DRIVER OF CHANGE IN TIMES OF DISRUPTION

ANNUAL REPORT 2020

LUXEMBOURG
INSTITUTE OF SCIENCE
AND TECHNOLOGY

LIST


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

DRIVER OF CHANGE IN TIMES OF DISRUPTION

Last year was a period of upheaval for all of us. The pandemic has forced us to adapt to a "new normal". We have learned to interact, live and work differently, and we will probably need to continue to do so as it is unlikely that the post-COVID-19 world will resemble the one we once knew. The coronavirus crisis and its economic and social consequences have in fact contributed to the acceleration of a number of trends that will shape society over the coming decades. This is particularly the case with digital transformation, with the increased pace of adoption of telemedicine, remote working, virtual events, online education and digital payments. The shortage of essential goods and raw materials – from masks to polymers – has also highlighted the lack of resilience of global supply chains, which will need to be reconfigured to ensure stronger logistics and manufacturing capabilities. In addition to the health crisis, 2020 – the second hottest year ever recorded – was also marked by extreme weather events around the world, reminding us how urgent it is that we act on climate change.

In this context of disruption, our research and innovation activities at LIST are becoming more relevant than ever. At the crossroads of computing, environmental technologies, space technologies and advanced materials, we are helping to create innovative solutions for the complex challenges faced by public and private organisations in Luxembourg and beyond, with the aim of creating a resilient and sustainable digital society.

Although 2020 was an exceptional year, LIST continued to deliver on its promise to work on projects that benefit society and to become an accelerator of global change:

- LIST has contributed to the fight against COVID-19 through eight projects implemented in record time and carried out either within the COVID-19 National Task Force or supported by the National Research Fund. Among these, the CORONASTEP initiative, which has monitored the presence of the virus in wastewater since the beginning of the epidemic, provides essential data for the government to make informed decisions about the pandemic. LIST's visualisation wall, a key component of Luxembourg's digital twin, has also helped our policymakers to understand the decision-making benefits of aggregating and reconciling data from multiple sources.
- At an institutional level, LIST has partnered with the European Space Agency (ESA) and the Luxembourg Space Agency (LSA) to create the European Space Resources Innovation Centre (ESRIC). This unique new LIST department, headed by Acting Director Mathias Link, aims to become the internationally-recognised centre of expertise in the scientific, technical, commercial and economic factors bound up with the use of space resources for human and robotic exploration, as well as for a future space economy.
- To support national activities related to e-learning and to create a central platform for services and innovation, the "Luxembourg Media and Digital Design Centre" (LMDDC) was set up as an economic interest group (EIG) between LIST and the government, represented by the Ministry of Education, Children and Youth and the Ministry of Higher Education and Research.
- Internally, six new innovative and exploratory projects were selected for the second edition of our InitiaLIST programme. This year's edition introduced sustainability criteria through the design of LIST, thus supporting LIST's firm commitment to becoming a sustainable RTO.

Despite working conditions that were at times made more difficult by the health crisis, LIST remained true to its partners and continued to fulfil its mission of pushing the boundaries of research for high-impact innovation:

- LIST's successful collaboration with Goodyear has stepped up, with the addition in the pipeline of new projects on sustainable mobility and materials of the future.
- Thanks to a second partnership with the French private company 3D-Oxides to develop materials for hydrogen production, a new shared laboratory was opened.
- Our Institute's research facilities will also be shared by the new "Multifunctional Ferroic Materials", Luxembourg's first ever inter-institutional research group created through a bilateral cooperation agreement with the University of Luxembourg.
- As part of their partnership with a shared laboratory, PM-International and LIST hosted the second edition of the "LIST International Award in Bioinnovation", won by Dr Ozan Ciftci, a world leader in food chemistry and engineering.

Increasing the number of shared laboratories is an integral part of LIST's strategy. While our expansion in the "Aile Nord Aile Sud" (North Wing South Wing) building and the set-up of the future "Engineers' Laboratory" in Belval will help address some of our internal needs and those of our partners, LIST will continue to expand its footprint in Hautcharage in order to accommodate larger pilot lines and laboratories. This infrastructure will enable LIST to better serve its industrial partners by allowing them to test their innovative technologies in a pre-commercial production environment.

Scientific excellence also remains the cornerstone of LIST's ambitions, as is attested by these figures: 110 national competitive projects, 37 international competitive projects and 128 collaborative projects in 2020, as well as 132 scientific publications ranked in the top 10% in their category, and 12 successfully defended doctoral theses.

This report presents the results of this unique year, notably through a series of success stories that highlight the impact we have and will continue to maintain in response to global challenges. An impact we certainly could not have without the talent, spirit of collaboration and extraordinary commitment of our staff.

Jacques Lanners
Chair of the Board of Directors

Dr Thomas Kallstenius
CEO

ENGAGED IN THE FIGHT AGAINST COVID-19

A STRONG SYNERGY BETWEEN ALL PLAYERS AT LIST

Our mission: to build, together with our partners, a resilient, sustainable and digital Luxembourg. In the face of the COVID-19 pandemic, these three pillars are essential for the rethinking and building of the Luxembourg of tomorrow: a strategic, local industry, but at the same time global, contributing to a solid economy.

In this particular context, the excellence of our scientists has played a key role in providing relevant strategic advice to support the government during the health crisis. These major advances, however, would not have been possible without the agility and adaptability of all those involved at LIST in maintaining operations and ensuring the safety of all in record time.

LIST'S AGILITY AND EXEMPLARY RESILIENCE

In the face of an unknown new virus, society has been on hold and many businesses have been affected. In this context, LIST has been able to thrive where others have failed thanks to effective crisis management.

Following the announcement of the first lockdown, it took less than 48 hours to ensure the simultaneous remote connection of all of our employees on our servers, as well as the placing of our laboratories on temporary standby. Essential activities were maintained and research laboratories reopened to priority staff as soon as the situation allowed.

We have taken health measures beyond those recommended by the government so that everyone can feel and be safe. Limited numbers in our buildings, distancing, disinfection, distribution of masks and gel: this effective strategy ensured almost zero contamination in our buildings.

From infrastructure to information technology, human resources, security, communication and R&D departments, there are many heroes behind our success. LIST organised the home delivery of work equipment, deployed new communication tools in advance, and made an online training platform available to all its employees. In order to ensure that all of our teams remained well informed, we developed a new section on LIST's intranet site dedicated to the crisis, and from March 2020 onwards organised a series of internal webinars introduced by our CEO, Thomas Kallstenius, as an effective way of keeping everyone connected and informed of the evolution of the pandemic.

UNION CREATES STRENGTH

The appearance of this new coronavirus has given rise to unprecedented collaboration among those involved in scientific research. Coordinated by the COVID-19 Task Force within Research Luxembourg, and funded largely by the National Research Fund (FNR), there are a number of LIST research projects underway to help combat the pandemic: from monitoring SARS-CoV-2 in wastewater to detecting infection with the virus through cough and voice analysis.

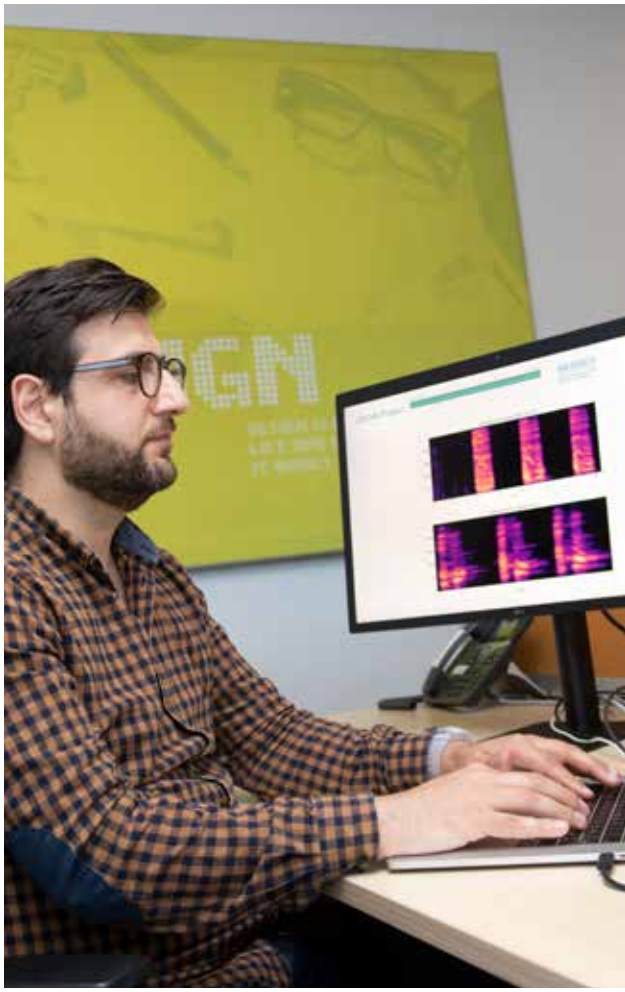
TRACKING THE VIRUS IN LUXEMBOURG'S WASTEWATER

As part of the CORONASTEP research project, five dedicated microbiologists work tirelessly to provide a detailed view of the evolution of COVID-19 in the Grand Duchy by tracking the presence of the new coronavirus in wastewater. Complementing clinical diagnostics carried out by our partners, our highly sensitive and reliable methodology is able to visualise where, when and in what concentration the SARS-CoV-2 is present in Luxembourg. This has made it possible, in particular, to trace the arrival of the virus in the country, as well as to track down areas of infection in near real time. These results provide early information (approximately 24-48 hours) on the pattern of circulation of the virus throughout the country. This health benefit has been noted and welcomed by the government, which since the start of the pandemic has relied on LIST's bi-weekly reports for agile management and decision-making. Faced with the unknown of this coronavirus, the members of the CORONASTEP team also play a major role in informing and raising awareness among the media and the population of Luxembourg by providing not only free access to their results and the background of their research, but also by answering as many questions as possible.

TOWARDS REMOTE AND EARLY DETECTION OF COVID-19

Respiratory problems caused by COVID-19 can make patients' voices distinctive. In response, researchers from LIST are developing a smart system capable of identifying infection with the virus through patients' voice signatures. This innovative approach could limit the risks of physical exposure, as well as help medical staff manage overloaded call centres at the time of a pandemic.

Another project initiated by LIST aims to develop technology capable of detecting infection at an early stage. The objective of this research team, using optical and electrochemical approaches, is to provide a reliable, easy and quick-to-use diagnostic device for better healthcare management and clinical outcomes.



