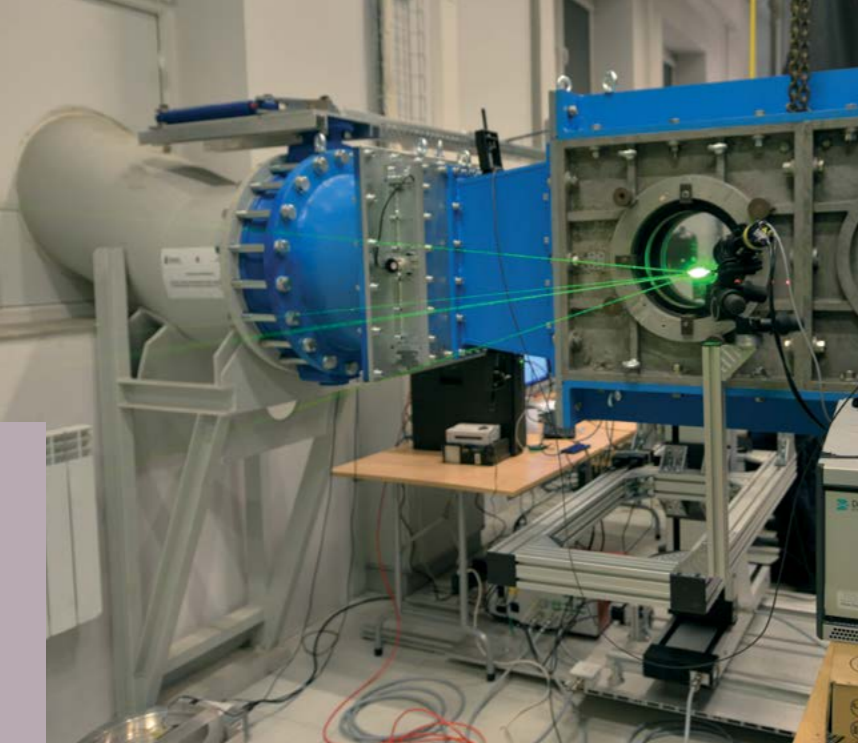


**INSTITUTE  
OF AERONAUTICS  
AND APPLIED  
MECHANICS**





# AIRCRAFT TURBINE AERODYNAMICS AND COMBUSTION LABORATORY TEAM (LATiS)

AT THE WARSAW UNIVERSITY  
OF TECHNOLOGY

MECHANICAL ENGINEERING, ENVIRONMENTAL  
ENGINEERING, MINING AND POWER ENGINEERING

#AERODYNAMICS #AVIATION #HYDRODYNAMICS #ACOUSTICS  
#ENVIRONMENTAL TESTS #AERODYNAMIC TUNNEL #TURBULENCE  
#COMPUTATIONAL FLUID MECHANICS #FLOW CONTROL

The Aircraft Turbine Aerodynamics and Combustion Laboratory Team (LATiS) is located at the Faculty of Power and Aeronautical Engineering (WUT), in the Institute of Aeronautics and Applied Mechanics. Our research areas include internal aerodynamics of aircraft engines, environmental aerodynamics, urban aerodynamics and broadly defined industrial aerodynamics. We provide our services mainly to businesses from the aviation, energy, automotive, lighting and urban development sectors.

The list of our clients includes companies and institutions such as Kongsberg Automotive S.A., Atmothem, Wentech, Philips Lightning Poland Sp. z o.o., RADMOR S.A., Signify, Zelmotor, PHN, Avio-Aero and Instytut Sportu.

## RESEARCH INFRASTRUCTURE

The LATiS team has a research infrastructure that is unique in Europe and rare to be found anywhere else in the world.

We have:

- the aerodynamic tunnel to test internal flows in turbines
- the variable-turbulence tunnel
- the transonic wind tunnel
- the tunnel for environmental testing
- the computational cluster, including necessary software for aero-acoustic tests and structural flow computations.
- measuring equipment, aerodynamic scales, pressure sensors (approx. 1,000 measurement points), equipment for measurements of velocity fields and turbulence levels, flow visualisation equipment, high-speed and thermographic cameras and a rapid-prototyping station.

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## SELECTED PROJECTS

- Advanced high-performance pressure turbine unit (NCBR, INNOLOT 2014–2019)
- Active vehicle vibration damping system (NCBR, PBS, 2015–2019)
- AboutFlow – Optimisation of non-stationary flows using the Hermitian adjoint (EU, 7th Framework Programme, 2014–2016)
- Tests to determine how wind influences the façade and structure of the tower building with a height of H=150 m located at Świetokrzyska St., and to investigate the impact of this building on the wind comfort of pedestrians in its vicinity (the project ordered by Polsko-Belgijska Pracownia Architektury Sp. z o.o., 2019)
- Optimisation of a wing aerofoil with mechanisation and tunnel tests to determine airfoil aerodynamic characteristics necessary for wing computations (Metal Master, 2018)

## PATENTS

- Supersonic rotary heat engine with a detonative wave combustion chamber (P.430728)
- High-performance supersonic rotary heat engine with a detonative wave combustion chamber (P.430727)
- Method of vehicle body vibration damping at high speeds through synchronised generation of fast-changing aerodynamic forces (P.426981)
- Sealing solution for the airbag of a vacuum train vehicle (P.425924)

## OFFERED SERVICES

- modelling (experimental and numerical) of single- and multi-phase flows with combustion
- investigations of the boundary layer, wakes and vane passage flows studies and investigations related to reducing blade profile drag, turbine noise, flow control and laminar-turbulent transition and the separation process
- development of turbine blade cooling methods
- investigation of hydrodynamic problems
- investigations of new types of turbine blade profiles with increased laminar flow range and controllable laminar-turbulent transition
- analysis of cascade operation under fluctuating feed pressure
- analysis of turbine blade cooling using flow through porous blade material and vents in blade walls
- analysis of operation of a cascade with curvilinear leading-edge blades, Gurney flap blades, with oblique blades
- investigations of flow control using the example of a vehicle
- experimental investigations of phenomena occurring in the atmospheric boundary layer
- problems related to pollution spread
- investigations of the effects of planned buildings on energy losses, changes in local wind conditions and air flows in nearby residential areas
- investigations of the effects of wind and building type on the costs of building heating and wind load
- model-based tests of flow devices and systems
- validation of numerical methods
- development of a methodology for measuring fast-changing pressure and velocity in one-, two- and three-dimensional compressible flow
- investigations related to propellers in wind power stations and the implementation of small power generation facilities with propellers having a vertical rotation axis to be used in the construction of single family buildings and small rural infrastructure



