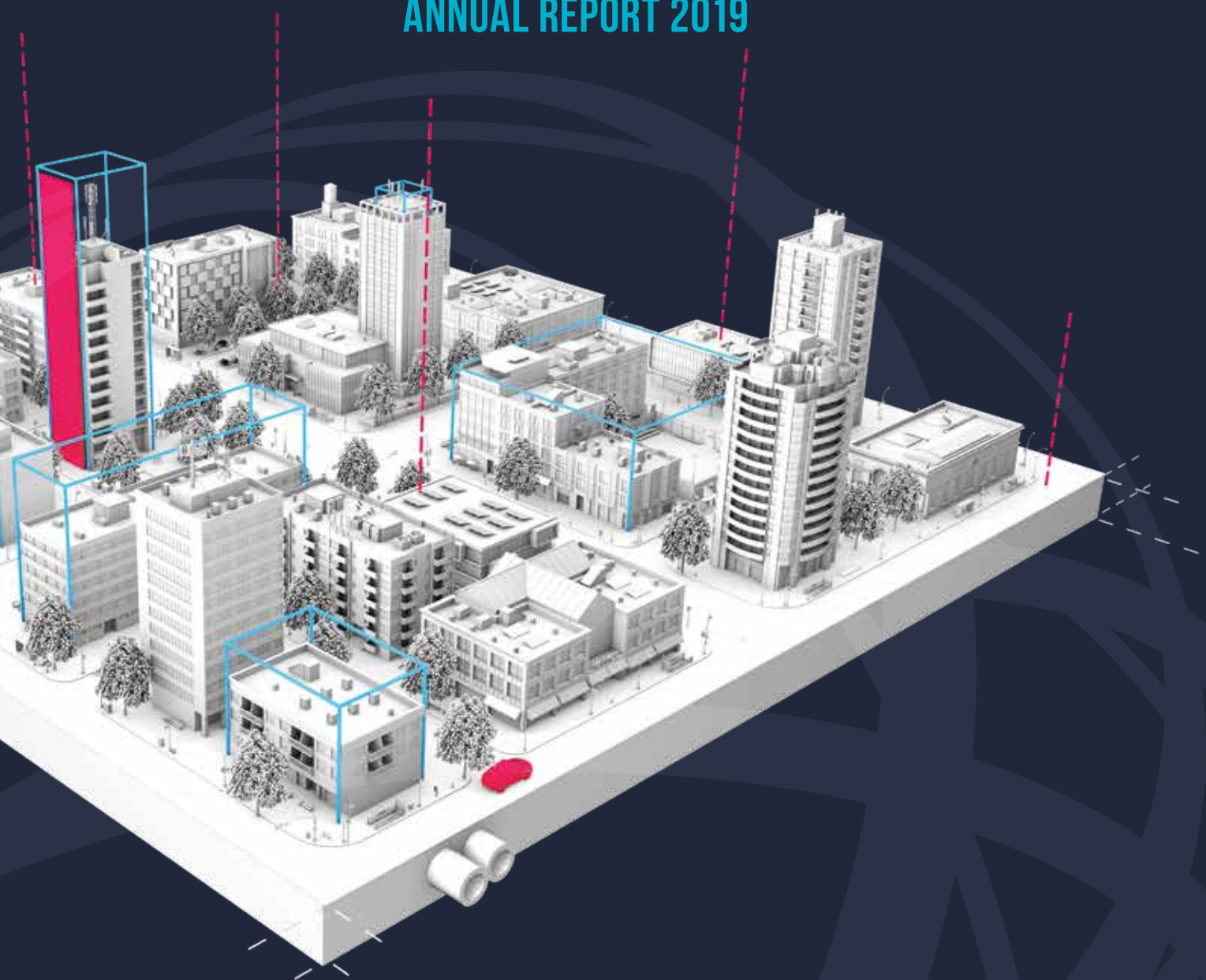
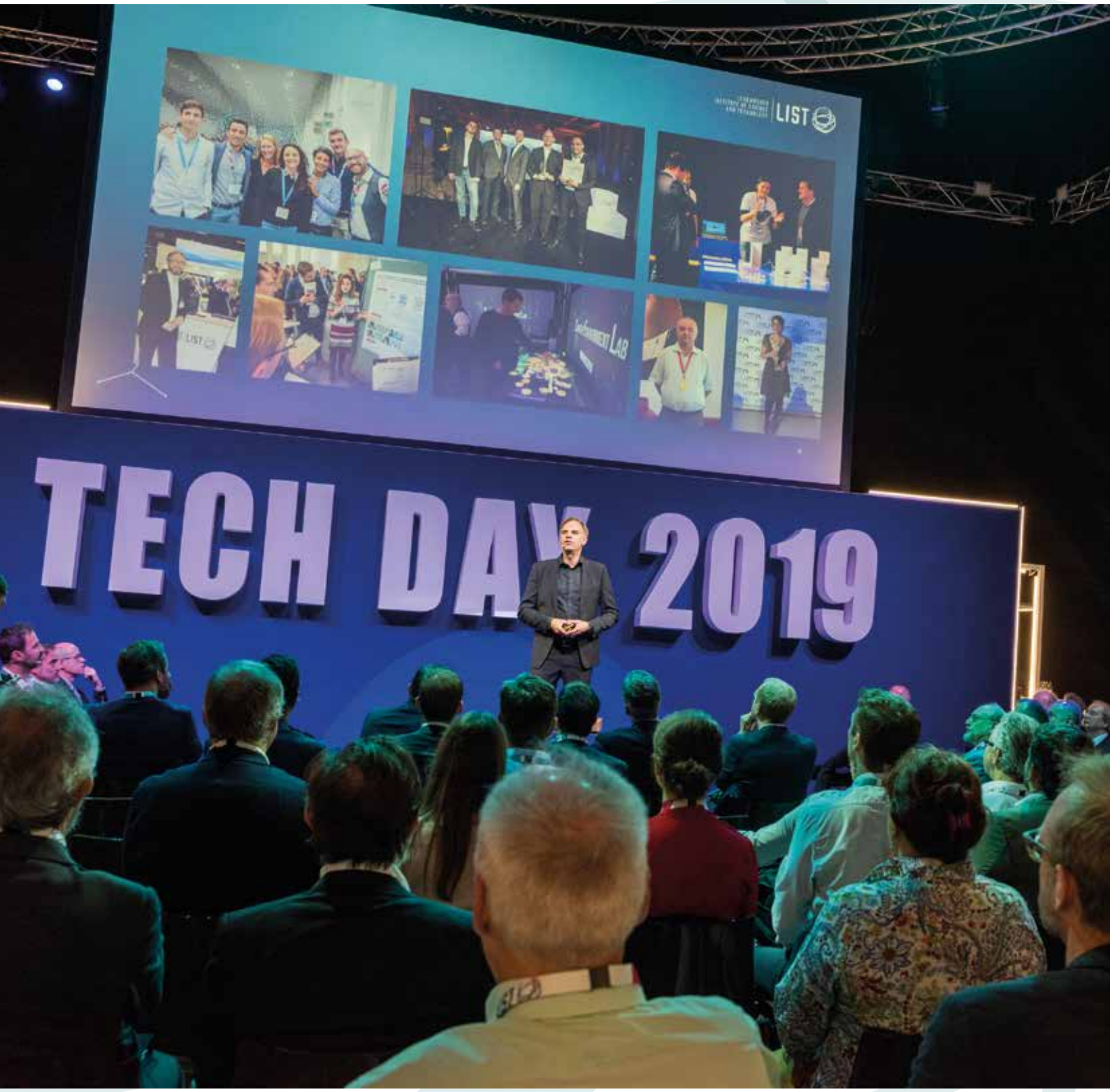
IMPACT: THE DRIVER OF OUR EXCELLENCE

ANNUAL REPORT 2019



LUXEMBOURG
INSTITUTE OF SCIENCE
AND TECHNOLOGY

LIST


LIST
TECH DAY 2019

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A FEW WORDS FROM THE CHAIR OF THE BOARD OF DIRECTORS AND THE CEO

IMPACT: THE DRIVER OF OUR EXCELLENCE

Dear Readers,

At the time of the COVID-19 crisis, we need to rethink our society and our economy. This crisis is weakening our economic systems, underlining the importance of a strong, strategic and local industry that helps to build a solid economy. It validates our main mission: to build the Luxembourg of tomorrow, a resilient, sustainable and digital nation, with you. Operating in the fields of information technology, materials and the environment, LIST has all the skills required to build a society that can take on the social, economic and environmental challenges that it faces. Because of the COVID-19 crisis, we need to reinvent ourselves, and LIST has already started pursuing some ambitious avenues of research. These include the "digital twin", a virtual double of the country that could help politicians and public authorities with their decision-making, while also involving citizens in the sharing of their data.

In 2019, LIST remained a major player in creating links between research and business. For the third consecutive year, LIST continued its extensive collaboration with the manufacturer Goodyear in the field of mobility and pneumatic materials of the future. In addition, 2019 saw the start of new industrial collaborations: with Arcelormittal in the field of energy efficiency, with Ceratizit to speed up its transformation to Industry 4.0, and with Anisoprint in the improvement of 3D printing technologies.

From an institutional point of view, LIST was chosen by the European Space Agency (ESA) to develop new anti-microbial and non-toxic surface treatments for the interior of space shuttles, research which is especially relevant given the current health crisis.

Scientific excellence remains the cornerstone of LIST's ambitions, as attested by 100 national competitive projects, 26 international competitive projects and 63 collaborative projects under way in 2019, as well as 230 scientific publications produced in the 1st quartile in their category, and 9 successfully-defended doctoral theses.

In 2019, LIST continued to invest in its infrastructure: the Green Tech Innovation Centre opened in June. It brings together infrastructures in terms of green chemistry, molecular biology, biotechnology and bioprocess engineering, as well as biological production platforms that make it possible to meet the needs of manufacturers in terms of "green tech". The Data Analytics Platform, which covers the entire range of data analytics activities, continued its development with the start of deployment of the "Cognitive Analytics Pillar" in September 2019 and the inauguration in December of the Visualisation Wall, a unique infrastructure in the Greater Region. Finally, the Materials department launched a project to extend the 1,000 m² Hautcharage site to accommodate new pilot lines: manufacturing lines to test new production methods and processes. Such assets represent a real advantage for our researchers and partners.

We are committed to strengthening the culture of innovation in all departments and disciplines at LIST. This is why we launched a new instrument in 2019, called InitiaLIST, which has made an excellent start with seven ambitious projects to its credit. Thus, LIST employees can propose three types of research project: projects with high risk during the start-up phase, projects for researching advanced or incremental technologies, and tangible and direct opportunities for setting up companies. In this way, we hope to give our researchers the confidence that they need to express their ideas, however bold they may be, and to enable them to acquire new skills through complex technological challenges.

Finally, the second edition of LIST Tech Day, held on Thursday 20 June at the Maison des Arts et des Etudiants in Belval, demonstrated once again that LIST fully meets its aims to stimulate innovation in Luxembourg and to make it an attractive place for international companies and researchers. It enabled 400 participants, decision-makers, researchers and company representatives to discover the potential of a partnership with a research and technology organisation (RTO).

In this Annual Report, you will find a whole series of success stories of which LIST is proud, including innovative research projects, unique infrastructures, fruitful partnerships, and dedicated support services for researchers. These excellent results would not have been possible without the unfailing investment of each of our employees: they form the core of our business and are architects of the sustainable, digital and resilient society, economy and industry that we want to build together with our partners.

Jacques Lanners
Chair of the Board of Directors

Dr Thomas Kallstenius
CEO

MISSION, VISION, VALUES

MISSION:

PUSHING THE FRONTIERS IN RESEARCH FOR HIGH-IMPACT INNOVATION

LIST brings together diverse and complementary skills in the fields of information and communication technologies, environmental technologies and advanced materials. This unique grouping makes it possible to create synergies that are essential for building a reinvented economy and society. In this way, LIST enables the adoption of a holistic approach to complex problems such as rejuvenating industry, modernising mobility, digitalising the economy, the sustainable management of energy and natural resources, and space technologies. Our aim: to be a catalyst for high-impact innovation.

VISION:

BE A REFERENCE IN RESEARCH AND INNOVATION FOR A DIGITALIZED, RESILIENT AND SUSTAINABLE SOCIETY

LIST aims to become the benchmark for research and innovation in the fields of information technology, the environment and materials. As a trusted partner for Luxembourg businesses, universities and public institutions, we aim to become an accelerator of international change. This starts with projects that are carried out locally, but which could potentially have a European-wide or even global impact. Our motto: think globally, act locally. We want to position Luxembourg as a model for Europe and the world. The size of the country enables us to make quick progress and generate high-impact innovations in good time for our partners and our country. By doing this, we want to pave the way for a new generation of RTOs (Research and Technology Organisations) with local impact and global standing.

