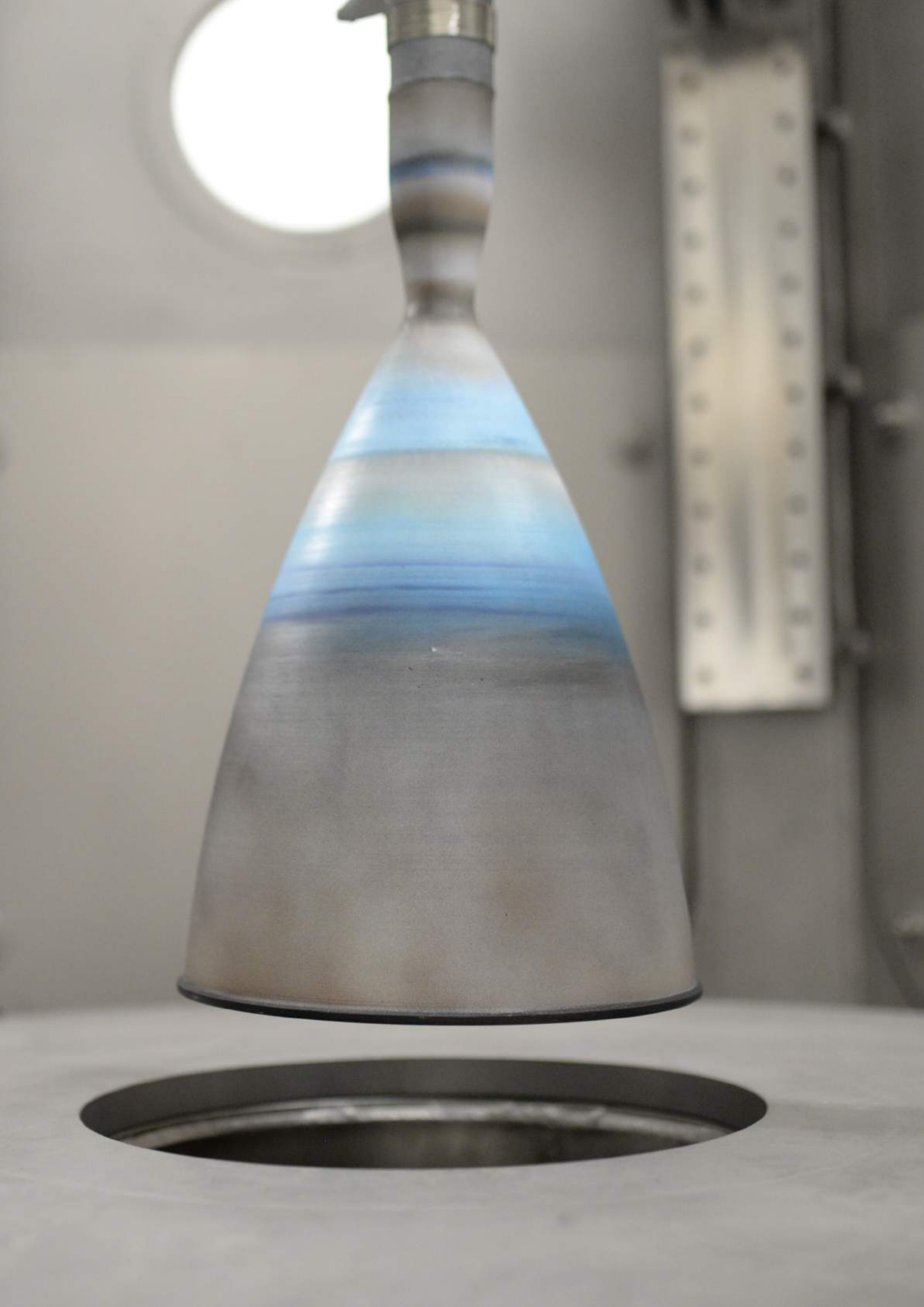
5. ENGINEERING SUPPORT:

In addition to conducting tests and preparing reports, we also provide engineering advisory services as part of project execution.

6. RESEARCH OBJECTIVES:

- Development of rocket propulsion and their components in the early design phase.
- Development of experimental designs and exploration of early concepts.
- Verification of propulsion system performance across the entire parameter range.
- Qualification of selected types of propulsion systems.





SPACECRAFT PROPULSION TEST FACILITY OF CONTINUOUS VACUUM CONDITIONS

The newest in Europe facility for rocket propulsion testing under vacuum conditions was opened in 2023. It allows for conducting research on rocket engines and their components under conditions similar to those of space. Precise measurement of parameters such as thrust, pressure, and operating time is crucial for optimizing the durability and reliability of rocket propulsion (satellites), which is a fundamental requirement for ensuring safety and success of space missions.