# AIRCRAFT DESIGN TEAM

## AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING

#AIRCRAFT DESIGN #GLIDER DESIGN #UNMANNED AERIAL VEHICLES  
 #MULTIROTORS #AIRCRAFT STRUCTURES  
 #COMPOSITE STRUCTURES #AIRCRAFT FLIGHT MECHANICS  
 #LIGHTWEIGHT HIGH-STRENGTH STRUCTURES  
 #AIRCRAFT PERFORMANCE #AERODYNAMIC ANALYSIS AND TESTS  
 #STRENGTH ANALYSIS AND TESTS #FATIGUE TESTS

The Aircraft Design Team is a group of aviation experts in designing, manufacturing and testing flying vehicles. Our Team comprises both experienced designers and top young graduate engineers, who are being recruited on an ongoing basis from among the graduates of the Faculty of Power and Aeronautical Engineering (WUT). In terms of our place in the WUT's structure, we mainly operate within the Aircraft Design Division of the Faculty of Power and Aeronautical Engineering (WUT). This allows us to draw on the technical legacy of former aircraft designers and from the existing human capital of one of the WUT's top faculties.

We have access to diverse infrastructure (including workshops, laboratories and the Przasnysz airfield) and experience gained in national and international projects, allowing effective cooperation with customers and sub-contractors, including both SMEs and major aviation companies (e.g the Glider Factory „JEŻÓW” and Airbus Polska)

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### RESEARCH INFRASTRUCTURE

- computer-aided design tools
- numerical tools for the analysis of:
  - aerodynamic characteristics
  - aircraft flight mechanics
  - structures strength
  - mechanism operation
- bonding laboratory allowing small-batch manufacture of composite components
- mechanical workshop allowing small-aircraft assembly
- processing workshop allowing CNC milling and lathing, electroerosive processing and 3D printing of polymers and metals
- aerodynamics laboratory
- strength laboratory
- strength test stand for full-size aircraft tests in elevated temperature
- Przasnysz airfield with flight test infrastructure

### SELECTED ACHIEVEMENTS

- PW-5 glider's win in the FAI "world-class glider" competition in 1993; implementation of the glider into batch production and production support (more than 300 gliders have been built and sold all over the world)
- Prime Minister's 1st Degree Team Award for the outstanding scientific and technical achievement: "PW-6 two-seater new-generation training glider"; implementation of the glider into batch production and support for its further development (Smart Growth Operational Programme 2020); more than 60 gliders have been built and sold all over the world
- design of the airframe of the first Polish multifunctional two-seater motor glider with electric propulsion (AOS-71), followed by prototype test flights and placing into service (KB/68/12823/IT1-B/U/08, 2008-2012); further development of this design with a fuel cell (PBS3/A6/24/2015, 2015-2018)
- development of the PW ZOOM unmanned aerial vehicle and its deployment during an Antarctic expedition to conduct research into the Antarctic ecosystem

### OFFERED SERVICES

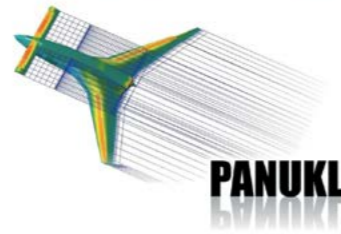
- design work:
  - designs of new aircraft : airplanes, gliders and highly autonomous unmanned aerial vehicles
  - designs of other constructions requiring weight minimisation
- aerodynamic, flight mechanics and dynamics and strength computations (including composite structures)
- testing services:
  - strength tests of samples and structures, including tests in elevated temperature
  - flight tests
- development and implementation:
  - production of composite structures
  - airframe integration
  - engineering support for the aircraft certification process

### SELECTED PROJECTS

- New-generation multi-functional two-seater motor glider (Ministry of Science and Higher Education, 2008–2012)
- Lightweight unmanned aerial vehicle (technology demonstrator vehicle) for surveillance in civilian applications – SAMONIT (Ministry of Science and Higher Education, 2007–2009)
- A new approach to monitoring climate changes in Antarctic ecosystems (POL-NOR, 2013–2016)
- Design and development of a mid- and long-range unmanned aerial vehicle dedicated to carry loads or measurement equipment (Smart Growth Operational Programme, Spectre Solutions Sp. z o.o., 2018–2021)







# AEROSPACE NUMERICAL ANALYSIS TEAM

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING

#AERONAUTICS #AIRCRAFT DESIGN #AERODYNAMIC ANALYSIS (CFD)  
 #STRUCTURAL ANALYSIS (FEM) #FLIGHT MECHANICS #FLIGHT DYNAMICS  
 #OPTIMISATION #NUMERICAL OPTIMISATION #SOFTWARE DEVELOPMENT

The research team operates within the Aircraft Design Division of the Institute of Aeronautics and Applied Mechanics at the Faculty of Power and Aeronautical Engineering at Warsaw University of Technology (WUT). The team collaborates with numerous research institutes and companies from the aerospace engineering sector.

The core scope of the Team's activity includes analyses in the field of flying objects design – both conceptual design and analysis of aerodynamics, flight dynamics, performance and others.

To perform computations and analyses, the Team uses commercial and proprietary software – designed and developed by members of the Team. Advanced numerical optimization procedures have been developed that link and use existing software modules. This software is still being developed and used in projects carried out by the team, and selected modules are used for teaching purposes, in commercial projects and by student-research clubs.

The team collaborated with the following partners and clients: Łukasiewicz Research Network – the Aviation Institute, the Military University of Technology, PZL „Warszawa-Okęcie”, Wojskowe Zakłady Lotnicze Nr 2 S.A., and ATP AVIATION Sp. z o.o.