OUR VALUES

1. FOCUS ON PEOPLE

In 2019, we created a more open, agile and positive culture at LIST, based on ownership and responsibility. We strive to nurture our existing talents at LIST and to attract new ones, with a view to becoming an RTO of European or even global standing in our research fields, and thus to give Luxembourg international prestige. To do this, we rely on a culture of transparency, high safety standards, recognition of our employees, and respect for people and decisions, and we promote a spirit of entrepreneurship within our organisation.

2. EXCELLENCE IN ALL WE DO

At LIST, we are not just at the cutting edge of the major scientific and technological subjects of our time. We go beyond the cutting edge, setting up ambitious projects, exploring complex and high-risk fields, and meeting global challenges. We are a bold partner, ready to take the risks that our industrial partners cannot take alone in their innovation processes. Our aim is to provide innovations that are useful and beneficial for society by excelling in everything that we do. For us to achieve this, everyone has a role to play, from our researchers to our support teams.

OUR VALUES

3. PASSION FOR IMPACT

LIST develops innovative and competitive solutions to meet the key needs of Luxembourgian and European companies and of society as a whole. We transfer our applied research to support public and private organisations, whether large groups, SMEs or public administrations, in order to strengthen their innovation projects. We therefore help to make the country more attractive and competitive. We are working on projects that benefit society and quality of life in general. In a nutshell, LIST is building the Luxembourg of tomorrow: a smart economy based on industrial and service transformation and committed to sustainable and responsible development.

4. COMMITMENT TO OUR STAKEHOLDERS

LIST works on projects with substantial added value for the market, on short and long-term research and innovation requests. We strive to understand the needs of our partners and to offer them the flexibility and agility that they need to optimise their time to market. We believe that strategic research and applied research are mutually reinforcing, and therefore we work with our partners in a “push and pull” dynamic: either we propose an innovation that will modify our industrial partner’s roadmap, or we adapt to their innovation needs. We work not only with private sector partners, but also with those in the public sector such as the Luxembourg Ministries of Research, Agriculture, the Environment, Defence and the Economy, as well as our Luxembourg research partners: the National Research Fund, the University of Luxembourg, the Luxembourg Institute of Health (LIH) and the Luxembourg Institute of Socio-Economic Research (LISER).

5. RESPONSIBLE AND INDEPENDENT RESEARCH

LIST participates in responsible, inclusive and sustainable research and innovation. This involves anticipating and assessing the potential implications and societal expectations regarding research and innovation. To this end, we involve the stakeholders of society (researchers, citizens, policymakers, companies, etc.) and work together throughout the research and innovation process, in order to better align both the process and its results with the values, ethical principles, needs and expectations of society.

6. SUSTAINABLE BY DESIGN

We recognise the impact our activities have on the environment and are committed to setting an example. This is why we launched a "Sustainability" Task Force in 2019 to improve LIST's ecological footprint. We plan to analyse the environmental impact of our own operations (buildings, purchases, travel, canteen, daily commutes, etc.), to define actions to be implemented, to monitor their performance and to review them each year in a process of continuous improvement. This is a voluntary approach, which we believe is essential for us to play our part and show the way towards a sustainable society.

OUR RESEARCH

1. USING BUSINESS ANALYTICS TO OPTIMISE BUSINESS DECISION-MAKING

« To help our partner Ceratizit with its digital transformation, we are mobilising the latest technologies for data analytics and Big Data architecture. Our aim: to explore various avenues with a view to improving product quality, increasing productivity and pushing technical boundaries. »

Uzma Iffat,
Business Analytics researcher

Today, every company in every sector needs to improve its decision-making processes. The advent of digital technologies and of cheaper high-density and high-speed storage devices, and the power of distributed computing, make it possible to capture, communicate, combine, store and process new data sources as never before. For organisations to speed up and improve their decision-making, they need Business Analytics (BA). Our team of data analytics and artificial intelligence experts covers various fields of application for BA in Luxembourg, including technologies related to regulatory compliance. Our research applies to financial services, to the acceleration of Industry 4.0 through digital transformation, to regulatory compliance and related technologies, and to improving the quality of organisational governance and processes.

Success story # 1

TOWARDS A MODERN AND POWERFUL PLATFORM

On 4 September 2019, LIST officially launched the deployment of the "Cognitive Analytics Pillar" as part of its Data Analytics Platform project. This €6.4 million project, funded by the European ERDF programme to the tune of €2.5 million, started in September 2016 and is scheduled to continue until December 2020. The selection of the solution proposed by Fujitsu and the start of its installation mark a major step forward for this ambitious project. In fact, it involves providing LIST's community of researchers and its partners with advanced technologies, services and solutions in the fields of data/business analytics, artificial intelligence and Big Data. Acquiring this infrastructure, combined with High Performance Computing (HPC) and the Visualisation Wall at the Belvaux site, gives LIST a level of state-of-the-art equipment worthy of an RTO. The architecture provides a two-tier hybrid infrastructure. Firstly, this solution combines the richness of IBM's Public Cloud service catalogue with the performance and increased security of a private cloud hosted by LIST. Secondly, this private cloud part is a solution in itself that combines the best of the proprietary model offered by IBM in the field of data science ("Watson") with an open-source model ("Hortonworks") offering a free and open structure, which is favoured by the research community and is designed to facilitate the integration of exogenous modules in an exploratory mode.

Success story # 2

LIST SUPPORTS YOU WITH YOUR DIGITAL TRANSFORMATION

Industry 4.0, commonly referred to as the "Connected Factory", represents the Fourth Industrial Revolution, following those of mechanisation, mass production and automation. Thanks to the arrival of digitisation, industry is becoming an interconnected global system in which humans, machinery, systems and products are in constant communication. Interconnection enables factories to become more competitive thanks to a higher level of performance and security. As a result, they produce both personalised products and related services.

Thanks to its Business Analytics expertise, LIST supported its partners Goodyear, Arcelormittal, Ceratizit and Paul Wurth with their digital transformations in 2019. For example, Ceratizit and LIST initiated a project on the design of a new architecture to facilitate the collection, storage, use and recovery of Big Data generated during the manufacturing process, which, given its volume, requires a specific type of structure. Big Data gathered in this way must be used to automate, optimise and enhance the reliability of manufacturing processes. To achieve this, different statistical analytics and Machine Learning approaches are used within the framework of the partnership. Moving towards Industry 4.0 represents the promise of real flexibility in manufacturing, mass customisation, increased speed, better quality and improved productivity.

Success story # 3

LIST HELPS YOU TO MAKE YOUR ORGANISATIONAL PROCESSES COMPLIANT

On 25 May 2018, the new General Data Protection Regulation (GDPR) came into effect in Europe: an important date for private companies, public administrations and associations that manage personal data. LIST has designed a GDPR process model that describes the organisational processes necessary to meet the requirements of the Regulation. It has also developed methodological and technological tools based on the collection and analysis of audit data to assess the capability of organisations with regard to GDPR processes. This process audit model has been successfully tested in two Luxembourg organisations: POST and the CNS.

2. MAKING OPTIMAL USE OF COGNITIVE ENVIRONMENTS

Cognitive environments, also known as “smart spaces”, can improve user performance and experience for collective tasks such as design, decision-making and problem-solving. These are connected physical spaces that provide users with digital tools enabling them to perform their tasks while detecting and measuring their activity, in order to provide them with feedback and predictions in a natural and multimodal way. These spaces are equipped with technologies that combine artificial intelligence, augmented reality, virtual reality, data analytics, data visualisation and the Internet of Things.

At LIST, we develop applications for the collaborative assessment of skills, *in situ* learning and assessment, and decision-making assistance for smart towns, town planning, digital twinning and Industry 4.0.

« Current information systems are becoming more and more immersive and are increasingly distributed between the items that we use on a daily basis and the physical spaces in which we live and work. They consist of a multitude of interconnected smart devices that exchange data and information, interacting with us in many ways and supporting us with an increasing number of features based on artificial intelligence. At LIST, we intend to use these new cognitive experiences to provide the best possible user experience. »

Luc Vandenabeele,
Multimodal Analysis and Natural Multi-User Interaction researcher

Success story # 1

BETTER UNDERSTANDING OF HUMAN-MACHINE INTERACTIONS

At the dawn of connected and autonomous vehicles (CAVs), a certain number of questions are arising in relation to complex human-machine interactions. Whether as an occupant of a car or as a pedestrian, each individual will face new situations for which behavioural reactions are not yet well-known. The European H2020 PAsCAL project, coordinated by LIST, aims to assess the acceptance level of European drivers, pedestrians and cyclists regarding the CAVs of the future. Individual reactions will be measured using eye-tracking (studying eye movement in order to know what a person is looking at), biosensors and behavioural analysis, and they will be tested in a cognitive environment: an immersive arena with 360° screens, sensors, cameras, depth cameras, microphones, etc., and cooperative devices such as touch tables.

Success story # 2

A NEW SUCCY STORY FOR LIST

A new partnership with Belgian company Succy, a spin-off from a LIST project called Kniwwelino, was officially signed in 2019. Kniwwelino is a creative tool for learning programming and electronics, developed by LIST as part of a Luxembourg National Research Fund (FNR) flagship project between 2017 and 2019. The aim is to support the learning of digital skills and to overcome the complexity of technologies for students and teachers. In 2019, LIST's Kniwwelino team also developed a "Classroom Kit", which is now aimed at all students in Luxembourg, and it launched the Kniwwelino community to ensure future development in Open Source.

Success story # 3

EXPERIENCING CULTURAL HERITAGE IN A GLOBAL, YET PERSONALISED WAY

Grasping cultural heritage from a global perspective, taking different existing viewpoints on the same subject into account, rather than from a single perspective (your region, your city or your country) is a real challenge when it comes to helping citizens better understand their own history. The cross-checking of information in time and space, whether between nations, eras, or collections of one or more cultural and heritage institutions (museums, historic buildings, etc.) is therefore very important in order to be able to tackle and analyse points of view.

Coordinated by LIST and concluded in 2019, the European CROSSCULT project produced an open technological platform that enables the creation of personalised interactive experiences relating to culture and cultural heritage. In addition, the Living Lab developed as part of the project was kept in operation, so that all the results, innovations and technologies implemented throughout the term of the project could remain in place after its conclusion.

3. RELIABLE AND QUALITATIVE SERVICE SYSTEMS

> « In an increasingly interconnected world, in which services provided by one entity are themselves reliant on services provided by others, the concept of service quality should be regarded as a systemic approach applied to a global ecological system, not merely at the level of a single isolated service provider. »
>
> Djamel Khadraoui,
> Head of the Trusted Service Systems Unit

Service reliability, data security, compliance of services with national and international regulations and standards, etc.: LIST meets the challenge of service quality in business service systems. To this end, we rely both on the properties of the computing infrastructure and on aspects related to the quality of applications deployed on this infrastructure, as well as the organisational and human dimensions necessary for the provision of services. Our research and innovation activities focus on three markets: mobility and logistics, security and essential infrastructure, and innovative, data-intensive computing services.

Success story # 1

NO TIME TO WASTE WITH POLYGONE!

LIST has developed a digital system through which digitisation processes, products and services can be improved, particularly through data science, modelling and digital optimisation. This has been applied to the waste industry, but could also apply to any company. In late 2019, LIST and its partner Polygone received the Innovation Award in the "Innovative Services" category from the Chamber of Skilled Trades and Crafts, for the SWAM and Octogone projects: a smart waste collection platform with data generated by sensor technology directly incorporated in waste containers, which, in particular, indicates their fill level; and a computer tool that makes it possible to optimise the planning of waste sorting centres.

Success story # 2

LIST-GOODYEAR: AN AWARD-WINNING PARTNERSHIP

On 10 September 2019, the Multi-Performance Optimisation team of the collaborative research project between Goodyear and LIST on data science for tyres received the “Best Article” award from the Tire Society in the United States. The winning article, “Application of Machine Learning Techniques to Tire Related Datasets”, was submitted and presented at the 2018 Annual Conference of the Tire Society in Akron, Ohio, the most important conference in the field of tyre science and technology. This is a major new success for a partnership that serves as a benchmark for LIST’s industrial collaborations.