1. RESEARCH SCOPE:

- Qualification testing for space propulsion with thrust ranging from 0.25 N to 500 N, using non-toxic propellants.
- Qualification testing of complete propulsion systems with thrust up to 500 N.
- Developmental testing at higher technological readiness levels (TRL 6-8).

2. EQUIPMENT:

Research setup is based on a vertical vacuum chamber arrangement

- Vacuum chamber for engines with a maximum thrust of 500 N, equipped with a cooled research station and a force measurement system with self-calibration. The chamber incorporates several proprietary technological solutions allowing for precise verification of all propulsion or entire propulsion system parameters (with its own propellant supply system).
- Diffuser with a pressure recovery coefficient of 1:30, externally cooled by water spray, enabling the continuous maintenance of reduced pressure conditions and verification of propulsion performance in vacuum conditions.
- 800 kW gas cooler, inlet temperature up to 2250°C, outlet temperature below 50°C.
- 1,500 kW water-based cooling system, closed loop, up to 2200 l/min, 5 bar(g).
- Fully equipped workshop with an ISO 8 cleanroom and laminar flow chamber.

Vacuum System

- Pumping speed up to 30,000 m^3/h at 30 mbar.
- Ultimate vacuum down to 2 mbar.
- ATEX certification for all components used, with permissible high oxygen concentration.
- Fully automated control and safety systems.

Control System

- Proprietary control system for tests, measurements, and safety.
- Central control system integrated with all subsystems.
- Data acquisition speed of 500 kS/s/ch, 16 channels up to 2 MS/s/ch.
- 3 high-speed CCTV cameras.
- Advanced emergency shutdown system.
- 150 various sensors collecting data on temperatures, pressures, flow rates, fluid levels, vibrations, and forces.

Oxidizer Supply System

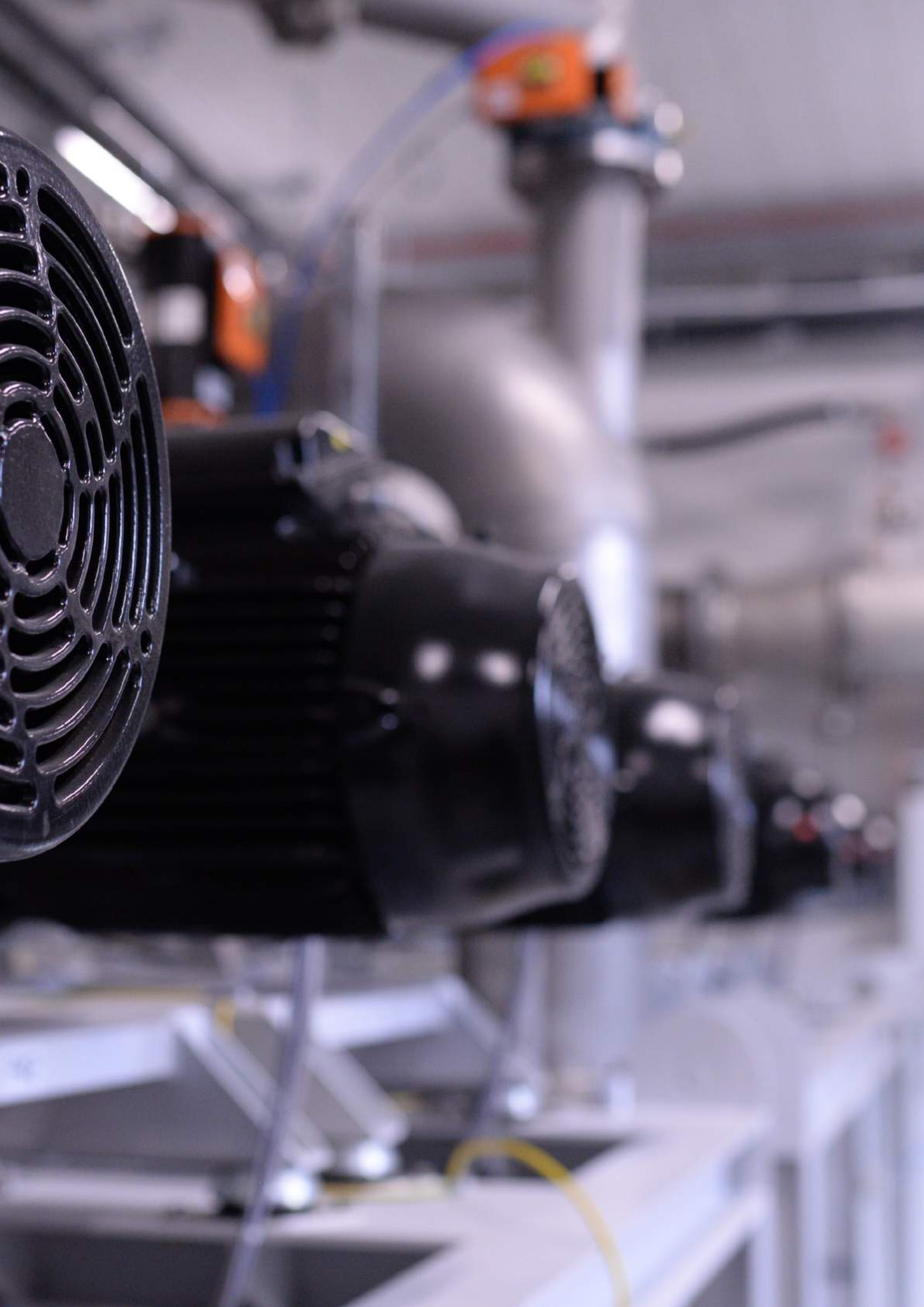
- Compatibility with > 98% hydrogen peroxide.
- Total capacity of 800 liters of oxidizer.
- Operating pressure up to 40 bar(g).
- Advanced two-stage safety system.

