Ultrasound Research Institute of Kaunas University of Technology (Lithuania)

The **Ultrasound Research Institute** represents majority of ultrasonic research groups at Kaunas University of Technology. Ultrasound research spans over 60 years of activity in the field of ultrasonic measurements and non-destructive testing, with more than 1000 publications, over 150 patents and created over 100 different techniques and measurement instruments developed for various industrial and scientific applications. Active involvement in master's and PhD studies, leading researchers of Institute are members of Electrical and Electronics Engineering PhD committee, and members of Measurement Engineering PhD committee.

The Ultrasound Research Institute of Kaunas University of Technology successfully participated and participates in 24 international FP5, FP6, FP7 and 2 Eurostars projects, 5 Horizon 2020 projects, 2 Horizon Europe projects, 2 Euratom and numerous international contracts with companies. The main area of interest covers development of new advanced ultrasonic measurement, imaging and non-destructive techniques for extreme conditions (high temperatures, strong radioactive radiation, high pressure, aerospace and chemical activity) and non-conventional applications of non-destructive testing (NDT), monitoring, quality control and predictive maintenance. Also measurements, material characterization, artificial intelligence based diagnostics and clinical decision support in medical field. Those techniques are oriented to solve the complicated questions related to the Industry 4.0 / NDT 4.0, smart factories, construction safety, defence applications, environment safety and human health.

<u>Examples of applied research for different industry fields are listed here:</u>

1. Development of novel ultrasonic NDT, testing, measurement and imaging technologies for ensuring safety of composite materials in aerospace sector:
- EC FRAMEWORK 5 project NANOSCAN, "New and novel systems for composite aircraft NDE" (involved end-user "Airbus")
- H2020-MSCA-ITN-2016 NDTonAIR: Training Network in Non-Destructive Testing and Structural Health Monitoring of Aircraft structures (involved end-user "Brussels Airlines")
- H2020-MSCA-ITN-2019 GW4SHM: Guided Waves for Structural Health Monitoring (involved end-user s:"Airbus", "Shell", "Dallara Automobili S.p.A.")
- Project 01.1.1-CPVA-V-701-14-0001: Center for Ultrasonic Non-Destructive Testing, Measurement, and Diagnostics (ULTRATEST), 2019-2022

2. Development of novel ultrasonic NDT, testing, measurement and imaging technologies for transport sector:
- EC FRAMEWORK 6 project MICROSCAN, "Development of comprehensive in-line quality control system for printed circuit board assemblies"
- EC FRAMEWORK 7 project RAILECT "Development of an ultrasonic technique, sensors and systems for the volumetric examination of alumino-thermic rail welds"
- EC FRAMEWORK 7 project ComPair, "Continuous health monitoring and non-destructive assessment of composites and composite repairs on surface transport applications"
- EC FRAMEWORK 7 project SpotTrack "Development of a hand-held spot weld tracking device to ensure adequate weld quality in repaired vehicles"
- Development of ultrasonic technologies for precise distance measurement, positioning and smart navigation of mobile robots, involved end-user "Volvo"
- Horizon Europe project Tempest "nexT gEneration MultiPle architEcture battery Systems for indusTry", 2023-2026

3. Development of novel ultrasonic NDT, testing, measurement, imaging and monitoring technologies for extreme conditions in thermal and nuclear power plants:

- Co-operative project between Belgian Nuclear Research Centre SCK/CEN and Ultrasound Institute CO-90 01 1487/V7606. "Development of ultrasonic transducers with a high temperature solder for accelerator driven system <u>MYRRHA</u>
- EC FRAMEWORK 7 project NOZZLEINSPECT, "Autonomous Robot for Automated Inspection of Nozzle Welds"
- EC FRAMEWORK 7 project CREEPTEST, "Development of a high sensitivity ultrasonic phased array Non-Destructive Testing (NDT) method for the early detection of creep damage (Type IV cracking) in alloy steels used in high temperature"
- H2020 FTI project CreepUT An ultrasonic non-destructive testing system for detection and quantification of early stage subsurface creep damage in the thermal power generation industry
- H2020 NFRP-2016-2017-1 project Advise „ADVanced Inspection of Complex StructurEs"
- H2020 project EIT KIC Raw Materials Upscaling Call FLAME: „FLy Ash to valuable MinErals"
- EU's research and innovation programme „Horizon 2020" project „Proof of augmented safety conditions in advanced liquid metal cooled systems / PASCAL", 945341, 2020-2024;
- Euratom Research and Training programme project „Advanced Nuclear Safety Evaluation of Liquid Metal Using Systems / ANSELMUS", 101061185, 2022-2026;
- Euratom Research and Training programme project „Intelligent Weld inspection / iWeld", 101061359, 2022-2026;