Success story # 3

MOBILITY OF THE FUTURE AT THE TEST BED

2019 saw the launch of two projects concerning mobility of the future: MODALES and 5G-MOBIX. MODALES aims to better understand the relationship between user behaviour and vehicle emissions from three main sources: engines, brake wear and tyre wear. Through international collaboration with 14 partners, this European project aims to improve practices related to low emissions, and to eliminate behaviour that leads to high emissions. Meanwhile, the 5G-MOBIX project aims to assess the relationship between 5G and road mobility, particularly by studying the impact of road topology on network connectivity, with a view to making recommendations on deployment strategies and the positioning of 5G antennas.

4. SMARTER BUILDINGS WITH BUILDING INFORMATION MODELLING

> « BIM is at the heart of the environmental transition for buildings. Now that it is beginning to spread in the construction value chain, its contribution to the design and delivery of energy-efficient buildings has become obvious. »
>
> Sylvain Kubicki,
> Building Information Modelling (BIM) researcher

LIST is working on the digital optimisation of the construction sector, particularly through BIM (Building Information Modelling). This is a highly collaborative process that enables several stakeholders and construction professionals (architecture, engineering, etc.) to work together in the planning, design and construction of a building in a single 3D model. It may also extend to the operation and management of buildings by using data to which owners have access. This data enables owners and stakeholders to make decisions based on relevant information derived from the model, even after construction of the building.

At LIST, this includes participative urban planning, collaborative 4D BIM planning during the pre-construction phase, smart construction management, energy performance simulation for buildings, and monitoring the thermal comfort of occupants. This test is fully in keeping with LIST's research concerning digital twinning.

Success story # 1

LEAN AND CONNECTED CONSTRUCTION SITES THANKS TO AN APPLICATION DEVELOPED BY LIST

Gone are the days of wastage on construction sites. LIST's "AndON" platform makes it possible to connect planning with data on a construction site, and contributes directly to "lean construction", a work method that involves eliminating all types of waste on construction sites, from storage of materials to acceptance of the work.

The main challenge on construction sites is obtaining real-time information and incorporating it into planning. With our AndON application, the planning manager has a dashboard with "visual checks": simple indicators of the status of tasks and their prerequisites (plans, materials, resources, etc.). Collection of information is structured and customisable, and relies on the Internet of Things by means of QR codes or RFID tags, for example, which can be stuck onto or built into materials. This allows users on site to view, manage and edit data in real time, which helps to highlight necessary actions or risks of bottlenecks and so support integrated, guided and collaborative decision-making.

In 2019, LIST produced a demonstrator and is now working on a prototype. With CLE (Compagnie Luxembourgeoise d'Entreprises), we have also set up a consolidation centre: a platform that makes it possible to outsource construction site logistics with the aim of supplying direct to work sites. The aim is to reduce environmental impact and congestion, and improve business productivity.

Success story # 2

HEALTHIER AND MORE COMFORTABLE SPACES THANKS TO OUR POESY PROTOTYPE

The purpose of the POESY ("Post-Occupancy Evaluation SYstem") prototype is to collect perceived comfort data and other data from sensors placed within the building, in order to detect sources of discomfort and then act in the interests of its occupants. The tool makes it possible to visualise all this data using a BIM (Building Information Model). The concept of occupant comfort within built spaces is now a priority for the construction sector. In addition to conventional standards dedicated to building sustainability, new standards are already being introduced with a view to promoting the design of healthier and more comfortable spaces. Through our developments, we aim to equip the construction sector accordingly.

Success story # 3

AN INDICATOR TO ASSESS A BUILDING'S INTELLIGENCE

In consultation with the Luxembourg Ministry of Energy, LIST is managing the trial of the "Smart Readiness Indicator", which was developed within the framework of the revision of the European EPBD (Energy Performance of Buildings Directive) in 2018. It is intended to assess the "smart" attributes of a building: 1) capacity to adapt to the needs of occupants, 2) ease of maintenance and energy consumption, and 3) the options providing flexibility of electrical demand on the grid.

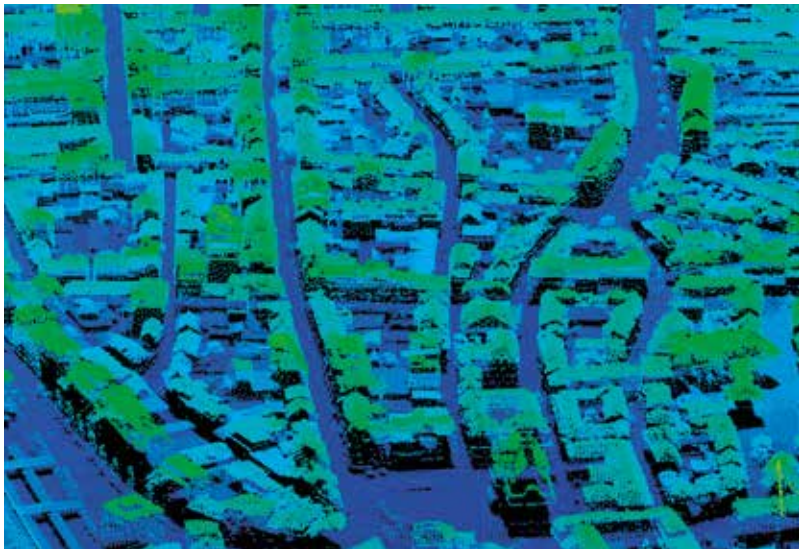
5. UNLOCKING THE POTENTIAL OF DATA

« LIST is conducting research in the field of environmental informatics: our researchers design information technology-based tools that contribute to a more sustainable future and enable us to meet current environmental challenges. Hence, our fields of application include, for example, precision agriculture, environmental crisis management, the circular economy, the energy and water sectors, and biodiversity. »

Benoit Otjacques,
Head of the Environmental Informatics Unit

The rate of data production has increased dramatically in recent years. This major trend raises difficult questions about how to effectively use these large and complex datasets to solve concrete problems in the scientific and industrial field. LIST addresses this issue with a combination of complementary approaches: data analytics, artificial intelligence, data visualisation, geoinformatics and augmented reality.

By doing this, we are studying how best to visualise the many interactions between the components of a complex system, such as a living organism or an industrial product. We are also looking at the use of advanced analytical techniques to detect events on social media that could be linked to environmental disasters (such as floods). Finally, we are developing innovative augmented reality-based technologies to help professionals to address risk and safety issues.



Success story # 1

ASSISTING PUBLIC AUTHORITIES WITH THEIR DECISION-MAKING

Cities have large amounts of data. Thanks to the “Smart City and Region Energy” platform developed by LIST, they can answer questions such as: What are the opportunities for renewable energy in our city? How can we optimise the use of renewable energy? Where can we install solar panels? Which roofs and façades would work? How do we renovate buildings to make them more energy-efficient? By how much could we reduce CO_2 emissions? This platform already covers several cities and can answer these questions by making optimal use of data access interoperability standards, satellite images, 2D (and soon 3D) maps, state-of-the-art geospatial analysis in high resolution, forecasting/analysis/visualisation tools, and meteorological information, by combining all the relevant elements to discover the renewable energy potential of cities.

Success story # 2

AUGMENTED REALITY FOR PROFESSIONAL TRAINING

Whether caused by terrorism or accidents, radiological incidents pose a significant threat to the environment, the public and first responders. Training solutions with augmented reality can provide a safer, faster, easier and more easily reproducible training method at a very low cost. According to Roderick McCall, who is in charge of this project at LIST: "We have been able to develop innovative augmented reality solutions for first responders, which enable training participants and operators to view risks such as radiation."

Success story # 3

ANALYSING SOCIAL MEDIA TO DETECT FLOODS

Forecasts from hydraulic models are essential for flood management around the world. However, it is still difficult to provide reliable forecasts, particularly in areas with low observation density or urban areas. The increased availability of flood spread maps (for example, radar images from the Sentinel-1 mission) opens up the prospect of improving the quality of forecasts. The PUBLIMAPE project is designed to combine satellite flood maps with information drawn from social media in order to build a better picture of areas affected by floods and improve flood forecasting models. In collaboration with the University of Geneva, LIST analyses the semantics and quality of data provided on social media, focusing on the multimodal content of social platforms, particularly tweets containing both text and images. It is developing a chain of tools to build operational knowledge and use it for monitoring major environmental events and crises. The project involves testing this innovative approach on a real-scale pilot use case involving a major flood: the region of the Colorado River between Columbus and the Gulf of Mexico, which was damaged by Hurricane Harvey between mid-August and mid-September 2017.

6. MONITORING THE ENVIRONMENT IN A CHANGING WORLD

« With the consequences of climate change receiving increasing attention, the race to develop technologies to forecast, monitor or mitigate the impact of natural disasters is under way. Our HASARD® tool offers scientists around the globe the ability to generate flood maps, from satellite images, in virtually any region of the world. Consisting of an algorithm and dedicated software, the HASARD® tool, which was recently trademarked by LIST, is of real benefit to flood management authorities. »

Marco Chini,
Environmental Sensing and Modelling researcher

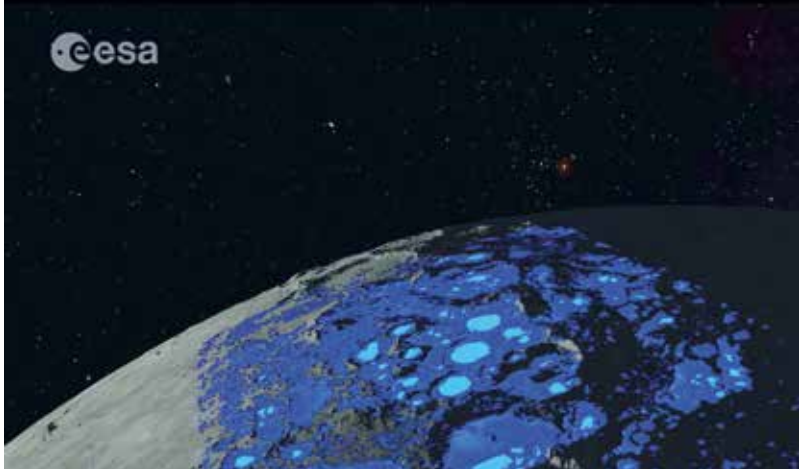
At LIST, we study environmental impacts, particularly climate change, with a view to developing tools for environmental monitoring, forecasting and prediction in a changing world. A multidisciplinary team of around 50 scientists, engineers, post-doctoral and PhD students assists the public and private sectors in the following areas:

- **Water resource management,**
- **Crop protection and precision agriculture,**
- **Natural disaster management, and**
- **Mitigation of climate change and adaptation to its effects.**

Success story # 1

WATER AND PLANT LIFE IN A CHANGING ENVIRONMENT

Environmental changes and changing land use are core concerns for the scientific community, which is trying to make reasonable predictions regarding their consequences for ecosystems and water resources. Faced with pressures such as climate change and deforestation, plants are subjected to many physical constraints that require them to change the way they function, particularly in terms of their interaction with water resources. Supported by the Luxembourg National Research Fund (FNR) through the ATTRACT programme, the WAVE project aims to provide a better understanding of ecohydrology and a model of the ways in which water and plants interact within a continuously changing environment. WAVE is also developing a new collaborative and open approach for environmental science in the broad sense: a community model and a framework for assessing hypotheses. With this approach, the WAVE project will make it possible to obtain a better understanding and a quantitative representation of the physical processes and biological compromises associated with plant-environment interaction: an initiative that will enable fully transparent scientific research, in line with the philosophy of Open Science.



Success story # 2

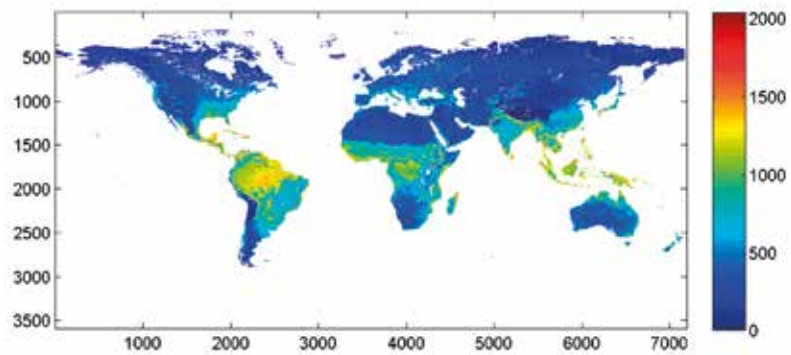
OBTAINING A BETTER UNDERSTANDING OF THE ORIGINS AND FUTURE OF LUNAR WATER

In 2019, an interdisciplinary team of experts in isotope hydrology and mass spectrometry from LIST joined the scientific team of the European Space Agency's PROSPECT mission. With its launch and Moon landing scheduled for 2025, the PROSPECT probe is a joint ESA-ROSCOMOS project to explore the Moon's water resources. LIST's contribution to this pioneering mission is to study the processes of splitting stable hydrogen and oxygen isotopes during the sublimation of water ice in a lunar environment. This new knowledge should ultimately enable us to obtain a better understanding of the origins and future of lunar water.