« Our partnership with LIST was THE key factor in developing a virucidal coating for facial masks in record time. Thanks to the outstanding work of LIST, which has developed a robust test protocol and carried out thousands of validation tests, we have gone from idea to CE-certified product in less than 12 months. »

Mark Jacobs,
Molecular Plasma Group (MPG) co-founder and Managing Director.

DECONTAMINATING MASKS

LIST and the Molecular Plasma Group (MPG) have been working together to find a method, based on the use of plasmas, for decontaminating used masks and personal protective equipment for reuse. At the end of 2020, MPG obtained substantial funding from the Ministry of the Economy to continue to optimise the functionality of masks during 2021, in collaboration with LIST. This innovative work will enable the production of "Made in Luxembourg" masks with a high level of virucidal efficacy.

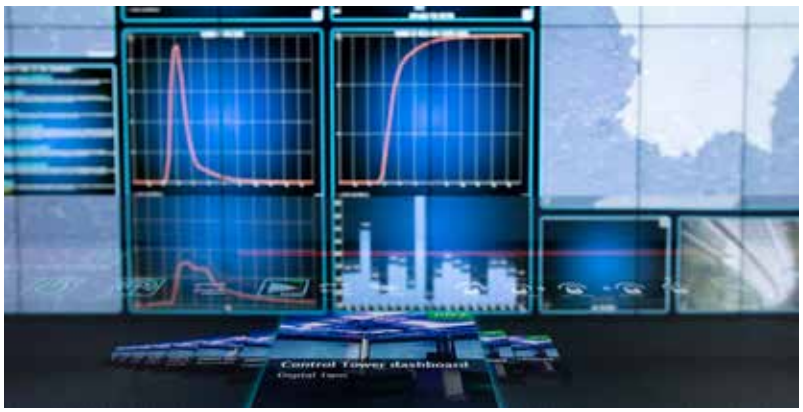
SORTING PANDEMIC DATA

Research today is pursuing a common goal: keeping the pandemic in check. Researchers, medical professionals and policymakers will, however, only be able to achieve this if they have quick and easy access to thousands of scientific works. Our researchers are adapting their "Papyrus" data research and information visualisation software, making it available to all.

At the same time, the Institute is transforming the thousands of items of data, concepts and terminology on COVID-19 described thus far into understandable graphs. This is a key way to properly understand what we know about this new coronavirus and get a snapshot of the evolution of knowledge on the subject over time.

VISUALISING FOR IMPROVED PREVENTION: THE CROSS-SECTIONAL DASHBOARD

In order to support decision-makers in crisis situations such as COVID-19, LIST has implemented a Cross-Functional Dashboard. It offers a synthetic but nonetheless as comprehensive a view as possible of the current situation and helps visualise the impact of different scenarios. This cutting-edge technology, combining our visualisation wall (VisWall) with interactive boards, also supports scientists in refining their models, validating underlying assumptions and assessing the quality of the data they use.



GUARANTEEING LOGISTICS AND SUPPLY IN TIMES OF CRISIS

In order to limit the disruption of logistics and supply chains during the pandemic, a prototype control tower was developed to facilitate decision-making. In partnership with the Luxembourg Centre for Logistics and Supply Chain Management (LCL) and INCERT, this prototype provides a way to assess the resilience of the supply chain; an interactive dashboard in an immersive environment; a simulator to assess the impact of different scenarios on inventory management; and a mobile application that enables rapid alerts and continuous access to key data. With the support of Santé Services, a subsidiary of the Robert Schuman Hospital Foundation, a healthcare supply chain application has been developed. Soon the control tower will offer more advanced features and ensure information security as well as guaranteeing visibility and transparency.

The COVID-19 Task Force Supply Chains and Logistics working group also analyses the impact of the pandemic and potential risks for supply chains, with a view to providing product-based advice. The team also looks at the various risk factors and makes recommendations to the government, as well as to private operators, so that they can increase their resilience.

DECISION SUPPORT TOOLS

In order to contain a crisis like COVID-19, it is essential to be able to detect and map the development of the virus in space and time. This is precisely the objective of LIST, through the development of a web platform and decision support tools. The idea of this platform is similar to that of street mapping, but instead of mapping local services, it will display and locate viral infections.

In order to support a revival of economic activity in Luxembourg while minimising the risk of new pandemics, our researchers are using their expertise to contribute to the creation of predictive scenarios within the framework of a joint project with the University of Luxembourg. This innovative hybrid technology approach will allow policymakers to predict what might happen depending on the chosen lockdown easing measures.

LIST: SUSTAINABLE BY DESIGN

WORKING FOR A SOCIETY THAT RESPECTS THE ENVIRONMENT

At the heart of our values, sustainability is more than just an approach for us. It is a mindset to be adopted and injected into each of our actions, both personal and professional. Our belief: we can and must all be the drivers of change for a society and for an economy that respects the environment and our future generations.

BEING AN EXAMPLE OF SUSTAINABILITY

Climate change, loss of biodiversity, exploitation of non-renewable resources, growth of inequality: within the scientific community there is no doubt how urgent it is to take action. We are committed to setting an example both in our research activities and in our day-to-day operations. Initiated in 2019 with the setting-up of the "Sustainability" working group, this year we completed an in-depth assessment of our carbon footprint according to the international "Greenhouse Gas Protocol" standard. We have analysed the impact of each of our operations, from our buildings to our procurement, consumption and even mobility habits.

This first phase has already allowed us to make several recommendations, some of which will be implemented as early as 2021. For example, we will improve the ability to monitor our power consumption and use certified green energy. With a view to continuous improvement, LIST undertakes to follow up these initiatives and their performance on a yearly basis. This is a voluntary approach, which we believe is essential for us to play our part and pave the way towards a sustainable society.

AN APPROACH FROM DESIGN ONWARDS

By adopting "Sustainable by Design" as a LIST value, we recognise the importance of taking the entire life cycle of a product or service into account in order to ensure a truly sustainable approach. To avoid any harmful bias or indirect effects, we must take the design, production, use and end-of-life phases of any object into consideration, including new technologies. This is why we have integrated identification of the positive and negative impacts of future technologies in our most recent call for InitiaLIST internal research projects. A reduction in the use of raw materials and an increased use of recycled or recyclable, biological or biodegradable materials are among the environmental criteria assessed by our researchers when defining projects.

Lastly, our research activities with and for our partners are also guided by our desire to reduce the environmental footprint of our society and promote a circular economy while avoiding any risk of "greenwashing". In order to operationalise sustainable design and quantification of impacts, we have used our expertise to develop a new methodological framework. Whether in terms of environment, materials or computing, our projects aim to develop new, more sustainable and responsible products, services, technologies and processes.

OUR RESEARCH

1. ENSURING AN AGILE ENVIRONMENTAL AND ENERGY TRANSITION

« Our research takes a broader view of a problem by carrying out sector or life cycle assessments, and our projects focus on putting these results into practice. We need this type of research – focused on an overview and rapid implementation – given that the window available to us to stem climate change and preserve biodiversity is closing. »

Claudia Hitaj,
Life Cycle Analysis (LCA) Researcher

In order to actively contribute to environmental and energy transition, we take a multidisciplinary approach to ensuring the sustainability of our societies. We aim to make an impact by focusing our research on the development of environmental and social indicators and the assessment of air quality and substance toxicity, as well as the creation of innovative solutions for sustainable construction and an agile use of renewable energies. In addition to supporting the development of informed environmental policies, we strive to support companies in all sectors in their initiatives, and to raise public awareness of the environmental challenges of the coming decades.

Success story #1

TOWARDS A SMART AND FLEXIBLE ENERGY DISTRIBUTION NETWORK

In December, two LIST projects to address the technical, economic and environmental energy challenges of the coming decades captured the attention of the European Commission: from the implementation of smart grids to the integration of renewable energies. Through a new European project, LIST will use its wealth of expertise in energy systems to develop and operationalise a secure platform for energy transmission and distribution operators. As key players in energy transition, they will be able to operate, maintain and plan the energy networks of tomorrow together. Alongside its European partners, the Institute also aims to ensure an agile response to a growing demand on the part of small and medium-sized distribution network managers. As part of this second project, operators will have an electrical grid system capable of dealing with the volatility of renewable energies, thanks to flexibility and the optimisation of old systems with smart technologies.

Success story #2

REDUCING THE ENVIRONMENTAL IMPACT OF BUILDINGS AND NEIGHBOURHOODS

Cities are responsible for 75% of the world's energy consumption and greenhouse gas emissions, of which over 40% is attributed to buildings. Committed to creating a responsible society, LIST and Cardiff University (UK) aim to reduce and positively control the impact of buildings on the environment through a new generation of analysis methods and tools. Their hypothesis: life cycle assessment, underpinned by semantics and fed by dynamic data, paves the way for more accurate assessment, while supporting decision-making and the active control of buildings and neighbourhoods. Starting in June and co-funded by the National Research Fund (FNR) and UKRI (UK), this research is also aimed at designing corrective actions based on real-time data from the Internet of Things and artificial intelligence.

Success story #3

A EUROPEAN FRAMEWORK FOR THE DEVELOPMENT OF NANO-PHARMACEUTICALS

Nano-pharmaceuticals have the potential to foster scientific and technological growth, offering great clinical and socio-economic benefits to society, industry, key stakeholders and patients. By definition, these medicines use nanotechnology in some form or other, for example to optimise the absorption and distribution of a drug. Establishing good manufacturing practices (GMP) for their large-scale production is a key stage in an efficient, safe and responsible transfer to the market. However, due to the lack of resources devoted to the implementation of these GMPs, the scaling up and production of these innovative products remains a challenge for the main players in the European nano-medicine market. Funded up to €11.1 million in 2020 by the European Commission through its H2020 programme, the PHOENIX project, coordinated by LIST, brings together a consortium of 11 academic and industrial partners. Its aim: to create an open innovation test bed for nano-pharmaceuticals in order to establish GMPs that guarantee industrial transfer.

2. FOSTERING A CIRCULAR BIOECONOMY

« To ensure the sustainability of primary resources, we need to convert widely available and still underused lignocellulosic biomass into valuable chemicals and biofuels. Our studies have enabled us to identify many microbes and enzymes of potential industrial interest. Now we need to transfer this knowledge into a real application. »

Magdalena Calusinska,
Systems and Bioprocess Engineering Researcher

At LIST, we draw our inspiration from the ingenuity of nature and the living world. We transfer to the market innovative solutions which promote a circular bioeconomy that takes into account the direct and indirect impacts of a product throughout its life cycle. Through analysis and assessment of the innovation potential of plant and microbial biodiversity, we design substances and grow microbial communities for promising applications in sectors such as energy, cosmetics, industry and agriculture. Derived from synthetic biology, bioinformatics and genetic engineering are two of our flagship approaches.

