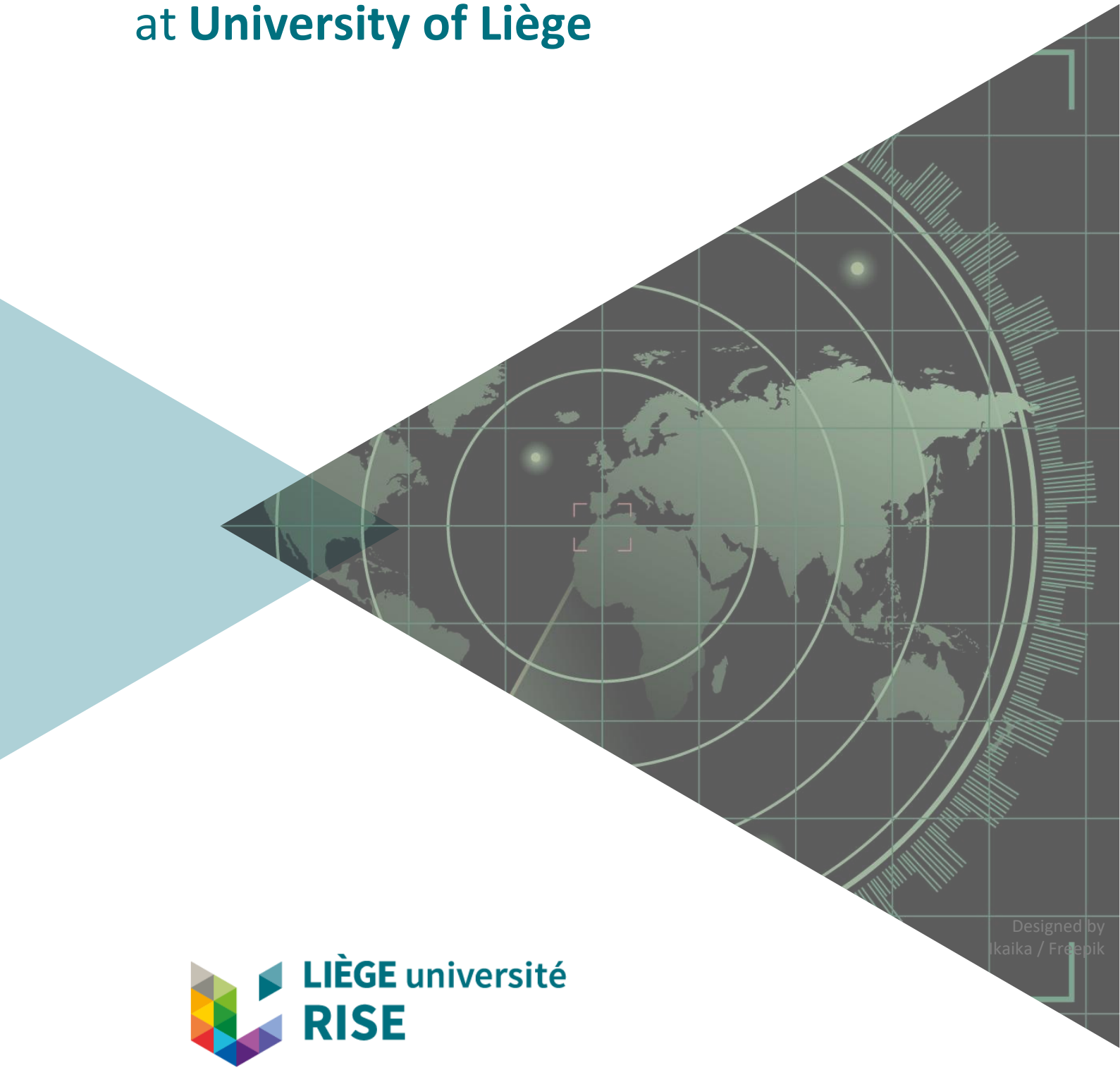
Expertise and Technology in Defense and Security Applications at **University of Liège**



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LIÈGE université
RISE

3100 Researchers

42 Interdisciplinary Research Units

216 New Collaborative Research Projects

112 Active Spin-offs

1493 Patents Granted

56 Laboratories with Expertise in Defense

600+ Scientists with Expertise relevant To Defense and Security Technology

INTRODUCTION

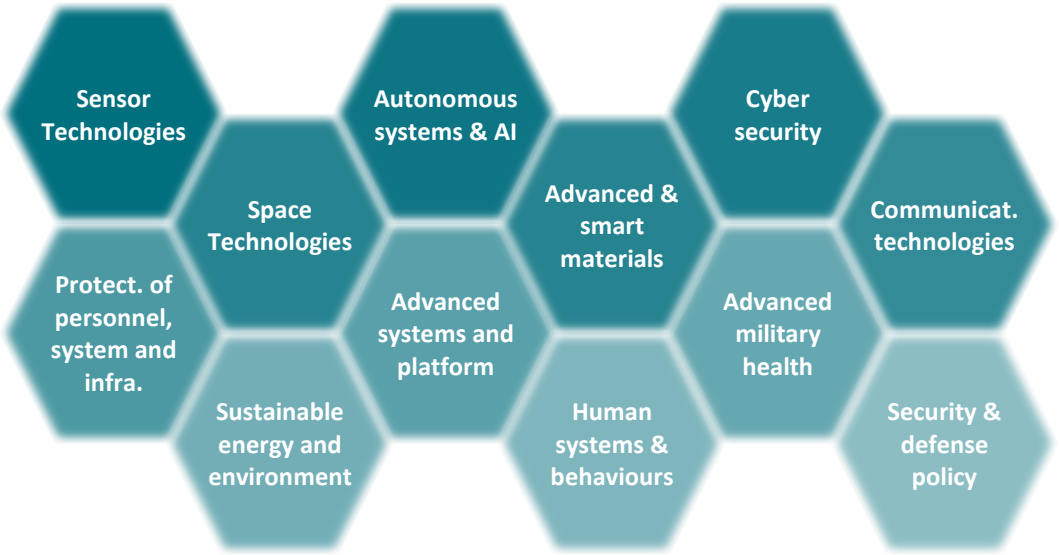
The University of Liège (ULiège) brings together more than 3,100 researchers, scientists, and technicians across a wide range of disciplines, including science, technology, engineering, life sciences, humanities and social sciences. Their work is grounded in three core missions: education, research, and civic engagement. ULiège fosters a research environment that encourages interdisciplinary collaboration and aims to produce both fundamental knowledge and practical applications.

In the field of defense and security, 57 laboratories involving over 600 scientists have developed a solid foundation of research and innovation. This includes both long-term academic inquiry and applied projects, as well as the transfer of knowledge and technologies through licensing and spin-offs. The university works closely with industrial, governmental, and international partners to support Europe's defense capabilities and strategic autonomy, with the goal to defend democracy.

This brochure provides an overview of ULiège's expertise, technology, infrastructure and platforms relevant to defense and security. While the brochure is organized around the university's Research Units, each laboratory is linked to one or multiple of the 12 priorities defined by the Royal Higher Institute for Defence. This structure helps align ULiège's research with the Belgian Ministry of Defense's capability development priorities.

As laboratories chart new paths in defense innovation, this brochure will continue to evolve—mirroring the new expertise acquired and the new projects launched at ULiège.

Defense's Research & Technology focus areas



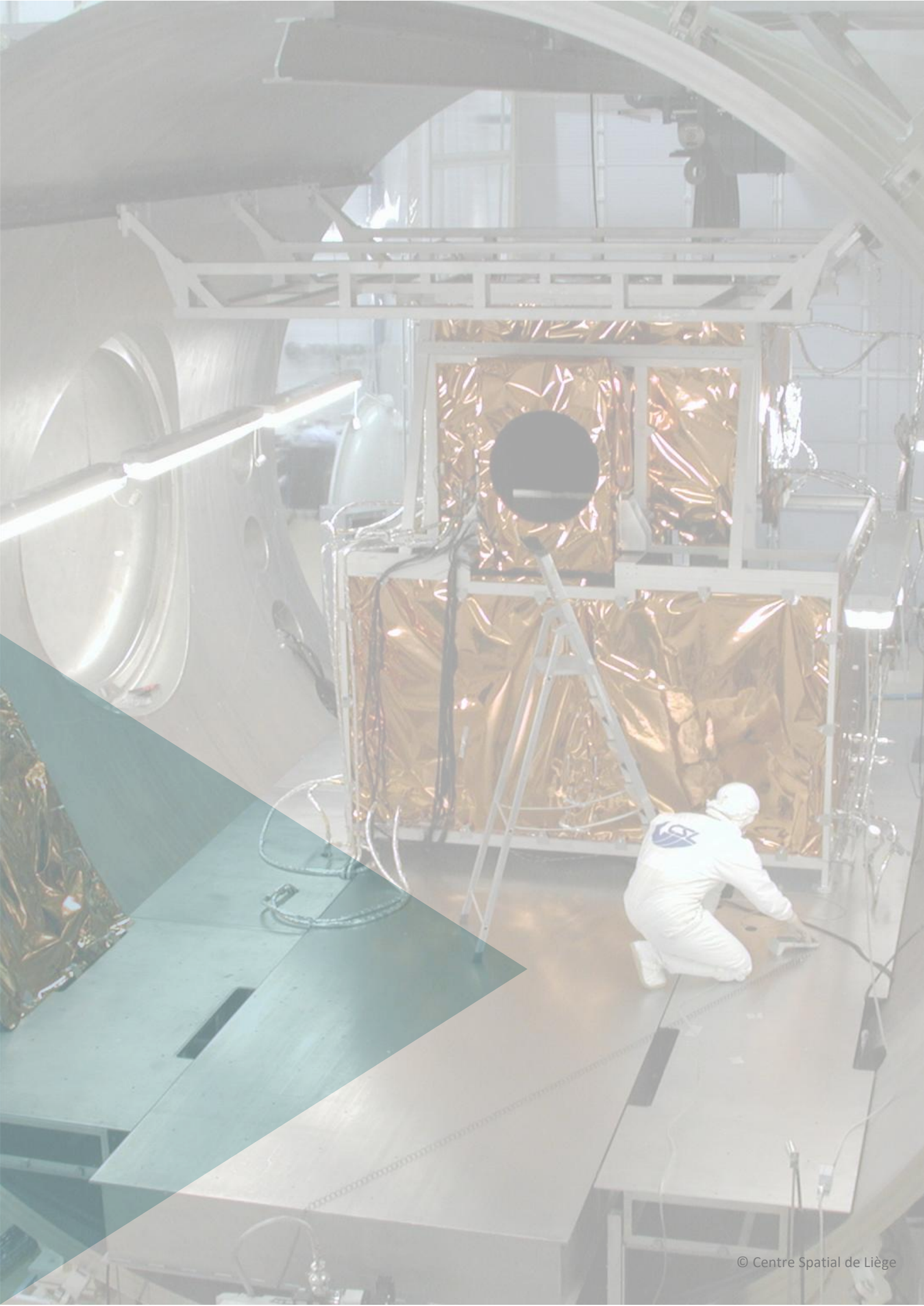


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Illustration générée à partir d'une intelligence artificielle

Overview - ULiège's Expertise along Defense's Research priorities

Research Unit in	Sensor technologies	Autonomous systems & AI	Cyber security	Advanced & smart materials	Communica-tion technologies	Space Technologies	Protection of personnel, system and infra.	Advanced systems and platform	Advanced military health	Sustainable energy and environment	Human systems & behaviours	Security & defense policy
Aerospace & Mechanics	●	○		●		●	●	●		●	○	
Complex and Entangled Systems from Atoms to Materials	●	○	○	●	○	○	○	●	●	●		
Electrical Engineering and Computer Science (Montefiore)	○	●	○	○	●	○	○	●	○	○	○	
Quantum Materials	●	○		●	●		○					
Chemical Engineering				○						○		
Molecular Systems	●	●	●	●		○	○	○	○	○		
Biomedical Research (GIGA)									●		○	
Urban and Environmental Engineering				○								
Earth Observation and studies	○	○				○				○		
Centre Spatial de Liège	●			●	●	●						
Other Research Units	●	●	●	●	●	●			●	○	○	●

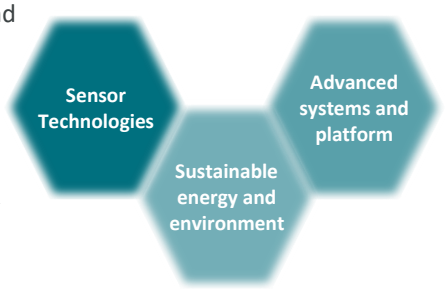
● Existing research in civil and defense applications

○ Existing research in civil applications, but relevant to defense

Research Unit in Aerospace & Mechanics

AEROELASTICITY AND EXPERIMENTAL AERODYNAMICS (AEA)

AEA is active in the fields of aeroelasticity, experimental aerodynamics and fluid-structure interaction. Applications include air vehicles, civil engineering structures and land vehicles.