Success story # 3

A WORLD-RENOWNED, STATE-OF-THE-ART EVAPOTRANSPIRATION MODEL

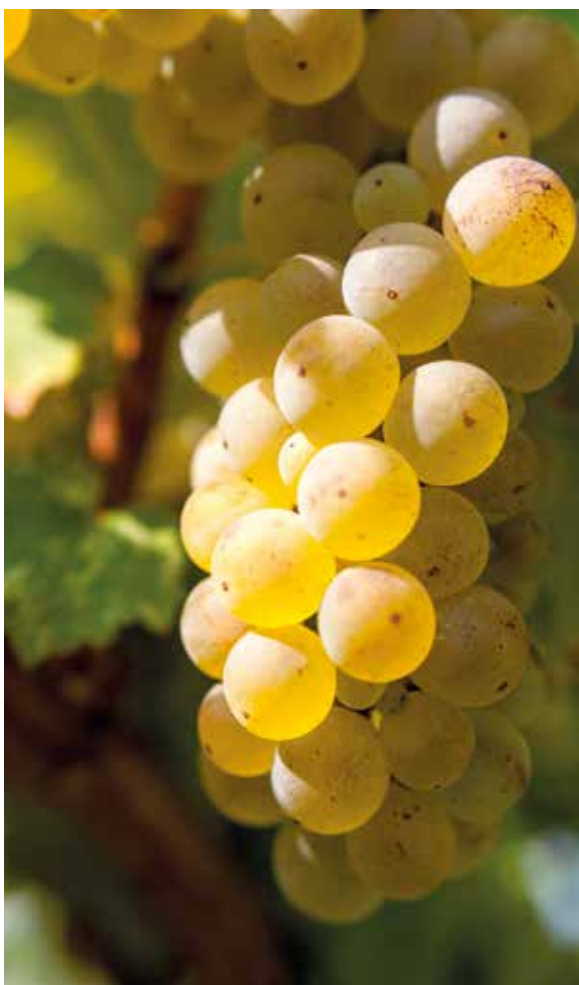
Evapotranspiration (ET) is the amount of water transferred to the atmosphere, by evaporation at soil level and at the level of precipitation interception, and by the transpiration of plants. Evapotranspiration varies greatly in space and time and plays a fundamental role in hydrology and earth-atmosphere interactions. In recent decades, the use of satellite data to map evapotranspiration on a regional scale has increased considerably. LIST has gained global recognition for its state-of-the-art evapotranspiration model based on remote thermal sensing. This model has received a great deal of attention and was included in the development of evapotranspiration products of ESA (European Space Agency) and NASA missions. It also inspired the collaboration of biometeorology and ecology research groups from the University of California, Berkeley, and Stanford University.



Success story # 4

ASSESSING AND LIMITING THE IMPACT OF CLIMATE CHANGE ON VITICULTURE

In light of the impact of climate change on plants, European viticulture could face critical pressures such as rising temperatures and the emergence of new diseases or pests. In order to assess and thereby limit the impact this has on vines, European countries must not only develop their knowledge and expertise, but must also formulate a common approach. Within the framework of the European Clim4Vitis project, LIST and its partners aim to share their current knowledge and complementary skills in order to develop a common database and a standardised family of vine models for different areas of European viticulture. This will make it possible to simulate the impact of climate change on the phenology of vines, as well as on the biology and epidemiology of grape diseases and pests.



7. TOWARDS A CIRCULAR BIOECONOMY

> Our bioreactors enable the cultivation of a large number of plant cells that produce molecules of interest. These enclosed environments, in which we can control various parameters, have the advantage of not requiring the intensive use of natural resources.

Jean-François Hausman,
Head of the Plant Biotechnologies Research Group

Industrial biotechnology offers a new, sustainable approach to the manufacture of materials, chemicals and energy from renewable resources, enabling what is called the "circular bioeconomy". Bio-based natural resources are essential for our economic system, but they are increasingly overexploited to provide food, materials and energy. Consequently, industrial biotechnology is intrinsically linked to environmental biotechnology, which aims to prevent, stop and reverse the effects of environmental degradation through the appropriate use of biotechnology in symbiosis with other technologies.

At LIST, we are working on the bio-based production of high-value chemicals and enzymes from plant cells and microbes. We are striving to develop biomass from plant waste and other waste streams from agro-food supply chains as a source of bioenergy, biopolymers and chemical components for innovative and commercially interesting applications.

Success story # 1

ORGANIC WASTE CONVERTED INTO GREEN ENERGY AND FERTILISERS

LIST is helping to design a circular local bioeconomy by working on the renewable and sustainable production of energy, biofertilisers and green chemicals. In particular, LIST is working on anaerobic biowaste digestion as a natural microbe-based process, which produces biogas that can be stored and used as energy. Biomethanisation is known to enable the production of green energy, but it also offers efficient recycling of organic waste in the form of natural fertilisers.

However, the current process of anaerobic digestion is subject to substantial constraints in terms of robustness and efficiency. LIST's efforts to better understand and characterise the diversity of anaerobic digestion microbiota have demonstrated that certain microbes, under laboratory conditions, can offer significant resistance to poisoning by volatile fatty acids (acidosis) – which is the most frequent failure of the process. LIST is working on Cloacimonetes, which are bacteria that could improve or restore the performance of anaerobic digestion reactors.

Success story # 2

SUSTAINABLE USE OF PLANT RESOURCES USING BIOTECHNOLOGY

From anti-ageing creams to dietary supplements and biocomposites, plants are an integral part of our daily lives. As a sustainable alternative, these natural resources contribute to the development of renewable products. However, they are also victims of increasing overexploitation. The use of biotechnology has therefore become a key approach for the development of plants as renewable resources, while also preventing degradation of the environment.

LIST is working on several research projects to provide the cosmetic or pharmaceutical industries with concrete and sustainable alternatives. By modulating the genetic parameters of apple cells, and those of the bioreactors in which they develop, LIST researchers have managed to optimise the production of a molecule of interest, called "triterpene". In particular, the latter has anti-ageing properties, which makes it possible to prevent premature ageing of the skin by inhibiting the human enzymes responsible for reducing skin elasticity. Triterpenes also have a strong anti-inflammatory property, which could be of great interest to the nutraceutical industry.

Success story # 3

DEVELOPING SUSTAINABLE CLEANING PRODUCTS WITH PROBIOTICS

Probiotics are living micro-organisms regarded as "good" bacteria that offer health benefits by improving or restoring intestinal flora. As its name suggests, the Luxembourg company Probiotic Group uses probiotics to develop cleaning and maintenance products that are both natural and environmentally friendly. At Tech Day 2019, together with the University of Luxembourg (specifically the Luxembourg Centre for Systems Biomedicine), LIST entered into a collaborative project with Probiotic Group to discover, characterise and produce new strains of probiotics.

8. MEASURING ENVIRONMENTAL IMPACTS AND RISKS TO FACILITATE BETTER DECISION-MAKING

At LIST, we are striving to identify the factors that underlie polluting emissions, as well as the opportunities to reduce the environmental impacts and risks associated with industrial activities, energy management and human consumption patterns. The aim is to transform our current linear economic model into a circular model that develops material resources and energy efficiency, to protect biodiversity and guarantee the well-being of individuals.

Thus, we help public players to define and implement environmental policies, as well as helping Luxembourg companies to fulfil their obligations. To this end, we develop guidelines, methods, measures and/or tools in the following areas:

- Assessment of the environmental and human hazards of chemicals
- Environmental management and regulations
- Assessment of the sustainability and circularity of products, technologies and policies, with a focus on the built environment (buildings, materials, nature-based solutions), mobility (electrical and H_2), natural capital (ecosystem services) and the manufacturing industry
- Operation and planning of energy systems, particularly the transparent incorporation of renewable energies into the electricity grid and the modelling of smart grids.

« We have also joined the House of Entrepreneurship: since June 2019, we have been meeting with business leaders one Tuesday per month to provide them with information on environmental policies and legal requirements. This initiative attests to LIST's major role in creating links between research and business. »

Caroline Fedrigo,
Project Manager in the
Environmental Policies Group

Success story # 1

AN APP FOR CHEMICAL SUBSTANCES OF VERY HIGH CONCERN

With Scan4Chem, consumers can scan a product's bar code to obtain information on substances of very high concern (SVHC) contained in the product. These substances are chemicals that are, for example, carcinogenic, mutagenic, toxic for reproduction or particularly harmful to the environment. The application is available free of charge from the app stores Google Play and App Store. Developed by LIST as part of the European LIFE AskREACH project, in collaboration with the REACH & CLP Helpdesk Luxembourg, the app was launched in 14 European countries, with the ultimate aim of covering most European countries over the next three years.

Success story # 2

DO YOU REALLY THINK YOU ARE A GREEN TRAVELLER?

Are electric cars always environmentally friendly? Mobility based on fossil fuels is inextricably linked to greenhouse gas emissions. However, although they do not have exhaust pipes, electric cars also generate greenhouse gas emissions. Even before they have travelled a single kilometre on the road, electric cars generate pollution right from the earliest stages of manufacturing. The batteries contain rare metals such as neodymium and cobalt, as well as graphite and lithium, particularly from China, the Democratic Republic of Congo, South America and Australia, and their assembly is also energy-intensive. LIST's online "CLIMOBIL" application helps citizens to check the ecological footprint of electric cars in order to reduce our CO_2 emissions.

Success story # 3

NEW PARTNERSHIP AGREEMENT BETWEEN LIST AND ARCELORMITTAL

On 29 October 2019, LIST and ArcelorMittal Luxembourg signed a partnership agreement regarding energy performance improvement. This five-year agreement covers the research and development of innovative projects and services in the areas of improving energy efficiency and the responsible use of resources, the optimisation of multiple energy efficiency measures, heat recovery and the production of electricity from excess heat. The field of research is in keeping with ArcelorMittal's process of transition to a circular economy and the production of circular steel.

This partnership is fully in keeping with ArcelorMittal's CSR (Corporate Social Responsibility) Policy in Luxembourg and, more generally, with the group's stated ambition to significantly reduce its carbon footprint by 2050, in accordance with its commitment to the Paris Agreement.

Success story # 4

ASSESSING THE ECOLOGICAL AND FINANCIAL IMPACT OF NATURE-BASED SOLUTIONS

Nature-based Solutions are "living" solutions inspired by, conveyed by or copied from nature, which are capable of simultaneously meeting environmental, social and economic aims. They can take various forms: restoration and sustainable management of wetlands, conservation of forests, re-naturing or restoration of arid areas, development of "green lungs" in urban areas, restoration of natural coastal systems, green façades on buildings, urban agriculture, etc. As a core partner in the NATURE4CITIES project, LIST managed the implementation of NBenefit$, a decision-making tool for politicians and town planners. NATURE4CITIES is a project from an international and interdisciplinary consortium (9 countries represented, 28 partners), funded by the European Research and Innovation Programme Horizon 2020. It aims to create a web reference platform for Nature-based Solutions, on which technical solutions, methods and decision-making tools for town planning will be offered. The objective is to help to meet the contemporary environmental, social and economic challenges faced by European cities.

9. EXPLORING THE INFINITESMALLY SMALL TO DEVELOP MATERIALS WITH EXTRAORDINARY PROPERTIES

The detection of gas or (bio)molecules, mechanical and vibrational strain, and the recovery, storage and use of energy are just a few examples of extraordinary properties made possible by nanotechnologies. LIST is working on the technological development of materials controlled at the nanometric level, which, combined with an innovative chemistry of these same materials, makes it possible to demonstrate properties that are all the more remarkable as they are incorporated into functional devices.

In addition, the engineering of specific nano-objects paves the way for disruptive medical applications (probes, bone regeneration, anti-bacterial coatings, etc.) and complex high-performance nanocomposites.