Our biotechnology production processes are developed, optimised and scaled up with state-of-the-art infrastructure and expertise in molecular biology, engineering, bioprocesses and bioinformatics. At the same time, we use our expertise in environmental microbiology to develop rapid diagnostic tools for emerging pathogens, or to validate decontamination technologies and cleaning agents.

Success story #1

AN INNOVATIVE BIOLOGICAL PROCESS CAPABLE OF PRODUCING BIOMETHANE

Through anaerobic digestion, various microbial communities make it possible to produce bioenergy and natural fertilisers from organic waste. As an illustration of a circular economy, this process could also play a key role in the energy portfolio of Luxembourg and the Greater Region. At LIST, we are developing a technology capable of increasing the production and quality of biomethane, while at the same time valorising the surplus renewable electricity resulting from an imbalance between production and demand. This two-step technology uses an innovative biological process capable of producing biomethane from hydrogen – produced through water electrolysis using excess renewable electricity – and carbon dioxide produced by microbial communities that naturally develop in anaerobic digesters. In 2020, this research led to the completion of a pilot-scale mobile prototype, consisting of two 800 litre bioreactors. Integrated into a marine container, it will be a valuable tool for assessing methanisation technology in anaerobic digestion units on a real scale.

Success story #2

TOWARDS SUSTAINABLE INDUSTRIAL PRODUCTION OF PLANT MOLECULES

Plants are valuable sources of bioactive compounds. Over the past decade, LIST has been interested in triterpenes, molecules naturally present in apples which are of great interest for cosmetic applications. Committed to the responsible and sustainable use of natural resources, the Institute has used its expertise in metabolomics, transcriptomics and functional genomics to develop several apple suspension cell lines for the industrial production of these compounds. In 2020, the market analysis carried out enabled promising contacts with key players in the cosmetics sector. In 2021, LIST is expected to take another step towards the production of cosmetic ingredients using plant cell crops. The team will lead the scaling-up of a biotechnology production process within the framework of a recently acquired H2020 project.

Success story #3

PROBIOTICS FOR NATURAL CLEANING PRODUCTS

Probiotics are microbial agents that have beneficial health effects when ingested or applied to the skin. They combat the installation of pathogenic microbes through various ecological mechanisms, such as competition for resources or the production of antimicrobial compounds. The project, in collaboration with the company Probiotic Group Luxembourg, is innovative in that it applies this same principle in the environment. This is a major challenge owing to the much lower level of knowledge of microbial communities present in a built environment (houses, hospitals, restaurants, etc.) than those of the human intestinal or skin microbiome. From various surfaces, ranging from kitchen tables to bathroom sinks, LIST, in collaboration with the University of Luxembourg, has succeeded in isolating more than 50 bacteria with a number of characteristics which are desirable in probiotics. By characterising them, the Institute verifies their ability to be mass-produced for incorporation into detergent products, replacing chemicals which are aggressive or harmful to the environment and our health. The aim is to be able to extend the range of natural household cleaning products as soon as possible.

3. ENSURING RESILIENCE IN A CHANGING WORLD

« For many years, we have been exploring how to use satellite data, defining and implementing innovative automatic algorithms for flood monitoring applications. Thanks to the development of satellite infrastructure, we have made progress towards an operational satellite flood monitoring system on a global scale, which is now an integral part of the spin-off WASDI. »

Ramona Pelich,
Environmental Detection and Modelling Researcher

In the face of climate change, we want to raise awareness and help everyone become a player in change by improving our understanding of ecosystems and their responses to new pressures. Water is seeing its cycle radically changed, with disruptions in its global distribution and an intensification of extreme weather events. Despite a mobilised scientific community, recent advances demonstrate the difficulty of forecasting and predicting the response of our environmental systems to global change. In order to reduce these uncertainties, we are pushing the boundaries of research to develop monitoring technologies with unprecedented spatial and temporal resolution, as well as help understand and optimise the use of this data in order to ensure the resilience of our agro-, eco- and hydrosystems.

Success story #1

MONITORING NATURAL DISASTERS IN NEAR REAL TIME

On 23 December 2020, LIST signed an agreement confirming the set-up of a new spin-off known as WASDI, or "Web Advanced Space Developer Interface". This transfers to the market the HASARD® technology developed and patented by LIST. Using satellite data, this unprecedented tool enables flood maps to be generated on a global scale. In particular, it proved its usefulness during cyclone-related floods in Mozambique in March 2019, and in Myanmar and South-East Asia in May 2019. While the maps generated attracted the attention of the Luxembourg and European space agencies, they were also used as part of the NASA Earth Science Disasters Programme, the World Food Programme and by various members of the Global Flood Partnership. Based on this technology, the WASDI consortium, comprising Italian company FadeOut, RSS Hydro and LIST, will develop and make available more applications, such as forest fire mapping, vessel movement monitoring and urban change mapping.

Success story #2

REVEALING THE MYSTERIES OF THE WATER CYCLE

As an essential resource for the environment and for all of our lives, water runs on often unknown paths that can both speed up and slow down its progress. As climate change increasingly threatens its future, following a drop of rain water from its impact on the ground to its arrival in a watercourse is essential in order to assess and contribute to the resilience of our water resources in the coming decades. Based on their experience in hydrology and hydrogeology, LIST researchers have seen their efforts in this area over several decades recognised at the "FNR Awards 2020" by the award for "Outstanding Scientific Publication". This distinction represents national recognition of their work published in 2017. Having monitored the circulation of water in the watersheds of the Grand Duchy for over a decade and with numerous international collaborations, researchers were able to demonstrate for the first time the dominant role of rock type in the age of water and its storage capacity. The more permeable or impermeable a rock is, the more it will delay or accelerate the reappearance of water, respectively. This can take days, months, years or even decades.

Success story #3

PREDICTING THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE

LIST's long-standing work on climate change gained new momentum in 2020, with projects acquired through competitive national and international funding programmes. Funded by FNR, one study looks at control of the hydraulic characteristics of plants with a view to reducing the uncertainty of drought prediction on the European continent under different climatic conditions. At the same time, the Institute is involved in a new European project to study the potential exacerbation of pests and plant diseases in the context of climate change. Researchers aim to better understand the interactions between plant vectors and viruses, taking into account physically and regionally consistent digital projections of climate change. Solutions will be proposed, including plant vaccines and biopesticides against virus vectors, as well as integrated pest management strategies. Similarly, a project funded by the Ministry of the Environment, Climate and Sustainable Development (MECDD) will provide custom climate projections for Luxembourg and the Greater Region, paving the way for future collaborative projects in the field of basic and applied climate research, as well as for the Institute's policy support activities.

4. SHAPING TOMORROW'S SMART SOCIETY

« Interactive tabletops and wall displays can help us address the complex challenges of the 21st-century world. They facilitate and support collaboration, and enable the presentation of large amounts of data. Decision-makers can visualise and work together on complex tasks, tracking each other's actions, reactions and intentions. »

Valérie Maquil,
Human-Computer Interaction Researcher

At LIST, we exploit the potential of data to draw the contours of tomorrow's society: a smart environment where interactions between humans, technologies and data are intertwined. In this way, we strive to improve performance, problem-solving and decision-making in these systems known as CPS-S (Cyber-Physical-Social Systems).

In order to ensure ethical and responsible use of data sciences, we model, design, implement and evaluate new computer technologies, such as artificial intelligence, while taking into account human capabilities. From this perspective, our work focuses in particular on the field of Human-Computer Interaction based on visualisation, collaborative systems and augmented reality.

Success story #1

FROM RESEARCH TO MARKET, ARTIFICIAL INTELLIGENCE UNDER THE SPOTLIGHT

From medicine to finance and the courts, a wide range of terminology is used by different entities and countries to describe a concept, data, or the relationship between them, and is expected to adapt as our knowledge evolves. To provide stakeholders with an agile solution, a decade of symbolic artificial intelligence (AI) research on managing the dynamics of knowledge evolution has come to a close this year. A new spin-off from the Institute, called DYNACCURATE, is therefore expected to be launched in 2021. The result of successful projects funded by FNR, this spin-off illustrates the transformation of our know-how regarding the evolution of knowledge graphs and its impact on alignments, as well as related semantic annotations, into innovative solutions in the market. The work carried out has already demonstrated its application potential for the Luxembourg health sector.

Success story #2

AUGMENTED REALITY AS A TRAINING TOOL

Since 2015, LIST has been a major player in the use of augmented reality for training needs. From law enforcement to the medical profession, this immersive technology allocates faster, simpler and safer training for the management of particular events. As such, the STARRI system developed by LIST for training in radiological incidents - of a terrorist or accidental nature - is now being marketed. 2021 will see the transfer to the market of this system, which will allow stakeholders and operators to visualise the radiation inherent in this type of incident. LIST is also leading other national and international competitive research projects to develop innovative solutions based on augmented reality.

Success story #3

OPTIMISING ARCELORMITTAL'S PRODUCTION PROCESSES

In recent years, LIST has established itself as a trusted partner in Industry 4.0. In a project in collaboration with ArcelorMittal, the Institute has developed cutting-edge, AI-based technologies to extract relevant knowledge from complex data. These technologies include, for example, non-linear dimension reduction methods and advanced exploratory analytics. The innovative software tool developed has made it possible to take full advantage of the potential of the collected data, by helping our partner to optimise its products, as well as by providing a more relevant analytical understanding of production processes. This project illustrates LIST's commitment to supporting its partners in their digital transformation through a portfolio of activities and advanced solutions on the theme of Industry 4.0, in particular the topic of "Explainable AI".

5. MEETING THE CHALLENGES OF A DIGITAL SOCIETY

« In the digital economy, 5G plays the role of a communication infrastructure, but also of a catalyst for emerging services such as mobility and autonomous vehicles. This makes us focus on security issues and new solutions for 5G core networks and affiliated technologies such as IoT. By working with industrial partners and LIST colleagues, our efforts will lead to the development of reliable technologies and contribute to the construction of a resilient society. »

Qiang Tang,
5G & IoT Security Researcher

In the context of an increasingly interconnected world, there are new challenges involved in ensuring reliable and high-quality service systems that take into account the needs of all stakeholders. At LIST, our aim is to ensure a safe and optimal digital transition. This is why our research and innovation activities focus not only on mobility and logistics of tomorrow, but also on compliance, security, essential infrastructure, and data-intensive computing services.

