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University  
of Science  
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*Wrocław University of Science and Technology is one of the leading academic and research centres of Poland, one whose position among technical tertiary institutes in Europe and other parts of the world is going up every year. The university's development is ensured by its world-class standard of research and laboratories, the high quality of teaching, innovation, as well as close relations with the business sector.*

*Our cooperation with entrepreneurs - micro-companies and small, mid-sized, as well as large organisations - is one of the pillars of our activity. Thanks of the knowledge and experience of the university's research staff, we can offer you a wide range of top rate research services, expert evaluations, technologies, and training programmes.*

*It is my pleasure to present you the latest publication detailing our services offered to business clients. We are open to cooperation in many fields, also ones beyond the scope of this catalogue.*

*I truly hope that the rich offering of the services provided by our university will help you reach your organisation's business goals and contribute to its gaining a competitive advantage.*

Professor Andrzej Kucharski, PhD, DSc, Eng



Vice-Rector for Cooperation with the Economy and Informatisation

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## ACOUSTIC AND ELECTROACOUSTIC MEASUREMENTS

### TRAINING

Methods of performing acoustic measurements with respect to the following:

- electroacoustic devices such as loudspeakers and loudspeaker devices, amplifiers, microphones, digital-analogue converters, and analogue-digital converters,
- electroacoustic systems - including amplification systems (sound level, frequency characteristics, speech transmission index - STI and STIPA),
- acoustics in architecture (reverberation time and related parameters, speech transmission index - STI and STIPA),
- construction acoustics (acoustic insulation power, noise in rooms).

### APPLICATION

Thanks to the knowledge obtained in the training, the participant will be able to carry out measurements on their own in order to perform the following tasks:

- draw up technical specifications for electroacoustic devices,
- verify the correctness of the operation of electroacoustic device prototypes and test them,
- perform adjustments to electroacoustic devices' and systems' settings, perform acceptance checks of such devices, as well as evaluate their compliance with relevant requirements,
- perform monitoring, commissioning, and evaluation of compliance with relevant requirements with respect to civil structures' acoustics.

#### Contact information

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## ACTIVE IMPACT OF ULTRASOUND ON A MEDIUM

### RESEARCH

Active impact of ultrasound on a medium is connected with the application of ultrasound of high intensity in or-

der to cause specific phenomena and impacts, most often in liquids and tissues, such as cavitation or overheating.

### APPLICATION

Fast degassing of liquids, ultrasonic cleansing of printed circuits and small elements of solid bodies, emulsification, particle separation, accelerating chemical reactions, denaturation of proteins, destroying bacteria and fungi, spraying liquids, coagulation, homogenisation, ultrasonic hyperthermia, etc.

#### Contact information

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## DESIGNING ELECTROACOUSTIC SYSTEMS

### TRAINING

Design of electroacoustic systems such as:

- amplification systems,
- sound alarm systems,
- voice information systems, broadcasting systems,
- concert systems,
- studio monitoring systems.

The training comprises the following:

- structures of electroacoustic systems,
- specification of requirements for electroacoustic systems and devices (also allowing for regulations concerning public orders),
- computer simulations of amplification systems performed with the EASE software.

### APPLICATION

Knowledge acquired in the training will allow its participants to draw up project documentation for electroacoustic systems:

- at any stage (functional-utility programme, concept design, or detailed design),
- with regulations with respect to public orders in mind,

- using knowledge related to digital devices and digital transmission standards,
- using modern computer simulation techniques.

#### Contact information

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## DEVELOPMENT OF ULTRASONIC CONVERTERS TO BE USED IN VARIOUS MEDIA

### TECHNOLOGY

Development of various types of wide frequency range ultrasonic converters intended to operate in solid, liquid, and gaseous media. Other, optional services include developing ultrasonic converters with different performance modes (continuous wave, pulse) and powers in mind.

### APPLICATION

Converters developed at the unit can constitute an essential element of instrumentation and devices intended for active applications (e.g. coagulation of liquids, production of emulsions or aerosols) and passive ones (e.g. non-destructive tests, measurement of liquid and gas flows, monitoring of precipitation levels, echo ranging measurements in all types of media, etc.). Converters developed at the unit can be applied in various fields of science, technology, and medicine.

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## DIAGNOSTICS OF DEVICES USING ACOUSTIC AND VIBROACOUSTIC METHODS

### RESEARCH

Based on a product's characteristics and analysis of the guidelines and standards of a given industry sector, a measurement system is designed and built to allow product diagnostics. Measurement systems can be applied during the design process or to control product quality.

### APPLICATION

Measurements of noise and vibrations generated by products.

#### Contact information

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## EXPERT EVALUATIONS OF ELECTROACOUSTIC SYSTEMS

### EXPERT REPORT

Expert evaluations focusing on electroacoustic systems at every stage of a development project:

- identification of system requirements at the stage of the functional and utility program or concept design,
- evaluation of the detailed design,
- verification of tenders' compliance with the specification of substantial requirements of the order, technical specification of the delivery and commissioning of the construction project, or requirements specified in other project or tender documents.
- as-built evaluations with respect to compliance with requirements,
- indication of causes of any cases of non-compliance with requirements,
- reports providing guidelines for corrective actions.

### APPLICATION

Expert evaluations for:

- investors,
- architects,
- users of civil structures equipped with an electroacoustic system.

### RESEARCH

Active impact of ultrasound on a medium is connected with the application of ultrasound of high intensity in order to cause specific phenomena and impacts, most often in liquids and tissues, such as cavitation or overheating. Build quality checks based on the characteristics of sounds and vibrations produced while using products. Evaluation of the quality of the sound produced while using a product (e.g. in the automotive industry). Support for the product design process. Monitoring the impact of changes to the design on the noise produced by the user-ready product.

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## LOUDNESS OF RADIO AND TELEVISION PROGRAMMES

### RESEARCH

Studies of the loudness of radio and TV programmes as well as audio-video material consist in the measurement of an audio stream's parameters. The measurements are performed in accordance with EBU and ITU recommendations. Based on the results of measurements, it is possible to establish the compliance of programmes under examination with relevant recommendations applicable in Poland.

### APPLICATION

Measurements of the loudness of radio and TV programmes as well as audio-video material published on websites. Consultancy services in relation to the organisation of production of materials intended to be broadcasted in the context of audio stream shaping. Monitoring radio and TV broadcasters.

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## STUDIES IN THE FIELD OF CONSTRUCTION ACOUSTICS

### RESEARCH

Studies of acoustic insulation between rooms against airborne and impact sound in field conditions, for parameters including the following:

- specific approximate acoustic insulating power ( $R'$ ),
- standardised level difference ( $DnT$ ),
- weighted index of specific approximate acoustic insulating power ( $R'w$ ),
- weighted index of the standardised level difference -  $DnT_w$ ,
- spectrum adaptation terms  $C$  and  $C_{tr}$ ,
- normalised impact sound pressure level ( $L'_{n,w}$ ),
- standardised impact sound pressure level ( $L'_{nT}$ ),
- weighted index of normalised impact sound pressure level ( $L'_{n,w}$ ),
- weighted index of standardised impact sound pressure level ( $L'_{nT,w}$ ),
- spectrum adaptation term  $C_I$ .

Studies of noise in buildings, for parameters including the following:

- mean sound level -  $A_{LA}$ ,
- equivalent sound level -  $A_{LAeq}$ , maximum sound level -  $A$ ,
- levels of acoustic pressure in 1/1 octave ranges.

The studies are performed in compliance with the following standards:

- PN-EN ISO 140-4:2000,
- PN-EN ISO 16283-1:2014,
- PN-EN ISO 717-1:2013,
- PN-EN ISO 140-7:2000,
- PN-EN ISO 16283-2:2016,
- PN-EN ISO 717-2:2013,
- PN B 02156:1987.

The laboratory is accredited by the Polish Centre for Accreditation (accreditation AB 796).

### APPLICATION

The results of the studies performed at the facility can be used for the following purposes:

- evaluation of compliance with the standards PN-B-02151-3:2015 and PN-B-02151-2:2018,
- evaluation of compliance with design-related requirements,
- as check-up and commissioning measurements.

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## STUDIES OF CODED AUDIO QUALITY

### RESEARCH

Studies of the quality of audio, coded using lossy and lossless methods, are based on objective and subjective tests. The former apply software for modelling psychoacoustic phenomena, thanks to which it is possible to obtain a measure of lossy-coded audio deformation but in the domain of perception (i.e. the answer is given to the question whether a given deformation is perceived and

what the extent of this effect is). The subjective tests are a classic approach to audio signal quality assessment, one involving a qualified and sufficiently large group of listeners (experts). They are carried out in the form of audio listening tests whose results undergo comprehensive statistical processing.

### APPLICATION

- tests of audio quality in digital audio broadcasting (DAB, hybrid radio) and online streaming,
- measurement and evaluation of audio codecs' quality.

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## STUDIES OF ELECTROACOUSTIC DEVICES

### RESEARCH

Measurements of electroacoustic devices' parameters such as:

- loudspeakers and loudspeaker devices,
- power amplifiers, integrated and voltage amplifiers,
- audio recorders and players (e.g. CD, DVD, Blu-ray), analogue-digital and digital-analogue converters (ADC, DAC),
- other electroacoustic devices

### APPLICATION

The following can be achieved using results of studies of electroacoustic devices:

- establishment of their technical specifications,
- evaluation of their compliance with standards (e.g. PN-EN 54-24) and standard-regulating documents,

- verification of the correctness of their operation,
- tests of prototypes and various design-related solutions,
- necessary adjustments,
- development of computer models of loudspeaker devices.

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## STUDIES OF ELECTROACOUSTIC SYSTEMS

### RESEARCH

Measurements of electroacoustic systems' parameters such as:

- sound alarm systems,
- voice information systems, broadcasting systems,
- amplification systems,
- studio monitoring systems.

Measurements are performed with respect to parameters such as the following:

- STI, STIPA, RASTI speech transmission index,
- LAeq sound levels, L<sub>C</sub>eq signals, interference, and acoustic background,
- levels of acoustic pressure in 1/1 and 1/3 octave ranges,
- frequency characteristics,
- impulse responses.

Studies are performed in compliance with the following standards:

- PN-EN 60268-16:2011,
- PN-EN 60849:2001,
- PN-EN 50849:2017,
- PN-EN 16584-2:2017.



The laboratory is accredited by the Polish Centre for Accreditation (accreditation AB 796).

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## STUDIES OF INDUSTRIAL NOISE

### RESEARCH

Studies of industrial noise in the environment:

- generated by installations and devices,
- impulse noise.

Methodology of measurements - reference methodology in compliance with the current directive of the Minister of the Environment on the requirements with respect to performing measurements of emissions and the quantity of water consumed,

The studies are performed using the following methods:

- measurements,
- calculations using professional software.

Measurement instrumentation:

- digital analysers/Class 1 sound level meters,
- measurements of the frequency characteristics of noise in 1/3 and 1/1 octave ranges,
- storage of measurement results in computer memory.

Results of noise level measurements:

- values of noise level indices LAeqD and LAeqN, values of LDWN and LN indices,
- expanded uncertainty at a confidence level of 95%.

The studies of noise generated by installations and devices are accredited by the Polish Centre for Accreditation (accreditation no. AB 796).

### APPLICATION

- periodic measurements of environmental noise generated by installations and devices,
- test check-ups and as-built measurements of environmental noise generated by installations and devices in order to determine whether environmental quality standards are met,
- forecasting levels of environmental noise generated by installations and devices for the purpose of environmental impact evaluations, action plans and integrated permits.

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## STUDIES OF LOUDSPEAKER PROPERTIES

### RESEARCH

Comprehensive services in the area of measurements of loudspeakers' and loudspeaker-based devices' properties:

- measurements of standard properties of loudspeakers and loudspeaker devices, such as characteristics of acoustic pressure and phase characteristics, electrical impedance characteristics, harmonic distortion,
- measurements of equivalent circuit parameters,
- measurements of non-linear parameters of loudspeakers,
- measurements of loudspeakers' and loudspeaker devices' properties using subjective methods,
- measurements of loudspeaker casing walls' vibrations,
- measurements of properties of loudspeaker membrane materials.

### APPLICATION

The studies' results enable the development of recommendations aiming to improve loudspeakers' and loudspeaker devices' properties, involving recommendations with respect to changes to the casing structure, soundproofing casings' interiors and walls, and improvements of loudspeakers' crossover network properties.

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## STUDIES OF ROOM ACOUSTICS

### RESEARCH

Measurements of rooms' acoustic parameters such as:

- T20 and T30 reverberation time,
- STI, STIPA, RASTI speech transmission index,
- early decay time (EDT),
- C80 clarity index,
- D50 definition.

Studies are performed in compliance with the following standards:

- PN-EN ISO 3382-1:2009,
- PN-EN ISO 3382-2:2010,
- PN-EN 60268-16:2011,
- PN-B-02151-4:2015.

The laboratory is accredited by the Polish Centre for Accreditation (accreditation AB 796).

### APPLICATION

The results of the studies performed at the facility can be used for the following purposes:

- evaluation of the compliance of rooms' acoustic properties with the requirements of standards or standard-regulating documents (e.g. PN B 02151-4:2015),
- evaluation of the compliance of rooms' acoustic properties with design requirements,
- design analyses enabling the adjustment of a room's acoustic properties to the user's needs.

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## MEASUREMENTS AND ANALYSIS OF VIBRATIONS AND NOISE USING LASER VIBROMETRY

### RESEARCH

Contactless measurement of vibrations using the laser scanning vibrometer and analysis of the emission of sound/noise generated by these vibrations. Vibrations are measured using a laser scanning vibrometer made by Polytec, while noise analysis applies advanced numerical methods (FEM and BEM) and Sysnoise software. The unit performs measurements of vibrations and analyses noise emission with respect to the following:

- very light objects,
- very small elements (single millimetres in size),
- very large objects (up to a few hundred metres),
- objects at extremely high or low temperatures, within a wide frequency range (up to 1 MHz).

### APPLICATION

Measurements and analysis of the following:

- parameters of electroacoustic transducers including speakers, microphones and loudspeaker sets, ultrasonic transducers, and light vibrating structures, e.g. foil, microprostheses,
- distribution of vibrations on miniature objects,
- distribution of vibrations on large-size objects, e.g. turbines, casings, and even buildings,
- vibrations of hard-to-access structures, e.g. at high temperatures or ones exposed to hazardous radiation,
- efficiency of vibration damping and noise reduction.

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## MEASUREMENTS OF PARAMETERS OF ULTRASONIC CONVERTERS AND MATRICES

### RESEARCH

Quick measurements of complex admittance in terms of frequency are performed in order to determine ultrasonic converters' most important parameters. The unit is also capable of measuring the parameters and distribution of the acoustic field produced by these converters in water and the air.

### APPLICATION

The research enables the determination of a converter's equivalent circuit and its most important electromechanical and electroacoustic parameters (e.g. resonance fre-

quency, band, and efficiency). Automatic measurements of the distribution of ultrasonic converters' and matrices' acoustic field in water or air make it possible to determine their sensitivity/efficiency, focusing method, acoustic pressure produced and the ultrasonic wave intensity.

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## ULTRASONIC IMAGING OF VARIOUS MEDIA'S INTERNAL STRUCTURES

### RESEARCH

Ultrasonic imaging of interior structure is based on using various acoustic parameters related to the transmission of ultrasonic waves, such as: wave propagation speed, damping, derivative of the attenuation coefficient in relation to centre frequency, and parameters related to the reflection of ultrasonic waves from the inhomogeneities of the medium's structure.

### APPLICATION

Research using ultrasonic tomography methods and echographic methods into various internal structures of media for the purposes of industry and medical diagnostics.

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## DEVELOPING SPATIAL MODELS BY MEANS OF PHOTOGRAMMETRY RESEARCH

Development of spatial (3D) models using the photogrammetry software AgiSoft and a supercomputer's computation power.

The following services are offered:

- training in the software,
- development of a 3D model based on photographs provided.

### APPLICATION

Development of 3D models of areas, architectural structures, and maps for the purpose of virtual reality presentations.

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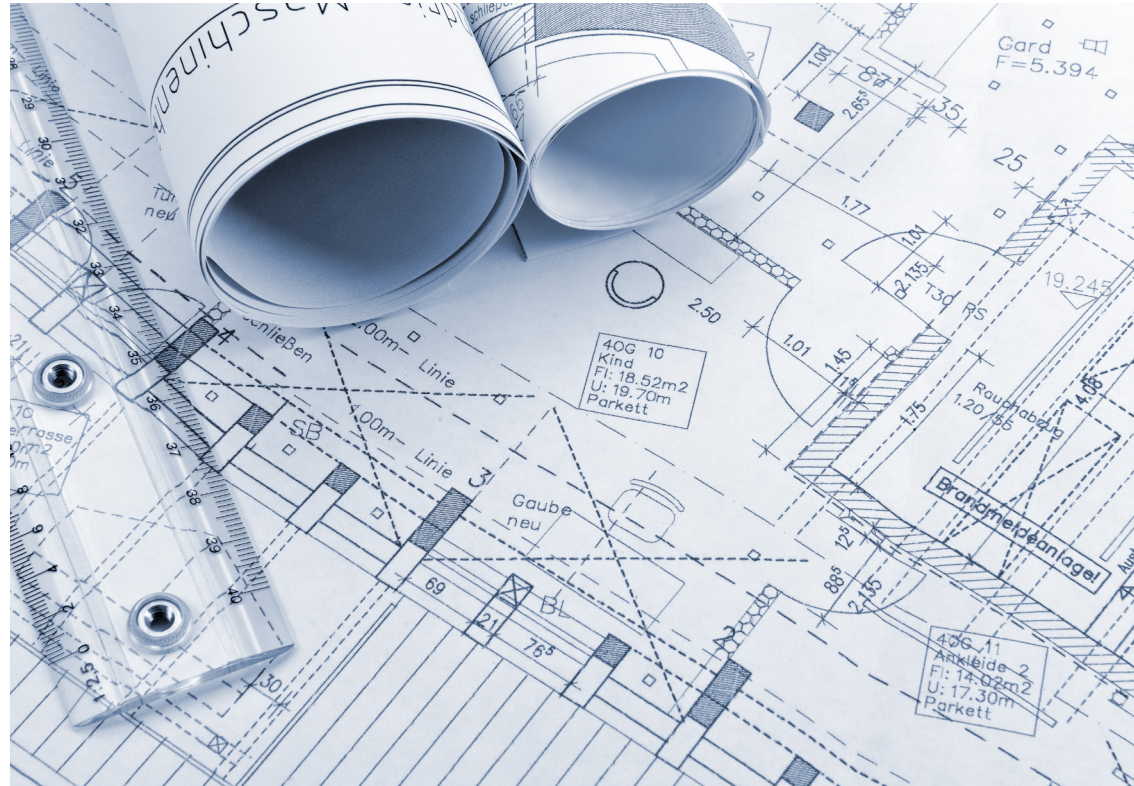
## STUDIES OF THE FLOW AROUND AND DEVELOPMENT OF VORTEX STRUCTURES NEAR OBJECTS BEING FLOWED AROUND

### RESEARCH

The research conducted at the laboratory aims to experimentally study the phenomenon of flow around an element and determine how vortices occur near it.

The studies, using a fast-rotating camera as well as laser light, are carried out in a water tunnel with an internal diameter of 100 mm x 100 mm and 2 metres in length. Models can be placed inside the tunnel to allow observation of vortex structures or paths occurring near them.

Elements placed in the tunnel can be, among other things, models of buildings - detached ones or constituting parts of residential estates, i.e. determining a very specific manner of pollution spread in such an area, creating zones



characterised by reduced air exchange or even airflow stagnation - ones with a high concentration of car fumes, for instance.

### APPLICATION

Experiments conducted in the water tunnel aim to investigate the principles behind the occurrence of vortex structures, the resulting detachment of the boundary layer, and the forming of new vortex structures from the vortex portion produced after the eruption process. The outcomes will be applied

primarily to reduce drags, but also undesired areas with concentrated pollution produced during the flow around the elements placed in the flow.

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## CONTROL AND MEASUREMENT SYSTEMS IN POWER ENGINEERING

### TECHNOLOGY

- designs of new devices for measuring electrical and non-electrical quantities,
- design and construction of comprehensive measurement and control systems,
- development and implementation of adjustment and control algorithms.

### APPLICATION

- test and pilot installations,
- industrial and medical applications.

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## DEDICATED INNOVATIVE SYSTEMS FOR CONTROLLING DEVICES AND TECHNOLOGICAL PROCESSES

### TECHNOLOGY

The following services are offered:

- concept analysis of the structure of a control circuit for specified/dedicated devices or technological processes,
- feasibility studies of control concepts,
- analysis of solutions applying simulation studies,
- analysis of circuits' functional security,
- development of control circuit structures through integration or with dedicated uC controllers,
- development of the design of a control circuit/controller for devices/technological processes,
- development of control algorithms,
- development of software for devices under design, support for measurement sensors, data analysis, and IoT,

- development/adaptation of SCADA and HMI type systems for device automation and technological processes,
- development of diagnostics, telemetry, and redundant systems for dedicated devices/technological processes,
- construction of models/prototypes/PCB's and control systems for dedicated devices
- author's supervision and support of control system start-up.

### APPLICATION

The offer caters to the following groups of professionals:

- process/structure/technological process designers,
- manufacturers of specialised devices requiring sophisticated control systems,
- integration companies operating in the automation business,
- investors intending to launch the manufacture of dedicated control systems,
- users of devices or technological processes which require complementing/extension through automatic remote control, monitoring, diagnostics solutions, etc.

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## DESIGN AND IMPLEMENTATION OF INDUSTRIAL CONTROL AND AUTOMATION SYSTEMS

### TECHNOLOGY

- design and implementation of industrial automation and control systems, modernisation of existing systems,
- design and implementation of microprocessor-based control and measurement systems,
- programming PLC controllers (mainly Siemens and Omron) and visualisation systems using HMI and SCADA.

### APPLICATION

Industrial automation systems are applied in various sectors of industry, in all manufacturing facilities and processing plants equipped with modern and automated technology lines.

### Contact information

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## INTEGRATION OF AUTOMATION SYSTEMS IN SMART BUILDINGS

### TECHNOLOGY

The following services are offered:

- start-up of integrated systems for controlling building automation,
- development of possibilities for control systems integration,
- development of algorithms for controlling a building's thermal comfort and light,
- implementation of laboratory test beds equipped with building automation devices.

### APPLICATION

The services offered aim to optimise control circuits in buildings equipped with thermal and light comfort control systems

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## MATHEMATICAL MODELS OF OBJECTS AND THEIR APPLICATION IN CONTROL SYSTEMS

### RESEARCH

Construction and verification of simple models of objects' dynamics based on phenomena description and/or the identification experiment, as well as development of control algorithms for the object being researched.

### APPLICATION

The dynamics model developed at the unit can be used to develop or optimise the control of a technological facility (mainly concerning heat generation and air conditioning plants).

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## MODELLING, SIMULATION AND OPTIMISATION OF THE THERMAL ENERGY BALANCE IN CIVIL STRUCTURES

### TECHNOLOGY

- analysis of civil structures in terms of the energy balance of heat sources and losses,
- development of simulations and mathematical models of thermal energy flows in civil structures,
- simulation studies of energy efficiency,
- specialised applications of IT tools for simulation studies,
- development of thermal energy management algorithms in civil structures,
- development of a concept of remote-controlling heat sources in civil structures,
- optimisation of control algorithms for heat sources in civil structures,
- application of optimisation methods in energy efficiency control,
- consultancy services in the area of the design of heating, air condition and

lighting systems in terms of energy efficiency optimisation,

- consultancy services in the area of selection of unconventional sources in terms of civil structures energy efficiency,
- author's supervision over solutions implemented in the area optimisation of power engineering effectiveness,
- support in the area of integration of the above mentioned systems with building automation systems.

### APPLICATION

- design of civil structures, heating and air conditioning installations, as well as ventilation and lighting solutions,
- facility management, optimisation of the operation of civil structures,
- manufacturing and integration of heating, HVAC, and lighting systems,
- design and applications of renewable energy sources.

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## MONITORING PRODUCTION QUALITY BY MEANS OF VISION AND THERMAL VISION SYSTEMS

### RESEARCH

- analysis of production processes (of every element and ones working continually) in terms of possibilities of the application of production (or semi-finished products) quality monitoring using vision systems in visible light and/or infra-red as well as other imaging systems,
- development of software and device concepts along with feasibility studies of such systems,
- development of dedicated image processing algorithms; supervision over the equipment selection process, and system start-up's.

### APPLICATION

Vision systems are currently applied to monitor production quality in practically all production areas, from the most advanced

technologies in the automotive and electronic sectors to sorting apples. Vision and thermal vision systems have considerably decreased in price, as a result of which the profitability of their application in industries such as food, manufacture of construction materials, packaging, and filling glass packaging has risen, too.

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## OPTIMISATION IN DATA UNCERTAINTY CONDITIONS

### RESEARCH

In the practice of logistics and manufacturing, one has to make decisions without having full knowledge of the process being optimised. The main goal of the research works is to attain the following:

- develop models of systems operating in data uncertainty conditions,
- design optimisation and support algorithms for decision-making in data uncertainty conditions.

### APPLICATION

The algorithms designed at the unit can be incorporated into existing IT systems in the form of modules. Optimisation and support modules for decision-making processes will suggest the following solutions:

- best in statistical terms,
- most resistant to unknown and uncontrollable parameters of the outside world.

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## OPTIMISATION OF PRODUCTION PLANNING

### RESEARCH

The modern ERP type IT systems enable effective management of a very large amount of data and events generated when tasks are being executed in the production system. The core element of such systems is the planning module, which is supported by optimisation algorithms in advanced systems. The main goal of the optimisation process is to increase the capacity of a production system while maintaining the technological and time-related constraints stemming from cooperation with business partners. The research conducted by the unit involves the development of computational models as well as design and implementation of optimisation algorithms for a wide range of production systems.

### APPLICATION

Optimisation algorithms implemented in the form of modules may be used (integrated) in various IT systems supporting the management of the production process (strategies such as just-in-time, lean manufacturing, etc.). They are dedicated primarily to production systems featuring pipeline and cell frameworks, as well as unitary, short-batch, and mass production requiring frequent real-time planning (prioritised production).

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## PROTOTYPING AND MEASUREMENTS OF ELECTRONIC AUTOMATION DEVICES

### TECHNOLOGY

- tests of a device's circuit concept, execution of the electronic assembly,
- start-up and basic electrical tests of an automation device,
- validation of a solution on the basis of its design principles,
- production and tests of a prototype.

### APPLICATION

The offer caters to the following client groups:

- industry,
- innovation-driven companies,
- planning and design companies,
- research institutions seeking a realistic opportunity to produce and test experimental electronic circuits for the purposes of broadly understood automation.

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## ROUTING AUTONOMOUS FLYING VEHICLES

### RESEARCH

The unit's offer involves development of solutions for many applications, particularly those related to monitoring and stock-taking of facilities or developing logistics. The tasks consist in automatic planning of flight routes allowing for a number of constraints such as flight time (battery capacity), terrain obstacles, and atmospheric phenomena (wind and air currents). With the technologies developed, it is possible to undertake UAVs' autonomous missions, also in difficult conditions. The solutions offer a possibility of transmitting an image in real time to a so-called earth station.

### APPLICATION

- video filming of objects,
- facility surveillance,
- facility inspection (conveyor belts, mines, any difficult-to-access areas),
- logistics.

#### Contact information

Workroom of Discrete Systems  
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## TRAINING IN THE KNX TECHNOLOGY

### TRAINING

The following services are offered:

- training in the field of building automation based on the KNX system,
- examination and a "KNX Partner" certification,
- training in the integration of control systems in building automation.

### APPLICATION

The services offered by the unit cater to people interested in building automation systems and their integration. The training allows its participants to acquire the skills of selecting and starting up integrated control systems.

#### Contact information

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## ACTUARIAL CALCULATIONS FOR COMPANIES OPERATING IN THE FINANCE AND INSURANCE SECTOR

### EXPERT REPORT

- calculation of the capital-related obligation of solvency in accordance with the standard formula, allowing for all measurable types of risk which an insurance company is exposed to,
- valuation of the cost of insurance products, technical and insurance reserves for the purpose of solvency, as well as technical and insurance reserves for accounting purposes,
- development of an actuary's report on the state of portfolio,
- tests of stress in insurance companies, analysis of insurance risk and proposals of its reduction using reinsurance.

Our team comprises a certified actuary and staff with experience of working at insurance companies.

### APPLICATION

The services offered can be applied in both insurance and audit companies.

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## MODELLING EXPERIMENTAL DATA USING ARFIMA SERIES

### EXPERT REPORT

Modelling data concerning threats to the environment and outer space obtained with sensors and space probes. The core methodology is based on the latest achievements in the theory of ARFIMA time series, enabling a description of signal processes and anomalous transport, in particular modelling air quality, energy consumption, electromag-

netic radiation near UMTS mobile telephony transmitting stations, solar activity, as well as cosmic and laboratory plasma.

### APPLICATION

The services offered by the unit can be used in companies/institutions analysing threats to the environment, as well as those operating in the space industry.

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## MODELLING OF MOLECULAR BIOLOGY DATA DYNAMICS

### EXPERT REPORT

Modelling the dynamics of data in molecular biology (dynamics of telomeres, proteins, receptors, mRNA molecules, etc.) obtained through experiments of single particle tracking type (SPT) using fluorescent microscopy methods. The statistical methods applied allow us to identify a theoretical model, validate it, and predict anomalous diffusion in time.

### APPLICATION

The service offering can be applied in biological and biophysical laboratories, as well as companies involved in pharmacological research.

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## STATISTICAL DATA ANALYSIS

### EXPERT REPORT

Analysis of experimental, survey, and measurement data including the following:

- selection of a model and evaluation of its quality,
- estimation of a model's parameters and tests of their statistical significance,
- forecast of the future value of the process under observation,
- cluster analysis, reliability analysis.

Statistical inference using the classic approach, Bayes' theorem, as well as the latest methods, such as data mining.

### APPLICATION

Statistical analyses can be applied primarily in areas such as

- marketing, e.g. market segmentation or studies of advertising effectiveness,
- medicine, e.g. clinical studies and survival analysis,
- finance, e.g. creditworthiness scoring,
- industry, e.g. studies of systems' reliability.

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## BIOMEASUREMENTS IN NANOSCALE

### RESEARCH

Imaging of bio- and nanomaterials in nano-scale and studies of intermolecular interactions between biomolecules examined; studies of samples' properties including elasticity, hydrophilicity, adhesion, etc.; molecular nano-manipulation.

### APPLICATION

Structural characteristics of biological objects and nanomaterials using atomic force microscopy (AFM):

- examination of sample surface topography,
- nano-scale imaging of bio- and nanomaterials,
- structural characteristics of antibacterial nanomaterials and materials for photodynamic therapy,
- studies of bioprocesses occurring in biological materials performed using fluorescence and confocal microscopy,
- measurements of a sample's physical properties: elasticity, hydrophilicity, and adhesion.

#### Contact information

Laboratory of Biomeasurements in Nanoscale  
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## DESIGN, CHARACTERISATION, AND LABORATORY AND INDUSTRIAL SCALE PRODUCTION OF LIPID NANOAGGREGATES FOR PHARMACOLOGY AND COSMETOLOGY

### TECHNOLOGY

The scope of research performed includes the following:

- thermodynamics of aggregate forming,
- kinetics of macroparticle aggregate forming using the technique of spectroscopic measurement in stopped-flow,
- determination of nanostructures and nanomolecules size distribution,

- determination of samples' atomic composition using the plasma emission spectroscopy method.

Additionally, the Laboratory has research capacities with respect to fluorescence techniques.

### APPLICATION

Design of nanostructures dedicated to selected applications in the fields of pharmacology and cosmetology. Development of methods enabling chemical, biophysical, and physico-chemical characterisation of pharmacological and cosmetological preparations.

#### Contact information

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## ELECTRICAL METHODS OF RESEARCHING LIPID MEMBRANES; COMPUTER MODELLING, ANALYSIS, AND ELECTROPORTION OF LIPID MEMBRANES

### RESEARCH

- studies of the properties and state of biomedical objects using electrical methods (measurement of functional potentials, impedance methods, etc.),
- modelling and analysis of (electrical, magnetic, thermal, etc) field distribution in biomedical objects.),
- electric field-stimulated production of hydrophilic 1-nanometre pores in lipid membranes.

### APPLICATION

Examination of medical objects in a wide frequency band for diagnostic and therapy purposes, including the following:

- evaluation of electro-medical equipment,
- development of new methods and devices for biomedical examinations,
- support for cancer chemotherapy and genetic therapies.

#### Contact information

Laboratory of Medical Electronics  
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## EXPERIMENTAL AND MODEL STUDIES OF VARIOUS IMPLANTS AND BIOMECHANICAL STRUCTURES

### RESEARCH

- analysis of implants and biomechanical structures in terms of strength,
- experimental analytical and numerical studies and evaluations,
- determination of mechanical properties of biological materials and biomaterials,
- analysis of deformations of dislocations of bones and plate implants in the osteosynthesis area,
- analysis of mechanical properties for static and/or cyclically variable loads,
- determination of mechanical properties of biomechanical structures according to an individual specification.

### APPLICATION

- implantology - practice, diagnostics, as well as production of implants and surgical instruments, jaw, face and skull surgery, and dental implantology,
- analysis of the osteosynthesis durability in biomechanical structures using various biomedical materials, such as plate, metal, and biodegradable implants.

#### Contact information

Workroom of Stomatognathic System Biomechanics  
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## OPTICAL MEASUREMENT METHODS, CHARACTERISTICS OF BIOMATERIALS AND BIOLOGICAL OBJECTS

### RESEARCH

Diffraction methods, microscopic characterisation, spectroscopic and fluorescence methods, bionanomaterials based on TiO<sub>2</sub> and SiO<sub>2</sub>, functionalisation of various surfaces e.g. of implants.

### APPLICATION

Optical identification of micro-objects, including bacteria, and defining bacteria colony numbers based on diffraction methods and image processing algorithms:

- optical characteristics of bionanomaterials,
- research into enhanced photodynamic activity,
- laser transillumination of interphalangeal joints,
- zol-gel materials based on TiO<sub>2</sub> i SiO<sub>2</sub>,
- modifications of fabrics and surfaces with active bionanomaterials.

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## PHYSICAL SIMULATION OF THE HUMAN LUNGS

### RESEARCH

Physical modelling of the respiratory system simulating changes during respiration support enabling independent, dynamically controlled (as a function of flow, pressure, volume and time) alteration of respiratory resistances and compliances, characteristic of various pathologies. The physical models enable performing close-to-clinical-conditions simulations with standard ventilators and medical measurement instrumentation.

### APPLICATION

Tests of ventilator performance correctness, tests of medical measurement instrumentation. Tests of new mechanical ventilation modes.

### Contact information

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## STUDIES OF TISSUES AND BIOMATERIAL SUSING SPECTROSCOPIC METHODS

### RESEARCH

- studies consisting in the determination and distribution of components in objects being researched, regardless of their transmission capability,
- experience of research into aorta and skin tendons, analyses of the secondary structure of proteins, and applications of spectroscopy to determine mechanical properties of these tissues,
- studies of native DNA and changes in the molecule structure caused by various factors,
- measurements of substances' transport to tissues using spectroscopic methods,
- studies of the presence of free radicals and determining an environment's viscosity at the molecular level,
- experience in the area of researching the properties of morphotic components of the blood: plasma, thrombocytes, leukocytes, and erythrocytes,
- determination of oxidation stress and the impact of factors on the activity, stability and physicochemical properties of blood.

### APPLICATION

- access to a well-equipped hematological laboratory,
- development of a method for protecting blood in extracorporeal circulation (hemo-dialysis, heart-lung machine); tests on animals (at the patent application stage).

### Contact information

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## TECHNOLOGIES FOR BIOMEDICAL ENGINEERING

### RESEARCH

The unit uses computer technologies for designing and producing medical products, applying 3D computer models of biomedical objects - including methods of developing 3D models by measuring objects' shape and internal structure, e.g. using computer tomography or optical scanning, methods of their processing and analysis, as well as methods of producing prototypes and user-ready medical products.

### APPLICATION

The technologies offered can be applied to design, analyse, and produce implants, prostheses, surgical instruments, rehabilitation devices, etc. The available materials which can be used to produce medical products include polymers (e.g. PLA), metals (titanium, cobalt-chrome, and steel), while the available methods of production include increment technologies (3D printing) , e.g. SLS, FDM, SLM, or EBM.

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## TERAHERTZ TECHNOLOGY

### TECHNOLOGY

Services offered by the unit:

Spectroscopy in the range of terahertz waves (0.3–3.5 THz), i.e. far infrared (10 to 100 cm<sup>-1</sup>).

### APPLICATION

- THz technology in the field of spectroscopy is applied to identify materials based on elaborate biochemical molecules. An example application of this technology is identification of medicines in pharmaceuticals and associating terahertz spectra with their bioactivity (pharmacology).
- Another example is identification of hazardous materials (public and military security).
- THz imaging – applications in medicine: identification of surface lesions, broadband HF telecommunication.

### Contact information

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## MODELLING OF FLOWS USING NUMERIC FLUID MECHANICS

### RESEARCH

- development of biopreparations for the purposes of waste management and bioremediation - aerobic bacteria biopreparations (autochthonous), lignolytic fungi, rhizosphere bacteria (phytoremediation) or mixed ones,
- isolation of strains capable of biodegrading selected xenobiotics,
- research into the effectiveness of biopreparations in the biodegradation of hydrocarbons, heavy metals, and other types of contamination.

### APPLICATION

The unit's offering serves the purpose of developing the following:

- biopreparations which can become an element of the remediation technology (e.g. of soils contaminated with petroleum products),
- biopreparation for stimulating the process of biological decomposition of pollutants, waste neutralisation, waste processing (e.g. wood waste) for commercial purposes,
- isolation of strains (including autochthonous ones), development of a method for obtaining a biopreparation, as well as determination of a biopreparation's effectiveness (up to the semi-commercial scale of production).

Biopreparations produced at the unit can be granted a certificate from the National Institute of Hygiene.

### Contact information

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## ANALYSIS OF PETROLEUM PRODUCTS FOR BUSINESS ENTITIES

### EXPERT REPORT

- calorific value and fractional composition of fuel, content of water and sulphur in fuel,
- flash point of middle distillates using the Pensky-Martens method,
- Reid vapour pressure of petrol,
- kinematic viscosity of petroleum products,
- pour point of fuel and technological oils,
- cold filter cloud and plugging point,
- solid particle contamination in oil products,
- ester content in oil in accordance with PN-EN14078:2005, antioxidant additives (BHT),
- group composition, carbon content in aromatic structures,
- analysis of C1-C6 gases,
- composition and chemical structure of residues of petroleum oils in accordance with ASTM D4124, structural parameters of asphaltenes, colloidal stability using Pauli's method,
- rheological properties of asphalt and residues of petroleum oil: softening point in accordance with PN-EN 1427; penetration at 25°C in accordance with PN-EN 1426; penetration index in accordance with PN-EN 12591; dynamic viscosity at 60-135°C in accordance with PN-EN 13702-2; elastic reverse in accordance with PN-EN 13398; RTFOT ageing test in accordance with PN-EN 12607-1; change of softening and penetration point after RTFOT ageing in accordance with PN-EN 1427 and PN-EN 1426,
- evaluation of susceptibility to biodegradation of organic compounds under aerobic conditions in a water environment (ISO 14593 and OECD 310),
- technical analysis of solid fuels.

### APPLICATION

The analyses of fuel composition carried out at the unit are an important element of transport safety for the local Airport (Port Lotniczy S.A. in Wrocław). Analysis of gas quality for Polska Spółka Gazownicza (Polish Gas Company), Wrocław Branch. Evaluation of fuel composition quality for LOTOS Biopaliwa (Czechowice –Dziedzice).

### Contact information

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## CHROMATOGRAPHIC ANALYSIS OF POLYCHLORINATED CONTENT IN ELECTROINSULATION OILS

### RESEARCH

Determination of polychlorinated biphenyl content is performed using the gas chromatography method, in an apparatus fitted with an ECD detector, in compliance with PN-EN 12766-1.

### APPLICATION

Basic analytical determination permitting the use of devices containing electro-insulating oils.