« With materials and processes dedicated to digital applications such as "Autonomous IoT", those with low carbon impact, and those specifically designed for space applications and transport, energy materials represent the 4th pillar of the department's activities. With a particular focus on the hydrogen sector, our research is committed to the generation, storage and efficient use of hydrogen to make Luxembourg and LIST the technological epicentre of this sector in the Greater Region. »

Damien Lenoble,
Director of the Materials Research and Technology Department

Success story # 1

MONITOR YOUR HEALTH WITH CHEMICAL NANOSENSORS

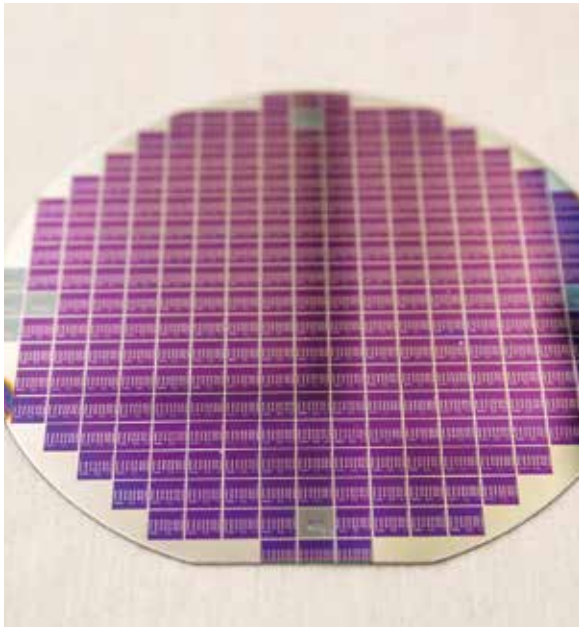
LIST is about to make a major contribution to personalised medicine with biologically sensitive field-effect transistors (BioFET): sensors that enable highly reliable biochemical detection. Making use of a large number of these nanosensors (FinFET) could be a revolutionary innovation for personalised medicine, such as in the fight against cancer or autoimmune diseases.

In 2019, we completed the Luxembourg National Research Fund (FNR) Attract NANO-PH project, delivering a platform capable of controlling chemistry at the nanolitre level. Electrochemical control of pH in cavities as thin as 100 µm, combined with the integration of FinFETs allowing the same pH to be measured with high sensitivity and reliability, are the essential elements of nanobiochemistry embedded on electronic chips. This technological demonstration is unique in the world and enabled us to acquire the H2020-FET-OPEN (ELECTROMED) project, one of the most competitive calls for research projects in Europe. Building on the achievements of the NANO-PH project, ELECTROMED will enable the screening of human or synthetic proteins: personalised, programmable, fast, cost-efficient and effective screening that will speed up progress towards emerging therapeutic concepts such as immunotherapy. ELECTROMED's aim is to demonstrate a revolutionary technology for precision medicine. It could also be of great interest to the food sector (detection of GMOs and toxins) and the defence sector (detection of biological warfare agents).

Success story # 2

HAPTIC SCREENS: THE FEELING OF REALITY

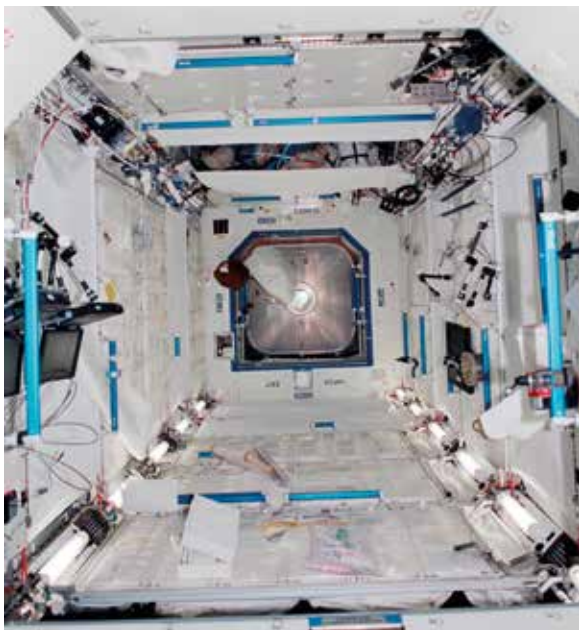
LIST has successfully integrated actuators by printing piezoelectric thin film on glass, thus paving the way for the 3D printing of these materials and therefore their industrialisation. This technology, which is in competition with the current use of bulky piezoelectric ceramics, enables the emergence of the large-scale industrialisation of new "haptic" functions, which are characterised by a surface texture that feels exactly as if you were touching real objects. With our industrial partner Hap2U, a French start-up, we are working on the very first haptic mobile phone based on thin piezoelectric layers. This technology will revolutionise our daily relationship between the virtual and real worlds by combining sight with touch!



Success story # 3

LIST IS IN THE STRATEGIC RACE FOR CELLULAR BATTERIES

Manufacturing batteries is a strategic imperative for Europe, both for the transition towards clean energies and for the competitiveness of its industry, particularly the automotive sector. LIST is collaborating with the engineering company XNRGI on the design of 3D micro-batteries. The aim is to place functional nanometric materials inside microporous silicon batteries in order to demonstrate unparalleled energy and power densities. To this end, LIST provides its expertise in the ALD (Atomic Layer Deposition) process. This process, used in the semiconductor industry, involves alternately exposing a surface to different chemical precursors (co-reactants) to obtain ultra-thin layers that are controlled at the atomic level. LIST is already producing samples and anticipates transferring this technology within three years, with the ultimate aim of industrialising the manufacturing process.



Success story # 4

ENSURING THE SAFETY OF SPACE SHUTTLE INTERIORS FOR FUTURE HUMAN MISSIONS

LIST was selected by the European Space Agency (ESA) to develop new anti-microbial and non-toxic surface treatments for the interiors of future space shuttles. On 4 March 2019, LIST officially launched the 18-month ESA NBACTSPACE research project, the aim of which is to improve the biosafety of space shuttle interiors in preparation for future human space missions. The confined environment of a space shuttle involves a high level of requirements in the development of surface treatments because of the accumulation of "pollutants" and the fast proliferation of pathogens in those special conditions, amongst other aspects. LIST will also contribute to greater knowledge and a better definition of the standards to follow in these confined environments. Furthermore, this applied research could have a significant socio-economic impact, as the development of a viable and sustainable alternative to metal-based surface coatings is the ultimate aim of this project. Indeed, the resulting technology should be transferable to our terrestrial environments, such as hospitals and medical devices or implants. The COVID-19 crisis further underlines the urgency of researching this type of coating, identified as an effective barrier against the proliferation of bacteria and viruses.

10. PUSHING THE BOUNDARIES WITH OUR NEW INSTRUMENTS AND PROCESSES

Speed, spatial resolution, atomic sensitivity and complex and dynamic data analysis. We enjoy meeting the challenges presented by scientific instrumentation and pushing the boundaries of this very special type of engineering. Our aim is to develop new instruments, processes and methodologies in the fields of plasma science and technology, thin-layer processing and nanoanalysis. Our research, development and innovation agenda ranges from fundamental science to prototypes of equipment, processes or materials analysis up to the pre-industrial scale.

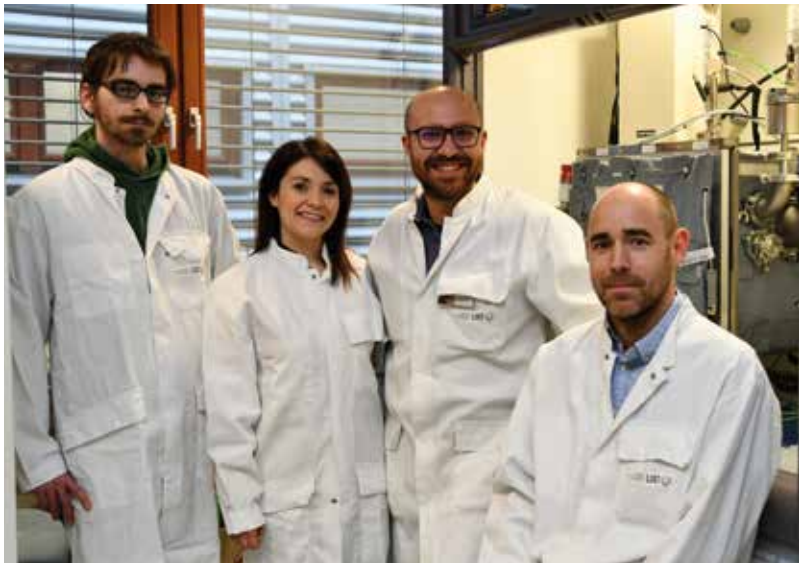
> « LIST's research activity, focusing on the development of scientific instruments such as ion microscopes and mass spectrometers, is clearly a niche. We have managed to create a critical mass in this field, enabling us to achieve a high level of international exposure. »
>
> Tom Wirtz,
> Head of the Scientific Instrumentation and Process Technology Unit

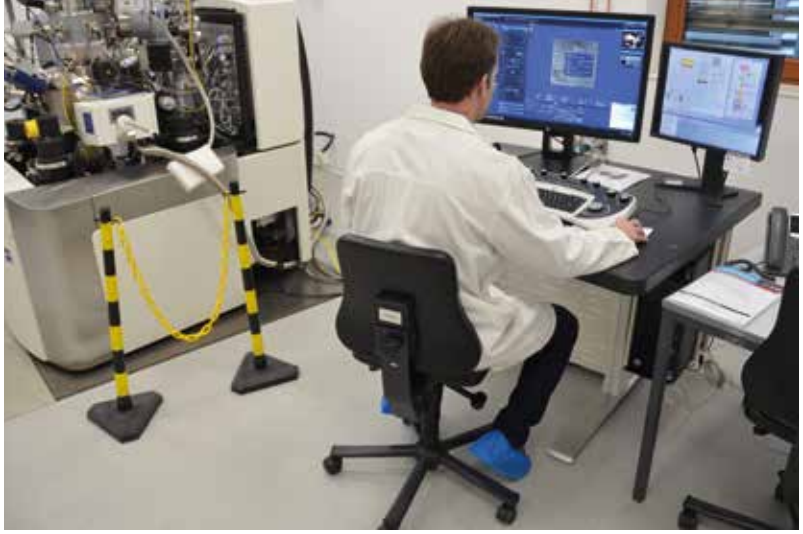
Success story # 1

LIST RESEARCHER NICOLAS BOSCHER IS AWARDED A PRESTIGIOUS ERC GRANT

In line with the Materials department's "21st Century Energy" strategy, LIST researcher Dr Nicolas Boscher was awarded the prestigious ERC Consolidator grant by the European Research Council (ERC) in December 2019, thus accelerating progress towards clean hydrogen technologies. Dr Boscher will receive EUR 1.9 million in funding over the next five years for the CLEANH2 project entitled "Chemical Engineering of Fused MetalloPorphyrins Thin Films for the Clean Production of Hydrogen".

Faced with the current global energy and environmental crisis, the CLEANH2 project aims to develop a new class of materials for the clean and efficient production of hydrogen from "solar water splitting". While solar water splitting has been implemented naturally for more than three billion years from abundant and sustainable resources, cost-effective artificial photosynthesis remains an unmet challenge. Nicolas Boscher will create photocatalytic polymers assembled from chlorophyll-related molecules (porphyrines). The field remains relatively unexplored, but if this breakthrough is achieved, this project could help to support a new economy built not on fossil fuels but on hydrogen.





Success story # 2

THE PROTOTYPE OF THE NPSCOPE INSTRUMENT IS NOW COMPLETE

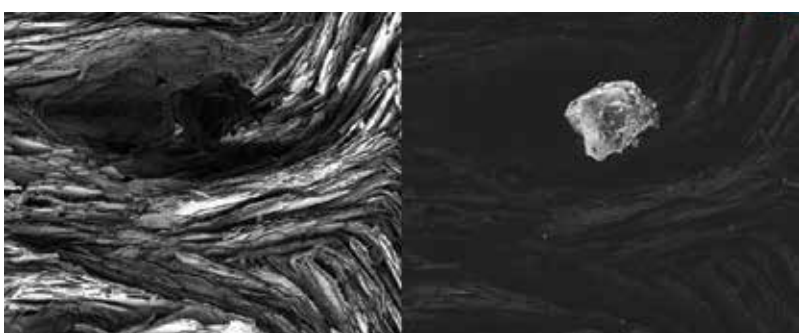
The advanced characterisation of nanoparticles will be made much easier by the new npSCOPE instrument, which was developed by an international team of researchers coordinated by LIST. Nanoparticles are everywhere: inside and around us. They can be found in food, cosmetics, textiles, paints, electronic devices, etc. When these items are intentionally modified to acquire specific properties, they may also present risks to human health, the environment and safety. It is therefore crucial to identify, study and limit these risks. In order to do this, it is necessary to carry out an adequate physico-chemical characterisation of these nanoparticles. In other words, we need to know what they look like, what they are made of, and what factors can affect their interaction with their environment.

To answer these three questions, a number of techniques are currently being used. However, until now, this multi-technical approach has been carried out on separate and expensive instruments. The European project H2020 npSCOPE aims to develop a single instrument that will provide answers to these three questions. Launched in January 2017, this project made excellent progress in 2019: the team of nine partners from six European countries successfully finished assembling the prototype of the npSCOPE instrument. In the coming months, the focus will be on demonstrating the potential of the npSCOPE instrument, using tests relating to nanotoxicology.