Notable equipment and facilities: The research group operates the University's large, closed return multidisciplinary low speed wind tunnel. It has two working sections, with a maximum cross-sectional area of 2.5x1.8m^2 (width x height) and a maximum airspeed of 60m/s.

www.wind-tunnel.uliege.be

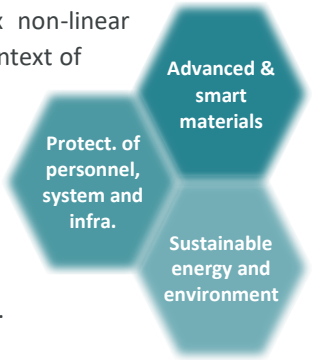
Academic
Prof. T. Andrianne

Contact
+32 4 366 93 36
t.andrianne@uliege.be

COMPUTATIONAL & MULTI-SCALE MECHANICS OF MATERIALS (CM3)

CM3 focuses on the developments of multi-scale numerical methods for complex non-linear engineered materials, such as polymers, composites, ductile metals (including in the context of nuclear energy), lattices, etc. The activities revolve around:

- Constitutive models development,
- Failure analysis,
- Stochastic analysis,
- Development of machine learning tools for simulations acceleration, model identification, non-linear optimisation,
- More recently, the introduction of quantum computing in computational mechanic.



www.ltas-cm3.ulg.ac.be

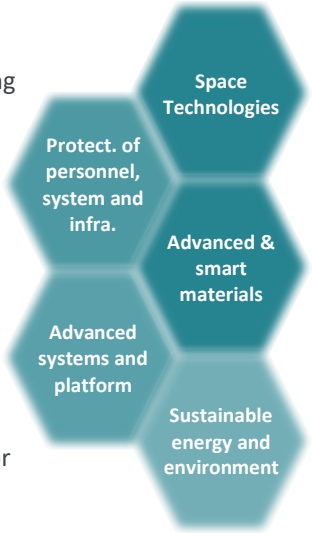
Academic
Prof. L. Noels

Contact
+32 4 366 48 26
l.noels@uliege.be

COMPUTER AIDED GEOMETRIC DESIGN GROUP

The group is active in research in Computer Aided Design, Manufacturing & Engineering (CAD/CAM/CAE) and the link with novel numerical simulation techniques. Among its research topics, the following have applications in aeronautics or defense:

- Novel simulation techniques like the Extended Finite Element Method (X-FEM),
- Application of the X-FEM to the simulation of composite structures (structural analysis or manufacturing techniques),
- Structural analysis-driven automatic model simplification,
- Mesh Generation for numerical simulation,
- Dimensional metrology and 3D scanners,
- X-Ray tomography for industrial parts.

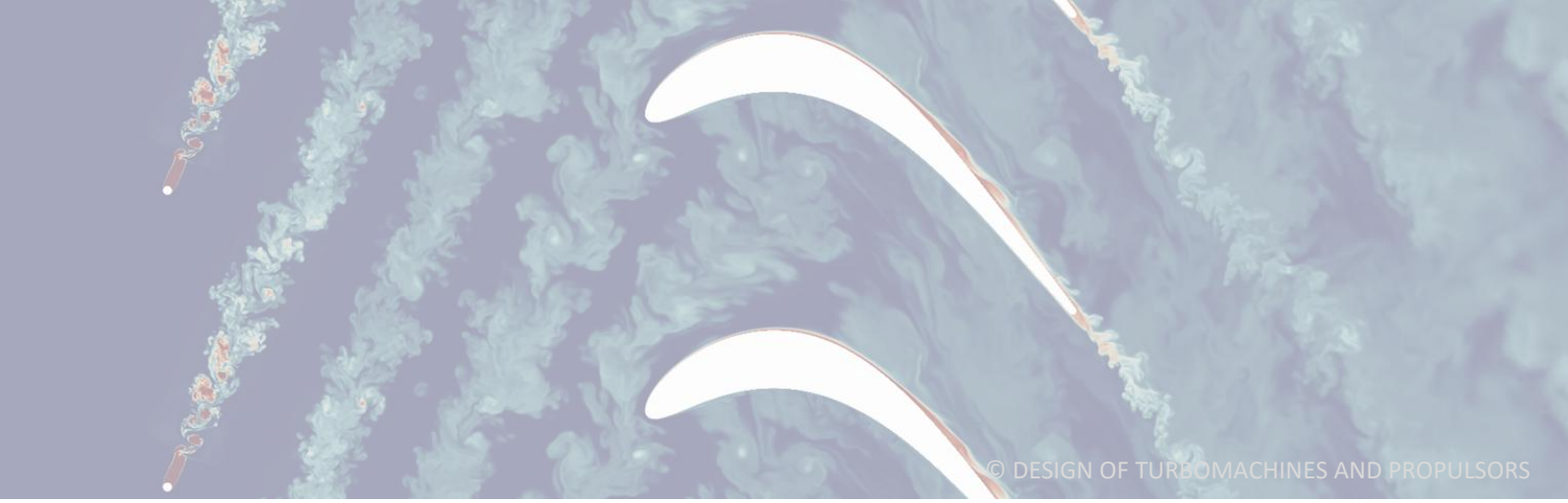


Notable equipment and facilities: The group owns a 3D scanner (accuracy ~30µm even for relatively large parts).

www.cgeo.uliege.be

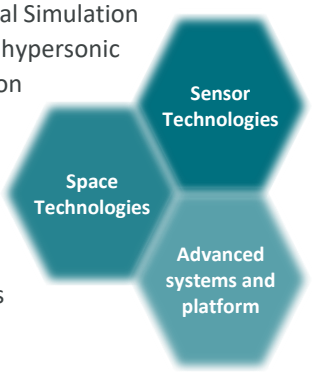
Academic
Prof. E. Béchet

Contact
+32 4 366 91 65
eric.bechet@uliege.be



DESIGN OF TURBOMACHINES AND PROPULSORS (DOTP)

DoTP specializes in the development and application of advanced numerical methods for aeronautical and spatial propulsion. This involves the development of high accuracy techniques for Direct Numerical Simulation (DNS) and Large-Eddy Simulation (LES) of compressible flows from transonic to hypersonic conditions, including rarified and plasma flows. Applications include the study of transition and turbulence in turbomachinery passages, virtual calibration of aerodynamic probes, electric propulsion (Hall Effect Thrusters, Atmosphere-Breathing Electric Propulsion), gas/plasma - wall interaction during atmospheric reentry. The Lab also works on improving industrial simulation techniques used during (automated) design of turbomachinery components, with a current focus on integrating inlet distortion at feasible cost. The Lab closely collaborates with local industry, and the research centres Cenaero and the von Karman Institute.



www.designofturbomachines.uliege.be

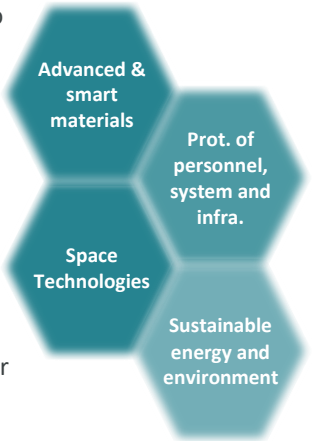
Academic
Prof. K. Hillewaert

Contact
+32 495 38 50 30
koen.hillewaert@uliege.be

METALLIC MATERIALS FOR ADDITIVE MANUFACTURING (MMS)

MMS aims at a better understanding of the relationships between the processing, microstructures, and usage properties of metallic materials. The main research focus is the processing of metallic materials and metal matrix composites by laser-based additive manufacturing (Laser Powder Bed Fusion LPBF and Directed Energy Deposition DED), following two major axes: the development of new metallic alloys and metal matrix composites towards enhanced properties; as well as the optimization of the additive manufacturing of commercial alloys.

Notable equipment and facilities: MMS owns a laboratory-scale Laser Powder Bed Fusion LPBF equipment (i.e. an Aconity Mini printer dedicated to the investigation of new materials). MMS is also equipped for microstructural characterization, for the study of microstructural changes in metallic materials, and for measuring thermophysical data up to high temperatures (Differential Scanning Calorimetry, Differential Thermal Analysis and Laser Flash Diffusivimeter operating up to 1500°C). Moreover, a quenching dilatometer equipped with a compression module is key to the identification of the constitutive laws determining the behavior of materials under complex thermomechanical histories involving high heating/cooling rates as typical of additive manufacturing processes. Looking at materials properties, a major activity is the study of the tribological behaviour from the nano- to the macro-scale thanks to the combination of a high temperature “pin-on-disc” tribometer and a high temperature nano-indenter. Furthermore, equipment’s for corrosion testing in aqueous media have been acquired in 2024.



www.metaux.ulg.ac.be

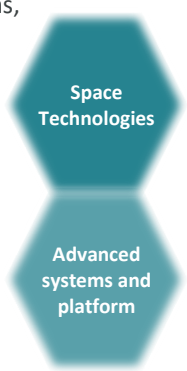
Academic
Prof. A. Mertens

Contact
+32 4 366 91 93
anne.mertens@uliege.be

MULTIBODY & MECHATRONIC SYSTEMS LABORATORY

The Lab develops modelling and simulation tools for the analysis, control and optimization of mechanical systems, with applications in the fields of robotics, deployable space structures and biomechanics. The main research focus is on the description of nonlinear phenomena in system-level models, which can originate from highly flexible nonlinear components (cables, rods, membranes or compliant mechanisms), nonsmooth contact interactions, nonlinear kinematics, or non-mechanical components (actuators, sensors and control units). Specific research topics:

- Unified formulations for complex flexible multibody systems composed of rigid bodies, beams, shells, kinematic joints and superelements,
- Numerical methods in nonsmooth contact dynamics,
- Modelling and simulation of mechatronic and multiphysics systems,
- Optimization methods and sensitivity analysis for mechanical and control design,
- Motion and vibration control methods for robotic systems,
- Planning methods for robot grasping and manipulation.



Notable equipment and facilities: Experimental studies are performed at the Robotics and Automation Laboratory, which is equipped with several industrial robots and cobots, and at the Motion Analysis Laboratory with its advanced 3D motion capture systems.

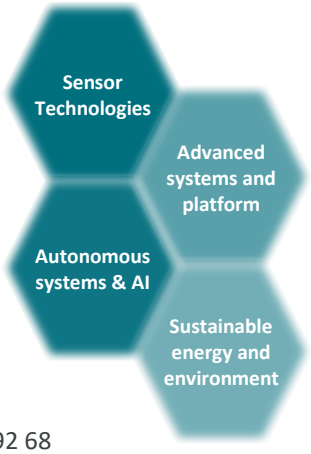
www.ltas-mms.ulg.ac.be

Academic
Prof. O. Brüls

Contact
+32 4 366 91 84
o.bruls@uliege.be

MULTIPHYSICS AND TURBULENT FLOW COMPUTATION (MTFC)

MTFC is specialized in computational fluid mechanics, and in particular the simulations of turbulent flows and flows involving complex multiphysics covering a broad range of applications, notably in aerospace. The Lab focuses on the development of robust and efficient numerical tools, and on large-scale simulations at different levels of fidelity: Direct Numerical Simulation (DNS), Large-Eddy Simulation (LES), Detached Eddy Simulation (DES) and Reynolds-Averaged Navier Stokes (RANS). The goal is to better understand the underlying physics and support the improvement of predictive models for optimizing engineering systems. The interest area of the research group is very broad with applications like steady and unsteady aerodynamics, fluid-structure interaction, viscoelastic turbulence, aeroelasticity, heat transfer, etc.