## CONTACT

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## RESEARCH INFRASTRUCTURE

- proprietary software, including:
  - aerodynamic analysis software implementing the low-order panel method (PANUKL)
  - export of numerical model for FEM analysis (integration with Calculix)
  - software tool for mass analysis of an aircraft's structure
  - dynamic stability analysis of an aircraft (stability, simulation, and control) – SDSA
  - numerical optimisation software
  - software for propellers design
  - integration of in-house tools with the commercial software ANSYS
- commercial software:
  - CAD/CAM (NX)
  - aerodynamic analysis (potential flow methods, Euler's methods)

## SELECTED PROJECTS

- Simulating Aircraft Stability and Control Characteristics for Use in Conceptual Design, SimSAC, (EU, 6th Framework Programme, 2006–2010)
- Tests of a micro UAV with a LEX and in a pusher propeller configuration (NCN, 2012–2014)
- Dynamically similar model of joined-wing aircraft (NCBR, PBS1, 2013–2016)
- Development of assumptions, design, and prototype manufacture of a new-generation TSA hybrid aircraft – dynamic stability analysis (ATP AVIATION Sp. z o.o., 2013–2015)
- Design and construction of unmanned medium and long-range aircraft enabling the transport of cargo or measuring equipment (Smart Growth Operational Programme, Spectre Solutions Sp. z o.o., 2018–2021)

## OFFERED SERVICES

- aerodynamic analysis
- structural analysis (finite element method – FEM)
- mass analysis of aircraft's structure
- analysis of dynamic stability and control of an aircraft based on existing criteria of handling qualities and airworthiness regulations
- design and analysis of propellers
- multidisciplinary optimisation of an aircraft configuration
- development of custom made software for aeronautical analysis
- integration of computational modules with the commercially available software Ansys

## SELECTED ACHIEVEMENTS

- Implementation of the proprietary software developed by team in the teaching process (University of Brighton)
- Application of software modules for conceptual studies (Airbus Poland)



# AIRCRAFT COMPOSITE STRUCTURES TEAM

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING

#PRIMARY AIRCRAFT COMPOSITE STRUCTURES #VBO PRE-IMPREGNATED MATERIALS #GLASS-EPOXY COMPOSITES #INFUSION #DESIGN #CARBON-EPOXY COMPOSITES #PROTOTYPE MANUFACTURING #NUMERICAL STRENGTH ANALYSIS #STATIC STRENGTH SUBSTANTIATION OF COMPOSITE AIRFRAMES #DESIGN AND MANUFACTURE OF MANUFACTURING TOOLS #REPAIRS #MECHANICAL TESTS #DETERMINATION OF MATERIAL PROPERTIES

The Aircraft Composite Structures Team is a part of the Faculty of Power and Aeronautical Engineering (WUT) in the Aircraft Design Division of the Institute of Aeronautics and Applied Mechanics.

The Team's research interests include:

- glass- and carbon-epoxy composite primary structures (mainly in aircraft applications),
- design and manufacturing of prototype composite airframe structures,
- numerical stress analysis and tests, including strength substantiation of composite airframe structures
- challenges related to introducing concentrated loads into thin-walled composite structures,
- design of manufacturing processes, including challenges related to dimensional accuracy and interchangeability of airframe components,
- design and manufacture of manufacturing tools (models, moulds) made of fibre-epoxy composite or tooling boards,
- investigation of damage processes, with a special focus on delamination.

Our Team provides comprehensive designs of CS22-category aircrafts and design of aircrafts of other categories to a limited extent.

Among our clients are Glider Factory „JEŻÓW” and WZL2 Bydgoszcz.

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## RESEARCH INFRASTRUCTURE

- INSTRON strength testing machine with 10 kN and 200 kN load cells, and a set of extensometers
- ElectroPlus machine with 3kN load cell for fatigue testing
- 4m x 1m x 8 m oven for curing polymer composites at temperatures up to 200°C,
- thermal chamber for strength testing at temperatures up to 60°C
- vacuum pumps
- temperature and pressure recorders
- hot bonder with a set of electric heated blankets, thermocouples, and a vacuum system
- portable system for composite material removal,
- AVIA X-5 1000/500 five-axis machining centres
- 3D printers:
  - Fortus 450MC
  - Orleas Creator
- strain measurement systems, including DIC and strain gauge measurement system
- linear position sensors
- OmniScan MX2 Phased Array
- SYLES S-Line-400 interrogator
- CAD software: Ansys, Nastran, NX Unigraphics

## SELECTED PROJECTS

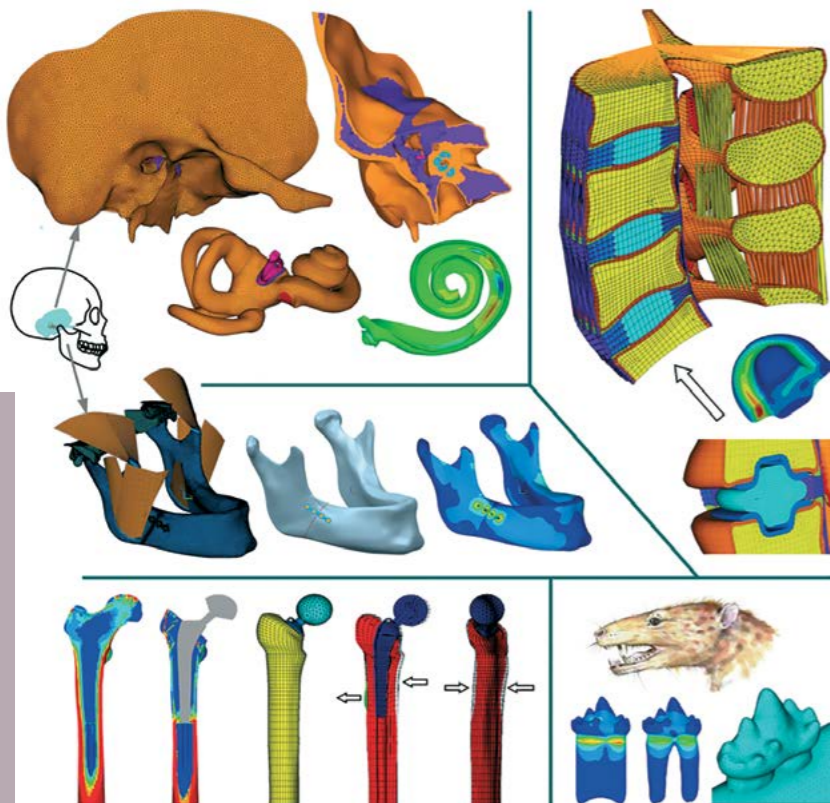
- Participation in the design, manufacture, testing, and certification processes of the ORLIK unmanned aerial vehicle (2020–ongoing)
- Design of a new fuselage for an aerobatic glider with an FES drive system (Glider Factory „JEŻÓW”, Smart Growth Operational Programme)
- Fuel cell-based Hybrid Drive of a lightweight aircraft (NCBR, 2015–2019)
- Development of non-adhesive metal-composite lock joint for introducing concentrated loads into primary layered structures made of carbon/epoxy prepregs (NCBR, 2012–2015)
- Development of an out-of-autoclave manufacturing process for composite aircraft structures made of carbon/epoxy prepregs (NCBR, 2012–2015)