Success story # 3

COLLABORATION AGREEMENT BETWEEN LIST AND ZEROK NANOTECH

In 2019, LIST signed a collaboration agreement with the American start-up zeroK NanoTech. By combining LIST's expertise in secondary ion mass spectrometry (SIMS) technology with zeroK's unique know-how in the field of low-temperature ion source (LoTIS) technology, the two partners are joining forces to construct a SIMS instrument with a spatial resolution of less than 10 nm and maximum sensitivity. An instrument of this kind will be of great interest to numerous areas of application, including material science (materials for batteries, photovoltaics, semiconductors, etc.), life sciences (such as subcellular imaging and nanoparticles in biological tissues), geology and astronomy.



Success story # 4

USING PLASMA TECHNOLOGY TO GIVE NEW PROPERTIES TO THE SURFACE OF A MATERIAL

LIST researchers use plasma technology and its deposit on an industrial scale to give new properties to the surfaces of materials (e.g. corrosion-resistant, anti-bacterial, self-cleaning, etc.). A project launched in 2018 with the Luxembourg company Ceratizit to develop a new hard-wearing, high-temperature-resistant coating began to show fruitful results in 2019. During the second half of the year, the development of the process and of the coating could be transferred to our partner's products: wear resistance tests in real conditions were launched in their machining centre.

11. DEVELOPING THE NEXT GENERATION OF COMPOSITE MATERIALS

LIST is stepping up its research activities to develop the next generation of composite materials. Our aim is to develop these new materials by focusing on their sustainability and recycling, and on unparalleled performance in terms of weight/mechanical properties, while optimising the core aspect of composite materials: fibre-filler/matrix interfaces. The entire development chain is taken into consideration, from the engineering of materials to their manufacture, via design stage optimisation and functional tests.

« Our team is strategically positioned within the framework of the Luxembourg National Composite Initiative to promote the development of high-performance and multi-functional composite materials. Pre-industrial-scale demonstrators and manufacturing processes for composite structures are provided to industry to serve Luxembourg, the Greater Region and European society. »

Cláudio Saul Faria Lopes,
Head of the Structural Composites Unit

Success story # 1

MAKING WOOD CONSTRUCTION PROJECTS EVEN MORE ENVIRONMENTALLY FRIENDLY

More than 5 million cubic meters of engineered wood products are produced every year in the EU and the market is growing, as these products offer a “green” alternative to steel and concrete in construction. However, wood products intended for construction are subject to more intensive chemical treatments than standard sawn timber. It is generally difficult to recycle them because of their composition and adhesives or metal joints.

The Interreg NWE Adhesive Free Timber Buildings research project has made it possible to provide a more environmentally friendly alternative method of assembling wood panels and structural elements, which uses compressed-wood dowels and fasteners. This assembly system enables the construction of buildings with very low environmental impact, while also potentially developing the market for thousands of hectares of sustainably managed wood. In this project, LIST’s composite material modelling team developed a calculation platform, making it possible to speed up the development of “Adhesive Free” structures, with the ultimate aim of significantly reducing the time to market.

Success story # 2

TRAINING YOUNG RESEARCHERS IN THE MODERN DESIGN OF COMPOSITE STRUCTURES

Composite structures are widely used in many fields of engineering. It is a real challenge to design materials of this kind, as it requires aptitudes and skills drawn from a range of different fields. Existing training programmes are often focused on specific themes and disciplines, rather than an expanded interdisciplinary approach that incorporates academic and industrial perspectives.

Funded by the European Horizon 2020 Programme, the FULLCOMP project has made it possible to train twelve early-career researchers using a cross-sector and interdisciplinary approach within an international framework, in order to develop analytical tools to improve the design of composite structures. The entire design chain of these structures, such as manufacturing, structural state monitoring, failure, modelling, multi-scale approaches, testing, and prognosis/diagnostics, has been applied to many sectors (aeronautics, automotive, mechanical, wind energy and space).

Success story # 3

A SOFTWARE PLATFORM FOR THE DESIGN OF COMPOSITE MATERIALS

Adapting the modelling capabilities of companies to meet the challenges posed by the design and manufacture of composite materials: this is the aim of the Composelector project. This “industry-oriented” computational platform will make it possible to align the modelling of new materials with the needs of the market, thanks to a computer simulation based on physics, data, automation and machine learning. Consequently, thanks to its exceptional features, which are derived from access to an extensive library of relevant data magnified by a complex multifactorial calculation, this platform is expected to achieve at least a fivefold increase in the speed of development of new products from high-performance composite materials and structures.

In 2019, the project delivered noteworthy results: three case studies (Airbus, Dow and Goodyear) confirmed that the Composelector project and platform could have a significant impact on their business.

12. FUNCTIONAL POLYMERS: MATERIALS WITH UNIQUE PROPERTIES

Functional polymers are macromolecules with unique properties. They are generally inexpensive and easy to synthesise. At LIST, we adapt and process polymers to demonstrate specific property improvements or multi-functionality. We focus on biopolymers, biocomposites and natural fillers, as well as polyelectrolytes and electroactive polymers.

« We are looking to develop environmentally friendly polymers. For example, we are working on biopolymers, also known as "bioplastics": organic materials derived from renewable carbon (biomass), which are therefore non-fossil resources. Biopolymers and related functional composite materials offer remarkably high potential and are among the materials of the future. Hence, renewable biological resources are now regarded as a sustainable resource for the design and production of polymer materials with high added value. »

Laura Puchot,
Biopolymers researcher

Success story # 1

COMPUTER MODELLING OF POLYMERS: A LIST RESEARCHER AT THE CUTTING EDGE

Molecular modelling and simulations are valuable tools for scientists and engineers working on polymers. These computer-based approaches make it possible to forecast and explain the macromolecular structure, dynamics, thermodynamics, and microscopic and macroscopic properties of materials observed in experiments.

Dr Karatrantos was the first author of a summary article published in 2019, in which several internationally renowned experts in the field of materials science participated, focusing on the computer modelling of polymer nanocomposites. At the same time, it obtained its first Luxembourg National Research Fund (FNR) INTER grant in the same scientific field, which enabled it to further expand its expertise and recognition in molecular modelling and advanced atomistic simulations.

Success story # 2

PROMISING MATERIALS FOR THE ENERGY SECTOR

Polymer electrolytes are materials that offer numerous advantages in the field of high-energy-density batteries. A recent Luxembourg National Research Fund (FNR) INTER project supports international collaboration with two well-known research groups to develop the future generation of solid-state supercapacitors. As coordinator of this research topic, Professor Alexander Shaplov also plays an editorial role in the journal "European Polymer" for a special issue collating 16 peer-reviewed articles from major research groups working in the field of Polymeric Ionic Liquids (PILs). At LIST, these materials are also used to develop safety-enhanced lithium-ion batteries.

Success story # 3

SUSTAINABLE MATERIALS FOR 3D PRINTING

A recent collaboration supported by the European Union concerns the study of sustainable materials for 3D printing. Coordinated by Dr Habibi, the latter has also been recognised by the "Renewable Materials" division of the American Chemical Society (ACS) for helping to organise numerous symposiums at the next ACS meeting, thus further enhancing LIST's strong international reputation in the field of lignocellulosic materials.

OUR RESEARCH INFRASTRUCTURE

A DETAILED LOOK AT THREE UNPARALLELED LIST INFRASTRUCTURES

In order to innovate, a company needs to have certain conditions in place: in addition to specific skills, it also needs a state of mind that is conducive to creativity, as well as essential infrastructure for pre-industrial development. At LIST, our state-of-the-art infrastructure is one of our major advantages. The diversity and quality of our equipment, and the fact that it is all in one place, are also great strengths. A partnership with LIST enables Luxembourg companies to pool their equipment in order to reduce costs and speed up their innovation agendas.

THE GREEN TECH INNOVATION CENTRE: A ONE-STOP SHOP FOR THE COMPLETE DEVELOPMENT OF BIO-BASED PRODUCTS AND PROCESSES

The Green Tech Innovation Centre (GTIC) is an open innovation facility focused on the development of bio-based products and processes of industrial interest, new biorefining concepts for more efficient and sustainable processes, and new technologies for the detection and treatment of environmental pollution. The Centre also has facilities for the development of pre-industrial-scale processes and can host companies in shared laboratories.

More than 60 scientists and engineers can offer complementary skills to assist customers, from the generation of an idea, through the laboratory and pilot phases, to safer, sustainable and ready-to-market substances, ingredients and products. We also help customers to optimise existing solutions at all stages of product and process development.

Innovations are generally based on industrial biotechnology, molecular biology techniques, metabolic engineering, the cultivation of plant cell lines and micro-organisms (bacteria, yeasts, fungi and micro-algae), anaerobic digestion, biocatalysis, green chemistry and product formulation.

Our unique set of equipment and infrastructure enables us to work on bioprocesses on a pre-industrial scale. Our unique state-of-the-art facilities for biotechnology research enable our customers and researchers to develop solutions, from laboratories to a pre-industrial scale. The platform can carry out a wide range of analytical services, relying on its instrumentation, infrastructure and know-how to offer customisable analysis. The total area of the bioprocess engineering facilities is no less than 500 m².

THE COMPOSITE MANUFACTURING PLATFORM: A CATALYST FOR THE DEVELOPMENT OF COMPOSITE TECHNOLOGIES

Composite materials are produced by combining several components with properties that complement each other. Composites are found in the automotive, aeronautics, electronics, telephony, sports and medical sectors. LIST's Composite Manufacturing Platform provides pre-industrial research infrastructure and key skills in the field of composite materials, including polymer processing, the manufacture and welding of structural composites, and analysis and testing of composite materials.

The purpose of the platform is to further fuel the development and processing of innovative materials. Its key aims are:

- To act as a catalyst at national level for the development and implementation of manufacturing technologies for advanced composite materials;
- To establish pre-industrial research infrastructures supported by specific skills in the composite materials field in Luxembourg;
- To focus on collaborative research and the transfer of technology and knowledge, primarily for national industry;
- To host and coordinate shared laboratories with manufacturers.

The Composite Manufacturing Platform consists of three laboratories:

- A **polymer processing laboratory** that makes it possible to process polymers at every scale, from grams up to hundreds of kilograms (pre-industrial scale);
- A **structural composite manufacturing laboratory** that enables the development of material combinations and innovative processes;
- A **thermal analysis laboratory**, dedicated to a broad range of advanced techniques to determine the thermophysical properties of materials and thus characterise their thermal behaviour.

THE DATA ANALYTICS PLATFORM: THREE PILLARS THAT MAKE LIST A REAL LEADER IN THE FIELD OF DATA ANALYSIS

The Data Analytics platform is a hybrid infrastructure (external and internal Cloud) covering the entire range of data analytics activities. The platform, which is partially funded by the European Regional Development Fund, supports LIST's research and innovation capacity and positions it as a true leader in this field. It is based on three pillars:

A HIGH-PERFORMANCE COMPUTING (HPC) INFRASTRUCTURE:

LIST's HPC infrastructure mainly supports in-house research project teams with the aim of solving advanced and complex computing problems, such as climate modelling simulations, hydrological simulations, flood simulations, molecular dynamics simulations and genome sequence alignments. The HPC consists of a cluster of 40 Linux compute nodes, comprising 1,280 CPU and 4,960 Cuda cores, with a central storage capacity of 321 TB, backup facilities and management infrastructure.

A "COGNITIVE ANALYTICS PILLAR":

The "Cognitive Analytics Pillar", launched in September 2019, aims to provide LIST's research community with advanced technologies, services and solutions in data/business analytics, artificial intelligence and Big Data (for more information, see page 12, "Towards a modern and powerful platform").

AN INTERACTIVE VISUALISATION WALL (VISWALL):

On Wednesday 4 December 2019, LIST activated the VisWall: a multi-touch, very high-resolution display wall with a motion tracking system that is unique in the Greater Region. The VisWall consists of an enormous high-resolution 50-million-pixel display, so that it can deal with unprecedented quantities of data based on multiple synchronised data views. This 7-metre screen, which is the size of a wall, makes it possible to make joint decisions on complex analytical tasks. The VisWall is paired with a powerful cluster of computers to perform on-the-fly calculations triggered by user interactions and provide immediate feedback. Users benefit from an immersive experience thanks to the many ways of interacting with the VisWall, including multi-touch interaction, motion tracking based on customised 3D interaction accessories for navigation within very large data spaces, which are orchestrated to meet their needs.