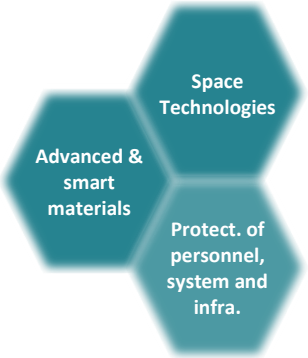
www.mtfc.uliege.be

Academic
Prof. V.E. Terrapon

Contact
+32 4 366 92 68
vincent.terrapon@uliege.be

SPACE STRUCTURES AND SYSTEMS LAB (S3L)

S3L research activities include the design of aerospace structures (including aircraft and satellites), vibration isolation and mitigation, nonlinear vibrations, and satellite orbits. The S3L mission is to develop the conceptual and pratical tools necessary for the design, implementation, and operation of aerospace engineering systems. S3L was the Principal Investigator of the OUFTI-1 nanosatellite launched in 2016 by the Soyuz rocket from Kourou.

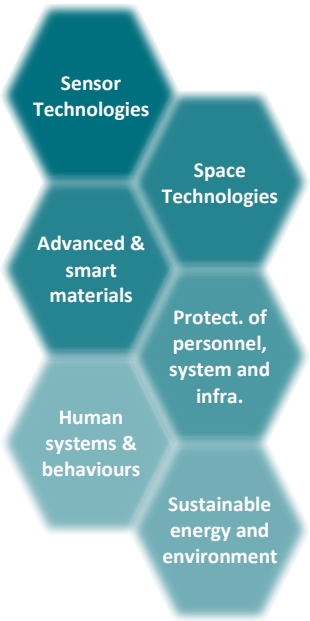


www.s3l.be

Academic
Prof. G. Kerschen

Contact
+32 4 366 48 52
g.kerschen@uliege.be

NON LINEAR COMPUTATIONAL MECHANICS (MN2L)



The Lab specializes in tailored software developments and numerical simulation of problems involving large deformations, complex contact situations and multi-physics couplings. Their finite element method (FEM)-based software METAFOR can deal with complex material behaviors including damage and fracture propagation, as well as phase-change, for both metallic and composite materials. To tackle complex fluid-structure interaction, as well as phase-change problems, they also develops numerical simulation codes based on Particle Finite Element Method (PFEM). Domains of application are:

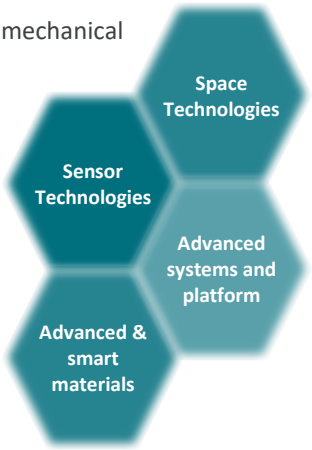
- Impact simulation and crashworthiness,
- Hot and cold metal forming processes, such as Additive Manufacturing and Automated Fiber Placement,
- Fluid-Structure Interaction problems,
- Tire mechanics & rubber,
- Bio-mechanics.

metafor.ltas.ulg.ac.be

Academic
Prof. J.-Ph. Ponthot

Contact
+32 4 366 93 10
jp.ponthot@uliege.be

VIBRATION OF TURBOMACHINES LABORATORY (TURBOVIB)



TurboVib specializes in both numerical and experimental dynamic analysis of jet engine mechanical components. The main areas of expertise and research are:

- Structural design of aircraft engines,
- Turbomachinery rotordynamics,
- Large-scale modelling of aircraft engine components,
- Tribology of components,
- Vibration testing and modal analysis,
- Development of cyberphysical system.

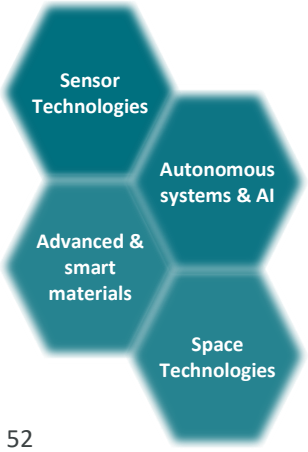
The research is conducted with the goal of implementing findings into industrial Computer-aided engineering (CAE) software. Experimental activities are integral to the laboratory's efforts, particularly in setting up vibration testing facilities.

www.turbovib.uliege.be

Academic
Prof. L. Salles

Contact
+32 4 366 91 77
l.salles@uliege.be

PRECISION MECHATRONICS LABORATORY (PML)



PML is developing instrumentation and strategies for actively measuring and controlling the vibrations of structures. Over the years, it has developed an internationally renown expertise in high precision control of large instruments dedicated to experimental physics, including gravitational wave detectors, particle colliders, segmented ground and space telescopes, satellites and light sources. PML is an active member of LIGO Scientific Collaboration and of the Einstein Telescope Collaboration.

www.pml.uliege.be

Academic
Prof. C. Collette

Contact
+32 4 366 91 52
Christophe.Collette@uliege.be

Research Unit in Complex and Entangled Systems from Atoms to Materials

GROUP OF RESEARCH IN ENERGY AND ENVIRONMENT FROM MATERIALS (GREENMAT)

GREEnMat is recognized for its expertise in the design and characterization of functional materials (inorganic, metallic, and hybrid) in the form of thin films, powders, or bulk solids.

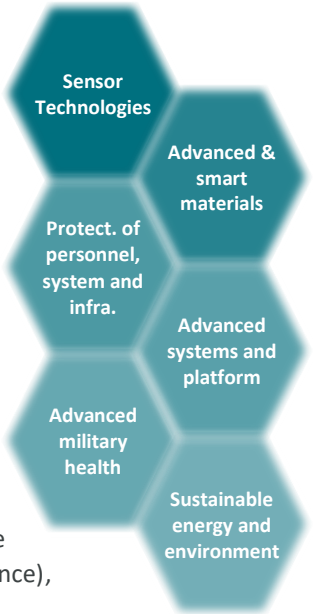
Its research projects target energy (next-gen photovoltaics, green hydrogen, advanced batteries, smart windows,…), light management (multispectral camouflage), environment (recycling of PV cells, batteries, metallic waste,…), and health (pharmaceutical powders, wearable biosensors,…).

The Lab operates semi-industrial research platforms, among these a powder platform with a huge potential for defense applications. In particular, GREEnMat has developed pilot-scale atomization (several kgs) of new powder mixtures for propulsion applications (ballistic and primers) and tactical deployment (smoke). It has ATEX facilities for producing reactive metal powders (aluminum, magnesium) on a pilot scale. GREEnMat's capabilities also include powder characterization, 3D printing of complex ceramic and metal parts, and powder recycling.

GREEnMat collaborates with academic and industrial partners, focusing on material-process compatibility for efficient technology transfer. It is a key partner for any project involving advanced powder technologies.

Notable equipment and facilities:

- Ceramics & Metal Powders Production and Engineering (from a few grams to several kilograms)
  - Two spray-drying units : atomization of aqueous or organic solutions/suspensions (ATEX - controlled O_2 atmosphere (70 ppm)), with production capacity up to 5 kg/hour,
  - A hydro/solvothermal synthesis reactor : 5-liter capacity (200 bar – 500 °C),
  - A pilot unit for melting/atomizing metallic powders : Al, Mg, steel and high temperature alloys,
  - Pilot-scale mills (micron/submicron/nanometric): dry or aqueous grinding.
- Additive Manufacturing (pilot industrial 3D printer for ceramics and metal)
  - SLA printer for ceramics : CERAMAKER 900 (3D Ceram),
  - LPBF (multi)material printer : MICRO (ACONITY 3D),
  - Binder-Jetting printer : P1 (DESKTOP METAL).
- Thin Film Deposition - Automated ultrasonic spray-coating robot : heated plate up to 500 °C (up to 25 cm x 25 cm) with various spray nozzles.
- Thermal Processing - Numerous furnaces for thermal treatments (expertise in debinding/sintering): up to 3000 °C and under various atmospheres (including hydrogen).
- Material/Device Characterization Platform
  - (Micro)structural and compositional properties: particle size distribution, specific surface area, powder rheology, carbon analyzer, thermogravimetric analysis, X-ray diffraction (including 1200 °C chamber), ICP analysis,
  - Spectroscopy: Mössbauer, UV-Vis-NIR, Impedance (EIS),
  - Surface properties and microscopy: optical profilometry, scanning electron microscopy, transmission electron microscopy (+ electron diffraction), atomic force microscopy,
  - Electrochemistry: photovoltaic simulator, battery assembly and testing line (coin and pouch cells), in situ analysis (operando XRD and operando impedance),
  - Mechanical properties: fracture strength, flexibility, and aging resistance.



www.greenmat.uliege.be
www.greenmat.uliege.be/defence

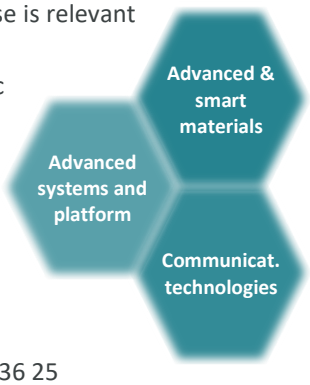
Academic
Prof. R. Cloots

Contact
+32 4 366 34 36
rcloots@uliege.be

GROUP OF RESEARCH AND APPLICATIONS IN STATISTICAL PHYSICS

GRASP is a research unit specialized in the physics of soft matter, bringing together around twenty researchers. The Lab explores systems such as powders, gels, and elastic or flowable materials, which differ from hard matter by their mechanical and flow properties. GRASP's research has led to national and European collaborations, notably with the European Space Agency (ESA) through the Spacegrains project focused on the behavior of lunar and Martian regolith under microgravity. The unit is also known for the PowderReg project (Interreg), which addressed industrial powder transport and flow properties. GRASP's expertise in soft matter also led to the creation of the spin-off Granutools in 2015, now providing advanced instruments to international. GRASP also continues to innovate in functional materials and deployable micro-robots, including concepts for remote-controlled elastic structures and miniature cooperative devices for terrain navigation, surveillance, or equipment deployment. GRASP's expertise is relevant to defense applications, particularly in 3 potential areas of research:

- Collective behavior and swarming algorithms for autonomous drones and robotic systems, enabling decentralized surveillance and rapid interventions in complex terrains,
- The development of electromagnetic cloaking devices designed to reduce or control radar signatures for enhanced stealth operations,
- Powder technology and physical characterization.



www.grasp.uliege.be

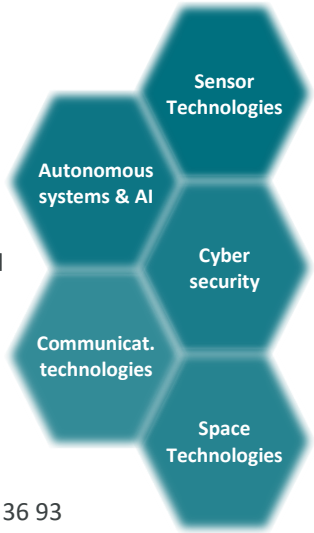
Academics
Prof. N. Vandewalle
Prof. L. Dreesen
Prof. G. Lumay

Contact
+32 4 366 36 25
nvandewalle@uliege.be,
laurent.dreesen@uliege.be,
geoffroy.lumay@uliege.be

ATOMIC AND NUCLEAR PHYSICS (IPNAS)

IPNAS is a leading research center in atomic and nuclear physics in the wide sense that covers both theoretical and experimental developments. In particular, IPNAS has specialized in atomic metrology (atomic clocks), cold atom physics, quantum information and open quantum system theory, as well as in low energy nuclear physics. The Lab has expertise to develop strategic technologies for defense, including

- Quantum computing and technologies (for secure, ultra-fast calculations and sensitive detection) that radically improve accuracy in detecting subtle anomalies or threats,
- Spaceborne atomic clocks (for timing and global positioning technologies), which are critical for military navigation and synchronization in degraded environments.



ipnas

Academics
Prof T. Bastin
Prof J. Martin
Prof. P. Schlagheck

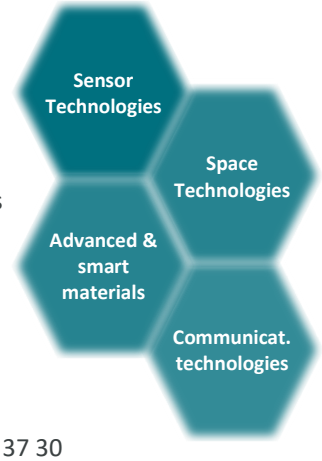
Contact
+32 4 366 36 93
t.bastin@uliege.be
jmartin@uliege.be
peter.schlagheck@uliege.be

Research Unit in Electrical Engineering and Computer Science (Montefiore Institute)

APPLIED AND COMPUTATIONAL ELECTROMAGNETICS (ACE)

ACE group is involved with various aspects of design, modelling and testing of electromagnetic phenomena and devices. The expertise of its members ranges from static and quasistatic electrotechnics to wave scattering and optics, as well as a wide variety of coupled multiphysic problems involving electromagnetic phenomena.