### Contact information

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## DESIGN, SYNTHESIS AND PROPERTIES OF CATALYSTS AND ADSORBENTS

### RESEARCH

- properties of catalysts' and adsorbents' surfaces: acidity - using the TPD-Nh3 and FTIR methods, alkalinity TPDCO2, susceptibility to reduction with TPR-h2 hydrogen, susceptibility to oxidation, characteristics of carbon deposits,
- characteristics of the porous structure of sorbents and catalysts: actual density, adsorption isotherms, sorption properties of sorbents, sorption dynamics; parameters of the porous structure,
- preparation of sorbents and catalytically active materials: selection and evaluation of materials for sorbent production; material modification; low-

- and high-temperature carbonisation, physico-chemical activation using steam, CO2, air + +O2; chemical activation,
- selection of adsorbents and evaluation of their use in petroleum product purification and water purification of organic products,
- evaluation the activity of catalysts in model reactions and in processes with the actual substrates in flow reactors and autoclaves (pressures of up to 15 Mpa, hydrogenation, hydrocracking, catalytic cracking, reduction of nitrogen oxides, VOC and Cl-VOC combustion),
- evaluation of photocatalysts' activity.

### APPLICATION

Research services consisting in the design, synthesis, and characterising properties of catalysts and adsorbents, with the following in particular:

- obtaining sorbents of defined porous structure parameters,
- evaluation of the usefulness of organic materials for the production of sorbents,
- characteristics of sorption materials' porous structure and measurements of standardised sorption parameters (methylene number, iodine number, etc.),
- selection of adsorbents and optimisation of adsorption refinement of petroleum products, including regeneration of oils in use.

### Contact information

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## DETERMINATION OF PARAMETERS OF A SOLID SUBSTANCE'S PARTICLE SIZE DISTRIBUTION

### RESEARCH

Device: Laser analyser of solid particles made by Beckman Coulter LS 13 320. Determination of the following properties in a sample of a polydisperse material: particle size distribution, average size (median) of particles, dominating size of particles, homogeneity of particle populations (by calculating the so-called coefficient of variation – CV). Measurement range: 0.04 – 2,000 µm.

 APPLICATION

Determination of the characteristics of the grain composition of a polydisperse material.

 Contact information

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**ELECTROCHEMICAL STORAGE OF ENERGY** RESEARCH

The Laboratory of Electrochemical Research offers services involving the analysis of materials in terms of storing electrical energy in lithium-ion batteries (anode and cathode) and electrochemical condensers using an EDLC or pseudocapacitive electrode (water or organic electrolyte). Additionally, we analyse the possibilities of diffusion electrodes in terms of electrocatalytic oxygen reduction in fuel cells and lithium-air batteries. We also perform routine studies of small and medium-sized electrochemical cells at a charge/ discharge current up to 4A and operating voltage up to 20V.

 APPLICATION

Electrochemical sources of current.

 Contact information

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**EVALUATION OF CHEMICAL SUBSTANCES' FLAMMABILITY AND EXPLOSIVENESS PROPERTIES** EXPERT REPORT

Evaluation of chemical substances' susceptibility to combustion, especially flash fire in technological processes, and during storage and transport. Analyses of the causes of fires, explosions, and other dangerous incidents.

 APPLICATION

The evaluations conducted at the unit are important for the assessment of the safety, storage, and transport of chemical substances.

 Contact information

Laboratory of High-Power Materials  
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**EVALUATION OF THE NEED TO REGISTER SUBSTANCES IN ACCORDANCE WITH THE GUIDELINES OF THE REGULATION OF THE EUROPEAN PARLIAMENT AND COUNCIL (CE) NO. 1907/2006 (REACH)** EVALUATION

The evaluation service provided by the unit involves an assessment of the substance being produced and the need of its registration in line with the guidelines of the Regulation of the European Parliament and the Council of the European Union (EC) no. 1907/2006 (REACH) regulating the issues related to the use of chemicals.

 APPLICATION

Documentation indispensable for undertaking the production and trade of chemical substances.

 Contact information

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**EVALUATION OF THE USEFULNESS OF COAL AND BIOMASS FOR THERMOCHEMICAL PROCESSING** EXPERT REPORT

- determination of the properties of coal types and mixes of coal, biomass and other solid fuels (technical and elementary analysis, determining forms of sulphur in solid fuels, combustion heat),
- evaluation of the usefulness of various coal types and mixes of coal for the coking process (plastic and dilatometric properties, sintering capability, slow swelling ratio),
- if needed, the unit carries out carbonisation and co-carbonisation processes with additives (process atmosphere: argon, nitrogen, hydrogen, air, process gases), analysis of the properties and structure of solid products of coal carbonisation,
- pyrolysis and fast pyrolysis of biomass, with the possibility of basic characteristics of bio-oils,
- evaluation of the usefulness of biomass as solid fuel or material for different uses, e.g. production of adsorbents,
- determination of the properties and structure of solid and liquid products of the carbonisation of coal, biomass, and their mixes.

 APPLICATION

The evaluation is useful for industrial facilities using coal and biomass to produce fuels and energy.

 Contact information

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## MASS CRYSTALLISATION FROM SOLUTIONS

### RESEARCH

Controlled extraction of the solid phase from water solutions in the batch or continuous crystallisation process. Determination of the impact of the composition of material and crystallisation parameters on the quality of the crystalline product: distribution of crystal size, homogeneity of the population, and chemical composition. Three fully automated and computer-controlled experimental facilities are used - two with a continuous mode of operation, and one with a batch mode.

### APPLICATION

Determination of the impact of the chemical composition of material and crystallisation parameters on solid phase extraction and the quality of the resulting product. Development of data for the purpose of process design.

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## MEASUREMENT OF CHEMICAL SUBSTANCES' REACTIVITY USING CALORIMETRIC METHODS

### RESEARCH

- measurement of reaction speed (thermal stability) of high-power materials in an adiabatic calorimeter APTAC264 made by Netzsch within the range of up to 500°C and 12MPa, with the temperature increase compensation of up to 400K/min. and allowing samples of up to 100g in weight,
- determination of the SADT parameter (Self Accelerated Decomposition Temperature) based on measurements,



- measurement of phase transformation heat as well as endo- and exothermic chemical reactions in an isothermal calorimeter C80D Setaram, at up to 300°C and 30MPa, allowing samples of up to 1g in weight,
- measurement of adsorption heat, heat capacity and heat conductivity,
- measurement of phase transformations and chemical reactions in solid materials using a scanning calorimeter STA409C Netzsch, at up to 1600°C, under atmospheric pressure in a neutral or reactive atmosphere, along with the analysis of gaseous products using the mass spectrometry method.

### APPLICATION

Determination of chemical substances' chemical reactivity with emphasis on their properties related to flammability and explosiveness.

#### Contact information

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## RECOVERY OF PHOSPHATES FROM WASTE SOLUTIONS AND SEWAGE - PHOSPHORUS RECYCLING

### RESEARCH

Obtaining magnesium and ammonium phosphate, as well as struvite from hexahydrate wastewater in the continuous precipitation crystallisation process. Magnesium and ammonium salts are the substrates. The research is conducted in two fully automated, computer-controlled laboratory facilities. Determination of optimal parameters for phosphorus recycling processes for specific, actual waste solutions. Struvite – NPMg fertiliser slowly releasing plants' nutritive components.

### APPLICATION

Development of technology and instrumentation related principles and assumptions for the process of recovering phosphates from waste solutions. Determination of the in-

fluence of decision-making parameters of the precipitation crystallisation process on the quality of the product extracted.

#### Contact information

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## STUDIES OF GAS STORAGE CAPACITY

### RESEARCH

The Laboratory of Sorption Research conducts studies of block sorbents capable of sorption storage of gases in increased pressure conditions, at ambient temperature, and cryogenic conditions. We offer services including the determination of the storage capacity of methane, hydrogen, carbon dioxide, and other gases up to 200 bar at temperatures of 77K, 203K, 273K, and 298K for any material (including particulate).

### APPLICATION

Characteristics of fillers of storage tanks for flammable gases; CO<sub>2</sub> sequestration.

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## STUDIES OF MEMBRANE SEPARATION EFFECTIVENESS

### RESEARCH

The Laboratory of Membrane Materials conducts research into the synthesis/modification of membranes as well as adjusting them to

specific separation processes. As far as electromembrane processes are concerned, membranes based on polyethylene, polyvinyl chloride, and polysulfone were developed. As for pressure processes, the unit has developed membranes based on polyamide, polyethylene, polysulfone, and polyphenylene oxide. The unit's studies of plasma and chemical modification have enabled the limitation of membrane fouling and biofouling phenomena. Additionally, series of smart membranes have been developed. The product changes its properties depending on the external stimulus applied (acidity, salinity, or/and temperature).

### APPLICATION

Membrane separation processes.

#### Contact information

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## STUDIES OF METHODS OF REMOVING XENOHORMONES FROM WATER SOLUTIONS

### RESEARCH

The Laboratory of Removal of Toxic Substances from Solutions conducts research related to the elimination of toxic substances occurring in water solutions in small quantities. For this purpose, the unit obtains polymer materials characterised by a considerable selectivity for substances being removed: polymers with molecular stamps. The research conducted at the unit enables selection of methods for the synthesis of such polymers, forming them in homogeneous grains (membrane emulsification) or membranes, as well as development of the synthesis of smart materials which are capable of selectively removing certain substances depending on the external stimulus (acidity, salinity, or temperature).

### APPLICATION

Separating harmful substances from water.

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## STUDIES OF METHODS OF THE RECOVERY OF PRECIOUS AND NOBLE METALS FROM SOLUTIONS

 RESEARCH

The Laboratory of Recovery of Metals from Solutions conducts research into the recovery of precious and noble metals from production waste and solutions produced in the process of leaching electronic waste. The studies apply own-developed polymer sorbents (e.g. core-envelope, gel, or porous sorbents), as well as commercial and hybrid sorbents. Separations use column methods, hybrid sorption-membrane methods, and electro-sorption methods.

 APPLICATION

Extracting metals from water solutions.

 Contact information

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## STUDIES OF POROUS MATERIALS' CAPACITY OF ADSORPTION FROM SOLUTIONS

 RESEARCH

The studies involve determination of adsorption isotherms and process kinetics. The processes are carried out in a water or organic solvent solution in static conditions at

temperatures ranging from 20 to 40°C. Balance state time is determined, as well as compound removal ratio, and the adsorption mechanism. The compounds adsorbed can be ions or organic compounds such as phenols, dyes, and humic acids.

 APPLICATION

The studies conducted at the unit enable the determination of porous materials' sorption capacity as well as possibilities of applying materials for adsorption-based purification of solutions.

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## STUDIES OF VARIABLE-PRESSURE GAS SEPARATION CAPACITY

 RESEARCH

The Laboratory of Sorption Research conducts studies of sorbents for separating gas mixes with the PSA method (Pressure Swing Adsorption). Analyses can be performed at temperatures of up to 250°C and pressure of up to 10 atm. The unit enables work with a gas mix including CO<sub>2</sub>, CO, H<sub>2</sub>, N<sub>2</sub>, etc.

 APPLICATION

Separation of gaseous products from technological processes.

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## TRACE ANALYSIS OF MATERIALS

 RESEARCH

The Laboratory of Spectrochemical Analyses performs comprehensive analyses of the elemental chemical composition of materials for the needs of chemical, food and pharmaceutical industries, as well as environmental conservation and medicine. The services offered consist in analyses of samples delivered by the client along with preparation of the materials for analysis - including homogenisation, mineralisation and/or extraction. Activities performed at the laboratory include determination using atomic absorption spectrometry with atomisation in a flame and graphite absorption cell (FAAS and GFAAS), atomic emission spectrometry with excitation in inductively coupled plasma (ICP-OES), as well as mass spectrometry with ionisation in inductively coupled plasma (ICP-MS). As far as As, Bi, Hg, Pb, Sb, Se and Sn are concerned, the technique applied involves generating volatile compounds enabling the determination of these elements at very low concentration levels (ppb). The determination works, with high-grade modern instrumentation applied, are carried out by a well-qualified and competent team boasting many years' professional experience.

 APPLICATION

Comprehensive elemental analysis of materials, with emphasis on samples with complex organic and inorganic matrices. Determination of metals, non-metals and semi-metals within a wide range of concentrations, in industrial, environmental, biological and pharmaceutical, as well as food samples.

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## DETERMINATION OF MODAL DYNAMIC PROPERTIES OF CONSTRUCTIONS AND STRUCTURES

### EXPERT REPORT

Delivery of an experimental, classic modal analysis (EMA) or operational modal analysis (OMA) enables experimental determination of dynamic (modal) properties of a structure, i.e. natural frequencies, natural forms, and modal damping. As a result, it is possible to perform correct dynamic modelling of a structure that reflects the actual condition, as well as validation and adjustment of the theoretical model (e.g. MES) and the experimental one. As far as civil engineering structures are concerned, the OMA analysis is a proper tool, one that doesn't require excluding the facility under investigation from operation and exciting its vibration. Only its response to environmental excitation is measured.

In cases of small structures, there is a possibility of performing measurements using the classic modal EMA analysis, when measuring both excitation and vibrations of a construction caused by an impact from a modal hammer. The study offered by the unit, apart from experimental results, can include the development of a calculation model.

### APPLICATION

Determination of modal qualities enables the following:

- identification of a structure's properties (e.g. Young module or damping level),
- review and update of the calculation model,
- estimation of a structure's dynamic response,
- forecast of a system's dynamic response after modification (changes to rigidity, support condition, damping elements, etc.).

Analysis of changes to modal properties during a structure's operation makes it possible to monitor the construction's condition and detect its degradation.



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## ENERGY EFFICIENCY OF BUILDINGS



### RESEARCH

Energy audit, thermal modernisation and energy performance certification of various types of buildings using renewable energy sources, among other things. Numerical modelling of the annual thermal balance of buildings. Numerical analyses of buildings and wall barriers in terms of heat and humidity.



### APPLICATION

Analysis and evaluation of energy efficiency of various types of buildings in an annual cycle. Adjusting buildings to various energy standards. Application of renewable sources of energy for the improvement of buildings' thermal balance. Evaluation of wall barriers constituting buildings' thermal sheathing in terms of heat and humidity.



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## EVALUATION OF CONSTRUCTION SCHEDULES



### EXPERT REPORT

Analyses of technological and organisational principles and assumptions for schedule development.



### APPLICATION

Studies of possibilities of applying other organisational solutions which impact the time and cost of a construction project.



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## EVALUATION OF DISRUPTIONS TO CONSTRUCTION DEVELOPMENT PROJECTS



### EXPERT REPORT

Studies of construction project documentation aiming to identify disruptions causing delays in the works. Evaluation of the impact of identified disruptions on deadline-keeping. Evaluation of the risk related to a construction project.



### APPLICATION

Evaluations and opinions provided by the unit can be used for litigation and conciliation purposes.



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## EVALUATION OF THE HARMFULNESS OF VIBRATIONS TRANSFERRED FROM THE SOIL TO BUILDINGS

### EXPERT REPORT

Measurements and analysis of vibrations aiming to determine their harmfulness to buildings.

In particular, studies in accordance with the standard PN-B-02170:2016-12 "Evaluation of the harmfulness of vibrations transferred from the soil to buildings", specifying the criteria of the impact of vibrations transferred from the soil to buildings and devices inside them. Vibrations specified in the above standard are caused by actions directly or indirectly depending on human activity. Sources of vibrations are located inside buildings (on separate foundations) or outside them, in a distance which is fixed or changing in time.

The basis of evaluation is the values of parameters describing vibrations transferred to buildings regardless of how they are propagated in the base from the source of vibrations to the building.

Optional analysis of vibrations in accordance with the German standard DIN 4150 or other guidelines.

### APPLICATION

Measurements and analysis of vibrations are used in the following fields:

- diagnostics related to the evaluation of ensuring vibration comfort to people staying in existing buildings and passively receiving vibrations coming from sources being used or projected,
- the phase of designing buildings which will be exposed to vibrations coming from sources being used or projected and in which people will be impacted by these vibrations,
- evaluation of vibrations' harmfulness to man.

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## EVALUATION OF THE IMPACT OF VIBRATIONS ON PEOPLE IN BUILDINGS

### EXPERT REPORT

Measurements and analysis of vibrations are performed to determine their impact of people inside buildings. Particularly in accordance with the standard PN-B-02171:2017-06 - "Evaluation of the impact of vibrations on people in buildings", specifying the methods of evaluating the impact on people staying in buildings and passively receiving vibrations as well as the criteria for ensuring the necessary vibration comfort to such people.

The standard details values of parameters of mechanical vibrations ensuring the necessary vibration comfort in different conditions of peoples' stay in rooms located in buildings. The evaluation is performed with respect to vibrations in the frequency range of 1 Hz to 80 Hz; vibrations can occur continually, or for a long or short period.

Optional measurement analysis of vibrations in accordance with other standards: Polish (impact of vibrations on people in the workplace), or foreign ones (e.g. ISO, BS, DIN – impact of vibrations on a man).

### APPLICATION

Measurements of vibrations and analysis of their harmfulness to buildings are applied in the following fields:

- diagnostics related to the evaluation of the impact of vibrations coming from sources being used or projected on an existing building and devices located in buildings,

- design of buildings to be located in the area of the impact of vibrations coming from sources being used or projected,
- evaluation of the harmfulness of vibrations generated by construction works, and road or rail traffic.

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## EVALUATION OF THE TECHNICAL CONDITION OF CIVIL ENGINEERING STRUCTURES

### EXPERT REPORT

- evaluation of the technical condition of civil engineering and industrial structures, including historic ones,
- mycological evaluation for the construction sector.

### APPLICATION

- analysis and evaluation of the technical condition of various civil engineering and industrial structures, including historic ones,
- establishing the extent of construction and finish elements' wear, also in terms of mycology,
- establishing causes of damage and indicating ways of repair.

### Contact information

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## EXPERT EVALUATIONS OF CONCRETE, REINFORCED CONCRETE AND MASONRY FACILITIES OF THE WATER AND SEWAGE INFRASTRUCTURE, AND UNDERGROUND TRANSPORT STRUCTURES

### EXPERT REPORT

We offer comprehensive evaluations of the technical condition of water supply and sewage facilities, and underground communication facilities including the following:

- material studies of concrete, brick, and stone, as well as insulation materials,
- studies of strength parameters of pipes,
- chemical studies of construction materials,
- static and strength calculations for verification purposes,
- evaluation of a facility's safety status and possibilities of its further use, development of guidelines with respect to repair works,
- development of designs of renovation projects as well as technical specifications.

### APPLICATION

Evaluations developed at the unit can be used to estimate the period of possible safe use of a facility as well as assessment of the scope and cost of renovation works enabling further safe use of a facility for an indicated period of time.

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## HUMAN THERMAL COMFORT IN ROOMS

### RESEARCH

Studies of elements of rooms' microclimate in various types of buildings. Studies of thermal and visual comfort in rooms.

### APPLICATION

Analysis and evaluation of the changeability of rooms' microclimate parameters in various types of buildings. Analysis and evaluation of the conditions of users' thermal and visual comfort.

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## IN SITU STUDIES OF HYDROTECHNICAL AND TRANSPORT FACILITIES (BRIDGES AND CULVERTS)

### RESEARCH

The unit offers services consisting in studies of hydrotechnical facilities in terms of evaluation of their technical condition and performance properties. We perform studies of concrete strength, the extent of wear and motion capacity of hydrotechnical seals, the clogging and washout of facility bottom, evaluation of embankments' and separation levees' condition, as well as evaluation of filtration phenomena.

### APPLICATION

Studies consisting in a 5-year evaluation of the technical condition of hydrotechnical structures, failure risks, compliance of facility construction and fittings with applicable regulations.

#### Contact information

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## LABORATORY AND IN SITU STUDIES AIMING TO EVALUATE PHYSICO-MECHANICAL PROPERTIES OF SOILS AND OTHER GEOMATERIALS AS WELL AS THEIR USEFULNESS FOR THE FOUNDATION OF STRUCTURES

### RESEARCH

The unit offers laboratory studies in the area of soil mechanics, e.g. triaxial compression, tests with a direct compression apparatus, tests with a Proctor apparatus, granulometric analysis, compressibility and consolidation tests in edometers and consolidometers, etc. The field studies are conducted by the unit using a self-propelled SCPTu caterpillar probe and devices for measuring noise and vibrations related to securing deep excavations with tight walls. Studies using an inclinometer for inclinometric measurements of safety solutions for deep excavations.

### APPLICATION

The research works offered by the unit allow a qualitative and quantitative evaluation of the qualities of subsoil and its usefulness for the foundation of buildings, as well as methods for securing deep excavations.

#### Contact information

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## LABORATORY STUDIES OF HYDROTECHNICAL AND TRANSPORT STRUCTURES

### RESEARCH

We offer studies of hydrotechnical structures in a field laboratory using large-size spatial models and a measuring flume. On-site apparatuses and equipment:

- 0 – 300 l/s pumping station,
- precision probes for measuring the speed of water - ADV - 2 units, PEMS - 2 units,
- sensors for measuring pressure.

### APPLICATION

The following types of studies are performed:

- dissipation of water energy,
- hydrotechnical loads,
- washouts in structures,
- rubble movements,
- turbulence parameters.

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## MODELLING OF THE SURFACE WATER FLOW

### RESEARCH

We offer numerical analyses of conditions and flows of surface waters using 1- and 2-dimensional models and GIS systems. We model flows in large river systems as well as flows through hydrotechnical facilities. Our analyses can allow for rubble motion, infiltration, and the impact of wind on flow parameters. We perform calculations of the transformation of a flood wave in river systems allowing for the control of the flow through hydrotechnical facilities such as weirs, polders, and storage reservoirs, if necessary.

### APPLICATION

We use the results of numerical simulations to develop the following:

- concept solutions with respect to new water structures and river adjustment,
- study works related to flood and drought protection,
- evaluations of navigation capacity in waterways,
- solutions related to increasing a waterway's grade allowing for the redevelopment of stages of fall, river bed adjustment, and the use of reservoirs for river alimentation.

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## NON-DESTRUCTIVE AND SEMI-DESTRUCTIVE TESTS OF CONSTRUCTION MATERIALS AND ELEMENTS, AND CIVIL ENGINEERING STRUCTURES

### RESEARCH

Studies of wall materials and elements, studies of concrete and elements made of concrete, studies of reinforced concrete elements and constructions, studies of fibre-cement materials and elements, and studies of layered concrete elements.

### APPLICATION

The purposes of the studies include the following:

- determination of humidity and salinity of wall materials and elements,
- evaluation of concrete resistance to compression,
- location of imperfections in concrete and reinforced concrete elements and structures,

- determination of the reinforcement lay-out in reinforced concrete elements and structures,
- evaluation of strength parameters of elements made of fibre-cement materials,
- determination of adhesion when tearing off layers in concrete elements.

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## NUMERICAL SIMULATIONS AND EVALUATION OF STRUCTURES' SAFETY

### RESEARCH EXPERT REPORT

Based on professional software for the numerical computation of concrete and steel land structures, the unit offers numerical computation and sequences of numerical simulations with respect to constructions in terms of their static and dynamic behaviour and elastic and non-elastic deformations. Depending of the problem, the calculations can be performed with respect to small and big dislocations and deformations - geometrical non-linearity. If necessary, the calculations allow for the changeability of constructions' and subsoils' mechanical parameters and random character. As a result of the numerical calculations, it is possible to evaluate constructions' safety and reliability. Land structures can be analysed as being fully or partly saturated with water: saturation and aeration zones.

### APPLICATION

The calculations performed will make it possible to evaluate the level of construction safety and enable recommendations with respect to additional protection technologies, if necessary.

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## REPORTS ON REINFORCED CONCRETE COOLING TOWERS AND INDUSTRIAL SMOKESTACKS

 EXPERT REPORT

Evaluation of the technical condition and safety of reinforced concrete constructions of cooling towers and reinforced concrete industrial smokestacks along with the determination of the scope and technologies of necessary renovation works. The scope of the works offered by the unit includes the following: in situ tests, geodesic and photogrammetric studies, subsoil studies, laboratory studies of material samples, as well as static and strength analyses.

 APPLICATION

The studies aim to ensure safe operation of reinforced concrete cooling towers and industrial smokestacks.

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## SCIENTIFIC SUPERVISION OF THE DESIGN, CONSTRUCTION, AND MAINTENANCE OF BRIDGES

 EXPERT REPORT

The evaluation-oriented research and scientific services offered include the following:

- scientific supervision over the design of innovative and complex bridge structures (for road and railway transport),
- scientific supervision over the construction of bridge structures using advanced technologies,
- inspections and evaluations of bridge structures along with assessment of their technical condition and usefulness,
- design of innovative methods of rehabilitation and reinforcement of bridge structures,
- expert systems with elements of artificial intelligence supporting decisions in the management of the bridge infrastructure.

 APPLICATION

The research and scientific services offered by the unit are applied in the following fields:

- planning and designing the transport infrastructure, with emphasis on engineering structures,
- supervision over the development of innovative systems for erecting bridge structures,
- systemic support for the management of the transport infrastructure, with emphasis on engineering structures.

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## STUDIES OF BUILDINGS USING THERMOVISION

 RESEARCH

- thermal diagnostics of buildings,
- thermovision studies of various types of buildings,
- active thermography (location and identification of material inclusions in wall barriers),
- thermal insulating power of wall barriers,
- studies of radiation properties of external surfaces of materials used for wall barriers.

 APPLICATION

- analysis and evaluation of the condition of the thermal insulating power of sheathing used for various types of buildings,
- studies and identification of thermal bridges in buildings, locations of excessive infiltration of air through wall barriers, as well as the location and extent of wall barriers' moistness,
- studies of wall barriers using active thermography to identify and locate material inclusions in wall barriers, mainly in historic buildings.

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## STUDIES OF CEMENT

 RESEARCH

Analysis of cement.

 APPLICATION

- test check-ups of cement batches,
- studies of cement resistance to compression.

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- inspection chambers,
- curbs, cobblestone, paving slabs,
- wall elements, lintels.

#### Contact information

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## STUDIES OF CONCRETE AND STRUCTURES

### RESEARCH

- J/5: mechanical studies of construction products, building materials, and civil structures,
- J/5/P: mechanical studies and taking samples of construction products, building materials, and civil structures,
- J/8: mechanical studies of construction products and materials, including metals and composites,
- N/5: studies of physical properties of construction products and materials, as well as civil structures,
- N/5/P: studies of physical properties and taking samples of construction products and materials, as well as civil structures,
- P/5: taking samples of construction products and materials, as well as civil structures.

### APPLICATION

Scope of the research services/product offered:

- concrete mix - taking samples,
- concrete - studies of physical properties,
- concrete in a construction,
- metals and steel for the reinforcement and prestressing of concrete,
- welded mesh for concrete reinforcement,
- precast construction products,
- concrete masts and posts,
- concrete lighting posts, irrigation ducts,
- pipes and fittings,
- inspection chambers' and inlet cappings for pedestrian and road traffic pavements,
- sewage inlets,

## STUDIES OF CONCRETE PROPERTIES

### RESEARCH

Studies of properties of vibrated and spun concrete, as well as new generation concrete types.

### APPLICATION

Applications in concrete, reinforced concrete and prestressed constructions.

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## STUDIES OF CONCRETE, REINFORCED CONCRETE AND PRESTRESSED ELEMENTS

### RESEARCH

Studies of lintel beams, concrete cobblestone, concrete paving slabs, concrete pressure pipes, and joints and fittings of wall elements made of aggregate concrete. Studies of reinforcement adherence in reinforced concrete structures. Stud-

ies of irrigation ducts. Studies of concrete curbs. Studies of concrete masts and posts. Studies of metal and steel samples. Studies of pipes and fittings of non-reinforced, steel fibre, and reinforced concrete. Studies of concrete lighting posts. Studies of manholes and wells used for other purposes made of non-reinforced, steel fibre, and reinforced concrete. Studies of sewer inlets in buildings. Studies of welded mesh for concrete reinforcement. Studies of inspection chambers' and inlet cappings for pedestrian and road traffic pavements.

### APPLICATION

Applications in concrete, reinforced concrete, and prestressed concrete constructions.

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## STUDIES OF CONCRETE USING THROWN SAMPLES AND PRECAST BORES

### EXPERT REPORT

Design of concrete mix compositions.


Studies of concrete and concrete products:

- concretes' resistance to compression,
- contraction of concrete samples using linear changes,
- bulk density (weight-volume method), density,
- abrasibility tested with the Boehme method,
- absorption capacity tested with the weight method,
- water penetrability,
- resistance to frost,
- concrete mix consistence,
- air content in a concrete mix.

 APPLICATION

Evaluations and opinions concerning the following :

- concrete,
- precast products,
- monolithic products,
- precast constructions,
- monolithic constructions.

 Contact information

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**STUDIES OF MATERIALS AND ELEMENTS OF THE BRIDGE INFRASTRUCTURE** RESEARCH

The studies of materials and elements of the bridge infrastructure offered by the unit include the following:

- studies of materials and structures during the construction of bridges,
- static and dynamic tests of bridges with programmed and random loads (operational loads),
- modelling and advanced static and dynamic numerical analyses of bridge structures with damaged elements (concrete, steel, and brick structures),
- evaluation and forecasting of the load capacity and durability of bridge structures based on results of experimental studies,
- monitoring of the condition of bridge structures in use.

 APPLICATION

The unit offers research services in the following areas:

- design of bridge structures with emphasis on innovative materials and construction solutions,
- monitoring the process of construction development,
- management of the operation and maintenance of the bridge infrastructure.

 Contact information

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**STUDIES OF MATERIALS AND ELEMENTS OF THE RAILWAY TRANSPORT INFRASTRUCTURE** RESEARCH

The studies of materials and elements of the railway transport infrastructure offered by the unit include the following:

- studies of the geometry of elements of railway and tramway track paving,
- evaluation of the technical condition and operational usefulness of track pavings,
- studies of vibroinsulation systems in railway and tramway track pavings,
- studies and evaluation of the impact of vibrations on civil structures and people.

 APPLICATION

Studies offered by the unit are applied in the following fields:

- design of elements of rail transport infrastructure with emphasis on innovative materials and construction solutions,
- monitoring the construction of railway and tramway track pavings,
- management of the operation and maintenance of the rail transport infrastructure.

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**STUDIES OF MORTARS** RESEARCH

Analysis of samples:

- regular mortars,
- masonry mortars,
- materials for floor coats,

- mortars for pointing tiles,
- mortars for repair purposes.

The following studies are performed:

- resistance to compression,
- resistance to bending,
- absorption capacity (weight method),
- humidity (water absorption by weight),
- bulk density tests (weight-volume method),
- contraction (measurement of linear changes to queen closures),
- adherence to the base (by tearing off a disk with a DYNA Z-16E dynamometer).

 APPLICATION

Studies of mortars.

Evaluations and expert opinions concerning the following: mortars produced in a laboratory and mortar samples taken from structures.

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**STUDIES OF NATURAL STONE** RESEARCH

Analysis of natural stone collected from a quarry or stone products such as:

- cobblestone, curbs,
- floor slabs,
- stair slabs,
- road slabs,
- cladding slabs,
- other.

Studies performed include the following:

- compression resistance,
- abrasibility using the Boehme method,
- bulk density tests using the weight-volume method,
- absorption tests (weight method).

### APPLICATION

Studies of natural stone and stone products. Evaluations and expert opinions.

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## STUDIES OF ROAD AND AIRFIELD MATERIALS

### RESEARCH

- analysis of asphalts and mineral-asphalt mixes,
- analysis of concretes and mixes,
- analysis of soil and subsoil, analysis of aggregates,
- analysis of road pavings.

### APPLICATION

Evaluation of the condition of the network of Polish roads and airfields.

#### Contact information

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## STUDIES OF THE EFFECTIVENESS OF WORK IN THE CONSTRUCTION INDUSTRY

### RESEARCH

The studies performed by the unit involve the organisation of workers' teams, logistic issues in construction processes, studies of construction work time-frames, identification of factors disrupting the course of works, and evaluation of the impact of identified disruptive factors on a team's effectiveness. We perform the studies using the timekeeping and shutter methods.

### APPLICATION

The purpose of the studies is to identify factors and evaluate their impact on the efficiency achieved.

#### Contact information

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## STUDIES OF THE PROPERTIES OF MICROSTRUCTURAL COMPOSITES AND EVALUATION OF THEIR MACROSCOPIC PARAMETERS

### RESEARCH EXPERT REPORT

Studies of properties of microstructural composites can be conducted using three devices offering different qualities of measurement - a scanning electron microscope (SEM), X-ray microtomograph (X-ray  $\mu$ CT), and nano-hardness tester. SEM studies enable the evaluation of surface microstructural measures: specific surface, surface porosity, and surface fractional share of components, while the EDS unit additionally allows identification of the chemical composition of the composite material under examination (maps of chemical components are created). X-ray  $\mu$ CT creates spatial images of a composite material's

structure and, using mathematical operations, enables its reconstruction and morphological analysis: twistedness of pores, extent of pores' connection, distribution of grain sizes, etc.

Using the sequential nanoindentation technique, the nano-hardness tester allows the evaluation of microstructural mechanical properties of composite materials such as hardness, indentation module, Young module, cohesion, and resistance to monoaxial compression.

### APPLICATION

The identification of microstructural properties of composite materials enables a qualitative and quantitative evaluation of the current condition of a composite material, as well as prediction of its durability, and development of recommendations for a methodology to be used to effectively rehabilitate it.

#### Contact information

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## STUDIES OF THE TECHNICAL CONDITION OF UNDERGROUND INFRASTRUCTURE FACILITIES

### RESEARCH

The following types of studies are offered by the unit:

- video inspection of underground infrastructure facilities for diameters ranging from DN80, including inspection of drains, supported with measurements of bottom gradient,
- studies of the tightness of network infrastructure ducts - diameters ranging from DN150 to DN500, including studies of joint tightness, service pipes' tightness, and any sections of up to 6 m in length; the studies are conducted using water or air,
- laser measurements of deformations (point-wise or section-wise) of network infrastructure ducts for diameters ranging from DN200,

- studies of watertightness of pipes, including renovation linings, determination of the elastic modulus of construction materials used to produce pipes and renovation linings,
- studies of adherence using the pull-off method,
- evaluation of the depth of concrete carbonatisation,
- studies of crack widths and their changes in time,
- comprehensive studies of parameters of concrete and elements of concrete structures,
- determination of flexible pipes' perimeter rigidity,
- studies of rigid pipes' compression strength.

### APPLICATION

Results of studies conducted at the unit can be used for the purpose of evaluating the technical condition of objects examined and constitute a basis for the development of solutions to emergency situations and in project activities, as well as forecasting the period of possible safe operation of the object under inspection.

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## STUDIES OF WALL BARRIERS IN CLIMATIC CHAMBERS

### RESEARCH

Climatic chambers and a small-size chamber are applied mainly to perform basic research and scientific works and for purposes related to the obtainment of an academic degree, as well as for the cooperation with the world of business.

The unit's set of two climatic chambers enables a variety of research into thermal and humidity related phenomena occurring inside and on surfaces of wall barriers as a result of certain temperatures and relative humidity of the air, as well as the intensity of thermal radiation. Additionally, the climatic chambers provide an opportunity to fully evaluate properties of wall barriers and construction materials and human and environment friendly building construction. Moreover, the unit's climatic chambers and small-size chamber make it possible to conduct studies of physical, chemical, and biological corrosion of construction materials and products.

### APPLICATION

The research services can concern certain groups of thermal insulation materials as well as multi-layer and heterogeneous walls, including ones with window or door woodwork. Tests in climatic chambers can be supported with classic thermovision and active thermography studies. The research services provided can also concern various types of machines, devices, and other products for which thermal and humidity related operational conditions are important.

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## TRAFFIC ENGINEERING AND THE DESIGN OF ROADS, STREETS, AND INTERCHANGES

### EXPERT REPORT

Studies of road and airfield materials and paving. Traffic studies, recommendations with respect to Poland's road network traffic.

### APPLICATION

Evaluation of road and airfield infrastructure.

#### Contact information

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## TRAINING FOR BRIDGE SURVEYORS

### TRAINING

Post-graduate courses for bridge surveyors comprise the following:

- Basic level "Training for road bridge surveyors",
- Advanced level "Training for road bridge surveyors",
- Basic level "Training for railway engineering structure diagnostics specialists",
- Advanced level "Training for railway engineering structure diagnostics specialists",

### APPLICATION

The training programmes offered cater to the following groups of trainees:

- road bridge surveyors employed at units responsible for managing the road infrastructure as well as companies dealing with the operation and maintenance of the road transport network,
- railway engineering structure diagnostics specialists employed at units responsible for managing the railway transport infrastructure.

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## ALGORITHMS APPLIED IN ELECTRICAL POWER ENGINEERING SECURITY AUTOMATION

### RESEARCH

Development of modern algorithms for the estimation of criteria quantities of digital security automation systems, development of new decision-making algorithms and criteria of digital security automation systems' operation (with artificial intelligence methods applied), research into improvements of specific security functions and control algorithms used in electric power systems, simulation-based analysis of the operation of security automation systems, modelling and simulation of electromagnetic transient states in electric power networks.

### APPLICATION

Implementation of algorithms developed in digital automation and control systems applied in the power industry. Applications aiming to improve the speed, sensitivity, and reliability of DSA systems.

#### Contact information

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## ANALYSES OF STEADY STATES OF AN ELECTRICAL POWER ENGINEERING SYSTEM'S OPERATION

### RESEARCH

The unit offers services consisting in research into steady states in transmission and distribution power networks, as well as isolated micro-networks. The studies of static voltage stability conducted at the unit are based on the New-

ton-Raphson method and use sparse arrays. Determination of critical areas of voltage adjustment in an electrical power system, selection of technically optimal wattless power compensation solutions. Analyses of power distributions in a heavy current system with FACTS systems based on own-developed software for distribution calculations with FACTS systems.

### APPLICATION

The system analyses offered are conducted on the basis of the unit's own-developed software for determining replacement parameters and analysing steady and shorting states in electrical power systems. The analyses cater to the needs of operators of transmission and distribution systems, and the electrical power engineering industry.

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## APPARATUSES FOR MEASURING ELECTRICAL AND NON-ELECTRICAL QUANTITIES

### RESEARCH

Clients of the unit are provided with access to test beds and research workstations. The works conducted at the unit include implementation tests, pre-implementation analyses, as well as studies and analyses related to product optimisation. Research workstations for measuring the degree of harmonic emissions, as well as voltage fluctuations and flickering generated by electric receivers. Testing electric receivers' resistance to voltage changes, dips, and short breaks; preliminary tests for compliance with standards. The research and development services offered by the unit include the following:

- measurement of mains and distorted currents,
- measurements of voltages and voltage drops with different forced currents,
- measurements of other electrical quantities (depending on the unit's technological potential),
- new current transformer designs,
- determination of metrological parameters of current and voltage converters,
- induction current converters,
- development of devices for measuring wattless energy, deformations, and systems for measuring non-electrical quantities.

### APPLICATION

The services provided by the unit are some of the actions involving the evaluation of compliance with the resolutions of the so-called "New Approach" of the European Union. A business entity launching a product labels it with the "CE" mark to attest to its compliance with the requirements. The unit's test beds' applications:

- determination of the metrological properties of measurement paths containing digital data processing systems,
- development of grade index for specific measuring apparatuses and converters,
- construction of measuring apparatuses.

#### Contact information

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## APPLIED ELECTROSTATICS—THREATS AND PROTECTION

### RESEARCH

Studies of electrostatic properties of weakly conductive materials, including antistatic and electret materials:



- measurements of the charge life span and decline in isothermic and thermally stimulated conditions (measurements of charges' half-life of decline and relaxation time),
- contactless measurements of potential and replacement voltage, as well as their distribution (up to +/- 20 kV),
- measurements and monitoring of constant and low-frequency fields' intensity, including measurements in technological conditions,
- measurements of charge and its density (total and deposited charge, surface and volume density),
- measurements and monitoring of charging currents in the conditions of continuous technological processes,
- measurements of high resistances and resistivities, including diagnostics and audits of antistatic floors and carpeting,
- measurements of electric permeability.

Studies and diagnostics of electrostatic technological processes (including electrification and charge dispersion).

Calibration of measuring apparatuses.