Success story #1

A NEW REGULATORY PLATFORM FOR TELECOM OPERATORS

In July 2020, the Luxembourg Regulatory Institute (ILR) inaugurated the new SERIMA ("SEcurity RIsk MAnagement") risk analysis platform. Designed by LIST and the ILR and developed by Westpole Luxembourg SA, this platform enables operators to carry out analysis to assess risks in the telecommunications sector. It is a revised and scalable version of the TISRIM risk management tool, originally developed by LIST in collaboration with the ILR. Already adopted by the Belgian Institute for Postal and Telecommunications Services (IBPT), the competent authority in the Belgian telecommunications sector, SERIMA also counts application in other areas among its aims. It targets in particular the sectors covered by the NIS (Network and Information Security) Directive, and will also serve as a platform for incident notifications.

Success story #2

ENSURING THE SAFE AND OPTIMISED DEPLOYMENT OF 5G IN LUXEMBOURG

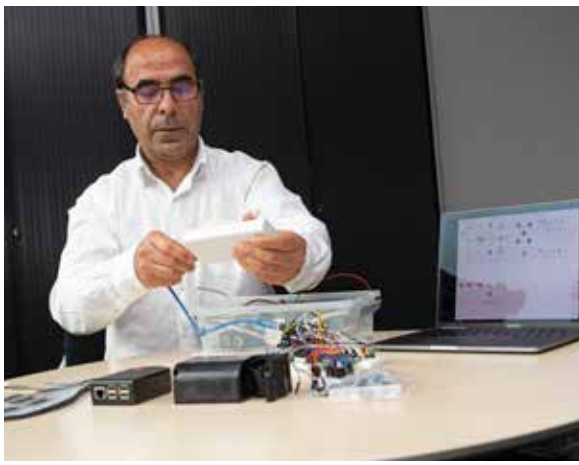
5G is based on a multitude of technologies with a variety of applications, some as yet unknown, which raise new issues. From the intensity of electromagnetic field (EMF) emissions to connected mobility or cybersecurity applications, the Institute is developing a multifaceted strategy to ensure the safe and optimised deployment of this new technology. In this regard, two LIST research projects were selected in 2020 by the Luxembourg Media and Communications Department (SMC) and will begin some time in 2021. Through one of them, the Institute will assess and facilitate the deployment of the 5G network in Luxembourg, taking into account the intensity of EMF

from base stations and current regulations. Our ambition: to develop a deployment monitoring platform for key stakeholders. This year FNR also selected a project co-ordinated by the University of Luxembourg in which LIST brings its expertise to the assessment of security issues in mobility applications operating 5G in cross-border areas.

Success story #3

TAKING ADVANTAGE OF DATA ECOSYSTEMS

Access to open data enhances transparency and the development of services, while stimulating economic growth. However, its potential is only rarely exploited, with a number of services created in a marginal manner. To overcome this problem, in 2016 LIST began to work with its partners, through an Interreg project, to unlock, reuse and extract the value of public sector information (PSI). They are now preparing to complete the development of innovative data-based services in the fields of health, infrastructure and the environment. The Institute was also commissioned by the Joint Research Centre of the European Commission (JIT) to issue recommendations on the implementation of ecosystems based on geospatial data. Completed in 2020, this study has helped to support the development of contemporary spatial data infrastructures and the implementation of data-based innovations, in line with the recently published European data strategy.



Success story #4

ASSESSING AND ENSURING DATA SECURITY

From economics to energy and modern technologies, LIST's multiple research activities in the field of data security all aim to support a strong, safe and ethical digital transition. Work is being carried out, for example, in partnership with the Ministry of Digitalisation, with a view to integrating Luxembourg into EBSI (the European Blockchain Services Infrastructure) through a case study of European use at a national level, while at the same time improving the robustness and overall security of EBSI. In collaboration with the University of Luxembourg, LIST is also interested in the development of procedures and tools for assessing the presence of "dark patterns" in online services. The objective: to reveal whether modern technologies instil false beliefs or influence users' behaviours without them realising. Lastly, a research project in collaboration with the ILR contributes to the use of the digitalisation of energy networks to improve the process of guaranteeing green electricity, understand citizens' consumption and production behaviour, and anticipate regulations and the impact of energy communities.

6. SUPPORTING THE DESIGN OF INNOVATIVE AND RESPONSIBLE MATERIALS

« Our activities are driven by industrial challenges to design and manufacture more lightweight, reliable and environmentally-friendly composite materials and structures. From raw materials to finished parts, our work allows us to understand interface phenomena, improve adhesion and reduce residual constraints. We also develop advanced modelling and digital simulation tools capable of understanding the links between scales and implementing them on a wide range of composite materials, including those with polymer matrix. »

Salim Belouettar,
Composite Materials Researcher

Committed with our partners to a strong and sustainable industry, we are designing the next generation of future composite materials. In order to ensure effective and environmentally-friendly design and manufacturing choices, we carry out collaborations and research which effectively combine modelling and experiments throughout the development chain: from engineering to production and design optimisation of structural composite materials and structures.

Success story #1

OPTIMISED RECYCLING OF COMPOSITES THROUGH CHEMISTRY

A new CORE project was granted by FNR and selected from over 30 proposals. Through this research, LIST wishes to incorporate smart chemical additives during the manufacture and assembly of composites. An innovative way to facilitate the separation of multi-material structures into single blocks, and the sub-parts of composites into raw materials. By promoting the repair, reuse and recycling of composite materials, the Institute aims not only to provide sustainable alternatives to stakeholders, but also to actively contribute to a responsible circular economy.

Success story #2

A DECISION SUPPORT SYSTEM TO BETTER CHOOSE AND DESIGN INNOVATIVE MATERIALS

In order to better understand societal issues and facilitate ecological and digital transition, while reducing potential costs and risks, manufacturers need to make informed decisions about the choice and design of materials. In 2017, LIST teamed up with strategic partners in Europe to develop COMPOSELECTOR: a decision support system – also known as "BDSS" – for the selection and design of polymer-based composites, which relies in particular on materials modelling and simulation. The research carried out by the Institute within this framework has enabled the devel-

opment of 11 major innovations making COMPOSELECTOR a unique recognised system. In 2020 and for the second year running, this project was identified by the European Commission's "Innovation Radar" as a high potential innovation. This tool enables manufacturers to improve selection and design phases, reduce costs and get used to digital innovation, by offering them the opportunity to adapt their activities to often volatile environments, thus guaranteeing them sustainable benefits.

Success story #3

A NEW FAMILY OF AEROSPACE AND AUTOMOTIVE MATERIALS

Together with strategic European partners, LIST aims to develop a new family of functional materials based on oxidised ceramic matrix composites (CMC) reinforced by oxidised ceramic fibres and carbon nanostructures. The aim: to transfer to the market a state-of-the-art material produced by 3D printing with improved thermomechanical properties and durability. These materials, which also incorporate mechanisms for detecting their structural quality, are very popular in the aerospace and automotive industries, in which monitoring the structural health of each part is of paramount importance. As such, for these sectors two functional prototypes will be produced and validated at Level 4 of the TRL (Technology Readiness Level) scale, including enhanced software to model mechanical properties and further optimise mechanical and detection performance.

Success story #4

A NEW WOOD FOR THE CONSTRUCTION INDUSTRY

Engineering wood structures have greater environmental benefits and lower intrinsic energies than conventional construction materials, such as steel and aluminium. However, the use of adhesives and metal fasteners poses problems which affect their durability, their recyclability and, more broadly, their environmental impact due to the emission of toxic gases. In order to ensure a sustainable approach at the design stage and throughout the life cycle of a product, LIST has developed a more environmentally-friendly technology for attaching wood laminates and structural elements with compressed wood (CW) dowels and fasteners. In collaboration with Luxinnovation, this high potential innovation, which comprises LIST's simulation tool and the promising wood components of its partner, resulted in a presentation to over 70 manufacturers in 2020.

7. NANOTECHNOLOGIES & NANOMATERIALS: VECTORS OF A DIGITAL AND SUSTAINABLE INDUSTRY

Our motto: impact is the driver of our excellence. Our research is guided by our desire to provide innovative solutions for the social, economic and environmental challenges of a society in transition. From energy challenges to health and cosmetics, we carry out fundamental work, such as the application of nanotechnologies and nanomaterials, which enable the transfer of high-performance technologies and processes to the market. By combining the nanometric scale control of materials with revolutionary chemistry, we ensure the development and application of unparalleled properties.

> « Within our unit, we develop so-called smart materials, which are capable of responding to various stimuli. Some can play a key role in hydrogen production or cosmetic products, while others create cold temperatures from an electrical voltage. Our work is recognised at the highest global level. »
>
> Emmanuel Defay,
> Head of the Ferroic Materials for Transducers Group

Success story #1

A REMARKABLE STEP FORWARD FOR THE FRIDGES OF TOMORROW

Approximately 20% of global energy consumption is used on refrigeration, and the total number of air conditioning units is expected to double by 2040, according to the International Energy Agency. As a source of greenhouse gases and noise pollution, current refrigeration systems, based on vapour compression, have reached their thermodynamic limit after 100 years of progress. The development of highly efficient and environmentally-friendly energy systems therefore plays a major role in mitigating global warming and promoting the sustainable use of natural resources. On 2 October 2020, LIST made a remarkable step forward in this direction with the publication of promising electrocaloric materials results in the prestigious magazine Science. Researchers crossed a crucial barrier by attaining a temperature differential of 13 degrees around ambient temperature in a prototype heat exchanger. As a result of several years of efforts in the field, this work confirms the value of electrocaloric materials for sustainable and responsible cooling applications.

Success story #2

IN SEARCH OF SUSTAINABLE HYDROGEN PRODUCTION

The Materials Department at LIST has made energy one of its strategic priorities and is exploring several possibilities that would enable the hydrogen sector to be viewed as a serious solution to the energy challenges of the 21st century. As such, the Institute has partnered with 3D-Oxides, a French company which develops functional materials with unique properties using CBVD (Chemical Beam Vapour Deposition) technology. This partnership, signed in April 2020 for a term of four years and including the setting-up of a joint laboratory, aims to conduct a research programme on the development of new materials for the hydrogen sector required to make fuel cells with a low catalyst content and to develop new generation electrolysers and high-performance photoelectrocatalytic systems. The ultimate goal: to make the splitting of water, or the recombination of the elements that make it up, easier, more efficient and more affordable, in an environmentally-friendly way.

Success story #3

MAKING THE MATERIALS OF THE FUTURE: MOVING TOWARDS BIOSOURCING

The marketing of natural cosmetics faces major limitations. Current technologies do not permit effective protection of the most sensitive active compounds. With a view to addressing this problem and promoting the development of effective natural products, the Institute has partnered with the prestigious company SRC-Nuxe through a new research project co-funded by FNR in December 2020. The aim of this research is to transfer to the market technologies which enable the responsible sale of new natural cosmetics products. To do this, LIST will draw on its wealth of expertise in the manufacture and engineering of biosourced particles.