Notable equipment and facilities: With more than 150 industrial references, ACE's Electromagnetic Compatibility (EMC) laboratory comprises a semi-anechoic room fully instrumented up to 26 GHz, and a new reverberating chamber. It recently started covering MIL STD 461 and part of RTCA DO 160, which are of particular interest to the aeronautic and space communities.



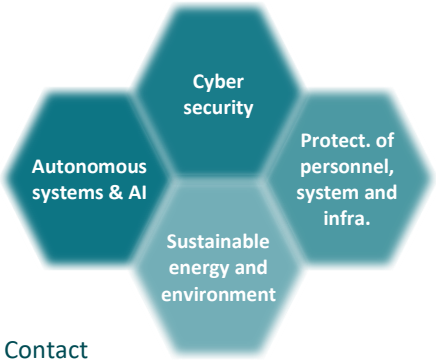
ace.montefiore.ulg.ac.be

Academic
Prof. C. Geuzaine

Contact
+32 4 366 37 30
cgeuzaine@uliege.be

STOCHASTIC METHODS

The Laboratory of Stochastic Methods carries out fundamental and applied research in machine-learning, optimization, control and statistics, and develops algorithms to manage the reliability and cyber-physical security of critical grid infrastructures.

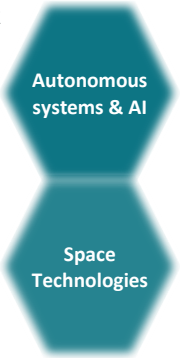


Academic
Prof. L. Wehenkel

Contact
+32 4 366 26 84
l.wehenkel@uliege.be

TELECOMMUNICATIONS AND IMAGING LABORATORY (TELIM) AND VISION AND INFORMATION UNDERSTANDING LABORATORY (VIULAB)

TELIM and VIULab have a deep expertise in computer vision and artificial intelligence, including work on perception in high-dimensional data, motion detection, long-form video understanding, memory in video neural networks, multimodal learning, and generative AI. Applications span biomedical imaging, sports performance analysis, remote sensing, surveillance systems, exoplanet detection, autonomous driving and aerial imaging. TELIM can bring its know-how to the development of autonomous systems for defense, particularly in vision-based artificial intelligence. Its capabilities include real-time background subtraction, object detection, camera calibration, and the autonomous operation of drones (UAVs) and vehicles. In addition, TELIM has expertise in space technologies, specializing in satellite imagery analysis and exoplanet detection, further expanding its potential contributions to security, recognition, detection, and space defense initiatives).



www.telecom.uliege.be
www.viulab.be

Academic
Prof. M. Van Droogenbroeck
Prof. A. Cioppa

Contact
+32 4 366 26 93
m.vandroogenbroeck@uliege.be
anthony.cioppa@uliege.be

RESEARCH UNIT IN NETWORKING (RUN)

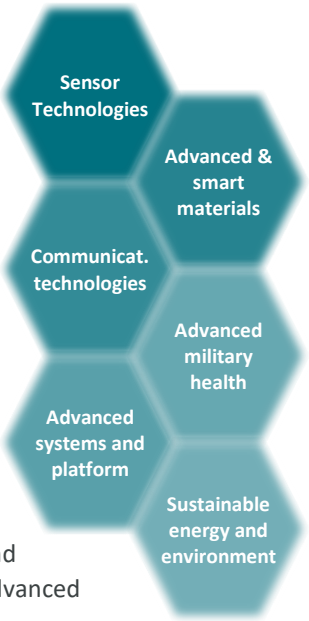
RUN focuses on cybersecurity and computer systems. Its research interest mainly addresses the design of new Internet architectures and algorithms in the context of cybersecurity risks. RUN develops methods and tools for efficiently monitoring the network but also considers unikernels as a way to protect systems. Finally, RUN also focuses on securing modern financial transactions (i.e., bitcoin, smart contracts).

cybersecurity-and-computer-systems

Academics
Prof. B. Donnet
Prof. L. Mathy

Contact
+32 4 366 27 79
benoit.donnet@uliege.be

ELECTRONICS, MICROSYSTEMS, MEASUREMENTS, AND INSTRUMENTATION (EMMI)



EMMI is a group of 3 laboratories sharing a common interest in developing original electric and electronic circuits, characterizing their behaviour in non-ideal conditions, and designing electrical engineering systems based on advanced materials through innovative measurement techniques and sophisticated numerical modelling.

The Microsys Laboratory (Prof. Redouté) conducts interdisciplinary research in the following domains: micro-assembly, interconnection methods and packaging of electronic circuits and sensors; design of integrated circuits, miniaturized electronic circuits and sensor interfaces; energy harvesters for biomedical and wearable applications and autonomous sensor nodes; ultra-low-power microsystems and connected sensor nodes; integrated SPAD-based imagers.

Notable equipment and facilities: Microsys' main facilities comprise a state-of-the-art clean room including equipment for micro-assembly, fabrication, interconnection and packaging of miniaturized sensors and corresponding interfaces, as well as an advanced electronics measurement laboratory.

The Electronics Laboratory (Prof. Vanderheyden) develops numerical models for the physical properties of superconductors, magnetic materials, and semiconductors, for their use in electrical engineering applications including power cables, magnetic sensors, magnetic shields, magnets, and low-temperature electronics. The group has co-developed a finite element toolkit for systems containing superconducting materials.

The Electrical Measurements and Instrumentation Laboratory (Prof.. Vanderbemden) aims at developing innovative measurement systems to characterize the interplay between electric properties and thermal, magnetic and mechanical properties of advanced or critical materials used in electrical engineering, possibly under non-ideal conditions (low and high temperatures, high voltages or large currents).

Notable equipment and facilities: The Laboratory is equipped with cryogenic measurement systems, including a Physical Property Measurement System with a 9 tesla magnet. The Laboratory has developed bespoke experiments dedicated, amongst others, to studying high temperature superconductors, low frequency magnetic shielding, mapping the 3D magnetic field distribution, measuring mechanical properties of electrically- or magnetically-activated shape memory polymers, measuring partial discharges, dielectric properties or breakdown voltage of insulators, and compact high voltage (> 200 kV) pulsed generators.

www.microsys.uliege.be
people.montefiore.uliege.be/vdh
www.life-hts.uliege.be

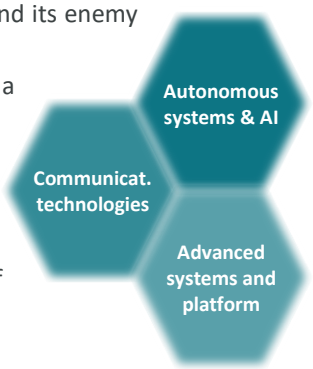
Academics
Prof. J.-M. Redouté
Prof. B. Vanderheyden
Prof. P. Vanderbemden

Contact
+32 4 366 56 05
jean-michel.redoute@uliege.be
b.vanderheyden@uliege.be
philippe.vanderbemden@uliege.be

SMART GRIDS

The Lab has been active in reinforcement learning for many years. This paradigm of artificial intelligence is the perfect choice when building autonomous systems, such as training intelligent agents to solve sequential decision-making problems for typical defense applications like:

- Controlling an effector, like drones or remote weapon stations. Training an effector and its enemy makes it possible to retrieve the best strategies,
- Assist command and control decisions. It includes providing a decision aid to a commander to orchestrate its forces with the best strategies,
- Planning infrastructure management, notably to decide which part of the system to replace or retrofit at the best time to minimize costs and failure risks.



Notable equipment and facilities: The Lab is equipped with the computing power required to provide proof of concept of reinforcement learning algorithms applied to the control of an effector.

Blog Smart Grids

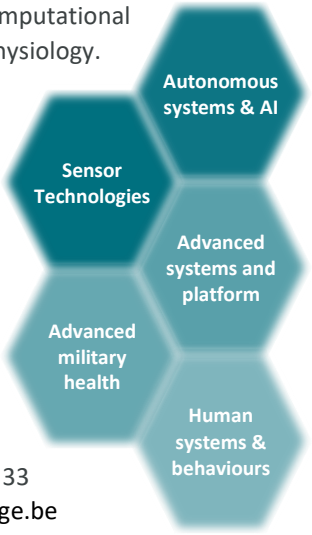
Academic
Prof. D. Ernst

Contact
+32 4 366 95 18
dernst@uliege.be

NEUROENGINEERING LAB

The Lab aims to advance our understanding of biological intelligence and leverage these insights to develop more adaptive, efficient, and sustainable intelligent machines. Their work brings together a rich blend of theoretical, computational, and experimental expertise, ranging from mathematical modeling, computational analysis, and control theory, to robotics, microelectronics, machine learning, and electrophysiology.
Their research is organized along two interconnected axes:

- Neural Engineering uses engineering approaches to better understand the brain. This research integrates both theoretical methods (computational neuroscience, mathematical modeling, simulation) and experimental approaches (cellular and system electrophysiology);
- Neuromorphic Engineering draws inspiration from the brain to develop novel engineering ideas and technologies. This research spans from theoretical frameworks in bio-inspired control to applications in neurorobotics, neuromorphic electronics, neuromorphic machine learning.



www.neuroengineering.uliege.be

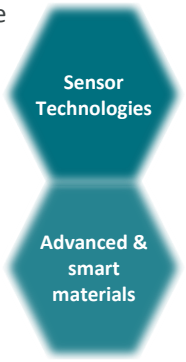
Academics
Prof. P. Sacré
Prof. G. Drion
Prof. A. Franci

Contact
+32 4 366 26 33
p.sacre@uliege.be
gdrion@uliege.be
afranci@uliege.be

Research Unit in Quantum Materials

EXPERIMENTAL PHYSICS OF NANOSTRUCTURED MATERIALS (EPNM)

EPNM focuses on the investigation of confinement effects in mesoscopic systems including nanomagnets, structured superconductors, plasmonics, and hybrids heterostructures, with the aim of unveiling new phenomena beyond the bulk response. During the last decades, we have witnessed continuous breakthroughs in the design and fabrication of tailor-made artificial templates at the nanoscale, so-called artificial materials. This is a consequence of the ongoing nanotechnology revolution that has permitted superior performance first on electronic devices, micro-electro-mechanical systems, micro-fluidic devices, and more recently in the manipulation and confinement of light. For defense technologies, EPNM's expertise opens innovative pathways, particularly metamaterials for magnetic field management: small-scale (millimeter to micrometer) metamaterials enable cloaking or shielding of DC and AC magnetic fields or the enhancement of magnetic field concentration. Applications include protecting sensitive on-chip electronics from electromagnetic interference and enhancing the efficiency of magnetic field detectors critical for secure communication, navigation, and surveillance systems.



www.epnm.uliege.be

Academic
Prof. A.V. Silhanek

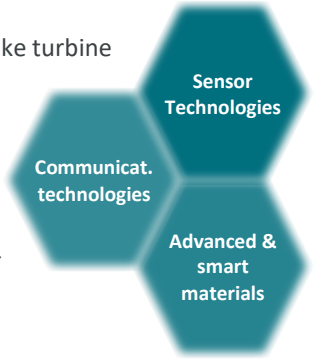
Contact
+32 4 366 36 32
asilhanek@uliege.be

MODELING OF NANOSTRUCTURED MATERIALS (NANOMAT)

Nanomat specializes in the theoretical and numerical study of the electronic structure of materials at the nanoscale, covering crystals, molecules, amorphous systems, and especially nanostructured materials. Understanding electronic structure is essential to predict key experimental properties, including crystal structure, electrical resistivity, optical characteristics, and mechanical strength. Nanomat's expertise offers strong potential for defense applications through several research axes, notably

- The use of flexible nanostructures with high optical absorption in next-generation (opto)electronic devices, including sensors and stealth materials,
- Predicting phonon behavior and designing thermal barriers for critical components like turbine blades or advanced cooling systems for electronics and defense equipment, and
- The prediction of transport properties of nanostructured and advanced functional materials.