Possible uses include data visualisation and advanced data analytics, the organisation of workshops and meetings, and teaching. There are also potential applications in numerous fields: space, infrastructure management, emergency response, modelling of biological or physical phenomena, improvement of business processes, and the design of industrial products. This equipment has no equivalent within a radius of 400 km.

OUR COLLABORATIVE MODELS

BILATERAL RESEARCH

Our dedicated partnership and business development teams offer you a wide range of collaboration models, with the aim of finding the ideal solution for your needs.

If you need specific expertise or would like to use the best research infrastructures, you need to enter into a bilateral collaboration with LIST. We offer you four types of bilateral collaboration:

SERVICE CONTRACT

For results that help you to achieve your innovation aims quickly: we share our highly-qualified experts with your company.

The service contract may also cover the provision of our infrastructure. You can access cutting-edge laboratories, equipment and methods to meet a specific need. Thus, you can make optimal use of our technological expertise, particularly in the fields of testing, measurement, analytics, innovation management, and method and software development. We offer an extremely wide range of standardised and customised services.

As part of the service contract, you bear all the costs but obtain quick results in return.

COLLABORATIVE PROJECT

This is a bilateral agreement in which LIST invests with you. We share our resources, expertise and infrastructure with our partner, but for a collaborative project, innovation costs are shared, and intellectual property is assigned to clearly identified contributors.

STRATEGIC PARTNERSHIP

For outstanding and sustainable results that require various skills: we jointly define a framework agreement for a medium or long-term strategic R&D partnership based on your innovation roadmap. This is a bilateral agreement that may involve the recruitment of PhD students dedicated to your research project. Intellectual property is assigned to the contributors to the invention.

"SPIN-OFF" OR "LICENSING"

Technology transfer is an important part of the value creation process. It involves transferring technologies to the market by creating new companies (spin-offs) or by granting licences to existing companies. This is how LIST innovations are transformed into products, economic activity and high-quality jobs. The agreement may take the form of capital sharing, royalty sharing or licence purchasing.

RESEARCH WITH MULTIPLE PARTNERS: LIST'S PARTNERSHIP PROGRAMS

LIST facilitates synergies between partners by bringing them together to share the benefits of its skills, talents and infrastructure. This collaboration model forms the cornerstone of LIST's innovation centres. The sharing of expertise, research and risks between partners throughout the value chain makes it possible to reduce costs for all parties concerned. All partners, as well as their own research teams, settle in at LIST and benefit from the unique advantages offered by LIST: an open research and technology infrastructure and first-rate talents.

How does it work? We implement a strategic programme. This is a multilateral agreement that involves the sharing of intellectual property between the various project partners.

KNOWLEDGE SHARING: FEEDING OUR KNOW-HOW BACK INTO SOCIETY

Knowledge and innovation are increasingly recognised as important drivers of economic growth, social development and job creation.

We share our knowledge and know-how with researchers from all over the world, for example at international scientific symposiums and conferences, and with players from the public and private sectors, as well as with society as a whole. This knowledge sharing is rights-free and makes it possible to advance scientific research and education, which is something that we value particularly highly.

RDI PARTNERS IN LUXEMBOURG AND EUROPE

adwäisEO
Arma Mundi Technologies
anisoprint
ArcelorMittal
BALZOLA
BLUE HORIZON
Carlex
CUTTING SOLUTIONS BY CERATIZIT
CIM research
CIRCUIT FOIL LUXEMBOURG
CLE
CODIPRO ALIPA
Electris
ENGIE
eurofoil
#BelieveInSmall
FONDATION ENOVOS
FREWITT
Globachem Your Crop Counts
CMC Commercial Metals
GOODYEAR
GUARDIAN INDUSTRIES
hap2U
HOUSE OF ENTREPRENEURSHIP
Infrachain
ILR INSTITUT LUXEMBOURGEOIS DE RÉGULATION
INTRASOFT INTERNATIONAL
ispace
Jindal Films
L'ORÉAL
LUXMOBILITY
LUXPLAN S.A. Ingénieurs conseils
MASSTECH
MET-LUX
mpg.
Myriada Cleantech
OHB LUXSPACE
PHILIP MORRIS INTERNATIONAL
PM-International
POST LUXEMBOURG
probiotic Group
ROAMSYS
ROTAREX VALVES - FITTINGS - REGULATORS
SAINT-GOBAIN
space 4 environment
life.augmented
SAH Stahlwerk Annahütte
Succy
SUD STROUM
Tarkett THE ULTIMATE FLOORING EXPERIENCE
ThermoFisher SCIENTIFIC
Unilever
VILLE DE LUXEMBOURG
XNRGI
ZEISS
ZERO NANOTECH

LIST

Our line ministry

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Enseignement supérieur
et de la Recherche

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère des Affaires étrangères
et européennes

Direction de la Défense

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Agriculture,
de la Viticulture et du
Développement rural

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Énergie et
de l'Aménagement du territoire

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Environnement, du Climat et
du Développement durable

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
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LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
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Service des médias et des communications

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Recherche Luxembourg

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SUPPORTING RESEARCH

SUPPORTING RESEARCH

One of LIST's ambitious aims is to become one of the best RTOs in Europe. In order to achieve this international status and succeed in its expansion, the Institute needs talented researchers, as well as efficient and effective support services. The vision and mission proposed by Thomas Kallstenius, the new CEO of LIST who assumed his role in 2019, requires a rethink of some of the Institute's support services. To ensure that support services are aligned with the needs of the RDI departments, the Executive Management team decided to launch several projects. They are intended to have a cross-disciplinary dynamic. In fact, *as a minimum,* each of these continuous improvement projects involves service support specialists and representatives from the research departments, the main beneficiaries of these advances.

1

TOWARDS A NEW ADMINISTRATIVE AND FINANCIAL TRACKING SYSTEM

The main aim of the SAFIRE project 1, launched in 2019, is to ensure the generation of reliable and useful administrative and financial reports in an end-user-friendly format. The project brings together 12 "customer-oriented" sub-projects. They focus on preparing dashboards and reports in Business Object (BO) to enable users to generate reports according to their needs. The team working on the project includes members of the Finance & Administration Units, members of the Collaborative Council, and end users.

EFFICIENT AND EFFECTIVE PROJECT MANAGEMENT

The internal project, entitled "LIst for NEw Research Administration" (LINERA) 2, is in keeping with the implementation of more efficient and effective project management. The aim is to harmonise the way in which project management operates at LIST, and to clarify the roles and responsibilities of each of the participants. LINERA has two phases.

The first phase covers everything from project conception to go-ahead, and it deals with the definition of the process. It was initiated in 2019 and completed in mid-November. The second phase concerns the implementation and archiving of the project, as well as project feedback. With the benefit of analysis and expertise provided by PricewaterhouseCoopers, a multidisciplinary internal project team was set up at the end of the year to implement a new, fully documented procedure.

2

RISK AND COMPLIANCE FOR GREATER SAFETY

The core of an RTO's activity lies in its laboratories. As well as making every effort to provide a research infrastructure that meets the expectations of its researchers, the "Infrastructure & Safety, Compliance and Quality" team 3 has conducted various projects to ensure that LIST has the best possible safety conditions. A series of risk and compliance analyses has been carried out. Its results have made it possible to define 10 priority actions that have been validated by the Health and Safety Committee, and which have an impact on safety or infrastructure at LIST.

For the same purpose, LIST has deployed the "Risk Process Assessment". It is intended to ensure that any risky new trials are subject to a risk analysis, a formal risk assessment process and a decision-making process.

3

Finally, an internal communication campaign called "Target Zero", to denote zero serious accidents at LIST, was launched from May to July to improve safety awareness among all our colleagues.

LIST: A GREAT PLACE TO WORK

In terms of human resources 4, LIST aims to provide a work environment that makes it a good place to work. With the arrival of new management, 2019 was a year of transition. This made it possible to carry out preparatory work with a view to implementing two major aims as early as 2020. The first is the creation of a "Talent Acquisition" team, whose task is to identify the best candidates and attract them to LIST. Its watchwords, like those of the entire department, are: HR advice, operational excellence, simple and effective processes.

The second aim is to prepare a training and development offering based on the needs expressed in 2019. Developed in collaboration with the staff delegation, this offering will be implemented in 2020. This will give the Institute new positive attributes, making it a good and attractive place to work.

4

5

IN ACCORDANCE WITH DATA PROTECTION

LIST decided to speed up the process of making its personal data protection-related activities compliant with the "General Data Protection Regulation" (GDPR). An in-house project was initiated by the Data Protection Officer, Caroline Roch 5, and the CEO. It is conducted in collaboration with colleagues from the IT for Innovative Services department, who contribute the personal data protection expertise that they have acquired as part of RDI projects, as well as their project management experience.

To reiterate, following the entry into force of the GDPR, LIST is required to take appropriate measures to ensure that the principles and requirements of this Regulation are in place. The role of the Data Protection Officer is, in particular, to inform and advise LIST and its employees about their obligations with regard to the GDPR and to ensure compliance with the Regulation.

LIST IN A NUTSHELL

HUMAN RESOURCES

As at 31/12/2019

617 employees

66% men

34% women

46 nationalities

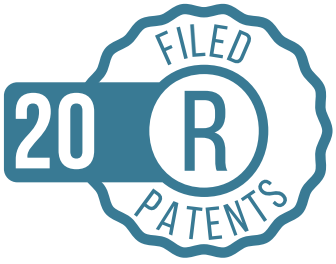
75% researchers or innovation experts

For the entirety of 2019

80 people recruited in 2019

93 PhD students hosted at LIST in 2019

SCIENCE AND TRANSFER



21 paid licences

230 scientific articles in 1st quartile journals

1 spin-off

R&D PROJECTS IN PROGRESS IN 2019

100 national competitive projects

25 competitive European projects

1 international competitive project (outside the EU)

7.87% of income from services

63 collaborative projects and similar

∑ 297 RDI projects and contracts in total

TYPES OF RESEARCH AGREEMENT

- Competitive projects are research projects that have successfully undergone an international scientific evaluation following a call for projects under national or international programmes.
- Collaborative projects are research projects involving effective collaboration between at least two independent parties seeking a common goal based on a division of labour. The two parties jointly define the scope of the project, contribute to its execution, and share its risks and results.

  Projects falling under public utility missions entrusted to LIST and European Space Agency (ESA) projects, as well as those co-funded by foundations, have been classed as collaborative projects.

Note that from 2018, Luxembourg National Research Fund (FNR) projects, including public-private partnerships, are included under collaborative projects.

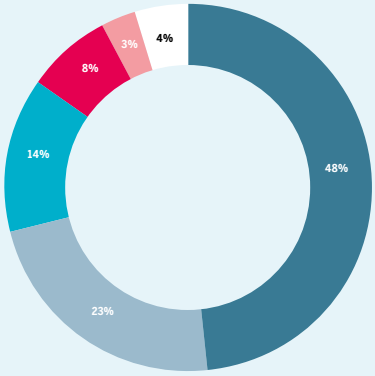
INTERNATIONAL COLLABORATIONS

NUMBER OF CONTRACTS PER COUNTRY

France	16
Belgium	9
Italy	7
Germany	6
Switzerland	6
United Kingdom	5
Netherlands	4
Austria	1
Bulgaria	1
Spain	1
Norway	1
Portugal	1
Romania	1

United States	4
Canada	2
Brazil	1

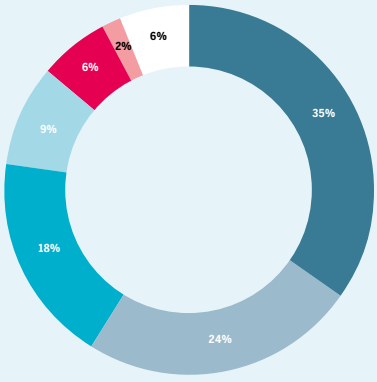
BREAKDOWN OF PARTNERSHIPS SIGNED IN 2019 BY TYPE OF PARTNER



Type of partner

- Universities (32)
- Companies (15)
- Research centres (9)
- Public institutions (5)
- Foundations and associations (2)
- Others (3)

BREAKDOWN OF PARTNERSHIPS SIGNED IN 2019 BY SECTOR



Business sector

- Energy & Environment (23)
- Materials (16)
- Mobility, Transport & Logistics (12)
- Information Technology (6)
- Biotechnology (4)
- Safety (1)
- Others (4)

DOCTORAL THESES DEFENDED

Gabriel Da Silva Serapiao Leal

"Decision support for interoperability readiness in networked enterprises",
University of Nancy, 11/01/2019

Gabriele De Pietro

"Modelling and design of multi-stable composite structures",
Polytechnic University of Turin, 08/03/2019