Evaluations and consultancy services in the area of electrostatic measurements and metrology.

### APPLICATION

Evaluation of ESD (ElectroStatic Discharge) threats in the following areas:

- ignition of flammable and explosive atmospheres,
- damage to electronic products - EPA (Electrostatically Protected Area) audits,
- examination of threats to personnel caused by ESD,
- materials and products (including antistatic ones).

Protection against ESD. Evaluation and diagnostics in the area of electrostatic technologies and electrostatic technological devices (including devices operating in the area of high voltages and strong electric fields - devices for painting, spraying, and flocking).

#### Contact information

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## AUTOMATION OF INDUSTRIAL PROCESSES

### TECHNOLOGY

The scope of services offered by the unit includes the following:

- design and modernisation of industrial control systems,
- programming PLC drivers, industrial robots, as well as vision systems,
- design of visualisation systems using operator panels and SCADA software,
- design and prototyping of microprocessor-based measuring, monitoring, and control devices.

### APPLICATION

- mechanical and electrical engineering industry,
- production and processing plants with automated technological lines,
- water supply and sewage management companies,
- innovation-driven and implementation companies.

#### Contact information

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## DESIGN OF CIRCUITS FOR UNINTERRUPTIBLE POWER SUPPLY

### TECHNOLOGY

- design of circuits for uninterruptible power supply,
- analysis of the effect of non-linear systems on the parameters of power supply networks,
- limiting the possibility of resonance in power supply networks.

### APPLICATION

All types of systems supplying power to non-linear receivers.

#### Contact information

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## DIAGNOSTICS OF INSULATION SYSTEMS FOR HIGH VOLTAGE DEVICES

### RESEARCH

- studies of electroenergetic insulators (insulator cores and interfaces) by means of steep-front impulse voltage,
- studies of dynamics of losses in composite insulator,
- surface properties under clean fog or rain conditions (recording of leakage current increase),
- studies of electrical insulators' silicone coatings,
- studies of modern multiphase high-voltage systems in terms of optimisation of these systems' technological parameters and diagnostics,
- studies of thin-film plasma coatings on unwoven fabrics with applications in the electromagnetic field screening technique in mind.

### APPLICATION

The services offered by the unit cater to entities operating in the field of professional power engineering, facilities manufacturing high-voltage devices, research and development units, etc. The offer consists in diagnostic studies whose results enable the evaluation of the condition of devices used in an electric power system. The proposed research programme can be applied to verify the operational correctness of newly designed insulation systems (e.g. high-voltage insulators) and treated as construction studies.

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## DIELECTRIC MATERIALS AND ELECTRO-INSULATING CIRCUITS

 RESEARCH

Diagnostics of electro-insulating, electret, and antistatic materials, as well as non-linear dielectrics, including ferro- and piezoelectric ones.

- climatic studies of materials and products in the temperature range of -40 °C to -180 °C and at humidity of 10 %-98 %,
- measurements of high resistances (up to 1 P Ω, i.e. 1015 Ω) and very low currents (lower than 1 fA),
- measurements of TSD currents and dispersion properties (electric permeability and the loss factor) of solid and liquid dielectrics in the frequency range of 10-5 – 109 Hz,
- studies of electric strength of solid and liquid dielectrics (and user-ready products) at a constant, alternating, and impulse voltage, as well as for complex oscillations,
- studies of partial discharges.

 APPLICATION

- studies of electrical properties of weakly conductive materials (antistatic materials and composites, electro-insulating materials, products, and systems) for the purposes of cataloguing, diagnosing, and learning,
- tests for compliance with specific standards.

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## ENVIRONMENTAL EVALUATIONS RELATED TO THE PROTECTION OF PEOPLE AND THE ENVIRONMENT AGAINST THE IMPACT OF ELECTROMAGNETIC FIELDS

 EXPERT REPORT

- development of reports on the environmental impact with respect to the electromagnetic field for various electrical power engineering facilities,
- evaluations involving the analysis of current problems related to the environmental impact of electromagnetic fields generated by power lines and substations,
- evaluations of possible impact of the electromagnetic field on people staying near its various sources,
- evaluations related to health and biological impacts of 50 Hz electromagnetic fields.

 APPLICATION

- reports on the environmental impact are some of the important documents analysed as part of proceedings with respect to the environmental impact evaluation and issuing a decision on environmental considerations,
- the evaluations can be used to establish minimum distances between residential buildings or other public utility buildings and overhead power lines or power cables,
- the evaluations can determine whether a 50 Hz electromagnetic field generated by electrical power engineering facilities can affect people staying near them.

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## EVALUATION OF THE IMPACT OF DISPERSED SOURCES APPLYING RENEWABLE ENERGY ON THE DISTRIBUTION NETWORK

 EXPERT REPORT

The scope of technical evaluation services offered by our unit: Analyses of the operational states of a distribution centre before inclusion of a power plant, including the following:

- transformer regulator setpoint at a switching station,
- power flows,
- wattless power compensation,
- identification of line sequences' connection parameters.

Analyses of post-inclusion operational states:

- impact on network load and losses,
- impact on voltage deviations,
- active power changes depending on frequency, voltage fluctuations,
- light flickering nuisance indicators, harmonics level,
- generators' angle and voltage stability reserves.

Analyses of the operational conditions of electrical power engineering automation:

- earth fault issues (automatic active component enforcement, cooperation with ARC),
- fault currents and powers,
- security automation (ATSE, ALS) at switching stations,
- adjusting security automation and selection of setpoints.

 APPLICATION

The systemic evaluations are performed at the unit using its own-developed software for determining replacement parameters and analysing steady and fault states in electrical power systems. The evaluations can be commissioned by operators of transmission and distribution systems as well as the electrical power engineering sector.

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## LOW POWER ELECTRICAL SWITCHES

### RESEARCH

Studies related to low-power arc discharge and glow discharge, allowing for various extinguishing media and various "climatic" conditions. The studies offered by the unit can be conducted in vacuum and using both negative pressure and overpressure of various technical gases. Allowing for the influence, type and technology of contact tips.

### APPLICATION

Coupling devices, relay contacts, reed relays.

#### Contact information

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## MEASUREMENT OF PHOTOVOLTAIC CELLS' ELECTRICAL PARAMETERS

### RESEARCH

Measurements of photovoltaic cells' current and voltage characteristics in standard test conditions. The 16-bit digital metering system applied at the unit performs measurements and advanced analyses of characteristics.

A system equipped with a C grade light source (in compliance with IEC 60904-9 standard). Maximum sample surface - 15x15 cm. Current measuring range - from 100  $\mu$ A to 15 A; voltage measuring range - from 0.65 V to 10 V.

### APPLICATION

Studies of photovoltaic cells:

- measurements of light and dark characteristics,
- measurements with optional illuminance fluctuation compensation (up to  $\pm 2\%$ ),
- determination of the cell's series resistance in compliance with the IEC 60891 standard,

- correction of characteristics to STC conditions in compliance with the IEC 60891 standard,
- approximation of characteristics to a substitute diode mode,
- determination of temperature coefficients, open circuit voltage, short circuit current, and the cell's maximum power.

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## MONITORING AND ANALYSIS OF ELECTRIC ENERGY QUALITY

### RESEARCH

Monitoring and evaluation of electric energy quality based on synchronous multi-point measurements performed in public utility and industrial electrical power networks using class A mobile recorders. The system ensures time synchronisation and remote data transmission. The studies and analyses are performed in compliance with applicable standards and in relation to the directive on detailed conditions of the operation of an electric power system and the instruction on the traffic and operation of electric power networks. An extended analysis of measurement results uses static algorithms, cluster data analysis, and correlation analysis along with stations' and areas' activity logs. Advanced methods of digital signal processing are applied for the purpose of analysis of dynamic disturbances.

### APPLICATION

- synchronous, multiple node monitoring and evaluation of electric energy quality in electrical power networks,
- analysis of the cooperation with an electrical power network of dispersed sources, including small and microinstallations,
- measurements and evaluation of the level of energy quality background

- and the impact of sources and recipients on the quality conditions of a network's performance at pick-up point,
- evaluation of dynamic disturbances, as well as static and cluster analyses.

#### Contact information

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## MONITORING AND DIAGNOSTICS OF MACHINES AND ELECTRIC PROPULSION SYSTEMS

### RESEARCH

- development, tests, and implementation of new methods of early detection of electric and mechanical failures in electric machines and converter propulsion systems,
- design of measurement and diagnostic systems enabling the monitoring of the operation of propulsion systems, as well as their diagnostics - also remotely, using Ethernet and GSM technologies.

### APPLICATION

Application of advanced signal processing algorithms and artificial intelligence techniques in machine diagnostics.

#### Contact information

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## MONITORING AND DIAGNOSTICS OF MECHANICAL DAMAGE TO MACHINES AND ELECTRIC PROPULSION SYSTEMS

### RESEARCH

- design of measuring and diagnostic solutions enabling monitoring and diagnostics of mechanical damage to electric machines and propulsion systems,
- studies of mains and frequency converter powered machines,
- development, testing, and implementation of new methods of detection of mechanical damage to propulsion systems.

The Laboratory is equipped with check cards, measuring sensors, mobile measuring systems, and a laser system for propulsion alignment.

### APPLICATION

Application of advanced signal processing methods and artificial intelligence for monitoring and diagnosing propulsion systems.

#### Contact information

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## MULTIMEDIA SERVICES WITH PARTICULAR EMPHASIS ON THEIR QUALITY ASPECTS, INCLUDING QoS AND QoE

### TECHNOLOGY

Multimedia services with emphasis on their quality aspects, including QoS and QoE, their organisation, and optimisation of protocols. The services enable "analysis" of QoS/ QoE aspects in a robotic system, in particular:

- determination of a model of a multimedia system user's behaviours (behaviour profiles, etc.),
- optimisation of the transaction process, particularly in multimedia systems,
- determination of a simulation model of a system/network providing interactive television services,
- determination of a simulation model of a system/network providing video connection services.

### APPLICATION

Studies of phenomena related to ensuring appropriate quality in broadband systems offering services, and in particular multimedia services referred to as "Triple Play" and the optimisation of negotiation, transaction, and traffic processes taking place in systems of this type stemming from the research conducted.

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## SECURITY AUTOMATION IN ELECTRICAL POWER ENGINEERING

### RESEARCH

- studies and analyses of sensitivity and errors of current and voltage transformers and converters, measurements of specific characteristics of electrical power transmitters and security solutions, as well as analysis of their operation in static and dynamic input function conditions; testing the criteria of the operation of electrical power engineering security automation, development of modern algorithms for measuring specific criteria quantities of security automation devices,
- analysis of operational characteristics of security automation devices, analyses of solutions related to transmitter security systems of separate electrical

power facilities, simulation analyses of the operation of electrical power engineering automation systems, and design of digital algorithms for the operation of electrical power engineering security automation systems.

### APPLICATION

- determination of the correctness of security criteria selection,
- evaluation of the selectiveness of the operation of electric power engineering security automation and development of new devices (signal converters and security solutions).

#### Contact information

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## SIMULATION STUDIES OF AC ELECTRIC MACHINES

### RESEARCH

Simulation studies of alternating current powered electric machines, determination of the optimal shape of a magnetic core and winding, determination of maximum operational parameters (efficiency and power factor).

### APPLICATION

The unit conducts studies of AC powered electric machines using the finite elements method: induction motors, synchronous generators induced electromagnetically and with permanent magnets, as well as synchronous motors induced electromagnetically and with permanent magnets.

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## STUDIES OF ELECTRICAL ENERGY QUALITY

### EXPERT REPORT

- studies of the quality of electrical energy in line with applicable standards (EN 50160; EN 61000-2-4),
- evaluation of disturbances in energy quality in office, industrial and public utility facilities,
- studies conducted in power switching stations - pick-up points and receiver feed points,
- analyses conducted at the unit concern supply voltage parameters: frequency, voltage and voltage change values, fast voltage changes, light flickering nuisance, supply voltage dips, short and long power supply breaks,
- voltage asymmetry, harmonics and inharmonics,
- wattless, active, and apparent current and power, as well as harmonics.

### APPLICATION

Electric energy supplied to its recipients should meet quality parameters specified in legal regulations and standards. The Laboratory uses instrumentation which enables monitoring and analysis of electric energy quality and the impact of the recipient on energy quality at the pick-up point. Mobile and synchronised energy quality analysers enable simultaneous measurements at a few points of a power system.

#### Contact information

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## STUDIES OF ELECTRIC DEVICES – MEASUREMENTS OF EMISSIONS AND TESTS OF RESISTANCE TO DISTURBANCES

### EVALUATION

The Laboratory conducts tests of energy receivers with rated current of less than 16 A. Measurements of the following types of disturbances are performed:

- current harmonics,
- voltage fluctuations and light flickering.

Studies of receivers' resistance to the following types of disturbances:

- voltage dips and short breaks in power supply,
- voltage fluctuations,
- frequency changes,
- harmonics in supply voltage.

The studies can be performed according to the client's procedures or to verify their compliance with standards, as well as in accordance with procedures recommended by the following standards: PN-EN 61000-3-2, PN-EN 61000-3-3, PN-EN 61000-4-11, PN-EN 61000-4-13, PN-EN 61000-4-14, PN-EN 61000-4-28.

### APPLICATION

- verification of the operational correctness of products in various conditions and their impact on other devices,
- meeting requirements of the standards harmonised with the directive on the electromagnetic compatibility of electric energy receivers constitutes the grounds for labelling products with the CE mark. The studies attest to products meeting such requirements.

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## STUDIES OF EMISSIONS AND RESISTANCE OF LOW-POWER RECEIVERS IN TERMS OF DISTURBANCES CONDUCTED UP TO 150 KHZ

### RESEARCH

- industrial studies of emissions of electric energy quality disturbances with respect to low-power receivers (up to 15 W): emission of current

harmonics PN-EN 61000-3-2, emission of voltage changes, voltage fluctuations and light flickering PN-EN 61000-3-3,

- industrial studies of small receivers' (of up to 15 W) resistance to electric energy quality disturbances: resistance to voltage dips, short voltage breaks and changes PN-EN 61000-4-11, resistance to low frequency disturbances, harmonics and inharmonics along with mains signals PN-EN 61000-4-13, resistance to voltage fluctuations PN-EN 61000-4-14, resistance to changes of power mains frequency PN-EN 61000-4-28,
- industrial studies of emission of 150 kHz disturbances (supraharmonics) in current without receivers and in voltage at pick-up point, the studies are performed at the unit with a programmable power unit and dedicated voltage and current recorders.

### APPLICATION

- evaluation of emissions and resistance of low-power receivers with respect to conducted disturbances such as voltage changes and fluctuations, light flickering, as well as harmonics and inharmonics,
- evaluation of the share of conducted disturbances up to 150 kHz.

#### Contact information

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## STUDIES OF INSULATORS

### RESEARCH

- studies of sparking voltage and electric resistance with all types of insulators with respect to constant voltages (up to 300 kV), variable voltages (up to 800 kV), and impulse voltages (1.2/50 us, up to 1.8 MV),
- studies and analysis of partial discharges, studies of lossiness at a high voltage (50 Hz),
- studies of the impact of ageing phenomena.

### APPLICATION

- studies and diagnostics of glass, ceramic, composite, and other types of insulators,
- studies for cataloguing purposes and for the purpose of compliance with standards,
- evaluation of the impact of dirt.

 Contact information

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## THERMALLY STIMULATED DIELECTRIC SPECTROSCOPY

### RESEARCH

Studies of relaxation processes in solid bodies (dielectrics and highly resistive semiconductors) using the method of thermally stimulated depolarisation currents (TSDC) and methods of computation intelligence (genetic algorithms and swarm algorithms). The unit's test bed enables measurements of a TDSC spectrum in the temperature range of 100 K – 450 K.

Requirements for samples:

- flat-parallel samples,
- maximum thickness - 1.5 mm,
- maximum diameter or diagonal - 15 mm.

### APPLICATION

Determination of solid dielectrics' relaxation processes.

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## ANALOGUE, DIGITAL, AND MIXED SIGNAL ELECTRONIC CIRCUITS AND SYSTEMS

### TECHNOLOGY

Design, prototyping and implementation of analogue, digital and mixed signal electronic systems particularly for measurement and control applications. The applications can include special circuits, such as optoelectronic and photometric circuits, wireless data transmission and microprocessor systems, as well as programmable circuits. System and circuit design may include all stages - from the very idea all the way through to the schematics and PCB, as well as system start-up and testing, including microprocessor system software.

### APPLICATION

The electronic systems and circuits designed at the unit are applied in numerous fields, while their functionality results from the expectations defined by the ordering entity.

#### Contact information

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## APPLICATIONS OF PROGRAMMABLE DIGITAL CIRCUITS

### TECHNOLOGY

Design, implementation, and tests of digital devices using CPLD and FPGA programmable logical systems.

### APPLICATION

Possible applications:

- organisation of built-in and single-circuit SoC (System on Chip) type systems,
- support for the DVI/HDMI interface and hardware algorithms of vision stream processing,

- implementation of processor architectures (CISC, RISC, SIMD),
- implementation of built-in USB controllers,
- application of non-volatile memory systems (Flash type) in series of parallel interfaces,
- support for standard Flash memory cards (SD, MMC, CF...), hardware support for SPI, I2C, PS/2, UART interfaces, etc.

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## APPLYING CONDUCTIVE, RESISTIVE, AND DIELECTRIC FILMS ON FLAT SURFACES

### TECHNOLOGY

Applying conductive, resistive, and dielectric films on substrates (ceramic, glass, polymer, etc.) using the screen printing technique. Minimum track width: 150 µm (standard screen printing), 50 µm (light-sensitive process).

### APPLICATION

Production of electronic circuits containing a network of conductive tracks, soldering fields, and passive elements.

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## CALIBRATION OF APPARATUSES FOR MEASURING ELECTROMAGNETIC FIELDS

### RESEARCH

The accredited laboratory AP- 078 offers services consisting in the calibration of instrumentation for measuring the following:

- electric field (in the range of DC-90 GHz),
- magnetic field (in the range of DC-1,000 MHz),
- electrostatic field,
- induced currents.

The certification and the scope of accreditation are available at: <http://www.ktt.pwr.wroc.pl/lwimp/certyfikaty/>

### APPLICATION

Calibration of probes and measuring instruments for measuring electromagnetic field applied in research related to environmental protection, health and safety in the workplace, EMC, as well as defectoscopy, and measurements of charges and the electrostatic field. We calibrate devices manufactured by the following producers: Narda, PMM, Wandel & Goltermann, Microrad, Wavelab, ETS Lindgren, Holaday Industries, Maschek, and Hirst Magnetic, among many others.

#### Contact information

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## CHARACTERISATION OF THIN FILMS

### RESEARCH

Studies and analysis of the following :

- geometrical structure of samples' surfaces using an optical profilometer (2D and 3D analysis of roughness, analysis of a shape's corrugation and profile),
- surface wettability,
- optical properties using the method of light transmission and reflection,

- electrical properties (resistivity, conductivity type, studies of electrical conductivity mechanisms),
- antistatic properties using the method of surface charge decay induced with a corona discharge.

### APPLICATION

Studies of thin layers.

#### Contact information

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## CONSULTANCY AND STUDIES IN THE AREA OF SPEECH AUDIO, MUSIC, AND VIDEO QUALITY EVALUATION

### TECHNOLOGY

Subjective measurements of the quality of audio including speech and music, as well as video, transmitted with various media (rooms, digital and analogue telecommunications channels, the Internet, DAB+, etc.) Objective measurements of the quality of speech signal transmission and coding.

### APPLICATION

Ensuring reliable evaluations of the quality of amplification in conference rooms and theatres. Testing the quality of audio including speech and music, as well as video, in various transmission systems.

#### Contact information

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## DETERMINATION OF PHOTOVOLTAIC CELLS' ELECTRICAL PARAMETERS

### RESEARCH EXPERT REPORT

Measurements and analyses of light and dark current-voltage characteristics with a grade A sunlight simulator (IEC 60904-9), in changeable lighting and temperature conditions. Measurement range: 1 mA –20 A. Determination of thermal indices of current, voltage, and power, as well as determination of parameters for a few versions of electrical diode-based replacement models of a cell (SEM, DEM, and VDEM).

### APPLICATION

Laboratory studies of photovoltaic cells and modules and long-term measurements of photovoltaic systems in natural conditions.

#### Contact information

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## DEVELOPMENT AND IMPLEMENTATION OF A TECHNOLOGY FOR EFFECTIVE ACQUISITION AND PRESENTATION OF DIGITAL DATA FOR A HETEROGENEOUS DIGITAL REPOSITORY

### TECHNOLOGY

- interactive 3D visualisations and simulations using the techniques of augmented reality and virtual reality (e.g. interactive 3D advertisements),
- passive algorithms for detecting 3D scene depth.

### APPLICATION

The works performed at the laboratory aim to develop and implement technologies for the acquisition and visualisa-

tion of digital data for a heterogeneous digital repository That includes, most notably, the following:

- software, image processing, and data compression algorithms, specialist digital hardware modules for image processing,
- new standards of image and video sequence (also 3D) processing,
- new methods of interactive visualisation of data using expanded and virtual reality techniques,
- data converters, e.g. image -> labels, etc. and converters between standards of data of the same type.

#### Contact information

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## ELLIPSOMETRY AND PROFILOMETRY STUDIES OF THIN FILMS AND SURFACES

### EXPERT REPORT

- measurements and analyses of the thickness and refractive index of thin films in the range of ultraviolet, visible light, and close infrared; the measurements are performed with a spectral ellipsometer,
- measurements and analyses of the roughness, corrugation, and form of materials' surfaces; the measurements are performed with a mechanical or optical profilometer.

### APPLICATION

The measurements serve the purpose of characterisation of thin films applied in scientific research and industrial technology.

#### Contact information

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## MEASUREMENTS OF BASIC ELECTRICAL QUANTITIES

### RESEARCH

Measurements of basic electrical quantities: voltage, direct and alternating current intensity, power and energy, impedance and RLC elements' parameters, frequency and period of periodic signals, duration of phenomena, parameters of electronic and electrochemical (storage cells) sources of voltage and current. The tests can be performed using direct or indirect methods, depending on specific needs, and the character of the object of measurement. The unit offers its instrumentation to be used over an agreed time by the client or by the laboratory's well-qualified staff.

### APPLICATION

Measurements of basic electrical quantities performed for business entities dealing with electronic equipment and interested in verifying their devices', or their components' operation.

#### Contact information

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## MEASUREMENTS OF ELECTROMAGNETIC FIELDS

### RESEARCH

The accredited laboratory AB-361 offers services involving measurements of electromagnetic fields in the range of DC-90 GHz for the purposes of environmental protection and health and safety in the workplace, as well as audits identifying potential sources of electromagnetic fields. The certificate and accreditation scope are available at: <http://www.ktt.pwr.wroc.pl/lwimp/certyfikaty/>

### APPLICATION

Measurements of electromagnetic fields for the purposes of environmental protection and health and safety in the workplace near various EMF sources, such as:

- electric power systems,
- radiocommunication systems,
- medical instrumentation,
- industry,
- wind power engineering.

#### Contact information

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## MULTI-LAYER CERAMIC SUBSTRATE (LTCC) TECHNOLOGY

### TECHNOLOGY

Production of multi-layer ceramic substrates containing surface and embedded conductor tracks (made of Ag, Au, Pt, Pd, and Ag), passive elements (resistors, coils, and condensers), as well as micromechanical and micro-flow structures (channels, containers, etc.), Active elements and integrated circuits can be installed on surfaces using standard assembly techniques (surface assembly, flip-chip, etc.).

### APPLICATION

Electronic circuits characterised by a high density of electrical connections for all applications, capable of operating at increased temperatures.

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## OPTICAL FIBRE LASERS AND AMPLIFIERS

### RESEARCH

Development of low-power lasers operating at 1,550 nm wavelength and generating ultrashort impulses with mode synchronisation, as well as sources of medium/high power of continuous and pulse operation - using the so-called MOPA set-up. The works include development of a single-frequency laser prototype (continuous power of 5W), as well as numerous solutions of medium- and high-power laser sources, offering both continuous and pulse operation and generating optical frequency combs of sub-picosecond pulse lengths, with materials including graphene as a saturable absorber.

### APPLICATION

Optical fibre amplifiers and lasers operating at 1,550 nm wavelength are applied in optical fibre telecommunications, free space telecommunications, remote vibrometry, laser micromachining, laser rangefinders, laser spectroscopy, laser metrology, and other fields.

#### Contact information

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## PRODUCTION OF THIN FILMS USING VACUUM METHODS

### TECHNOLOGY

- deposition of metallic, insulation, and semiconductor coatings using PVD methods (magnetron spraying, electron beam evaporation, and resistance evaporation),
- design, construction, modernisation, production, and repair of vacuum components (electron and magnetron guns),
- design of optical coatings for various applications.

### APPLICATION

Thin films (in the form of single layers or multi-layer films) are currently widely applied (microelectronics, optical elements, architectural windows, medicine, and tools). Applying films on the surface of objects and devices is intended to improve their specific properties (functionalisation) important from the viewpoint of usefulness.

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## “SMART PACKAGE” CERAMIC CASING TECHNOLOGY

### TECHNOLOGY

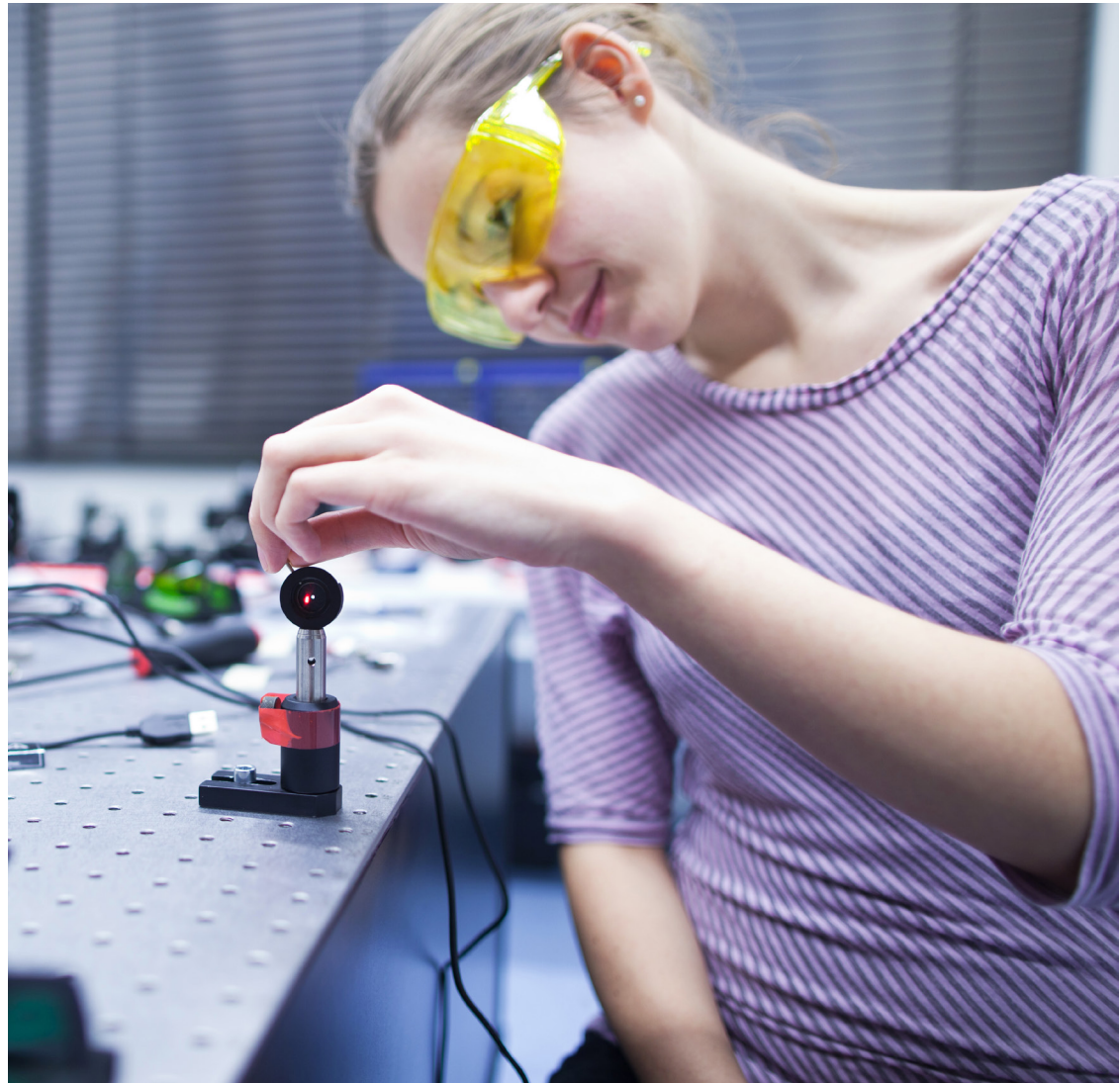
Production of “smart package” ceramic casings for semiconductor structures, integrated circuits, etc. The casings can contain a network of conductive tracks, micro-channels improving heat transport, integrated sensors, and converters.

### APPLICATION

Casings for semiconductor structures protecting them from environmental impacts and ensuring appropriate operational conditions.

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## STUDIES OF ELECTROMAGNETIC COMPATIBILITY (EMC) OF DEVICES, SYSTEMS AND INSTALLATIONS

### RESEARCH

Studies of electromagnetic compatibility (EMC) of devices intended to be used in home and industrial environments, as well as in the fields of aviation, power engineering, automotive industry, naval engineering, health care, as well as measurement and control devices. The research involves the following:

- measurements of continuous conducted (up to 30 MHz) and radiated (up to 40 GHz) disturbances,
- measurements of mains current distortion (harmonics and flickering) in AC supply networks (1 and 3-phase, 50 Hz/60 Hz, up to 90 A/phase),
- studies of resistance to continuous and impulse electromagnetic disturbances generated in interface conductors as well as AC and DC power supply (e.g. in on-board power networks),
- studies of immunity to radiated disturbances (up to 200V/m, 80 MHz-18 GHz),
- studies of immunity to disturbances occurring in power terminals (DC - 230 MHz) and interface terminals (150 KHz - 230 MHz).

Devices for testing can be 3 metres in height/width and up to 3 tons in weight. They can be battery, DC, or AC powered (up to 32 A/phase, and some - up to 3x400 V and 200 A/phase).

### APPLICATION

EMC studies carried out by our accredited research laboratory (accreditation certificate AB 167 issued by the Polish Centre for Accreditation) in compliance with European standards make it possible to determine whether essential requirements of the European EMC (2014/30/EU) directive are met. Positive test results in the conformity evaluation procedure are necessary for the manufacturer or its authorised representative to be able to submit a declaration of conformity and label a product to be introduced to the EU market with the CE mark.

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## TESTS IN A CLIMATIC CHAMBER INTEGRATED WITH A VIBRATION EXCITER

### RESEARCH

The unit's climatic chamber with an integrated exciter enables the performance of the following tasks:

- passive and active tests of electric, electronic, and mechatronic devices, as well as microsystems, and photovoltaic cells,
- fatigue tests - studies of resistance to hazards changing in time (e.g. cyclic temperature or lighting changes and vibrations),
- ageing tests - studies of resistance to hazards not changing in time (e.g. storage at a fixed temperature or humidity, exposure to light, etc.),
- quick tests in which hazards are combined (e.g. temperature cycles + vibrations, increased temperature + increased humidity + indoor/outdoor lighting),
- detection of events and measurement of the time elapsed until damage occurs,
- tests performed in accordance with international and domestic standards (e.g. IPC, JEDEC, PN, PN-EN, etc.).

### APPLICATION

The unit's climatic chamber with an integrated exciter enables the performance of tests for the needs of the following industry sectors:

- electronics and microsystems (e.g. manufacturers of electric and electronic devices, microsystems, manufacturers of photovoltaic cells),
- the electric appliances,
- materials engineering (e.g. units developing composite materials),
- civil engineering, food production.

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## THERMOVISION STUDIES

### RESEARCH


Thermovision studies make the following possible:

- determination of thermal parameters of thin layers (emissivity, heat diffusion, and evaluation of the efficiency of heat transport through film made of nanomaterials),
- measurement of surface emissivity,
- measurement of an object's temperature in the steady state (determination of permissible operation conditions and evaluation of a device's lifetime depending on environmental conditions),
- measurement of the speed of temperature changes of an object in the steady state,
- determination and analysis of temperature gradient,
- measurement of contact point's thermal resistance,
- measurement of materials' thermal diffusivity,
- evaluation of the effectiveness of the selection of thermal conductive material and the cooling system applied (optimisation and comparative analyses),
- studies of an object's response to energy received from outside (active thermography).

### APPLICATION

A thermovision camera enables studies for the needs of industry sectors including the following:

- electronics and microsystems (e.g. manufacturers of electric and electronic devices and microsystems),
- electric technologies,
- industrial devices,
- materials engineering (e.g. research units working on composite materials, as well as thermoconductive and thermal insulation materials),
- building construction.

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## X-RAY INSPECTION AND COMPUTER MICROTOMOGRAPHY

 RESEARCH


The facility's system for X-ray inspection and computer microtomograph enable the following tasks:

- broadly understood defectoscopy of objects damaged during use, or ones after manufacturing processes or reliability tests (electronic systems and components, microsystems, as well as hydraulic, electromagnetic and mechanical elements),
- studies of electronic elements and microsystems (construction quality evaluation, evaluation of compliance with manufacturer documentation, comparative analyses, reverse engineering, etc.),
- evaluation of technological process results (all kinds of joining processes such as soldering, welding, gluing, sintering, bonding, as well as processes of printed-circuit board manufacturing, metal plating, etching, laminating, printing, cutting, drilling, threading, airtight sealing, moulding, etc.),
- evaluation of the compliance of objects and processes with international and domestic standards (e.g. IPC, JEDEC, PN, PN-EN, etc.),
- structural studies of modern materials (hybrid and laminated materials, materials containing nanoparticles and microparticles, etc.).

 APPLICATION

X-ray inspection and computer microtomography enable research for the needs of the following industry sectors:

- electronics and microsystems (e.g. companies assembling electronic components on PCB's, printed circuit manufacturers, and manufacturers of electronic components and microsystems),
- materials engineering (e.g. units developing composite materials)
- automotive (e.g. manufacturers of hydraulic and pneumatic components).

 Contact information:

Faculty Division of Electronic and Photonic Technologies  
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## DETERMINATION OF THE CONTENT OF PAH AND OTHER ORGANIC COMPOUNDS USING GAS CHROMATOGRAPHY WITH MASS DETECTION (GC/MS)

 RESEARCH

The unit offers sample-taking services and tests performed with a chromatograph or GC/MS immission tests. The type of material provided by the client or samples taken determine the selection of parameters of the method, as well as instrumentation, and reagents used to determine specific chemical substances. The following chemical compounds can be determined:

- polycyclic aromatic hydrocarbons - 16 compounds, in accordance with EPA standards,
- volatile organic compounds (VOC),
- chloro and fluorine derivatives of hydrocarbons,
- other organic substances - at the client's request.

 APPLICATION

The studies aim to provide a qualitative and quantitative evaluation of the content of organic compounds in a sample. For this purpose, an analysis is conducted using a gas chromatograph coupled with a selective mass spectrometer. The studies are conducted using a gas chromatograph made by Agilent Technology, series 7890B and a 5977A MSD mass spectrometer

 Contact information

Workroom of Emission Studies  
Associate Professor of WUST Anna Janicka, PhD, Dsc, Eng  
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[www.laboratorium-emisji.pwr.edu.pl](http://www.laboratorium-emisji.pwr.edu.pl)

## ENVIRONMENTAL EVALUATIONS AND ANALYSES

 EXPERT REPORT

The unit offers expert evaluations in the following areas:

- spread of pollution in the air (Operat FB),
- noise propagation,
- spatial analysis of environmental data (GIS),
- evaluations of environmental impacts (EEI),
- project information sheets (PIS),
- other environmental studies and evaluations.

 APPLICATION

The services offered consist in environmental research and evaluations using reference methodologies and models. Such evaluations are indispensable, e.g. when applying for environmental permits (including those related to construction development projects). The comprehensive service consists in laboratory studies, field studies, and modelling pollution emissions (including noise).

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## IDENTIFICATION OF AEROSOL AND ODOURANTS ALLOWING FOR METHODS OF THEIR ELIMINATION FROM THE ENVIRONMENT

 RESEARCH

Identification of sources of aerosol and odourants along with the development of solutions aiming to limit their emission to the atmosphere.

## APPLICATION

### Research goals:

- identification of the sources and determination of emissions of particulates and odourants to the atmosphere,
- evaluation of their distribution in particular areas,
- development of concepts of reducing pollution and deodorisation.

### Contact information

Laboratory of Preparation of Particulate and Odour Samples,  
Laboratory of Olfactometric Research, accreditation: AB 1461  
Professor of WUST Izabela Sówka, PhD, DSc, Eng  
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## IDENTIFICATION OF SOURCES OF AIR POLLUTION AND THEIR EVALUATION IN SPECIFIC AREAS ALONG WITH RISK ANALYSIS

### EXPERT REPORT

The unit offers expert evaluations and reports in the following areas:

- methodologies of collecting pollution samples and measuring pollution of the atmospheric air (including odours),
- statistical and mathematical tools for evaluating the quality of the atmospheric air,
- methods of identification of the dynamics of global changes in the air,
- methods of evaluation of the carbon footprint in the environment,
- environmental risk, evaluations of the impact of construction projects on the environment,
- applications of low-emission solutions and techniques of limiting/eliminating pollution,
- health-related consequences of atmospheric pollution.

## APPLICATION

### Research goals:

- identification of sources of pollution,
- assessment of air quality along with risk analysis.

### Contact information

Division of Atmosphere Protection and Engineering  
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## MEMBRANE PROCESSES

### RESEARCH

The Laboratory has the necessary facilities and experience of work related to the following fields:

- application of pressure-based and ion-exchange membrane processes: micro-, ultra-, and nanofiltration, electro dialysis, Donnan dialysis, diffusion dialysis,
- characteristics of ceramic and polymer membranes' properties, determination of the impact of technological parameters on membrane processes' effectiveness,
- analysis of membrane blocking phenomenon.

### APPLICATION

Studies related to the application of membrane processes and the use of membranes can be applied for purposes including the following:

- water conditioning and sewage treatment,
- recovery of high quality water and valuable ingredients from waste streams,
- in hybrid processes - water and waste treatment, desalting,
- removal of undesirable ingredients from water,
- optimisation of the technological process line for water conditioning or sewage treatment.

### Contact information

Laboratory of Membrane Separation Processes  
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## MICROBIOLOGICAL CONTROL OF TREATMENT AND DISTRIBUTION OF WATER INTENDED FOR HUMAN CONSUMPTION

### RESEARCH

- microbiological control of water treatment processes along with a sanitary analysis,
- detection of substances producing mutagenic and toxic effects in tap water on the basis of short-term bacterial tests,
- studies of the biodiversity of microorganisms forming biological growths in water supply networks, on the basis of conventional and molecular biology methods,
- detection of micro-biological growths forming in water supply networks by means of impedance spectroscopy and biochemical tests,
- studies of the degree of adhesion of microorganisms and the kinetics of the formation of biofilm on construction materials of water pipes,
- studies of the presence of microorganisms resistant to antibiotics and disinfectants in tap water.

### APPLICATION

The research services offered cater to institutions responsible for the quality of water intended for consumption in terms of health impacts, as well as supervision and consultative bodies - e.g. Water Treatment Company, Voivodship's Environmental Protection Inspectorates, Sanitary and Epidemiological Stations, etc.

### Contact information

Laboratory of Environmental Biotechnology  
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## MONITORING OF THE BIOREMEDIATION PROCESS

### RESEARCH

The following services are offered:

- monitoring and control of the efficiency of soil purification (ex situ/in situ),
- monitoring of the natural biodegradation process (physico-chemical ana-

lyses, quantitative and qualitative composition of microorganisms, enzymatic activity of soil microbiota),

- evaluation of the efficiency of the bioremediation process (microbiological analyses, chemical analyses, total quantity of naphthenes/BTEX/WWA) studies of changes to the toxicity extent during the bioremediation process.