## OFFERED SERVICES

- prototyping and manufacture of primary glass- and carbon-epoxy composite structures
- using hand lay-up vacuum-assisted process, or infusion process, or VBO prepregs
- numerical strength and stiffness analysis of composite structures, static strength, and stiffness tests, and fatigue tests of composite structures at temperatures of up to 60°C, including static strength substantiation of composite airframe structures under CS22
- determination of material properties necessary for performing strength, stiffness, and fatigue analyses
- design and manufacturing of models and moulds made of fibre-epoxy composite or tooling boards for parts that will be produced in low quantities







# FEM NUMERICAL BIOMECHANIC SIMULATIONS TEAM

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING; BIOMEDICAL ENGINEERING

- #FE SIMULATIONS #PARAMETRIC MODELS OF TISSUES
- #TISSUE GEOMETRY MAPPING #IMPLANT-BONE STRUCTURES
- #INTERVERTEBRAL DISC IMPLANTS #STABILISING PLATES
- #MANDIBLE INTERNAL FIXATION SYSTEMS
- #BONE REMODELING SIMULATIONS
- #ABRASIVE WEAR OF IMPLANTS #BONE CONDUCTION STIMULATION

Our Team works at the Faculty of Power and Aeronautical Engineering (WUT) in the Institute of Aeronautics and Applied Mechanics. The Team consists of employees and doctoral students of the Division of Strength of Materials and Structures, and cooperates with medical institutions in Poland.

Throughout its long history, the Team has been primarily involved in conceiving models of biomechanical structures for finite element method (FEM) based numerical simulations, validating numerical models based on experimental test results and using the obtained models for setting out guidelines to be followed when designing new types of implants or developing new materials for implants.

Our Team's partners have included: the Medical University of Warsaw, the Central Institute of Labour Protection – National Research Institute, the Institute of Paleobiology of the Polish Academy of Sciences – State Research Institute, Aurismed S.A. and Signovia International Sp. z o.o

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## RESEARCH INFRASTRUCTURE

- laboratory of numerical methods in structural mechanics (two computer-equipped rooms)
- ANSYS software with the Academic Research license

## SELECTED PROJECTS

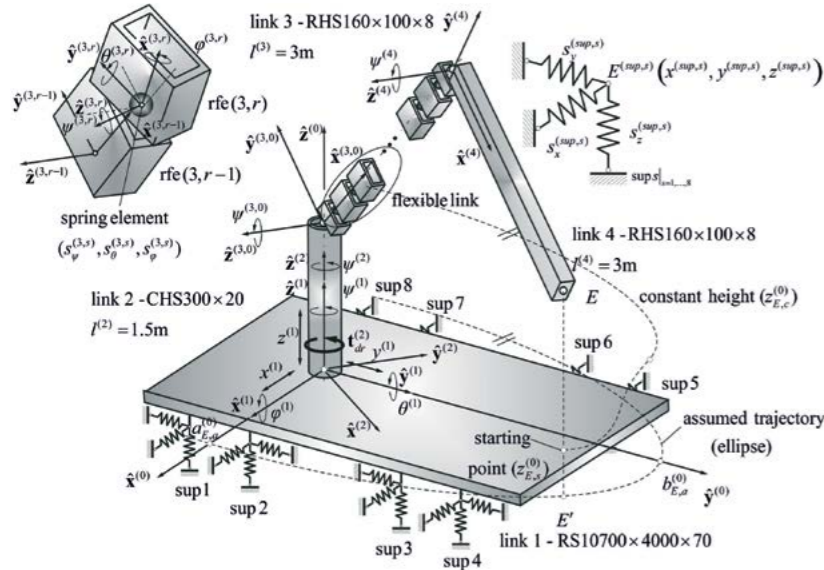
- Development of an innovative method for the direct stimulation of inner ear structures through bone conduction (NCBR, project implemented by the consortium of Medical University of Warsaw – Warsaw University of Technology – Aurismed S.A. – Signovia International Sp. z o.o., 2015–2019)
- Elastic materials for use in intervertebral disc implant structures (NCBR, project implemented by the Faculty of Materials Engineering, Faculty of Chemistry and Faculty of Power and Aeronautical Engineering of the Warsaw University of Technology, 2010–2013)
- Development and verification of the properties of a polyurethane nanocomposite for use as an intervertebral disc implant (Ministry of Science and Higher Education, 2009–2010)

## OFFERED SERVICES

- preparing anatomical structure geometry in the ANSYS system based on processed CT imaging data (e.g. spine, temporal bone, inner ear, mandible)
- producing parametric models for selected bone structures and implants (spine, mandible, artificial intervertebral discs, stabilisation plates for fractured mandibles, bone conduction stimulators)
- numerical modelling of isotropic and anisotropic properties of tissues and of phenomena such as thermal stress, contact, plasticity, viscoelasticity, hyperelasticity, bone remodeling processes, abrasive wear of implants
- structural analysis of biomechanical problems in the ANSYS system related to statics (linear and non-linear analysis) and dynamics (free vibration, harmonic vibration, transient analysis)

## PATENTS

- Flexible intervertebral disc implant (patent/license number: 401816)
- Intervertebral disc implant (patent/license number: 213019)



# MECHANICAL SYSTEM MODELLING AND CONTROL METHODS RESEARCH TEAM

AT THE WARSAW UNIVERSITY  
OF TECHNOLOGY

MECHANICAL ENGINEERING

#ROBOTIC SYSTEMS #DYNAMIC MODELS OF CONTINUUM SYSTEMS  
#AIRBORNE SYSTEMS #DYNAMIC CONTROL SYSTEMS  
#UNDERWATER VEHICLES #DYNAMIC MODELS OF DISCRETE SYSTEMS  
#SPACE SYSTEMS #ANALYSIS OF MECHANICAL SYSTEM MOTION  
#DESIGN OF MECHANICAL SYSTEM CONTROL

The Mechanical System Modelling and Control Methods Research Team works at the Division of Automation and Aeronautical Systems of the Institute of Aeronautics and Applied Mechanics at the Faculty of Power and Aeronautical Engineering (WUT). Our Team consists of research fellows with experience in methods of nonlinear modeling and control design.

Our partners are researchers and university teachers from the Faculty of Mechanical Engineering at the University of Bielsko-Biała, Cranfield University UK, Northampton University UK, Creotech and the SENER Poland companies. The doctoral students collaborating with our team are also employed at mechanical engineering and space sectors in Poland.

We specialize in modelling complex discrete, continuous and discrete-continuous mechanical systems, and in nonlinear control designs for them. Our primary focus is on modelling dynamics of ground and underwater vehicles, space systems including satellites and space robots, motion analysis and designing control systems for them. We have developed and offer for use original and effective tools to generate and validate numerical models of discrete-continuous system dynamics. We also collaborate with partner foreign universities in our research.