8. INNOVATION IN CUTTING-EDGE INSTRUMENTS, PROCESSES AND TECHNOLOGIES

« Through our new PlaSprayNano project, we continue our quest for the clean fuel of tomorrow: hydrogen. The aim of our research is to develop a process for the synthesis of bi-material nanoparticles which enable the production of hydrogen just from sunlight and water. »

Simon Bulou,
Plasma Processes and Applications Researcher.

We are working to push the boundaries of current manufacturing and characterisation processes to develop new instruments, processes, and methodologies that are essential for an efficient standalone industry. From research to innovation, our activities draw on our fundamental knowledge to devise innovative industrial-scale demonstrators. Our expertise focuses in particular on plasma sciences and technologies, thin-film processing and nanoanalysis, and we are strengthening our position in the modelling and process automation field. Our aim is to put in place automated synthetic infrastructures which can self-optimise according to pre-defined target parameters, increasing the overall efficiency of the systems.

Success story #1

A REVOLUTIONARY, INTERNATIONALLY-RECOGNISED MICROSCOPE

LIST has been awarded the prestigious "Microscopy Today Innovation Award 2020" for its revolutionary mass spectrometry system. Back in 2011, LIST began to research microscope technology that is capable not only of observing samples in their entirety, but also of simultaneously establishing what they are composed of. This major breakthrough in the world of microscopy has been internationally recognised, and led to the creation of the spin-off start-up LION Nanosystems in 2018. The mass spectrometer, developed by the Institute in close collaboration with the company Zeiss, now forms part of the top-of-the-range ionic microscopes of all major manufacturers, and enables visualisation and chemical characterisation with nanometric resolution. The prize awarded to LIST thus highlights both its scientific and technological innovation and its commercial success. This "made at LIST" research has significantly advanced the nanometric-scale understanding of the physico-chemical mechanisms that govern the most strategic technologies of society post-COVID-19: semiconductors, batteries and hydrogen.

Success story #2

LIST'S PLASMA TECHNOLOGY FOR THE ADMINISTRATION OF MEDICINES

In 2020, LIST achieved promising first results for one of its research projects, the aim of which was to revolutionise the performance and properties of hydrogels. These gels have a wide spectrum of applications in the medical field and elsewhere. For example, they can be used in contact lenses, or to promote the healing process in implants. By combining two of its atmospheric pressure plasma polymerisation technologies, the Institute aims to provide a cost-effective and flexible new approach to the preparation of hydrogel coatings. Through the direct deposition of coatings loaded with antimicrobial peptides, LIST has obtained excellent antibacterial properties on plastic and metal surfaces at log level 6 (used in the medical sector to refer to a highly effective sterilisation process). The deposition approach has also made it possible to strengthen the biocompatibility of 3D-printed zirconia surfaces.

Success story #3

A NEW METHOD OF QUANTITATIVE IMAGING ON A NANOMETRIC SCALE

In 2020, LIST was the very first to demonstrate simultaneous bright and dark field imaging using transmitted helium ions. An innovative process for the world of microscopy, the use of transmitted helium ions, instead of electrons, allows new functionalities. Due to the nature and size of these ions, new contrast methods are available, even for the sub-superficial characteristics of a sample. This imaging method also enables the quantitative study of variations in ionic transmission and angles of diffusion with nanometric scale lateral resolution. These results, confirmed by proof-of-concept demonstrations, pave the way for advanced experiments in fundamental physics as well as applications in materials technologies, such as semiconductor circuit editing.

9. REINVENTING PLASTIC MATERIALS: SUSTAINABLE, HIGH-PERFORMANCE BIOSOURCED POLYMERS

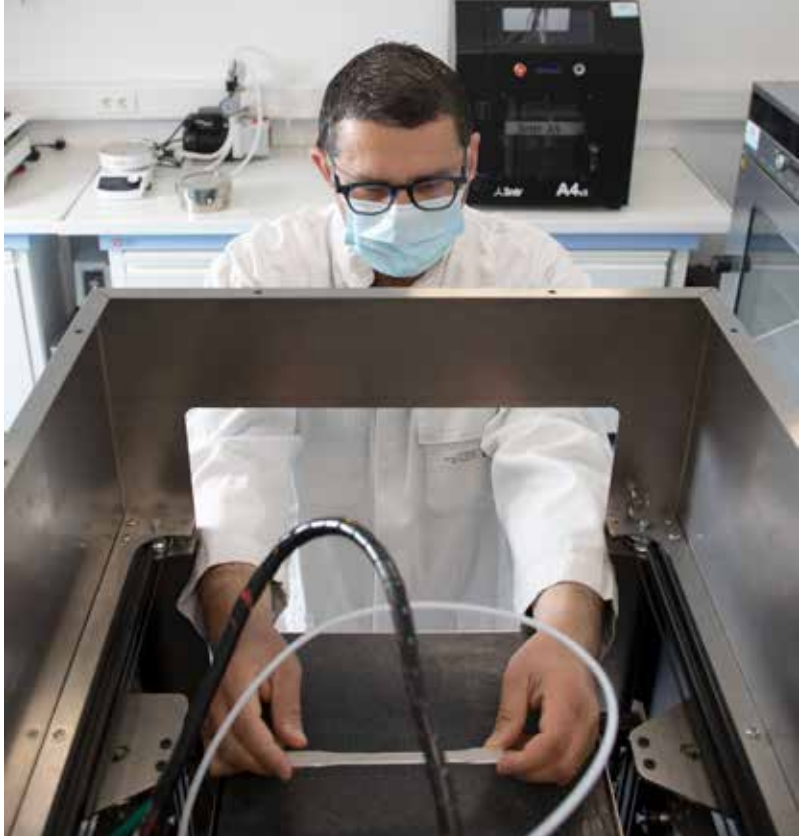
Working closely with our national and international partners, we synthesise, formulate and process polymers to transfer to the market optimised multifunctional materials. Functional polymers are extraordinary macromolecules with unique properties of great interest for a wide range of sectors, including the aerospace and automotive industries. We strive to fully exploit the potential of these polymers in order to facilitate the sustainable transition of our society. LIST's research activities focus on the development of sustainable polymer materials, as well as the chemistry and physics of so-called smart/reactive polymers.

> « One of the activities our unit is involved in is the development of new thermoset resins for the development of new, sustainable materials. As part of an internal project, we are developing new repairable, reusable and recyclable composite materials from biosourced resins. »
>
> Laura Puchot,
> Biopolymers and Functional Polymers Researcher

Success story #1

PATENTED VEGETABLE OILS FOR OPTIMISED TYRES

In 2020, our collaboration with Goodyear once again attracted the attention of the international scientific community at the prestigious virtual "International Elastomer Conference". Young PhD student Arpan Datta Sarma was awarded the "2020 Best Presentation Award" for his presentation of the research carried out within the framework of this partnership, on the subject of the modification of vegetable oils and in-depth study of their effect on the treatment and performance of new SBR rubber compounds loaded with silica. This innovative research has already led to the development of oils modified and patented by LIST. These not only improve the treatment of the rubber that makes up Goodyear tyres, but also its rolling resistance. Prior to this discovery, there were no available treatment additives which could perform both of these functions together.



Success story #2

3D PRINTING: AT THE HEART OF OUR COLLABORATION WITH GUALA CLOSURES

Additive manufacturing is an innovative solution for the development of multifunctional forms and parts. However, these elements pose major challenges when used in an industrial context. In order to guarantee their quality and even improve their design, it is essential that we know and are able to precisely measure both internal mechanical loads and the constraints and deformities to which they are subject depending on conditions of use and mechanical demands. With this in mind, LIST and the Guala Closures Group have been working together within the framework of a new research project funded by FNR. Their aim is to integrate sensors measuring *in situ* the deformation of parts manufactured additively and subject to various constraints, in particular temperatures. In the medium to long term, these smart structures should help reduce maintenance costs, detect critical failure parameters in real time, and control their integrity.

Success story #3

TOWARDS SAFE, EFFECTIVE AND FLEXIBLE SUPERCAPACITORS

Because of their power and energy density, supercapacitors are very popular for storing and returning energy quickly. They offer many advantages in areas such as mobility. Started in 2019, a LIST research project, in collaboration with two international partners, has made considerable progress for the future generation of polymer electrolyte-based supercapacitors. As a result of the work carried out on the project by PhD students and researchers, as many as eight new Polymeric Ionic Liquids (PILs) with high ionic conductivity have been synthesised, one of which is among the five most conductive PILs to date.

10. TOWARDS THE USE OF SPACE RESOURCES

«ESRIC's mission is focused on infrastructure and research activities, commercial partnerships and support for start-ups, as well as community relations and knowledge management. In terms of research, we shall begin to set up a state-of-the-art laboratory and install a variety of demonstrators for the extraction of oxygen and metals from lunar regolith.»

Mathias Link,
Acting Director of the ESRIC Department

2020 was marked by the creation of a unique research department: the «European Space Resources Innovation Centre – ESRIC». As a result of a joint initiative between LIST, the European Space Agency (ESA) and the Luxembourg Space Agency (LSA), this innovation centre strengthens the position of Luxembourg as a key player in the exploration and use of space resources.

From the extraction of *in situ* resources to their use for different applications in space, the activities will cover the entire value chain for high-impact innovation. ESRIC therefore aims to become an internationally recognised centre of expertise from a scientific, technical and economic perspective. Through its active support for business initiatives and start-ups, the new LIST Department will contribute significantly to the transfer of technology as well as to the economic growth of Luxembourg.

Timeline

1. FIRST MEMORANDUM

ESRIC follows on from the "Memorandum of Cooperation in the field of Space Resources" signed by Luxembourg and the ESA at the ESA Council meeting at ministerial level (Space19+) in November 2019 in Seville.

2. COOPERATION AGREEMENT

On 4 August 2020, a cooperation agreement for the implementation of the national component of ESRIC was signed between the Ministry of the Economy (the supervisory body of LSA) and LIST. In the first phase, this innovation centre was created in the form of a new LIST department at the Belvaux premises.

3. IMPLEMENTATION AGREEMENT

An implementation agreement covering ESRIC's cooperation activities was signed between the Ministry of the Economy (the supervisory body of LSA), LIST and the ESA on 18 November 2020. The terms of this agreement state that the ESA will provide equipment, implement research activities within ESRIC and provide technical and commercial support for a new support programme for start-ups.

4. INAUGURATION OF ESRIC

ESRIC was inaugurated at LuxExpo on 18 November 2020, in the presence of the Minister of the Economy, Franz Fayot, and the Minister of Higher Education and Research, Claude Meisch. This hybrid event, which also saw the unveiling of the official ESRIC website, was broadcast live to more than 1,300 people.