### APPLICATION

The purposes served by the research offered are as follows:

- evaluations of the efficiency of bioremediation in the area under examination (ex situ) or specific pollution (in situ),
- determination of the direction of further actions and recommendations aiming to improve the effectiveness of the technology applied (biostimulation, biopreparations).

#### Contact information

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## QUALITY MANAGEMENT - SYSTEMS AND METHODS

### TRAINING

Training and support in the following areas:

- analyses, implementation, and streamlining of quality management systems in accordance with ISO 9000 standards,
- identification of a context of an organisation's operation as well as risks and opportunities in uncertain conditions,
- methods of perfecting, optimising, and monitoring manufacturing processes,
- methods of researching process stability and capability (SPC), as well as uncertainty and capability of measuring systems (MSA),
- methods and techniques of perfecting quality (FMEA, Design of Experiments), methods and tools applied under the Six Sigma strategy.

### APPLICATION

The services offered cater to organisations which

- want to implement and develop a systemic approach to quality manage-

ment which allow for risk aspects,

- want to perfect their processes by applying the right concepts, methods and streamlining tools.

#### Contact information

Centre for Advanced Manufacturing Technologies  
– Fraunhofer Project Center  
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## STUDIES OF MICROBIOLOGICAL BIODIVERSITY OF ENVIRONMENTAL SAMPLES

### RESEARCH

Identification of microorganisms, using both conventional methods and the methods of molecular biology, occurring in different elements of the environment: water, wastewater, sewage sludge, soil, as well as external and internal air.

### APPLICATION

Identification of microorganisms, using both conventional methods and the methods of molecular biology, occurring in different elements of the environment can be useful when performing the following tasks:

- assessment of the operation of devices in environmental engineering (water treatment, waste treatment, or water industrial installations),
- assessment of the sanitary condition of water, soil, and sewage sludge, works related to bioremediation/phytoremediation of water, soil, and sewage sludge,
- studies of the biodegradation of oppressive environmental pollution factors and the development of biopreparations to trigger the process of their biological decomposition,
- identification and studies of the biological activity of biodegradation transformations' metabolites,
- studies of the spread of bioaerosols around emitters of microbiological contamination (mainly solid waste dump sites and wastewater treatment plants) as well as determining the extent of their impact on the environment.

#### Contact information

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## TOXICOLOGICAL TESTS

### RESEARCH

The unit offers research services in the following areas:

- toxicity - based on standard mutagenicity tests (Ames MPF), genotoxicity, cytotoxicity (MTT-XTT),
- ecotoxicity (including microbiotests).

The studies can be performed on environmental samples (water, soil, and soil extracts), but also waste, exhaust gases, and indoor air.

The offer also involves evaluation of cytotoxicity and actual toxicity of gas mixtures using the BAT-CELL® method on an own-developed test bed

### APPLICATION

The unit's research services can be helpful when determining the extent of pollution, as well as estimating health hazards and environmental impacts. As for studies related to indoor air quality, the research services offered will be useful for the assessment of the impact of a room's microenvironment on living organisms and evaluation of air-conditioning devices' effectiveness. Furthermore, the studies can support tasks such as monitoring of the biodegradation process, evaluation of biodegradation effectiveness (also using biopreparations), and determination of actual toxicity of exhaust gases.

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## COMPREHENSIVE STUDIES OF WATER SOLUTIONS AND SEWAGE USING SPECTROPHOTOMETRY - CUVETTE TESTS

### RESEARCH

The unit offers spectrophotometric studies using cuvette tests. The services offered comprise the following types of determination:

- cations,
- anions,
- general organic carbon (TOC),
- ammonia nitrogen,
- formaldehyde,
- and other ones.

The unit's offering includes preparation of water solutions (water extracts) from soil or other materials, as well as gas samples. The studies are performed using the spectrophotometric method. Tests are carried out with a DR3800 spectrophotometer by HACH.

### APPLICATION

The studies aim to determine the content of specific ions and chemical compounds in solutions, water extracts, and sewage.

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## CUTTING RAW MATERIALS

### TECHNOLOGY

- the services offered by the unit concern software for cutting raw materials,
- the application was developed using the set of programming tools Microsoft Visual Studio 2017, enabling the production of graphical applications

for MS Windows systems; the programming language applied to write the software, along with its algorithms, was C#,

- this simple application enables optimisation of cutting materials by applying an algorithm for setting cutting patterns and the number of times they are to be used, as well as an algorithm setting the sequence of placing elements on templates,

- to ensure best performance, the algorithm for setting cutting patterns and the number of times they should be used, as well as the algorithm for setting the sequence of placing elements on templates, were tested in terms of calculation time and selection of appropriate parameters; the function of the aim was crop size,

- the application comprises two basic parts: the base of elements to be cut and the optimisation procedure, which facilitates and streamlines using the software in practice.

### APPLICATION

- optimisation of cutting raw materials makes it possible for enterprises to save considerable funds related to the cost of raw materials thanks to reducing waste volumes,
- currently, the application is being used in numerous furniture factories in Poland.

#### Contact information

Workroom of Control and Optimisation  
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## DETERMINATION OF THE CONTENT OF VOLATILE ORGANIC COMPOUNDS (VOC) IN EMISSION AND IMMISSION USING GAS CHROMATOGRAPHY

### RESEARCH

The unit offers sample-taking services and qualitative and quantitative determination of volatile organic compounds (VOC) using gas chromatography (GC/FID method). The tests

are performed using a Varian 450-GC gas chromatograph with a flame ionisation detector.

### APPLICATION

Determination of VOC's content in emission and immission in rooms, vehicle cabins, and exhaust gases aims to evaluate the harmfulness of the atmosphere in which people breathe. Apart from the standard evaluation of VOC's content, assessments of the effectiveness of solutions decreasing concentrations of volatile organic compounds are performed.

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## EVALUATION OF THE EXTENT OF CONTAMINATION OF PARTICULAR AREAS OF THE ENVIRONMENT USING BIOINDICATION TESTS

### RESEARCH

Bioindication is a method of a complete quality assessment with respect to the following substances:

- waters,
- sewage,
- soil,
- waste,
- air.

A study of this kind involves of a series of biotests based on using unicellular or small multicellular organisms belonging to various trophic levels, which as a result of contact with a given sample present a specific response. Based on bioindication tests, we are capable of evaluating the overall toxicity or genotoxicity of all chemical substances present in a specific sample. The unit's offer comprises studies in the following areas:





- detection of genotoxic substances in samples of water, sewage, sewage sediments, soil, and dust air pollution, based on short-term bacteria tests,
- detection of toxic substances in samples of water, sewage, sewage sediments, soil, and plant extracts, based on quick, miniaturised tests which constitute industry standard in the field of acute and chronic toxicity studies.

## APPLICATION

The services offered by the unit can be useful in areas including the following:

- estimation of potential health risks resulting from the contamination of the natural environment,
- specification of the extent of contamination and selecting places which must be subjected to further chemical tests or reclamation,
- monitoring the effectiveness of remediation processes,
- tests of the degree of wastewater and sewage sludge toxicity,
- monitoring waters in order to protect sources of water intended for consumption and living organisms,
- reports on the environmental impacts of construction development projects.

## Contact information

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## PHYSICAL STUDIES AND CHEMICAL ANALYSES OF WATER, SEWAGE, WASTE, SOILS, AIR, AND BIOLOGICAL MATERIAL

## RESEARCH

Physico-chemical analyses using classic and instrument-based methods: electrochemistry, potentiometry, VIS molecular spectroscopy, and absorption and emission atomic spectroscopy,

## APPLICATION

Determination-oriented projects for the needs of industry, municipal services management, and state administration bodies:

- determination of physico-chemical parameters and the content of metals in elements of the environment,
- determination of the total content of metals in packaging materials.

## Contact information

Laboratory of Toxicology and Environmental Research  
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## STUDIES OF THE IMPACT OF POLLUTION ON LIVING ORGANISMS

## RESEARCH

- evaluation of the quality of rivers using macroinvertebrates,
- evaluation of the quality of soil and the extent of land ecosystems degradation using soil arthropods,
- ecotoxicological studies aiming to evaluate environment toxicity using living organisms,
- evaluation of possibilities of using waste for the revitalisation of degraded post-industrial areas,
- identification of plant clusters in degraded areas (mine waste dumps, waste sites, post-flotation ponds, etc.) along with a comprehensive evaluation of the character of anthropogenic transformations of the environment and recommendations with respect to biological restoration,
- application of spider webs for the purpose of comprehensive evaluation of the atmospheric air quality.

## APPLICATION

The research services offered by the unit can be useful for tasks such as: environmental stock-taking projects in areas intended for construction development, environmental impact evaluations, as well as development of reports for investment projects' information sheets (the environmental part).

## Contact information

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## FINANCIAL ENGINEERING

## EXPERT REPORT

Evaluations and research in the field of risk management in companies - both from the point of view of the trade department (market/credit risk management) and in relation to the entire business (enterprise risk management), valuation and management of financial instrument portfolios (including derivative instruments and exchange traded products), as well as construction of protective strategies (so-called hedging).

## APPLICATION

The aim of the evaluation is to increase the level of a company's risk awareness, develop principles of a well-performing risk management system tailored to a company's needs, streamline trade portfolio management, as well as assist it in the selection of instruments/contracts securing the current exposure to risk.

## Contact information

Team of Economic Modelling  
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## SPATIAL INFORMATION SYSTEMS (LIS/SIS), SPECIALIST ANALYSES OF SPATIAL DATA IN GIS

### RESEARCH

- studies conducted for public administration units, industrial plants (including mining facilities), and research institutions,
- management of GIS systems implementation projects,
- consultancy services in the area of the implementation of GIS systems in accordance with the INSPIRE directive,
- spatial analyses of environmental and other data and development of digital theme-based maps,
- construction of spatial geological models and spatial (3D) visualisations of engineering structures,
- training in the use of commercial and open source GIS software.

### APPLICATION

- studies for the purposes of environmental, planning, economic, social, geological and mining, and other types of analyses (e.g. analyses of the distribution of air, soil, and water pollution; modelling the range of mining deformations, and visibility analyses),
- multi-variant and multi-criterion analyses (e.g. of construction project locations),
- 3D models of buildings and other structures; analyses of surfaces used for advertising purposes,
- theme-specific geoportals.

### Contact information

Laboratory of GIS,  
Photogrammetry and Teledetection  
Jan Blachowski, PhD, DSc, Eng  
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## SPECIALIST GEODETIC MEASUREMENTS AND LASER SCANNING OF CIVIL ENGINEERING STRUCTURES

### RESEARCH

- measurement of engineering structures' technical condition,
- measurements and evaluations of dislocations and deformations of civil engineering structures along with an analysis and interpretation of results,
- stock-taking measurements of technical buildings and structures (e.g. bridges, flyovers, or tunnels), roads, and railway lines, technical infrastructure, etc.

### EXPERT REPORT

### APPLICATION

Measurements, along with the development of studies of measurement results, in the areas of geodesy, satellite technology (GNSS and teledetection), photogrammetry (measurements performed using drones), and ground-based laser scanning with equipment made by RIEGL (stationary and mobile - starting January 1, 2019).

### Contact information

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## METEORITES AND EXTRATERRESTRIAL MATTER

### EXPERT REPORT

We offer expert evaluations involving the identification of extraterrestrial origin of natural objects - meteorites. We issue certificates of extraterrestrial origin of rock matter - meteorite and perform the classification of meteorites along with entering of a meteorite in the Meteoritical Bulletin database maintained by the Meteoritical Society.

### APPLICATION

The unit provides evaluations concerning meteorites and develops documents indispensable for classifying a meteorite and including it in the international database published in the Meteoritical Bulletin maintained by the Meteoritical Society.

#### Contact information

Laboratory of Geology and Planetology  
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## RADON

### TECHNOLOGY

The unit offers designs of dry radon wells for obtaining radon from soil air or active protection of rooms inside buildings against soil-originated radon.

### APPLICATION

Dry radon wells are used for active protection of buildings against radon, a radioactive gas pervading their interiors from soil, as well as capturing radon, which can then be applied for therapeutic treatment in health-resorts, sanatoriums, and natural therapy facilities.

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## UNDERGROUND, THERMAL, AND THERAPEUTIC WATERS, BRINE, WATER INTENDED FOR CONSUMPTION, AND BOTTLED WATER

### RESEARCH EXPERT REPORT

We offer expert evaluations in the following fields:

- search, identification, and documentation of the exploitation of waters intended for human consumption, bottled water, and fossil waters: thermal waters, therapeutic waters, brine, and gasified waters.

The evaluations concern all geological, hydrogeological, mining, hydrochemical, and geophysical aspects. We develop designs of geological works, hydrogeological documentation, deposit development designs, as well as issue certifications attesting to therapeutic properties of natural therapeutic materials. We offer measurements of the content of radioactive isotopes of radon ( $^{222}\text{Rn}$ ) and radium ( $^{226}\text{Ra}$  and  $^{228}\text{Ra}$ ) in water and rock samples, as well as radon ( $^{222}\text{Rn}$ ) in the air inside buildings and underground facilities, e.g. underground tourist trails. We perform measurements of basic physico-chemical parameters of waters (e.g. temperature, pH, proper electrolytic conductivity, and redox potential). Additionally, we conduct chromatographic analyses of the content of geogenic gases in underground, therapeutic, and thermal waters, as well as brine, etc., and analyses of the chemical composition of gases in underground excavations and other types of locations.

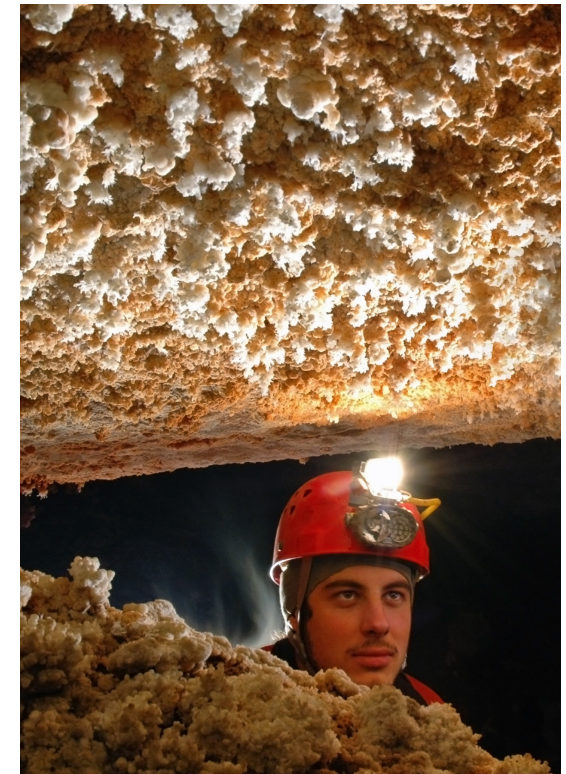
### APPLICATION

We draw up documents required by law with respect to the water resources law, geological law, mining law, and

health-resort law, as well as specialist evaluations of particularly complex problems related to the search, documentation, and exploitation of waters. Additionally, we conduct analyses necessary to determine therapeutic properties of radon waters, sorrels, and other underground waters, as well as analyse waters intended for consumption in terms of the permissible content of radioactive substances (radium and radon).

#### Contact information

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## INTERDISCIPLINARITY IN SCIENCE AND RESEARCH ORIENTED TOWARDS COMMERCIALISATION

### RESEARCH TRAINING

The services offered include the following:

- training and services applying creative methods in the field of design of machines and devices,
- training and implementation in the areas of the Design Thinking methodology, Heuristics, Syntectics, and Triz,
- design and development of solutions in science, business, education to create a space for innovation, training and implementation in the area of methods supporting concept design,
- conduct and management of interdisciplinary research and development projects,
- conduct and management of interdisciplinary projects for industry,
- offers with respect to using creative space for design purposes,
- development of new products and services using the Design Thinking methodology,
- project works using the methods of simplified prototyping of products and services,
- project works using the methods of user-designer interaction,
- research and project works using user surveying methods - user tests,
- training oriented towards developing soft competences.

### APPLICATION

The services offered consist in studies and works in the area of scientific and research interdisciplinarity, as well as the development of creative design aiming to introduce new projects, solutions, and technologies. The offering is designed to contribute to the following aims:

- interdisciplinary research and development projects for industry,
- interdisciplinary (inter-laboratory, inter-faculty, and inter-university) research and implementation projects,
- development of creative methods in research and project processes, science, business, and education to create a space for the development of the Design Thinking methodology,

- Design Thinking in the field of design and development of solutions in science, business, and education to create a space for innovation,
- development of new products and services using the Design Thinking methodology,
- methodologies of simplified prototyping of products and services, development of user surveying competences,
- students' research and implementation projects oriented towards industry.

### Contact information

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## MODELLING OF FLOWS USING NUMERIC FLUID MECHANICS

### RESEARCH

The unit's offering consists in simulation studies of fluid flow (liquid and/or gas) in flow systems and machines allowing for the phenomena occurring in them (including chemical reactions, heat transfer, and radiation). Thanks to simulations, it is possible to observe and predict the phenomena, which enables the design, diagnostics, and modernisation of flow systems. The following services are offered:

- development of 3D models,
- development of numerical 3D meshes,
- computation for specific boundary conditions using models adequate for a specific model (Ansys-Fluent - commercial licence),
- analysis of 3D results,
- comparison with results of experimental studies (if possible).

### APPLICATION

The aim of the services offered by the unit is to improve the quality of the object under design/examination and optimise the indispensable construction and technology-related meas-

ures related to numerical modelling of numerous geometrical models' CFD flow. Modern software enables calculations of substances' turbulent flow allowing for the injection of the discrete phase (pollution) of heat flow, mixture flow, chemical reactions (surface and volume-related), and noise.

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## OPTIMISATION FOR INDUSTRY 4.0

### RESEARCH

- comprehensive service consisting in studies and implementation of technologies optimising manufacturing and transport (logistics) with respect to the scope of Industry 4.0,
- the following areas are covered: modern robotised manufacturing processes including large volume and batch production, machine rearming, and inter-city transport,
- the studies aim to design dedicated solutions (software) for corporate clients with attention paid to the specificity, constraints, and requirements of the manufacturing system.

### APPLICATION

The methods, techniques, and software offered cater to large manufacturing companies and facilities planning to decrease the cost of production and/or transport through optimisation of production and transport schedules.

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## STUDIES OF METAL INCREMENT TECHNOLOGIES (METAL 3D PRINTING)

### RESEARCH

- studies of the additive SLM (Selective Laser Melting) technology,
- studies of the additive EBM (Electron Beam Melting) technology,
- development of new materials,
- applications of 3D print in aviation,
- analyses of powder materials (distribution of particle diameters, measurements of powder particles, determination of shape),
- studies of porosity, joint penetration, faults, and materials' discontinuity with destructive and non-destructive methods (X-ray microtomography),
- analyses and studies of materials, technologies, as well as inspection and measurements.

### APPLICATION

The Laboratory conducts research in the field of incremental technologies based on metal powders (3D print), such as stainless steel (316L), tool steel (H13), titanium alloys (Ti6Al4V, Ti6Al7Nb), nickel-based alloys (In718, In 625, etc.), CoCr, aluminium, tungsten, molybdenum, rhenium, and silver alloy, etc. It specialises in solutions applied in industry, mainly aviation (a few on-going projects with manufacturers of aircraft and aircraft parts) and medicine (personalised implants).

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## AGILE BUSINESS ANALYSIS IN SOFTWARE DEVELOPMENT

### EXPERT REPORT

Identification and selection of business analysis elements for drawing up software specifications (using agile methodologies of developing a software prototype) handling a business process in the company. The aim of the analysis is to draw up software specifications in a rapid manner, solving the decision-making problem in the company's business process.

### APPLICATION

Development of a repository of knowledge of the company's managed business processes. It can be useful for both the analysis of business processes and solving specific decision-making problems using IT methods.

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## ANALYSIS AND IMPROVEMENT OF IT SYSTEMS' EFFECTIVENESS

### EXPERT REPORT

The operation of enterprises increasingly often depends on various IT systems. They are usually implemented according to needs as opposed to a pre-developed strategy, which results in various systems running in parallel while not being integrated with one another. The efficiency of an enterprise's operation only in theory increases with more and more systems or functionalities being implemented.

An appropriately conducted analysis of a company's needs and its IT systems will make it possible to determine organisational, financial, legal, and technical changes related to IT systems used by it. These changes will aim to streamline the

enterprise's operation through a general improvement of the system's elements and the correlations between them to strengthen the synergy effect.

### APPLICATION

The unit's services consisting in an evaluation of enterprises' IT systems operation cater primarily to companies whose core activity is based on their use in business practice. The result of the evaluation is a strategy for changes to the systems being used or the development of new solutions.

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## ANALYSIS OF DIGITAL RESOURCES

### EXPERT REPORT

- knowledge extraction at the user's request,
- automatic knowledge search requested by the user,
- evaluations in the field of digital data forgery (photographs, films, audio, etc.).

### APPLICATION

Design, development, and implementation of new technologies (methods, procedures, and applications) to ensure the following:

- plagiarism control,
- forgery control (with respect to image and sound),
- intelligent systems for searching information in a repository,
- intelligent systems for searching information in other network and Internet based systems,
- analyses and processing of mass data,
- effective methods of searching massive databases (proteins, amino acids, composite materials, chemical compounds, etc.).

The works will be performed both at the stage of information search in heavily compressed text data and text stored as digital and graphic images.

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## ANALYSIS OF OPINIONS, INCLUDING THE SPREAD OF OPINIONS AND INFORMATION

### RESEARCH

Many micro-social processes, such as social impact, the flow of information or the spread of opinion, happen through social relations in interpersonal interactions. Patterns and structures of interaction and contacts are important for the spread (diffusion) of information, opinions and attitudes. The spread is a process occurring when an opinion is being transmitted via specific channels of communication between members of a social system. Analysis of relevant patterns and structures is of paramount importance to the reach and speed of opinion dissemination.

### APPLICATION

identification of factors relevant to the speed and range of diffusion, such as identification of sources (seed selection), e.g. (with a limited budget) identification of persons and the order of their infection to maximise the range or speed of an advertising campaign, blocking or limiting the spread of rumours, negative opinions, (natural or computer) viruses, etc. when, for instance, one wants to identify key individuals who require inoculation in order to limit or stop the epidemic.

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## ANALYSIS OF PARALLELY PROCESSED LARGE DATA SETS (MAPREDUCE, BSP)

### RESEARCH

Analysis of large data sets (Big Data) is associated with the rapid development of new IT technologies for processing large data sets and the development of knowledge methods and algorithms for the extraction of knowledge from large data sets. Measuring and monitoring instrumentation, objects being included in the Internet, and social media generate vast amounts of data, whose processing is a new challenge for science and practice. Parallel processing is an analysis technique - a way to perform computation where many instructions are carried out at the same time.

### APPLICATION

Analysis of large data sets is a process aiming to obtain useful knowledge from databases. Techniques of this kind are applied wherever correlations between phenomena are sought. The method for exploring data can be used in many areas of life, such as the following:

- business applications,
- medical diagnostics,
- metrology,
- every field of business or science where large amounts of data are collected and examined.

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## ANALYSIS OF SOCIAL MEDIA

### RESEARCH

Social media analysis makes it possible to avoid crisis situations, make plans, and assess the effectiveness of communi-

cation with customers, as well as contribute to the planning of long-term marketing strategies, and identify the customer's needs and opinions.

### APPLICATION

Analysis of social media, such as:

- blogs,
- news services, wikipe-dias,
- micro-blogs (e.g. Twitter),
- social portals (e.g. Facebook or Google+),
- photo and video portals (e.g. YouTube or Instagram),
- discussion forums.

for the purpose of researching sentiment, needs, and opinions among their customers, as well as identifying the force of a product's impact on the Internet users.

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## ANALYSIS OF THE DYNAMICS OF COMPLEX, MULTIDIMENSIONAL, AND MULTI-LAYERED NETWORKS

### RESEARCH

Modelling complex systems, with correlated components of specific input and output quantities, is related to the identification of single elements with complex connections between them in mind.

### APPLICATION

Simultaneous analysis of various networks, e.g. ones created using Facebook, Twitter, Instagram, etc., aiming to examine complex processes and transfers between different net-

works. Example: analysis of how an advertising campaign carried out on Facebook can propagate itself to other services. Correlated networks can also have a completely different character, but an analysis of their co-dependencies can considerably affect their qualities such as reliability. Example: correlation between computer and power networks.

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## ANALYSIS OF SENTIMENT, ATTITUDE, AND EMOTIONS IN TEXT DATA, SENTIWORDNET

### RESEARCH

Analysis of sentiment consists in the identification of the character of a subjective judgement expressed by an author of a statement and placing it in one of the following three categories: a positive, negative, or neutral statement. The analysis is performed with specially designed machine learning algorithms and specialised dictionaries supported by natural language processing tools and methods applied primarily to monitor content published on the Internet.

### APPLICATION

The results of sentiment analysis can be applied for the following purposes:

- a basis for the evaluation of marketing campaigns and benchmarking (comparisons against the competition),
- studies of communities' attitude to a product, brand, or person (e.g. a politician).

Studies of a society's attitude along with the determination of the key words and phrases make it possible to determine what qualities of a product, or a person, are perceived negatively, thus streamlining quality management.

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## ANALYSIS OF SOCIAL NETWORKS, ANALYSIS OF SOCIAL GROUPS

### RESEARCH

Social Network Analysis is a modern and increasingly popular tool enabling studies of complex, i.e. multi-element and multi-level structures of relations between various social entities. This tool, deep-rooted in many disciplines (computer science, physics, mathematics, sociology, anthropology, chemistry, statistics, etc.), responds to the challenges related to the process of the shaping of the complex structure of the network society and the development of a knowledge-based economy.

### APPLICATION

With the development of relevant software solutions, Social Network Analysis has become an important research tool used not only in science but also in business, and the following fields thereof in particular:

- consultancy services supporting various aspects of management,
- analysis of social media and customer behaviour trends,
- directed marketing,
- spread of information and opinions in customer networks,
- limitation of customer retention,
- analysis of customer behaviours and needs.

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## APPLICATION OF SEMANTIC METADATA TO ANALYSE DATA FROM NEW PERSPECTIVES

### TECHNOLOGY

Currently, documents, companies, people, products, and events can be identified with a so-called URI, which is an identifier most often beginning with `http://` or `https://`. Using URI results in creating links between objects, which should be understood as relations (Linked Data). These relations can be analysed on many levels, e.g. with respect to their coherence and conformity. On the basis of these principles, a method was developed to allow analyses and then establish a ranking to present search results for specific objects.

The technology presented here enables the following, among other things:

- development of dedicated solutions related to searching for content depending on assumed context and maintaining coherence and conformity of the outcome collection, on the basis of pre-set relevance thresholds, grouping documents in a collection,
- improving document rankings.

### APPLICATION

The technology's applications include the following:

- analysis of commonly available information about businesses, people, or products,
- grouping and organising documents.

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## ARITHMETIC AND CODING

### TRAINING

Computer arithmetic and construction of digital circuits. Design and application of corrective codes in digital transmission.

### APPLICATION

Acquisition of knowledge and practical skills.

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## AUDIT OF APPLICATIONS' SECURITY

### EXPERT REPORT

The audit of applications' security aims to detect all susceptibility, vulnerabilities, and non-compliance with safe programming practices and, if applicable, the security policy of the environment in which the application is used. Both dynamic tests (the blackbox method) are carried out as well as static code analysis (the whitebox method). If application source codes are unavailable, reverse engineering methods, decompilation, and disassembling are applied. The tests result in a report describing each problematic area found, i.e. how it was detected, a possible way to use it, the extent of its vulnerability to attack, and a proposed way to eliminate the problem. The service can concern an application developed using any technology, e.g. a web application (Django, Ruby, On Rails, Spring, Node.js, etc.), as well as a network server written in a low-level language (e.g. C, C++, Objective-C).

### APPLICATION

The service enables the verification and improvement of an application's resistance to various classes of teleinformatic attacks. Moreover, a security audit helps maintain compliance with legal regulations related to data security, and personal data in particular.

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## AUDIT OF COMPUTER SYSTEMS' SECURITY

### EXPERT REPORT

Comprehensive research into the security of local networks, computer systems connected to these networks, network infrastructure, and connection to the Internet (corporate website, demilitarised zone, firewall, and vpn).

### APPLICATION

Detection of weaknesses in computer systems as well as recommendations for remedy solutions.

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## BIOMETRY

### TECHNOLOGY

Algorithms for verification/identification of individuals based on their iris pattern.

### APPLICATION

The technology is applied to verify/identify an individual based on their iris pattern.

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## BLOCKCHAIN TECHNOLOGY

### TECHNOLOGY

The offer consists in the development of an analysis of solutions based on a so-called blockchain. Blockchain tech-



nology as a dispersed register of transactions is a reliable source of information about events, as it offers resistance to modifications guaranteed by the system's participants. This makes the technology a desired solution wherever a guarantee of register coherence and resistance to modification is required.

The following services are offered:

- design of blockchain-based solutions,
- analysis of the usefulness of solutions' migration to the blockchain technology,
- analysis of blockchain solutions' scalability,
- analysis of possibilities of use or integration with existing blockchain-based platforms.

#### APPLICATION

Blockchain solutions are being applied in a growing number of undertakings. Dispersed registers guarantee inviolability with a trusted third party missing, which makes them the right choice in fields such as health care, finance, or security (including teleinformatic security). They can be successfully implemented for the purpose of tracking the supply chain or commodities markets, which is why the unit's offer concerns an analysis of possible blockchain solutions in many sectors.

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## BUSINESS MODELLING AND SYSTEM ANALYSIS I

### RESEARCH

Taking advantage of the achievements of software engineering and data science, clients can perfect their software development processes by undertaking the following activities, among other things:

- building prediction models allowing the prediction of the complexity/time consumption of the delivery of particular tasks (e.g. user stories) supporting the processes of planning and estimating tasks' time and cost,
- identifying locations in software where quality assurance (QA) activities should be focused - e.g. code reviews or tests - to minimise the number of defects in the software provided to the client, as well as the time and cost of software quality assurance.

The improvement of processes (including QA) makes it possible to reduce costs (e.g. see <https://doi.org/10.1515/fcds-2018-0002>). Know-how in the field where software engineering and data science meet can ensure that a company achieves a competitive advantage as well as improving the quality of its software and increasing the speed of its production.

Read more on: [www.madeyski.e-informatyka.pl](http://www.madeyski.e-informatyka.pl), [www.twitter.com/LechMadeyski](https://twitter.com/LechMadeyski)

#### APPLICATION

Prediction models applied to predict the following:

- software defects, also in real time, with feedback for developers (they make it possible to perfect the processes of software development and ultimately deliver better quality software),
- the complexity of project tasks, e.g. user stories (they support the processes of planning and estimating the time and cost of task delivery).

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## BUSINESS MODELLING AND SYSTEM ANALYSIS II

### RESEARCH

Business modelling is the first stage in the production of software systems designed to support business activities of enterprises. It allows the description and understanding of

### EXPERT REPORT

the context in which the system is intended to operate while providing the basis for the identification of the requirements of the software to be developed. In addition, business modelling allows the improvement (reorganisation) of existing business processes.

Analysis of the system follows the requirement identification phase, resulting in the specification of software requirements in terms of interaction scenarios, definitions of interface prototypes, and information models. In this sense, specification can serve as a basis for making design-related decisions, defining test cases, or producing user manuals.

#### APPLICATION

- development and evaluation of business models specified in select notations and modelling languages (e.g. BPMN, UML, OCL, or ERD),
- specification and evaluation of business rules (such as RuleSpeak, SBVR, UML, and OCL),
- development and evaluation of analytical models specified in select notations and modelling languages (e.g. UML, OCL, or SysML),
- studies of analytical models' conformity with business models.

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## COMPUTER GRAPHICS AND IMAGE PROCESSING

### RESEARCH

The scope of research performed includes the following:

- modelling and visualisation of 3D scenes,
- analysis of digital images' integrity,
- recording motion using optical methods.

We perform research work in the following fields:

- exploration of data related to association rules,

- data grouping,
- prediction models,
- applications of data exploration methods in biomedicine.

### APPLICATION

- 3D scenes modelling and visualisation,
- analysis of digital image integrity,
- analysis of large sets of information with emphasis on detecting hidden dependencies between data.

#### Contact information

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## COURSE IN C# PROGRAMMING LANGUAGE FOR EMPLOYEES - INTRODUCTION

### TRAINING

- the offer caters to the needs of employees of companies operating in Lower Silesia and focuses on C#, one of the currently popular programming languages,
- the training is delivered most often by students in the last years of their degree programmes, active members of the Scientific Circle EKA.NET, the Faculty of Electronics, which cooperates with the company Microsoft.

### APPLICATION

Training for employees of companies running their own IT centres and operating in various industries.

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## COURSE IN JAVASCRIPT PROGRAMMING LANGUAGE FOR EMPLOYEES

### TRAINING

- "Simply extraordinary results using the JavaScript language" caters to employees of companies operating in Lower Silesia and focuses on JavaScript, one of the currently very popular programming languages,
- JavaScript primarily enables easy and attractive computer graphics,
- the training is delivered most often by students in the last years of their degree programmes, active members of the Scientific Circle EKA.NET at the Faculty of Electronics, which cooperates with the company Microsoft.

### APPLICATION

JavaScript training programme caters to employees of companies running their own IT centres and operating in various industries.

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## CYBERSECURITY

### TECHNOLOGY TRAINING

- audit of systems' security,
- implementation of copyright protection procedures,

Training in the following areas:

- cryptography and cryptographic algorithms underpinning modern information protection systems,
- security and protection of computer systems,
- analyses of computer and network systems' security,
- security audits and penetration tests,
- security of mobile devices and wireless communication,
- security in the area of writing and developing applications (defensive programming methods, testing, etc.).

Analyses and expert opinions in the following areas:

- security of cryptographic algorithms intended for data protection,
- security of cryptographic devices,
- security of data protection devices and systems,
- analysis of computer systems security,
- security of access to IT systems and applications of appropriate authorisation methods,
- security in WSN and IoT networks,
- development of specifications of security requirements for electronic data protection systems,
- configuration and deployment of computer systems and networks security tools as well as systems detecting and counteracting attacks on computer systems (IDS, IPS), firewall systems,
- analysis of the security of microprocessor based cards applied in electronic ID documents,
- training in computer systems and networks security,
- training in programming using SSL,
- participation in the development of courses in security for the needs of BAITSE and ENGENSEC projects.

### APPLICATION

Development and implementation of technologies for the following purposes:

- secure and confidential storage of digital data,
- procedures of protection from deliberate attacks from the outside,
- procedures of protection from accidental hardware failures,
- methods of preventing unauthorised users from access,
- procedures for granting and monitoring users' authorisations in the large-scale access model,
- preventing unauthorised copying of digital resources,
- copyright protection.

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## DATA ANALYSIS AND EXPLORATION

### RESEARCH

Data exploration, also referred to as Knowledge Discovery in Databases and Database Mining, consists in automatic discovery of non-trivial and previously unknown dependencies, relations, similarities, or trends - generally called patterns - in large data repositories. Sources containing patterns discovered in the exploration process most often take the form of logical rules, classifiers, (e.g. decision trees), separated groups, etc.

### APPLICATION

The purpose of the exploration is to analyse data and processes to gain more extensive knowledge and understanding of them. Automatic data exploration opens new opportunities in the area of extracting useful knowledge from data sets and their practical application for the improvement of existing processes and services, or their better adjustment to users' needs.

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## DESIGN AND OPTIMISATION OF TELEINFORMATIC SYSTEMS AND NETWORKS

### RESEARCH

The design and optimisation of ICT systems and networks is a complex endeavour. If big systems are designed, it is necessary to develop a mathematical model enabling effective optimisation of the system/network being considered. The next step consists in the development of an algorithm

to optimise this model using exact or heuristic methods in order to obtain optimal or suboptimal results. This allows one to achieve a solution that minimises the cost of developing a system or network which meets the user's essential requirements, including those related to the quality of service and reliability. The support offered by the unit applies to the design and optimisation process of ICT systems and networks – including the development of an ICT system or network from scratch as well as the modernisation of existing ICT systems and networks. Extensive knowledge and experience of the use of advanced modelling and optimisation is employed in the works to guarantee exceptional quality of the result.

### APPLICATION

Issues related to system and network design and optimisation are widely applied in many areas of the economy. Among others, they are used by the following types of entities:

- telecom operators,
- companies and institutions with their own ICT systems and networks,
- providers of distributed computing, including cloud computing, consulting companies providing expert services in the area of ICT systems and networks,
- companies offering online services.

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## DEVELOPMENT OF PERSONAL AND ADAPTIVE E-LEARNING COURSES

### TECHNOLOGY

Research shows that fine-tuning educational material to the user's needs and preferences increases their motivation to

learn, thus ensuring their attainment of better results over a shorter time. The offer consists in the personalisation of the learning process at each stage of education. At the very beginning, information on the user is collected and their needs, preferences, learning styles, interests, or features of character, are identified. Next, based on the data collected, the system uses appropriate methods to generate a learning scenario (selection of materials, materials order, and the form of their presentation) best-suited to the student. The learning process is strictly connected with the knowledge evaluation process, which is also personalised. If the student has problems mastering the material, there are also methods of modification of the learning scenario so that it better matches the student's characteristics.

### APPLICATION

- at educational institutions, as an alternative to the classic lessons; as compensatory lessons for weaker performers; as an opportunity to develop best students' skills and broaden their knowledge,
- in companies, to deliver training - it ensures economy of time (an opportunity to have extra training when employees find it most suitable) and financial outlay (a training programme once prepared can be used for many years, for many employees, and without other people's help or supervision).

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## E-LEARNING

### TECHNOLOGY

- new methods of quick and low-cost development of electronic educational materials,
- new multimedia e-learning methods,
- maintenance of a repository of electronic lectures.

## APPLICATION

Design, development, and implementation of new technologies for the following purposes:

- quick and low-cost preparation of classes (lectures, practical classes, examinations, etc.) in the electronic form, for a mass audience,
- delivery of practical laboratory classes in a virtual and remote manner,
- applications of various new multimedia forms in the area of e-learning,
- evaluation of the effectiveness of remote classes,
- development and management of e-lesson recording standards,
- collecting e-lectures in a digital repository,
- effective management of a database of e-lectures,
- development of a system for automatic adjustment of classes' difficulty level to the user's knowledge and activity (University of the Third Age, extraction of knowledge from the user's activity).

The Laboratory enables the use of experiences provided by existing e-learning platforms.

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## EVALUATIONS, ANALYSES, AND CONSULTANCY IN THE FIELD OF BROADLY UNDERSTOOD IT AND TELEINFORMATICS

### EXPERT REPORT

- expert opinions and evaluations with respect to acknowledging technological knowledge as a new technology,
- pre-implementation analysis of IT systems,
- analysis of the state of information, review of concepts and project assumptions and principles for the implementation of teleinformatic technologies,
- analysis of users' requirements, issuing opinions on projects and providing relevant consultancy services,
- development of feasibility studies of IT systems,

- evaluation of the technical value of business proposals with respect to informatisation,
- assistance in the area of drawing up tender documentation (Specifications of Essential Terms of Contract) consisting in identifying requirements and selecting proper IT and teleinformatic systems,
- comparative analyses of hardware and software based IT solutions,
- development of decision support systems using smart methods and other optimisation techniques for problems related to planning teleinformatic networks,
- making resource sharing plans, and planning production stages, among other things.

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## EVALUATIONS IN THE FIELD OF IT SYSTEMS AND TECHNOLOGIES

### EXPERT REPORT

Analysis and empirical studies of IT systems and computer networks (hardware, setting up, etc.), software, data processing algorithms, and security procedure). The analyses are conducted with respect to the following criteria:

- effectiveness,
- reliability,
- data validation,
- security,
- efficiency.

The analysis results in identification of correlations, the system's potential errors and weaknesses, as well as causes of its malfunction.

### APPLICATION

- issuing opinions on an IT system's innovativeness,
- evaluations of the correctness of a system's design and implementation,

- recommendations with respect to improvements of reliability, security, and effectiveness.

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## INFERENCE FOR NETWORK DATA

### RESEARCH

Probabilistic inference consists in updating a conviction of hypotheses' truthfulness when certain observations (premises) occur. Regardless of the network structure, the following cases are considered:

- a specific case of inference (determination of the distribution of probability for a single hypothesis),
- a general case (determination of the distribution of probability for all hypotheses).