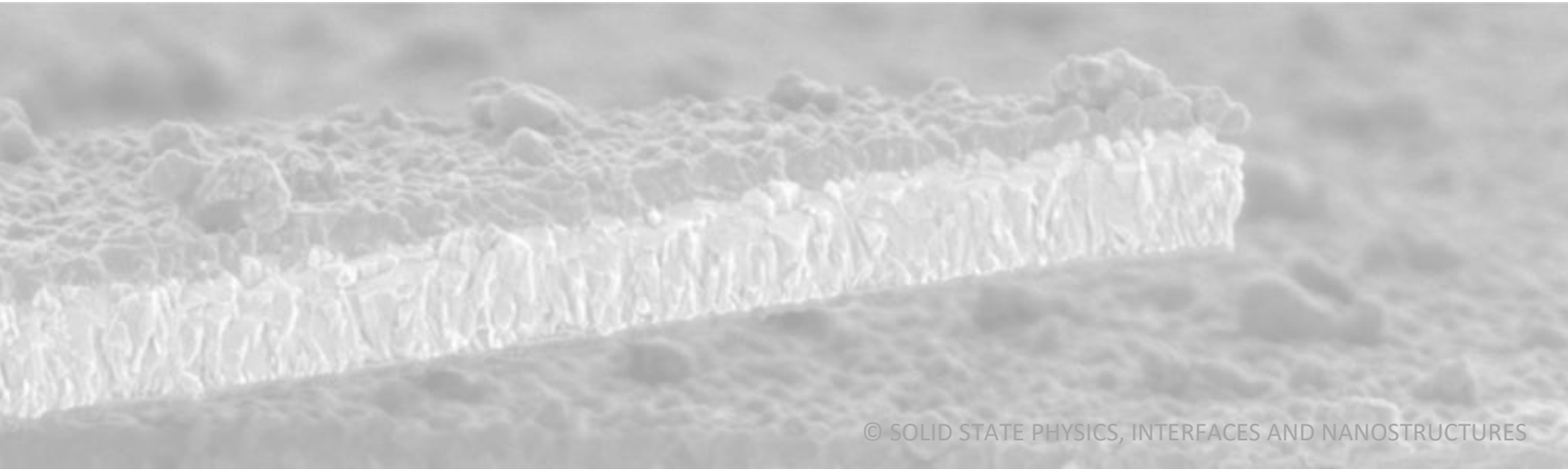
In addition, the Lab contributes to several open source software platforms (ABINIT, TDEP, BoltzTrap2) for atomistic and multi-scale modeling of material properties, which support applications in spintronics, energy storage, and robust sensor technologies under extreme conditions.



www.nanomat.ulg.ac.be

Academic
Prof. M.J. Verstraete

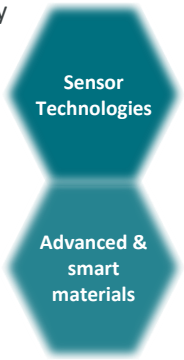
Contact
+32 4 366 90 17
matthieu.verstraete@uliege.be



SOLID STATE PHYSICS, INTERFACES AND NANOSTRUCTURES (SPIN)

SPIN conducts fundamental research on the properties of materials at the nanoscale, particularly focusing on electronic and optical phenomena, leading to advanced applications in optoelectronics and energy. SPIN's expertise contribute to defense technologies, notably:

- Wide bandgap metal oxides: Research in binary metal-oxide compounds offering excellent resilience in harsh environments. Applications include selective gas sensors for detecting hazardous leaks and solar-blind photodetectors for plume detection and battlefield surveillance;
- Low-emissivity materials: Metallic nanostructures can be integrated as low-emissivity materials in coatings for reduced thermal radiation, passive radiative cooling and electromagnetic shielding.



www.spin.uliege.be

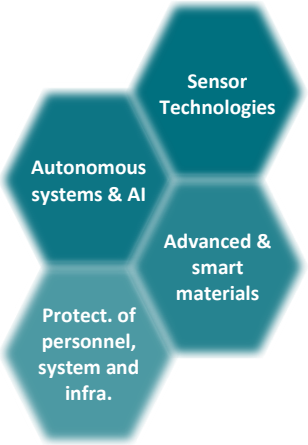
Academic
Prof. Ngoc Duy Nguyen

Contact
+32 4 366 36 04
ngocduy.nguyen@uliege.be

TOPOLOGICAL ORDERS IN MATTER (TOM)

The TOM group is dedicated to the theoretical study of topologically non-trivial non collinear textures for spintronics applications. Spintronics is a new field of research that utilizes not only the charge of the electron but the quantum spin to carry and process information. TOM's expertise leads to innovative opportunities for defense applications through several research areas, including

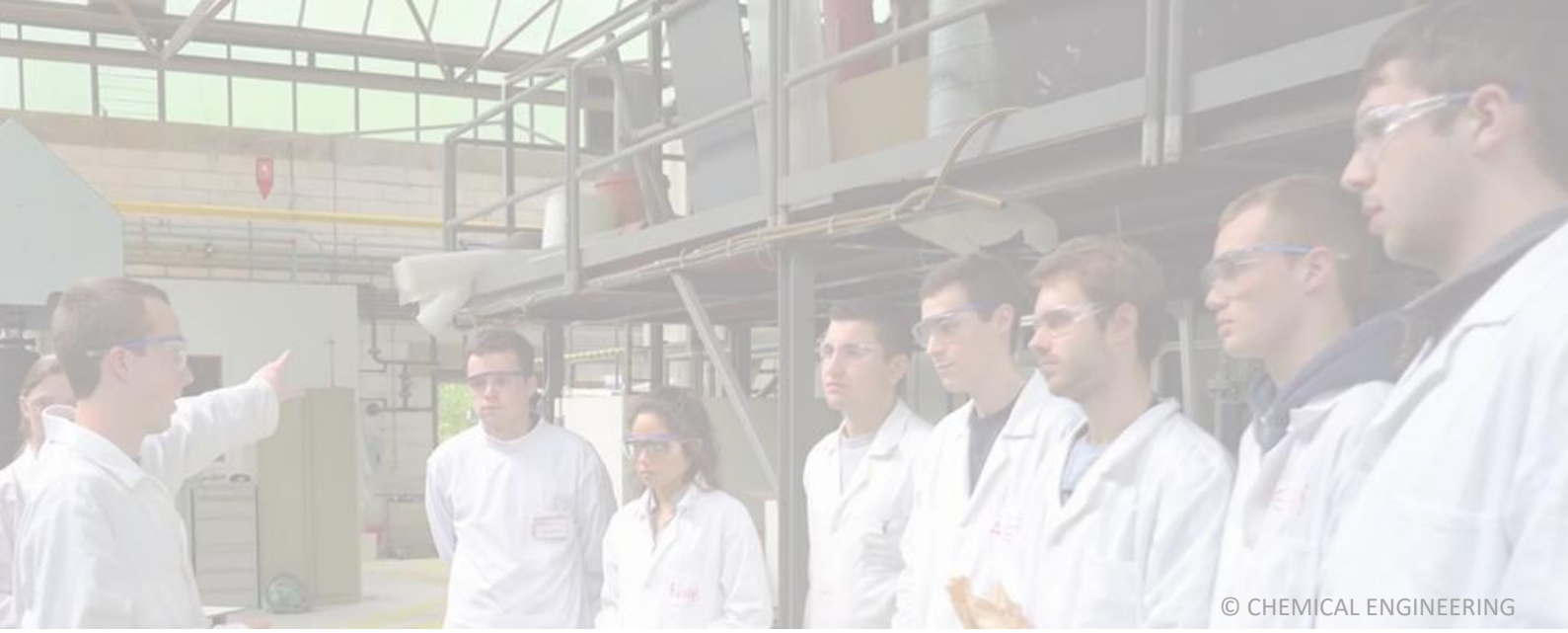
- New materials for superconducting Q-bits, which are optimized for quantum information operations,
- GPS positioning with magnetic nano-oscillators to improve positioning accuracy for satellite networks such as Galileo,
- Magnetic-based signal jamming and countermeasures.



www.tom.uliege.be

Academic
Prof. B. Dupé

Contact
+32 4 366 25 16
bertrand.dupe@uliege.be



Research Unit in Chemical Engineering

The several Labs of this Research Unit develop sustainable processes for the transformation of materials, energy, and living cells. It has recognized expertise in catalysis, electrochemistry, thermochemical processes, and multi-scale analysis. Its research notably covers CO_2 capture and utilization, hydrogen technologies, micro batteries, life cycle analysis, eco-design, functional materials (antimicrobial, photocatalytic), and air and water treatment.

Advanced & smart materials

Sustainable energy and environment

Notable equipment and facilities: Born from the unit's multidisciplinary expertise, the CARPORVISU platform enables multi-scale characterization and visualization of materials using innovative equipment for porosimetry, pycnometry, microtomography, thermogravimetry, and dynamic vapor sorption.

Several projects incorporate critical technologies for defense applications: multifunctional filters (biocidal/CO_2), antimicrobial textiles for protective equipment, energy conversion, Li-ion battery recycling, and production.

www.chemeng.uliege.be

chemeng-carpor

Academics
Prof. S. Lambert
Prof. A. Léonard
Prof. N. Job
Prof. C. Gommes
Prof. D. Toye

Contact
+32 4 366 47 71
stephanie.lambert@uliege.be

Research Unit in *Molecular Systems*

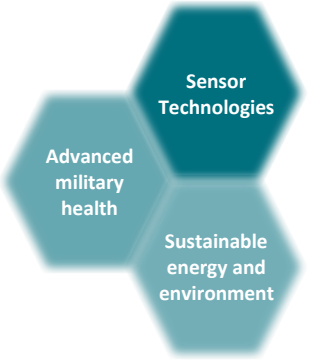
ORGANIC AND BIOLOGICAL ANALYTICAL CHEMISTRY LABORATORY

OBiAChem is a leader in the field of chemical content characterization of complex matrices. The Lab is specialized in the hyphenation of unique multidimensional chromatography tools with state-of-the-art mass spectrometry. We conduct fundamental research on novel technologies development in sampling, separation, characterization and data mining to provide complete analytical solutions. We use our expertise to develop analytical strategies for medical, forensic, food, and various industrial applications. We closely collaborate with instrument and software developers as well as application-driven industries to solve practical analytical challenges.

For Defense applications, the OBiAChem Laboratory is specialized in automated sample preparation, multidimensional chromatography, mass spectrometry, and advanced data processing, which is used to monitor air composition (e.g., detection of contaminants and toxic compounds), sample headspace (e.g., food and raw materials) but also forensic detection (e.g., explosives, drugs, decomposition). In military health, the Lab excels in biofluid metabolomics for early detection of exposure to toxins and warfare agents. It also creates non-invasive sampling kits (breath, skin, micro-blood) suitable for operational use. In energy and sustainability, OBiAChem characterizes pyrolysis and recycled oils to develop greener fuels and lubricants, supporting defense energy resilience.

Notable equipment and facilities:

- GC×GC-LRTOFMS Pegasus 4D (LECO),
- GC×GC-MRTOFMS BenchTOF 4D (LECO),
- GC×GC-HRTOFMS (LECO, JEOL),
- GC×GC-MRTOFMS (JEOL),
- GC×GC-FID (DANI),
- GC-TOFMS (DANI),
- GC-TripleQuadMS (JEOL).



www.obiachem.uliege.be

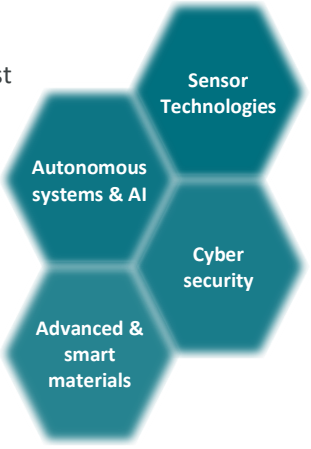
Academic
Prof. J.-F. Focant

Contact
+32 4 366 35 31
jf.focant@uliege.be

THEORETICAL PHYSICAL CHEMISTRY (TCP)

TCP activities focus on the theory and modeling of the dynamics of molecular systems subject to external perturbations (optical, electrical and magnetic, mechanical, collisions), with applications to:

- Molecular logic using quantum intra- and inter- molecular dynamics on of nano particle and molecular hardwares for the design of sensors (classical and quantum),
- Quantum computing : design of algorithms for molecular quantum dynamics,
- Attochemistry and photochemistry: control of chemical reactivity by ultrafast (attosecond and femto second) optical excitation in molecules,
- Mechanochemistry : response of materials to external forces at the molecular leve.l
- Quantum dynamics of excited states in dense level systems and the control of energy and charge transfer induced by collision and photoexcitation: polyatomic molecules, high molecular Rydberg states, site-selected reactivity in small ionized peptides, nanomaterials,
- Electronic, structural, optical, transport and magnetic properties of molecular and nano materials,
- Systems biology: Information Theoretic Approach for the analysis of high throughput genomic and proteomic data.



www.tcp.ulg.ac.be

Academic
Prof. F. Remacle

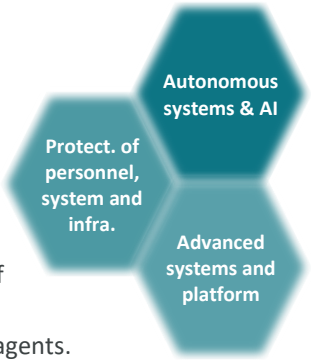
Contact
+32 4 366 23 47
fremacle@uliege.be

CENTER FOR INTEGRATED TECHNOLOGY AND ORGANIC SYNTHESIS

The Center for Integrated Technology and Organic Synthesis (CiTOS) is a unique research unit at the intersection of organic synthesis, flow process engineering, and computational chemistry. CiTOS gathers a 25-members team with a strong international footprint. Research at CiTOS aims to develop compact, safe, and scalable chemical technologies with high relevance for both industry and public-interest sectors.