Yanchuan Hui

"Multi-scale Modelling and Design of Composite Structures",
Polytechnic University of Turin, 11/03/2019

Shankari Nadupalli

"Stress-Modulated Bulk Photovoltaic Effect in Polar Oxide Crystals",
University of Luxembourg, 27/03/2019

Carlos Escorihuela Sayalero

"Second-principles methods for large-scale simulations of realistic functional oxides",
University of Luxembourg, 29/04/2019

François Loyer

"Study of Nanosecond Pulsed Discharges for Plasma-Initiated Polymerization: Experimental Characterization and Theoretical Understanding of the Growth Mechanisms in the Deposition of Functional Polymer Thin Films",
University of Luxembourg, 18/07/2019

Urszula Czuba

"Multifunctional titanium implant surfaces based on the attachment of natural biomolecules on catecholrich plasma methacrylic thin films",
University of Liège, 21/11/2019

Divya Balakrishnan

"Acidity control in miniaturised volumes",
University of Twente, 29/11/2019

Serena Rollo

"A new design of an electrochemical (bio)sensor: High aspect ratio Fin-FET",
University of Twente, 29/11/2019

LIST AT A GLANCE

BOARD OF DIRECTORS 2019

Photo from left to right: Thomas Kallstenius, Robert Kerger, Etienne Jacqué, Eva Kremer, Marie-Christine Mariani, Nicolas Gengler, Georges Bourscheid, Diane Wolter, Isabelle Kolber, Amal Choury, Hubert Jacobs van Merlen. (Absent: Stéphane Jacquemart, Fernand Reinig and Gaston Schmit)

OBSERVERS

Thomas Kallstenius [1]
CEO

Fernand Reinig [2]
Acting CEO

Stéphane Jacquemart
Chair of the Staff Delegation

GOVERNMENT COMMISSIONERS

Robert Kerger [3]
Advisor to the Ministry of Higher Education and Research

Gaston Schmit [4]
First Government Advisor to the Ministry of Higher Education and Research

MEMBERS OF THE BOARD OF DIRECTORS

Georges Bourscheid
Chair of the Board of Directors

Hubert Jacobs van Merlen
Vice-Chair of the Board of Directors

Amal Choury
Member, CEO of e-Kenz

Nicolas Gengler
Member, Professor at the University of Liège

Etienne Jacqué
Member, Corporate R&D Manager at CEBI International S.A.

Isabelle Kolber
Member, Head of Laboratory at SEBES

Eva Kremer
Member, Deputy Director of SNCI

Marie-Christine Mariani
Member, Founder and CEO, MCM Steel

Diane Wolter
Member, former Philanthropy Advisor at the Banque de Luxembourg

[1] from 01/02/2019
[2] until 31/01/2019
[3] until 31/01/2019
[4] from 01/02/2019

EXECUTIVE MANAGEMENT

Dr Thomas Kallstenius [1]
CEO

HUMAN RESOURCES

Dr Fernand Reinig [2]
Human Resources Director

Kristel Williquet [3]
Human Resources Director

FINANCE & ADMINISTRATION

Laurent Cornou [4]
Administrative and Financial Director

PROGRAMMES

Dr Aziz Zenasni [5]
Director of Programmes

RDI DEPARTMENTS

Prof. Dr Lucien Hoffmann
Director, Environmental Research and Innovation (ERIN)

Prof. Dr Eric Dubois
Director, IT for Innovative Services (ITIS)

Dr Damien Lenoble
Director, Materials Research and Technology (MRT)

[1] from 01/02/2019
[2] from 01/02 to 21/07/2019
[3] from 22/07/2019
[4] from 25/03/2019
[5] until 14/12/2019

BALANCE SHEET AS AT 31 DECEMBER 2019

APPROVAL OF ACCOUNTS

The accounts were audited by statutory auditors PricewaterhouseCoopers and approved by the Board of Directors during their meeting of 24 April 2020.

The full financial report is available at www.list.lu

	2019	2018
Fixed assets		
Intangible fixed assets	658,491.56	669,118.93
Concessions, patents, licences, trademarks and similar rights and assets	658,491.56	669,118.93
Tangible fixed assets	23,636,202.55	22,047,154.84
Land and buildings	459,697.36	1,008,591.58
Plants and machinery	20,234,147.74	17,405,068.64
Other fixtures and fittings, tools and equipment	1,223,056.31	1,324,468.13
Payments on account and tangible assets under development	1,719,301.14	2,309,026.49
Financial fixed assets	460,938.20	770,103.92
Shares in affiliated undertakings	410,938.20	410,938.20
Amounts owed by affiliated undertakings	-	359,165.72
Securities held as fixed assets	50,000.00	-
Total fixed assets	**24,755,632.31**	**23,486,377.69**
Current assets		
Inventories	374,088.69	284,592.32
Raw materials and consumables	374,088.69	284,592.32
Receivables	23,317,420.05	22,884,152.60
Receivables from goods and services	2,788,234.22	2,730,781.20
Other Receivables	20,529,185.83	20,153,371.40
Cash at bank and in hand	72,483,196.58	65,758,027.08
Total current assets	**96,174,705.32**	**88,926,772.00**
Accruals	763,295.59	523,664.91
Balance sheet total (assets)	**121,693,633.22**	**112,936,814.60**

	2019	2018
Equity	86,332,785.70	81,297,539.66
Capital contribution	37,518,673.70	33,497,399.82
Reserves	43,778,865.96	43,602,775.95
Profit for the financial year	5,035,246.04	4,197,363.89
Provisions	70,000.00	95,504.85
Other provisions	70,000.00	95,504.85
Liabilities	32,669,112.27	29,133,750.82
Payments received on account for orders where not separately deducted from inventories	24,559,069.71	21,672,654.68
Trade creditors	2,638,665.67	2,015,043.88
Other liabilities	5,471,376.89	5,446,052.26
Tax debts	1,199,096.82	1,815,239.52
Social security debts	1,532,290.18	1,560,731.28
Other liabilities	2,739,989.89	2,070,081.46
Accruals	2,621,735.25	2,410,019.27
Balance sheet total (equity & liabilities)	**121,693,633.22**	**112,936,814.60**

PROFIT AND LOSS ACCOUNT FOR THE FINANCIAL YEAR 2019

	2019	2018
Net turnover	**8,492,157.53**	**7,087,108.90**
Other operating income	65,485,112.93	60,673,954.70
Raw materials and consumables, and other external expenses	-15,192,309.30	-12,197,275.17
Raw materials and consumables	-5,371,156.65	-4,109,401.57
Other external expenses	-9,821,152.65	-8,087,873.60
Staff costs	-46,659,340.76	-44,970,151.61
Salaries and wages	-41,221,565.07	-39,662,630.41
Social security expenses	-5,371,221.07	-5,261,501.46
covering pensions	-3,225,918.68	-3,114,948.76
other social security expenses	-2,145,302.39	-2,146,552.70
Other staff costs	-66,554.62	-46,019.74
Value adjustments	-5,666,324.78	-5,027,135.13
on formation expenses, and intangible and tangible fixed assets	-5,402,861.78	-5,027,135.13
on current assets	-263,463.00	-
Other operating expenses	-1,441,252.74	-1,385,839.17
Other interest and financial income	21,938.43	22,353.17
derived from affiliated undertakings	-	-
other interest and financial income	21,938.43	22,353.17
Value adjustments in respect of financial fixed assets and in respect of transferable securities held as current assets	-	6,561.11
Interest and other financial expenses	-4,735.27	-12,212.91
concerning affiliated undertakings	-	-
other interest and financial expenses	-4,735.27	-12,212.91
Profit after income taxes	5,035,246.04	4,197,363.89
Profit for the financial year	**5,035,246.04**	**4,197,363.89**

REFERENCED PROJECTS:

- DAP FEDER: "Data Analytics Platform", a project co-funded by the European Regional Development Fund
- PAsCAL: "Enhance driver behaviour and Public Acceptance of Connected and Autonomous vehicLes", a project co-funded by the European Commission's Horizon 2020 Programme
- CrossCult: "Empowering reuse of digital cultural heritage in context-aware crosscuts of European history", a project co-funded by the European Commission's Horizon 2020 Programme
- SWAM: "Smart Waste Collection Systems", a project co-funded by the Luxembourg National Research Fund
- OCTogone: "Optimization of the management of waste sorting centres for Polygone", a project co-funded by Polygone
- MODALES: "Adapting driver behaviour for lower emissions", a project co-funded by the European Commission's Horizon 2020 Programme
- 5G-MOBIX: "5G for cooperative & connected automated MOBIlity on X-border corridors", a project co-funded by the European Commission's Horizon 2020 Programme
- SECURE: "Smart Energy Cities and Regions", a project co-funded by the ENOVOS Foundation
- PUBLIMAPE: "Public Information Mapped to Environmental Events", a project co-funded by the Luxembourg National Research Fund
- WAVE: "Water and vegetation in a changing environment", a project co-funded by the Luxembourg National Research Fund
- Clim4Vitis: "Climate Change Impact Mitigation for European Viticulture", a project co-funded by the European Commission's Horizon 2020 Programme
- CLOMICS: "Omics-assisted characterisation and cultivation/enrichment of the candidate phylum Cloacimonetes - the context of anaerobic digestion", a project co-funded by the Luxembourg National Research Fund
- AskREACH: "Enabling REACH consumer information rights on chemicals in articles by IT-tools", a project co-funded by the European Commission's LIFE Programme
- Nature4Cities: "A Nature Based Solutions knowledge diffusion and assessment platform for re-naturing cities", a project co-funded by the European Commission's Horizon 2020 Programme

- ElectroMed: "Electrochemically-enabled high-throughput peptidomics for next-generation precision medicine", a project co-funded by the European Commission's Horizon 2020 Programme
- NBactspace: "Easily up-scalable and non-toxic coatings with antimicrobial broad spectrum activity for spacecraft indoors", a project co-funded by the European Space Agency (ESA)
- CLEANH2: "Chemical Engineering of Fused MetalloPorphyrins Thin Films for the Clean Production of Hydrogen," a project funded by the European Research Council (ERC)
- npSCOPE: "A new instrument for physico-chemical characterisation of nanoparticles", a project co-funded by the European Commission's Horizon 2020 Programme
- AFTB: "Towards Adhesive Free Timber Buildings", a project co-funded by the European Regional Development Fund and the European Commission's INTERREG North-West Europe Programme
- FullComp: "FULLy integrated analysis, design, manufacturing and health-monitoring of COMPosite structures", a project co-funded by the European Commission's Horizon 2020 Programme
- COMPOSELECTOR: "Multi-scale Composite Material Selection Platform with a Seamless Integration of Materials Models and Multidisciplinary Design Framework", a project co-funded by the European Commission's Horizon 2020 Programme

Find out all about these projects and many more on our website:
www.list.lu/en/projects

IMPRESSUM

Editor
Luxembourg Institute of Science and Technology

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Luxembourg Institute of Science and Technology

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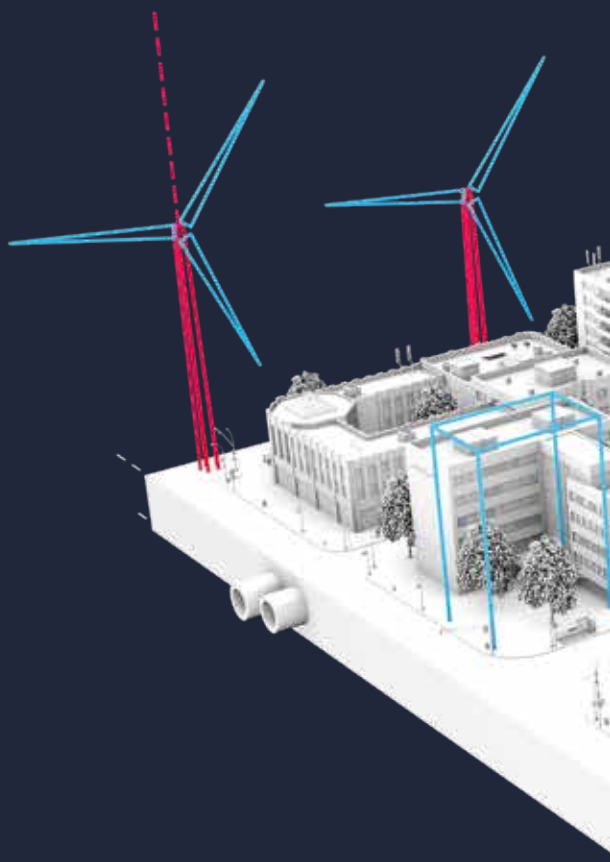

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