### APPLICATION

Relational learning enables the acquisition of extra knowledge of networks, and particularly knowledge related to an individual's profile (gender, age, interests, characteristics, etc.) in a situation where one's knowledge is related to only a small number of individuals in a network, with correlations between individuals being an important or even the only source of information.

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## IT PROJECT MANAGEMENT

### EXPERT REPORT

Management of IT projects is an issue involving management aspects related to both soft and technical competences. Our team's substantive knowledge and experience allow us to include all key elements of management in an IT project, from the feasibility study to the stage of post-implementation support. Audits and evaluations offered in the area of various types of IT projects and numerous successfully completed projects made it possible to develop standards, methods, and solutions making it possible to manage projects effectively, both on the part of the supplier and the ordering party. Extensive professional practice allows the unit's staff to perform evaluations in the areas of project scheduling and budgeting, as well as substantive assessments of all significant aspects of projects, with special emphasis on analyses of structural models with respect to business and database logic and projects' behavioural elements.

### APPLICATION

The above-described expert support for institutions and entities conducting IT projects as suppliers and ordering parties will allow an independent view of undertakings being executed, and thus an objective evaluation of set goals and ways to achieve them.

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## INTEGRATION AND MAPPING OF ONTOLOGIES

### TECHNOLOGY

In business conditions, there is an increasing need for integration of independent computer systems enabling the exchange of data used by these networks while ensuring their accuracy, and consistency and independence of the source systems. Commonly used relational databases may not be sufficiently expressive and flexible, and the data to be stored in them is characterised by increasing diversity in terms of content, structure, and size. One solution to the above problems may be the use of ontology, which is an increasingly popular method of knowledge representation in computer systems. It can be used in a very simplified form, containing only taxonomy of certain terms, as well as complex and semantically rich descriptions of the adopted area of knowledge. Among related issues of significant practical importance are methods of mutual reproduction of ontologies determining fragments of two ontologies that refer to the same objects in a similar manner.

### APPLICATION

Data integration in enterprises whose operation is based on frequent exchange of data with other organisations. Optimisation of the IT system operation in companies using a few independent computer systems whose communication is required not only in terms of physical exchange of data but also a semantic exchange of knowledge.

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## INTEGRATION OF DATA AND KNOWLEDGE FROM AUTONOMOUS SOURCES

### TECHNOLOGY

Knowledge management systems can use different kinds of data or knowledge sources, and in particular retrieve data from external applications and databases. These sources may have heterogeneous structures, or be developed with different technologies and using different meta-models, for example an object-oriented and relational database. In such cases, combining them requires employing advanced methods and algorithms for data and knowledge integration, which will make it possible to use them within a single coherent system. Data sources can also function independently of each other, which requires additional functionality to ensure the operation of an entire system. This includes appropriate communication protocols and integration methods for incomplete or inconsistent data and knowledge. Despite these additional requirements, the use of a system with autonomous data and knowledge sources increases the system's resistance to unusual conditions as well as making it possible to obtain new results in the inferring process.

### APPLICATION

- better use of an enterprise's IT systems,
- development of new systems integrating data from multiple heterogeneous sources,
- inference on the basis of knowledge from various sources,
- development of systems supporting knowledge management.

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## KNOWLEDGE EXTRACTION FROM MASS DATA

### TECHNOLOGY TRAINING

- analysis of mass data commissioned by the user,
- automatic system for extracting knowledge from the Internet resources,
- data analysis (including large volume data) using machine learning methods and data mining,
- development of classification and regression models, models based on unsupervised learning algorithms using feature selection/volume reduction methods. Example scenarios: development of production quality evaluation methods on the basis of data from the production status monitoring system; development of methods for early detection/signalling of emergency situations on the basis of monitoring of the process/system status,
- analysis of data in the field of bioinformatics, including data from massive – throughput studies (e.g. micro-matrix studies), pathway analysis/gene set analysis,
- design and production of an environment prototype for data analysis in the areas specified above,
- training and consultancy services in the areas specified above.

### APPLICATION

Development and implementation of new technologies, such as machine learning and artificial intelligence, in the following areas:

- extraction of knowledge from digital resources,
- application of extraction methods in e-learning.

The laboratory studies also concern using the data mining technology, among other ones, to enable the following:

- determination of relations between categories of knowledge being sought along with other categories (in prediction and association),
- clustering (grouping) data (e.g. related to users) with similar characteristics.

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## LPWAN NETWORKS FOR THE INTERNET OF THINGS

### TECHNOLOGY

- design of LPWAN networks for the Internet of Things,
- design of end devices.

The design work involves both hardware and software.

### APPLICATION

Networks used to connect devices such as water and gas meters, or smog sensors, to the Internet. A network designed at the unit can be applied to collect data from sensors spread across a large area (transmission range of more than a dozen kilometres).

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## MACHINE LEARNING AND CLASSIFICATION

### RESEARCH

Machine learning, or learning machines, is a relatively young and rapidly developing field, which is one of the sciences dealing with artificial intelligence (AI). It is an interdisciplinary science, with particular emphasis on areas such as computer science, robotics, and statistics. Its main objective is the practical application of achievements in the field of artificial intelligence in the development of an automatic system, capable of self-improvement through accumulated experience (i.e. data) and the acquisition of new knowledge on this basis. Machine learning is a consequence of the development of the idea of artificial intelligence and the methods of its practical implementation.

### APPLICATION

Machine learning keeps finding new practical applications.

In the future, every aspect of technology will involve some form of implementation of machine learning algorithms, for example:

- speech recognition,
- machine translation,
- navigation and control of vehicles, as well as route finding,
- automation of manufacturing and mining systems,
- disease diagnosis on the basis of symptoms,
- medicine-based therapy modelling,
- handwriting recognition,
- prediction of trends in financial markets on the basis of economic data.

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## METHODS AND ALGORITHMS OF MACHINE LEARNING AND MODELLING AND IDENTIFICATION OF COMPLEX SYSTEMS

### RESEARCH

The offer's scope includes the applications of the methods of systemic analysis in the area of IT systems design, with the following in particular:

- modelling and identification of different types of objects, including identification of complex systems,
- machine learning methods and algorithms, image recognition methods and algorithms.

### APPLICATION

Results of the research conducted are used for the purpose of developing the application of IT in various fields. The methods developed are useful in areas including the following:

- biomedical engineering,
- image processing,
- robotics,
- intelligent decision support systems as well as systems for the development of knowledge exploration algorithms.

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## MODELLING, ANALYSIS, AND OPTIMISATION OF MANUFACTURING PROCESSES

### TECHNOLOGY

Modelling real-life business processes requires an efficient language capable of expressing their key aspects and elements. The existing solutions, such as BPMN2, are oriented towards managerial approaches based on the idea of instances of processes with flowing tokens representing the activity of a given process element. Real-life business processes are not instance-based, i.e. they rely on the concept of continuous or discrete change of the states of particular elements of the industrial system where there is a flow of resources and information, including control signals as well as component monitoring signals. Intensive research carried out has led to the development of a method for describing this type of phenomena in a comprehensive manner using a single descriptive language. The construction of a complete and correct model is the key to the analysis of complex industrial process systems in terms of assessing their effectiveness, optimisation, and risk management.

### APPLICATION

- development of a map of the enterprise's business processes,
- optimisation of systems' performance,
- reorganisation of enterprises using the process-based approach,
- development of document circulation systems.

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## MULTI-LABEL CLASSIFICATION

### RESEARCH

Multi-label classification refers to a situation where each of the observed objects is described using explanatory variables and a set of labels - classes assigned to them. A model which allows the prediction of the right set of labels for new objects described by already known features is developed based on learning data.

### APPLICATION

Multi-label classification methods are used in such fields such as the following:

- text categorisation,
- automatic annotation of images,
- genomics, and many other ones.

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## PARALLEL OPTIMISATION ALGORITHMS

### RESEARCH

- optimisation of production, logistics, and computation-heavy problems,
- implementation of time-consuming algorithms on parallel machines (GPU, multi-GPU, coprocessors, and computation clusters).

### APPLICATION

The application of the research involves the design and implementation of fast parallel optimisation algorithms for issues such as matrix computation, task sequencing, production scheduling (very large problem instances or real-time planning), transport optimisation, and operational planning, allowing for data uncertainty.

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## RECOMMENDATION, DESIGN, AND IMPLEMENTATION OF SYSTEMS BASED ON THE SOA PARADIGM, ALONG WITH ISSUING CERTIFICATES OF INNOVATION WITH RESPECT TO SERVICE-ORIENTED SYSTEMS

### RESEARCH

Services related to recommending, designing, and implementing systems based on the SOA paradigm (Service Oriented Architecture) as well as issuing innovativeness certificates for service-oriented systems.

Audits of web and mobile systems' usefulness employing the following methods:

- expert assessment: experts' work enables the determination of the degree of a product's conformity with standard project principles, commonly applied heuristics, and other criteria,
- focus studies: the result of a session with users is remarks, comments, and arguments related to the product under examination,
- tests with individual users involved: their basis is observation of a user performing set tasks, when working with the products being examined, also using thermovision and EEG cameras for monitoring the user's emotional states, click-tracking: a research technique consisting in recording the places of clicks across the user's graphic interface,



- eye-tracking: a technique making it possible to record the user's eye focus point during their work with a product.

Research and development of solutions with respect to modelling users of information systems.

Research and solutions with respect to the application of natural user interfaces in systems using the following technologies:

- touch screens,
- motion sensors,
- Augmented Reality (AR) and Virtual Reality (VR) systems,
- diverse built-in systems (e.g. production of interactive large-size systems).

### APPLICATION

The following types of entities are potential users of the laboratory's services:

- organisations developing various IT systems, where human-computer interaction is a considerable aspect of the system's operation,
- organisations which purchase diverse IT solutions, seeking independent auditors of the quality of interactions of products delivered or ones under development.

#### Contact information

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## REMOTE ACCESS TO DIGITAL RESOURCES

### TECHNOLOGY

- new tools for quick publication of electronic magazines, bulletins, newspapers, etc.,

- new applications for mobile devices offering access to digital resources,
- virtual reality in access to digital resources,
- new technologies offering access to mass resources,
- automatic reading of text and speech recognition,
- monitoring and analysis of network traffic, including the availability of services,
- development of replicated services.

### APPLICATION

Development and implementation of new technologies (procedure and software) and evaluation of solutions' effectiveness for the following purposes:

- safe and quick sharing of library resources with the mass recipient,
- quick publication of electronic magazines, bulletins, and newspapers,
- access to digital resources via a computer network (also a wireless one); it primarily concerns availability and load, as well as access procedures (rental life time, partial access, and on-line access),
- transparent databases, specialised browsers (also ones for mobile devices) and plug-ins for existing browsers,
- dispersed audio and video streaming servers (e-learning), hardware for specialised multimedia forms (virtual reality, polysensory experience, e-paper, etc.), and development of relevant assessment criteria for access to data (scalability, search time, etc.).

Programming replicated services and mobile devices.

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## RESIDUE PROCESSORS

### TECHNOLOGY

Extremely fast processors based on residual arithmetic. Design of a processor circuit and, if needed, development of a prototype simulation.

### APPLICATION

Fast signal and image processing. Construction of fast digital filter circuits.

#### Contact information

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## PROFILING, CLASSIFICATION, AND CLUSTERING

### TECHNOLOGY

Profiling entities is a very effective mechanism for building a base of knowledge focused on a list of objects important for a given application. The objects can be business entities, public administration, and research units, e.g. current or potential clients, business partners, companies, or enterprises. Profiling consists in gradual searching for important information and processing it so that it complements the existing knowledge. Thanks to profiling, it is possible to effectively classify entities and assign to them pre-defined types/categories where they can be included, allowing for a specific set of characteristics and metrics with the entities' similarity being computed. Clustering of entities based on profiles built for them enables identification of clusters of entities that can be described as similar. The similarity depends on the adopted criteria and ways of evaluating it.

### APPLICATION

The primary group of recipients of this solution are financial institutions, market research companies, and - most importantly - those dealing with consumer behaviour studies and institutions assessing and analysing various aspects of numerous populations of entities. The solution makes it possible to ensure considerable automation of the profiling and classification process, resulting in building effective decision-making systems based on data processed in this way.

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## SCHEDULING AND CONTROL IN TRANSPORT AND SERVICE SYSTEMS

 RESEARCH

Application of IT tools, such as Matlab, Python, LINGO, CPLEX, Wonderware InTouch, Step7 MicroWin, S7 TIA Portal, or PAccess to perform the following tasks:

- analysis and visualisation of computer-modelled and real-life control systems based on Siemens PLC controllers, PCs as well as Modbus, AS-i, and Profibus networks,
- design, implementation, and simulation of task scheduling algorithms, including heuristic and intelligent algorithms.

 APPLICATION

- scheduling and optimisation of production, service, and transport processes (the work of drivers, timetables and passenger/cargo transport schemes in road and rail transport),
- design and tests of human-machine interface systems based on Siemens PLC controllers, including creating HMI using Wonderware InTouch for PC, (Web interfaces or mobile applications),
- experimental evaluation of the effectiveness of intelligent control and scheduling algorithms.

 Contact information

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## SERVICES IN THE AREA OF DEVELOPMENT, CIRCULATION, AND MANAGEMENT OF INTELLIGENT ELECTRONIC DOCUMENTS

 TECHNOLOGY

A system for drawing up, circulating, and managing intelligent electronic documents, i.e:

- developing and editing electronic documents,
- converting paper documents into electronic ones,
- developing and processing electronic questionnaires,
- processing paper and electronic surveys,
- handling digital elections.

 APPLICATION

The technology enables effective preparation and management of a repository of intelligent electronic documents (with features such as image, history of processing, digital signature, or processing procedure in their hidden part). The technology enables research into the following:

- forms of description and automatic generation of electronic documents,
- technology of drawing up documents,
- bases of intelligent electronic documents,
- tools for managing such documents.

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## SERVICES IN THE AREA OF INFORMATION TECHNOLOGY FOR THE BLIND AND VISUALLY IMPAIRED

 TECHNOLOGY

The laboratory's offering of scientific and research services:

- adaptation of educational materials (print-outs using the Braille alphabet and preparation of graphics for the blind and visually impaired),

- preparation of materials in the electronic version (using the Braille alphabet and enlarged letters),
- consultancy in the area of developing websites and mobile applications for disabled people and other ones endangered with digital exclusion,
- consultancy in the area of the universal design and implementation of e-learning and web systems in terms of being used by disabled people,
- review of cooperation with assistance technologies used in the most popular mobile systems,
- review of the usefulness of application support provided by external devices (keyboards, Braille rulers, etc.),
- dissemination of knowledge of the current advancements in the technologies for the blind and visually impaired,
- assistance with the selection of hardware and assisting software suited to the type and extent of the user's eyesight impairment.

 APPLICATION

The Laboratory designs, implements, and develops new methods of sharing information to enable the following:

- elimination of social and technical barriers to disabled people's accessing education,
- support for the mobility of people with impaired eyesight,
- development of teaching materials in an accessible form,
- practical use of the standards for technical content for people with impaired eyesight,
- delivery of training in the area IT for the blind and visually impaired.

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## SERVICES IN THE AREA OF MANAGEMENT, OPTIMISATION, AND SECURITY OF IT SYSTEMS

### TECHNOLOGY RESEARCH

The team members' knowledge, skills, and experience enable the delivery of tasks in the following fields:

- modelling users' requirements,
- analysis, optimisation, and management of service systems,
- analysis and optimisation using machine learning methods (e.g. in the area of transport, production systems, etc.),
- methods and algorithms for collecting, transferring, and processing stream data,
- design and development of the architecture of devices for the purpose of the Internet of Things (IoT),
- analysis and design of solutions in the areas of health care, transport, and production systems using the Internet of Things, as well as multimedia services and systems,
- design of solutions and methods of managing resources in heterogenic, cloud-based IT systems,
- control over the circulation and ensuring the quality of services in teleinformatic networks,
- analysis and methods of ensuring security and reliability for dispersed service systems.

### APPLICATION

The services offered, such tools and algorithms, as well as analytical methods, are applied in organisations, hailing from various business sectors, whose potential and success are strictly dependent on the quality of their IT systems. The purpose of the solutions offered is to develop and implement innovative methods for security, support for decision-making, optimisation, and machine learning to streamline business activity.

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## SMART DATA ANALYSIS SYSTEMS AND MACHINE LEARNING

### TECHNOLOGY EXPERT REPORT TRAINING

We offer analysis and problem-solving services related to data analysis, including the design of new algorithms based on machine learning methods and improvement of the effectiveness of decision-making algorithms applied in an organisation.

### APPLICATION

- advertising sector - design of advertising campaigns, including omni-channel marketing,
- banking,
- insurance,
- tourism,
- healthcare.

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## STUDIES IN THE AREA OF 3D VISUALISATION AND VIRTUAL PROTOTYPING

### TECHNOLOGY

The unit's works consist in the following types of research and services:

- photorealistic digital 3D visualisation, creation of virtual spaces,
- development of presentations (visualisations) of products based on virtual models (configurators),
- development of virtual product matrices (visual and functional matrices),
- development of methods for the communication between visualisation sys-

tems and documentation management systems - PDM/ERP),

- application of creative methods in research and project processes,
- development of materials using the 360 technology (video and photographs),
- development of presentations and video material using the 360 technology for VR purposes,
- development of VR based materials and systems,
- presentations with the application of VR goggles in mind,
- interactive VR and 360 video applications,
- rental of VR space and equipment (Samsung S8 VR portable goggles, VR HTC Vive goggles).

### APPLICATION

The Laboratory conducts studies in the field of 3D visualisation and virtual prototyping for the purpose of developing and implementing new designs, solutions, and technologies in the form of presentations and products' virtual matrices.

The services offered include the following:

- studies related to methods of product visualisation as well as presentation methods,
- digital and photorealistic 3D visualisation (spatial visualisation),
- development of visualisation methodologies and technologies using 3D - VRED software,
- interdisciplinary approach in 3D visualisation methods,
- development of product presentation (visualisation) methodologies based on virtual models (configurators),
- development of virtual matrices for products (visual and functional matrices),
- development of quick presentation systems applying products' visual matrices.

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## DESIGN, PRODUCTION AND STUDIES OF COMPOSITE STRUCTURES

### RESEARCH

Design, production (technology development), and studies of the following:

- high-pressure composite containers, including containers with an openable bottom,
- composite servo-motors,
- composite shafts,
- composite pipelines,
- other fibre-reinforced composite constructions.

Preferred technologies are the following:

- filament winding method and pultrusion,
- RTM,
- autoclave methods, etc.

We offer a wide range of research services, particularly with respect to composite materials and constructions.

### APPLICATION

- high-pressure storage of liquids and gases, e.g. CNG, LNG, air, and hydraulic oil,
- high-durability composite elements and constructions of machines and devices, transport medium.

Industries:

- machine construction,
- vehicle engineering,
- aviation,
- petrochemical,
- oil processing,
- weapons manufacturing.

### Contact information

Interdisciplinary Research and Development Team

for Heavy-Duty Composite Constructions

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## DESIGN, SIMULATION STUDIES AND CONSTRUCTION OF MECHATRONIC MECHANISMS AND SYSTEMS

### RESEARCH

The works performed at the unit entail the analysis and design of flat and spatial machine units, applied in practically all industry sectors. The unit's studies focus on the application of theoretical and operation-oriented aspects of mechanics, dynamics, kinematics, the theory of machines and mechanisms, robotics, and mechatronics in solving problems related to the design, operation and studies of machines. Another area of the research services offered involves the design of mechatronic systems with specific technical applications in mind. The works include the design, studies, simulations, and production of the mechanical part and propulsion systems.

The unit specifically offers the following:

- design of mechanisms, manipulators, mobile robots,
- computer simulation studies of machines,
- mechatronic design,
- design of robotic workstations and image analysis systems,
- design of human limb rehabilitation systems,
- experimental studies of machines and devices.

### APPLICATION

The works offered can be applied in the field of design and modernisation of machines used in technology, including the following:

- mining and drilling machines,
- robotic assembly and machining workstations,
- machine mechanisms,
- manipulators,
- mobile robots,
- rehabilitation devices.

### Contact information

Team of Mechatronics and Theory of Mechanisms

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## DEVELOPMENT OF WELDING AND BRAZE WELDING TECHNOLOGIES

### TECHNOLOGY

Development of welding and braze welding technologies.

The scope of the services offered includes the following:

- selection (development) of additional materials (fluxing agents, various forms of solders, gas shrouds, vacuum),
- test soldering and braze welding,
- a broad range of studies of joints: metallography studies, strength and technological tests, and measurements of hardness,
- training and consultancy services in the field of soldering and braze welding.

The unit's research team boasts extensive experience stemming from its 40 years' cooperation with industry.

### APPLICATION

Possibilities of application in many industry sectors, e.g.:

- automotive industry, power engineering,
- machine construction and operation.

### Contact information

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## DIAGNOSTIC TESTS OF AUTOMOTIVE VEHICLES

### RESEARCH

We offer diagnostic tests of geometric properties of automotive vehicles' wheels, suspension, and brake systems. The measurements are performed at the unit with devices including Hunter HawkEye WA 360 and a VTEQ diagnostics line.

## APPLICATION

The services offered aim to evaluate wheel, suspension, and brake systems in terms of construction and performance significant from the traffic safety standpoint. The studies can constitute an important evaluation tool in arbitration with respect to road traffic incidents.

### Contact information

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## EXPERIMENTAL STUDIES AND NUMERICAL SIMULATIONS IN FLUID FLOW MACHINES AND THEIR SYSTEMS

### RESEARCH

The Division of the Fundamentals of Fluid Flow Constructions and Machines conducts research activity in fields including hydraulic machines science, with respect to the following:

- physical modelling,
- identification of phenomena occurring in hydraulic operation processes of fluid flow machines and their systems,
- mathematical impact of construction parameters on fluid flow phenomena and energy-related changes occurring in them.

Studies performed at the unit in the area of modelling and forecasting hydraulic properties of fluid flow machines and the development of their design basics involve the following:

- mass transport machines and devices (pumps and hydraulic transport),
- using natural sources of energy (turbines and hydroelectric plants),
- hydrokinetic couplings and gears.

The unit boasts extensive experience in researching and optimising pump systems. The 300 sq m laboratory undertakes studies of model prototypes of fluid flow machines



and hydraulic devices with power outputs of up to 50 kW and efficiencies of up to 0.250 m<sup>3</sup>/s.

### APPLICATION

- numerical analysis of flow,
- strength analyses,
- optimisation of hydraulic fluid flow machines: pumps, water turbines, agitators, as well as hydrokinetic couplings and gears,
- studies of hydraulic machines and devices, including pumps and water turbines,
- simulation and optimisation of pump systems,
- energy-oriented audits of pump systems and arrays,
- design of pumps and water turbines,
- analyses of rivers' potential for water-power engineering applications,
- small hydroelectric plants.

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## FUNCTIONAL COATINGS: DESIGN, COATING PROCESSES, AND ANALYSIS OF PROPERTIES

### RESEARCH

- studies of properties of coatings applied using surface engineering methods (including composition, structure, hardness, and surface topography),
- development of processes consisting in the deposition and regeneration of coatings using plasma spraying (APS) and laser techniques,
- development of new coating materials,
- analyses of technological properties of powders used for spraying (APS),
- processes of manufacturing shell tools (e.g. stamping dies and injection moulds) for short prototype batches,

### APPLICATION

Anti-wear and functional coatings are applied in the following industry sectors:

- automotive,
- aviation,
- mining,
- machine construction and operation.

### Contact information

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– Fraunhofer Project Center  
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## FUNCTIONAL COATING TECHNOLOGY USING ATMOSPHERIC PLASMA SPRAYING (APS)

### TECHNOLOGY

- technologies for the production of coatings based on plasma spraying processes (APS) and laser techniques,
- adaptation of the composition and technology of coating deposition to the conditions of product use,
- implementation of hybrid processes of composite coating deposition, operational studies of coatings,
- development of evaluations in areas including analyses of coatings' properties, causes of damage to them, and possibilities of eliminating malfunctions.

### APPLICATION

- applying anti-corrosion, anti-erosion, anti-abrasion, and anti-cavitation coatings, as well as heat barriers (TBC),
- coatings deposited on components in industries including aviation, automotive, mining, power engineering, and medicine,
- production of Rapid Tooling (matrices, patrices, and stamping dies),
- regeneration of parts of machines and devices.

### Contact information

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## HYDRAULIC PROPULSION AND CONTROL, NUMERICAL METHODS

### RESEARCH

#### Design

- design and modernisation of hydraulic and electro-hydraulic components and systems,
- miniaturisation of hydraulic components,
- optimisation of hydraulic components and systems,
- participation in projects resulting in completely new technical solutions contracted by ordering parties representing the industry sector,
- quality evaluation and validation of hydraulic designs,
- methods of pressure pulse damping in hydraulic systems.

#### Numerical simulations

- simulation of dynamic phenomena in hydraulic components and systems,
- modelling the flow of viscous and compressible liquids allowing for thermodynamic changes,
- studies and calculations of multi-phase flows, e.g. flows with cavitation,
- strength calculations (MES) with respect to hydraulic components.

#### Test bed studies

- durability studies of hydraulic components,
- identification of phenomena related to the flow of working liquid in hydraulic systems.

#### Measurements and diagnostics

- diagnostics of hydraulic systems' and components' operational parameters, performed both at the Laboratory and with the real-life object,
- analysis and identification of hydraulic systems' malfunction.

## APPLICATION

The services offered cater to the needs of industrial companies, with emphasis on cooperation related to hydrostatic propulsion. The unit is equipped with unique test beds and stands for teaching purposes using power stations with an efficiency of 300 l/min. and maximum pressure of 42 MPa for studies of seals, cylinders, valves, including proportional slide valves, servomechanisms, as well as studies of cavitation, type and character of flow, and obliteration, as well as dynamic studies of hydraulic elements and systems.

### Contact information

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## INFRARED THERMOGRAPHY

### RESEARCH

The unit offers thermography studies in the infrared range between - 40°C and +2000°C with the accuracy of ±1°C. The studies are performed using the following methods:

qualitative method (location of thermal artefacts):

- determination of patterns in a thermographic image,
- checking airtightness of joints,
- analysis of electric installations,
- detection of damage to installations,
- medical applications,
- analysis of fluid flows.

quantitative method (analysis of thermographs):

- measurements of temperature,

- introduction of compensation,
- classification of problem seriousness.

## APPLICATION

The infrared thermography studies offered focus on thermal analysis of machines and devices. The service offered includes location of temperature fields and, on this basis, making conclusions about anomalies in devices' performance. The qualities determined at the unit include the following:

- loss of joints' airtightness,
- fluid flow in pipelines,
- correctness of electric installations' performance.

The research services offered also include medical thermography.

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## MATHEMATICAL MODELLING, EXPERIMENTAL STUDIES, AND CONTROL OF UNMANNED AERIAL VEHICLES

### RESEARCH

- numerical and experimental studies of unmanned aerial vehicles using a water tunnel,
- development of mathematical models of aerial vehicles' aerodynamic systems,
- development of control algorithms for unmanned vehicles.

## APPLICATION

- programming autopilots of unmanned vehicles,
- construction of unmanned vehicles' simulators,
- implementation of control algorithms in real-life aerial vehicles.

### Contact information

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## MEASUREMENTS OF MICROCLIMATE

### RESEARCH

The unit offers studies in the area of determining thermal microclimate by measuring and evaluating the following:

- local turbulence (Tu) intensity for the calculation of DR (Draft Rating),
- WBGT (wet-bulb temperature) index with or without solar radiation,
- WCI index (wind chill index),
- average radiation temperature,
- temperatures of the air at the height of the head (1.7 m for a standing person, 1.1 m for a sitting person),
- temperatures of the air at the height of the abdomen (1.1 m for a standing person, 0.6 m for a sitting person),
- temperatures of the air at the height of the ankle (0.1 m),
- temperatures at the floor level,
- temperatures of an AC powered radiometer.

## APPLICATION

The offer consists in the evaluation of the microclimate in closed spaces - both closed rooms in buildings and vehicles' cabs intended to be used by people - affecting the comfort of work of life in such spaces to a considerable extent. The evaluation of thermal comfort is directly reflected by the level of active and preventive safety, thus constituting an essential element of such measurements.

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## NUMERICAL MODELLING OF FLOWS AND HEAT EXCHANGE

### RESEARCH

- development of mathematical and numerical models related to flows and heat exchange,
- modelling compressible and incompressible flows,
- modelling cryogenic issues,
- OpenFOAM software.

### APPLICATION

- simulations of flows in various geometries, simulations of flows of fluids with different properties,
- simulations of heat exchange for various devices,
- studies of flows in various conditions,
- studies of heat exchange in various conditions.

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## OPERATIONAL TESTS OF AUTOMOTIVE VEHICLES

### RESEARCH

We offer tests of automotive vehicles with all types of power transmission. Studies and evaluations are performed as

- laboratory measurements of automotive vehicles: using a chassis dynamometer with DMC of up to 5.5 tons (including motorcycles) and maximum power of more than 1,000 kW,
- studies of real-life operation (RDE tests),
- studies using an engine test bed with a power output of up to 450 kW, aiming to evaluate fuel or energy consumption and combustion gas emissions in line with the latest standards,
- durability tests of combustion engines' components and systems, hybrid systems, and electric propulsion systems.

We perform studies using instrumentation including a low and high temperature chamber (from -20°C to +50°C), with dimensions of 5x5x4 m and featuring lamps simulating sunlight and PEMS combustion gas analysers.

Additionally, we have extensive workshop facilities allowing modernisation works or production of prototype elements. The above is ensured by well-qualified staff and the unit's technical equipment, including a 5-axis machine tool, 3D printer, diagnostic scanner, a system for measuring geometrical properties of suspension, and a fully equipped car servicing station.

### APPLICATION

The services offered by the unit include operational diagnostic and verification tests of both existing vehicles and prototypes, as well as their power transmission systems. The unit's research potential creates unlimited conditions for conducting a wide range of studies of vehicles and their components.

#### Contact information

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## PLASTICS PROCESSING

### TECHNOLOGY

Development of technologies for manufacturing plastic products, including the following:

- injection,
- extrusion,
- thermal forming,
- injection mould constructions,
- extrusion head constructions,
- templets for thermal forming.

### APPLICATION

The technology development enables the start-up or modernisation of production in an enterprise within the scope defined by the ordering party.

#### Contact information

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## REVERSE ENGINEERING, 3D DIGITISATION AND COMPUTER TOMOGRAPHY

### RESEARCH

We offer services consisting in the digitisation of physical objects into 3D computer models using contact measurement, optical, and large-size methods, as well as computer tomography. The resulting 3D models can have various forms, depending on the planned application - from a triangle mesh, through a set of NURBS surfaces, to a fully parameterised model body.

The laboratory has a certification conferred by the Polish Centre for Accreditation attesting to its management system's compliance with the standard PN-EN ISO/IEC 17025:2005.

### APPLICATION

Data obtained through 3D measurements, after appropriate processing, can constitute a basis for the following tasks:

- comparison of products with their construction models as well as between
- one another - quality control and inspection,
- design works - development of new products based on digitised 3D shapes,
- computation analyses - numerical simulations of structures' strength, fluid and gas flows, thermal and electromagnetic phenomena, etc.,
- other applications using 3D computer models.



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## SIMULATIONS AND EXPERIMENTAL STUDIES OF MACHINES

### RESEARCH

Scientific and research activity related to the issues of computer simulations at the stages of designing new machines, devices, and vehicles, as well as modernisation of existing ones. Moreover, simulations of fluid and gas flows (FLU-ENT) are performed. Another area of the unit's activity is implementation works and the development of innovative solutions. In addition, experimental studies of machines are conducted, comprising the following:

- measurements of deformations, frequency of proper and forced vibrations of machine structures,
- measurements performed using a fast camera during crash-tests of machines' and devices' protective elements,
- strength tests of power devices in thermal and dynamic load conditions,
- scanning the geometry of machines' carrying structures,
- non-destructive defectoscopic NDT studies,
- measurements with an acoustic camera,
- thermovision measurements.

### APPLICATION

- evaluation of machines' and devices' technical condition,
- analysis of existing machines and devices or ones being designed in terms of strength,
- dynamic, thermal, and fatigue analysis of machine constructions,
- design of new machines and devices,
- design of mechatronic measurement systems,

- impact simulations (crash-tests),
- modernisation of existing machines and devices,
- identification of cracks in machines' carrying structures,
- ballistic simulations and measurements.

#### Contact information

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## STUDIES AND HEAT CALCULATIONS OF POWER MACHINES AND DEVICES

### RESEARCH

We offer studies and measurements in the area of heat and mass transport in power machines and devices. The main scope of the research works offered is as follows:

- heat and mass balance,
- thermographic and thermogravimetric analyses,
- studies of thermal comfort in rooms or vehicles,
- thermodynamic studies of dynamic phenomena, e.g. explosions or combustion in combustion engines.

### APPLICATION

The research services offered by the unit aim to identify the energy demand and energy yield in devices and machines. The studies and calculations carried out at the unit primarily concern combustion engines, pyrolytic installations, and gasification installations. Thermal anomalies constitute a basis for inferring incorrect operation of devices; areas of damage are located and the extent of problems is identified.

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## STUDIES AND OPTIMISATION OF TECHNICAL SYSTEMS' MAINTENANCE PROCESSES

### RESEARCH

The services offered by the unit consist in studies and optimisation of technical systems' maintenance, including the following:

- measurement and analysis of statistical data related to damage to technical facilities and systems,
- selection of maintenance and repair strategies,
- determination of the terminal life cycle of technical facilities,
- estimation of the profitability of reusing replaceable components,
- planning supply materials and spare parts procurement,
- evaluation of technical systems' reliability and security,
- development of knowledge bases concerning machines' reliability and security using specialists' expertise,
- design of a system for evaluating processes of technical facilities operation based on quantitative measurements and using a set of dedicated indices and metrics.

### APPLICATION

The research works offered are applied for purposes including the following:

- selection of the type and frequency of maintenance actions depending on the considerations of the operation process (e.g. number of facilities, susceptibility to damage, repair facilities owned, etc.),
- improvement of technical systems' reliability (e.g. minimising production lines' down time), determination of the cost-effectiveness of replacing a technical facility with a new one, determination of optimal parameters of managing stocks while ensuring the fulfilment of the service strategy selected, development of a knowledge base concerning the operation of facilities as well as an evaluation system supporting managers' decision-making processes.

#### Contact information

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## STUDIES OF SEALS AND INDUSTRIAL FITTINGS

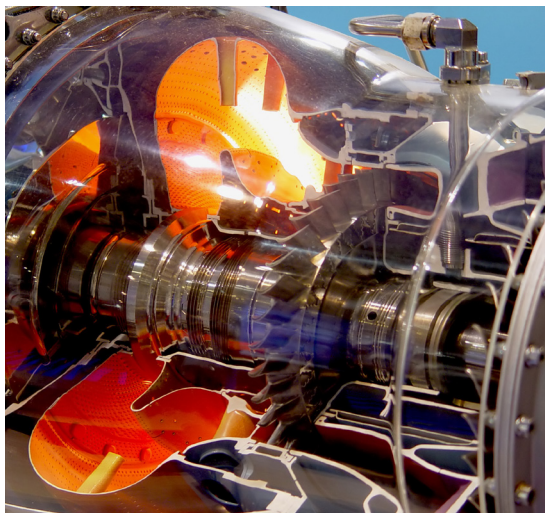
### RESEARCH

The offer includes the following:

- flow studies of valves,
- studies of external and internal leaktightness of valves,
- strength and fatigue studies of valve elements,
- studies of valves at an increased and decreased temperature,
- studies of static seals at different temperatures,
- studies of seals for rotational motion,
- numerical analyses of flows (CFD) and solid bodies (MES),
- designs and calculations with respect to complex high-power pipelines.

### APPLICATION

The recommended scope of works can be applied in the design and operation of industrial fittings and related componentry and installations.



### Contact information

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## TUNING OF COMBUSTION ENGINES

### RESEARCH

The unit offers works oriented towards the tuning of existing combustion engines and design of new ones, according to the ordering party's needs. The detailed tasks performed are as follows:

- analysis of needs and determination of engine types,
- gas dynamics calculations using CFD methods,
- production of a combustion engine head using a CNC tool,
- modernisation of the engine block and connecting rods using a CNC tool,
- design of new or modification of existing maps controlling the engine,
- design and production of new engine controllers.

### APPLICATION

The services offered consist in fine-tuning combustion engines to the ordering party's needs. The detailed offering includes the following:

- increasing an engine's power or torque,
- improving a combustion engine's efficiency,
- decreasing combustion gas emissions - in particular toxic compounds,
- adjusting a combustion engine's characteristics to needs involving special tasks,
- adjusting an engine to another type of fuel (LNG, CNG).

### Contact information

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## VIBROACOUSTIC DIAGNOSIS OF MACHINES AND DEVICES

### RESEARCH

Measurements and diagnostics

- location of sources of vibrations and noise produced by machines and devices using an acoustic probe or holography,
- measurements of noise and vibrations, including measurements in an at-tested reverberation chamber,
- reduction of vibrations and noise produced by machines and devices,
- development of methods for controlling emissions,
- design of vibroinsulation systems,
- vibroacoustic synthesis of machines, objects, and signals, as well as application of vibroacoustic signals for diagnostic purposes,
- evaluation of the harmfulness of vibroacoustic processes,
- technical evaluation with respect to permissible (standard) levels,
- identification of ways of energy propagation in the environment.

### APPLICATION

The services offered by the unit cater to industrial enterprises with particular emphasis on cooperation in the area of vibroacoustic diagnosis of machines and devices. The instrumentation and infrastructure (reverberation chamber) at the unit's disposal allows studies in the area of evaluation and identification of vibroacoustic energy sources in machines and devices. We are Poland's only research unit authorised to validate hydraulic components and systems in terms of noise emission. Moreover, we provide services for the automotive industry, as well as sectors including aviation, mining, and construction.

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## ACCOUNTANCY FOR MICRO-, SMALL, AND MID-SIZED ENTERPRISES

### TRAINING

The purpose of the training programme is to familiarise the participants with the basics of business accounts with emphasis on the specificity of micro-, small, and mid-sized enterprises. The training comprises two parts. The first part focuses on the basics of financial accounting, i.e.:

- posting business transactions and keeping records of the costs of business operation,
- documentation correctness,
- drawing up basic financial statements (balance sheet and profit and loss account),
- establishing the financial result as tax base.

The second part of the training will concern basic issues of management accounting, chiefly cost calculation and planning for the purpose of minimising the enterprise's losses.

### APPLICATION

The training will allow entrepreneurs hailing from the SMB sector to maintain their business accounts on their own allowing for applicable legal regulations. The added value of the programme is the knowledge of establishing revenues and costs of business operation, as well as forecasting profits.

#### Contact information

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## ANALYSIS AND EVALUATION OF INTELLECTUAL PROPERTY PROTECTION MANAGEMENT SYSTEMS IN SMB'S AND OTHER ORGANISATIONS

### EXPERT REPORT

Selection of the most favourable variant of protection and methods of its shaping, depending on the market conditions and other strategic determinants (e.g. mergers, takeovers, strategic cooperation, etc.). The scope of the unit's expert services comprises both one-off undertakings and long-term, consistent maintenance of a company's intellectual protection management system, in the institutional and external dimensions (know-how protection, the company's sensitive information, etc.).

### APPLICATION

The unit offers studies and expert reports in the following areas:

- procedures and regulations,
- templates of agreements including provisions related to intellectual property protection,
- design of a process-based approach to protection,
- diagnostic reports, etc.

Field studies for SMB's are applied to obtain cross-sectional contexts of knowledge with respect to the following: business models applying intellectual property protection, the scope of intellectual property protection solutions along with relevant preferences, as well as managers' awareness of the matter.

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## ANALYSIS AND SHAPING OF A COMPANY'S MISSION

### EXPERT REPORT

Analysis of a company's mission in terms of its usefulness for the business strategy; improvement of a company's mission.

### APPLICATION

The mission is an effective tool contributing to the increase in employees' commitment, the primary purpose of the enterprise's operation, and an element that helps build relationships with the organisation's environment.