4. Development of novel ultrasonic NDT, testing, measurement and imaging technologies for accident prediction in oil and gas sector:
- EC FRAMEWORK 6 project TANK INSPECT, "Condition monitoring of large oil and chemical storage tanks using ultrasonic guided wave tomography without the need to empty and clean the tanks"
- EC FRAMEWORK 6 project LRCUM, "Long range ultrasonic condition monitoring"
- EC FRAMEWORK 7 project TestPEP, "Development and Validation of an Automated Non-Destructive Evaluation (NDE) Approach for Testing Welded Joints in Plastic Pipes"
- EC FRAMEWORK 7 project SPRINKTEST, "Medium range Ultrasonic inspection technique for detecting micro-biologically induced corrosion in automatic fire sprinkler systems"

5. Development of novel ultrasonic NDT, testing, measurement, imaging and monitoring technologies for renewable energy sector (wind, tidal):
- EC FRAMEWORK 7 project WINTUR DEMO, "In-situ wireless monitoring of on- and offshore WINd TURbine blades using energy harvesting technology – Demonstration"
- EC FRAMEWORK 7 project TIDALSENSE, "Development of a condition monitoring system
- EC FRAMEWORK 7 project TIDALSENSE DEMO, "Demonstration of a Condition Monitoring System for Tidal Stream Generators"
- EC FRAMEWORK 6 project CONCEPT, "The development of portable high energy nanofocus computed tomography system for glass reinforced plastic wind turbine blades"
- EC FRAMEWORK 6 project LRCUM, "Long range ultrasonic condition monitoring"
- EC FRAMEWORK 6 project OPCOM, "Development of ultrasonic guided wave inspection technology for the condition monitoring of offshore structures"
- EC FRAMEWORK 7 project WINTUR "In-situ wireless monitoring of onshore/offshore wind turbine blades using energy harvesting technology"

- EU's research and innovation programme „Horizon Europe" project „nexT gEneration MultiPle architEcture battery Systems for indusTry / TEMPEST", 101103681, 2023-2026

6. Development of novel ultrasonic NDT, testing, measurement and imaging technologies for quality control of industrial processes and Industry 4.0 applications:
- EC FRAMEWORK 7 project NOVAPRESS, "Novel Ultrasonic Sensor-System for In-Line Density Gradient Determination of Ceramic Tiles"
- EC FRAMEWORK 7 project Polysense, „Development of a low cost in-line polymer inspection system to improve the use of recycled materials in plastics processing industry"
- EC FRAMEWORK 7 project SAFEJOINT, "Enhancing structural efficiency through novel dissimilar material joining techniques"

7. Development of novel ultrasonic non-invasive testing, measurement, diagnostic, imaging and decision support technologies for medical applications:
- EC FRAMEWORK 7 project CLEARWATER PMPC, "Development of a Chemical Free, Low Maintenance ClearWaterPMPC System for the Prediction, Monitoring, Prevention and Control of Algae Based on Ultrasound Technology"
- EC FRAMEWORK 7 project SKINDETECTOR, "Application of the innovative data fusion based non-invasive approach for management of the diabetes mellitus"
- H2020 project "WIDESPREAD-1-2014 – Teaming", Centre of Excellence in Science and Technology for Healthy Ageing, "HEALTH-TECH"
- HORIZON-EIC-2022-PATHFINDERCHALLENGES-01-05: "DNA Microfactory for Autonomous Archiving (DNAMIC)", 2023-2026
- Eurostars project SKINMONITOR, "Diagnosis of skin cancer based on ICT tools" (E!4846)
- Eurostars project NICDIT, A Non-Invasive Expert System for Diagnosis of Intraocular Tumours (E!4297)
- EC FRAMEWORK 6 project TROY "Endoscope Capsule using Ultrasound Technology"

8. Development of novel ultrasonic NDT, testing, measurement, imaging and predictive maintenance technologies, which are suitable to be applied in defense sector:

- EC FRAMEWORK 5 project NANOSCAN, "New and novel systems for composite aircraft NDE" (involved end-user "Airbus")
- EC FRAMEWORK 6 project MICROSCAN, "Development of comprehensive in-line quality control system for printed circuit board assemblies"
- EC FRAMEWORK 6 project TANK INSPECT, "Condition monitoring of large oil and chemical storage tanks using ultrasonic guided wave tomography without the need to empty and clean the tanks"
- EC FRAMEWORK 6 project LRCUM, "Long range ultrasonic condition monitoring"
- EC FRAMEWORK 6 project CONCEPT, "The development of portable high energy nanofocus computed tomography system for glass reinforced plastic wind turbine blades"
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Examples of partnerships:

Belgium nuclear research centre SCK*CEN (Belgium); EDF (Electricité de France, France); CEA (Commissariat à l'énergie atomique et aux énergies alternatives, France), Fraunhofer Institute for Non-destructive Testing (Saarbrücken, Germany); Bundesanstalt für Materialforschung und -prüfung (BAM, Germany); Flemish Institute for Technological Research NV VITO (Belgium); École polytechnique fédérale de Lausanne EPFL (Switzerland); Universiteta Degli Studi di Perugia (Italy); company „Robert Bosch GmbH" (Germany); company „INETEC - Institute for Nuclear

Technology" (Croatia); company „Vermon SA" (France); company „M2M" (France); company EXTENDE " (France) etc.

Opinion of international experts:

Prof. Manfred Horvat, independent expert in European Union stated that among CESAER (Conference of European Schools for Advanced Engineering Education and Research) members Kaunas University of Technology (KTU) is a leader in European Union according to the number of FRAMEWORK projects for benefit of SME. From 18 projects in KTU 16 were won by Ultrasound Institute. Stephen J. Ciesinski, Stanford Research Institute, USA, during international conference „Local Hubs in Global Networks" presented the Ultrasound Institute as an example of the successful international activity. Ken Singer, Centre for Entrepreneurship and Technology, University of California, Berkeley, USA, in 2013 named the Ultrasound Institute as possessing the highest potential in high technologies. In the year 2015 assessment of research in technological sciences in Lithuania was performed by a team of international experts. The experts from the Panel T2 visited Lithuania on February 9 – 13, 2015 and during this period they made site-visits. The Panel was asked to evaluate research using the following criteria: research quality, economic and social impact, infrastructure, research management and development potential. They have made conclusion that the Ultrasound Research Institute is a strong international player. The most prominent merits are the high volume of the work carried out within competitive European projects (16 FP7 projects), a very good infrastructure, links with industry and the quality of the research demonstrated by publications in international refereed journals.

Activity of Ultrasound Institute, Kaunas University of Technology:

We possess unique know-how and experience in the following fields:
- ultrasonic measurements and imaging in high temperature environments;
- measurement and analysis of physical and mechanical properties of materials (solid, liquid, gas) using ultrasonic methods;
- diagnostics and condition monitoring systems and technologies for components of land, water, air and space transport ;
- diagnostics and condition monitoring systems and technologies for components of oil&gas, nuclear energy and renewable energy;
- ultrasonic characterization of multi-layered and composite materials;
- ultrasonic long range testing techniques using ultrasonic guided waves;
- air-coupled NDT ultrasonic technologies;
- signal and image processing, modelling and decision support in ultrasonic measurements, NDT and imaging;
- material characterization, process control and medical applications;
- X-ray computed microtomography for material characterization.
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Development of new advanced ultrasonic measurement and non- destructive techniques includes:
- Feasibility study (fundamentals, modelling, experiments, signal, data and image processing);
- Development of measurement techniques including a software with integrated features of artificial intelligence (AI), prediction maintenance and decision support;
- Development of pilot version of instrumentation/technique including ultrasonic transducers;
- Development of industrial version of instrumentation for *in situ* measurements.

Facilities of Ultrasound Institute, Kaunas University of Technology:

- Ultrasonic measurement and NDT systems with large immersion tanks (6 degrees of freedom, tank dimensions 2 m x 1.5 m x 1 m, 11 degrees of freedom, tank dimensions 2.5 m x 1.5 m x 1.5 m) ("Tescan", Canada, calibrated on-site);
- X-ray microtomography system RayScan 250E (10 - 225 kV, 50 - 450 kV, resolution up to a few micrometers) ("RayScan Technologies GmbH", Germany, calibrated on-site);
- Ultrasonic microscope KSI V8 (immersion, scanning step 0.25 micrometer, frequency of focussed ultrasonic transducer up to 230 MHz) ("KSI", Germany, factory calibrated);
- Ultrasonic microscope easySAM with photoacoustic option (immersion, frequency of focussed ultrasonic transducer up to 400 MHz) ("KIBERO", Germany, factory calibrated);
- Immersion NTR acoustic intensity measurement system (AIMS) that allows measuring and mapping of acoustic fields in liquids. It is the heart of any ultrasound measurement system, suitable for medical imaging, pulsed and CW Doppler, therapeutic devices and industrial ultrasound between 0.25 and 60 MHz. Sensitivity of needle and membrane type calibrated hydrophones is up to 160 nV/Pa. ("Onda systems", Canada, factory calibrated);
- Laser vibrometer "Polytec" OFV-5000, displacement decoder DD-300 (34 kHz..24 MHz, ±75 nm), velocity decoder VD-09 (up to 1.5 MHz), measurement head OFV-505 ("Polytec", Germany, factory calibrated);
- Laser based excitation and reception systems of ultrasonic waves generation and reception (laser excitation, for reception 2D and 3D laser vibrometer subsystems from "Polytec" up to 25 MHz, also ultrahigh frequency vibrometer subsystem up to 2.4 GHz);
- Multi-channel ultrasonic phased array system „Dynaray" 64/256 (bandwidth from 0.20 up to 25 MHz, at -6 dB) with set of phased arrays (central frequencies from 0.5 MHz up to 10 MHz, number of elements from 16 up to 128) and software „Ultravision" for data acquisition, processing and imaging („Zetec", Canada, factory calibrated – for use in nuclear sector);
- Multi-channel ultrasonic phased array system "Verasonics Vantage 32 LE Low Frequency" (bandwidth from 50 kHz up to 1500 kHz, at -3 dB) („Verasonics", United States, factory calibrated);
- Multi-channel ultrasonic phased array system "Verasonics Vantage 128" (bandwidth from 0.5 MHz up to 27 MHz, at -3 dB) („Verasonics", United States, factory calibrated);
- Multi-channel ultrasonic phased array system „Sitau" 128/128 (bandwidth from 0.5 MHz up to 20 MHz, at -3 dB) („DaselSistemas", Spain, factory calibrated);
- Multi-channel low frequency ultrasonic phased array system „Sitau" 32/128/2 (bandwidth from 30 kHz up to 2 MHz, at -3 dB) („DaselSistemas", Spain, factory calibrated);
- Multi-channel portable ultrasonic phased array (up to 128 ch.) and eddy current (up to 32 ch,) system „Olympus Omniscan Mx" ("Olympus", Japan, factory calibrated);
- Modern phased array equipment "Eddify Gekko" for medium and higher frequencies (NDT and sets of phased array transducers) and "Eddify Teletest" equipment for low frequency guided waves generation/reception in metal pipes;
- Modern real-time ultrasonic camera "Dolphicam 2" 5 MHz, for 2D / 3D imaging of metal/composite constructions ("Dolphitech", Norway)
- Ultrasonic measurement, data acquisition and imaging systems "Ultralab" for low (up to 2 MHz), middle (up to 30 MHz) and high frequency (up to 50 MHz) applications (KTU UI, Lithuania, calibrated by KTU UI developers on-site);
- Precise 3 axis Cartesian scanner (*x-y* step 10 μm, *z* step 1 μm) for air-coupled and immersion applications (KTU UI, Lithuania, calibrated by KTU-UI developers on-site);
- Precise 4-axis angular scanner for immersion and air-coupled applications ("ADEPT", USA, calibrated by KTU UI on-site);
- Precise 2-axis angular scanner for tomography purposes using the low frequency set-up (KTU UI, Lithuania, calibrated by KTU-UI developers on-site);