One key research axis at CiTOS focuses on the neutralization of chemical warfare agents (e.g., mustard gas, VX), with a strong emphasis on *in silico* design, operational simplicity, and deployable solutions. These technologies—validated with industrial partners—demonstrate potential for rapid, field-ready applications relevant to military stockpiles, legacy munitions, and humanitarian decontamination.

CiTOS' broader expertise in intensified chemical processes, regulatory compliance (especially regarding dual-use substances), risk minimization, and automation further aligns with national and European defense-related priorities. CiTOS is recognized as a Corning® Advanced-Flow™ Reactor Qualified Laboratory and leads FloW4all, a technology platform bridging academic innovation and applied development.



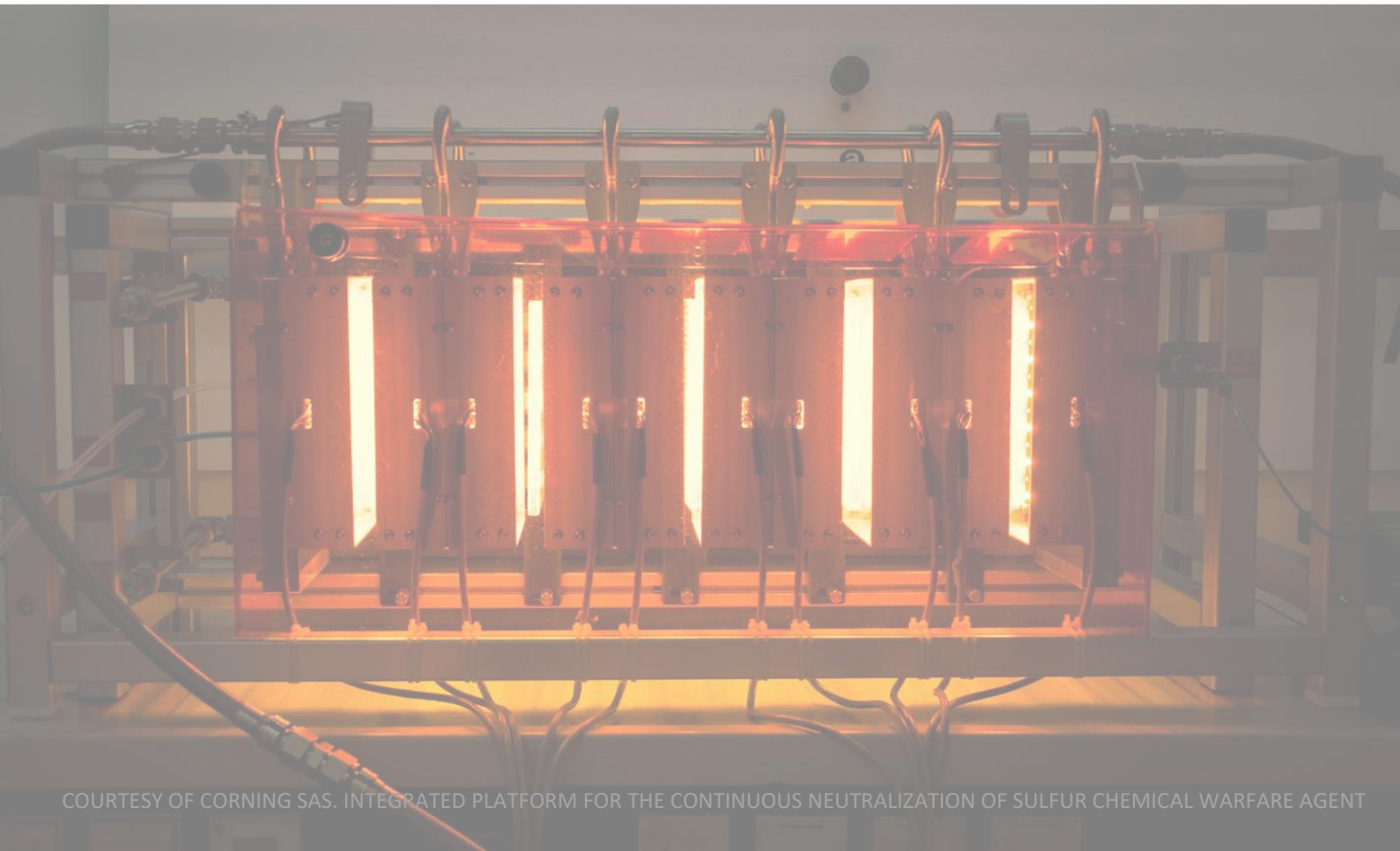
In defense specifically, CiTOS expertise include:

- Use of AI and quantum mechanics to simulate neutralization conditions for chemical weapons, and to design simulants (chemically similar but non-toxic molecules) for laboratory validation of neutralization simulations,
- Development of autonomous systems for drug production via mobile/low-footprint platforms for decentralized manufacturing in hard-to-reach areas,
- Development of autonomous and mobile/portable systems for the destruction of chemical warfare agents,
- Development of kits/methods/platforms for the neutralization of chemical warfare agents.

www.citos.uliege.be
flow4all.uliege.be

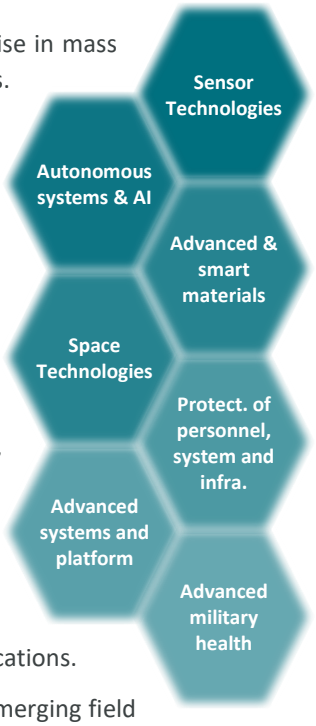
Academic
Prof. J.-C. Monbaliu

Contact
+32 4 366 35 10
jc.monbaliu@uliege.be



COURTESY OF CORNING SAS. INTEGRATED PLATFORM FOR THE CONTINUOUS NEUTRALIZATION OF SULFUR CHEMICAL WARFARE AGENT

MASS SPECTROMETRY LABORATORY (MSLAB)



MSLab is a multidisciplinary consortium bringing together chemists with strong expertise in mass spectrometry, Ion Mobility Spectrometry (IMS), Raman Spectroscopy, and optical sensors. The Laboratory designs and develops innovative analytical solutions combining complementary technologies to address current and future challenges in health, environmental safety, defense, and materials science. MSLab is recognized for its ability to translate complex laboratory technologies into portable and miniaturized devices, enabling real-time, on-site detection of toxins, pathogens, and Chemical Warfare Agents (CWAs).

In the field of defense and security, MSLab has developed advanced expertise in IMS and Raman-based technologies for the rapid detection and identification of hazardous substances in complex environments. These complementary approaches offer high sensitivity and selectivity, allowing the detection of trace levels of toxic agents in air, liquids, or on surfaces. Optical sensors based on Raman or Surface-Enhanced Raman Spectroscopy (SERS) exploit functionalized nanoparticles to target specific analytes, while IMS provides fast and robust identification of chemical threats through drift-tube, Differential Mobility Spectrometry, or Atmospheric Pressure Ion Mobility Spectrometry configurations. Both technologies are integrated into portable or miniaturized systems, specifically designed for field deployment and point-of-care applications.

MSLab also develops innovative biosurveillance tools based on sweat proteomics, an emerging field offering non-invasive access to physiological information. Through collaborations with industrial partners, the Laboratory has designed a microfluidic skin patch for the passive collection of sweat, stabilized for advanced proteomic analyses or rapid screening. This technology opens new perspectives for real-time health monitoring in operational conditions, including the detection of stress, fatigue, dehydration risks, early immune responses, or exposure to toxins and pathogens. Integrated with miniaturized biosensors, it represents a promising tool for personalized protection and preventive health surveillance of military personnel or first responders.

Beyond detection technologies, MSLab contributes to the development of advanced materials to enhance sensor performance. The Laboratory engineers selective membranes, Surface-Enhanced Raman Spectroscopy (SERS) nanoparticles, and optimized sample introduction systems to improve sensitivity and specificity in complex matrices. Raman Spectroscopy is also applied for non-destructive material characterization, structural analysis, and forensic investigations.

The Laboratory's expertise extends to the structural characterization of bioactive compounds, including toxins, venoms, and neurotoxins, using advanced mass spectrometry approaches. This work supports the development of neutralization strategies, pharmacological models, and therapeutic agents, contributing directly to military medicine, biodefense, and biosecurity.

Finally, MSLab actively contributes to the integration of multimodal analytical platforms, combining IMS, Raman, optical sensors, and mass spectrometry modules into autonomous vehicles, robotic systems, mobile laboratories, or drones. Inspired by space instrumentation, MSLab designs and prototypes miniaturized Raman systems for mobile or embedded applications — ideal for on-field deployment by Defense or Civil Protection units. These flexible, modular solutions reinforce field capabilities for rapid detection, health monitoring, and protection of personnel, infrastructure, and critical systems.

www.mslab.uliege.be

Academics
Prof. G. Eppe
Prof. L. Quinton
Dr. G. Mazzucchelli
Dr. C. Malherbe

Contact
+32 4 366 34 22
g.eppe@uliege.be
loic.quinton@uliege.be
gabriel.mazzucchelli@uliege.be

Interdisciplinary Biomedical Research Center *(GIGA)*

CYCLOTRON RESEARCH CENTER (CRC) HUMAN IMAGING

Advanced military health

Human systems & behaviours

GIGA CRC Human Imaging team brings together several neuroscience research laboratories, many of whose themes are relevant to Defense: sleep deprivation, fatigue, and states of consciousness that affect cognition. This includes, for example, interindividual variability in vulnerability (phenotypic/genotypic) to sleep deprivation, decision-making under uncertainty, and mental states likely to alter cognitive performance.