#### Contact information

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## ANALYSIS, EVALUATION, AND DEVELOPMENT OF AN ENTERPRISE'S ORGANISATIONAL STRUCTURES

### EXPERT REPORT

Evaluation of existing structural solutions, introduction of changes to the organisational structure, and development of structural solutions.

### APPLICATION

Supporting managerial decisions in the area of organisation.

#### Contact information

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## ANALYSIS OF A COMPANY'S STRATEGY

### EXPERT REPORT

Analysis of a company's strategy along with recommendations for strategic directions and streamlining. The point of departure for the analysis will be a study of the enterprise's environment as well as its strategic potential including its innovation characteristics. If strategic decisions are to be formulated, different possibilities will be devised with respect to the enterprise's growth and directions of its streamlining will be developed.

### APPLICATION

Translating a strategy into current operations, particularly in terms of creating a good atmosphere for innovation, as well as controlling the results of its execution.

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## ERGONOMICS STUDIES

### RESEARCH

- anthropo-medical and biomedical studies making it possible to determine the extent of the researched object's adjustment to the requirements and limitations of a human user,
- measurements of the extent of load, risk, and threats to human health resulting from physical factors of the work environment and their adjustment to standardised requirements in a given operational situation,
- studies of the optimality of human-machine communication systems (product), making it possible to evaluate the extent of correctness of various types of systems for transmitting information in the context of existing results of ergonomics research,
- studies and optimisation of the organisation of production systems involving human participation,
- identification of causes of musculoskeletal disorders,

- evaluation of manual labour load (energy expense, static loads, repetitive work) and intellectual work load (including monotony), as well as evaluation of work fatigue.

### APPLICATION

The main application is ergonomic intervention, i.e. improvement of the conditions in which work is performed. The analyses aim to define the causes of employees' loads and seek possible methods of reducing these loads through technical and organisational streamlining.

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## AN ENTERPRISE'S COST BALANCE

### TRAINING

The training comprises the following issues:

- identification of costs and assigning them to specific groups of the costs of an enterprise's operation,
- calculation of an enterprise's costs for the needs for its pricing policy,
- methods of financial observation and investigating an enterprise's structural changes,
- preparation and development of cost-related information for both internal and external recipients,
- preparation of data for reporting purposes,
- summary and analysis of costs related to managing an organisation,
- identification of "redundant" costs,
- identification of causes and locations of deviations of actual costs from intended costs,
- forecasting costs for upcoming periods.

### APPLICATION

The optimisation of the costs of an enterprise's operation is a difficult process. The training will cater to owners

and executives of enterprises. It aims to familiarise decision-makers with the cost account for the effective cost management, thereby securing effective company management. The training's added value is an opportunity to find out ways of eliminating redundant costs and drawing up cost forecasts.

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## COMPANY DEVELOPMENT STRATEGY

### TRAINING

Delivery of a strategic session in the form of managerial training aiming to develop and implement a business strategy, business model, or a marketing strategy on the B2B market. The purpose of the workshop is to develop a coherent and comprehensive strategic plan including a diagnosis of a given enterprise's strategic position, model of competitive advantage, as well as directions of its operation on the general and functional level.

### APPLICATION

Acquisition of practical skills indispensable in the process of formulating and interpreting a strategy and gaining the most up-to-date knowledge in the field of strategic management

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## CONCEPTS OF BUSINESS ANALYSIS IN THE AGILE SPECIFICATION OF THE DECISION-MAKER'S NEEDS

### RESEARCH

Identification and analysis of elements of business analysis aiming to develop models of concepts specifying the subject matter of business processes identified by the decision-maker as being in need of IT support. The research will result in models (ontologies) usable in the agile specification (prototyping) of the needs of a decision-maker solving a specific decision-related problem within the organisation.

### APPLICATION

Development of a repository of knowledge related to managed business processes for the company's decision-makers. It can be useful in the area of business process analysis and for solving specific problems that involve decision-making using IT methods.

### Contact information

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## DESIGN OF CORPORATE PROCESSES

### EXPERT REPORT TRAINING

- analysis and evaluation of an enterprise's processes,
- a project consisting in streamlining an enterprise's processes,
- training in process management.

### APPLICATION

- support on managerial decisions in processes involving organisational changes,
- broadening employees' knowledge.



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## DEVELOPMENT OF A COMPANY'S ABILITY TO LEARN

 EXPERT REPORT

Comprehensive diagnosis and evaluation of a company's ability to learn.

 APPLICATION

Support for managerial decisions in processes involving organisational changes.

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## DIAGNOSIS OF AN ORGANISATION'S CORPORATE CULTURE

 EXPERT REPORT

Comprehensive diagnosis and evaluation of an enterprise's organisational culture.

 APPLICATION

Support for managerial decisions in processes involving organisational changes. Broadening employees' knowledge.

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## DIAGNOSIS OF AN ORGANISATION'S CORPORATE SOCIAL RESPONSIBILITY STATUS AND POSSIBILITIES OF SHAPING IT


 EXPERT REPORT

It is increasingly common to expect an enterprise's activity in competitive conditions to have values related to social responsibility. The essence of this is the development of long-lasting and positive relations with stakeholders. There are numerous model and standardised formulas for initiating and executing a company's corporate social responsibility (CSR) strategy. Thanks to the application of simple analytical tools, a CSR diagnosis will make it possible to evaluate the conditions, manner of execution, and potential of changes stemming from the enterprise's expectations and capacities.

 APPLICATION

The diagnostic services offered include the following:

- evaluation and analysis of existing solutions in seven dimensions of responsibility (in accordance with ISO 26000),
- research into the possibilities of changes to the extent of fulfilment of social responsibility criteria formulated on the basis on gaps defined in the process,
- development of proposals for specific solutions in accordance with the set priorities.

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## DIAGNOSIS OF CONTROLLING SOLUTIONS IN AN ENTERPRISE

 EXPERT REPORT

The diagnostic actions comprise the identification of determinants for implementation and controlling solutions (functional, organisational, and instrumental ones) in an enterprise. Recommendations for improving solutions in line with

set priorities will be developed based on the diagnosis results.

 APPLICATION

Support on managerial decisions in the processes involving organisational changes.

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## DIRECTIONS OF INNOVATIVE TECHNOLOGIES' DEVELOPMENT

 EXPERT REPORT

Development of forecasts with respect to technologies' or companies' development as well as the design of directions of such development; forecasting an economy's or market sector's development trends. Directions of development will be identified based on foresight studies (e.g. technological foresight), as well as research into the needs and behaviours of potential consumers and other stakeholders. The forecast will be supplemented by a market analysis as well as an economic, legal, and social analysis of the client's enterprise or market sector.

 APPLICATION

Forecasts developed by the unit are intended to establish long-term directions of a company's development as well as contributing to its faster growth. From the sector's standpoint, the forecasts can be used for establishing strategic goals for a given sector, help develop a strategy for its development, or indicate key specialisations in need of support.

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## EVALUATIONS OF COMPANIES' BUSINESS PLANS

### EXPERT REPORT

- evaluation of a company's chosen form of business activity,
- evaluation of a company's strategy in terms of market/product selection,
- evaluation of a business case in terms of investment outlay,
- evaluation of a business plan in terms of operational costs,
- evaluation of SWOT/competition/market potential analyses,
- evaluation of selected forms of promotion and sales activity patterns.

### APPLICATION

Comprehensive evaluation of a company's strategy and business plan performed prior to their submission to financial institutions.

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## FINANCE AND INVESTMENT

### TRAINING

Primary scope of the training:

- a company's financial strategies,
- financial markets and instruments,
- finance management strategies,
- methods of financial forecasting,
- combining different segments of the financial market,
- principles of the stock exchange in Poland and other countries,
- principles of investing in the financial market - possibilities of investment strategies,
- development of a complex investment portfolio,
- evaluation of the economic and financial situation in financial markets.

### APPLICATION

The training aims to familiarise the participants with basic categories of the financial market, financial strategies and

transactions conducted in the financial market, along with the classification and characteristics of investments, as well as equipping them with the ability to understand, analyse, and interpret basic phenomena occurring in the financial market.

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## FORESIGHT METHODS IN STUDIES AND EVALUATION OF DETERMINANTS OF STRATEGIC UNDERTAKINGS

### EXPERT REPORT

Building strategies for the implementation of new products and technologies based on foresight study methods (e.g. technological foresight) allowing for the needs of various groups of stakeholders. We offer an analysis of implementation conditions and the impact of new products and technologies on the enterprise allowing for market-related, economic, technological (technology development trends), and social aspects. One of the elements of the analysis is evaluation of investment profitability.

### APPLICATION

The evaluation developed by the unit is intended to assess the conditions implementation, and the impact of new products and technologies on enterprises. For this purpose, it is necessary to allow for market-related, economic, technological (technology development trends), and social aspects.

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## FORMULATION AND EVALUATION OF AN ORGANISATION'S STRATEGY

### EXPERT REPORT

Development of an organisation's strategy. Evaluation of existing strategic documents.

### APPLICATION

Support on managerial decision-making in the strategic management process.

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## FUNDAMENTALS OF INVENTICS

### TRAINING

The service offered by the unit consists in training in the fundamentals of inventics. The training concerns methods of creatively solving problems encountered in organisations. It can comprise methods such as:

- synectics,
- the morphological method,
- creatics, etc.

### APPLICATION

The training aims to allow its participants to acquire the skills of solving problems by applying specific inventic methods. Moreover, thanks to the training, it will be possible to define problems

competently to have a better understanding thereof. The training also aims to allow its participants to improve decisions they make.

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## IMPLEMENTATION OF ORGANISATIONAL CHANGES

### EXPERT REPORT

Development of change management plans for change processes within organisations.

### APPLICATION

Support on managerial decisions in the area of managing organisational changes.

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## METHODS OF PROCESS QUALITY IMPROVEMENT

### TRAINING

The training comprises theoretical issues and practical exercises in the area of methods and techniques of quality improvement that can be used to solve problems related to organisations' processes. In particular, the participants will have an opportunity to become acquainted with the following issues:

- graphic techniques of process description,
- classic and new quality improvement methods,

- the PFMEA method,
- the QFD method,
- the force field analysis method.

### APPLICATION

The training will cater to the needs of managers and other employees participating in projects aiming to improve their organisation's processes. Its purpose is to familiarise the participants with methods and techniques of improving the quality of an organisation's processes and allow them to acquire the ability to put them into practice in their organisation.

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## MS EXCEL AS AN ESSENTIAL MANAGEMENT TOOL

### TRAINING

The training programme caters to those who are willing to streamline their work with Excel software. It enables the participant to make their work with the software smoother and ensure that it is better suited to their needs. The training comprises the following areas:

- using advanced functions of Excel (logical and mathematical ones, etc.),
- using analytical tools for data analysis,
- pivot tables and graphs,
- protection of files and data,
- macros,
- creating and managing databases,
- serial correspondence.

### APPLICATION

After completing the training, the participants will be able to create advanced Excel spreadsheets on their own to calculate

costs or analyse data. The intention behind the training is to familiarise the participants with the functionalities of the program which will help them streamline their day-to-day work with it while optimising work time with little effort.

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## PROJECT AND COST MANAGEMENT

### TRAINING

- training in the basics of project management,
- training in the basics of cost management and budgeting.

### APPLICATION

Research, social, organisational, innovation, and implementation projects.

#### Contact information

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## PROJECT MANAGEMENT


### EXPERT REPORT

Evaluation of a project management methodology in an organisation based on a case study.

### APPLICATION

Improvement of the effectiveness of an organisation's project management practices through streamlining project management methodology.



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## SHAPING OF A SUSTAINABLE COMPANY

 EXPERT REPORT

Training in the essence of a sustainable enterprise. Business model growth towards sustainable development.

 APPLICATION

Support on managerial decisions in the processes involving organisational changes. Broadening employees' knowledge.

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## SHAPING OF THE SYSTEM FOR STRATEGY AND INNOVATION PROCESS MANAGEMENT IN SMB'S AND OTHER ORGANISATIONS

 EXPERT REPORT

An enterprise's pro-innovation initiatives alone will not guarantee success measured with the number of new products, new customers, or new markets in a situation where there is no certainty as to an enterprise's actual intentions in this area - whether it is a conscious need or a camouflage game serving short-term goals and particular interests. At least a two-level strategic coincidence is necessary - on the level of an en-

terprise's functional strategy and general strategy. A lack of innovation strategy on the functional level results in various units within the organisation exercising different priorities and tasks. The barriers diagnosed make up a map of considerations blocking the development of innovation processes in the enterprise.

 APPLICATION

The evaluation can serve the purpose of a diagnosis of the type and significance of barriers and constraints, as well as the proposals of changes enabling the limitation thereof. Additionally, the goal is to design a specific business solution, e.g. with an unclear division of responsibility in an organisation for the development of innovations - by diagnosing the situation and presenting an approach which is new in terms of quality, as well as a scope of competence division in this area.

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## SHORT- AND MID-TERM FORECASTING

 TECHNOLOGY

A wide range of econometric/statistical tools for short (up to a few days) and mid-term (up to several months) forecasting of prices, demand, etc. available in the context of point prediction (i.e. the most probable or expected value) as well as the increasingly popular probabilistic forecasts (i.e. a range of values obtained with a certain probability). The unit also offers studies and expert evaluations concerning the selection of forecast methods adjusted to the specificity of the client company's operation (e.g. allowing for trends and seasonability).

 APPLICATION

Improvement of the quality of forecasts applied so far, and - as a result - streamlining company management - on both the operational and strategic levels.

 Contact information

Team of Economic Modelling  
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## THE MODERN MANAGER

 TRAINING

Training oriented towards the development of a modern manager's skills:

- learning to listen competently,
- staff management through employee development,
- work time optimisation,
- planning work with subordinates based on Lean Canvas,
- creative thinking strategies,
- optimisation of financial costs and other areas,
- identification of problems within an organisation,
- answering the question: how does an accountant think?
- coping in difficult situations and with difficult employees.

 APPLICATION

Training programme catering to people who plan to hold executive positions or have assumed them recently. The training aims to teach the participants to effectively cope with their new role thanks to appropriate staff management: by listening, analysing, and empathising with the employee.

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## WORKSHOP ON BUILDING STRATEGIES IN CAPITAL GROUPS AND COMMERCIAL COMPANIES AND PARTNERSHIPS

### TRAINING

Development of a general strategy:

- determination of the area of business activity,
- selection of the market and form of activity,
- defining company goals.

Stages of strategy development:

- diagnosis of an enterprise's condition or potential for a new initiative,
- evaluation of the market and competition,
- definition of products/services provided by a given company,
- evaluation of potential in terms of profitability,
- evaluation of market entry barriers,
- determination of the level of necessary financial outlays and operational costs.

Marketing and sales strategy:

- determination of a company's competitive advantages,
- selection of forms and principles of sales/distribution of a company's products,
- determination of ways to promote a company's products,
- rules and criteria related to employee compensation.

Establishment of an action plan:

- development of a company's activity schedule for the nearest year and more years to come,
- division of duties/development of an organisational structure,
- development of business cases for specific products,
- determination of risks and possibilities of eliminating them,
- establishment of yardsticks for task execution - KPI's.

### APPLICATION

The workshop will allow its participants to learn hands-on about the principles of developing the strategy of both an existing company and one being founded.

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## WORKSHOP ON THE MANAGEMENT OF COMMERCIAL COMPANIES AND PARTNERSHIPS

### TRAINING

The scope of the executive board's tasks:

- procedure for appointing the executive board, who is eligible for the board,
- supervisory bodies in a joint-stock company and a limited liability company,
- regulations related to the executive board's cooperation with the supervisory board,
- a board member's mandate - ways of its expiry.

Tasks, role, and responsibilities of a company's president and board members:

- strategic management in a company,
- operational management in a company,
- the executive board's rights and obligations towards the company,
- the scope and procedure of civil law and criminal liability for the company's commitments specified in the Commercial Companies Code.

Employing and compensating board members:

- the legal relationship between a board member and the company,
- forms of employment,
- manager's contract vs. a board member's employment contract,
- who is entitled to sign agreements specifying an employment relationship with a board member,
- rules and criteria of compensating and awarding a board member.

The board's role as an employer:

- the scope of responsibility and obligations towards employees, pay rises, bonuses, and penalties,
- responsibility for supervision.

### APPLICATION

The workshop will allow the participants to learn about the principles of managing a commercial company or partnership, as well as the rules, obligations, and accountability related to the management.

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## WORKSHOP ON THE MANAGEMENT OF WHOLESALE TRADE OF ELECTRIC ENERGY, GAS, AND PROPRIETARY RIGHTS

### TRAINING

- What is the character of the operation of a company specialising in the wholesale trade of energy, gas, and proprietary rights.
- A model of the energy and gas market in Poland and the rest of Europe.
- Up-to-date rules of wholesale trade of energy and gas (stock market and OTC market).
- Risk management process. Organisation of trading:
  - what organisational structures of trading desks are most often used on electricity markets (front-mid-back division, for what participants it is logical to separate simple screen traders and originators),
  - how software is used at all stages of the trading process: from origination to accounts.
- The process of planning and budgeting business operation.
- Evaluation of the effectiveness of trading, controlling, and KPI's.
- Operation of a separate trading department.

### APPLICATION

The workshop will allow its participants to learn about the operation of a company involved in energy and gas trading.

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## ANALYSIS OF MATERIALS' POROSITY

### RESEARCH

The Laboratory of Sorption Research enables a comprehensive analysis of the porous texture of materials in the range of meso- (2-50 nm), micro- (<2 nm) and ultramicropores (<0,7 nm) using adsorption/desorption of practically any non-toxic and non-corrosive gas. A standard analysis of porosity involves determining the adsorption and desorption isotherms of nitrogen at a temperature of 77K and of carbon dioxide at a temperature of 273K. Analysis using argon (77K), hydrogen (77 or 273K), and methane (273K) is applied as well. Parameters characterised include specific surface, pores' summary volume, and the distribution of pores' dimensions in the material under examination.

### APPLICATION

Characteristics of carbon and aluminosilicate sorbents, as well as catalysts.

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## LASER TECHNOLOGY FOR THE PRODUCTION OF THIN AND ULTRATHIN FILMS OF POLYMERS AND MOLECULAR MATERIALS ON SOLID SUBSTRATES

### RESEARCH

The technology enables the production of very thin film of material (from a few to a few hundred nanometres) using a solution. The films are characterised by high thickness homogeneity, and

in the case of molecular materials, high crystallinity and orderliness. The material can be coated on any solid substrate - the condition being the absorption of laser radiation by the substrate as well as appropriate adhesion of the material applied.

### APPLICATION

The method may be applied to modify the surface of materials by applying a thin layer of material with required properties (e. g. waterproofing of a surface). The unit is capable of producing films which absorb radiation, or electrically conductive ones. It can be used as a modification of existing film coating methods aiming to decrease film thickness and to reduce the consumption of the material being applied.

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## MATERIALS-ORIENTED AND MECHANICAL STUDIES IN TECHNOLOGICAL PROCESSES AND 3D PRINTING

### RESEARCH

- development of new materials,
- macro- and microstructure-oriented studies using light, electron, and confocal microscopy methods,
- determination of mechanical properties of metals, composites, plastics, etc. (linear and superficial distribution of micro- and macro-hardness, measurements of thin layers, static tension test, and fatigue test),
- studies using a Scanning Electron Microscope,
- analysis of crack propagation with a high speed camera,
- microanalysis of the chemical composition of EDS ,
- 2D and 3D surface topography measurements (corrugation, roughness, and calculations of actual surface),
- analyses of powder materials (distribution of particle diameters, measurements of powder particles, determination of shape),

- studies of porosity, joint penetration, faults, and materials' discontinuity with destructive and non-destructive methods (X-ray microtomography),
- analyses and studies of materials, technologies, as well as inspection and measurements.

### APPLICATION

Projects involving inspection, materials and mechanics-related audits aiming to identify important factors affecting the technological process. Modern manufacturing tools, mainly for laser technologies, of functional surfaces and spatial micro- and macrostructures require constant improvement and determination of the impact of the process on the material being processed.

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## MATERIALS-ORIENTED STUDIES OF MACHINE ELEMENTS

### EXPERT REPORT

Materials-oriented studies of elements and parts of machines. The scope of the offer includes the following:

- metallographic studies of metallic materials, plastics, and ceramics,
- determination of hardness and micro-hardness,
- analyses of causes of damage to machines and machine malfunction,
- qualitative evaluation of welded connections, padding welds, and layers treated superficially and thermo-chemically,
- determination of causes of corrosion-related damage to materials.

If needed, metallographic studies can be complemented with mechanical tests.

The unit's research team boasts extensive experience stemming from its 40 years' cooperation with industry.



### APPLICATION

Possible applications in many industry sectors, e.g.:

- automotive industry,
- power engineering,
- electrotechnical engineering,
- machine construction and operation.

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## NON-DESTRUCTIVE STUDIES OF WELDED AND PRESSURE-WELDED JOINTS AND MATERIALS' PROPERTIES

### EXPERT REPORT TRAINING

The non-destructive tests of materials offered by the unit include the following:

- studies of the quality of fusion welds, soldered joints, superficial cracks,
- studies of electrical conductivity using the eddy-current method,
- measurements of thickness of non-conductive coatings applied on ferromagnetic and non-ferromagnetic materials,
- measurements of thickness of metallic materials and plastics.

### APPLICATION

The unit's infrastructure allows conducting non-destructive studies that enable the determination of the following characteristics:

- properties of materials and thin sheet metal plates, including welded, glue-welded, and soldered joints, and internal structures of microprocessors and electronic circuit boards,
- quality of spot welds for the automotive and aviation industry,
- superficial cracks and measurements of coatings' thickness,
- leaktightness of welds.

 **Contact information**

Workroom of Non-Destructive Tests  
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## PRODUCTION OF FUNCTIONAL MATERIALS USING THE ZOL-GEL METHOD AND STUDIES OF PREPARATIONS' MORPHOLOGY AND CRYSTALLINE STRUCTURE

 **RESEARCH**

The offer's focus is on the production of nanomaterials using the zol-gel method, which guarantees low prices and mild production conditions. The particles produced may be characterised by biological, magnetic, and optical activity. In order to prevent aggregation, nanoparticles are placed on SiO<sub>2</sub>/TiO<sub>2</sub> carriers or added to oxide films. The powder with active nanoparticles may be used as a filler providing a product with required properties, e.g. of a biological or magnetic nature. Such powders can be added to fabrics, packaging, and paint coatings to improve their usability and provide them with anti-septic and self-cleansing properties.

 **APPLICATION**

Due to a possibility of controlling the zol-gel process, nanomaterials produced in this manner may be widely used. They can be used in the form of a powder as fillers providing products with required characteristics. Additionally, they can be applied directly to surfaces, even featuring a complex shape in the form of thin films. Thin films prepared using this method, depending on their chemical composition, provide surfaces with anti-corrosive, catalytic, or biological properties.

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## SPECTRAL ANALYSIS

 **RESEARCH**

Analyses of chemical composition using the spectral method.

 **APPLICATION**

Studies of materials for various areas of industry.

 **Contact information**

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## SPECTRAL ANALYSES OF THE CHEMICAL COMPOSITION OF STEEL AND ALUMINIUM ALLOYS

 **EXPERT REPORT**

Spectral analyses of the chemical composition of metallic materials such as:

- alloy and non-alloy based steel,
- aluminium alloys.

 **APPLICATION**

- determination of a material's grade based on the content of alloy elements,
- checking materials' compliance with the standard.

 **Contact information**

Laboratory of Chemical Analyses  
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## STUDIES OF ENGINEERING MATERIALS' MICROSTRUCTURE

 **RESEARCH**

The unit offers studies of engineering materials' microstructure, including the following:

- metal alloys,
- engineering composites,
- plastics,
- ceramics.

Imaging and analysis of microstructure using the following research methods:

- light microscopy,
- scanning electron microscopy,
- transmission electron microscopy.

Electron microscopy methods also enable microanalysis of materials' chemical composition, which means accurate determination of the chemical composition of each ingredient of a composite or alloy. The scales of imaging and examination offered by the unit begin with the macro scale, through micro-, to the nano-scale (the maximum image resolution corresponding with atomic surfaces of a crystal lattice).

 **APPLICATION**

Microstructure analysis (and supplementary determination of basic mechanical properties, offered in parallel) allows solving numerous engineering problems, such as:

- determination of the cause of an element's defect/damage along with recommendations for a corrective solution,

- evaluation of coatings' thickness (in the range of up to ten of nanometres),
- increasing products' durability by designing and optimising thermal processing methods.

#### Contact information

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## SYNTHESIS AND MODIFICATION OF CARBON MATERIALS

### RESEARCH

The Laboratory of Synthesis and Modification of Carbon Materials and Nanomaterials offers research services oriented towards a controlled synthesis of conventional carbon materials (coke) - by means of pyrolysis (up to 500°C), carbonisation (up to 1,300°C), or gasification/activation (up to 1,000°C), as well as nanostructural ones (nanofibres and nanotubes) using the CCVD method. We are involved in works on superficial modification of carbon-based materials with CVD (methane, propane, etc.), ammonisation, amoxidation, and reduction in hydrogen. We analyse the dynamics of the processes of carbonisation, gasification, and activation of air, nitrogen, carbon dioxide, and steam to the temperature of 1,000°C based on changes to the raw material weight. We perform studies of the quantitative composition of solid products (CHNS elemental analysis), liquid substances (GC-MS and DSC), and gases (TD/GC-MS).

### APPLICATION

Production of cokes and carbon nanocomposites. Production of active carbons. Biomass processing.

#### Contact information

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## SYNTHESIS AND MODIFICATION OF POLYMER MATERIALS

### RESEARCH

The Laboratory of Special Polymer Materials offers research services involving the synthesis and application of polymer materials in distributive processes. The works involve obtaining selective polymer and hybrid sorption and membrane materials for the acquisition of valuable substances from water solutions and removal of toxic compounds. Moreover, the unit conducts studies of the application of polymer materials as intelligent carriers of active substances: catalysts or medicines, as well as separators.

### APPLICATION

Separators sensitive to external stimuli, selective sorbents and ion exchangers, and semipermeable membranes. The scope of the materials' application: water treatment, obtainment of raw materials from water solutions, hydrometallurgical processes, and innovative medical procedures.

#### Contact information

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## THERMAL SPRAYING - PRODUCTION AND STUDIES OF COATINGS

### TECHNOLOGY

Services offered by the Workroom of Plasma Spraying and Cold Spray Technique and the Workroom of Powder Production include the following:

- spraying coatings of various kinds: coatings protecting from abrasive wear, anti-corrosion, conducting current, coating-based thermal barriers, low friction, biocompatible, decorative, etc.
- depositing coatings based on nanometric/submicrometric powders,
- metallisation of plastics,
- regeneration of machine elements using thermal spraying,
- building spatial structures,
- production of metal powders with the gas atomising method,
- studies of powder materials and coatings: sieve analysis, studies of morphology and microstructure, analysis of chemical composition, hardness tests, studies of functional properties depending on a coating's purpose.

### APPLICATION

Production of coatings improving machine parts' properties. Regeneration of worn out elements, recreation of geometrical properties, and surface protection. The unit's installation producing powders with the gas atomisation method is one of Poland's few facilities of this kind. The powder materials produced at the unit can be applied for purposes such as bonding technologies, thermal spraying, or additive technologies (3D printing). Production of powders from metal and non-metal alloys (with the exception of Al, Ti),

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## ANALYSES OF MATERIALS' MICROSTRUCTURE

### RESEARCH

Analyses of the microstructure of metallic materials and plastics using computer processing and image analysis methods.

### APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

#### Contact information

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## CONDENSED GASES IN INDUSTRIAL PROCESSES, MEDICINE, AND POWER ENGINEERING

### TECHNOLOGY

Application of condensed gases in industrial processes, medicine, and power engineering.

### APPLICATION

Design and supervision over the production of systems using condensed gases in medicine, industrial technologies, and power engineering.

#### Contact information

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## DEVELOPMENT OF PRODUCTS AND PROCESSES

### RESEARCH

- studies concerning technological planning and CAD CAM MES,
- accredited reverse engineering and virtual reality studies,
- quick product development (3D printing),
- planning technological processes,
- simulation-based modelling and optimisation of manufacturing systems,
- integrated IT solutions,
- Lean Manufacturing analyses,
- quality management,
- design and optimisation of manufacturing machines and processes,
- optomechatronic and vision systems,
- laser technologies (cutting, hardening, and pad welding),
- functional coating technologies,
- materials-oriented and mechanical tests,
- CNC processing.

### APPLICATION

CAMT-FPC undertakes strategic industrial projects in the areas of new technology implementation, optimisation of manufacturing processes, automation, and robotisation. It mainly provides its services to market sectors including aviation, automotive, mining, medicine, and agriculture. The unit performs expert analyses of technology innovativeness, commercialisation potential, as well as feasibility studies.

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## LIGHT AND SCANNING MICROSCOPY


### RESEARCH

Determination of the grade and structure of materials along with the condition of their thermal and thermo-chemical processing using light and/or scanning microscopy



 APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

 Contact information

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## MATERIALS SCIENCE ANALYSES OF COMPONENTS OF RENEWABLE ENERGY SOURCE INSTALLATIONS

 EXPERT REPORT

Renewable energy installations are made of metal-based materials and plastics, or amorphous materials. Over time, every device, including a renewable energy source installation, undergoes wear and tear, due to which, it is necessary to evaluate its technical condition and, in case of damage, establish the cause of such an occurrence.

 APPLICATION

- determination of the cause of damage to elements of renewable energy source installations,
- determination of a way to remove the causes of damage (e.g. by applying other materials which meet relevant requirements)

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## MEASUREMENTS OF HARDNESS AND MICRO-HARDNESS

 RESEARCH

Measurements of hardness and determination of the thickness of superficially and thermally processed layers.

 APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

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## METAL ELEMENTS TECHNOLOGY

## RESEARCH

Recreating technologies for the production of elements without their operation sheets, optimisation of existing technologies and development of new ones.

 APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures.

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## MULTI-CHANNEL LASER VIBROMETRY

 RESEARCH

The unit offers services consisting in contactless measurements of an object's vibrations using a laser-optical fibre vibrometer. The device's most important parameters are as follows:

- analysing laser beam wavelength: ~1550nm,
- four independent measuring channels (simultaneous measurement),
- measurements at measuring points located at even very close distances between each other (in every channel, a different laser beam wavelength is used),
- three-axial (3D) measurements,
- range of vibrations' velocities measured: 0-3m/s,
- frequency of vibrations measured: 0-500 kHz,
- resolution of dislocation measurement: 10nm,
- resolution of velocity measurement: 1mm/s,
- number of phase/frequency modulators: 3,
- measurement distance: 0.1 – 2m with a possibility of increasing the upper limit to more than ten metres,
- automatic signal search system,
- supplementary laser radiation for locating measurement points ~635nm.

 APPLICATION

Our unique device enables simultaneous measurements of vibrations in four independent measurement points, which makes it possible to investigate the phase relations between the vibration points. It can be applied in areas including the following:

- diagnostics of electrical household appliances,
- automotive industry (tests of body and engine vibrations),
- diagnostics of rolling bearings,
- location of damage to materials,
- protection against vibrations and noise.

 Contact information

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## RAPID PRODUCT DEVELOPMENT TECHNOLOGIES

### RESEARCH

The Laboratory conducts research and development projects commissioned by the industrial sector, as well as carrying out research projects funded with domestic and EU resources. The Laboratory cooperates with many national and foreign research units and scientific institutions.

For nearly 20 years, it has been involved in the field of 3D printing, which enables quick transition from a 3D digital CAD model of a future product to its physical shape using any material (polymers, metals, or ceramics). Additionally, we undertake design projects using CAD 3D systems.

### APPLICATION

- rapid prototyping technologies,
- rapid tooling - technologies for quick production of prototype series,
- rapid manufacturing - technologies for individualised prototyping,
- development of generative technologies,
- development of marketable products,
- support in the area of market research,
- support on marketable product implementation,
- consultancy and training services.

### Contact information

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## STRENGTH TESTS

### RESEARCH

Strength tests of materials, constructions, and construction elements.

### APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

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## STRUCTURAL AND CRYSTALLOGRAPHIC ANALYSIS OF MATERIALS

### RESEARCH

Structural and crystallographic analysis of metallic materials and plastics produced with X-ray methods using electron, transmission, and scanning microscopy.

### APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

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## STUDIES OF CARRYING STRUCTURES' TECHNICAL CONDITION

### EXPERT REPORT

The unit offers research services and evaluations in the field of mechanics, i.e. materials' and structures' strength (static, cyclic, and dynamic loads), as well as integrity in terms of materials and construction. Also provided are analyses of causes of damage to materials and structures.

### APPLICATION

- evaluation of causes of cracking and decohesion of materials and structures,
- evaluation of the strength of materials and carrying structures,
- analyses of causes of mechanical degradation of materials and structures.

### Contact information

Laboratory of Strength of Materials  
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## STUDIES OF CAUSES OF DAMAGE TO PARTS OF MACHINES AND CONSTRUCTION ELEMENTS

### RESEARCH

Determination of causes of mechanical, corrosion-, and fatigue-induced damage, studies of repair conditions and methods, as well as corrosion protection technologies.

### APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

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## STUDIES OF FUSION AND PADDING WELDS' QUALITY

 RESEARCH

Determination of the quality and correctness of welded connections, padding welds, as well as superficially and thermo-chemically processed layers.

 APPLICATION

Materials-oriented studies for various areas of industry involving both the production and operation of machine parts or elements of civil engineering structures - enabling the determination of their quality, the correctness of technology applied, extent of wear, and causes of damage.

 Contact information

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## STUDIES OF MATERIALS' RESISTANCE TO CRACKING

 RESEARCH

- studies of materials' resistance to cracking in accordance with K1ciCTOD criteria,
- determination of the speed of fatigue crack propagation.

 APPLICATION

Determination of materials' usefulness (particularly elasto-brittle ones) for the purposes of structures exposed to fatigue loads.

 Contact information

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## STUDIES OF STRENGTH IN SIMPLE AND COMPLEX STATES OF STRESS

 RESEARCH

- analysis of the issues of mechanical and thermal fatigue, as well as construction materials' creep,
- determination of physical properties of metals, plastics, composites, and composite constructions in static and dynamic tests in simple and complex states of stress,
- mesomechanics,
- fatigue tests of plastics and fibre-reinforced materials,
- measurements of deformations using electric resistance tensometry, including determination of specific stress using the hole-drilling method,
- measurements of deformations using the touchless method in 3D, determination of impact energy in an impact resistance test.

 APPLICATION

- determination of mechanical properties of construction materials and structures,
- strength tests of whole constructions or their elements exposed to static or cyclic variable loads,
- analysis of mechanisms, mechanical damage, and ways to prevent operational failures.

 Contact information

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## TECHNICAL AND ECONOMIC EVALUATION OF TECHNOLOGICAL PROCESSES DESIGNED FOR NUMERICALLY CONTROLLED MACHINE TOOLS (NCMT)

 TECHNOLOGY

The following services are offered:

- simulation-based tests of the correctness of processing activity designs,
- design and prototyping of systems for evaluating product quality directly on a machine tool,
- evaluation of cutting capabilities of cutting devices,
- evaluation of the quality of cutting tools for particular manufacturing tasks,
- development and implementation of NCMT software,
- support on developing and implementing software for NCMT,
- training in theoretical and practical aspects of programming numerically controlled machine tools,

 APPLICATION

All industry sectors.

 Contact information

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## 3D MODELLING OF DEPOSITS, DESIGN OF MINES AND RECLAMATION, PLANNING, AND OPTIMISATION OF EXTRACTION; VISUALISATION OF 3D MODELS IN THE VR ENVIRONMENT

### RESEARCH

- analyses for the needs of deposit documentation, mining excavation design, planning and scheduling of mining activity, as well as evaluation of environmental parameters,
- 3D geological modelling using geostatic methods,
- methods of open-pit mine optimisation,
- computer-aided resource identification,
- computer-aided design of underground and open-pit mines,
- inclusion of the risk factor in the plans for mines' development and exploitation activity (conditional and Monte Carlo simulations).

### APPLICATION

Planning the development of mines, planning and optimisation of the mining operation.

#### Contact information

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## ECONOMIC AND FINANCIAL ANALYSES OF INVESTMENT UNDERTAKINGS AND COMPANIES ALONG WITH PROFITABILITY AND RISK EVALUATION

### RESEARCH

- economic optimisation of the deposit identification process and planning its exploitation allowing for uncertainty and risk (VaR and CFaR methods, Monte

Carlo simulation, conditional simulation, binary trees, and the real options method),


- works involving studies and analyses in the area of designing mining excavations, identifying balance resources using optimisation algorithms, and planning a mine's progress with emphasis on open-pit mines with a continuous operation and transport system,

- non-standard studies and analyses in the spatial modelling and design environment, e.g. studies of the impact of the selection of an open-pit mine's transport model on its economic results, analyses of variant consequences of CO2 emission taxation scenarios on the volume of coal resources justifying mining operations, application of fuzzy sets and conditional simulations in generating an open-pit mine's target excavation.



 APPLICATION

Planning the development of mining companies.

 Contact information

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## STUDIES OF CONVEYOR BELT ROLLERS

 RESEARCH

- studies of rollers applied in belt conveyors operating in underground and open-pit mines,
- evaluation of rollers' conformity with the standards PN-M-46606:2010, equivalent to PN-ISO 1537, as well as DIN - 22112-2,
- determination of basic measures of a roller's functional properties which are a source of information about its technical condition - i.e. measurements of rotation resistance, testing radial run-out, measurements of bearing units' temperature, as well as unbalance tests,
- studies of rotation resistance in carrying rollers under loads, in terms of real-life forces which rollers are subjected to in mines, as well as laboratory evaluation of durability, based on an own-developed method consisting in determining approximate effective distribution of rollers' operation time.

 APPLICATION

- evaluation of rollers' conformity with applicable standards,
- evaluation of rollers' durability,
- quality review during a tendering procedure,
- development of innovative roller construction solutions for a specific area of use,
- setting new quality standards for rollers to be used with high-performance energy-efficient conveyor belts.

 Contact information

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## STUDIES OF CONVEYOR BELTS, THEIR CONNECTIONS, AND RUBBER

 RESEARCH

- comprehensive check-up tests of fabric conveyor belts and belts with steel cords,
- studies of resistance to conveyor belt connections' rupture along their full length,
- certification studies of belts and evaluations aiming to ensure a permit for the use in underground mining facilities,
- studies of physico-mechanical properties of rubber mixes, studies of conveyor belts flammability using the flame method, frictional method with a drum, hot surface, and fire simulation (propane grate method - A and B, and model drift - C),
- determination of the oxygen index for conveyor belts as well as rubber and plastic products,
- studies of anti-electrostatic parameters of conveyor belts,
- studies of belts outside the scope of applicable standards, including resistance to puncture and longitudinal cuts, as well as belts' refusal to rolling on the rollers,
- analyses of the durability of belts and their connections; analyses of connections' and belt's build quality; training in belt connecting.

 APPLICATION

The Laboratory of Belt Conveying is equipped with instrumentation and test beds used for the determination of all standardised physico-mechanical properties of conveyor belts, including Poland's only test bed for studies of belts' flammability using the propane grate method and a tensile testing machine for testing connection along their full length.

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## STUDIES OF FUNDAMENTALS OF MINERALOGICAL PROCESSES AND DEVELOPMENT OF RAW MINERAL MATERIAL ENRICHMENT TECHNOLOGIES

 RESEARCH

Fundamentals of the technology of enrichment and application of minerals, including non-ferrous metals' ores, mono and polymetallic ores, carriers of rare earth elements, heavy minerals, free gold and platinum metals, coal, waste rock, waste produced by ore processing, and secondary raw materials. The unit's instrumentation enables studies of mineral materials, carrying out various mineralogical processes (including magnetic, electrical and gravitational separation, floatation, coagulation, agglomeration, comminution, sieving, dehydration, drying, analyses of size composition, as well as determination of organic carbon and metallic elements), determining wettability and other physico-chemical properties.

 APPLICATION

Technologies of enriching minerals and application of waste.

 Contact information

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## CHARACTERISATION OF NANOSTRUCTURES USING OPTICAL METHODS

### RESEARCH

The Laboratory of Optical Spectroscopy of Nanostructures conducts optical research into single nanostructures and systems with dimensions ranging from a few to a few dozen nanometres. The optical studies use the following experimental techniques: luminescent and optical spectroscopy as well as time-resolved modulation spectroscopy.