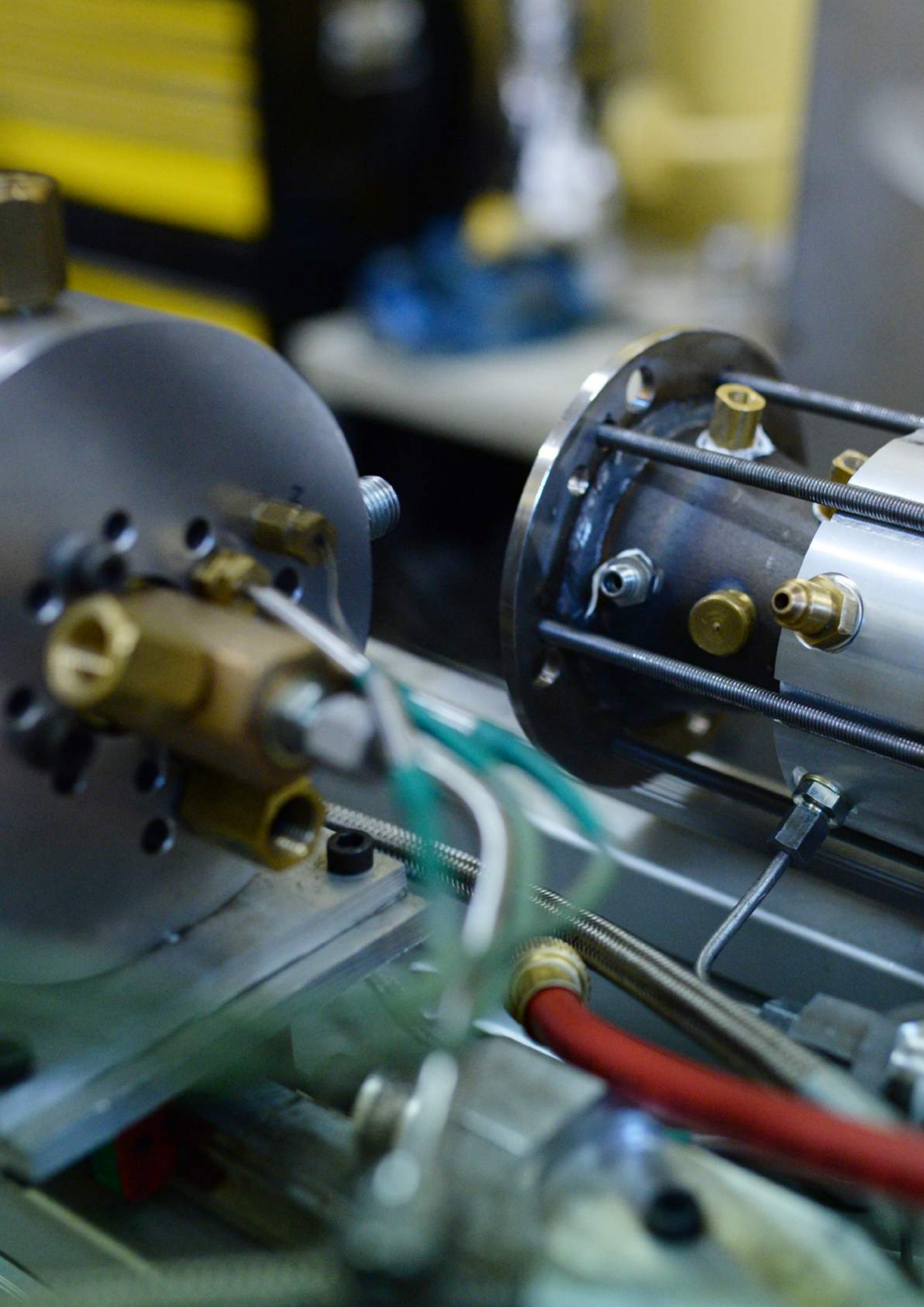
Fuel Supply System

- Ability to use various fuels.
- 2 tanks of 200 liters each.
- Operating pressure up to 40 bar(g).
- Advanced two-stage safety system.
- Ability to use various types of fuels.

3. RESEARCH OBJECTIVES:

- Verification of space propulsion performance in a realistic (vacuum) environment.
- Performance and durability testing.
- Qualification of propulsion components and systems.





ROTATING DETONATION ENGINE TEST FACILITY (RDE)

The facility is equipped with a research test bench for measuring the parameters of rotating detonation combustion engines operating in a pulsed detonation system. Measured parameters include propellant mass flow rates, rapidly changing pressures in the combustion chamber, average pressures in the combustion chamber, engine thrust, and outlet temperatures.

1. RESEARCH SCOPE:

Engines with thrusts ranging from 10 to 500 N for rocket engine test facilities and 4 kN for air-breathing engine test facilities.

2. EQUIPMENT:

- Propellant supply systems: Oxygen (gaseous), Methane (gaseous), Hydrogen (gaseous), Air (gaseous), Liquid Nitrous Oxide, Liquid Propane, Liquid Ethane.
- Hot air supply system with a maximum airflow rate of 1.6 kg/s and a temperature of 180°C to replicate flight conditions at speeds up to Mach 2.2.

3. MEASUREMENT CAPABILITIES: THE MEASUREMENT SYSTEM, BASED ON LABVIEW SOFTWARE, INCLUDES ESSENTIAL SENSORS FOR DETONATION PROCESS STABILITY MEASUREMENTS:

- Piezoelectric pressure sensors (KISTLER 603CAB) with a measurement frequency of 1 MHz and a range of 0-1000 bar.
- Averaged pressure sensors in the combustion chamber (ranges: 1-9 bar, 0-10 bar, 0-16 bar, 0-25 bar, 0-100 bar).
- Thermocouples: Type K, Type B.
- Coriolis flowmeters (20 g/s - 2200 g/s).
- Heating system for propellants (total power of 3 kW).
- Solenoid valves, Manometers.

4. SAFETY:

Tests are conducted in specially adapted rooms. The control room is separated from the test chamber. Propellant and fuel supply systems are equipped with safety switches that immediately cut off the propellant supply in case of emergency. The rooms are monitored and equipped with a fire alarm and fire detection system.

5. RESEARCH OBJECTIVES:

- Experimental investigations of basic detonation parameters.
- Experimental investigations of rocket detonation engines (RDE).
- Experimental investigations of air-breathing RDEs (air breathing RDE).

ROCKET SUBSYSTEMS AND COMPONENTS

Apart from dedication to propulsion the Institute has developed crucial subsystems for rocket vehicles and spacecraft. Gained know-how enables to design specifically addressed components.

PYROTECHNICAL DEVICES

- Drogue guns, pyrotechnic cutters, cumulative linear charges, pyrovalves, igniters.

RECOVERY SYSTEMS FOR ROCKETS

- Parachute-based systems, wind tunnel testing, utilization of flat spin phenomenon, drop tests, simulations, sea recovery systems.

CONTROL AND ELECTRONIC SYSTEMS FOR ROCKETS

- On-board computers, launch management systems, data acquisition, control systems.

SEPARATION MECHANISMS

- Booster separation systems, main stage separation, retro-propulsion.
- Łukasiewicz Research Network – Institute of Aviation successfully demonstrated the following methods of stage separation:
  - "Fire in the hole",
  - Pyrotechnical separation,
  - Aerodynamic stage separation.

AVIONICS ROCKET CONTROL SYSTEMS

The Avionics Department at the Łukasiewicz Research Network - Institute of Aviation works on the avionics equipment of rockets in three areas.

MEASUREMENTS

The team has extensive experience in the integration of measurement systems, including basic flight parameters such as linear and angular velocity and the spatial position of the rocket. The team has developed proprietary inertial navigation algorithms that enable short-term autonomous navigation calculations. They were used in the rocket computers developed by the Institute.