Notable equipment and facilities: The GIGA-CRC-HI is supported by the GIGA In Vivo Imaging technological platform, which provides cutting-edge multimodal imaging infrastructure tailored to biomedical research (3T & 7T MRI, EEG/ECG/EMG, actimetry, neuropsychological testing, etc.).

www.gigacrc.uliege.be
www.gigaivi.uliege.be

Academics
Prof. F. Collette
Prof. G. Vandewalle
Prof. C. Phillips

Contact
+32 4 366 23 16
f.collette@uliege.be
gilles.vandewalle@uliege.be
c.phillips@uliege.be

NEURORECOVERY LAB

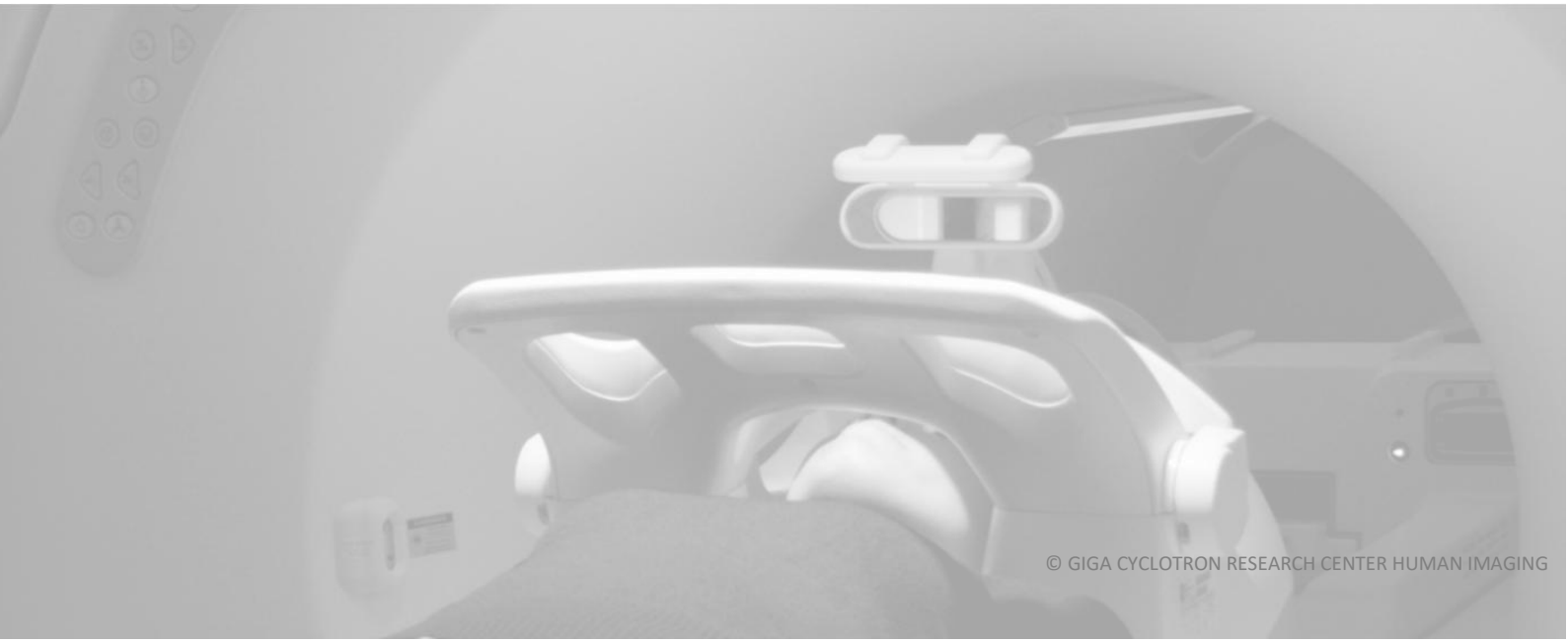
The NeuroRecovery Lab focuses on advancing neurorehabilitation by exploring how non-invasive brain stimulation (NIBS) can support recovery from brain injuries, from mild traumatic brain injury (mTBI), commonly known as concussion, to severe disorders of consciousness (DoC). Using techniques like transcranial direct current stimulation (tDCS), transcranial alternating current stimulation (tACS), and transcutaneous auricular vagus nerve stimulation (taVNS), the Lab aims to enhance brain plasticity, functional connectivity, and cognitive recovery. Their multidisciplinary approach combines neuroimaging, neurophysiology, and clinical expertise to develop personalized, translational therapies. The Lab values ethical conduct, collaboration, and empathy, striving to close the gap in long-term care for brain-injured patients while advancing scientific understanding.

Advanced military health

www.giganeurorecovery.uliege.be

Academics
Prof. A. Thibaut
Prof. G. Martens

Contact
+32 4 323 36 12
athibaut@uliege.be
geraldine.martens@uliege.be



INSTITUTE OF EPIDEMICS

Epidemics have punctuated human history, reshaping societies and influencing economic, political, and cultural structures. They have been documented since Antiquity, but since the 1980s, they have occurred with increasing frequency, highlighting the persistent vulnerability of human populations to infectious agents—despite advances in medicine and biomedical technologies. Epidemics are also more likely to occur under unstable conditions, particularly during times of war.

The COVID-19 pandemic revealed how unprepared states were for epidemic and pandemic threats, which could pose a major issue during armed conflict. However, it also provided an opportunity to identify all the necessary actions to effectively anticipate future health crises. For example, developing epidemic response scenarios and ensuring they can be rapidly implemented if needed, strengthening epidemiological surveillance and testing systems, relocating the production of essential equipment and supplies for epidemic response, building sufficient strategic stockpiles, improving the training of healthcare professionals in epidemic management, and enhancing hospital capacity.

Aware of their civic responsibility and the growing threat to humanity, scientists at ULiège who played a key role in the fight against COVID-19 (37 Principal Investigators are members of the Institute) decided to continue their efforts by creating an Institute of Epidemics within their university. The term “epidemics” is understood here in a broad sense, encompassing both human and animal outbreaks, whether local or global (pandemics). The Institute’s primary goal is to serve society—and especially policymakers—by contributing to better anticipation of epidemics and pandemics, as well as to the implementation of active responses when such crises occur.

Concretely, its main missions include active epidemiological monitoring outside of crisis periods, identifying infected individuals or animals (screening), and measuring their immune responses post-infection and post-vaccination during declared epidemics/pandemics. It also aims to establish a biobank (a library of infectious and non-infectious samples and infectious agents) accessible to all researchers, and to develop rapid response protocols (logistics, supply of materials and reagents, identification of infectious agents and their variants, screening, vaccination) in the event of an outbreak.

The Institute of Epidemics thus aims to offer society a turnkey solution for better anticipation and resolution of future epidemics and pandemics, which, unfortunately, are likely to occur given overpopulation, increasing human mobility, and growing instability and conflict.

Advanced military health

Academic
Prof. F. Bureau

Contact
+32 476 37 86 74
fabrice.bureau@uliege.be

Research Unit in Urban and Environmental Engineering

MATERIALS AND SOLID MECHANICS (MSM)

MSM focuses on material models (steel, Ti, Al,...). The development and the identification of constitutive thermo-mechanical-metallurgical laws rely on macroscopic phenomenological or multi- scale approaches and crystal plasticity models. Implemented within Finite Element Methods (FEM) codes, these laws predict stress, strain, and damage fields during forming processes, specific static or cyclic loading cases. Since 1984, MS team has developed its own non linear finite element code Lagamine, recently a Phase Field code and a Mean Creep Field model have been developed and applied.

Advanced & smart materials

Mecanique-des-solides-et-des-materiaux

Academics
Prof. A. Habraken
Prof. L. Duchene

Contact
+32 4 366 94 30
anne.habraken@uliege.be
l.duchene@uliege.be

MATERIALS AND STRUCTURES MECHANICS (M&S)

M&S offers possibilities for aeronautical firms to carry out mechanical tests on different types of aircraft components like rods, lubrication groups, bearing supports, flaps actuator parts, engines composite or metallic carters.

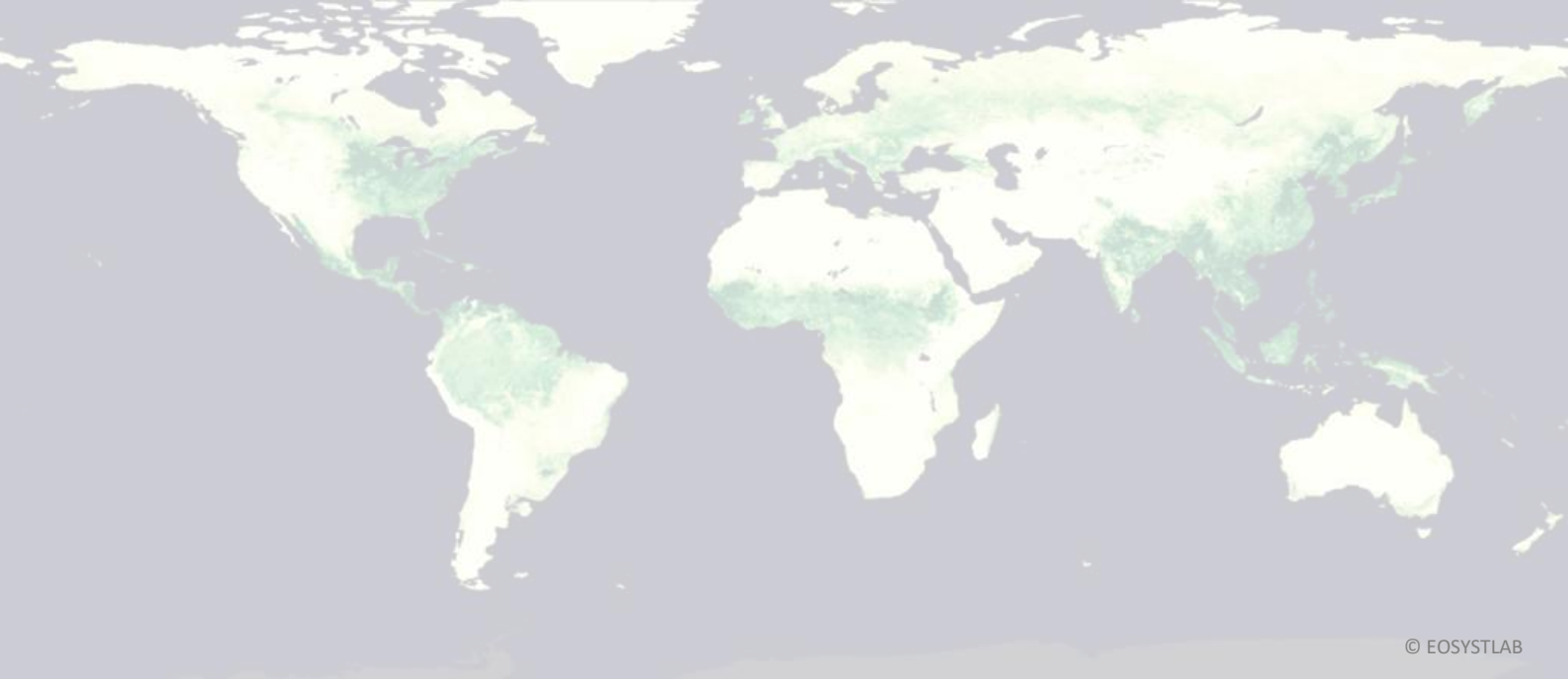
Notable equipment and facilities: The equipment park includes hydraulic and electro-mechanic machines with a load capacity from 10 kN to 2500 kN, allowing performing quasi static and fatigue tests. On a test strong floor (11mx21m), specific testing setup can be built, using movable static hydraulic jacks (50 to 1000 kN) and dynamic hydraulic jacks (100 to 1000 kN), to test real scale components.

Advanced & smart materials

Constructions-metalliques-et-mixtes
Laboratoire-de-mecanique-des-materiaux-structures

Academic
Prof. J.F. Demonceau

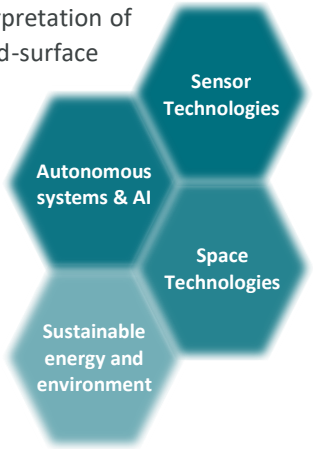
Contact
+32 4 366 93 58
jfdemonceau@uliege.be



Research Unit in Earth Observation and Studies *(SPHERES)*

EARTH OBSERVATION AND ECOSYSTEM MODELLING (EOSYSTLAB)

EOSystLab is a research laboratory specializing in the acquisition, processing, and interpretation of multi-source remote sensing data to support environmental monitoring and land-surface analysis. The Lab places particular emphasis on leveraging new-generation satellite-based Earth observation technologies—including hyperspectral imaging, LiDAR, active and passive microwave systems, and thermal sensors. In addition to its expertise in satellite remote sensing, the Lab is a pioneer in the field of unmanned aerial vehicle (UAV) remote sensing. By integrating UAV-based LiDAR, hyperspectral or thermal data with advanced modelling frameworks—such as AI-driven algorithms and process-based models—the Lab develops innovative solutions for mapping, monitoring, and predicting environmental changes. These integrated methods provide enhanced spatial and temporal insights to inform strategic decision-making across a range of applications.