### APPLICATION

Nanoengineering, material engineering, telecommunications, optoelectronics, and semiconductor optics.

#### Contact information

Laboratory of Optical Spectroscopy of Nanostructures  
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## CHARACTERISATION OF SEMICONDUCTOR DEVICES

### RESEARCH

Research into defects in semiconductors using photoelectric methods.

### APPLICATION

Testing semiconductor devices:

- basic electrical measurements of semiconductor connectors such as: measurements of I-V, C-V characteristics in a wide range of temperatures from 20 to 350 K, as well as measurements of the photoelectric effect,
- research involving the characterisation of defects in semiconductor structures using the technique of electrically (DLTS) and optically (ODLTS) stimulated non-stationary capacitance spectroscopy, as well as with the conventional lock-in and Laplace DLTS methods,
- research involving the characterisation of defect kinetics using the technique of time-resolved photoconduction and photocapacitance spectroscopy,

- research involving the electrical characterisation of defects using the thermally stimulated capacitance technique (TSCAP),
- research into relaxation processes in semiconductor connectors using the impedance spectroscopy method.

#### Contact information

Laboratory of Semiconductor Research with Electrical Methods  
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## CRYOSTATING SUPERCONDUCTOR DEVICES: ACCELERATORS, LASERS, AND OTHER ONES

### EXPERT REPORT

Modelling, studies, and expert evaluations of systems for cryostating superconductor devices, including accelerators, lasers, etc.

### APPLICATION

Cryostating superconductors, helium distribution systems, and studies of materials in liquid and superfluid helium.

#### Contact information

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## DESIGN, PROTOTYPING AND IMPLEMENTATION OF TECHNICAL SOLUTIONS IN THE AREAS OF OPTICS, OPTOMECHANICS, AND PRECISION ENGINEERING

### TECHNOLOGY

Design and production of components and devices combining precision mechanics, instrumental optics, and electron-

ics. The unit comprises three design engineering and production teams which offer the following services:

- measurements, analysis, and design of optical elements and systems,
- production of optical elements (lenses, prisms, wedge filters, optical parallels, etc.),
- design and production of mechanical systems.

The services provided by the unit concern broadly understood instrumental optics, with unique and one-off solutions in particular. Apart from design and production, the unit performs technical analyses and evaluations.

The unit uses a well-equipped stock of tools enabling the following technological processes:

- machining steel, non-ferrous metals, and plastics (cutting, turning, and milling),
- welding steel elements,
- precision laser processing: cutting and engraving (plastics and organic materials),
- complete technological line for processing optical glass: cutting, grinding, and polishing; interferometric measurements.

### APPLICATION

- design and production of prototype devices and short batches, modernisation and renovation of mechanical and optical devices,
- design and production of mechanical elements and systems,
- design of lighting optics systems, as well as photometric and colorimetric measurements,
- interferometric measurements of surface shape, measurements of light refraction ratio and its spatial distribution.

#### Contact information

Laboratory of Optical Technologies  
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## MEASUREMENTS OF PROPERTIES OF THE EYE, OPHTHALMIC DIAGNOSTICS

### RESEARCH

Measurements of geometrical, optical and biomechanical properties of the eye. Optical tomography, videokeratometry, tonometry, biomechanics - corneal visco-elasticity and interferometry of the tear film.

### APPLICATION

Development and application of new methods and apparatuses for the diagnostics of the optical and biomechanical properties of the eye. Innovative analysis of measurement data obtained using modern ophthalmological devices (ORA, PASCAL, and OCT).

#### Contact information

Laboratory of Visual Optics  
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## OBTAINING FERROIC CERAMIC MATERIALS

### TECHNOLOGY

Ceramic materials are obtained by sintering in appropriately adjusted temperatures. The ceramics are doped with chromium or rare earth metals in order to obtain high efficiency luminescent materials. The technology is used to produce ferroic piezoelectric and electro optical materials.

### APPLICATION

The ceramic materials can be used to develop high efficiency laser materials, piezoelectric converters, and electro optical materials.

#### Contact information

Laboratory of Physics of Dielectrics  
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## OBTAINING POROUS GLASS-BASED FERROIC NANOCOMPOSITES

### TECHNOLOGY

Porous glasses are obtained from homogeneous sodium borosilicated glasses. Phase separation is carried out by heating the material at an appropriately adjusted temperature. The temperature and time of heating determine porous glasses' parameters. The next stage consists in etching the sodium-boron phase with hydrochloric acid. Silica gel present in the pores is leached with potassium hydroxide. The pores are filled with a solution or alloy originated ferroelectric material.

### APPLICATION

Composites can be applied in the construction of memory components and electromechanical converters and photonic systems. The materials are used in basic research – i.e. studies of dimensional effects in ferroic nanoparticles and their results useful for the purposes of the construction of new multi-purpose materials.

#### Contact information

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## OPTICAL MEASUREMENTS, OPTICAL TWEEZERS

### RESEARCH

Optical vortex interferometer: enables high-resolution measurements of two or three parameters simultaneously.

The measurements offered by the unit include the following: wave front geometry, properties of doubly refracting media, and small rotation angles. A compact polarimeter is a small device with which it is possible to determine three parameters characterising doubly refracting media, i.e. azimuth angle, ellipticity angle, and phase shift with a single measurement.

The resolution of the measurements is relatively low, but a simple analysis and a single measurement provide an opportunity to measure media with fast changing characteristics. Optical traps are generated holographically in the optical tweezer system. As a result, more than twenty traps can be generated and independently controlled at the same time. Each trap's parameters can be defined independently.

Application: trapping and manipulating cells, large-size biological aggregates (e.g. lipid film), DNA, and other dielectric micro-objects.

### APPLICATION

- determination of the quality of optical elements, measuring rotation angles and surface quality, as well as making fast polarimetric measurements.
- biomedical research using optical tweezers.

#### Contact information

Laboratory of Interferometric and Polarimetric Metrology  
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## OPTICAL SPECTROSCOPY

### RESEARCH

Determination of the quality of light radiation:

- emitted by light sources,
- transmitted by objects (e.g. optical filters).

### APPLICATION

Spectroscopy is based on analysis of radiation emitted, transmitted, or absorbed by objects or substances depending on the wavelength (or the radiation frequency). This kind of analysis allows us to determine the composition of a substance or different properties of objects (e.g. parameters of optical filters or the quality of radiation emitted by light sources). The tool used at the unit to measure spectra is the spectrometer.

## Contact information

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## PHOTOVOLTAICS AND PLASMONICS OF METALLIC NANOSTRUCTURES

### RESEARCH

Nano-scale quantum technology for the purposes of research into a new generation of plasma-modified solar cells.

### APPLICATION

Photovoltaic and photonic applications of plasmonics.

## Contact information

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## QUANTUM CRYPTOGRAPHY

### RESEARCH

Modern systems for quantum distribution of the cryptographic key using entangled and non-entangled photons.

### APPLICATION

IT security, completely secure special connections in the IT domain.

## Contact information

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## RAMAN AND AFM SPECTROSCOPY

### RESEARCH

High resolution Raman spectroscopy and atomic force microscopy.

### APPLICATION

Advanced studies of materials.

## Contact information

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## SPECIALITY OPTICAL FIBRES, OPTICAL FIBRE SENSORS

### RESEARCH

Optical fibre systems for measuring different physical parameters based on speciality optical fibres and optical fibre elements such as Bragg gratings, long period gratings, rocking filters, and photonic crystal fibres.

### APPLICATION

Measurements of physical parameters including temperature, elongation, hydrostatic pressure, and bending. Possible applications of the services cater to the needs of the construction industry (monitoring large structures' state), as well as the area of technological process check-ups and mechanical engineering.

## Contact information

Laboratory of Optical Fibre Optics  
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## ANALYSIS OF THE EFFECTIVENESS OF HYDROGEN PRODUCTION FROM HIGH-TEMPERATURE ELECTROLYSIS AND GASIFICATION OF SOLID FUELS AND BIOGAS

### RESEARCH

Laboratory of Energy Conversion of the Division of Boilers, Combustion and Power Engineering Processes offers services in the following areas:

- studies of the processes of electrolysis, gasification, and purification of syngas and biogas to hydrogen,
- evaluations of hydrogen effectiveness and purity.

### APPLICATION

- determination of optimal conditions and efficiency of hydrogen production for various methods,
- selection of techniques of conversion of syngas and biogas to hydrogen,
- application in PEM fuel cells - evaluation of effectiveness.

## Contact information

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## BALANCE OF WASTE ENERGY IN A COMPANY AND SELECTION OF RELEVANT RECOVERY TECHNOLOGIES

### EXPERT REPORT

- execution of a company's energy balance,
- determination of the forms of waste energy generated in technological processes,
- characteristics of waste energy resources in terms of efficiency, quality, and possible uses,
- determination of possible energy recovery techniques and evaluation of their impact on a company's energy efficiency.

 APPLICATION

Development of expert evaluations in the form of energy balances catering to the needs of companies conducting energy management activity.

 Contact information

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## CHARACTERISATION OF FUELS AND WASTE FOR THE PROCESSES OF COMBUSTION, GASIFICATION, PYROLYSIS, AND CARBONISATION, AS WELL AS SELECTION OF TECHNOLOGIES TO REDUCE CONTAMINATION

 RESEARCH

The Laboratory performs studies of fuels, biomass, waste, and RDF involving the following:

- determination of properties of raw fuels and fuels which underwent torrefaction, pyrolysis, gasification, and combustion processes,
- determination of fuel slagging indices,
- studies of the behaviour of various fuels in the combustion and co-combustion process using a laboratory-grade vertical flow reactor (heat power of about 25 kW), along with a possibility of selecting combustion parameters and evaluation of gaseous and powder contamination,
- studies of the process of biomass transformation into syngas (gasification, fermentation, torrefaction, and pyrolysis),
- evaluation of sorbents' reactivity and the effectiveness of desulphuring, denitrating, and carbon dioxide separation from combustion gases using solid calcium or liquid sorbents,
- pilot studies of the processes of drying, torrefaction, pyrolysis, and gasification of solid fuels,
- measurements of the combustion chamber and boilers, in particular at professional and industrial power engineering facilities.

 APPLICATION

- torrefaction, pyrolysis, and gasification - selection of parameters,
- technical and elemental analysis of fuels and the mineral substance,
- studies of mercury in fuels, ashes, and combustion gases,
- measurements of gaseous and solid contamination emissions resulting from combustion,
- optimisation of systems for desulphuring, denitrating, and CO<sub>2</sub> separation,
- balance measurements and evaluation of emissions from boilers applied in the power engineering sector,
- evaluation of the corrosion risk of boiler furnaces,
- distribution of temperatures and concentrations of gas components in the boiler's furnace chamber.

 Contact information

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## CONSULTANCY, EXPERT EVALUATIONS, AND ISSUING OPINIONS ON MODERNISATION AND INVESTMENT PROJECTS RELATED TO BOILER ROOMS AND HEATING SYSTEMS

 EXPERT REPORT

The scope of services offered by the unit includes consultancy and expert evaluations, as well as issuing opinions on modernisation and investment projects with respect to the following areas:

- boilers and low power boiler rooms,
- conventional heating systems,
- heating systems based on renewable energy sources,
- environmental protection.

 APPLICATION

The services offered include the following:

- consultancy, expert evaluations, and opinions with respect to modernisation and investment undertakings related to boiler rooms and heating systems,
- selection of boiler room facilities and instrumentation,
- the operation and modernisation of boiler rooms and heating systems,
- applications in project solutions related to advanced, energy-efficient, and environmentally friendly heating techniques.

 Contact information

Laboratory of Consultancy, Evaluations, and Reports on Modernisation and Investment in Boiler Rooms and Heating Systems  
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## DATA MONITORING AND ACQUISITION

 EXPERT REPORT


The Centre for Data Monitoring and Acquisition offers cooperation in the following areas:

- planning and design of data acquisition systems,
- consultancy services in the area of measurements teletransmission,
- design of dedicated database servers,
- design of relational databases,
- organisation of management and maintenance of diagnostic procedures,
- integration of heterogenic control and measurement systems,
- remote facility monitoring and control.

 APPLICATION

- integration of management systems and archiving of data obtained by measuring the quality of electric energy in distribution networks using dispersed generation,
- supervision of specific diagnostic elements responsible for secure operation of an electric power engineering system,
- standardisation of the format of data recorded by energy quality analysers in the context of definitions, standards, and directives applicable in the power engineering industry.



 Contact information

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## DETERMINATION OF FIRE AND EXPLOSION PARAMETERS AND EVALUATION OF THREATS

 RESEARCH

The Laboratory of Combustion and Explosion Science of the Division of Boilers, Combustion, and Power Engineering Processes offers services in the following areas:

- studies of fuel combustion processes (solid, liquid, and gaseous fuels),
- studies of emissions of gaseous pollution and properties of furnace waste products,
- studies of fire and explosion properties of gases and dusts, as well as explosion threat,
- diagnostic studies and monitoring of corrosion threats to boiler furnaces.

 APPLICATION

- determination of explosive parameters of gases and dusts and design of explosion protection solutions for power and industrial installations,
- diagnostics and ongoing monitoring of corrosion threats to pulverised-fuel boilers,
- studies and optimisation of fuel combustion processes in terms of limiting the emission of pollutants from boiler furnaces.

 Contact information

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## DIAGNOSTICS OF STEAM BOILERS' CORROSION RISKS

 RESEARCH

The Laboratory of Combustion and Explosion Science of the Division of Boilers, Combustion and Power Engineering Processes offers services in the area of studies of the extent of high-temperature corrosion threat to boiler furnaces' heatable surfaces. The studies are performed using a system of continuous monitoring of the combustion gases composition in the boundary layer, as well as sediment and resistance probes.

 APPLICATION

- diagnostics of corrosion risks in pulverised-fuel boilers,
- uninterrupted monitoring of the composition of combustion gases in pulverised-fuel boilers' boundary layer,
- studies of the impact of the properties of fuel being combusted on the threat of increased high-temperature corrosion,
- optimisation of combustion processes in steam boilers.

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## EVALUATION OF A COMPANY'S ENERGY EFFICIENCY AND IDENTIFICATION OF POSSIBLE METHODS OF ITS IMPROVEMENT

 EXPERT REPORT

- analysis of an enterprise in terms of the effectiveness of its use of various forms of energy,
- indication of technological processes where it is possible to improve the energy use effectiveness (also through the inclusion of energy from alternative sources),

- determination of feasible techniques aiming to increase technological processes' effectiveness and evaluation of how their application affects a company's energy efficiency.

 APPLICATION

Development of evaluations in the form of reports catering to the needs of enterprises streamlining their energy management.

 Contact information

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## EVALUATION OF FIRE AND EXPLOSION THREATS

 RESEARCH

The scope of the unit's services includes studies, measurements, consultancy, evaluations, and reports with respect to modernisation and investment undertakings involving the following:

- determination of the maximum explosion pressure (p<sub>max</sub>), maximum pressure accretion (dp/dt), deflagration index (K<sub>st</sub>), lower explosive limit (LEL), and minimum oxygen concentration,
- determination of ignition characteristics, e.g. minimum flash point of a dust-air cloud; minimum flash point of a dust layer (t<sub>5mm</sub>),
- determination of the minimum self-ignition temperature,
- determination of the dust flame propagation speed,
- determination of the reaction (reactivity) speed and a reaction's thermal effect, as well as reaction product composition,
- determination of ignition in the fluidal layer conditions,
- determination of the minimum ignition energy,
- evaluation of threats during grinding and co-combustion of biomass and alternative fuels,

- security of the operation of transport devices and storage areas,
- measurements of boilers and mill installations,
- measurements of a boiler's efficiency during biomass combustion and co-combustion,
- implementation of new technologies related to the use of fuels, renewable fuels or energy sources, or waste.

### APPLICATION

The Laboratory performs the following measurements and studies in the field of fuel characterisation:

- physico-chemical properties of fuels and fuel mixes (coal, coal waste, biomass, etc.),
- determination of parameters of ignition and self-ignition of a dust-air mix, as well as explosion protection solutions in power engineering and industrial installations,
- determination of parameters characterising fuels according to fire and explosion threats.

The Laboratory also performs tasks consisting in the classification of explosion threats to facilities.

#### Contact information

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## EVALUATION OF THE TECHNICAL CONDITION OF ELECTROFILTERS

### EXPERT REPORT

Evaluation of the technical condition of electrofilters involving the following works:

- inspections of electrofilters involving the following:
  - the mechanical part,

- the electric part and the automation circuits of the power supply systems - measurements of the electrical parameters of an electrofilter's operation,
- measurements of the electrical parameters of an electrofilter's operation,
- necessary tests and analyses of the dust-gas medium entailing the following:
  - distribution of speed at the duct collector chamber's inlet (two inlets),
  - grain composition of the volatile ash at the inlet,
  - physico-chemical properties of ash,
- gathering data related to dust emission and operational parameters of the dusting source.

### APPLICATION

The works proposed, consisting in a detailed analysis of basic components and a comprehensive evaluation of an electrofilter's technical condition, aim to establish actions to ensure maintaining or improving dust removal efficiency. The resulting technical solutions and/or organisational actions proposed, allowing for the current state of knowledge of the existing facility, will enable dust removal efficiency levels that guarantee compliance with applicable environmental standards.

#### Contact information

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## FURNACE INSTALLATION FOR THE COMBUSTION OF LOW CALORIE GASES, LIQUID WASTE FUELS, AND DIVIDED BIOMASS

### TECHNOLOGY

The problem of recycling low calorific waste gases of variable composition, as well as solid and liquid organic waste

substances characterised by high viscosity, requires special solutions. Organic waste substances can be used in the locations of their origin as an additional source of heat energy, which is why the unit has developed a technology of special furnace/pre-furnace chambers and burners enabling stable combustion. The combustion of top gas in vortex chambers was undertaken at the Copper Smelter in Legnica, at the feed preparation department. Burners for liquid glycerol fuels were tested at Koziencie power plant, while HAST company performed tests with waste biomass burners.

### APPLICATION

Application of gaseous, liquid, and solid waste fuels at the place of their origin for their integration with an existing energy generation system or as a separate installation using heat for technological purposes.

#### Contact information

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## HEAT ACCUMULATION IN PHASE-CHANGE MATERIALS (PCM)


### TECHNOLOGY

Technology of accumulating low-, mid-, and high-temperature heat in heat accumulators using phase-change materials (PCM), involving the following activities:

- thermal flow calculations,
- selection of phase-change materials,
- development of a technical design of an installation and a heat accumulator.

### APPLICATION

- storage of the surplus of the heat produced for further use,
- stabilisation of heat stream fluctuations in unsteady processes.

 Contact information

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## HEAT ACCUMULATORS

 TECHNOLOGY

- designs and analyses of household and industrial installations of heat energy accumulators based on porous ceramic and stone beds operating in the temperature range of 0–400°C,
- energy analyses of the operation of an installation cooperating with accumulators in a 24h, a season's, or a year's cycle, including ones based on Typical Meteorological Year data.

 APPLICATION

- household installations of heat energy accumulators make it possible to develop low-energy or passive house technologies where heat energy accumulated allows the stabilisation of a building's temperature over a period of 24 hours, season, or even the whole year,
- industrial installations of heat energy accumulators enable the development of production technologies where the accumulated heat energy enables stabilisation of the temperature of production processes over a period of 24 hours, a season, or even the whole year,
- accumulators can also be used for waste heat recovery from technological processes for the purpose of its further use, e.g. for preheating or heating of rooms,
- energy analyses allow technical and economic evaluations of the usefulness of an installation being considered without a need for constructing it.

 Contact information

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## LABORATORY STUDIES OF CHARACTERISTICS OF FUELS, COMBUSTION, GASIFICATION, AND PYROLYSIS OF SOLID FUELS, BIOFUELS, AND WASTE

### RESEARCH

The Laboratory performs the following measurements and studies in the field of fuel characterisation with respect to the following:

- physico-chemical properties of fuels (coals, waste, sewage sediments, biomass, etc.),
- optimisation of fuel mix selections,
- determination of parameters characterising fuels in terms of causing fire and explosion threats,
- slagging and ashing threats,
- emission of pollution caused by gases and heavy metals including mercury,
- corrosion and erosion threats,
- implementation of new CFS type technologies using conventional fuels.

### APPLICATION

The service involves research, measurements, consultancy, expert evaluations, and issuing opinions with respect to the following areas:

- fuel and energy management, clean coal technologies,
- biomass combustion and co-combustion in boilers,
- waste and environmental protection management,
- waste utilisation for power generation purposes - fuel, sorbents and catalysts, ignition and self-ignition,
- studies of the limitation of the phenomenon of mercury emission during combustion,
- protection of boilers against slag and ash depositing,
- measurements of combustion, pyrolysis, torrefaction, and gasification of solid fuels and waste,
- evaluation of fire and explosion threats occurring during grinding and co-combustion of fuels,
- measurements of boilers and mill installations, and renewable waste in the power engineering sector and industry.

### Contact information

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## MEASUREMENTS OF A 50 HZ ELECTROMAGNETIC FIELD

### RESEARCH

- measurements of the electromagnetic field in the workplace, field generated by electrical power engineering systems and electric AC supply installations in the power engineering industry,
- measurements of the electromagnetic field in the environment, near electrical power installations,
- computation based identification of 50 Hz electromagnetic fields near electric and electrical power devices.

### APPLICATION

- computation and measurement based identification of 50 Hz electromagnetic fields near overhead and cable power lines, heavy current stations, and other electrical power devices,
- analysis of threats to people and the environment caused by electromagnetic fields generated by electrical power devices,
- analysis and evaluation of the conditions of work in 50 Hz electromagnetic fields.

### Contact information

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## MODELLING HEAT AND FLOW PROCESSES USING CFD

### EXPERT REPORT

Modelling heat and flow processes using CFD. Our experience includes the following areas:

- modelling of the course of a flood wave,
- modelling of condensers applied at power plants,
- modelling of cooling towers,
- modelling of flows in geometrically complex channels.

### APPLICATION

Mathematical and numerical modelling enables the following:

- optimisation of industrial structures,
- streamlining technological processes,
- construction of diagnostic systems,
- construction of early warning systems.

### Contact information

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## OPTIMISATION OF CONVERSION PROCESSES AND ENERGY USAGE IN THE HEAT AND ELECTRIC POWER INDUSTRY

### EXPERT REPORT

- analysis of the technical condition of the client's company including indication of the areas of its technological path where improvement of energy conversion performance is possible (e.g. conversion of fuels' chemical energy into electric energy or heat),
- application of waste heat sources,
- development of a concept for the improvement of process effectiveness along with a multi-variant technical and economic analysis.

## APPLICATION

Heat and power engineering.

### Contact information

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## OPTIMISATION OF POWER MACHINES AND DEVICES IN TERMS OF HEAT AND FLUID FLOW

### EXPERT REPORT

- analysis of a machine in terms of flow and heat,
- indication of a machine's elements with unfavourable flow and heat related phenomena (flow disturbances, turbulences, etc.),
- determination of feasible technical solutions aiming to improve the energy efficiency of machines by minimising or eliminating the impact of unfavourable flow and heat phenomena,
- optimisation of a machine's construction using solutions selected.

## APPLICATION

Development of evaluations in the form of reports for the needs of enterprises manufacturing various types of machines and devices.

### Contact information

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## OPTIMISATION OF THE ELECTRICAL/HEAT ENERGY POWER UNIT AND ICE WATER PRODUCTION IN TERMS OF ENERGY EFFICIENCY AND REDUCTION OF GASEOUS POLLUTION

### EXPERT REPORT

- analysis of an existing system producing electric energy, as well as a cogeneration system and a tri-cogeneration system, aiming to assess the possibilities of improving its efficiency and limiting emissions of gaseous pollutants while minimising energy and financial costs,
- a concept for system modification in terms of production and reduction of pollutants (sulphur dioxide, nitrogen oxides, and carbon dioxide) - selection of technology,
- 3D modelling of flow with combustion, heat exchange and precipitation of deposits in power boilers.

## APPLICATION

- boiler combustion technology,
- CFD simulations,
- modelling elements of power plants and power engineering systems,
- on-line analysis of systems' measurement data,
- modelling boilers in minimum load conditions,
- techniques used to improve boilers' flexibility and performance stability,
- simultaneous nitrogen and sulphur removal,
- selection of techniques and sorbents for decreasing NOx SOx and mercury content,
- formation of sediments, slagging, and contamination of heatable surfaces.

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## PHYSICAL AND NUMERICAL MODELLING OF ATMOSPHERE CONSERVATION DEVICES

### RESEARCH

Modelling atmosphere conservation devices (electrofilters, desulphurisation reactors, catalytic inserts for denitrating systems using the SCR method) and technological devices (flues and cooling towers) aiming to optimise their performance. The services offered by the unit include the following:

- physical modelling of objects, which enables studies of the gas flow aerodynamics using linear scale models with geometrical and hydrodynamic similarity ensured,
- numerical modelling of objects or their parts, which can supplement physical studies or constitute the integral whole of the research conducted.

## APPLICATION

The primary purpose of the studies is to optimise the construction and operational parameters of the specified objects on the basis of the following:

- evaluation of the spatial distribution of speed,
- evaluation of pressure losses,
- visualisation of flow and its photographic documentation.

### Contact information

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## POWER ENGINEERING MATERIALS SCIENCE I

### RESEARCH

Research work and expert evaluations in the area of power engineering materials science, including, most notably, the following:

- studies of degradation and ageing processes in materials such as fuels, ashes, and dielectrics,
- determination of temperatures of sintering ashes from coals, biomasses, and sewage sediments using the pressure method, strength method, as well as electric AC/DC method.

- measurements of mechanical and electrical (AC and DC) properties of fuels, ashes from fuels, and dielectrics at room temperature and in situ at temperatures from room to 1,200°C,
- evaluation of the efficiency of purifying dry and humid gas mixes (including simulated boiler gases) from sulphur dioxide (adsorption method) and nitrogen oxide (catalytic reduction method).

### APPLICATION

- evaluation of the extent of operational threats during the combustion of various fuels, as well as evaluation of fuels' quality,
- measurement and evaluation of mechanical and electrical (AC and DC) properties (in RT and in situ in the range of RT - 1200°C),
- evaluation of purification efficiency of gas mixes.

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## POWER ENGINEERING MATERIALS SCIENCE II

### RESEARCH

evaluation of mercury content in various materials, in particular:

- solid fuels (coals, biomasses, and waste),
- liquid fuels,
- gases and gaseous fuels,
- measurements of mercury emissions in combustion gases, allowing for element separation,
- evaluations in the area of modernisation and operation activities related to measurements of mercury in installations and limitation of mercury emission.

### APPLICATION

- studies and evaluations aiming to limit the phenomenon of mercury emission occurring in combustion processes,
- analysis of fuels and power engineering processes affecting transformations of mercury in combustion gases and solid furnace waste.

### Contact information

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## RECOVERY AND RECYCLING OF WASTE HEAT FROM PROCESS GASES

### TECHNOLOGY

Technology of recovery and use of waste heat from gases (e.g. exhaust gases from boilers using solid fuels and process gases), allowing for the condensation of steam which they contain. The technology comprises the following:

- analysis of a possibility of using recovered waste heat,
- heat and design calculations with respect to exchangers,
- technological design of a system for the recovery and use of heat along with determination of technical and economic results of solutions proposed.

### APPLICATION

Improvement of the cycle efficiency and putting waste heat to use in another part of the system or another process.

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## SOLAR COLLECTORS

### TECHNOLOGY

Designs and analyses of solar collector constructions and industrial solar collector installations

- flat, low temperature liquid (up to 70°C) systems,
- flat, medium temperature (up to 120°C) systems,
- converging, high temperature (up to 400°C) systems,
- overhead collectors.

Energy analyses of a solar installation's operation in a 24 hour, a season's, and a year's cycles, in particular based on Typical Meteorological Year data.

### APPLICATION

Solar collectors enable conversion of free energy of solar radiation into useful heat energy. Solar collector installations make it possible to use the energy of solar radiation and partially or fully replace the energy from traditional sources (combusted fuels and electric power). Energy analyses allow a technical and economic assessment of the usefulness of applying a solar installation under consideration in the Polish climatic conditions without a need to build it.

### APPLICATION

- heating installations,
- drying installations,
- heat used in technological processes.

### Contact information

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## STUDIES AND DEVELOPMENT OF MODERN ENVIRONMENTALLY FRIENDLY COOLING AND HEAT PUMP TECHNOLOGIES

### RESEARCH

We offer services consisting in research, development, computation, and optimisation works with respect to cooling devices and heat pumps using the left-side thermodynamic cycle, and in particular:

- we have experience in the field of numerical modelling and designing left-side cycle devices, also ones based on the phenomenon of adsorption; our competencies involve chemical and physical adsorption processes and phase changes of natural cooling agents in decreased pressure conditions.

- our work entails research and modification of the properties of working media applied in cooling devices and heat pumps by doping with nanoparticles; our focus is nanoliquids based on water with graphene oxide and its derivatives.
- the scope of our expertise also includes thermosiphon heat exchangers and heat pipes serving the role of passive systems supporting the operation of heating and cooling installations, applied in fields such as road infrastructure and civil engineering.

### APPLICATION

The rapid development of global economies and the quality of life leads to an increase in the demand for cooling technologies, both for people's technical comfort and for the purpose of food transport and storage. It is necessary to disseminate technologies which have a lesser impact on the environment than the compressor based systems applying synthetic agents used so far. The technologies offered by our unit are future solutions relying on natural substances and renewable energy sources.

#### Contact information

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## STUDIES AND EVALUATION OF ELECTRICAL RISKS

### EXPERT REPORT

- research in the field of electric shock protection techniques,
- tests of electric appliances with respect to operational security,
- studies of electric shock risk and the efficiency of electric shock protection measures of electric systems and appliances,
- model and physical tests of different types of earths and earth systems,
- studies of the impact of dispersed renewable energy specificity on electrical security.

### APPLICATION

- analysis of electric shock protection systems' efficiency at the stage of technical design,
- studies and evaluation of low voltage systems' technical parameters,
- evaluation of the impact of dispersed power sources on parameters determining electrical safety,
- evaluation of the possibility of applying adaptive (intelligent) electric shock protection systems to control electrical safety.

#### Contact information

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## STUDIES OF HEAT-FLOW PROCESSES COMBINED WITH NUMERICAL CFD ANALYSIS

### RESEARCH

Studies of power engineering devices in terms of energy efficiency, mainly heat-flow processes, and their optimisation using advanced numerical CFD (Computational Fluid Dynamics) techniques. For this purpose, we perform comprehensive studies/measurements, i.e.:

- measurements of heat parameters such as temperature and heat stream,
- measurements of flow parameters such as local speed values, as well as flow intensity in terms of mass and volume,
- development of mathematical models of heat-flow processes and their analyses, e.g. prototype power engineering devices,
- heat-flow optimisation of power engineering device constructions such as heat exchangers, boilers, and furnaces, for purposes including improving heat effectiveness or minimising pressure losses,
- assistance with designing innovative heat-flow construction solutions.

### APPLICATION

In order to improve the heat effectiveness and decrease flow losses of power engineering devices, it is necessary to conduct heat-flow analyses. Then, a virtual model can be developed using CAD type software and implemented.

Device models developed at the unit can be used for optimisation of constructions with specific parameters in mind, such as maximising heat stream, minimising pressure losses, or economic aspects.

#### Contact information

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## STUDIES OF MATERIALS' RESISTANCE TO CAVITATION

### RESEARCH

- studies of the phenomenon of cavitation caused by applying the flow method and the ultrasound method,
- determination of materials' resistance to cavitation erosion.

### APPLICATION

Selection of materials for hydraulic installations and fluid flow machines exposed to cavitation.

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## STUDIES OF THE TECHNICAL CONDITION OF RENEWABLE ENERGY SOURCE INSTALLATIONS

### RESEARCH

Renewable energy installations consist of a number of elements and systems, whose technical condition determines

the durability and reliability of the whole installation. To ensure them, it is necessary to perform comprehensive tests of the elements of renewable energy installations such as photovoltaic cells, solar collectors, heat pumps, as well as installations using them to heat rooms and prepare utility water, as well as combustion engines using renewable fuels.

### APPLICATION

- determination of the technical condition of elements of renewable energy installations,
- determination of the extent of the wear of elements of renewable energy installations,
- evaluation of the potential time left before reaching the limit state of elements of renewable energy installations.

### Contact information

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## STUDIES OF THERMOPHYSICAL PROPERTIES OF MATERIALS, MOLECULAR STUDIES OF SORPTION AND MOLECULAR DYNAMICS

### RESEARCH

- studies of materials' thermophysical properties specific heat, heat of phase changes) and energy-related effects of physical and chemical processes (heat of chemical reactions) using the method of differential calorimetry scanning (DSC) and thermogravimetric analysis (TGA),
- numerical simulations of heat exchange in heat exchangers and heat accumulators with phase change/adsorption/chemical reaction,
- molecular simulations of sorption and molecular dynamics with force field methods and the density functional method (DFT).

### APPLICATION

- development of new, innovative materials for storing energy and studies of their properties,

- design of innovative energy warehouses and optimisation of their construction in terms of heat exchange intensification,
- design of innovative materials to be used in the power engineering sector: sorbents and catalysts.

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## TECHNICAL DUE DILIGENCE STUDIES OF HEAT AND POWER GENERATION COMPANIES

### EXPERT REPORT

- analysis of a company's technical resources (including their current technical condition) necessary to undertake an investment,
- analysis of investment outlay, including resources related to environmental protection,
- SWOT analysis.

### APPLICATION

- analysis of financial outlays,
- analysis of outlays in the area of environmental protection,
- SWOT analysis.

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## TECHNOLOGY OF GASIFICATION AND PYROLYSIS; DEDUSTING OF GASES OBTAINED

### TECHNOLOGY

- technology of gasification and pyrolysis of solid fuels - biomass, waste, and fossil fuels, including the design of installations for fuel gasification and pyrolysis,

- dedusting process gases from gasification and pyrolysis; high-temperature purification of process gases - selection of sorbents and catalysts.

### APPLICATION

- application of waste fuels and low-value biomass fuel (possible production of heat and power in a cogeneration model),
- recycling of industrial and municipal waste.

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## TECHNOLOGY OF LOW TEMPERATURE DRYING OF FUELS, SEWAGE SEDIMENTS, AND HIGH MOISTURE CONTENT WASTE - INTEGRATION WITH AN EXISTING POWER ENGINEERING SYSTEM

### TECHNOLOGY

- development of a technology for drying lignite, sewage sediments, and digestate using waste heat and solar radiation energy in the so-called closed cycle for energy production,
- development of a system for using waste heat and solar energy in a power unit's regeneration systems and accumulating energy; the technology aims to improve the efficiency and flexibility of power units - it is necessary to apply technologies leading to an increase in energy production efficiency in units using coal with variable loads in mind,
- balance and economic evaluation of power units integrated with installations for waste heat recovery, RES, and energy accumulation, evaluation of a power unit's and specific devices' efficiency,
- development of technologies for producing energy from high moisture content waste, including sewage sediments, digestate, etc.
- optimisation of hybrid power engineering systems in terms of efficiency and flexibility.



## APPLICATION

- improvement of a power unit's efficiency and flexibility with a drying system and the application of heat from various sources for drying; improvement of the efficiency of power units with an accumulation system with variable loads,
- application of a low-temperature installation for drying coal and paste-like waste (sewage) with a possibility of using waste heat sources or heat energy obtained from a concentric solar collector with an accumulation system,
- accumulation of low-temperature heat using heat pumps.

## Contact information

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## VALORISATION OF FUELS AND LOW EMISSION COMBUSTION TECHNOLOGIES

### RESEARCH

The unit performs many tasks in the fields of industrial and commercial power engineering. The team conducts research related to the following processes:

- thermal valorisation of fuels on a pilot scale,
- drying, torrefaction, gasification, and pyrolysis of solid biomass fuels,
- low emission technologies - combustion in an atmosphere enriched with oxygen and integrated with CO<sub>2</sub> capture,
- biomass co-combustion and combustion with evaluation of sediments,
- application of renewable sources of energy in the power production process; development of bioenergy technologies.

### APPLICATION

- production of biocoal from biomass with torrefaction and slow pyrolysis methods,
- gasification of low calorie fuels, waste and biomass integrated with the production of electric energy and heat,
- combustion of high viscosity liquid fuels in dynamic and atomising burners,
- combustion and co-combustion of biomass with additives in order to minimise deposits,

- separation and removal of CO<sub>2</sub> from combustion gases,
- application of low temperature heat sources in ORC systems,
- improvement of power units' performance.

## Contact information

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## WASTE GASIFICATION, SYNGAS PURIFICATION, AND PLASMA TECHNIQUES

### RESEARCH

The research works performed at the Division involve the analysis of the potential and application of microwave plasma in purifying and conditioning of gases. The research conducted concerns the following areas:

- improvement of the quality of raw syngas (decrease in the content of hydrocarbons and CO<sub>2</sub> with increased CO and H<sub>2</sub> content),
- removing CO<sub>2</sub> from syngas (through dissociation and reduction using C<sub>x</sub>H<sub>y</sub> and H<sub>2</sub>),
- small-scale studies using a microwave plasma reactor with a single microwave generator (3 kW), 60 cm in length,
- mid-scale studies using four serial microwave generators (2x3 kW and 2x2 kW), 150 cm in length,
- analysis of the composition/quality of plasma/gaseous products obtained as a result of its effect (spectroscopy with a CCD camera, gas chromatographs - MS, FID, TCD).

### APPLICATION

- studies of plasma ignition,
- plasma-supported start-up of boilers,
- purification of combustion gases,
- aftercombustion of post-process gases.

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## WASTE HEAT RECOVERY FROM THE BOILER OUTLET COMBUSTION GAS

### TECHNOLOGY

- the technology of recovery and use of waste heat from gases (e.g. exhaust gases from boilers using solid fuels), including condensation of steam which they contain,
- analyses of the application of recovered waste heat,
- calculations of exchangers' thermal and design parameters,
- technological design of a system for the recovery and use of heat along with determination of technical and economic results of solutions proposed.

### APPLICATION

Recovery and use of waste heat transmitted to the atmosphere with combustion gases results in an increase in the effectiveness of the conversion of fuels' chemical energy into electrical energy (in a conventional power plant) or heat (in a heat generating plant or CHP plant) through a decrease in the cost of fuel used in the process and reduction of pollution, chiefly with CO<sub>2</sub>.

## Contact information

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## DESIGN AND ORGANISATION OF MANUFACTURING SYSTEMS

### EXPERT REPORT

Our unit offers analyses, evaluations, and reports with respect to manufacturing systems. The areas on which we focus are as follows:

- effectiveness of using production resources,
- possibilities of using new technologies,
- introduction of new products or modification of existing ones,
- design of new manufacturing systems and processes,
- possibilities of shortening execution times of manufacturing schedules,
- implementation of new production methods,
- identification of wastage and proposals for decreasing production costs as well as decreasing stock levels,
- shortening production cycles,
- other fields.

Our services also include consultancy with respect to optimisation of manufacturing systems and processes, including the design of new production lines and facilities.

Additionally, we offer training programmes in the area of production management, manufacturing organisation methods, Lean Manufacturing, simulation of manufacturing processes, etc.

### APPLICATION

- reorganisation and streamlining of a manufacturing system in accordance with specific optimisation criteria,
- design of new manufacturing systems,
- improvement of the effectiveness of the manufacturing process, decreasing raw materials and finished products stock levels, limiting production in progress,
- optimisation of the layout of workstands,
- elimination of wastage in manufacturing processes,
- evaluation of risk in the manufacturing process,
- training in the management, reorganisation, modelling, and optimisation of production.

### Contact information

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## INTEGRATION OF IT SYSTEMS AND BUSINESS PROCESSES IN MANUFACTURING COMPANIES

### EXPERT REPORT

Analyses and re-engineering of business processes in the areas of product development, planning and manufacturing:

- mapping business and manufacturing processes (UML, BPMN, IDEFO, VSM),
- analyses and simulations of processes,
- streamlining the company's processes.

Implementation of modern methods of work organisation at various levels of the enterprise.