CONTROL

Algorithms have been developed to control the flight of rockets made at the Institute. In the AMBER rocket, the on-board computer controls the rocket's flight by means of the coordinated tilting of the steering surfaces, i.e., four canards placed symmetrically at the front of the rocket. In other rockets, this is achieved by means of control engines placed around the rocket fuselage.

SPECIAL FEATURES

Algorithms responsible for the implementation of the assumed flight plan and the electrical initiation of other rocket systems have also been developed, such as: a launch system, a separation system, or a landing part recovery system. One such solution is the designed and manufactured AMBER on-board computer.

The developed algorithms and control methods are implemented by on-board computers that have been designed, performed and tested in a certified laboratory of the Avionics Department.

ONBOARD COMPUTER FOR THE ILR-33 AMBER 2K ROCKET

As part of the ILR - 33 AMBER 2K program projects, the Institute's engineers have developed a mission control computer with the following functionalities:

- Performance of navigation calculations according to the author's inertial navigation system (INS) algorithms.
- Missile flight control.
- Providing telemetry and video communications between the rocket and ground control station over a distance of up to 100 km.
- Starting of rocket pyrotechnic initiators.


SECURE
THE FUTURE
IMV
RT
750
ENTROTECNICA

ENVIRONMENTAL TESTING OF SPACE SYSTEMS

The Łukasiewicz Research Network – Institute of Aviation conducts research in the field of resistance and resilience to mechanical and climatic exposures, as well as functional testing of products. Due to the significant development of the space sector in Poland and the projects carried out within the Łukasiewicz Research Network – Institute of Aviation, the scope of services has been expanded to include thermal-vacuum testing of products and solutions used in space structures.

ENVIRONMENTAL TESTING LABORATORY

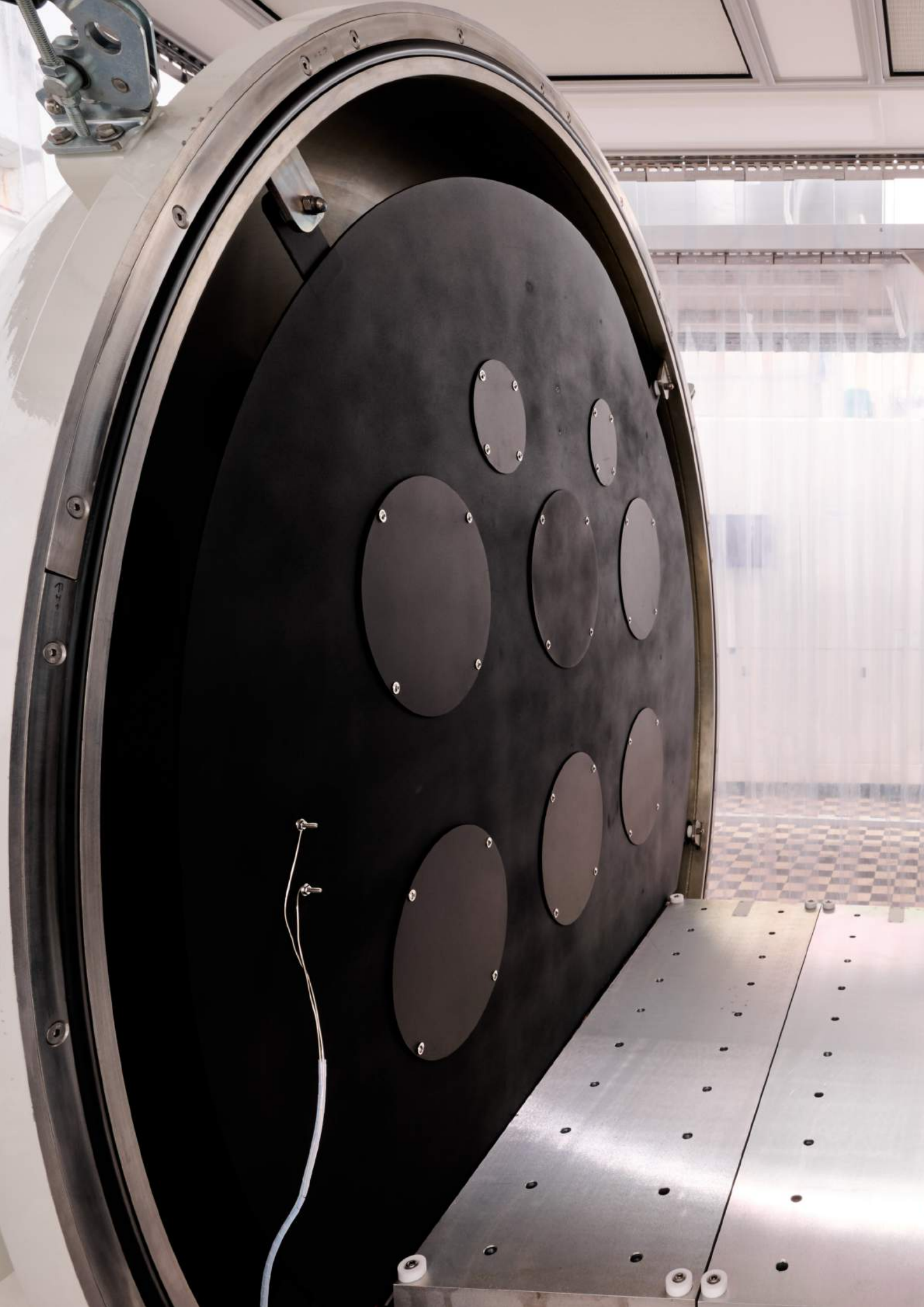
The current equipment allows for various tests compliant with space standards and manufacturers' test programs, including high-acceleration vibration, temperature change, and low-pressure tests. It is also possible to use a portable clean room during testing.