Funded by the Ministry of the Economy, ESA, LIST and FNR, ESRIC forms part of the SpaceResources.lu government initiative launched in 2016 to establish an ecosystem that encourages the development of activities related to space exploration and the use of space resources.

esric
powered by LSA, ESA & LIST

OUR RESEARCH INFRASTRUCTURE

FOCUS ON AREAS OF KEY INFRASTRUCTURE

Our research and technology infrastructure in the fields of the environment, computing and materials are there to serve our continued quest for high-impact innovation. We use our multidisciplinary expertise and complementary state-of-the-art equipment to develop new processes and technologies which enable the market launch of unique solutions and products for public and private companies in Luxembourg, as well as other European countries.

In 2020, LIST set a new direction for a strong and strategic industry. Through the expansion and reorganisation of our research and technology infrastructure, our aim is to ensure the competitive positioning and international visibility of our stakeholders within their sectors of activity: from the aerospace and automotive industries to cosmetics, health, energy, the environment, biotechnologies, smart construction, finance technologies and Information and Communication Technologies.

Ambitious business extensions will not only help push the boundaries of research, but also develop new pilot lines to meet the needs and challenges of our society, economy and environment. Through the acquisition of new premises at our Hautcharage and Belval sites, the Institute also aims to promote new synergies and collaborations with its partners.

THE COGNITIVE PILLAR: TOWARDS A DIGITAL TWIN AT NATIONAL LEVEL

Launched in September 2019, the cognitive pillar, or CogPil, links up with our visualisation wall (VisWall) and our HPC to form the Data Analytics Platform. This unique infrastructure, funded in part by the European Regional Development Fund, covers the entire range of data analytics activities, and aims to support the research capabilities of LIST and its partners, as well as foster innovation and collaboration.

In a world in digital transition, CogPil makes it possible to fully exploit the potential of big data and highlight its potential to provide solutions in the form of high-value-added services in data/business analytics, optimisation, artificial intelligence and big data. In parallel with the efforts to configure and optimise CogPil, the first case studies were carried out in 2020 in collaboration with partners of the Institute, such as Ceratizit, one of the stars of industry in Luxembourg, in order to use the value of their data to improve production processes.

The benefits identified and demonstrated by the authorities in Luxembourg through initial monitoring schemes and simulation scenarios as part of the fight against the COVID-19 pandemic. In combination with VisWall, the cognitive pillar is a strategic tool for informed, transparent decision-making that will shape tomorrow's smart society. FNR has also selected the Institute for its first Digital Twin project at national level. This revolutionary technology will enable the virtual representation of physical systems, infrastructure, human behaviour and assets throughout the country. Initial use cases have been identified and the architecture will be set up during 2021.

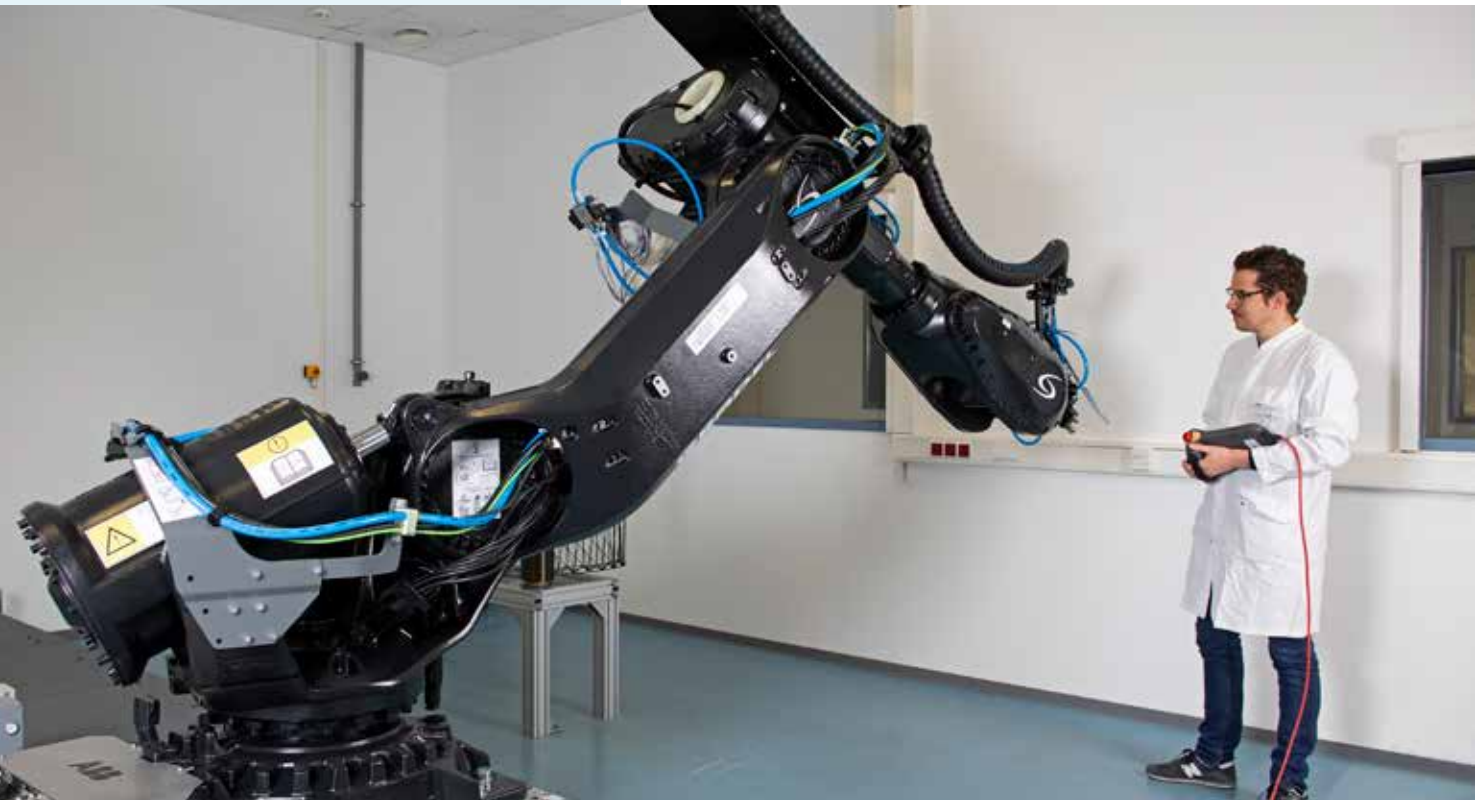
SPACE: A STRONG INTERDEPARTMENTAL SYNERGY

In 2020, LIST hosted a new strategic research department for the exploration and exploitation of space resources, placing Luxembourg firmly on the international stage: the "European Space Resources Innovation Center – ESRIC". The result of a joint initiative between LIST, the European Space Agency and the Luxembourg Space Agency (LSA), this innovation centre continues to be installed alongside our cutting-edge materials platforms. One of its main objectives is to extract water from the surface of the moon. A challenge for which our expertise and platforms in advanced material transformation and characterisation, as well as our knowledge of exohydrology, are essential. This natural bridge between our research departments has already resulted in the development and submission of joint research projects to the ESA and FNR.

EXPANSION OF MATERIALS PLATFORMS FOR COMPETITIVE SEMI-INDUSTRIAL SOLUTIONS

Materials research and technology platforms offer a combination of recognised scientific and technological skills and cutting-edge equipment in the fields of advanced characterisation, testing, composite manufacturing and prototype engineering. As a driver of our excellence, the Institute's platforms allow us to push technological boundaries every day in order to support our industrial partners in their development. This is why we are continuing to expand with the introduction of new high-performance laboratories and equipment to offer advanced solutions on a semi-industrial scale.

An example of this is the automated combination of a hydraulic press, capable of applying pressure up to 300 tonnes and equipped with a 700 x 700 mm heater plate up to 420°C +/-3°C, with a 6-axis maintenance robot and an infrared oven. It is an outstanding pilot line within our composite materials manufacturing platform, which further positions the Institute as a strategic partner in the automotive, transport, aeronautics and space sectors. LIST has also acquired a new 15-metre pilot line for physical vapour deposition, which will be fully operational in 2022.



GREENTECH INNOVATION CENTRE: SUSTAINABLE PRE-INDUSTRIAL PRODUCTS & PROCESSES

The GreenTech Innovation Centre is an open innovation facility focusing 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. Established in 2016, this centre has established itself as a strong and reliable player in advanced solutions and services in sectors such as industrial biotechnology, biocontrol, biowaste and biomass valorisation, cosmetics and environmental health.

Our goal: to meet the national and regional needs of private companies and society for a sustainable and resilient circular bioeconomy, by providing a solid capacity to develop pre-industrial production. To achieve this, the GreenTech Innovation Centre will see its initial surface area almost triple in 2022, with the installation of new pilot lines including, in particular, bioreactors with a capacity of up to one cubic metre. Following in-depth market analysis carried out in 2020, this reorganisation and expansion of research activities will also provide the centre with the opportunity to increase spaces in higher-grade security laboratories in order to develop biotechnology activities, as well as in laboratories shared with manufacturers.

A NEW PLATFORM FOR CENTRALISED NATIONAL HYDROCLIMATOLOGICAL DATA

The Observatory for Climate, the Environment and Biodiversity (OCEB) combines the know-how, expertise and multidisciplinary knowledge of our researchers and engineers with our state-of-the-art technological infrastructures to meet the scientific, environmental and social challenges of a changing world. Our sampling procedures and approach to field data collection aim to provide innovative monitoring and evaluation of the different components of the "Critical Zone", a thin layer of the Earth's surface where rock, soil, water, air and living organisms interact with each other.

From the scientific community to national and European policymakers and research offices, we offer a wide range of services to support our stakeholders through the recent organisation of the OCEB into two strategic hubs: one focusing on biodiversity monitoring and assessment and the other on hydroclimatological observation and detection technologies. In 2020, the latest also inaugurated and made available to all a new data platform based on hydroclimatological observations carried out since the 1990s in Luxembourg, particularly at experimental watersheds ranging from 0.45 to 410 square kilometres. Future stages will focus on making this environmental data available in near real-time through an online "made by LIST" platform.

OUR COLLABORATIVE MODELS

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

Whether you would like to collaborate with our experts in specific strategic areas for the development of your business, or whether you would prefer to use our infrastructure boasting cutting-edge technologies and processes, choose the appropriate bilateral collaborative model for you:

COLLABORATIVE PROJECT

This is a bilateral agreement in which LIST invests alongside you. We share our resources, expertise and infrastructure. Within the framework of a collaborative project, the innovation costs are shared, and the intellectual property belongs to clearly-identified contributors.