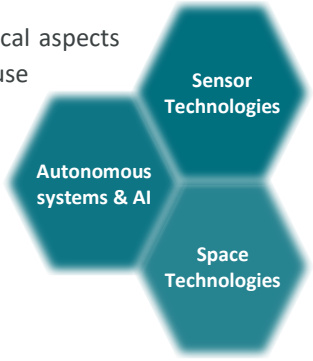
www.eosystm.uliege.be

Academic
Prof. F. Jonard

Contact
+32 4 366 58 80
francois.jonard@uliege.be

GEOSPATIAL DATA SCIENCES AND CITY INFORMATION MODELING

GeoScITY specialises in spatial information modeling. Its activities cover both theoretical aspects (qualitative spatial reasoning, spatial ontologies, etc.) and operational developments (use of AI methods in geospatial data processing, development of spatial data infrastructures, etc.). Its research focuses mainly on urban applications, from the territorial to the building scale, without excluding other themes such as digital heritage.



www.geoscity.uliege.be

Academic
Prof. R. Billen

Contact
+32 4 366 36 37
rbillen@uliege.be

Centre Spatial de Liège (CSL)

The Centre Spatial de Liège (CSL) has been a cornerstone of space activity development in Belgium since the early 1960s. As one of the oldest space science laboratories in Europe, it has operated for decades as an ESA-coordinated facility. Today, CSL employs approximately 105 staff members, 60% of whom are engineers and scientists. CSL offers a wide range of advanced infrastructure for space environmental testing, including five thermal vacuum chambers, two shakers, and a broad suite of specialized equipment, all housed within clean rooms covering more than 1,000 m². CSL specializes in the development of space optical instruments and has contributed to numerous payloads for space and Earth observation missions. It also plays a key role in the advancement of enabling space technologies and provides expert services across several domains.

Optics & Imaging

- Optical design and simulation,
- High-precision metrology and calibration,
- Straylight analysis and mitigation,
- Optical assembly and integration,
- Synthetic Aperture Radar (SAR) signal processing.

Space Environment

- Thermal vacuum testing (including cryogenic temperatures),
- UV exposure and solar illumination,
- Radiation testing and analysis.

Coatings & Surface Technologies

- Advanced optical coatings,
- Micro- and nanostructure fabrication,
- Optical materials characterization,
- Optical sensor development,
- Molecular contamination control and analysis.

Thermal & Mechanical Engineering

- Thermal design a& analysis,
- Mechanical design,
- Cryogenics,
- Materials & processes.

Electronic Engineering

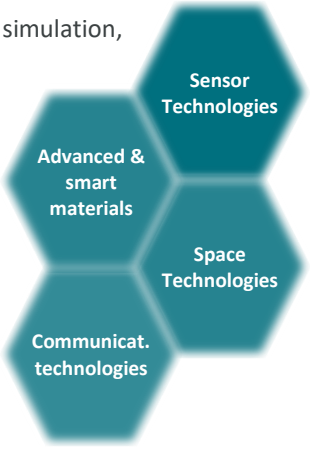
- Development of electronic ground calibration systems,
- Design and integration of space scientific payloads,
- Embedded systems engineering.

Quality

- Space quality and risk management,
- Product assurance for space systems,
- National Surveillance Organization for launchers.

Notable equipment and facilities:

- Clean rooms (ISO 5 and ISO 7): Over 1,000 m² for assembly, integration, and surface engineering,
- 5 Thermal vacuum chambers: Ranging from 1.5 m to 6 m in diameter, including cryogenic capabilities,
- 2 Shakers for vibration testing,
- Comprehensive environmental test facilities: Climatic chambers, UV exposure, solar simulation, radiation environments,
- Optical ground support equipment (UV to IR) for calibration and test,
- Spectrometers spanning far-ultraviolet to far-infrared,
- Optical coatings and microfabrication labs,
- BRDF (Bidirectional Reflectance Distribution Function) measurement system,
- Straylight characterization and molecular contamination analysis facilities.



CSL's capabilities and developments are relevant to the defense sector, particularly in areas such as: embedded electronic systems, SAR signal processing, laser-based positioning and communication systems, calibration of Earth observation instruments, environmental testing of optical sensors, and end-to-end development of space weather instruments as well as on-board calibration systems for remote sensing payloads.

www.csl.uliege.be

Academics
Prof. S. Habraken
Prof. L. Jacques

Contact
+32 4 382 46 30
kfleury@uliege.be

Other Research Units

THE LABORATORY OF RURAL ECONOMICS AND DEVELOPMENT

This Lab from Gembloux AgroBioTech specializes in the analysis of agricultural and agri-food systems, from input suppliers (fertilizers, seeds, etc.) to the consumption of final products (human food, animal feed, bioenergy, bio-based materials, etc.). The studies conducted focus in particular on the socio-economic aspects of agricultural value chains, both in Belgium and in developing countries. This includes the profitability of agricultural production, processing, and marketing; market analysis; business management; innovation adoption; producer organization; income diversification; household resilience; analysis of agricultural policies and international trade relations; supply balances; and the economic development of rural areas. Depending on the case, these studies are carried out at the micro-, meso-, or macroeconomic level.

economie-et-developpement-rural

Academics
Prof. P. Burny
Prof. T. Dogot

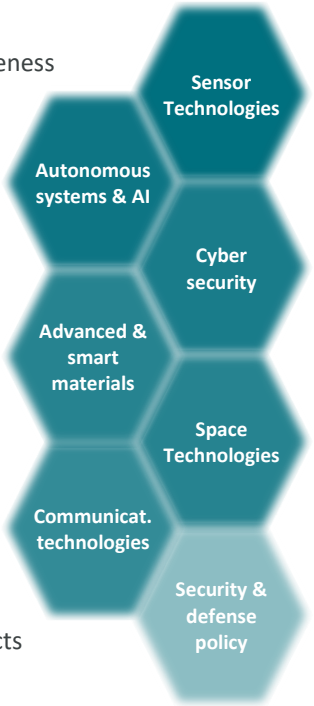
Contact
+32 81 62 26 47
philippe.burny@uliege.be
thomas.dogot@uliege.be

THE EUROPEAN STUDIES UNIT (ESU)

ESU is a research unit within the Faculty of Law, Political Science and Criminology. ESU's work focuses on the European Union from a politico-legal perspective, examining the EU's institutions, governance, and policies as well as the legal and political challenges facing Europe today.

ESU's main research areas include:

- European governance and policies: Analyzing the structures, processes, and effectiveness of EU governance, as well as the development and implementation of EU policies,
- Non-proliferation of weapons of mass destruction (WMD) and CBRN (Chemical, Biological, Radiological, and Nuclear) controls: Investigating the legal and policy frameworks that regulate the proliferation of WMDs and the management of related risks within and beyond the EU,
- Strategic Trade Control: Studying the regulation of trade in conventional weapons, dual-use items (goods and technologies that can be used for both civilian and military purposes), conflict minerals, items related to torture, and cultural goods. This includes examining EU and international export control regimes and their impact on security, trade, and compliance.



ESU provides expertise to European institutions, international organizations, member states, and the private sector. It is recognized for its annual seminars, outreach activities, and academic research on the intersection of international security and the trade of sensitive items, technologies, and services. The unit's team includes professors, researchers, and PhD students with specialized knowledge in areas such as EU security and defense, environmental policy, intelligence oversight, and the legal aspects of strategic trade control.

www.esu.ulg.ac.be

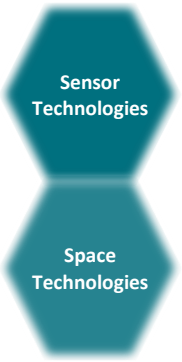
Academic
Prof. Q. Michel

Contact
+32 4 366 30 64
qmichel@uliege.be

ATOMIC AND NUCLEAR SPECTROSCOPY, ARCHAEOMETRY (SANA)

SANA is active in experimental atomic and nuclear physics. It specializes in the interaction of charged particles with matter as well as non-destructive testing.

Notable equipment and facilities: It is equipped with three particle accelerators (proton, helium, heavy ions) covering energy ranges from 100 keV to 20 MeV. This infrastructure allows for testing under ionizing radiation for component qualification and nanoscale mechanical wear measurements using radiotracer implantation. The Lab has a mobile laboratory for on-site non-destructive analysis (X-ray Fluoresecence, Raman, Fourier Transform Infrared FT-IR, hyperspectral imaging, etc.).



Academic
Prof. D. Strivay

Contact
+32 4 366 36 95
dstrivay@uliege.be

RESEARCH UNIT FOR A LIFE-COURSE PERSPECTIVE ON HEALTH AND EDUCATION (RUCHE)

The Department of Motor Sciences offers expertise that could benefit the defense sector, particularly in optimizing the physical training and preparation of military personnel. Starting from an analysis of performance factors and the specific physical qualities to be developed, it is possible to identify the most appropriate tests and to reflect on training methodologies to be implemented based on each soldier's characteristics and the objectives to be achieved.

Professor Boris Jidovtseff contributes his expertise in training methodology and planning. Catherine Theunissen, educational coordinator, has developed specialized knowledge in the creation of training logbooks, which can be used not only during physical training but also as part of the initial education of military personnel.

Academic
Prof. B. Jidovtseff

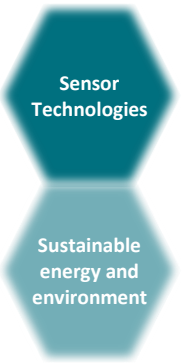
Contact
+32 4 366 38 94
b.jidovtseff@uliege.be

OCEANOLOGY LABORATORY

The Lab conducts multidisciplinary research on ocean resource exploitation and marine environment protection, with strong expertise in detecting chemical contaminants in water, sediments, and biota. It supports Defense needs by monitoring pollution from military activities, detecting toxic elements from munitions and explosives such as:

- Toxic elements in projectiles and casings: Lead (Pb), Antimony (Sb), Copper (Cu), Zinc (Zn), Barium (Ba), Nickel (Ni), Iron (Fe),
- Explosive-related materials: Nitrogen (N), Aluminum (Al), Magnesium (Mg),
- Detonators and primers components: Mercury (Hg), Lead (Pb), Barium (Ba), Antimony (Sb), Silver (Ag).

These capabilities support projects aiming to assess the environmental footprint of munitions storage, battlefield residues, and sunken ordnance (e.g., munitions dumped in the North Sea). The Lab's expertise could contribute to risk assessment studies, remediation efforts, and long-term monitoring programs linked to Defense activities.



Notable equipment and facilities:

- ICP-MS Agilent 7900 (Inductively Coupled Plasma Mass Spectrometer),
- Various mercury analyzers for high-precision detection of Hg in environmental matrices.

www.oceanobio.uliege.be

Academics
Prof. K. Das
Prof. S. Gobert

Contact
+32 4 366 33 21
krishna.das@uliege.be

LABORATORY OF STUDIES ON NEW FORMS OF WORK, INNOVATION AND CHANGE (LENTIC)

LENTIC is a research unit within HEC Liège—Management School, focusing on strategic human resource management, change and innovation management, leadership, and organizational behavior. LENTIC adopts a multidisciplinary perspective, combining fields such as sociology, human resource management, management sciences, organizational behavior, and psychology. Its primary interest lies in the human and organizational aspects of change processes and new forms of work.

LENTIC's main research areas include: the evolution and role of the HR function, the link between human resource management and organizational strategy, new forms of work, social dialogue, change and innovation management, career transitions, leadership, team management, and the management of well-being and behavior at work.

LENTIC has solid experience in collaborations with both private organizations and public institutions; it also coordinates national and international research projects on these topics.

www.lentic.be

Academic
Prof. M. Parmentier

Contact
+32 4 360 30 70
michael.parmentier@uliege.be

LIÈGE université
RISE

Université de Liège

Recherche, Innovation,
Support et Entreprises

Avenue Pré-Aily, 4
B-4031 Liège
Belgique

www.uliege.be
www.recherche.uliege.be

ULiège - RISE
ULiegeRechercheInnovation
RiseULiege
Uliegeinthelab

Contact
Olivier Gillieaux
+32(0) 4 349 85 13
O.Gillieaux@uliege.be

RISE
rise@uliege.be

www.enmieux.be

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UNION EUROPÉENNE
Wallonie
LE FONDS SOCIAL EUROPÉEN ET LA WALLONIE
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