Since 1997, the laboratory has been certified by the Polish Accreditation Center under No. AB 132. As part of accreditation in accordance with the requirements of PN-EN ISO/IEC 17025:2005, the laboratory conducts tests related to resistance and resilience to mechanical and climatic exposures, as well as functional testing of products.

THERMAL VACUUM CHAMBER

One of the crucial aspects in environmental testing is the vacuum that can be achieved in specialized chambers.

The Environmental Testing Laboratory conducts tests in the Thermal Vacuum Chamber (TVC). The lowest achievable pressure in the chamber is 10^-6 mbar. Temperature can be changed in the range of -180°C to +165°C, and the usable capacity is 4.5 m³. This is the first device of this size used in Poland



As of today, the Environmental Testing Laboratory promotes research for the space sector, including:

- Verification of design and its mechanical execution.
- Confirmation of proper operation during the flight:
  - Demonstrating structural integrity.
  - Verification of operation in accordance with the specification in the characteristic environment.
  - Measurement of critical performance parameters (power dissipation).
- Verification of performance (within the specification) in the target environment.
- Measurement of critical performance parameters (heat energy dissipation).
- Confirmation of thermal model assumptions.
- Conducting a bake-out and verifying the type of degassed particles.

Types of tests:

- Environmental load tests.
- Performance verification.
- Thermal equipment verification (temperature, excluding IR lamp).
- Degassing tests with dynamic mass loss exclusion.
- Bake-out (80°C, 10^-6 mbar).

The laboratory equipment includes:

IMV I250/SA4M-CE SHAKER WITH MEDALLION II CONTROLLER

- Vibration frequency: 5 -2500 Hz.
- Max. displacement amplitude: 50 mm.
- Maximum strength: 40 kN.
- Maximum acceleration:
  - For sinusoidal vibrations: 500 m/s^2,
  - For random vibrations (rms): 140 m/s^2,
  - For shock: 800 m/s^2.

- Additional equipment:
  - Sliding table, dimensions: 750 x 750 mm,
  - Head-expander, dimensions: 700 x 700 mm,
  - Head-expander, diameter: 610 mm.

THERMAL-VACUUM CHAMBER WEISS 4500L

- Temperature range: -180°C to +165°C.
- Vacuum range: AP to 10^-6 mbar.
- Cooling rate: 2°C/min. (-150°C to +150°C).
- Heating rate: 2°C/min. (-150°C to +150°C).
- Temperature stability: ±1°C.
- Plate uniformity: ±3°C.
- Shield uniformity: ±4°C.
- Vacuum range: AP to 10^-6 mbar.
- Plate dimensions:
  - Szerokość: 1000 mm.
  - Długość: 2100 mm.

SATELLITE REMOTE SENSING

An important area of the Institute's activity is widely understood remote sensing, including the acquisition and analysis of Earth observation data. The modern technical facilities and the experience of the employed specialists enable the implementation of interdisciplinary projects. We integrate and process data obtained from numerous sources in order to create operational, competitive tools for modern industry, administration and natural resource protection.

SATELLITE IMAGE ANALYSIS

- Analyses of a specified area in accordance with set criteria, analysis of optimal investment location.
- Integration and development of large data sets with particular emphasis on aerial and satellite images.
- Land Cover classification, creation of algorithms for object detection and identification.
- Creation of raster maps and vector maps.
- Analyses for the needs of modern agriculture and forestry, yield forecasts, creation of fertilization plans, and evaluation of biomass quantity.
- Analysis of vegetation condition and multi-criteria analysis of areas covered with vegetation.