For example, we are addressing the challenges of cost-effective and environmentally-friendly hydrogen production through a collaborative project with the French company 3D-Oxides. Signed in April 2020 for a duration of four years, its aim is to conduct a research programme focused on energy, and in particular on the development of new materials for the hydrogen sector. This bilateral research led in particular to the setting-up of a joint laboratory where 3D-Oxides' expertise in Chemical Beam Vapour Deposition (CBVD) processes is combined with our expertise in the synthesis of thin-film functional materials, in the characterisation of these materials and in the prototyping of functional devices.

STRATEGIC PARTNERSHIP

For outstanding and sustainable results that require a variety of skills: we jointly define a framework agreement for a medium or long-term strategic R&D partnership based on your own innovation road map. 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.

To support ArcelorMittal in its ambition to significantly reduce its carbon footprint by 2050, in line with its commitment to the Paris Agreement, we have established a five-year strategic partnership with this key player in Luxembourg industry. Since 2019, we have been working together on the research and development of innovative projects and services in the fields of increased 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 objective: to support ArcelorMittal in its transition towards a green economy and steel production.

"SPIN-OFF" OR "LICENSING"

Technology transfer is an important part of the valorisation process and involves bringing our know-how to market through the creation of new companies (spin-off) or by licensing 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.

For the new spin-off WASDI, it all began with the patented LIST technology known as HASARD®, which enables the generation of accurate flood maps from satellite data on a global scale (see "Monitoring natural disasters in near real-time" p. 6 for more information). Potential for the application of this "made by LIST" tool has attracted attention. The companies FadeOut Software and RSS-Hydro have joined forces with us to bring WASDI to life and to deploy other fields of application, such as forest fire mapping.

STRATEGIC PROGRAMME

LIST facilitates synergies between partners by bringing them together to share the benefits of its skills, talents and infrastructure. The sharing of expertise, research, investment and risks between several 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: a modern research and technology infrastructure and first-rate talents. How does it work? We put a strategic programme in place that we run and review over several years. This is a multilateral agreement that involves the sharing of intellectual property between the various project partners.

SERVICE AGREEMENT

For results that help you to achieve your innovation aims quickly: our highly-qualified experts are at your disposal. The service agreement may also cover the provision of our infrastructure. You can access unique laboratories, equipment and know-how to meet a very specific or one-off need. You can thus make optimal use of our experience, particularly in the fields of testing, measurement, analytics, and method and software development. We offer an extremely wide range of standardised and customised services. As part of the service agreement, you bear all the costs but obtain quick results in return.

With a view to making informed decisions during the COVID-19 pandemic, the Luxembourg Government Ministry of Health has drawn on our leading-edge expertise and infrastructure for the visualisation of data related to the crisis in the Grand Duchy. Thanks to innovative graph visualisation software developed at LIST, epidemiologists at the Ministry of Health have been able to have a comprehensive and accurate view of sources of infection and channels of transmission of the virus.

SHARING OUR KNOWLEDGE WITH SOCIETY AND BUSINESSES

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.

For example, our passionate scientists are transferring their knowledge in environmental impact analysis to Luxembourg society through an interactive and public conference cycle called "So you think you're green". At each conference there is a key theme: mobility, housing, food, expenses. We also support small, medium and large companies in their compliance with environmental regulations, and raise awareness of the benefits of doing so. Several dedicated national platforms, such as Betriber & Emwelt or the Reach&CLP Helpdesk, raise awareness on a daily basis and inform entrepreneurs in Luxembourg about the evolution of regulations.

There is no age limit for creativity, innovation and ambition. This is why our engineers, technicians and researchers are playing an active role in events for the general public, sowing the seeds of passion and introducing younger generations to the world of research.

RDI PARTNERS IN LUXEMBOURG AND EUROPE

3D-OXIDES
adwäisEO
anisoprint
ArcelorMittal
armacell
BrighterBins
CUTTING SOLUTIONS BY CERATIZIT
CIRCUIT FOIL LUXEMBOURG
CLE
CONVIS
DUPONT
DYNACCURATE
Electris
#Believe InSmall
YOUR FUTURE
FONDATION ENOVOS
GCL INTERNATIONAL
FREWITT
GOODYEAR
GRADEL
hap2U
HOUSE OF ENTREPRENEURSHIP
HYDROSAT
a sense for innovation IEE
Infrachain
INTRASOFT INTERNATIONAL
ispace
LUXMOBILITY
LUXPLAN S.A.
LUXSENSE geodata s.à r.l.
Maastricht University
MET-LUX
mpg.
Myriado Cleantech
NO-NAIL BOXES
OHB LUXSPACE
PHILIP MORRIS INTERNATIONAL
Pierre Fabre
PM-International
POLYGONE votre partenaire
Post
probiotic Group
proximus
ROAMSYS
ROTAREX VALVES - FITTINGS - REGULATORS
RSS-Hydro
SIACH
sisaf
life.augmented
Succy
SÜD STROUM
VILLE DE LUXEMBOURG
XNRGI
ZEISS
ZEROK 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 de l'Agriculture,
de la Viticulture et du
Développement rural

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SUPPORTING RESEARCH

Our vision: to become a benchmark in research and innovation for a resilient and sustainable digital society. In order to achieve this ambition, the Institute's central and RDI departments work closely together. Since 2019, a number of continuous improvement projects have therefore been set up in order to ensure consistency and efficiency between all of LIST's activities. From human resources to infrastructure and communication, the agility and adaptability of our staff have been amply demonstrated during this year, marked by the COVID-19 pandemic. In the context of the crisis, they have been able to very rapidly deploy safe and flexible working conditions for all.

> « When it comes to building a house, every resident has their own ideas. Our mission is to build an environment together where everyone feels at home. »
>
> Sabina Quijano,
> Diversity and Inclusion Officer

PROMOTING INDEPENDENT RESEARCH IN A RESPONSIBLE AND SUSTAINABLE WORKING ENVIRONMENT

Respect is at the heart of LIST's values, whether towards the environment or its employees. In order to foster a responsible and sustainable work ecosystem, a "Sustainability at LIST" team has been set up, combining representatives from our central and research departments. During 2020, this working group carried out a detailed assessment of the Institute's carbon footprint and issued initial recommendations. The latter, approved by the Management Committee, will be implemented as early as 2021.

For us, diversity is synonymous with personal and professional wealth. This driver of innovation can only be fully expressed when intercultural bias is wiped out to make room for respect. To achieve this, Sabina Quijano is in charge of the new "Diversity & Inclusion" project at LIST. As a first step towards establishing the foundations of an inclusive corporate culture, a comprehensive review began at the end of the year with the aim of defining a Charter for Diversity and Inclusion in 2021. Parallel initiatives are being carried out with a view to implementing in 2021 a Code of Ethics and Ethical Committee adapted to the Institute's administrative, research and partnership activities. Since 2016, LIST has also been a member of the Luxembourg Agency for Research Integrity (LARI), which aims to promote responsible research conduct and to ensure independent inquiry and investigation in the event of suspected scientific misconduct.

ATTRACTING AND SUPPORTING NEW TALENT

As a result of preparatory work carried out in 2019, the recently-established "Talent acquisition" team has helped identify and attract more than 80 new talents over the course of the year. Continued success with the configuration of "Skeeled", a new predictive talent acquisition software which will be rolled out in early 2021. Our human resources assignments in 2020 also focused on developing new tools and resources to best support each individual in his or her professional development. In the face of the pandemic, offers of professional training have been adapted, in particular by making the LinkedIn Learning platform available to all. Preparatory work has also been initiated and will continue in 2021 with a view to offering employees the opportunity to develop their Personal Development Plan.

A SAFE AND RELIABLE RESEARCH ENVIRONMENT

Due to its research activities, LIST faces significant risks to health, safety and the environment. From gas equipment to electrical installations and chemicals, multiple aspects are taken into account to ensure a safe working environment. As such, an internal continuous improvement project is working on the development and optimisation of tools, training, systems and procedures in order to maintain the Institute's "Zero Objective" and eliminate any risk of serious accident. In addition to an internal awareness campaign, preliminary studies carried out in 2020 made it possible to draw up an action plan for an improved tool for monitoring incidents, accidents and regulations, as well as to submit new chemical inventory software for tender, and to draw up a framework of standardised biosafety directives.

To ensure a reliable and innovative work environment, LIST is also interested in its management of research data. An in-house survey was conducted with a view to drawing up recommendations and developing optimised solutions to effectively store and process the Institute's research data during its life cycle. This new tool is expected to be launched soon. It will also enable researchers to be supported in managing their project data, for which funding agencies increasingly require a defined management plan.

PUSHING THE BOUNDARIES OF INNOVATION

Impact is the driving force behind our excellence and many of LIST's initiatives are designed to ensure the transfer of research results to the market. In order to encourage strategic technological innovation, the Institute decided to create a "Technology Transfer Office - TTO" in 2020. The TTO will support LIST in its mission by transferring our technologies and promoting the commercialisation of our research across several fields of action, such as industrial partnerships, European affairs and intellectual property, as well as consulting and incubation for start-ups.

LIST has also supported innovation by implementing a policy governing the launch of new companies and processes relating to intellectual property. Lastly, the Institute has also strengthened its CRM for optimised partnership management and active market surveillance within our RDI departments.

OPTIMISED MONITORING FOR GREATER EFFICIENCY

Regardless of its nature, each project requires efficient and harmonious management with clearly-defined roles and responsibilities for those involved. To this end, an internal project began in 2019, and 2020 saw the continuation of its first phase, focused on defining the process. As part of this, approximately 60 projects were selected during that year. The second phase will focus on the performance of the project, its archiving, feedback, and also on tools. As a continuous improvement initiative, a survey will also be carried out in 2021 in order to gather constructive proposals from LIST's stakeholders.

Started in 2019, optimisation efforts carried out to ensure more effective financial returns (reporting, analysis) have proved successful. New reports are now available to our researchers via the BusinessObjects platform. A new application has also been deployed to better manage and leverage the resources involved in our projects. This ergonomic and intuitive interface provides both a holistic and individual view of the efforts invested.

LIST IN A NUTSHELL

HUMAN RESOURCES

As at 31/12/2020

646 employees

65 % men

35 % women

54 nationalities

76 % researchers or innovation experts

For the entirety of 2020

83 people recruited in 2020

94 PhD students hosted at LIST in 2020

SCIENCE AND TRANSFER

30 FILED PATENTS

9 paid licences

205 scientific articles in 1st quartile journals

1 spin-off

R&D PROJECTS IN PROGRESS IN 2020

110 national competitive projects

36 competitive European projects

1 international competitive project (outside the EU)

6,58 % of income from services

128 collaborative projects and similar

∑ 345 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.