Our team's clients and partners are SENER Polska, Creotech, Cranfield University UK, Northampton University UK, TU Berlin Germany, Worcester Polytechnic Institute USA. Przykładowymi klientami i partnerami grupy są m.in.: SENER Polska, GMV Polska, Cranfield University, University of Northampton, TU Berlin oraz University of Alabama at Birmingham.

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## RESEARCH INFRASTRUCTURE

- dedicated software – we have developed and use original and effective tools to create and investigate numerical models of discrete-continuous system dynamics

## SELECTED PROJECTS

- A Unified Dynamic Control Strategy Based upon an Error Function (NCN, 2011–2014)
- Development of Kalman filtering methods for unsteady processes in geodesy and navigation (NCN, 2012–2014)
- Navigation Systems for Servicing Tasks on an Orbit and Formation Flights (NCBR, 2013–2016)
- Preliminary Performance Assessments and Control System Requirements for Hydrogen Micromix Combustion Systems – ENABLING Cryogenic Hydrogen-Based CO<sub>2</sub>-free Air Transport (EU, Horizon 2020, 2019–2020)

## DEVELOPED METHODOLOGIES

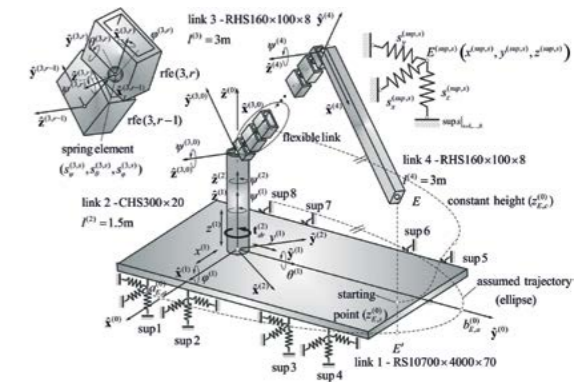
- Methodology for modelling complex mechanical structures: numerical procedure – Computational Procedure for Constrained Dynamics (CoPCoD) – to investigate models of complex discrete-continuous systems structured as open and closed chains
- Methodology of designing tracking control for task-constrained discrete-continuous systems

## OFFERED SERVICES

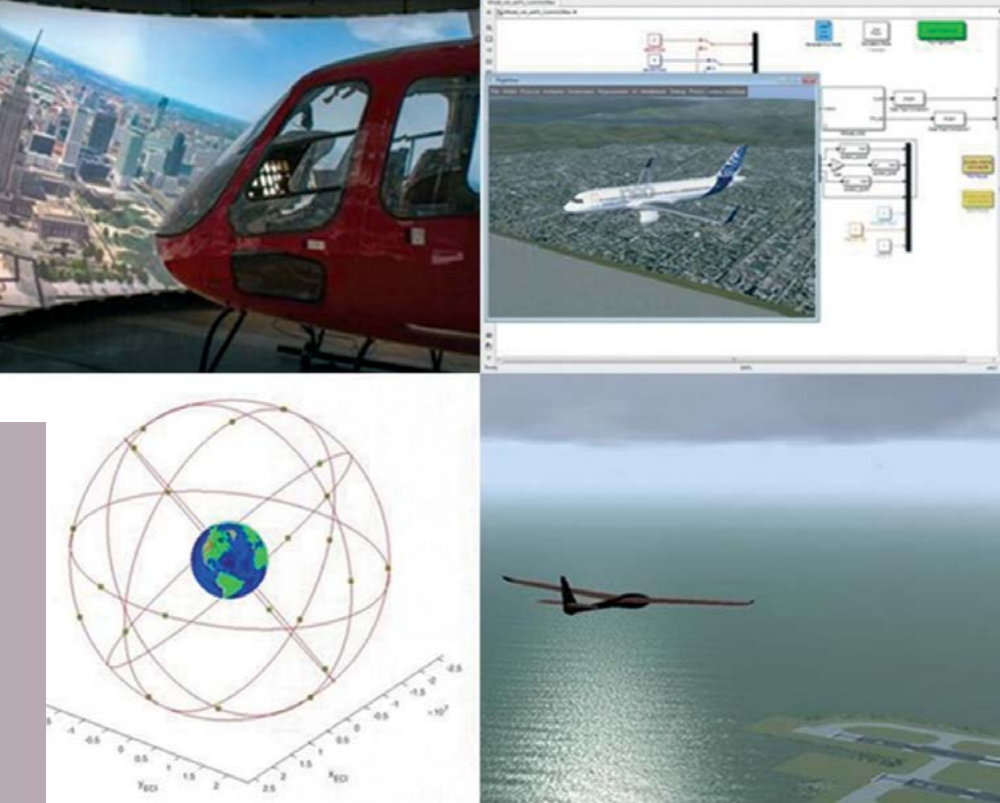
- modelling and computational technique projects
- motion analysis of dynamic systems (e.g. machines and robotic devices) and control design

## OTHER ACHIEVEMENTS

- European Commission's expert qualifications to issue assessments, reviews and provide expert opinions on aeronautical and aerospace technologies, and on control and robotics (prepared for projects implemented as part of Horizon-ITC-2019, Horizon-FE- TOPEN-2018-2019-2020 and Horizon-EIC-2021-PATHFINDER competitions, among others)







# FLIGHT DYNAMICS AND CONTROL TEAM

## AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING

#AIRPLANE FLIGHT DYNAMIC #ROTORCRAFT FLIGHT DYNAMIC #MISSILES FLIGHT DYNAMIC #SPACECRAFT FLIGHT DYNAMIC #AUTOMATIC FLIGHT CONTROL SYSTEM #FLIGHT SIMULATORS #NAVIGATION SYSTEMS #HMI #BIOFEEDBACK #DIGITALTWINS

Our Research Team is a part of the Division of Automation and Aeronautical Systems of the Institute of Aeronautics and Applied Mechanics, Faculty of Power and Aeronautical Engineering (WUT).

We are involved in R&D in the area of dynamics, control and navigation of flying objects. Our core research areas include:

- design of dynamic models of flying objects (airplanes, rotorcraft, missiles, and spacecraft, including UAV),
- design, analysis and synthesis of navigation and control system algorithms for flying objects,
- simulation tests of flying objects dynamics and control, including Hardware in the Loop and Software in the Loop techniques, also with the use of flight simulators,
- human-machine interaction, biofeedback analysis.

We have access to diverse research infrastructure, including two laboratories and an airfield at which we can carry out tests involving UAVs research.