*The Institute has a country-wide unique **Earth Observation Mission Control Centre (Centrum Operacyjne Misji Obserwacyjnych Ziemi (COMOZ))**, which enables the simultaneous acquisition, processing, sharing, and visualization of data.*

*Among the large-scale key projects that are based on aerial and satellite data is the **FITOEXPORT** project planned for implementation in 2019-2021. One of the core objectives of the project that have been defined for the Institute is the development and implementation of modern remote sensing methods and the support of the activities of the Main Inspectorate of Plant Health and Seed Inspection.*

GNSS USAGE

- Precise positioning and navigation using GNSS and INS.
- Geodetic measurements and vector map creation, support for the investment process.

ATMOSPHERE PROBING

Probing the atmosphere with weather balloons and aircraft

- Measurement from the surface of the Earth up to an altitude of 35 km.
- Atmosphere probing to determine the vertical profiles of wind direction and speed and the distribution of pressure and temperature.
- Detection of gases and determination of vertical profile atmospheric composition.
- Direct measurement with radiosonde and weather balloon.
- Data presentation in both tabular and graphical form.
- Real-time data transmission.

Low ceiling atmosphere probing using unmanned vertical take-off and landing aircraft with integrated electronic wind meter

- Measurement of wind speed and direction by ultrasonic method from the earth's surface up to a height of 2 km.
- Possibility of continuous measurement of wind speed and direction for up to 30 minutes, depending on the height of the probe.
- Detection of gases and determination of the atmosphere composition in the vertical profile.
- Data presentation in tabular and graphical form.
- Real-time data transmission.

Prepared by the remote sensing facility based on Sentinel-2 images.

ASTROBIOLOGY

Łukasiewicz Research Network - Institute of Aviation researches the integration and automated analysis of data from optoelectronic sensors, chromatographs, and spectrometers selected in designed space missions to the ocean worlds of the outer Solar System (Jovian and Saturnian satellites: Europa, Ganymede, Callisto, Enceladus, and Titan). This work aims to develop methods, techniques, and solutions for the remote detection of the potential presence of archaeons and bacteria on their icy surfaces, in geyser plumes, and planetary rings. These research results are also the basis for an automated service for the low-gravity microbiological experiments on suborbital rockets.

EXAMPLES OF CONDUCTED WORKS AND RESEARCH PROJECT

- Remote detection of methanogenic bacteria and archaea in the water plumes of Enceladus, the Saturnian satellite, based on kinetic models of microbiological component transport in the subsurface ocean, through ice crust, and geyser plume to Saturnian E-ring.
- Sedimentation of the organic molecules near geyser plumes origins in Bagdad and Damascus breaks. Cassini probe Imagining System multispectral data investigation. Preparing boundary conditions of the instruments for future astrobiological landing missions.
- Estimation of the influence of biotic component presence on the bubble scrubbing effect under the conditions on the surface of Enceladus. Gathering of reference multispectral data in vacuum chamber experiments as an analog of space conditions. Instrumental analysis (multispectral cameras, mass spectrometers) in proposed missions to the outer Solar System: Enceladus Orbiter (NASA), Enceladus Life Finder (NASA), Explorer of Enceladus and Titan (ESA, NASA) and THEO mission (JPL, MissionX).

IT SOLUTIONS

The Łukasiewicz Research Network - Institute of Aviation creates and delivers original IT solutions. One of the areas of specialization is creating complete IT solutions, with particular emphasis on application development. They support modern management, automation and process optimization in various branches of economy. Activities carried out in the area of new technologies in the IT sector build the potential of enterprises and have a direct impact on the level of development of the country.

AREAS OF SPECIALIZATION:

- Creation of Geographical Information System (GIS) and development of software for the modern management and optimization of industrial processes.
- Creation, integration and calibration of modern image acquisition systems including multispectral techniques and the Internet of Things (IoT).
- Advanced algorithmics, integration and automatic development of large data sets with special emphasis on aerial and satellite images:
  - Creation of photogrammetric products,
  - Land cover classification,
  - Object detection and identification.
- Measurement and sharing of spectral signatures of objects, analysis of spectral curves, and extraction of information about biophysical parameters of objects based on their spectral data.
- Advanced visualization of geodata with particular emphasis on 3D modelling and integration of vector, raster and descriptive data.