- Standard eddy current inspection system "Eddy Max" ("TMT", Germany, factory calibrated);
- Impedanse meter „Olympus B600M" for detection of disbond type defects in composite materials;
- Ultrasonic thickness and coatings meter „Olympus 38 DLPlus";
- Low frequency multielement ultrasonic discharge and gas leakage detector: Fluke ii910;
- Discharge detection system of high voltage electrical components „Doble DFA300";
- High intensity action ultrasound system MPI AMMM3000 with reactor for processing of liquids;
- Acoustic cavitation meter „Onda" MCT-0320 with calibrated hydrophone Onda HCT-2000;
- Special set of ultrasonic transducers for NDT, material characterization and biomedicine (operating frequency from 0.05 up to 230 MHz) ("Olympus" and others, factory calibrated);
- Special set of ultrasonic phased array for NDT and material characterization (operating frequency from 0.5 up to 10 MHz) ("Olympus" and others, factory calibrated);
- Impedance analyzer Wayne Kerr 6500 B (operating frequency from 40 Hz up to 120 MHz) („Wayne Kerr Electronics", UK, factory calibrated);
- Stereo microscope width digital camera „Olympus" MVX10 (zoom range 7x-115x, maximum zoom 230x) („Olympus corporation", Japan, factory calibrated);
- Digital arbitrary waveform generators (up to 100 MHz) and digital oscilloscopes (up to 600 MHz) ("Agilent technologies", USA, factory calibrated);
- Workstation type multi-processor computers for numerical simulations, like modelling using the finite element and the finite differences techniques;
- "Civa" software for numerical simulation of the ultrasonic non-destructive testing („Extende", France);
- Software for simulation of ultrasonic fields and measurement processes (KTU UI, Lithuania);
- Passive high resolution thermography system based on "Flir T1020", for thermal picture and video stream acquisition;
- Drone with high resolution thermal and optical camera DJI M300, DJI XT2;
- Active thermography system "Automation Technologies IrNDT"with controlled heat sources and high speed thermal camera;
- Digital videoscope system „Olympus" IPLEX GX/GT IV9620G for visual inspection of closed cavities;
- X-ray fluorescent analyzer „Olympus VANTA XRF" for investigation of the metal structures;

Ultrasound Research Institute of KTU hosts the European level research Infrastructure ULTRATEST: „Ultrasonic Non-Destructive Testing, Measurement and Diagnostics Center" (contact: Prof. dr. Renaldas Raisutis)
ULTRATEST is included in the database of European research infrastructures:
http://portal.meril.eu/meril/view/facilitys/15504
Project supported by EU structural funds 01.1.1-CPVA-V-701-14-0001 Center for Ultrasonic Non-Destructive Testing, Measurement, and Diagnostics (ULTRATEST), 2019-2022

Our purpose:
We are ready to meet the new challenges in the R&D field, to use our exceptional competence and experience in order to satisfy the market demand (solving non-typical problems in industry, energy, renewable resources and nuclear field, extreme conditions, aerospace, medical and etc.). We are open for various forms of collaboration (e.g. R&D services, multi-stage development contracts with industry and research institutions, partnership in Horizon 2020, Horizon Europe projects and etc.) and ready to establish the new contacts !

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Corrosion deposit of the tank bottom

Ultrasonic non-destructive testing of condition of petroleum tank bottom plates in oil and gas sector. No emptying and cleaning of the tank is required !
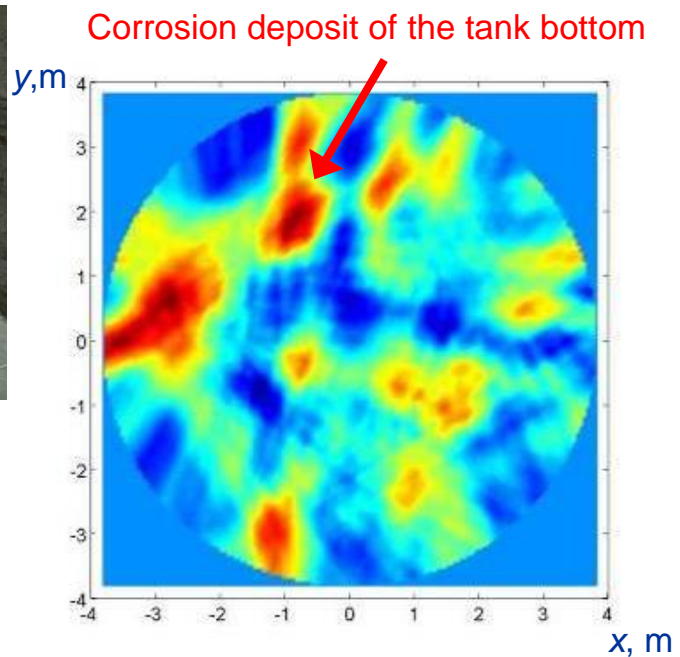
Ultrasonic investigation of internal structure of multi-layered composite materials: aerospace, microelectronics, wind and tidal power plants

Amplitude C - scan of impact type damages of composite panel from aviation

Amplitude C-scan of electronic microchip