### CONTACT

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Members of our Team have gained their experience through involvement in various research projects, domestic and international, cooperating with leading Polish and international research centers, universities, and companies in the aerospace industry. Our Teams' partners include: Boeing, Lockheed Martin, PZL-Świdnik, MESKO, Thales Alenia Space, ETC PZL Aerospace Industries, WB Electronics, Łukasiewicz Research Network – Institute of Aviation, Deutsches Zentrum für Luftund Raumfahrt, Rzeszów University of Technology and Technische Universität Braunschweig.

### RESEARCH INFRASTRUCTURE

- SIMULATION RESEARCH CENTER
  - reconfigurable equipment – one- and three-channel visual systems with a spherical screen, virtual reality; interchangeable pilot and UAV operator stations
  - open architecture – possibility of implementation of new and modification of existing dynamic models of objects, adjustment of simulator configuration to the current object and research program
- UNMANNED ROTORCRAFT AND MOBILE ROBOTS LABORATORY
  - integrated vision navigation system
- FlightLab software dedicated for modelling rotorcraft dynamics
- Airfield with infrastructure for UAV testing
- Dedicated biofeedback measurement equipment (EEG, ECG, GSR, Eyetracker)

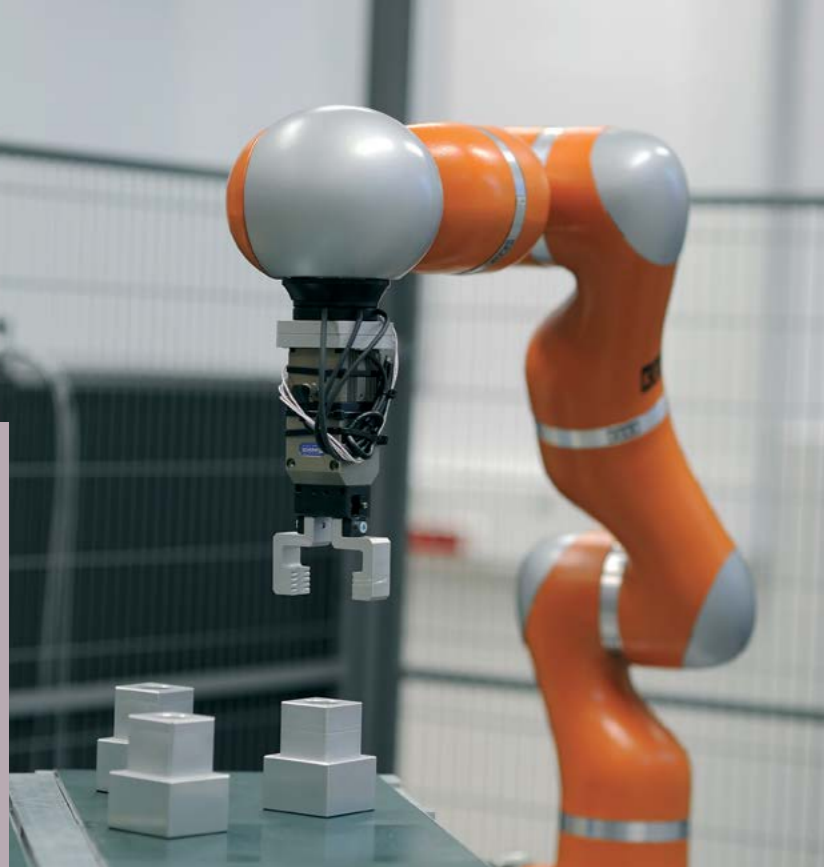
### OFFERED SERVICES

- research related to flight dynamics
- simulation tests of flying objects
- research related to aircraft performances and control, and human-machine interactions using flight simulators
- research related to automatic flight control systems, including Hardware in the Loop and Software in the Loop tests using available laboratory infrastructure
- research related to developing and implementing new methods and algorithms for navigation and flight control
- development of advanced models of rotorcraft dynamics
- simulations of rotorcraft dynamics and control systems
- research related to Human-Machine Interactions, assessment of pilot/operator control effectiveness and workload assessment

### SELECTED PROJECTS

- Modification of an optionally piloted helicopter for maritime mission performance (HELMARIS)(NCBR, INNOLOT, 2017–2020)
- Operational Network of Individual Observation Nodes (ON-ION) (Horizon 2020, 2016–2017)
- Methods of synthesis of aircraft control system in emergency situations (NCBR, PBS2, 2013–2016)
- Advanced Cockpit for Reduction of Stress and Workload (ACCROS)(EU, 7th Framework Programme, 2013–2016)
- New Aircraft Concepts Research (NACRE)(EU, 6th Framework Programme, 2005–2009)





# ROBOTICS AND DYNAMIC SYSTEMS TEAM

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING;  
AUTOMATION, ELECTRONICS AND ELECTRICAL ENGINEERING

#ROBOT #MANIPULATOR #MECHANICAL SYSTEM DYNAMICS  
#MOTION CONTROL AND PROGRAMMING SYSTEMS #OPTIMISATION  
#NUMERICAL COMPUTATIONS #MULTIBODY SYSTEMS #DYNAMIC SYSTEMS  
#MECHANICAL SYSTEMS #MACHINE AND MECHANISM DESIGN #BIOROBOTICS  
#BIOMECHANICS

The Robotics and Dynamic Systems Team is affiliated with the Division of Theory of Machines and Robots at the Institute of Aeronautics and Applied Mechanisms of the Faculty of Power and Aeronautical Engineering.

Our Team's research interests include:

- computational robotics – trajectory planning, dynamic modeling, control of manipulators and mobile robots,
- multibody systems kinematics and dynamics – modeling, identification, simulation and optimization of complex mechanical systems,
- design of robotic systems and mechanisms – medical robots, rehabilitation devices, actuating systems
- biorobotics and biomechanics – walking (multilegged) machines, humanoid robots, occupational and impact biomechanics, passive safety systems.

Our Team's partners include: Łukasiewicz Research Network – Industrial Research Institute for Automation and Measurements PIAP, PCO S.A., MESKO S.A., ZAP Robotyka L.L.C., and Central Institute for Labour Protection – National Research Institute.