The Copernicus Masters award in the Sustainable Development Challenge *category, received in 2017 by the scientists of the Łukasiewicz Research Network - Institute of Aviation, is still the only achievement of this type obtained by scientists from Poland. The award was granted for creating an innovative web and mobile application for precision farming.*

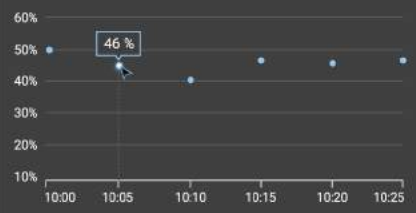
Missions Robots Log Out

Home > Mission_1

Mission_1

LOCATION	MISSION DATE	START TIME	END TIME	MISSION TIME	ROBOT	MISSION VISIBILITY
Puławy 51.418006, 21.969516	18.03.2020	10:00	10:25	00:25:11	Robot_1	Private

SOIL MOISTURE



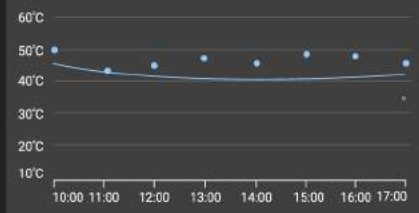
SOIL MOISTURE
COLLECTED MEASUREMENTS

10:00:00	50%
10:05:00	46%
10:10:00	40%
10:15:00	48%
10:20:00	47%
10:25:00	48%

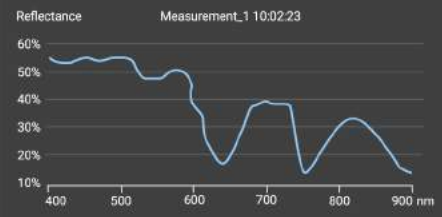
SOIL TEMPERATURE
COLLECTED MEASUREMENTS

10:00:00	50°C
11:00:00	43°C
12:00:00	45 C
13:00:00	48°C
14:00:00	47°C
15:00:00	49°C

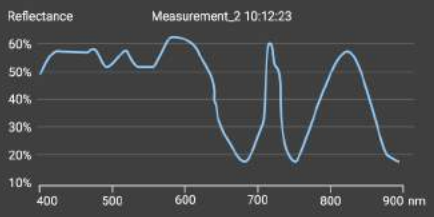
SOIL TEMPERATURE



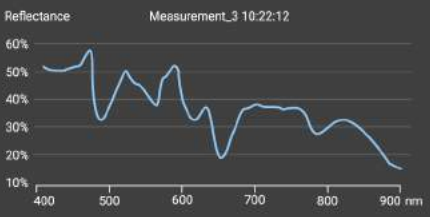
SPECTROMETER



SPECTROMETER



SPECTROMETER



Missions Robots Log Out

Home

Missions

Mission_1	Puławy	18.03.2020	Robot_1	Private
Mission_2	Wrocław	16.03.2020	Robot	Private
Mission_3	Kielce	16.03.2020	Robot	Private
Mission_4	Karczma Borowa	23.05.2019	HESOFF	Public
Mission_5	Krotoszyn	23.05.2019	HESOFF	Public
Mission_6	Krotoszyn	5.04.2019	HESOFF	Public

COOPERATION

Łukasiewicz Research Network – Institute of Aviation realizes projects from the European Space Agency (ESA), European Commission (EC), European Defence Agency (EDA), Polish Space Agency (POLSA) and National Center for Research and Development (NCBiR). Intensive cooperation with the space technology industry is present, with commercial activities carried out for leading European entities working with space flight hardware.

EUROPEAN COMMISSION	EUROPEAN SPACE AGENCY
EUROPEAN DEFENSE AGENCY	POLISH SPACE AGENCY
THE NATIONAL CENTRE FOR RESEARCH AND DEVELOPMENT	GERMAN AEROSPACE CENTER (DLR)
THE NATIONAL CENTRE FOR SPACE STUDIES (CNES)	THE FRENCH AEROSPACE LAB (ONERA)
SWEDISH SPACE CORPORATION (SSC)	AIRBUS SPACE & DEFENCE
THALES ALENIA SPACE	ARIANE GROUP
OHB SYSTEM AG	NAMMO
AVIO	JAXA
GMV	

CONTACT

ŁUKASIEWICZ RESEARCH NETWORK - INSTITUTE OF AVIATION
AL. KRAKOWSKA 110/114, 02-256 WARSZAWA, POLAND
E-MAIL: INFO@ILOT.LUKASIEWICZ.GOV.PL
PHONE: (+48) 22 846 00 11 | WWW.ILOT.LUKASIEWICZ.GOV.PL


Łukasiewicz
Institute
of Aviation