Development of dedicated IT solutions, such as:

- digitisation of documentation and product development processes,
- management of enterprises' business processes, e.g. the business proposal process,
- management of works and projects in a dispersed business environment,
- management of construction, technological, production, and office documentation,
- integration of IT systems and data sources.

Implementation of own-developed comprehensive IT solutions for enterprises. Consultancy services with respect to selecting IT systems for production scheduling, manufacturing control, and product life cycle management. Systems' pre-implementation analyses and support at the implementation stage. Training in manufacturing process organisation and management using IT tools.

### APPLICATION

The unit undertakes commercial projects related to the development and integration of IT solutions for industry, in particular systems supporting the management of new product development in construction, technology, and production planning departments. The team applies modern IT solutions to support the implementation of effective methods for the organisation of work in manufacturing companies - the process-oriented manufacturing management in particular.

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## MODELLING AND SIMULATION OF TRANSPORT, LOGISTIC, AND MANUFACTURING PROCESSES

### RESEARCH

The profile of the Laboratory's operation involves the following: Modelling and simulation of transport, logistic, and manufacturing processes:

- process mapping (e.g. collection, reloading, use, storage, and distribution),
- measurements - data acquisition, statistical analysis of data using Statistica software,
- development of models enabling visualisation and optimisation of a specific process using the simulation environments Flexsim and Simulink,
- development of reference models of process infrastructure elements (e.g. belt conveyor, sorter, warehouse rack of shelves, or reloading area).

Training in the area of the use of simulation software for analysis and optimisation of transport, logistic, and manufacturing processes.

Additionally, we offer extensive support with raising funds for the research projects entailing the works we perform.

## APPLICATION

Simulation models are widely applied during the execution of various types of industrial projects, allowing a review of principles adopted and an evaluation of project outcomes, e.g.:

- reorganisation of internal transport processes,
- start-up/modernisation of a production line,
- optimisation of the operation of a raw materials and finished products warehouse,
- introduction of new reloading and transport solutions.

### Contact information

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## OPTIMISATION ALGORITHMS IN MANUFACTURING AND TRANSPORT SYSTEMS

### RESEARCH

The following services are offered:

- own-developed optimisation algorithms whose considerable efficiency has been attested to with computer tests and high profile publications of theoretical and practical results in international literature,
- analysis of the production process in terms of optimisation (streamlining control and management),
- development of new optimisation algorithms for specific problems related to scheduling and transport, including applications in Industry 4.0, flexible manufacturing, unmanned and robotised systems, and AGV transport,
- we develop algorithms in the form of an “engine” (program kernel), which can be built into any ERP, ERP II, OPT, or JIT system,
- (we ensure) integration with existing IT systems.

## APPLICATION

- design and implementation of optimisation algorithms for the needs of scheduling the operation of manufacturing systems, service systems, warehousing systems, assembly lines, operation of transport systems, etc.,

- development of dedicated ERP and ERP II systems, systems supporting production planning, transport, scheduling, as well as OPT and JIT systems,
- preparation of implementation and start-up.

### Contact information

Laboratory of Optimisation and Control of Discrete Manufacturing Processes  
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## LOGISTICS AUDIT

### RESEARCH

The services offered by the unit consist in auditing logistic and transport processes along with identification of areas where such processes could be streamlined, i.e.:

- process analyses oriented towards effectiveness evaluation and identification of limitations,
- audit of internal procedures and evaluation of the execution of specific logistic functions,
- statistical analyses concerning supply, production, and distribution systems - selection of quantitative models for enterprises' needs,
- multi-criteria analyses of threats constituting a basis for risk management in logistic processes,
- development of systems for logistic measurements oriented towards monitoring process-related incorrectness and analysis of the effectiveness of action taken,
- evaluation and improvement of information exchange systems in enterprises with respect to materials outflow,
- development of action algorithms and parameters for controlling stock systems,
- optimisation of cargo transport routes and improvement of the effectiveness of cargo space usage.

## APPLICATION

Studies consisting in audits of logistic and transport processes enable the following:

- increased effectiveness of logistic processes, in particular: supply and stock,
- management systems, internal transport, warehousing, and distribution systems,

- streamlined logistic operations thanks to limited wastage,
- improved organisation of logistic systems.

### Contact information

Team of Logistic and Transport Systems Operation  
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## OPTIMISATION OF THE CONSTRUCTION AND OPERATION OF MACHINE TOOLS AND MACHINING SYSTEMS

### RESEARCH

The unit's offer primarily consists in experimental studies, modelling and numerical analyses of operational properties of machine tools. The studies concern mainly the minimisation of thermal errors and their compensation in controllable pivots by appropriately correcting the tool's track. Additionally, they consist in identification of thermal, static, and dynamic properties with a view of improving them.

## APPLICATION

The studies proposed are intended to benefit manufacturers and users of machine tools by increasing the effectiveness of the machining process, shortening the time, and increasing the accuracy of production processes.

### Contact information

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## WELDING AND RELATED PROCESSES – SOLDERING, PRESSURE-WELDING, AND GLUING

### RESEARCH TECHNOLOGY EXPERT REPORT

The scientific research activity of the Laboratory of Welding comprises the following:

- development of technologies for bonding materials, including light metals and dissimilar materials (welding, bonding, soldering, gluing, etc.)
- aspects of welding processes metallurgy, production and metallurgy of powder materials,
- destructive and non-destructive studies of materials and welded, soldered, bonded, and glued connections,
- quality control in the field of welding, automation of welding processes,
- application of numerical methods in bonding technologies, expert evaluations in the area of welding and similar processes.

### APPLICATION

Studies in the areas of arc welding, soldering, bonding, thermal cutting, metallurgy of welding processes, gluing engineering materials, development of welding works standards, design of technological processes and welded constructions, as well as studies of welded connections. The scope of the unit's research activity is oriented towards the fields of welding and bonding (including FSW), depositing coatings (including the Cold Spraying method), and the application of non-destructive methods in research into connections and for online control.

#### Contact information

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## DIAGNOSIS OF THE POTENTIAL OF AN ORGANISATION'S STAFF; STAFF TRAINING

### EXPERT REPORT TRAINING

Diagnosis and training of an organisation's specific groups of employees or whole staff using psychological tools and methods relevant to the organisation- or management-related problem. The team uses own-developed questionnaire tools, as well as tools for qualitative ethnographic studies - including content observation and analysis. The diagnosis concerns the following areas:

- levels of motivation, commitment, and job satisfaction, as well as employees' competences,
- declared professional values and their correlation with the organisation's values,
- psychological variables affecting work (emotional intelligence, styles of thinking and acting strategically, management styles, interests, etc.).

Training programmes are delivered in the following areas:

- communication in a group, task-oriented team, or organisation,
- knowledge and techniques of improving the effectiveness of project- and task-oriented teams ,
- teams' creativity,
- recognising and resolving conflict in the workplace, as well as coping with difficult situations.

### APPLICATION

Data and conclusions obtained based on the analyses will make it possible to enable optimal use of the potential of an organisation's human resources - individuals, groups, and teams. The evaluation will enable streamlining of the operation of people and teams in various respects (motivation, organisation of work, communication, leadership, etc.). The training aims to improve the competences of employees, teams, and managers in different areas of an organisation.

#### Contact information

Team of Psychologists and Ergonomists  
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## STUDIES OF INFORMATION SYSTEMS' QUALITY IN TERMS OF USABILITY AND PERFORMANCE

### RESEARCH

- the unit can make its instrumentation available to business entities for the purpose of research work in line with the laboratory's profile,
- services offered to businesses and consisting in tests of the quality of IT systems as well as IT systems design (in line with the ISO 9241 standard).

### APPLICATION

- studies of the usability of information systems, both existing and under design, in line with the ISO 9241 standard,
- scientific research in the field of searching information in visual communication (particularly for the needs of ergonomics and marketing),
- studies of relations between visual communication factors and human behaviours in terms of emotions; the laboratory enables user-involving tests both as subjective studies and recording of selected psycho-physiological parameters during tests. The unit applies innovative and unique instrumentation for automatic recognition of a person's emotional behaviours when working with information systems. Particular emphasis is on eye-tracking studies (oculography), consisting in examination of the path of the eye's tracking information displayed on a computer screen, a document, as well as advertising or marketing materials, etc.

#### Contact information

The Laboratory of Functional Quality of Information Systems  
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## MEASUREMENTS OF ANTENNAS IN THE FAR FIELD

### RESEARCH

Measurements of the following parameters in the range of 800 MHz-8,5 GHz:

- antennas' radiation characteristics,
- antennas' directive gain,
- antennas' power gain.

The service aims to provide information about antennas' field parameters.

#### Contact information

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## MEASUREMENTS OF CIRCUITAL PARAMETERS

### RESEARCH

Measurement of a four-element scattering matrix [S] in the frequency range of 10 MHz-67 GHz.

### APPLICATION

The service aims to provide information about circuital parameters of elements under examination.

#### Contact information

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## MEASUREMENTS OF ELECTRIC PERMEABILITY

### RESEARCH

Measurements of permeability of dielectric materials using the cavity method at frequencies of 2.41 GHz and 5.13 GHz.

### APPLICATION

- measurement of electric permeability at the frequency of 2.41 GHz,
- measurements of electric permeability at the frequency of 5.13 GHz.

#### Contact information

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## MEASUREMENTS OF ELECTROMAGNETIC INTERFERENCE (EMI)

### RESEARCH

Measurement of radio devices' spurious emission within the frequency range of 800 MHz-18 GHz for devices weighing up to 100 kg and with maximum dimensions of 100x100x50 cm.

### APPLICATION

The service enables obtaining information on a radio device before introducing it on the European market and issuing a document attesting to its compliance with the standards.

#### Contact information

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## MEASUREMENTS OF RADIO COMMUNICATION DEVICES

### RESEARCH

- measurement of characteristics of radiation, directive gain, and power gain of passive antennas in the range of 800MHz-40GHz (antenna weight of up to 100 kg; diameter of up to 1.5 m),
- measurement of radiation characteristics of radio devices in the OTA (Over The Air) mode, i.e. all radio devices with antennas built-in or integrated with the transmitter device,
- measurement of radio communication devices' parameters such as: TRP (Total Radiated Power), EIRP (Equivalent Isotropic Radiated Power), and ERP (Equivalent Radiated Power),
- measurement of radio communication devices' spatial sensitivity.

### APPLICATION

The service enables obtaining information on a radio device before introducing it on the European market and issuing a document attesting to its compliance with the standards.

#### Contact information

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## MEASUREMENTS OF THE EFFICIENCY OF ELECTROMAGNETIC SCREENING

### RESEARCH

Measurements of the efficiency (SE) of screening materials, cables, casings, as well as telecommunications cabinets and rooms, aiming to determine the efficiency of their protection against electromagnetic radiation. Studies of screening efficiency are conducted within the frequency range of 10 kHz to 20 GHz - both at the stage of development of new constructions and as tests for meeting particular requirements and compliance check-ups.

 APPLICATION

Determination of materials' efficiency in the area of protection against electromagnetic radiation. The studies performed aim to determine the degree of screening efficiency. Their results can be applied for classifying materials and object and checking their compliance with requirements. Moreover, they can be used for designing electromagnetic barriers and checking properties of user-ready products.

 Contact information


Laboratory of Electromagnetic Compatibility,  
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**NUMERICAL SIMULATIONS OF ANTENNAS AND MICROWAVE SYSTEMS** RESEARCH

- numerical simulations of antennas and microwave systems using software including ANSYS HFSS, CST Microwave Studio, and FEKO,
- design of antennas and antenna arrays, from the idea to the prototype.

 APPLICATION

- the service makes it possible to optimise user-ready designs of antennas and microwave systems,
- the service makes it possible to design antennas and antenna arrays, all the way from the idea to the prototype.

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**PROTOTYPING PLASTIC ELEMENTS WITH A 3D PRINTER** TECHNOLOGY

Prototyping plastic elements with maximum dimensions of 450x450x450 mm.

 APPLICATION

- casings,
- cantilevers,
- plastic elements.

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**PROTOTYPING PRINTED CIRCUITS** TECHNOLOGY

Production of printed circuits and microstrip antennas using laser milling and burning (PCB's maximum size - 180x250 mm).

 APPLICATION

The service enables production of two-sided printed circuits on laminated materials.

 Contact information

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**MEASUREMENT OF (1- AND 2-TRACK) VEHICLES' POWER USING A CHASSIS DYNAMOMETER** RESEARCH

The unit offers services consisting in measurements of 1- and 2-track automotive vehicles' power using a chassis dynamometer. 2-track vehicles are tested for torque of up to 500 Nm (axle). The measurement concerns power curves and simulations of load or forced velocity. The unit also performs measurements of chemical compounds in exhaust gases produced in spark ignition engines.

 APPLICATION

The measurements are performed to evaluate vehicles' motion parameters, including a review of their propulsion systems' torque and power, engine rotational speed, vehicle speed, and evaluation of chemical compounds produced in the process. Measurements can be performed for both diagnostic and evaluation purposes.

 Contact information

Workroom of Mechatronics  
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**PROFESSIONAL TRAINING FOR DRIVERS USING A LORRY AND BUS SIMULATOR** TRAINING

Our unit offers training programmes for drivers using a lorry and bus simulator with six degrees of driver freedom. The station comprises a fully equipped driver's cab along with projection devices and measuring instrumentation. The route is projected on a cylindrical screen with a diameter of 8 m.

Training for drivers takes place in various load conditions of a vehicle, in diverse atmospheric conditions, using routes of diverse difficulty levels. One of the training programme's advantages is a lack of risk of damaging the vehicle during the simulated ride and/or road incidents. The training is delivered as

- compulsory, pursuant to the directive of the Minister of Infrastructure of July 2, 2008 on training drivers transporting good or people (Journal of Laws of 2008, No 124, item 805),
- individual training in driving technique, driver's behaviour in difficult conditions, eco-driving, and safe driving.

### APPLICATION

The training programme serves the purpose of letting the trainee acquire the skill of handling the vehicle appropriately in various conditions as well as obtain qualifications under the following:

- compulsory driving simulator training for drivers who obtained their class D driving licence after September 10, 2008,
- compulsory driving simulator training for drivers who obtained their class C driving licence after September 10, 2009,
- training in driving in special conditions,
- training in eco-driving and road traffic safety.

We offer training programmes specified in §7 item. 4 (Journal of Laws No. 53 item 314), with respect to quick preliminary qualification using the technical device "Simulator of a high grade lorry and bus", stipulated in art. 39g sec.11, item 2 of the act of February 12, 2010 (Journal of Laws No. 43, item 246) in driving in special conditions.

### Contact information

Workroom of Vehicle Operation  
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## STUDIES AND DESIGN OF TRAIN TIMETABLES AND THE PROCESSES OF THE RAILWAY SYSTEM'S OPERATION

### RESEARCH

The unit's offering includes research in the following areas:

- solutions to issues related to scheduling tasks in railway transport,
- development of methods enabling the shaping of timetabled train traffic allowing for a realistic time reserve stemming from operational needs of the infrastructure and rolling stock,
- development of operational algorithms when setting up systemic or process-related reserves, including the following:
  - time reserves,
  - rolling stock reserves,
  - crew reserves,
  - for set conditions of transport system operation,
  - possibilities of increasing the transport system's robustness to interference thanks to its resilience.

### APPLICATION

The research offered is applied for the following purposes:

- increasing the transport system's robustness,
- development of dispatch algorithms allowing reorganisation-related decisions in a disrupted transport process,
- development of the structure of a timetable, circuits and work schedules of crews enabling trouble-free and effective reconfiguration of the transport process in accordance with pre-set rules.

### Contact information

Workroom of Railway Traffic Engineering and Train Timetables  
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## STUDIES OF HARMFUL AND ARDUOUS FACTORS IN THE WORK ENVIRONMENT, AND THE IMPACT OF INDUSTRIAL FACILITIES ON THE SURROUNDING ENVIRONMENT; EVALUATION OF OCCUPATIONAL HAZARD

### RESEARCH

The Laboratory of Work Safety offers the following research services:  
Accredited research (accreditation no. AB 905)

- concentrations of breathable and respirable fraction of industrial dust,
- content of free crystalline silica in dust,
- audible and ultrasonic noise,
- noise generated by installations, industrial devices and facilities,
- vibrations generally affecting the human body and those transmitted by upper limbs (general and local vibrations),
- electric lighting.

Non-accredited research

- computational models of emission and immission of noise, industrial dust, and gas pollution into the environment aiming to complete information sheets or environmental impact reports,
- infrasound and low-frequency noise,
- energy expenditure in the workplace,
- noise with the dosimetry method,
- evaluation of professional hazard in the workplace,
- cold and hot microclimate in the workplace.

As for research not included in the list of research works, the Laboratory of Work Safety cooperates with many accredited laboratories.

### APPLICATION

- evaluation of the impact of industrial projects on the environment,
- evaluation of the professional hazard related to the presence of harmful factors and ones posing nuisance in workplaces.

### Contact information

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## ACADEMIC ENTREPRENEURSHIP INCUBATOR OF WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY



The Academic Entrepreneurship Incubator (AEI) active at Wrocław University of Science and Technology embraces innovative technological start-up companies founded by students, doctoral students, graduates, and employees of the University. We create the right conditions for the beginner entrepreneur to develop their business while minimising their initial costs. People who have an idea for their own business operation but lack the experience of running a company can expect substantive support until their new initiative is capable of operating on the market on its own. The Incubator supports young entrepreneurs for 3 years by offering them the following forms of aid:

- a virtual office (obtainment of an address necessary to register and run a business),
- equipped office facilities, leased on preferential terms, in the area of Wrocław University of Science and Technology and Wrocław Technology Park,
- access to a conference room,
- legal and accounts consultancy,
- business consultancy,
- participation in conferences organised by AEI, as well as seminars, training sessions, workshops, etc.,
- substantive support on obtaining EU-funded subsidies,
- promotion in the media.

### AREAS OF CO-OPERATION OFFERED

- assistance with establishing cooperation with start-ups hailing from Wrocław University of Science and Technology,
- organisation of networking events in the area of Wrocław University of Science and Technology,
- organisation of conferences, workshops, seminars, and business meetings,
- promotion of programmes supporting innovative entrepreneurship in the start-up milieu of Wrocław University of Science and Technology.

### Contact information

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## CAREER OFFICE



The Career Office is a bridge between the academic milieu and the labour market. If you're interested in recruiting employees or interns, we offer you our support in the area of recruitment processes and developing your company's image as an employer. It is just a part of the catalogue of our activities covering jobs most often undertaken, so you are more than welcome to contact us if you have other ideas or see areas that could use our team's support.

### AREAS OF CO-OPERATION OFFERED

What can we do for you?

- we run a website enabling you free of charge to publish job and internship offers available to the entire academic community,
- we enable recruitment activity in the area of the University's campus,
- we organise events at which employers meet students (e.g. presentations, training programmes, open doors days, trips to companies, etc.),
- we facilitate the appointment of the company's ambassador - the University's student or doctoral student whose task is to support the company in its image-oriented and recruitment activity,
- we organise the biggest recruitment event at Wrocław University of Science and Technology: Job and Internship Fair – Campus Recruitment,
- we organise the Employers' Gala, at which we award the best employers as voted by students of Wrocław University of Science and Technology,
- we issue "The Catalogue of Employers" – a printed and electronic publication including the most important information about enterprises and their recruitment rules.

All of our services can be provided on a one-off basis but also as comprehensive and long-term campaigns, thanks to which you will quickly reach the candidates you seek and become an employer by choice in the eyes of students and graduates.

### Contact information

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## OFFICE FOR THE COOPERATION BETWEEN ACADEMIC AND BUSINESS ENVIRONMENTS



The main goals of the office's operation are as follows:

- handling matters related to the activity of the Consortium Institute "Motorway of Technology and Innovation" (IMTI),
- maintaining contacts with business environment organisations (clusters and associations),
- facilitating cooperation between researchers and entrepreneurs, including seeking partners in the areas of science and industry, particularly IMTI's partners.

### AREAS OF CO-OPERATION OFFERED

Our offer for business comprises the following:

- opportunity to find the right partner from the scientific milieu to enable innovative research, development, and implementation projects involving enterprises being IMTI's partners,
- participation in cyclic meetings attracting representatives of the worlds of science and industry (IMTI Monday Business Meeting), whose main purpose is to find out about the needs of entrepreneurs with respect to innovation, technology development, and opportunities to undertake relevant projects



involving IMTI's researchers,

- access to a base of knowledge on IMTI's partners' research and scientific potential.

#### Contact information

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## CONGRESS CENTRE OF WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY



The Congress Centre of Wrocław University of Science and Technology is a perfect venue to hold scientific conferences, symposia, company events, training sessions, discussion panels, or promotional events. The Congress Centre is located at the University's main campus, in Grunwaldzki Square – Wrocław's important transport hub as well as a commercial and leisure centre. It is perfectly connected with the city centre, the main railway and coach stations, and popular hotels.

#### AREAS OF CO-OPERATION OFFERED

The centre comprises three conference rooms, which thanks to their modularity can be arranged in the following ways:

- room with 620 seats,
- room with 320 seats,
- room with 300 seats,
- room with 460 seats,
- 2 rooms with 160 seats each.

Also, 3 smaller conference rooms can be used - 70 m<sup>2</sup> each – offering two arrangement modes: 42 seats (classroom arrangement) or 80 seats (cinema screening room arrangement).

Equipment:

- system for simultaneous translation, including special booths, multimedia projectors and screens,
- access to a wireless Internet connection, and Wi-Fi,
- microphones, visualiser with a camera, presenters,
- laptops, DVD,
- changeable lighting system,
- audio recording equipment for conferences.

Apart from the conference rooms, we own an exhibition complex located in very close proximity. It can be used for accompanying exhibitions, poster sessions, or catering. The complex comprises the following parts:

- right foyer – floor area 241 m<sup>2</sup>,
- left foyer – floor area 179 m<sup>2</sup>,
- mezzanine – floor area 217 m<sup>2</sup>.

The Section for Organisation of Events and Conferences provides customer services at the Congress Centre. The following services are offered:

- design and production of conference materials: leaflets, posters, roll-up's, conference programmes, badges, and lanyards,
- registration of conference participants,
- organisation of optional trips,
- services related to the facility's simultaneous translation system,
- hotel booking (negotiating good prices).

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## CENTRE FOR LIFELONG LEARNING OF WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY



Centre for Lifelong Learning at the Wrocław University of Technology, in cooperation with the faculties, conducts postgraduate programmes and organises various courses and training schemes. The educational offer includes over 32 postgraduate programmes and 15 courses in response to employers' and the labour market's demand. The centre ensures the development of employees' qualifications as well as the growth of companies' adaptive potential through promotion of the idea of life-long learning and continuous delivery of the highest quality of its services. Thus, pursuing studies on the course programmes offered makes it possible to update one's knowledge in line with the latest research. Besides the postgraduate programmes, which have been delivered for many years, the complete offer of the Centre for Lifelong Learning also comprises flexible services that cater to the client's expectations. It enables the organisation of postgraduate studies, training sessions, as well as courses in the area of the research-oriented and educational activity of the University.

#### AREAS OF CO-OPERATION OFFERED:

- cooperation in the area of professional development of managerial staff and company employees through postgraduate education,
- cooperation in the area of organisation and delivery of specialist training sessions and courses commissioned by companies,
- initiating and supporting cooperation with business, support and implementation of training outsourcing enabling companies to focus their growth potential on their key business processes,

■ dissemination of continuing academic education in the context of employees' professional development.

#### Contact information

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e-mail: [cku@pwr.edu.pl](mailto:cku@pwr.edu.pl) [www.cku.pwr.edu.pl](http://www.cku.pwr.edu.pl)

## CENTRE FOR SCIENTIFIC AND TECHNICAL INFORMATION



### THANKS TO STATE-OF-THE-ART INFORMATION TECHNOLOGIES, WE ENSURE FREE OF CHARGE ACCESS TO THE FOLLOWING RESOURCES:

- WUST base of inventions (<http://biznes.pwr.edu.pl/badania-i-rozwoj/baza-wynalazkow>) - Department of Intellectual Property and Patent Information, e-mail: [patent@pwr.edu.pl](mailto:patent@pwr.edu.pl), phone: + 48 71 320 35 66, + 48 71 320 22 56,
- patent information (including the patent procedure, types of patent property rights, and possibilities of obtaining patent protection, as well as a wide range of analyses) - Department of Intellectual Property and Patent Information, e-mail: [patent@pwr.edu.pl](mailto:patent@pwr.edu.pl), phone: 71 320 35 66, + 48 71 320 22 56,
- WUST research offers (<http://biznes.pwr.edu.pl/badania-i-rozwoj/oferta-laboratoriow>) - Center for Science and Economy Co-operation, [biznes@pwr.edu.pl](mailto:biznes@pwr.edu.pl), phone: + 48 71 320 47 56, + 48 71 320 47 59,
- key instrumentation bases (<http://biznes.pwr.edu.pl/badania-i-rozwoj/baza-kluczowej-aparatury>) - Center for Science and Economy Co-operation, [biznes@pwr.edu.pl](mailto:biznes@pwr.edu.pl), phone: + 48 71 320 47 56, + 48 71 320 47 59

■ bases of WUST laboratories (<http://biznes.pwr.edu.pl/badania-i-rozwoj/baza-laboratoriow>) - Center for Science and Economy Co-operation, [biznes@pwr.edu.pl](mailto:biznes@pwr.edu.pl), phone: + 48 71 320 47 56, + 48 71 320 47 59,

■ bases of WUST literature resources (DONA), with information about published and unpublished papers (reports, patent applications, and doctoral theses), as well as complete theses made available in accordance with licences and regulations of the copyright law - Open Science Department, e-mail: [dona.pwr.edu.pl](mailto:dona.pwr.edu.pl), phone: 71 320 31 61, 320 31 63, <https://dona.pwr.edu.pl/szukaj/>,

■ Polish Standards (including access to European standards - EN, International standards - ISO, IEC, HD - incorporated into PS) and American Standards - ASTM - Standards Information Point, e-mail: [pin@pwr.edu.pl](mailto:pin@pwr.edu.pl), phone: + 48 71 320 35 27, <http://biznes.pwr.edu.pl/badania-i-rozwoj/normy>,

■ simple information related to standards, i.e. collections of standards and standardisation documents, standards' validity, standards' replacements, prices of documents, and specialist information about relations between Polish Standards and international and regional standards - Standards Information Point, e-mail: [pin@pwr.edu.pl](mailto:pin@pwr.edu.pl), phone: + 48 71 320 35 27, <http://biznes.pwr.edu.pl/badania-i-rozwoj/normy>.

### WE ALSO OFFER ACCESS TO COMMERCIAL SERVICES PROVIDED BY MULTIDISCIPLINARY LABORATORIES, SUCH AS:

- 2D digitisation (preparation of materials for digitisation: documents and literature - books, magazines, standards, photographic film, small-frame negatives, other transparent materials, maps, drawings - in formats of up to A0), graphic processing of digitised object files, metadata description of digitised objects - Laboratory of Methods of Digitisation and Multimedia, [anna.komperda@pwr.edu.pl](mailto:anna.komperda@pwr.edu.pl), [bc@pwr.edu.pl](mailto:bc@pwr.edu.pl), phone: + 48 71 320 3161, +48 71 320 47 50,
- photorenovation of photographs - objects - Laboratory of Methods of Digitisation and Multimedia, [anna.komperda@pwr.edu.pl](mailto:anna.komperda@pwr.edu.pl), [bc@pwr.edu.pl](mailto:bc@pwr.edu.pl), phone: + 48 71 320 31 61, + 48 71 320 47 50
- archiving objects using the Platon service - Laboratory of Methods of Digitisation and Multimedia, [anna.komperda@pwr.edu.pl](mailto:anna.komperda@pwr.edu.pl), [bc@pwr.edu.pl](mailto:bc@pwr.edu.pl), phone: + 48 71 320 31 61, + 48 71 320 47 50,
- 360 degree photography, i.e. series of rotational images, creating packshots - objects - Laboratory of Methods of Digitisation and Multimedia, [anna.komperda@pwr.edu.pl](mailto:anna.komperda@pwr.edu.pl), [bc@pwr.edu.pl](mailto:bc@pwr.edu.pl), phone: + 48 71 320 31 61, + 48 71 320 47 50

## CENTER FOR SCIENCE AND ECONOMY CO-OPERATION

We deliver comprehensive services with respect to all forms of cooperation with Wrocław University of Science and Technology, with the needs of companies willing to become more competitive in mind. We have cooperated with the business sector for years and we know what the market expects.

- we have developed effective patterns of cooperation with business entities, for which we received the LUMEN award from eminent representatives of the worlds of science and business,
- we initiate and coordinate scientists' cooperation with entrepreneurs,
- we provide consultancy on the selection of the right research team, laboratory or specialist of Wrocław University of Science and Technology. Regardless of the type of commission - be it an expert evaluation, opinion or a piece of research, our experience will make it possible to solve problems and indicate alternative units to cooperate with,
- we identify and monitor scientific research projects with high commercial potential,
- we provide information and consultancy on technology transfer feasibility and procedures, as well as financial support under EU or NCBIr projects,
- we boast a competent team of people responsible for effective cooperation with business - we will reply to every enquiry,
- we provide comprehensive support, making sure - on entrepreneurs' behalf - that all formalities have been gone through; we ensure formalities-oriented and legal services in the area of negotiation, drawing up, performance and financial settling of agreements related to the execution of research works, consortium agreements and agreements of research-related cooperation,
- we support innovative ideas in the process of gaining business partners; we cooperate with entities including chambers of commerce, as well as technology, science and industrial parks,
- additionally, we offer access to patent information and training programmes in the area of the effective use of patent resources in data bases, protection of industrial property and copyrights, including securing an enterprise's interests when introducing new products and brands on the market.

#### Contact information

Center for Science and Economy Co-operation  
phone: + 48 71 320 47 59  
e-mail: [biznes@pwr.edu.pl](mailto:biznes@pwr.edu.pl)  
<http://biznes.pwr.edu.pl/en/research>

### CONTACT POINT FOR TECHNOLOGY TRANSFER

The Contact Point is a place where researchers, entrepreneurs, and students can make the first contact and obtain information about the transfer of technology at Wrocław University of Science and Technology. Entrepreneurs can use it to familiarise themselves with the up-to-date research offering of the University and technologies ready to be commercialised. The course of the cooperation along with the very signing of the agreement is handled by the Center for Science and Economy Cooperation or WUST'S Wrocław Centre for Technology Transfer.

#### Contact information

Contact Point for Technology Transfer  
phone: +48 71 320 47 42  
e-mail: [transfer.technologie@pwr.edu.pl](mailto:transfer.technologie@pwr.edu.pl)

### THE COMPLEX OF SCIENTIFIC AND RESEARCH LABORATORIES

The Complex of Scientific and Research Laboratories, operating at the Centre for Scientific and Technical Knowledge and Information (CSTKI), comprises 14 laboratories offering services consisting in research, implementation works, and consultancy in the fields of innovative multimedia and information technologies (ICT).

#### AREAS OF CO-OPERATION OFFERED

- user studies,
- project and R&D interdisciplinarity,

- development of virtual applications and augmented reality,
- implementation of the Design Thinking methodology,
- eye-tracking in shopping spaces and advertising materials,
- studies of websites' usability,
- studies of service devices' interfaces,
- adaptation of materials using the Braille alphabet and graphics for the blind and visually impaired,
- digital accessibility audits.

#### Contact information

The Complex of Scientific and Research Laboratories  
phone: + 48 71 340 78 12, phone: + 48 71 320 39 93  
e-mail: [centrum.lab@pwr.edu.pl](mailto:centrum.lab@pwr.edu.pl)  
[www.biznes.pwr.edu.pl/laboratoria](http://www.biznes.pwr.edu.pl/laboratoria)

### WROCLAW CENTRE FOR TECHNOLOGY TRANSFER



Wrocławskie Centrum  
Transferu Technologii

The Centre is Poland's oldest institution serving the purpose of technology transfer. The unit was established in 1995 - from the very beginning, its mission has been to support enterprises' innovative and technological activity, particularly with respect to the SMB sector, as well as support the commercialisation of research results. WCTT's services cater to the following groups of recipients: researchers, enterprises (also those starting their business operation), scientific and business consortia, and research and development institutions.

Most of WCTT's services are free of charge.

#### AREAS OF CO-OPERATION OFFERED

Innovations and transfer of modern technologies:

- we offer inventions and technologies developed by researchers, supporting buyers on the implementation process,

- we perform analyses of new technologies' market potential and evaluate new technological solutions,
- we conduct technology, design, and marketing audits,
- we assist businesses with the development of innovative products and services,
- we help businesses protect their intellectual property.

Cooperation with foreign entities:

- we develop export strategies,
  - we seek foreign partners for companies via the Enterprise Europe Network,
  - we organise trips to foreign trade fairs, economic missions and meetings aiming to establish cooperation,
  - we develop market analyses for selected business sectors and countries,
  - we deliver consultancy services in the areas of law and patents.
- Raising non-repayable finance (grants):
- we indicate a domestic or European programme that is most suitable for a given undertaking,
  - we assist with drawing up application documents,
  - we provide consultancy services at the stage of project execution and accounting/financial settlements.

Raising capital:

- we review the entrepreneur's planned business model,
- we provide assistance with business plan development,
- we facilitate contact between the entrepreneur and a suitable seed or venture fund,
- we provide assistance in the area of investor presentations for the needs of meetings with fund representatives,
- we provide support on negotiations with investors.

#### Contact information

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e-mail: [wctt@wctt.pl](mailto:wctt@wctt.pl)  
[www.wctt.pl](http://www.wctt.pl)

## Laboratory of Civil Engineering Structures at the Division of Concrete Structures

FACULTY OF CIVIL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 455

### SCOPE OF RESEARCH:

- Mechanical and metallography tests
- Studies of physical properties
- Sample-taking, laboratories accredited for sample-taking

### OBJECTS OF RESEARCH:

- Construction products and materials, civil engineering structures
- Structural products and materials including metals and composites



#### CONTACT INFORMATION:

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## Laboratory of Construction Materials

FACULTY OF CIVIL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 1569

### SCOPE OF RESEARCH:

- Mechanical and metallography tests
- Studies of physical properties

### OBJECTS OF RESEARCH:

- Construction products, construction materials, civil engineering structures



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## Research Laboratory of Transport Infrastructure Facilities

FACULTY OF CIVIL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 1211

### SCOPE OF RESEARCH:

- Mechanical and metallography tests
- Non-destructive tests
- Studies of physical properties

### OBJECTS OF RESEARCH:

- Construction products, construction materials, civil engineering structures



#### CONTACT INFORMATION:

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[antoni.szydlo@pwr.edu.pl](mailto:antoni.szydlo@pwr.edu.pl); [lboit@pwr.edu.pl](mailto:lboit@pwr.edu.pl)

## Chemical Laboratory of Multielemental Analyses

FACULTY OF CHEMISTRY  
RESEARCH LABORATORY, ACCREDITATION NO. AB 696

### SCOPE OF RESEARCH:

- Chemical research and analytics

### OBJECTS OF RESEARCH:

- Agricultural products including feedstuffs for animals
- Biological objects and materials intended for studies
- Chemicals, cosmetics, chemical products - including fertilisers and paints
- Environmental samples, air, water, soil, waste, sediments, and sewage
- Products intended for human consumption - including food



#### CONTACT INFORMATION:

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[malgorzata.mironiuk@pwr.edu.pl](mailto:malgorzata.mironiuk@pwr.edu.pl)

## Laboratory of Electromagnetic Field Standards and Metrology

FACULTY OF ELECTRONICS  
RESEARCH AND CALIBRATION LABORATORY, ACCREDITATION NO. AB 361, AB 078

### SCOPE OF RESEARCH:

- Environmental engineering studies (environmental and climatic)

### SCOPE OF CALIBRATION ACTIVITY:

- Magnetic and electromagnetic quantities

### OBJECTS OF RESEARCH:

- Environmental samples, air, water, soil, waste, sediments, and sewage

### OBJECTS CALIBRATED:

- power density meters; ■ magnetic induction meters; ■ electric field intensity meters; ■ magnetic field intensity meters; ■ induced current meters



#### CONTACT INFORMATION:

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[www.lwimp.pwr.wroc.pl](http://www.lwimp.pwr.wroc.pl)  
[lwimp@pwr.edu.pl](mailto:lwimp@pwr.edu.pl)

## Research Laboratory of Acoustics

FACULTY OF ELECTRONICS  
RESEARCH LABORATORY, ACCREDITATION NO. AB 796

### SCOPE OF RESEARCH:

- Acoustic and noise tests - also tests of noise caused by vibrations
- Studies related to environmental engineering (environmental and climatic)

### OBJECTS OF RESEARCH:

- Construction products and materials, civil structures
- Electrical, telecommunications, and electronic products
- Environmental samples, air, water, soil, waste, sediments, and sewage
- Machines, production facilities, fittings and equipment - including nuclear installations



#### CONTACT INFORMATION:

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[lba@pwr.edu.pl](mailto:lba@pwr.edu.pl)

## Laboratory of Electromagnetic Compatibility

FACULTY OF ELECTRONICS  
RESEARCH LABORATORY, ACCREDITATION NO. AB 167

### SCOPE OF RESEARCH:

- Electromagnetic compatibility tests (EMC)

### OBJECTS OF RESEARCH:

- Electrical, telecommunications and electronic products
- Electronic fittings and equipment (including software)
- Medical equipment
- Vehicles



### CONTACT INFORMATION:

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## Laboratory of Electromagnetic Field Measurements (LEFM)

FACULTY OF ELECTRICAL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 1568

### SCOPE OF RESEARCH:

- Environmental engineering studies (environmental and climatic)

### OBJECTS OF RESEARCH:

- Environmental samples, air, water, soil, waste, sediments, and sewage



### CONTACT INFORMATION:

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[zbigniew.wroblewski@pwr.edu.pl](mailto:zbigniew.wroblewski@pwr.edu.pl)

## Laboratory of Belt Conveying

FACULTY OF GEOENGINEERING,  
MINING AND GEOLOGY  
RESEARCH LABORATORY, ACCREDITATION NO. AB 710

### SCOPE OF RESEARCH:

- Fire tests
- Mechanical and metallography tests
- Studies of physical properties

### OBJECTS OF RESEARCH:

- Products made of plastics and rubber



### CONTACT INFORMATION:

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[monika.hardygora@pwr.edu.pl](mailto:monika.hardygora@pwr.edu.pl)

## Laboratory of Work Safety

FACULTY OF GEOENGINEERING,  
MINING AND GEOLOGY  
RESEARCH LABORATORY, ACCREDITATION NO. AB 905

### SCOPE OF RESEARCH:

- Chemical research and analytics
- Environmental engineering studies (environmental and climatic)
- Studies of physical properties
- Sample-taking, laboratories accredited for sample-taking

### OBJECTS OF RESEARCH:

- Environmental samples, air, water, soil, waste, sediments, and sewage



### CONTACT INFORMATION:

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## Laboratory of Olfactometric Research

FACULTY OF ENVIRONMENTAL CONSERVATION  
RESEARCH LABORATORY, ACCREDITATION NO. AB 1461

### SCOPE OF RESEARCH:

- Sample-taking, laboratories accredited for sample-taking
- Sensory studies

### OBJECTS OF RESEARCH:

- Environmental samples, air, water, soil, waste, sediments, and sewage



### CONTACT INFORMATION:

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## Department of Machine Construction and Research

FACULTY OF MECHANICAL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 659

### SCOPE OF RESEARCH:

- Mechanical studies, metallography studies

### OBJECTS OF RESEARCH:

- Machines, production facilities, fittings and equipment – including nuclear installations
- Other products
- Vehicles



### CONTACT INFORMATION:

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[eugeniusz.rusinski@pwr.edu.pl](mailto:eugeniusz.rusinski@pwr.edu.pl)  
[jerzy.czmochocki@pwr.edu.pl](mailto:jerzy.czmochocki@pwr.edu.pl)

## Laboratory of Reverse Engineering

FACULTY OF MECHANICAL ENGINEERING  
RESEARCH LABORATORY, ACCREDITATION NO. AB 969

### SCOPE OF RESEARCH:

- Studies of physical properties

### OBJECTS OF RESEARCH:

- Construction products and materials- including metals and composites,
- Glass and ceramic products
- Other products
- Products made of plastics and rubber
- Wood



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