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## RESEARCH INFRASTRUCTURE

- ROBOTICS LABORATORY
  - two KUKA LWR 4+ experimental redundant robots equipped with an open control system and joint torque sensors allowing for force and torque measurements
  - KUKA Agilus robot with a positioner
  - Fanuc M10iA robot equipped with a wrist torque/force sensor and a two-axis positioner
  - Fanuc M1iA parallel robot
  - a research kit for investigating a swarm of small mobile robots
  - two Seekur Jr mobile robots (one is equipped with a 5-DOF manipulator and a gripper)
  - Pioneer P3-DX mobile robot
  - additional equipment: machine vision cameras, RGB-D cameras, feeders, grippers, a test track
- MEASUREMENT, AUTOMATION AND CONTROL LABORATORY
  - NI measurement computers (PXI 1078, CompactRIO 9038)
  - an assortment of sensors and data acquisition cards
  - high-speed cameras (FASTEC TSHRMS, PHANTOM 310v) with ancillary equipment
  - 3D Smarttech scanner
  - PLC test stand (Simatic S7)
  - QUANSER research platform
  - Maxon EPOS2 testbeds
- ASUS ESC4000 G4 HPC node (2x Xeon Gold 6242, 192 GB RDIMM DDD4 2933 MHz, NVidia Quadro RTX6000)
- Custom and commercial engineering software ADAMS, Matlab, LabView, etc.

## PATENTS

- Device for correction of vertebral column and measuring system (US 9949884)
- Device for transporting children in vehicles (PL 236856)
- Short-transmission subscriber terminal locator (PL 227323)
- Device for forcing the transmission from a GSM subscriber terminal to enable it to be located

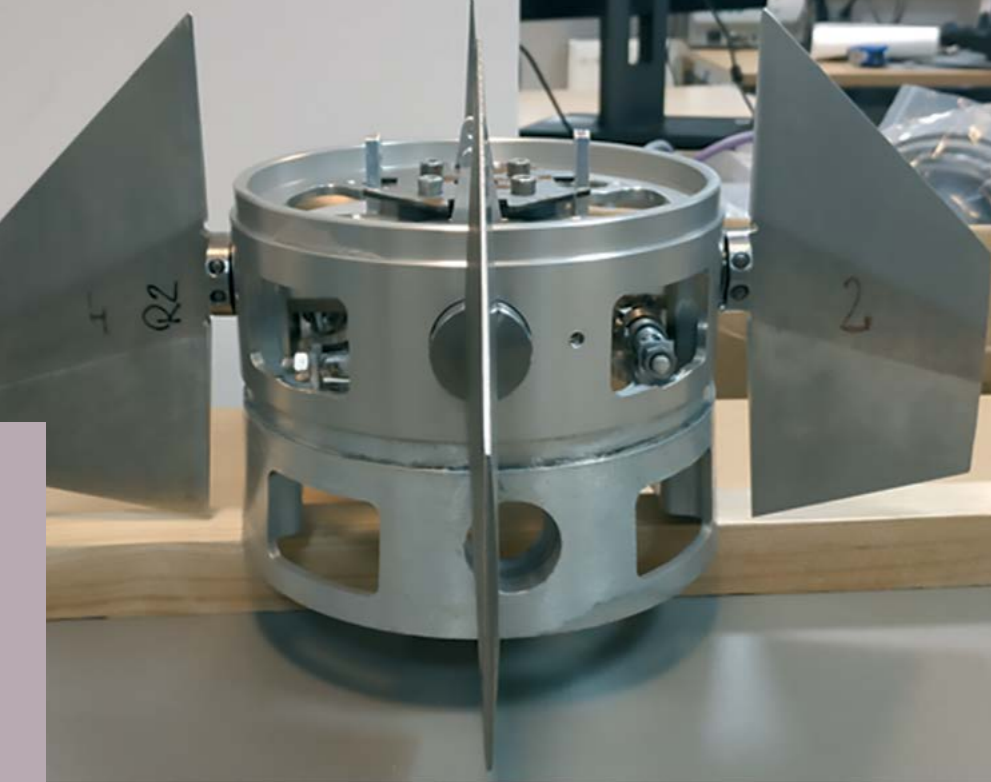
- GSM subscriber terminal forced-transmission inducer enabling GSM subscriber terminal location (PL 227116)
- Device for spine correction (EP2974709A1)

## OFFERED SERVICES

- research on kinematics and dynamics of robotic and multi-body systems, and their experimental identification
- design, integration, and optimization of robotic manipulators (including those for medical and rehabilitation use) and mobile robots
- model-based design and control of robotic systems
- technical support in industrial robot (KUKA, Fanuc) and complex robotic systems programming
- research on trajectory planning methods for manipulators and multi-robot systems working in dynamic environments
- human motion capture and analysis
- motion planning and motion programming for multi-legged, wheeled, tracked, and other types of mobile robots

## SELECTED PROJECTS

- PROTEUS – Integrated mobile system for support of antiterrorist and emergency response activities. (in cooperation with PIAP, NCBR, POIG 2007–2013)
- SwarmITFix – Self Reconfigurable Intelligent Swarm Fixtures for machining flexible aircraft parts (in cooperation with the Faculty of Electronics and Information Technology, WUT, EU, 7th Framework Programme, 2008–2012)
- Flexible, overconstrained multibody system modelling using sequential and parallel methods (NCN, OPUS, 2013–2017)
- Hamiltonian approach toward efficient modeling of large-scale multibody systems with friction and toward real-time simulations of robotic systems (NCN, OPUS, 2019–2022)



# MISSILE AND ROCKET CONTROL SYSTEMS TEAM

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING;  
AUTOMATION, ELECTRONICS AND ELECTRICAL ENGINEERING

#CONTROL SYSTEMS #ROCKET TECHNOLOGY  
#GUIDED MISSILES #ROCKET-CONTROL EXECUTIVE SYSTEMS  
#ROCKET AND MISSILE DYNAMICS MODELLING

Our Team works at the Faculty of Power and Aeronautical Engineering (WUT) in the Institute of Aeronautics and Applied Mechanics.

Relying on our long-standing experience in rocket technology, we carry out research projects and prepare expert opinions for businesses. As part of our R&D projects, we engage in extensive works involving missile and rocket control systems.

Our Team cooperates with Polish Armaments Group companies (including MESKO S.A.), private Polish and foreign companies (e.g. Lockheed Martin, THALES), research institutes and universities concerned with subjects around guided missiles, as well as small tech startups, the Ministry of National Defence and the Armed Forces of the Republic of Poland.