INTERNATIONAL COLLABORATIONS

NUMBER OF CONTRACTS IN PROGRESS BY COUNTRY

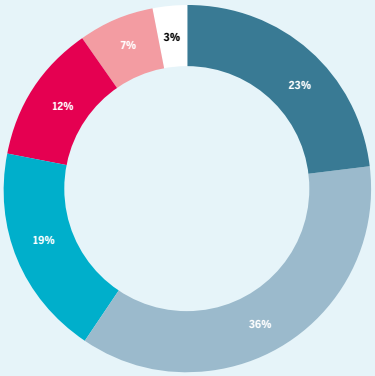
EUROPE

France	110
Germany	68
Belgium	59
Spain	56
Italy	52
United Kingdom	44
The Netherlands	38
Portugal	28
Austria	21
Greece	20
Finland	19
Turkey	14
Denmark	12
Hungary	11
Poland	10
Czech Republic	9
Bulgaria	8
Norway	8
Switzerland	8
Croatia	6
Ireland	6
Sweden	6
Cyprus	5
Estonia	5
Lithuania	5
Latvia	4
Slovakia	3
Slovenia	3
Romania	2
Albania	1
Serbia	1
Ukraine	1
Iceland	1

WORLD

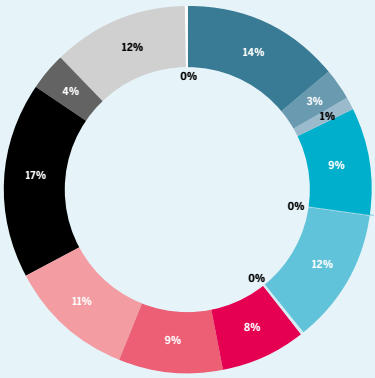
United States of America	11
Canada	3
Tunisia	3
Egypt	2
Israel	2
Australia	1
Ethiopia	1
Iran	1
Morocco	1
Sierra Leone	1
Singapore	1

BREAKDOWN BY TYPE OF PARTNER OF ONGOING PARTNERSHIPS IN 2020



- Universities (156)
- Companies (243)
- Research centres (125)
- Public institutions (82)
- Foundations and associations (46)
- Others (19)

MARKET COVERAGE OF ONGOING PARTNERSHIPS IN 2020



- Agro & Natural resources (112)
- Automotive / Aeronautics (22)
- Biotech / Cleantech (9)
- Construction (74)
- Educational Tech (1)
- Energy (94)
- Fin Tech & Reg Tech (2)
- Health & Med tech (60)
- Homeland security (73)
- ICT (88)
- Industry (136)
- Logistics (28)
- Mobility (94)
- Space (1)

DOCTORAL THESES DEFENDED

ANTONELLI Marta:

"Tracing hydrological connectivity", University of Wageningen, 25/05/2020

BENGASI Giuseppe:

"Synthesis and Deposition of Directly Fused Porphyrin Tapes by Chemical Vapour Deposition Approach", University of Mainz, 08/05/2020

BERTUCCI Marie:

"Bioprospecting for new carbohydrate active enzymes from the microbiomes of the termite gut and the anaerobic digestion process: an omics mediated approach", Université Catholique de Louvain, 18/12/2020

CHARY Aline:

"In vitro model development for the assessment of the sensitizing potential of chemicals at the alveolar barrier", University of Trier, 29/06/2020

DAHER Elie:

"Enabling Participation In Performance-Driven Architectural Design In The Early Design Stage", KU Leuven, 27/11/2020

DEPAIFVE Sébastien:

"Thermal conductivity enhancement of graphene nanoplatelets/epoxy composites - covalent functionalization with nitrene chemistry for reducing the interfacial thermal resistance", Université du Luxembourg, 11/09/2020

GLASER Barbara:

"On synergies between spatially-distributed, physically-based simulations and field observations in catchment hydrology", University of Bayreuth, 30/04/2020

GODART Nicolas:

"Inkjet-printed piezoelectric films for transducers", Université du Luxembourg, 15/07/2020

MARYNOWSKA Martyna:

"Unravelling the termite digestion process complexity - a multi-omics approach applied to termites with different feeding regimes", Université libre de Bruxelles, 24/04/2020

PEREIRA GONCALVES Mauro:

"Study Of Complex Ferroic Oxides By Large-Scale First-Principles Simulations", Université du Luxembourg, 20/07/2020

RASTOGI Rishabh:

"Engineered Electromagnetic Hot-Spots For Highly Sensitive (Bio)Molecular Detection By Plasmonic Spectroscopies", Université de Technologie de Troyes, 06/11/2020

RODRIGUEZ Nicolas:

"Improving the conceptualization of the streamflow travel time distribution and its estimation from isotopic tracers", Karlsruhe Institute of Technology (KIT), 04/02/2020.

LIST AT A GLANCE

BOARD OF DIRECTORS 2020

Photo from left to right: Robert Kerger, Etienne Jacqué, Letizia Lukas, Candi Carrera, Thomas Kallstenius, Marie-Christine Mariani, Eva Kremer, Jacques Lanners, Tom Battin, Caroline Roch, Diane Wolter, Isabelle Kolber and Stéphane Jacquemart

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CEO

Stéphane Jacquemart
Chair of the Staff Delegation

GOVERNMENT COMMISSIONER

Robert Kerger
Advisor to the Ministry of Higher Education and Research

ADMINISTRATIVE SECRETARY

Caroline Roch
Head of legal service

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Eva Kremer
Deputy director of the Société Nationale de Crédit et d'Investissement (Luxembourg) - Vice-chairman

Tom Battin
Professor at the Ecole Polytechnique Fédérale de Lausanne (Switzerland)

Candi Carrera
Country manager at Microsoft Luxembourg (Luxembourg)

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Letizia Lukas
Managing director of exigo SA (Luxembourg)

Marie-Christine Mariani
CEO of MCM SARL (Luxembourg)

Diane Wolter
Independent philanthropy advisor (Luxembourg)

EXECUTIVE MANAGEMENT

Dr Thomas Kallstenius
CEO

RDI DEPARTMENTS

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

Dr Mathias Link
Acting Director, European Space Resources Innovation Centre (ESRIC)

Prof. Dr Eric Dubois
Director, IT for Innovative Services (ITIS) until 31/07/2020

Dr Markus Eisenhauer
Director, IT for Innovative Services (ITIS) from 01/08/2020

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

HUMAN RESOURCES

Kristel Wiliquet
Human Resources Director

FINANCE & ADMINISTRATION

Laurent Cornou
Administrative and Financial Director

BALANCE SHEET AS AT 31 DECEMBER 2020

APPROVAL OF ACCOUNTS

The accounts were audited by statutory auditors PricewaterhouseCoopers and approved by the Board of Directors during their meeting of 23 April 2021.

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

Assets (in euros)	2020	2019
Fixed assets		
Intangible fixed assets	696.967,11	658.491,56
Concessions, patents, licences, trademarks and similar rights and assets	696.967,11	658.491,56
Tangible fixed assets	27.440.114,82	23.636.202,55
Land and buildings	331.786,91	459.697,36
Plants and machinery	20.397.924,66	20.234.147,74
Other fixtures and fittings, tools and equipment	1.380.744,02	1.223.056,31
Payments on account and tangible assets under development	5.329.659,23	1.719.301,14
Financial fixed assets	468.832,74	460.938,20
Shares in affiliated undertakings	415.938,20	410.938,20
Amounts owed by affiliated undertakings	-	-
Securities held as fixed assets	52.894,54	50.000,00
Total fixed assets	**28.605.914,67**	**24.755.632,31**
Current assets		
Inventories	488.118,66	374.088,69
Raw materials and consumables	488.118,66	374.088,69
Receivables	32.031.272,11	23.317.420,05
Receivables from goods and services	3.623.685,92	2.788.234,22
Other Receivables	28.407.586,19	20.529.185,83
Cash at bank and in hand	68.072.784,59	72.483.196,58
Total current assets	**100.592.175,36**	**96.174.705,32**
Accruals	1.120.581,48	763.295,59
Balance sheet total (assets)	**130.318.671,51**	**121.693.633,22**

Equity & liabilities (in euros)	2020	2019
Equity	91.404.756,97	86.332.785,70
Capital contribution	37.518.673,70	37.518.673,70
Reserves	45.056.865,96	43.778.865,96
Carried forward	3.757.246,04	
Profit for the financial year	5.071.971,27	5.035.246,04
Provisions	145.000,00	70.000,00
Liabilities	37.933.013,71	32.669.112,27
Payments received on account for orders where not separately deducted from inventories	28.490.069,33	24.559.069,71
Trade creditors	3.128.670,36	2.638.665,67
Other liabilities	6.314.274,02	5.471.376,89
Tax debts	1.333.413,55	1.199.096,82
Social security debts	1.659.690,77	1.532.290,18
Other liabilities	3.321.169,70	2.739.989,89
Accruals	835.900,83	2.621.735,25
Balance sheet total (equity & liabilities)	**130.318.671,51**	**121.693.633,22**

PROFIT AND LOSS ACCOUNT FOR THE FINANCIAL YEAR 2020

	2020	2019
Net turnover	6.884.068,34	8.492.157,53
Other operating income	71.511.472,23	65.485.112,93
Raw materials and consumables, and other external expenses	-14.506.072,71	-15.192.309,30
Raw materials and consumables	-5.644.615,43	-5.371.156,65
Other external expenses	-8.861.457,28	-9.821.152,65
Staff costs	-50.634.886,13	-46.659.340,76
Salaries and wages	-44.819.958,89	-41.221.565,07
Social security expenses	-5.702.174,75	-5.371.221,07
covering pensions	-3.460.167,45	-3.225.918,68
other social security expenses	-2.242.007,30	-2.145.302,39
Other staff costs	-112.752,49	-66.554,62
Value adjustments	-5.942.771,90	-5.666.324,78
on formation expenses, and intangible and tangible fixed assets	-5.829.294,90	-5.402.861,78
on current assets	-113.477,00	-263.463,00
Other operating expenses	-2.219.181,54	-1.441.252,74
Other interest and financial income	15.285,22	21.938,43
derived from affiliated undertakings	-	-
other interest and financial income	15.285,22	21.938,43
Value adjustments in respect of financial fixed assets and in respect of transferable securities held as current assets	-	-
Interest and other financial expenses	-35.942,24	-4.735,27
concerning affiliated undertakings	-	-
other interest and financial expenses	-35.942,24	-4.735,27
Profit after income taxes	5.071.971,27	5.035.246,04
Profit for the financial year	**5.071.971,27**	**5.035.246,04**

IMPRESSUM

Editor
Luxembourg Institute of Science and Technology

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Luxembourg Institute of Science and Technology

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