## CONTACT

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## RESEARCH INFRASTRUCTURE

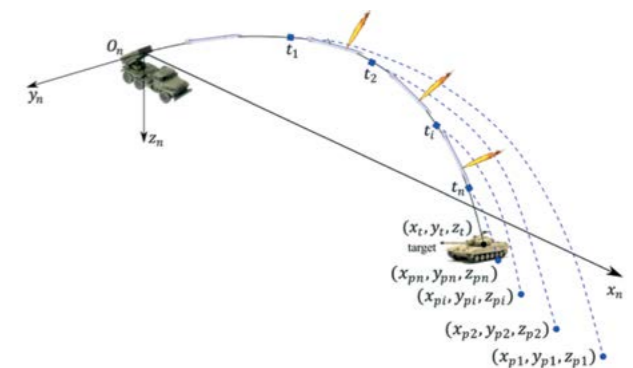
- proving ground-tested simulation environment
- hardware in the loop laboratory for rocket system testing
- dedicated software and methodologies for the identification of rocket and missile dynamic

## SELECTED PROJECTS

- Development of technologies for rocket control executive systems (NCBR, BIO, 2016–2020)
- Development of a gas-operated control unit for precision missile guidance (NCBR, BIO, 2021–2024)
- Universal inertial measurement unit (IMU) for missile control and guidance systems (NCBR, BIO, 2021–2024)
- Research on the Feniks rocket for the Langusta multiple rocket launcher (MESKO S.A., 2016–2019)
- Pulse control of smart missile flight using guidance methods based on artificial neural networks (Ministry of Science and Higher Education, 2004–2006)

## OFFERED SERVICES

- modelling missile and rocket dynamics and control systems
- development and tests of control algorithms and autopilots
- analysis of in-flight test results
- identification of rocket and guided-missile flight dynamics
- tests of executive control systems in rockets and missiles
- system tests at the hardware in the loop laboratory







# AVIATION RESEARCH CENTRE AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING;  
AUTOMATION, ELECTRONICS AND ELECTRICAL ENGINEERING

#AVIATION #CONTROL SYSTEMS #UNMANNED AERIAL SYSTEMS #DRONES  
#NAVIGATION AND CONTROL #FLIGHT CONTROL #FLIGHT DYNAMICS #CLEAN ENERGY #PROPULSION SYSTEMS

WUT's Aviation Research Centre (ARC) is a part of the Faculty of Power and Aeronautical Engineering in the Institute of Aeronautics and Applied Mechanics.

The Aviation Research Centre is recognized as one of the UAV competence centre in Poland, focused on research in precision agricultural and forestry. ARC is a partner together with Agricultural Advisory Centres, State Forest and hunting clubs.

Within the research projects that are currently developed at the ARC, most of the work is aimed in developing UAV technologies and systems related to BVLOS, autonomy flights and system of systems cooperation.

The other research area that is developed at the ARC are manned and unmanned platforms to support reducing the environmental impacts of aviation pollution. As a part of those efforts the research is focused in use of clean energy from renewable energy sources by using electric motors in order to increase the engines efficiency. Some research on optimization of the power distribution and consumption, as well as the navigation and control systems are being developed.

We continue our partnership in the research with the various aviation companies, UAV startups, universities and research institutes, local authorities, state administration and Services.

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## RESEARCH INFRASTRUCTURE

- airfield in Sierakowo near Przasnysz, including the infrastructure
- aviation and autonomous systems laboratory
- unmanned systems of systems laboratory
- precision agricultural and forestry UAV laboratory
- aera surveillance laboratory (passive radars)
- aircraft and propulsion systems laboratory
- divers fleet of UAVs equipped with the various sensors and measurement systems
- aircraft systems laboratory
- computational laboratory
- CNC machines, 3D printing laboratory
- composite workshop (including thermal chamber, and structure verification machine)
- advanced dyno for testing various propulsion systems

## OFFERED SERVICES

- research with the use of UAV and manned systems
- testing and verification BVLOS systems and special class systems
- advanced measuring systems (RGB, thermal, lidar, multi-spectral and others)
- investigation and testing the new propulsion systems for aircraft
- crop and wildlife monitoring



For: S. Koscielniński





# STRENGTH OF MATERIALS AND STRUCTURES LABORATORY

AT THE WARSAW UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING

#STRENGTH OF MATERIALS #EXPERIMENTAL TESTS  
 #DETERMINATION OF MATERIAL PROPERTIES #LOW- AND HIGH-CYCLE FATIGUE  
 #FRACTURE MECHANICS #FLAW DETECTION TESTS #ACCIDENTS

The Strength of Materials and Structures Laboratory of the Faculty of Power and Aeronautical Engineering (WUT) conducts research to determine mechanical properties of metal and composite materials based on static and dynamic testing. Furthermore, our Laboratory carries out statistical studies and stress tests of complete mechanical constructions and their sub-assemblies to identify relationships between loads in the form of forces or moments and corresponding displacements, deformations and stresses.

Our Team performs non-destructive tests using penetration, ultrasonic, eddy current and X-ray techniques, and detects, and identifies the location, configuration and size of, material-, process-, and wear-related defects.

Our Laboratory performs measurements as part of research projects as well as assignments from other research institutions and industrial establishments. We provide our services mainly to companies from the aviation, energy and automotive industries.

Our Team's clients have included the State Commission on Aircraft Accidents Investigation, the Air Force Institute of Technology and a range of companies from the small-enterprise sector.

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## RESEARCH INFRASTRUCTURE

- statics strength and stress testing machines up to 500kN
- multichannel mobile systems for tensometric deformation measurements
- interrogator for multi-channel deformation measurement using optical fibres
- optical deformation measurement system (DIC)
- CNC machines for preparing samples, ancillary equipment and prototype construction
- flaw detectors: ultrasonic (phase array), eddy current and X-ray
- mkiroVickers hardness tester
- Charpy impact test hammer

## SELECTED PROJECTS

- Expert opinion on the broken-off propeller of a gyroplane (State Commission on Aircraft Accidents Investigation, 2021)
- Strength test of main-rotor blade fragments (Air Force Institute of Technology, carried out by the Aviation Institute, 2019)
- Strength test of filtration membranes (Huber Technology Sp. z o.o., 2019)
- Strength test of walls as per PN-EN 594 standard (PROCYON Sp. z o.o., 2017)
- Strength test of composite materials (Air Force Institute of Technology, 2017)

## OFFERED SERVICES

- static tensile, compression and bending strength tests of metallic and composite materials (up to 500kN)
- ultimate strength tests of welded, heat bonded and adhesive-bonded composite and metallic materials
- determination of material properties as required for strength, stiffness and fatigue reliability evaluation
- deformation measurements on real-life constructions using tensometric methods
- DIC-based deformation measurements
- residual strain measurements
- penetrant, ultrasonic, eddy current and X-ray flaw detection

## PATENTS

- Rescue unit for gyroplanes (PL 231190)
- Method for machine-rotor balancing (PL 225923)

